LG TRRIP

Local Government Transport & Roads Research & Innovation Program

An initiative by:

WALGA

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Technical Report: Low-cost safety improvements for rural Local Government roads in WA

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About LG TRRIP

The Local Government Transport and Roads Research and Innovation Program (LG TRRIP) is an initiative between Main Roads Western Australia and the Western Australian Local Government Association.

LG TRRIP has a strategic commitment to the delivery of collaborative research and development that positively contributes to the design, construction and maintenance of safe, sustainable transport infrastructure in Western Australia.

Summary

The Local Government Road Research and Innovation Program (LG TRRIP) initiated the program with this project on Low-cost road safety improvements for rural Local Government roads in Western Australia. The purpose of the project was to develop documents that would guide local government practitioners in selecting appropriate options for their local network.

The literature review, provided in the this Report, found that while general guidance on the design of low-cost road safety improvements is available in various guidance documents, little context-specific guidance exists to support the implementation of these improvements for rural local government roads in WA. The review identified several low-cost safety treatments that are discussed in the *Practitioners Guide: Low-cost road safety improvements for rural Local Government roads in WA*, including shoulder sealing, lane widening, longitudinal linemarking, audio-tactile linemarking, speed limit review and zoning, guide posts, warning signs, guide signs, vehicle activated signs, raised reflective pavement markers, surface corrections, road safety barriers, improving skid resistance and flag lighting.

The Practitioners Guideline provides guidance for the implementation of low-cost road safety improvements on rural local government roads in Western Australia (WA). In WA, the majority of the road fatalities occur on regional roads, with an estimated cost of $4.6 billion for fatalities on regional roads in WA out of a total $7.1 billion for road fatalities on all WA roads during the 5-year period between 2018 to 2022. The Guideline is based on research and analysis of existing guidance documents documented in this Report, case studies and best practice.

The Guideline provides a list of low-cost safety treatments, including engineering guidance on the selection of suitable treatments and calculation of unit rates. It is designed to help local governments save time and costs associated with road safety improvements on their local road networks. In addition to the documents, the project outputs include a presentation providing an overview of the Guideline and its use.

Acknowledgements

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1 Introduction

1.1 Background

These documents on the Low-cost road safety improvements for rural Local Government roads in WA have been developed by the National Transport Research Organisation (NTRO) for the Western Australian Local Government Association (WALGA) with the support of Main Roads Western Australia (MRWA) under the Local Government Transport and Roads Research and Innovation Program (LG TRRIP).

LG TRRIP was established in 2022 by MRWA and WALGA as a research and innovation program dedicated to the needs of the local government road network in WA. The objective of the program is to achieve better implementation of innovative practice by improving the specialist capability of local government through a collaborative program of projects which deliver advanced technology and cost-effective solutions to roads and transport issues for the people of Western Australia.

By providing this guidance, local governments will be better equipped to identify and implement the most appropriate and cost-effective solutions to improve road safety on their local road networks. This will not only reduce the risk of crashes and fatalities but will also create a safer and more comfortable road environment for all road users.

Crash Risk for Roads in Rural Areas

Between 2018 and 2022, 61% of road fatalities in WA took place on regional roads. This statistic reveals that out of the total 819 fatalities recorded on WA roads during this 5-year period, a total of 501 occurred on regional roads, while 318 were reported on metropolitan roads (see Figure 1.1).

Fatalities have a significant economic impact. The total cost of these fatalities was estimated to be approximately $7.1 billion for the 5-year period between 2018 and 2022, with metropolitan road fatalities accounting for $2.5 billion and rural road fatalities accounting for $4.6 billion (based on crash costs obtained from Main Roads WA via email correspondence).

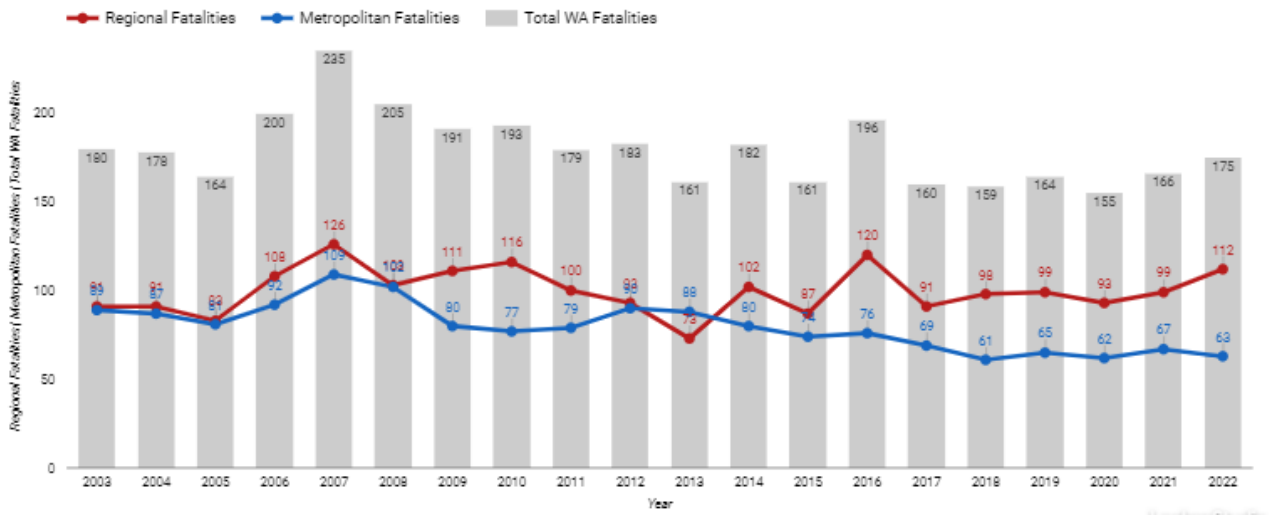
The local government road network in WA is an important component of the state's public infrastructure, comprising 87.2% of the total road network spanning over 127,336 km. This network is divided into 2 categories, with 14,168 km of metropolitan roads and 113,168 km of non-metropolitan roads, representing 11% and 89% of the road network, respectively (Western Australian Local Government Association 2021).

In FY 2020–21, the total funding allocated to local government roads was $942.2 million, providing significant support for the maintenance and improvement of these transport links. Of this funding, metropolitan roads received $235 million, accounting for 25% of the available funding. Non-metropolitan roads received a significantly larger share of the funding, with a total allocation of $707 million, representing 75% of the available funding (Western Australian Local Government Association 2021).

Figure 1.1: Number of road fatalities in WA

Regional and Metropolitan figures are based on regional boundaries defined by WA Police.

(1) The annual fatalities statistics have been derived from WA Police data but the calculations have not been endorsed by WA Police.
(2) The information was sourced from the WA Police via the WA Police Traffic Enforcement and Crash Executive Information System.
(3) The information is provisional and may be subject to revision.



Source: Road Safety Commission (2022).

1.2 Purpose

Road safety affects everyone who uses the road network. While general guidance on the design of low-cost road safety improvements is available in various guidance documents, little context-specific guidance exists to support the implementation of these improvements on rural local government roads in WA.

Local governments have the responsibility of ensuring the safety of their local road networks. However, in some cases, the selected materials for implementing these safety improvements are not readily available. To support the delivery of safety projects, local governments may benefit from guidance on the relative benefits, selection, and implementation of low-cost road safety improvements.

Such improvements may include but are not limited to:

- guide posts
- warning signs (curve, intersection, and advisory speed)
- guide signs (chevron alignment markers)
- raised reflective pavement markers
- surface corrections
- speed limit review and zoning
- longitudinal linemarking (centre/edge)
- shoulder sealing
- lane widening
- audio-tactile linemarking (centre/edge)
- road safety barriers

- improving skid resistance
- vehicle activated signs
- flag lighting.

By providing this guidance, local governments will be better equipped to identify and implement the most appropriate and cost-effective solutions to improve road safety on their local road networks. This will not only reduce the risk of crashes and fatalities but will also create a safer and more comfortable road environment for all road users.

The objective of this document is to provide the technical basis for a Guideline for practitioners for the selection of low-cost safety treatments on rural local government roads in WA. These roads are primarily situated in regional or peri-urban locations, predominantly characterised by both sealed or unsealed surfaces and typically without kerbs.

1.3 Structure

The following documents have been prepared:

- Practitioners Guideline
- **Technical Report** (this document).

The content and relationship between these 2 documents are summarised in Table 1.1.

Table 1.1: Structure of the documents

Document	Content
Practitioners Guideline	The Guideline is presented in a user friendly format and provides key information needed for practitioners to select the appropriate improvements.
Technical Report	The technical report contains the background research and supporting technical information.

1.4 Scope and Methodology

The Technical Report provides local government with the basis of the Practitioners Guideline.

The Practitioners Guideline includes the following sections.

- Section 1 provides an introduction to the Guideline.
- Section 2 provides a matrix to assist in the selection of treatments as well as fact sheets for each road safety treatment which contains detailed engineering guidance.
- Section 3 summarises the case studies for selected low-cost treatments. Each case study discusses the success and effectiveness of the relevant treatment, including any challenges faced during implementation.
- Section 4 provides recommended applications to practitioners.

The Technical Report includes the following sections.

- Section 1 provides an overview of the documents objectives and scope.
- Section 2 summarises the review of current guidelines and research. The summary provides a background and context for the implementation of low-cost safety treatments and was used as the basis for the implementation opportunities identified in this report.
- Section 3 summarises the opportunities for implementation of low-cost safety treatments on rural local government roads in WA.

The Guideline provides a list of low-cost safety treatments, including engineering guidance on the selection of suitable treatments and calculation of unit rates where possible. The anticipated benefits of the Guideline

are time savings for local government in the selection and design of low-cost treatments and an increase in cost savings associated with road safety improvements within local governments.

The Guideline is based on research and analysis of existing guidance documents, consultation with local government, case studies and best practices. The Guideline has been developed in consultation with local government to ensure applicability for the Western Australia. Appendix B contains the results of the consultation with local governments.

2 Key Outcomes from Literature Review

This section summarises the key findings of the literature review and acknowledges the sources used in the research. The review focused on identifying low-cost road safety treatments in Western Australia and used 15 specified sources of reference, as listed in Table 2.1.

The sources used in the review include research papers, reports and other relevant publications that provide information and insights into the effectiveness of different treatments, cost-benefit analysis and best practices for implementing road safety measures. Table 2.2 provides a summary of the specific treatments covered within these sources.

This summary of key outcomes serves as a foundation for the treatment fact sheets, presented in Section **Error! Reference source not found.**. By referencing the sources used in the research, transparency and credibility are provided to the findings. Refer to Appendix A for further elaboration of the literature review.

Table 2.1: List of sources reviewed

	Literature
1	Austroads (2016a), *Safe System Assessment Framework*
2	Austroads (2016b), *Safe System Roads for Local Government*
3	Austroads (2019b), *Guide to Road Safety Part 5: Road Safety for Regional and Remote Areas* Superseded document
4	Austroads (2021a), *Guide to Road Safety Part 2: Safe Roads*
5	Austroads (2021b), *Guide to Road Safety Part 3: Safe Speed*
6	Austroads (2022), *Guide to Road Safety Part 6: Road Safety Audit*
7	Cogo et al. (2021), *R99: Identification of Safety Risk and Development of Mitigating Treatments for Narrow (4 m) Sealed Roads: 2020/21*
8	iRAP (2022), *Road Safety Toolkit*
9	Main Roads Western Australia (Main Roads Western Australia 2021), *Treatment Resource Guide*
10	Main Roads Western Australia (2022b), *Speed Zoning: Policy and Application Guidelines*
11	Taylor et al. (2019), *R85: Review of Engineering Treatments for Urban Fringe Environments: 2018/19*
12	Australian Standard 1742.2:2022 *Manual of Uniform Traffic Control Devices: Part 2: Traffic Control Devices for General Use*
13	Australian Standard 1742.4:2020 *Manual of Uniform Traffic Control Devices: Part 4: Speed Controls*
14	Austroads (2020), *Guide to Traffic Management Part 10: Transport Control – Types of Devices*
15	U.S. Department of Transportation Federal Highway Administration (2019)

Table 2.2: Literature review and specific treatments matrix

Treatments	Literature														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Shoulder sealing	X	X	X	X	X	X	X	X	X		X	X		X	
Lane widening	X			X			X	X	X		X			X	
Longitudinal linemarking	X	X	X	X		X	X	X	X		X	X		X	
Audio-tactile linemarking	X	X	X	X		X		X	X			X		X	X
Speed limit review and zoning	X	X	X	X	X		X	X	X	X	X	X	X		X
Guide posts		X		X	X		X	X			X	X		X	
Curve warning signs	X	X	X	X	X	X	X	X	X	X	X	X		X	
Intersection warning signs	X	X	X	X	X	X	X	X	X	X		X		X	
Advisory speed signs	X	X	X	X	X	X	X		X	X		X		X	
Guide signs – i.e. CAMs	X	X	X	X		X	X	X	X		X	X		X	X
Vehicles activated signs	X		X		X				X		X			X	
RRPMs	X	X		X		X		X	X		X	X		X	
Surface corrections	X					X		X							
Road safety barriers	X	X	X	X	X	X		X	X		X	X			
Skid resistance	X			X		X		X	X			X			X
Flag lighting				X					X						

3 Implementation Opportunities

Road safety is a significant issue in WA, particularly on rural local government roads where a significant number of road fatalities occur. The research conducted prior to the development of this Guideline identified a need for consolidated guidance on low-cost road safety improvements specific to rural local government roads in WA.

The Practitioners Guideline provides practical guidance on low-cost safety treatments to help reduce crash risk on these roads and is best used alongside the technical report when further detailed information is required. This Guideline considers current guidelines, provides case studies and best practices to provide a Guideline for the selection and delivery of low-cost safety treatments.

With the implementation of low-cost road safety treatments on local government road networks Local government supports a reduction in the risk of crashes and fatalities. Local Governments will be able to identify and implement the most appropriate and cost-effective solutions for improving road safety on their local road networks. The documents include engineering guidance, unit rate calculations, and examples of case studies and considerations have been developed specifically for WA's local road context.

These documents ensure Local Governments have additional tools to make informed decisions. Further implementation opportunities include community engagement and education in road safety helps to create values in road safety and encourage road users to adopt safer road behaviours.

These documents are published with the best knowledge available but changes in local road contexts and the availability of new materials and technologies are expected. Updates to these documents made from time to time will maintain the currency of the information.

References

Austroads 2014, *Methods for reducing speeds on rural roads: compendium of good practice,* AP-R449-14, Austroads, Sydney, NSW, accessed 15 May 2023, < https://austroads.com.au/publications/road-safety/ap-r449-14/media/AP-R449-14-Methods-for-Reducing-Speeds-on-Rural-Roads.pdf>.

Austroads 2016a, *Safe system assessment framework*, AP-R509-16, Austroads, Sydney, NSW, accessed 15 May 2023, <https://austroads.com.au/publications/road-safety/ap-r509-16>.

Austroads 2016b, *Safe system roads for local government*, AP-R518-16, Austroads, Sydney, NSW, accessed 15 May 2023, <https://austroads.com.au/publications/road-safety/ap-r518-16>.

Austroads 2016c, *Achieving safe system speeds on urban arterial roads: compendium of good practice*, AP-R514-16, Austroads, Sydney, NSW.

Austroads 2018, *Guide to pavement technology part 8: pavement construction*, AGPT08-09, Austroads, Sydney, NSW, accessed 15 May 2023, <https://austroads.com.au/publications/pavement/agpt11/media/AGPT08-09_Guide_to_Pavement_Technology_Part_8_Pavement_Construction.pdf>.

Austroads 2019a, *Guide to pavement technology part 5: pavement evaluation and treatment design*, AGPT05-19, Austroads, Sydney, NSW, accessed 15 May 2023, <https://austroads.com.au/publications/pavement/agpt05 >.

Austroads 2019b, *Guide to road safety part 5: road safety for regional and remote areas*, 2nd edn, AGRS05-19, Austroads, Sydney, NSW (superseded).

Austroads 2020, *Guide to traffic management part 10: transport control – types of devices*, AGTM10-20, Austroads, Sydney, NSW, accessed 15 May 2023, <https://austroads.com.au/publications/traffic-management/agtm10 >.

Austroads 2021a, *Guide to road safety part 2: safe roads*, AGRS02-21, Austroads, Sydney, NSW, accessed 15 May 2023, <https://austroads.com.au/publications/road-safety/agrs02>.

Austroads 2021b, *Guide to road safety part 3: safe speed*, AGRS03-21, Austroads, Sydney, NSW, accessed 15 May 2023, <https://austroads.com.au/publications/road-safety/agrs03>.

Austroads 2021c, *Guide to road design part 3: geometric design*, AGRD03-16, Austroads, Sydney, NSW, accessed 15 May 2023, <https://austroads.com.au/publications/road-design/agrd03>.

Austroads 2022a, *Guide to road safety part 6: road safety audit*, 6th edn, AGRS06-22, accessed 15 May 2023, <https://austroads.com.au/publications/road-safety/agrs06>.

Austroads 2022b, *Guide to road design part 6: roadside design, safety and barriers,* 4th edn, AGRD06-22, accessed 15 May 2023, < https://austroads.com.au/publications/road-design/agrd06>.

Burke, A 2015, *'Effectiveness of portable speed warning signs'*, 2015 Australasian Road Safety Conference, Gold Coast, Queensland, Australia.

Cogo, K, Milling, D, Hay, K & Trejo, C 2021, *R99: Identification of safety risk and development of mitigating treatments for narrow (4 m) sealed roads: 2020/21)*, contract report 015695, prepared for Queensland Department of Transport and Main Roads under the NACOE program, ARRB, Port Melbourne, accessed 15 May 2023, <https://www.nacoe.com.au/wp-content/uploads/2021/07/R99-20-21-Identification-of-safety-risk-and-development-of-mitigating-treatments-for-narrow-4-m-sealed-roads_for-publication.pdf>.

iRAP 2022, *Road safety toolkit*, website, International Road Assessment Programme, London, UK, accessed 15 May 2023, <https://toolkit.irap.org/safer-road-treatments/>.

Lyons, M, Garton, D, Martin, T, Moffatt, M, Milling, D, Patrick, S, Harrison, J, Thomas, L & Rice, Z 2020, *Sealed roads: best practice guide 3,* ARRB, Port Melbourne, Vic.

Main Roads Western Australia 2016, *Pavement marking specification 604,* MRWA, Perth, WA, accessed 15 May 2023, <https://www.mainroads.wa.gov.au/globalassets/technical-commercial/technical-library/specifications/600-series-traffic-facilities/specification-604-pavement-marking.docx>.

Main Roads Western Australia 2021, *Treatment resource guide*, MRWA, Perth, WA, accessed 15 May 2023, <https://www.mainroads.wa.gov.au/globalassets/technical-commercial/road-safety/treatment-resource-guide.pdf>.

Main Roads Western Australia 2022a, *Policy and guidelines: vehicle activated signs*, MRWA, Perth, WA, accessed 15 May 2023, <https://www.mainroads.wa.gov.au/globalassets/technical-commercial/technical-library/road-and-traffic-engineering/traffic-management/vehicle-activated-signs-policy-and-guidelines.pdf>.

Main Roads Western Australia 2022b, *Safety and traffic barrier systems,* specification 603*,* MRWA, Perth, WA, accessed 15 May 2023, < https://www.mainroads.wa.gov.au/globalassets/technical-commercial/technical-library/specifications/600-series-traffic-facilities/specification-603-safety-and-traffic-barrier-systems.docx>.

Main Roads Western Australia 2022c, *Speed zoning: policy and application guidelines*, MRWA, Perth, WA, accessed 15 May 2023, <https://www.mainroads.wa.gov.au/globalassets/technical-commercial/technical-library/road-and-traffic-engineering/traffic-management/speed-zones/speed-zoning-policy-and-application-guidelines.pdf>.

Queensland Department of Transport and Main Roads 2020, *Pavement rehabilitation manual*, TMR, Brisbane, Qld, accessed 15 May 2023, <https://www.tmr.qld.gov.au/_/media/busind/techstdpubs/pavements/pavement-rehabilitation-manual/pavement_rehabilitation_manual.pdf?sc_lang=en&hash=D97DFAFB06AF97D1A1CE457172068897>.

Rice, Z, Grenfell, J & Patrick, S 2020, *Road materials: best practice guide 1*, ARRB, Port Melbourne, Vic.

Road Safety Commission 2022, *Annual road statistics Western Australia*, Government of WA website, Perth, WA, accessed 15 May 2023, <https://www.wa.gov.au/organisation/road-safety-commission/annual-road-statistics-western-australia>.

Taylor, S, Steer, G & Affum, J 2019, *R85: Review of engineering treatments for urban fringe environments: 2018/19*, contract report PRS18075, prepared for Queensland Department of Transport and Main Roads under the NACOE program, ARRB, Port Melbourne, Vic, accessed 15 May 2023, <https://www.nacoe.com.au/wp-content/uploads/2021/03/R85-Final-Report.pdf>.

Western Australian Local Government Association 2021, *Report on local government road assets & expenditure 2020-2021*, WALGA, West Perth, WA, accessed 15 May 2023, <https://walga.asn.au/getattachment/Policy-Advocacy/Our-Policy-Areas/Infrastructure/Roads/Report-on-Local-Government-Road-Assets-and-Expendi/Road-Assets-and-Expenditure-Report-2020-21-website.pdf?lang=en-AU>.

U.S. Department of Transportation 2019, *Proven Safety Countermeasures*, FHWA website, McLean, Virginia, accessed 15 May 2023, < https://highways.dot.gov/safety/proven-safety-countermeasures>.

Standards Australia

AS 1742.2:2022, *Manual of uniform traffic control devices: part 2: traffic control devices for general use*.

AS 1742.4:2020, *Manual of uniform traffic control devices: part 4: speed controls*.

AS 1906.3:2017, *Retroreflective materials and devices for road traffic control purposes.*

AS 4049:2005, *Paints and related materials – pavement marking materials.*

Appendix A Literature Review

Refer to A.1 to A.20 for literature review detailing all treatments.

A.1 Austroads (2016a) Safe System Assessment Framework

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
–	–	–	Seal the shoulders to a minimum of 1.0 m on each side of the.	–	Supporting treatment	–	Reduces head-on crashes.	–	–	–	–	–	–
Lane widening													
–	–	–	–	–	Supporting treatment	–	–	–	–	–	–	–	–
Longitudinal linemarking													
Centreline and edge lines along the entire length of the road together with raised reflective pavement markers through each bend, with the required road widening on bends in the first instance.	–	–	–	–	Supporting treatment	Audio-tactile linemarking	–	–	–	–	–	–	–
Audio-tactile linemarking													
–	–	–	–	–	–	Shoulder sealing	• Alert a driver to their own distraction or fatigue. • Reduce the occurrence of run-off-road crashes. • Reduce the likelihood of collisions with roadside barriers.	–	–	–	–	–	–
Speed limit review and zoning													
–	–	–	• Function of the road. • Road environment. • Current speed limits. • Any recent changes to the speed limit. • Is it similar to other roads of similar type. • Type of road users.	–	Primary treatment	• Educational campaigns. • Signage. • Interim speed limits.	–	–	–	–	–	–	–
Guide posts													
–	–	–	–	—	–	–	–	–	–	–	–	–	–
Curve warning signs													
–	–	–	–	–	Supporting treatment	–	–	–	–	–	–	–	–
Intersection warning signs													
–	–	–	–	–	Supporting treatment	–	–	–	–	–	–	–	–
Advisory speed signs													
–	–	–	–	–	Supporting treatment	–	–	–	–	–	–	–	–
Guide signs (i.e. CAMs)													
–	–	–	–	–	Supporting treatment	–	–	–	–	–	–	–	–
Vehicle activated signs													
–	–	–	–	–	Supporting treatment	–	–	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
RRPMs													
–	–	–	–	–	Supporting treatment	Pavement marking – centreline and edge lines	–	–	–	–	–	–	–
Surface corrections													
–	–	–	–	–	Supporting treatment	–	–	–	–	–	–	–	–
Road safety barriers													
–	–	• Continuous median- or mid-barrier separation of opposing directions. • Continuous side-barriers with minimum breaks, no hazardous breaks and no hazardous barrier terminations.	–	–	Primary treatment	–	–	–	–	–	–	–	–
Skid resistance													
–	–	–	–	–	Supporting treatment	–	–	–	–	–	–	–	–
Flag lighting													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

A.2 Austroads (2016b) Safe System Roads for Local Government

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
–	In rural environments for Australia, no significant difference in the percentage of Fatal and Serious Injury (FSI) for sealed and unsealed roads.	–	–	–	–	Common for audio-tactile edge lines to be installed when sealing shoulders on a rural road.	Having unsealed shoulders is one of the several factors contributing to crashes.	–	–	–	–	Medium	–
Lane widening													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Longitudinal linemarking													
–	–	–	Linemarking is transversable.	–	–	Audio-tactile linemarking	Delineation for motorists.	–	–	–	–	Low	–
Audio-tactile linemarking													
Audio-tactile linemarking are painted edge or centreline markings that provide an audio-tactile stimulus to drivers if they cross the edge of their travel lane.	–	• On the shoulder side of the road. • Centre of the road.	Common for audio-tactile edge lines to be installed when sealing shoulders on a rural road.	–	–	Shoulder sealing	Warn fatigued, errant or inattentive drivers that they are leaving the roadway.	–	–	–	–	–	–
Speed limit review and zoning													
Speed limits can provide an indication of the function of the road, e.g. lower speed limit roads are generally lower on the road hierarchy. It should be noted that the speed limit analysis reflects the definitions adopted for urban and rural road environments, i.e. urban road environments generally include roads with lower speed limits, while rural road environments feature roads with higher speed limits.	–	–	• Review speed limits in response to changing land use and traffic. • Local speed reduction campaigns.	–	–	Deploy movable vehicle speed feedback displays to reinforce speed limits.	–	–	–	–	–	–	–
Guide posts													
Guide posts can be installed on the outside of curves to help improve delineation. They are fitted with small reflectors near the top to improve night-time effectiveness.	5%	Sites with poor existing delineation.	–	–	–	–	–	–	–	–	–	Low: cost-effective delineation treatment	–
Curve warning signs													
–	–	–	–	–	–	–	Change road user behaviour by providing warning/advice to seek appropriate behaviour.	–	–	–	–	Medium	–
Intersection warning signs													
–	–	–	–	–	–	–	Change road user behaviour by providing warning/advice to seek appropriate behaviour.	–	–	–	–	Low	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Advisory speed signs													
–	–	–	–	-	–	–	Change road user behaviour by providing warning/advice to seek appropriate behaviour.	–	–	–	–	Low	–
Guide signs (i.e. CAMs)													
Chevron alignment markers (CAMs) are used to indicate the presence and severity of upcoming curves.	–	–	–	–	–	Can be installed with retroreflective posts that enhance the sign's conspicuity and visibility	Improve the lateral positioning of vehicles, moving them away from centre of the carriageway, thereby reducing the likelihood of head-on crashes.	–	–	–	–	Low	–
Vehicle activated signs													
–	–	–	–	–	–	–	–	–	–	–	–	Medium	–
RRPMs													
RRPMs are used in combination with linemarking to improve delineation, especially at night and during adverse weather conditions.	• Crashes on rural highways: 4%. • Fatal crashes on rural highways: 17%. • Overall crash reduction: 10%. • At night: 22%. • Wet roads: 25%.	–	–	–	–	–	• To improve delineation, especially at night and during adverse weather conditions. • Give drivers a longer sight distance of delineation. Provide an audio-tactile warning when departing a lane.	–	–	–	–	–	–
Surface corrections													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Road safety barriers													
A road safety barrier should be provided to protect vehicles from colliding with a hazard that could not otherwise be removed or relocated. The aim of a safety barrier or crash cushion is to lower the crash severity outcome in the event of a crash with the hazard.	–	• Areas that can lower the crash severity outcome in the event of a crash with the hazard. • Rigid barriers: urban environments and areas with high proportion of heavy vehicles.	• Flexible barriers: Designed to transfer the kinetic energy of a collision into the lateral deflection of the barrier. • Semi-rigid barriers: Designed to deform in the event of a vehicle impact and guide the vehicle in the direction of the traffic flow. • Rigid barriers: Generally constructed of reinforced concrete and experience negligible deflection when impacted.	–	–	–	• Contain and redirect the vehicle away from a roadside obstacle. • Decelerate the vehicle to a safe stop. • Break away readily, fracture or give way. • Controlled penetration. • Can be traversable.	• Risk of errant motorcyclists being injured by the sharp wire ropes or posts in the event of a crash.	• Flexible barriers: Wire rope barriers. • Semi-rigid barriers: steel guard rails. (W-Beam, ThrieBeam, or Modified Thrie-Beam) • Rigid barriers: Reinforced concrete. (New Jersey, F type, Vertical face, Single slops, or High containment)	–	–	–	–
Skid resistance													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Flag lighting													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

A.3 Austroads (2019) Guide to Road Safety Part 5: Road Safety for Regional and Remote Areas (Superseded Document)

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
Targeted treatment of road sections known to have a higher incidence of fatigue-related crashes using proven single vehicle run-off-road countermeasures, e.g. widened and sealed shoulders.	–	–	–	–	–	–	–	–	–	–	–	–	–
Lane widening													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Longitudinal linemarking													
Road markings could be used/improved to assist the driver in understanding the road environment (e.g. upcoming curve, etc.)	–	–	• Identify and prioritise corridors with the highest death and serious injury risk within the network. • Develop corridor safety plans to consistently apply treatments.	–	–	–	Effective at controlling the speed to and through horizontal curves.	–	–	–	–	–	–
Audio-tactile linemarking													
Transverse audio-tactile treatments (i.e. audible edge lines) as an alerting device to regain control over the vehicle and maintain lane position.	–	–	–	–	–	–	–	–	–	–	–	–	–
Speed limit review and zoning													
The most obvious method of managing speed is by setting appropriate speed limits. However, when speed limits were initially introduced there was little knowledge of the relationship between speed, crash risk, vehicle safety and vulnerable road users. Over time, the population has become accustomed to driving at high speeds and undoing this practice requires long-term, ongoing strategies.	5% increase in mean speed leads to around a 10% increase in all injury crashes and a 20% increase in fatal crashes.	• Introduce a reduced default speed limit outside built-up areas in jurisdictions where limits exceed 100 km/h. • Introduce reduced speed limits on unsealed roads to 80 km/h. • Revise speed limits on roads lacking safe infrastructure to determine more appropriate limits.	The association between higher vehicle speed = increased crash rates and injury severity.	–	–	In addition to speed limits, alternative speed countermeasures include engineering treatments and enforcement-related options.	–	–	–	–	–	–	–
Guide posts													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Curve warning signs													
Warning signs could be used/improved to assist the driver in understanding the road environment (e.g. upcoming curve, etc.), as well as additional, multiple signage to advise drivers of upcoming rest locations.	–	–	–	–	–	• Edge lines. • Improved cross sections.	Improved curve delineation, reducing run-off-road crashes at curves.	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Intersection warning signs													
Warning signs could be used/improved to assist the driver in understanding the road environment (e.g. upcoming curve, etc.), as well as additional, multiple signage to advise drivers of upcoming rest locations.	–	–	–	–	–	–	–	–	–	–	–	–	–
Advisory speed signs													
Engineering-based countermeasures (i.e. speed advisory signs) aim to alert the driver to potential hazards so that they reduce their speed sufficiently before encountering the hazard.	Countermeasures for risky curves have been associated with a reduction in crashes of up to 40% and for hazardous intersections a reduction in crashes of up to 70% (Austroads 2014).	–	–	–	–	–	Effective at controlling the speed to and through horizontal curves.	–	–	–	–	–	–
Guide signs (i.e. CAMs)													
Engineering-based countermeasures (i.e. chevron alignment markers) aim to alert the driver to potential hazards so that they reduce their speed sufficiently before encountering the hazard.	Countermeasures for risky curves have been associated with a reduction in crashes of up to 40% and for hazardous intersections a reduction in crashes of up to 70% (Austroads 2014).	–	–	–	–	–	Effective at controlling the speed to and through horizontal curves.	–	–	–	–	–	–
Vehicle activated signs													
Engineering-based countermeasures (i.e. vehicle activated signs) aim to alert the driver to potential hazards so that they reduce their speed sufficiently before encountering the hazard.	Countermeasures for risky curves have been associated with a reduction in crashes of up to 40% and for hazardous intersections, a reduction in crashes of up to 70% (Austroads 2014).	–	• Identify and prioritise corridors with the highest death and serious injury risk within the network. • Develop corridor safety plans to consistently apply treatments.	–	–	–	• Effective at controlling the speed to and through horizontal curves. • Alert drivers before encountering hazards.	–	–	–	–	–	–
RRPMs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Surface corrections													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Road safety barriers													
The latest research evidence suggests that corridor protection is among the best options (Austroads 2018). Corridor protection consists of continuous lengths of flexible barrier along roadsides and the median.	–	–	Continuous flexible barriers on either the roadside or the median are a supporting treatment compatible with future Safe System improvements.	–	–	• Lower speed limits and roadside infrastructure improvements. • Curve delineation and signing.	• Reduce the incidence of single vehicle run-off-road crashes.	–	–	–	–	–	–
Skid resistance													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Flag lighting													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

A.4 Austroads (2021a) Guide to Road Safety Part 2: Safe Roads

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
Shoulders may be wholly or partially sealed. Sealing of shoulders is frequently done to reduce maintenance costs and to improve moisture conditions under pavements, especially under the outer wheel path.	–	–	• Most of the benefit being achieved by a shoulder seal width of 0.5 to 1.5 m. • The width of shoulder sealing will depend on traffic speed, volume and composition, environmental conditions and the nature of the roadside area.	–	–	• Safety benefits of sealed shoulders were also evident on rural roads with lower speed limits, e.g. 80 km/h. • Audio-tactile edge line.	Reduce crash rates, particularly with respect to run-off-road crashes.	–	–	–	–	–	25 years
Lane widening													
–	–	Widening of the road pavement may be required at curves in the road, dependent on curve radius, lane width and the design vehicle for the road.	–	–	–	–	–	–	–	–	–	–	25 years
Longitudinal linemarking													
Edge lines are used to delineate the outer limits of the travelled way.	–	• Greatest benefit during poor light conditions and weather conditions, and when approaching and driving through a curve. • Centrelines should be marked to separate opposing directions of traffic flow on sealed pavements at least 5.5 m wide. On pavements narrower than this, centrelines are not usually provided other than where sight lines for overtaking are deficient.	Barrier lines should not be used on pavements of insufficient width where it is not practicable for all vehicles to travel on their side of the line.	–	–	RRPMs	Discourage travel on the road shoulder, to assist drivers to track away from the edge of the road and to provide a visual cue of the path of the road.	–	–	–	–	–	–
Audio-tactile linemarking													
Audio-tactile linemarking can be provided with raised, transverse bars of thermoplastic material placed at short intervals. The purpose of this marking is to alert drivers that they are drifting out of their lane, either across the road shoulder, across into another lane or into the opposing lanes of traffic.	Tactile edge lines can reduce casualty crashes by 23%, while centreline tactile linemarking may reduce casualty crashes by 15%.	Audio-tactile edge lines should be considered where there is a recorded history of fatigue-related crashes, and may be considered on roads prone to fog.	Hard to hear in large vehicles such as four-wheel drives and is often impossible to hear in heavy vehicles.	–	–	–	–	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Speed limit review and zoning													
The management of vehicle speeds via speed limits continues to be the subject of much contention; however, it is acknowledged as a key element of achieving significant gains in the safety of the road network. Speed is known to have a significant impact on the likelihood and severity of crashes. A good evidence base now exists regarding the survivability of road users for different crash types based on impact speed.	–	Speed limits and speed management are essential factors in determining how road space is utilised in respect of Movement and Place. Broadly speaking, speed limits are likely to be higher on roads where movement is the primary function and lower speed limits are likely to be important in creating a sense of 'place'.	–	–	–	Where speed has been identified as a contributory factor to crash severity and/or causation, appropriate management of speed should be investigated as a countermeasure. At intersections, techniques include the installation of channelisation, roundabouts or threshold treatments. At mid-block locations, appropriately designed traffic calming can be used. Some enforcement activities are shown to be effective at improving a specific behaviour but do not show a corresponding reduction in crashes.	Applying appropriate speed management can influence the likelihood of a crash.	–	–	–	–	–	–
Guide posts													
Guide posts are used to show the edge of the road and enhance the delineation of the road's path for drivers. They should be installed at a uniform distance from the edge of the road and should be fitted with retro-reflective delineators.	–	On straight road sections, guide posts should be arranged in pairs at a spacing of 150 m, although this spacing may be amended according to conditions outlined in the standard. The standard also specifies the spacing of guide posts on curves, crests, cuttings, bridges and culverts. Guide posts should be installed to be 1 m high above ground level.	In Australia, red delineators are used on the left side of the roadway, white delineators on the right side of two-way roadways and yellow delineators on the right side of one-way roadways (including divided roads).	–	–	• Linemarking and warning signs at substandard curves.	–	–	–	–	–	–	–
Curve warning signs													
While guide posts and linemarking can be used to delineate the path of a road, some of the more unexpected aspects of the road's geometry will require additional signage to convey its severity and nature to drivers. Curve warning signs, advisory speed signs and chevron alignment markers (CAMs) are all appropriate treatments for substandard curves.	–	–	On sections of road that have curved alignment and a crash history, and pass through an environmentally sensitive landscape, it may be desirable to provide an enhanced warning sign at both approaches to the road section.	–	–	• Guide posts. • Linemarking.	–	Regular maintenance (e.g. loss of reflectiveness).	–	–	• Tree obscure sections. • Longitudinal and lateral positioning away from the curve.	–	–
Intersection warning signs													
–	–	–	–	–	–	–	–	Regular maintenance (e.g. loss of reflectiveness).	–	–	• Tree obscure sections. • Longitudinal and lateral positioning away from the curve.	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Advisory speed signs													
While guide posts and linemarking can be used to delineate the path of a road, some of the more unexpected aspects of the road's geometry will require additional signage to convey its severity and nature to drivers. Curve warning signs, advisory speed signs and chevron alignment markers (CAMs) are all appropriate treatments for substandard curves	30%	–	–	–	–	–	–	–	–	–	–	–	–
Guide signs (i.e. CAMs)													
While guide posts and linemarking can be used to delineate the path of a road, some of the more unexpected aspects of the road's geometry will require additional signage to convey its severity and nature to drivers. Curve warning signs, advisory speed signs and chevron alignment markers (CAMs) are all appropriate treatments for substandard curves	–	–	Spacing of the signage can affect effectiveness.	–	–	–	–	–	–	–	–	–	–
Vehicle activated signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
RRPMs													
RRPMs may be used to augment painted lines or instead of painted lines for the provision of lane lines, separation and barrier lines, edge lines and traffic islands and medians.	–	Where it is intended that they simulate marked lines.	RRPMs are used in various colours as follows: • White markers are used to augment lane lines, markings at traffic islands and freeway ramp gore areas. • Yellow markers can be used to augment dividing lines, the right-hand edge lines of one-way carriageways and markings at median islands. • Red markers are used where appropriate to augment left-hand edge lines of two-way and one-way carriageways. • Blue markers are used to mark the location of fire hydrants on roads. In this case a single marker is placed near the road centreline opposite the position of the hydrant on that side of the road. • Green markers may be used to denote freeway/motorway exits and entries.	–	–	Linemarking.	• Not obscured at night under wet conditions. • More prominent than reflectorised painted markings. • Provides an audible and tactile signal when traversed by vehicle wheels.	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Surface corrections													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Road safety barriers													
In instances where a roadside hazard cannot be made safe, removed or relocated, it may be necessary to provide physical protection from the hazard. Safety barriers are available for a variety of applications and this document advice on selecting, installing and maintaining safety barriers.	–	If there is a risk that a batter slope is severe/steep enough to cause an errant vehicle to overturn during a crash, installation of a safety barrier should be considered.	Safety barriers are potential roadside hazards. When considering whether to install a safety barrier, it is important to remember that the barrier will present some danger to the occupants of errant vehicles, and especially to unprotected road users such as motorcyclists. A barrier should only be installed if collision with it will present less of an injury risk to vehicle users and occupants than would result from collision with the roadside hazard that is to be shielded by the barrier.	–	–	–	–	–	–	–	–	–	–
Skid resistance													
A road surface needs to be constructed and maintained to a sufficient standard to ensure adequate skid resistance. Skid resistance is the frictional resistance provided by the pavement to vehicle tyres during braking or cornering manoeuvres, normally measured on wet surfaces. Situations where a pavement can hold water instead of draining properly can contribute to vehicles aquaplaning.	–	–	To be sure of the condition of an existing pavement it is necessary to conduct skid resistance measurements as well as an assessment of the level of rutting and the occurrence of potholes.	–	–	–	–	–	–	–	–	–	–
Flag lighting													
–	–	Where a high frequency of night-time crashes is involved, consider street lighting.	–	–	–	–	–	–	–	–	–	–	–

A.5 Austroads (2021b) Guide to Road Safety Part 3: Safe Speed

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
–	• At speed limit of 100 km/h: 14% • At 110 km/h: 25%	–	–	–	–	–	–	–	–	–	–	–	–
Lane widening													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Longitudinal linemarking													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Audio-tactile linemarking													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Speed limit review and zoning													
Speed management is a key factor in the safe and efficient operation of the road network. Speed limits need to reflect varying road user types, road environments, vehicle types and community needs such as safety, amenity and economics.	• 10 km/h reduction from a road with 100 km/h speed limit: 20%. • 10 km/h reduction from a road with 110 km/h speed limit: 20%.	–	• Effective speed management needs appropriate infrastructure, accompanied by education and enforcement to maximise compliance and appropriate travel speeds. • A speed zone is generally not applied as a means of addressing isolated roadside hazards	–	–	Methods to manage speed include: • Roads and roadside infrastructure – such as speed calming treatments. • Speed limits and speed enforcement. • People – such as influencing people's attitudes and behaviours regarding risk and safety. • Vehicles – such as speed limiter devices, adaptive cruise control.	• Reduced travel speeds can help reduce harmful emissions, enhance traffic flow, decrease user costs and improve safety.	Minor increase in travel time for motorists.	–	–	–	Low	–
Guide posts													
–	–	–	–	–	Supporting treatment	–	–	–	–	–	–	–	–
Curve warning signs													
–	–	Alignment of the road (i.e. whether it is straight or curved, and if it is flat or steep). Short sections of a road with an adverse alignment should be treated with advisory warning signs.	–	–	–	–	–	–	–	–	–	–	–
Intersection warning signs													
–	–	Alignment of the road (i.e. whether it is straight or curved, and if it is flat or steep). Short sections of a road with an adverse alignment should be treated with advisory warning signs.	–	–	–	–	–	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Advisory speed signs													
–	–	Alignment of the road (i.e. whether it is straight or curved, and if it is flat or steep). Short sections of a road with an adverse alignment should be treated with advisory warning signs.	–	–	–	–	–	–	–	–	–	–	–
Guide signs (i.e. CAMs)													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vehicle activated signs													
–	–	Alignment of the road (i.e. whether it is straight or curved, and if it is flat or steep). Short sections of a road with an adverse alignment should be treated with advisory warning signs.	–	–	–	–	–	–	–	–	–	–	–
RRPMs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Surface corrections													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Road safety barriers													
Safety barriers provide a key way to manage kinetic energy.	–	–	–	–	–	–	–	–	–	–	–	–	–
Skid resistance													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Flag lighting													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

A.6 Austroads (2022a) Guide to Road Safety Part 6: Road Safety Audit

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
–	–	–	• Are shoulders wide enough to allow drivers to regain control of errant vehicles. • Are shoulders wide enough for broken-down or emergency vehicles to stop safely.	–	–	–	–	–	–	–	–	–	–
Lane widening													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Longitudinal linemarking													
–	–	–	Centre and edge lines to conform to the local Manual of Uniform Traffic Control Devices (MUTCD).	–	–	–	–	Introduces confusion and uncertainty when obsolete linemarking have not been properly erased or covered when change in design.	–	–	–	–	–
Audio-tactile linemarking													
–	–	–	–	–	Supporting treatment	–	–	–	–	–	–	–	–
Speed limit review and zoning													
–	–	–	Is the speed limit compatible with the function, road geometry, land use and sight distance.	–	–	–	–	–	–	–	–	–	–
Guide posts													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Curve warning signs													
–	–	–	Is the horizontal and vertical alignment suitable for the (85th percentile) traffic speed? If not: • Are warning signs installed? • Are advisory speed signs installed? • Are the posted advisory speeds for curves appropriate?	–	Change Road User Behaviour	–	Provide warning/advice to seek appropriate behaviour.	–	–	–	–	–	–
Intersection warning signs													
–	–	–	–	–	Change Road User Behaviour	–	Provide warning/advice to seek appropriate behaviour.	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Advisory speed signs													
–	–	–	Is the horizontal and vertical alignment suitable for the (85th percentile) traffic speed? If not: • Are warning signs installed? • Are advisory speed signs installed? • Are the posted advisory speeds for curves appropriate?	–	Change Road User Behaviour	–	Provide warning/advice to seek appropriate behaviour.	–	–	–	–	–	–
Guide signs (i.e. CAMs)													
–	–	–	Is the horizontal and vertical alignment suitable for the (85th percentile) traffic speed? If not: • Are warning signs installed? • Are advisory speed signs installed? • Are the posted advisory speeds for curves appropriate?	–	Change Road User Behaviour.	–	Provide warning/advice to seek appropriate behaviour.	–	–	–	–	–	–
Vehicle activated signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
RRPMs													
–	–	–	If RRPMs are installed, are they correctly placed, correct colours, in good condition.	–	–	–	–	–	–	–	–	–	–
Surface corrections													
In certain situations, environmental factors will be relevant to the design and operation of the project and could include: • Locations prone to surface water and flooding.	–	–	Is surface water likely to drain across a carriageway and increase the risk of aquaplaning under storm conditions.	–	–	–	–	–	–	–	–	–	–
Road safety barriers													
–	–	Is there a need for safety barriers to protect road users from signs, gantries, parapets, abutments, steep embankments or water hazards.	• Are the safety barriers provided long enough. • Are specific barrier systems required for motorcyclists. • If there are roads on both sides of the fence is an interlocking design necessary to prevent impalement on impact.	–	–	–	–	May obscure other safety treatments such as warning signs. Motorists not being able to detect the warning signs adequately increases the risk of a road user not recognising and adjusting to the road condition.	–	–	–	–	–
Skid resistance													
–	–	Does the pavement appear to have adequate skid resistance, particularly on curves, steep grades and approaches to intersections.	–	–	–	–	–	–	–	–	Skid resistance testing to be carried out where necessary.	–	–
Flag lighting													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

A.7 R99: Identification of Safety Risk and Development of Mitigating Treatments for Narrow (4 m) Sealed Roads: 2020/21

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
–	–	–	–	–	–	• Centreline marking. • Guide posts. • Guardrail. • Roadside hazard removal.	–	–	–	–	–	–	–
Lane widening													
Lane widening, particularly on a curved horizontal alignment, can reduce the risk of head-on crashes as drivers will have additional sealed width to allow opposing vehicles to remain to the left of the road with improved sight distance. Localised widening can also assist in the reduction of run-off-road and sideswipe crashes.	–	• Horizontal sight distance is inadequate. • Vertical sight distance is inadequate. • Crests and curves.	• Frequent passing locations. • Crests, curves, crest/curve combination. • Soft shoulder.	–	–	• Increasing bend radius. • Centreline marking, guide posts, advanced. • Warning signage. • Guardrail. • Roadside hazard removal.	• Drivers utilise own lane to travel. • Sight distance is improved. • Provides other opportunities to fix other road surface issues such as crossfall and drainage. • Less shoulder maintenance.	• Costly treatment and localised, i.e. 100 m either side of hazard section. • Extensive earthworks. • Removal of roadside vegetation and native flora. • Vehicle speeds may increase.	–	–	–	Medium to high	15+ years
Longitudinal linemarking													
–	–	–	–	–	–	• Lane widening • Guide posts. • Guardrail. • Roadside hazard removal.	–	–	–	–	–	–	–
Audio-tactile linemarking													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Speed limit review and zoning													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Guide posts													
Guide posts are provided to give the road user a visual cue of the alignment of the road ahead. They are useful at horizontal and vertical alignment curves. Guide posts are generally 1 m high and placed at the edge of the road formation (1.2 to 3 m) with a minimum clearance of 7 m between opposite posts. Longitudinal spacing varies along different alignments to ensure visibility of the road alignment.	–	• Horizontal sight distance is inadequate. • Vertical sight distance is inadequate. • Crests and curves. • Road with no linemarking.	• Siting and alignment. • Spacing: different requirements for straight, curves, cuttings, crests, bridges and culverts. • Colour and mounting height of delineator. • Consider flexible (self-correcting) delineator post.	–	–	• Improve shoulder material and compaction. • Cut back batter to provide better sight lines. • Sealing inside of curve.	• Assists road users to maintain a lateral vehicle position and highlights the upcoming change in road alignment to change driving behaviour. • Assists in night-time and low visibility conditions.	• Inconsistent siting, alignment, height and spacing. • Ongoing maintenance. • Poorly maintained.	Guide posts are fitted with a reflector/delineator which makes them useful at night. They are lightweight and frangible and made with durable material (timber and steel) to withstand different climates.	–	–	Low	5+ years
Curve warning signs													
Static warning signs provide drivers with early indications of changing circumstances, including an approaching intersection, a change in horizontal and vertical alignment or approaches to narrow bridges and structures to allow time for the driver to react to adjust driving behaviour.	–	• Substandard horizontal curved alignment. • Bridges and structures. • Substandard vertical alignment. • Sight distance restrictions.	• Signage type and size. • Advisory speed where sight distance is restricted due to horizontal and vertical alignment.	–	–	• Flatten batters. • Improve sight distance.	• Informs road users of the upcoming change in road conditions and to change driving behaviour.	• Does not eliminate the hazard. • Poorly maintained. • Can be hazardous if installed too close to the edge of the road.	–	–	–	Low	5+ years

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Intersection warning signs													
Static warning signs provide drivers with early indications of changing circumstances, including an approaching intersection, a change in horizontal and vertical alignment or approaches to narrow bridges and structures to allow time for the driver to react to adjust driving behaviour.	–	• Substandard horizontal curved alignment. • Bridges and structures. • Substandard vertical alignment. • Sight distance restrictions.	• Signage type and size.	–	–	• Flatten batters. • Improve sight distance.	• Informs road users of the upcoming change in road conditions and to change driving behaviour.	• Does not eliminate the hazard. • Poorly maintained. • Can be hazardous if installed too close to the edge of the road.	–	–	–	Low	5+ years
Advisory speed signs													
Static warning signs provide drivers with early indications of changing circumstances, including an approaching intersection, a change in horizontal and vertical alignment or approaches to narrow bridges and structures to allow time for the driver to react to adjust driving behaviour.	–	• Substandard horizontal curved alignment. • Bridges and structures. • Substandard vertical alignment. • Sight distance restrictions.	• •Signage type and size. • Advisory speed where sight distance is restricted due to horizontal and vertical alignment.	–	–	• Flatten batters. • Improve sight distance.	• Informs road users of the upcoming change in road conditions and to change driving behaviour. • Advisory speed can provide information on the comfortable speed that the curve can be negotiated.	• Does not eliminate the hazard. • Poorly maintained. • Can be hazardous if installed too close to the edge of the road.	–	–	–	Low	5+ years
Guide signs (i.e. CAMs)													
Static warning signs provide drivers with early indications of changing circumstances, including an approaching intersection, a change in horizontal and vertical alignment or approaches to narrow bridges and structures to allow time for the driver to react to adjust driving behaviour.	–	• Substandard horizontal curved alignment • Bridges and structures. • Substandard vertical alignment. • Sight distance restrictions.	• Signage type and size.	–	–	–	• Informs road users of the upcoming change in road conditions and to change driving behaviour. • Advisory speed can provide information on the comfortable speed that the curve can be negotiated.	• Does not eliminate the hazard. • Poorly maintained. • Can be hazardous if installed too close to the edge of the road.	–	–	–	Low	5+ years
Vehicle activated signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
RRPMs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Surface corrections													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Road safety barriers													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Skid resistance													
–	–	–	–	–	–	–	–	–	–	–	–	Medium	–
Flag lighting													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

A.8 iRAP (2022) Road Safety Toolkit

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
When a driver has accidentally travelled onto the road shoulder, the risk of crashing will be less if the vehicles can either stop on the shoulder or safely travel back into the traffic lane.	25% to 40%	–	–	–	–	Edge lines.	• Reduce run-off-road and head-on crashes. • Allow vehicles to pull off the road in emergency situations and have clearance from through traffic. • Safer cycling space. • Structural support to the road pavement. • Reduce 'edge drop' between road surface and shoulder heights.	Shoulders that are too wide create a hazard if they are used as an additional lane.	–	–	–	Medium	5 years to 10 years
Lane widening													
Lane width has an influence on safety, especially at certain key road locations. Vehicles typically use more of the travel lane on bends than on straight road sections, and head-on crashes can happen on bends when drivers accidentally (or intentionally) 'cut the corner'.	25% to 40%	–	• Urban roads: 2.75 m to 3.75 m. • Rural roads: 3.5+ m.	–	–	–	• Reduced head-on crashes. • Reduced run-off-road crashes. • Reduced sideswipe crashes. • Improved traffic flow.	• Increase in vehicle speeds. • A lane that is too wide might be used as 2 lanes.	–	–	–	Medium to high	5 years to 10 years
Longitudinal linemarking													
Centre and edge delineation treatments help drivers judge their position on the road and provide advice about conditions ahead.	10% to 25%	• Centrelines can be used to discourage overtaking or accidental 'drifting' from the lane. • Edge lines help drivers judge the alignment of the road ahead and can reduce run-off-road crashes.	Consistency throughout the area.	–	–	• Profiled linemarking • RRPMs • Guide posts	• Reduce lane departures. • Reduce run-off-road and head-on crashes. • Reduce shoulder damage, therefore in reducing maintenance costs.	• Linemarking is ignored. • Poorly designed and installed can add to crash risk. • Regular monitoring and maintenance required.	–	–	Require a good quality road surface.	Low	1 year to 5 years
Audio-tactile linemarking													
Transverse rumble strips (also referred to as bar markings) are placed across the traffic lane to alert motorists to hazards ahead (such as bends, intersections or areas of pedestrian activity). They are most effective where drivers have been travelling at sustained high speed for long periods.	10% to 25%	• Placed across the traffic lane to alert motorists to hazards ahead (such as bends, intersections or areas of pedestrian activity). • Delineation for longitudinal placement.	Those living near to the road as rumble strips can generate noise.	–	–	–	• Reduced run-off-road and head-on crashes. • Reduced collision at diverge gores. • Improved visibility of edge lines or centrelines during wet weather. • Potential for reduced maintenance of road shoulder. • Advanced warning to hazards. • Where used on high-speed roads, transverse bar markings have been shown to reduce speeds on approaches to intersections such as roundabouts.	• Hazard to cyclists and motorcyclists.	–	–	At least 150 mm of sealed road outside longitudinal rumble strips or the road may be weakened.	Low	1 year to 5 years

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Speed limit review and zoning													
Regulating traffic speed to levels commensurate with the road environment is crucial to the delivery of forgiving roads.	25% to 40%	–	The design considers cyclists needs	–	–	Speed limit setting is not an effective speed management measure if used in isolation. It must be complemented by: • Design of the road infrastructure which aligns with the desired travel speed, so that the road is self-explaining and that a driver or rider can more intuitively regulate their speed based on the look and feel of the road. • Traffic calming measures such as raised tables or chicanes may be deployed to ensure compliance. • Effective speed enforcement.	• Reductions in travel speeds save lives and prevent injuries. • Effective area-wide benefits. • Reduced traffic volumes on local roads. • Improved environment for pedestrians and cyclists. • Increasing accessibility and encouraging walking and other sustainable modes of transport. • Reducing vehicle noise, acceleration and deceleration. • Reducing the need for obtrusive and unsightly traffic safety devices such as crash barriers. • The wider benefits of reducing speeds include improved fuel consumption, lower greenhouse gas emissions and less traffic noise.	–	–	–	Some local traffic problems, such as racing or speeding, should be resolved in partnership with police.	Medium	5 years to 10 years
Guide posts													
Guide posts assist the road user by indicating the alignment of the road ahead, especially at horizontal and vertical curves.	10% to 25%	Alignment of the road ahead, especially at horizontal and vertical curves.	Consistency throughout the area.	–	–	Can be equipped with reflectors or painted with reflective paint.	• Delineation improvements have been shown to reduce head-on and run-off-road crashes. • Helps drivers to maintain a safe and consistent lateral vehicle position within the lane. • Reduction in night-time and low-visibility crashes. • Reduction in pavement deterioration due to vehicles driving onto the shoulder.	Poorly designed or located guide posts can add to crash risk.	Should not constitute a roadside hazard, and so should be constructed of lightweight, frangible, durable material.	Usually about 1 m high and set about 1 m from the edge of the road.	–	Low	1 year to 5 years
Curve warning signs													
Warning signs inform drivers of the nature of a hazard they are approaching. Tell drivers how to navigate the hazard safely.	10% to 25%	–	–	–	–	–	• Delineation improvements. • Cost-effective treatments to make roads safer.	• Too many signs can confuse drivers. • Regular monitoring and maintenance required. • Poorly designed or located can add to crash risk. • Consistency throughout the area.	–	–	–	Low	1 year to 5 years

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Intersection warning signs													
Warning signs inform drivers of the nature of a hazard they are approaching. Tell drivers how to navigate the hazard safely.	10% to 25%	–	–	–	–	–	• Delineation improvements. • Cost-effective treatments to make roads safer.	• Too many signs can confuse drivers. • Regular monitoring and maintenance required. • If poorly designed or located can add to crash risk. • Consistency throughout the area.	–	–	–	Low	1 year to 5 years
Advisory speed signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Guide signs (i.e. CAMs)													
Warning signs inform drivers of the nature of a hazard they are approaching. Tell drivers how to navigate the hazard safely.	10% to 25%	–	–	–	–	–	• Delineation improvements. • Cost-effective treatments to make roads safer.	• Too many signs can confuse drivers. • Regular monitoring and maintenance required. • if poorly designed or located can add to crash risk. • Consistency throughout the area.	–	–	–	Low	1 year to 5 years
Vehicle activated signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
RRPMs													
Retro-reflective pavement markers or road studs ('cats eyes') are usually used in conjunction with painted linemarking to warn drivers of changes in alignment in the road ahead.	10% to 25%	–	–	–	–	Painted linemarking.	Helpful in darkness or during wet weather when linemarking becomes difficult to see.	–	–	–	–	Low	1 year to 5 years

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Surface corrections													
A paved road surface, commonly constructed of bituminous material or concrete, should provide a durable, predictable, running surface with adequate skid resistance which is able to withstand the effects of weather. When the road surface condition becomes poor or defective, rehabilitation or resurfacing work is needed to restore the pavement surface to the required level of service.	25% to 40%	–	The choice of road pavement design, surfacing materials, design mix and aggregate properties should be carefully considered. Ensure appropriate texture depth, individual aggregate properties such as polished stone value (PSV) and the skid resistance value (SRV) of the road surface are suitable for the location and expected traffic use.	–	–	–	• Can provide an even running surface free from major defects and hazards. • Can provide a road surface with a high resistance to skidding, helping to reduce loss of control and rear-end type crashes. • Can increase pavement strength, weatherproofing and extend life of pavement structure. • Provides the opportunity to fix other road surface problems, such as crossfall and drainage. • Provides the opportunity for adding or replacing road surface delineation such as painted markings or reflective road studs.	–	–	–	• Weather conditions during construction of bituminous surface courses can affect the laying operation and subsequent performance. • Temporary traffic management at road works sites must be carefully designed and managed to ensure the safety of all those who may be affected including site operatives (road workers), road users, members of the general public and local residents.	Medium	10 years to 20 years
Road safety barriers													
Road safety barriers are designed to redirect the vehicle and have a lower severity than the roadside hazard they protect.	40% to 60%	–	• Flexible barriers: Made from wire rope supported between frangible posts. Best option for minimising injuries to vehicle occupants; however, may pose risk to motorcyclists. • Semi-rigid barriers: Usually made from steel beams or rails. Deflect less than flexible barriers and so they can be located closer to the hazard when space is limited. • Rigid barriers: Usually made of concrete and do not deflect. Should be used only where there is no room for deflection of a semi-rigid or flexible barrier.	–	–	–	If properly designed, installed and maintained, barriers should reduce the severity of crashes involving 'out of control' vehicles.	• Can be more dangerous if not properly designed, constructed and maintained. • Hazard to motorcyclists.	• Flexible barriers: Wire rope supported between frangible posts. • Semi-rigid barriers: Steel beams or rails. • Rigid barriers: Concrete.	–	On existing roads retrofit of safety barriers can be challenging due to incompatibility between road layout, ground condition, roadside space, etc. and technical criteria for the installation of safety barriers. In these circumstances, solutions are often context-sensitive and may need to be tailor-made. Solutions for existing roads should be formulated with on-site surveys, comparison of options and risk assessments.	Medium	10 years to 20 years

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Skid resistance													
Loss of control through skidding can be a significant factor in many crashes (especially when the road is wet). Particular attention should be paid to the skidding resistance properties of the carriageway surface at areas where braking commonly occurs.	25% to 40%	Areas where braking commonly occurs such as on the approaches to intersections, roundabouts, pedestrian crossings and on bends or steep grades.	–	–	–	–	• Help to prevent both rear-end and run-off-road crashes. • Extend life of pavement surface. • Environmental benefits with the materials. Quick and repeatable treatments with low traffic disruption.	• Regular monitoring required, especially on roads with lots of heavy vehicle traffic.	–	Retexturing: This method includes the mechanical reworking of the existing surface to improve its frictional characteristics and therefore the resistance to skidding. Typically involves the removal of material from the road surface. Methods include diamond grooving, shot-blasting, bush hammering, high velocity water blasting. Resurfacing: These include relatively low-cost thin surfacing treatments that not only improve the surface texture and resistance to wet road skidding but can also seal the surface against water penetration and arrest disintegration of the existing road surface.	• Existing road surface must be sound. • Skid resistance of the entire road surface (right up to the edge) should be maintained for the safety of bicycles and other slow-moving vehicles.	Low to medium	5 years to 10 years
Flag lighting													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

A.9 Main Roads Western Australia (2021) Treatment Resource Guide

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
A sealed shoulder provides drivers with an appropriate surface on which to regain control of an errant vehicle.	–	• Sealed shoulders should be accompanied by ATLM edge lines. • Horizontal curves, particularly on the outside of curves. • At locations of greatest risk, taking into account its road function, crash history, alignment and roadside hazards.	• Maintain consistent shoulder width based on traffic volumes and the proportion of heavy vehicles. • Provide shoulders of 1.5 m to 2 m wherever possible and up to 2.5 m to 3 m on higher volume roads.	–	–	ATLM edge lines	• Allow drivers to pull off road in emergencies. • The shoulder provides essential support to the adjacent pavement area. • Safe recovery for vehicles stopped on roadside. • Improve pavement life. • Enhance car driver comfort. • Can be used by cyclists and pedestrians.	May promote undesirable driver behaviour for motorists driving along the sealed shoulder.	–	–	–	Sealing 0.5 m to 1.5 m: low to medium	20 years
Lane widening													
Lane widening of an existing narrow lane width can result in crash reduction and traffic flow benefits.	–	• Horizontal curves, particularly on the inside of curves to accommodate rear wheel tracking of heavy vehicles. • At locations of greatest risk, taking into account its road function, crash history, alignment and roadside hazards.	• Low volumes with limited numbers of heavy vehicles: lane widths can be 3.1 m wide minimum. • Optimum rural safe lane width: 3.5 m wide.	–	–	Sealed shoulder.	• Improves traffic flow, especially if there is a large proportion of heavy vehicles. • Allow drivers more margin for error.	• Increasing lane width can increase vehicle speeds.	–	–	–	Low to medium	20 years
Longitudinal linemarking													
Painted edge line: A painted line at the edge of the traffic lane. A centreline is used to separate opposing streams of traffic.	25%	• Edge line to provide a guide of the alignment of the road. • Centrelines are provided on two-lane sealed pavements which are 5.5 m or more wide and where the traffic volumes are significant.	Edge lines should be implemented over a continuous length rather than isolated sites.	–	–	• Audio-tactile linemarking • Guide posts • RRPMs	• Help to make driving safer and more comfortable, especially under adverse conditions and at night. • Reduced unsealed shoulder maintenance costs. • Reduce the likelihood of lane departures.	–	–	–	–	Low	5 years
Audio-tactile linemarking													
Audio-tactile linemarking (ATLM) provides audible and tactile feedback to road users.	• 40% for ATLM edge line • 23% for ATLM centreline	ATLM may replace or supplement standard edge line or dividing line on road sections where: • Traffic volumes are high • Significant number of run-off-road crashes • Specific site problems such as poor visibility, frequent or heavy rain, or night-time crash history.	To be installed over a continuous length, not at isolated sites.	–	–	–	• Reduced unsealed shoulder maintenance costs. • Reduce the likelihood of lane departures.	• May present a hazard to cyclists and motorcyclists. • Less noticeable for heavy vehicles. • Noise disturbance for adjoining land users.	–	–	–	Low	5 years
Speed limit review and zoning													
A speed limit reduction involves changing the	–	–	• Safe System principles should be considered.	Must consult with relevant Main Roads	–	–	• Increase vulnerable road users' level of safety with lower speed limits.	• Must be considered as part of an overall trauma reduction	–	–	–	Low	10 years

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
regulatory speed limit of the road.			• Numbers of pedestrians, changes to roadside development, road upgrade, change in road function, presence of traffic calming devices and poor road safety history.	representatives upon any changes.			• Could lead to reductions in fuel consumption, noise and carbon dioxide emissions.	plan, not an isolated treatment. • Often additional features are required to reinforce the new reduced speed limit. • Compliance by drivers with the new speed limit.					
Guide posts													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Curve warning signs													
The provision of signage can delineate/draw attention to specific hazards. From a risk management perspective, signs are amongst the lowest form of control; however, they can be an effective measure to reduce crashes for little cost where more expensive interventions cannot be achieved.	10% to 30%	Static curve warning signs Curve warning signs are placed in advance of curves to alert drivers/riders of an upcoming change in the road's horizontal alignment.	–	–	–	May be accompanied by advisory speeds sign.	–	• The signs are prone to vandalism. • Enforcement is needed to encourage/promote compliance.	–	–	–	Low	5 years
Intersection warning signs													
The provision of signage can delineate/draw attention to specific hazards. From a risk management perspective, signs are amongst the lowest form of control; however, they can be an effective measure to reduce crashes for little cost where more expensive interventions cannot be achieved.	10% to 30%	–	–	–	–	–	–	• The signs are prone to vandalism. • Enforcement is needed to encourage/promote compliance.	–	–	–	Low	5 years
Advisory speed signs													
Used in combination with curve warning signs, advisory speed signs are supplementary signs that show the speed a driver/rider should take to comfortably navigate the curve.	–	Typically used in locations where the design speed of the curve is significantly lower than the speed limit.	–	–	–	–	–	• The signs are prone to vandalism.	–	–	–	Low	5 years

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Guide signs (i.e. CAMs)													
Horizontal curves are among the most hazardous situations for drivers. Advance warning of alignment changes can be conveyed to the driver in numerous ways. Can provide a better view of the curve on the approach. As the driver traverses the curve, the delineation device provides a continuous reminder for positive guidance thereby assisting the driver to position the vehicle within the proper travel lane while negotiating the curve.	–	This treatment tends to affect driver speeds on a horizontal curve, which is particularly important because excessive speed is a significant factor in crashes at horizontal curves.	–	–	–	–	–	• The signs are prone to vandalism.	–	–	–	Low	5 years
Vehicle activated signs													
Vehicle activated signs (VAS) triggered by speed are mainly installed in locations with known/identified speeding problems or speed-related crash history or in instances where the use of standard static speed and warning signs has not been effective in lowering travelling speeds or altering driver behaviour.	–	At a site where standard reflectorised warning signs have been tried and have been found not to be sufficiently effective in warning drivers to reduce their speeds in order to safely negotiate the hazardous site.	–	–	–	–	Alert the targeted driver to the hazard so that they adjust their behaviour accordingly (i.e. reduce their speed). The signs have the advantage of being blank (i.e. black) when not activated, thereby targeting relevant road users and limiting their visual intrusion on other drivers. Vehicle activated signs (speed) can be used to collect speed data for monitoring, although only on sign approach, not at the hazard.	• The signs are prone to vandalism. • Power supply in rural areas can be problematic. Solar-powered devices are available but are also subject to theft and vandalism. • Enforcement is needed to encourage/promote compliance.	–	–	–	Medium to high	10 years
RRPMs													
Raised reflective pavement markers (RRPMs), provide excellent night-time delineation.	15%	–	–	–	–	Dividing lines and median treatments.	• Enable the alignment of the road to be seen from a greater distance, particularly under wet conditions. • Provide tactile and audible warnings to drivers when vehicles cross over the RRPMs.	–	–	–	–	Low	–
Surface corrections													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Road safety barriers													
Crashes between vehicles which leave the road and roadside hazards are a major safety problem, especially in the rural environment. Clear zones are areas either side of the carriageway where roadside hazards have been removed. Roadside barriers are designed to prevent vehicles from impacting roadside hazards that remain.	–	Roadside barriers: the appropriate barrier type should be applied for the context. Flexible barrier systems are the most forgiving to passenger vehicles in particular; however, they should only be applied where there are sufficient deflection zones behind the barrier. More rigid barriers may be required where this is not possible.	• Flexible barriers: made from wire rope supported between frangible posts. Flexible barriers may be the best option for minimizing injuries to vehicle occupants. • Semi-rigid barriers: made from steel beams or rails. These deflect less than flexible barriers and so they can be located closer to the hazard when space is limited. • Rigid barriers: made of concrete and do not deflect. Rigid barriers should be used only where there is no room for the deflection required for a semi-rigid or flexible barrier. • Should be applied on continuous lengths, rather than isolated sections protecting specific hazards.	–	–	–	Reduction in run-off-road crashes.	• Increase the collision due to the proximity to the roadside. • Can redirect traffic back into the live traffic lane. • Significant maintenance costs.	–	–	–	• Rigid barriers (1 km of treated road section): Medium • Flexible or Semi-rigid barriers: (1 km of treated road section): Low to medium	10 years
Skid resistance													
Skid resistance treatments are speciality treatments applied to an existing pavement to enhance surface friction.	–	Enhance existing pavement surface friction where it is critical, such as on corners or intersection approaches.	–	–	–	–	Enhance durability with the sealing of a road and reduce maintenance requirements.	–	Usually applied with a specialty binder.	–	–	Low to medium	10 years
Flag lighting													
The use of flag lighting at remote intersections can also help to highlight the presence of the intersection to drivers, heightening their awareness thereof.	10%	Flag lighting at remote intersections (night crashes only) involves illuminating intersections in rural locations where general lighting of the roadway is typically not provided.	–	–	–	–	–	Ongoing costs will be associated with the running and maintaining, including the clearing of vegetation. Can be a roadside hazard and suitable measures, such as slip bases, barriers or crash attenuators, should be provided to reduce this risk particularly in high-speed environments.	–	–	–	Low to medium	20 years

A.10 Main Roads Western Australia (2022c) Speed Zoning Policy and Application Guidelines

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lane widening													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Longitudinal linemarking													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Audio-tactile linemarking													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Speed limit review and zoning													
Speed limits are an essential mechanism to ensure the safe and efficient operation of road networks. Travel speeds on WA roads must address a broad range of objectives. The application of appropriate speed limits and other traffic management measures is a key mechanism in managing vehicle speeds to achieve desired safety, mobility, traffic management, local amenity and road user expectations.	–	Place describes the form and function of land uses and activity beside or along the roadway corridor. Place values influence the activity pattern along the roadway and have a significant bearing on naturalistic operational speed. Many Place values are also strong indicators of potential road user risks and may highlight other considerations for appropriate target speed selection.	Speed limits in WA take the form of: • default speed limits (which apply in the absence of signage) • posted speed limits (where a specific maximum speed limit is applied to a road, road section or defined area, either permanently or temporarily) • advisory speed limits (which provide the driver with a recommended travel speed at a known hazard) • specific vehicle limits (where certain kinds of vehicles, including vehicles towing, are subject to an absolute maximum speed limit even where posted regulatory speed limits may be higher). Speed limits must be consistent with the purpose and physical environment of the roadway.	To commence a speed zone review the applicant must provide evidence to support a target speed different to the current regulatory speed. Applications for general speed zones and/or changes to existing speed zones should be addressed to the Manager Traffic Management Services for the Metropolitan Region and the Network Manager or Network Operations Manager in the Regional Office.	–	• Supported by signage where necessary. • Changes in the road design and alignment, such as wide shoulders, linemarking, edge treatments, guide posts, roadside and median barriers, etc. • Alterations in the urban design of the roadway, such as modification of street furniture, lighting, crossing points, etc. • Introduction of traffic management devices, such as horizontal or vertical deflection points or other Local Area Traffic Management (LATM) measures.	–	–	–	–	Monitoring and enforcement activities.	–	–
Guide posts													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Curve warning signs													
–	–	Warning signage should be implemented as direct strategies to mitigate the underlying crash risk.	–	–	–	Assessed for signing with curve warning and advisory speed signs.	–	–	–	–	–	–	–
Intersection warning signs													
–	–	Warning signage should be implemented as direct strategies to mitigate the underlying crash risk	–	–	–	–	–	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Advisory speed signs													
–	–	Advisory speed signing shall be limited to horizontal and vertical curves (including LATM devices) on sealed highways, main roads and other speed zoned roads that have a safe operating speed less than the speed limit.	–	–	–	–	–	–	–	–	–	–	–
Guide signs (i.e. CAMs)													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vehicle activated signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
RRPMs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Surface corrections													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Road safety barriers													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Skid resistance													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Flag lighting													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

A.11 R85: Review of Engineering Treatments for Urban Fringe Environments: 2018/19

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
The provision of a sealed and unsealed shoulder provides an area whereby a vehicle may successfully recover during a run-off-road event. Run-off-road crashes can be significantly reduced if wide shoulders are provided, particularly where none existed previously.	30%	–	• Urban fringe roads: Minimum sealed shoulder width of 1.0 m. • A hazard-free clear zone – any hazards that are deemed necessary (e.g. signage, guide posts, light poles) should be set back as far as practicable from the road shoulder and be motorcyclist/cyclist-friendly or protected by a less severe hazard such as a motorcycle-friendly safety barrier.	–	–	Good delineation including edge lines, centrelines, RRPM's, guide posts and lighting where appropriate	–	–	–	–	–	–	5 years to 10 years
Lane widening													
–	–	–	–	–	–	• Sealed shoulder. • Delineation in good condition, which includes edge lines, centrelines, guide posts, raised reflective pavement markers (RRPMs), and road lighting.	–	–	–	–	–	–	–
Longitudinal linemarking													
–	–	–	–	–	–	• Guide posts, raised reflective pavement markers (RRPMs) and road lighting.	–	–	–	–	–	–	–
Audio-tactile linemarking													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Speed limit review and zoning													
Involves managing posted speed limits, revising them towards Safe System levels.	25%	–	–	–	–	–	–	–	–	–	–	Low	10+ years
Guide posts													
All sharp curves (radius of 200–500 m) on urban fringe roads should be treated to ensure they are clearly delineated with linemarking and guide posts, have advanced warning signs, speed advisory signs and chevron alignment markers (CAMs).	–	–	Consistent application of delineation, signage and other treatments should be applied on a route basis.	–	–	–	–	–	–	–	–	–	–
Curve warning signs													
All sharp curves (radius of 200–500 m) on urban fringe roads should be treated to ensure they are clearly delineated with linemarking and guideposts, have advanced warning signs, speed advisory signs and chevron alignment markers (CAMs).	–	–	Consistent application of delineation, signage and other treatments should be applied on a route basis.	–	–	–	–	–	–	–	–	–	–
Intersection warning signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Advisory speed signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Guide signs (i.e. CAMs)													
All sharp curves (radius of 200–500 m) on urban fringe roads should be treated to ensure they are clearly delineated with linemarking and guide posts, have advanced warning signs, speed advisory signs and chevron alignment markers (CAMs).	–	–	Consistent application of delineation, signage and other treatments should be applied on a route basis.	–	–	–	–	–	–	–	–	–	–
Vehicle activated signs													
–	–	For any high-risk curves, vehicle activated signs and perceptual countermeasures should be considered to reduce the risk of crashes on these curves.	–	–	–	–	–	–	–	–	–	–	–
RRPMs													
–	–	–	–	–	–	Edge lines, centrelines, guide posts and road lighting.	–	–	–	–	–	–	–
Surface corrections													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Road safety barriers													
Where a roadside hazard exists, road users should be protected/shielded with a safety barrier or designed to be frangible.	–	It is recommended that urban fringe roads have hazard protection, where possible, for roads with a posted speed limit of 70 km/h or more.	Consideration of heavy vehicles in barrier design – heavy vehicles will not be contained by a normal roadside safety barrier and a car may be extensively damaged by an impact with a barrier designed for trucks.	–	–	–	–	–	–	–	–	–	–
Skid resistance													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Flag lighting													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

A.12 AS 1742.2-2022 Manual of Uniform Traffic Control Devices Part 2: Traffic Control Devices for General Use

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
–	–	–	A different coloured aggregate from that used on the travelled part of the pavement may be used to provide contrast and to discourage driving on the shoulder.	–	–	Edge lines shall be provided at the edge of the running lane.	–	–	–	–	–	–	–
Lane widening													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Longitudinal linemarking													
A longitudinal line shall consist of a continuous or a broken line, or a combination of both, marked generally parallel to the direction of travel.	–	• Dividing lines should be used on sealed pavements 5.5 m or greater in width but may not be required if the traffic volume is less than the following: (a) Rural roads – > 300 VPD, AADT (b) Urban road – > 2,500 VPD, AADT • Edge lines are used to provide a continuous guide to the driver and to discourage traffic from travelling on shoulders.	• Edge lines shall not be used unless a dividing line or lane line is also marked. When used, they shall be placed on both sides of the sealed surface of the roadway.	–	–	• Audio-tactile linemarking. • Guide posts. • RRPMs.	• Able to convey information to drivers without diverting their attention from the road.	• May not be clearly visible if the road is wet or dusty (e.g. near an edge or a median). • Subject to traffic wear and usually require frequent maintenance. • Can be obscured by traffic.	• Refer to AS 4049 (series) for the requirements of various kinds of pavement markings. • Shall be reflectorised at night.	–	–	–	–
Audio-tactile linemarking													
Longitudinal lines may be installed as audio-tactile linemarking in the form of regularly spaced ribs added to a uniform thickness line.	–	Audio tactile linemarking may be in the form of edge line or dividing line.	Raised ribs may be white, matte black or matte grey in colour. White ribs shall be retroreflective. Matte black or matte grey ribs shall not be retroreflective.	–	–	Raised reflective pavement markers	Reduce the likelihood of lane departure crashes typically attributed to fatigue and inattention.	Noise generated from vehicles running on audio-tactile linemarking may impact on the amenity of residents living near roads.	–	–	• The recommended maximum offset is 200 mm from the linemarking • Shall only be installed in conjunction with dividing lines	–	–
Speed limit review and zoning													
–	–	Where it is required to impose a permanent speed limit on a bridge, a speed zone shall be signposted.	–	–	–	–	–	–	–	–	–	–	–
Guide posts													
Guide posts are used to mark the edge of the road formation in the absence of other features, such as safety barriers or bridge rails. They assist the road user by indicating the alignment of the road ahead.	–	On straight sections, on curves, on curve transitions, in cuttings, at crests, bridges and culverts.	–	–	–	Road safety barriers.	–	–	–	Guide posts shall be placed at or near the edge of formation. The distance from the pavement edge shall be consistent, generally between 1.2 m and 3.0 m.	Guide posts should be set out so that their tops are on a smooth grade.	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Curve warning signs													
–	–	Used for substandard horizontal curves	–	–	–	• Raised retroreflective pavement markers. • Guide posts.	–	–	–	–	–	–	–
Intersection warning signs													
–	–	Warning signs in this series should be provided in advance of an intersection where sight distance along the main road to a vehicle about to enter from the side road is less than the required stopping sight distance value for the corresponding travel speed on the main road.	It is preferable to implement engineering changes to achieve the required stopping sight distance rather than to rely on intersection warning signs. Care is needed to ensure that intersection warning signs, if used, do not draw attention away from, or otherwise reduce the effect of, the Give Way or Stop signs.	–	–	–	–	–	–	–	–	–	–
Advisory speed signs													
Horizontal curves shall be considered to be substandard if the advisory speed of the curve is at least 15 km/h less than the 85th percentile speed on the immediately preceding section of road. The advisory speed is the maximum speed at which a curve may be comfortably negotiated under good road and weather conditions.	–	–	–	–	–	–	–	–	–	–	Advisory speed signs shall not be used on unsealed roads.	–	–
Guide signs (i.e. CAMs)													
Curve alignment markers (CAMs) shall only be used to augment the delineation of substandard curves. They shall not be used for the delineation of islands or other obstructions, or for any other purpose.	–	–	–	–	–	–	–	–	–	–	The mounting height of CAMs shall not be more than 1.2 m to the underside of the sign. The mounting height above the road pavement shall be consistent throughout a curve.	–	–
Vehicle activated signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
RRPMs													
Retroreflective raised pavement markers (RRPMs) are used to augment painted lines, stripes and chevrons when it is deemed necessary or desirable to improve their visual properties.	–	To augment painted linemarking.	• RRPMs are intended to be trafficable when placed within a painted island or median strip. • RRPMs shall not be displayed towards oncoming traffic on the right-hand edge lines on undivided roads. • Colour (yellow, white, red, green and blue) depending on the painted line type. • Different spacing requirements for dividing lines, curves, unlit/lit roads, outlining islands and edge lines.	–	–	Pavement markings.	• Not generally obscured at night under wet conditions. • Provide an audible and tactile signal when traversed by vehicle wheels. • Conspicuous in all conditions.	• Effect of noise in or near residential areas.	Requirements for the dimensions, retroreflective elements and photometric performance of RRPMs are specified in AS 1906.3.	• Placed 25 mm to 50 mm from the linemarking.	• Self-cleansing properties under traffic.	–	–
Surface corrections													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Road safety barriers													
–	–	–	–	–	–	• Edge lining. • Vertical obstruction markers.	–	–	–	–	–	–	–
Skid resistance													
–	–	–	–	–	–	Slippery warning sign shall be used to warn of a section of pavement on which the skid resistance has been reduced to an unexpectedly low level.	–	–	–	–	–	–	–
Flag lighting													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

A.13 AS 1742.4-2020 Manual of Uniform Traffic Control Devices Part 4: Speed Controls

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lane widening													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Longitudinal linemarking													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Audio-tactile linemarking													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Speed limit review and zoning													
The purpose of speed limits is to assist with the safe and orderly	–	The setting of effective speed limits will usually be based on	Experience and research have demonstrated that arbitrarily	–	–	Installation of speed limit signs and pavement markings adjacent	–	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
movement of traffic and the interactions of motorised vehicles with each other and other road users. This involves consideration of safety, mobility and amenity.		a road's traffic function, traffic activity and layout and roadside development and activity.	imposed speed limits that are too low for the particular road, traffic and roadside environments on a section of road attract poor levels of compliance, regardless of the level of enforcement.			to static speed limit signs, where desired.							
Guide posts													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Curve warning signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Intersection warning signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Advisory speed signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Guide signs (i.e. CAMs)													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vehicle activated signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
RRPMs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Surface corrections													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Road safety barriers													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Skid resistance													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Flag lighting													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

A.14 Austroads (2020) Guide to Traffic Management Part 10: Transport Control Types of Devices

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
–	–	–	The preferred minimum cross-section width of a sealed roadway for the use of ATLM is 9.0 m comprising two 3.5 m lanes and two 1.0 m sealed shoulders.	–	–	–	–	–	–	–	–	–	–
Lane widening													
–	–	–	• Consideration should be given to	–	–	–	–	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
			culverts and bridges. • Taper lengths at these locations should comply with the design speed. • May be a need to relocate services.										
Longitudinal linemarking													
Edge lines provide a continuous guide for drivers by delineating the edge of the travelled way. They are marked to make driving safer and more comfortable, particularly at night. Centrelines separate traffic streams travelling in either the same or opposing directions and provide warning to drivers who might drift from the traffic lane.	–	Generally, edge lines are provided on: • Motorways (urban and rural) and on other rural arterial roads where the shoulder is partly or fully sealed. • Urban arterial roads where street lighting is of a low standard and extra delineation at the kerb line is required. • Rural roads where the AADT is greater than or equal to 2,500 vehicles per day (VPD). • Rural roads in high rainfall areas (greater than 1,000 mm per annum) or where the road is subject to fog or wet days for significant periods and the AADT is greater than or equal to 1,000 VPD. • Rural roads where the heavy vehicle AADT is greater than 300 VPD.	• Location: Visibility of markings can be greatly affected by crest vertical curves and may be obscured by other vehicles. • Cannot be used on unsealed roads.	–	–	Often used in conjunction with each other to provide a traffic treatment for any given situation.	–	• Subject to traffic wear and require programmed maintenance to ensure their effectiveness. • Can be partly or wholly ineffective on wet roads at night, or when dust or snow is present. • Can cause skidding problems if materials are not carefully selected.	–	–	All longitudinal lines must be reflectorised at night. Glass beads used in pavement marking materials must comply with AS 1742..	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Audio-tactile linemarking													
Audio-tactile linemarking (ATLM) is generally associated with edge lines as a road-based measure to reduce fatigue-related crashes by minimising run-off-the-road crashes and is therefore primarily used in rural areas	• 20% for ATLM edge line • 15% for ATLM centre line	Audio-tactile linemarking should be considered where there is a recorded history of fatigue-related crashes and may be considered on roads prone to fog. Fatigue-prone areas are generally well known to local authorities, emergency services and jurisdictions, and may be verified by an analysis of a state or territory crash database. Network road safety audits may also identify potential locations.	The minimum continuous length of ATLM that should be applied to a road is 1 km. It is desirable that ATLM should not be installed within 500 m of a residential building (where practicable) with a minimum of 200 m, unless appropriate noise barriers are installed or unless the frequency and severity of fatigue-related crashes in the area are such that a continuous treatment is considered essential on safety grounds.	–	–	–	Provide a noise (audio) and vibratory (tactile) warning to drivers starting to stray due to fatigue or fog, although another significant benefit is its superior wet weather delineation. Drivers also tend to focus on the edge line for guidance when traffic is approaching from the opposite direction at night to avoid being dazzled by headlights.	–	–	Projections are created by fixing small, raised objects of non-compressible material to the road surface – most commonly either extruded thermoplastic ribs or plastic raised pavement markers.	ATLM is created by installing a line of small projections or depressions in the road surface, although depressions are not recommended for general use. ATLM should not be installed: • unless the structural integrity of the surface, base and subbase is sufficient to prevent cracks developing between the carriageway and the shoulder • where substantial portions of the road (say more than 25%) are likely to require resurfacing within 3 years of installation.	–	–
Speed limit review and zoning													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Guide posts													
Guide posts with reflectorised delineators are placed in a series in pairs on both sides of the road formation to indicate to road users the alignment of the roadway ahead, especially at horizontal and vertical curves.	–	The location and spacing of guide posts are described in AS 1742.2 for a range of situations.	As outlined in AS 1742.2, the following colours should be used for delineators: • White: for posts facing oncoming vehicles on the right side of two-way roads. • Yellow: for posts facing oncoming vehicles on the right side of one-way roads (including divided roads). • Red: for posts facing oncoming vehicles on the left side of the road.	–	–	–	Provide effective long-range delineation for night driving and can be an advantage in fog-prone areas. Guide posts with delineators may also be used to alert drivers approaching an intersection.	–	The colour of the guide posts is white. Guide posts should be constructed so that when struck by a vehicle, they do not constitute a safety hazard.	Wherever practicable, guide posts should be placed at a uniform distance from the pavement edge. On unkerbed roads, they should be erected at the outside edge of the shoulder of the roadway. For kerbed carriageways, they should desirably be set back 1 m from the face of the kerb.	As specified in AS 1742.2, guide posts typically have a height of 1 m above the shoulder edge with a display face width of 100 mm facing the traffic. However, if posts of this height obstruct visibility, as may be the case on the inside of a curve on a crest, shorter posts should be used.	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Curve warning signs													
Warning signs are used to alert drivers to hazardous or potentially hazardous conditions that may not be apparent or discernible owing to road geometry or environmental conditions. Warning signs advise the driver and other road users of conditions that require caution and possibly a reduction in speed for their own safety and that of other drivers, pedestrians and bicyclists.	–	A warning sign should generally be erected on the left side of the carriageway and be positioned so that it will convey its message effectively without restricting lateral clearance or sight distance. If considered necessary, the sign or a duplicate sign may be erected on the right side of the carriageway.	–	–	–	Advisory speed plates with curve warning signs.	Alert drivers to hazardous or potentially hazardous conditions that may not be apparent or discernible owing to road geometry or environmental conditions.	Improper use leads to reduced effectiveness of warning signs generally.	–	–	Warning signs should be placed at a point where legibility is achieved in sufficient time for the driver to respond to the warning. This time includes that required to read the sign, react to it, and safely decelerate to an appropriate speed or stop.	–	–
Intersection warning signs													
Warning signs are used to alert drivers to hazardous or potentially hazardous conditions that may not be apparent or discernible owing to road geometry or environmental conditions. Warning signs advise the driver and other road users of conditions that require caution and possibly a reduction in speed for their own safety and that of other drivers, pedestrians and bicyclists.	–	A warning sign should generally be erected on the left side of the carriageway and be positioned so that it will convey its message effectively without restricting lateral clearance or sight distance. If considered necessary, the sign or a duplicate sign may be erected on the right side of the carriageway.	–	–	–	–	Alert drivers to hazardous or potentially hazardous conditions that may not be apparent or discernible owing to road geometry or environmental conditions.	Improper use leads to reduced effectiveness of warning signs generally.	–	–	Warning signs should be placed at a point where legibility is achieved in sufficient time for the driver to respond to the warning. This time includes that required to read the sign, react to it, and safely decelerate to an appropriate speed or stop.	–	–
Advisory speed signs													
–	–	–	–	–	–	Advisory speed plates with curve warning signs.	–	–	–	–	–	–	–
Guide signs (i.e. CAMs)													
Chevron alignment markers should be used to augment the delineation of substandard curves wherever an engineering assessment indicates that other prescribed or recommended delineation by means of pavement markings and post delineators is insufficient to delineate the curve adequately.	–	–	They should be reserved exclusively for curve delineation and should not be used for the delineation of islands or other obstructions, or for any other purpose.	–	–	–	–	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Vehicle activated signs													
–	–	• A signalised intersection on the outskirts of a city or town where drivers are failing to adjust from the high-speed rural environment to the urban environment, evidenced by an unacceptably high number of crashes. • An unsignalised intersection that has an unacceptable crash history and funds are not yet available for permanent treatment. • A vertical crest curve on the approach to traffic signals where insufficient sight distance exists to the intersection or to the back of a stationary queue of vehicles. • A sharp horizontal curve that has a history of run-off-road crashes. • The main road approaches to low volume rural intersections where traffic approaching on the side road activates a reduced speed limit on the main road.	–	–	–	–	Effective in warning drivers of hazardous intersections or curves.	–	–	–	–	–	–
RRPMs													
RRPMs are used to augment painted lines, stripes and chevrons when it is necessary to improve their visual properties. They are intended to be trafficable when placed within a painted island or median strip. They are not obscured at night under wet conditions as the retroreflective panels sit above the surface and are more prominent than reflectorised painted markings. In addition, they provide an audible and tactile signal when traversed by vehicle wheels.	–	As a guide, they may be used to augment painted separation and barrier markings on: • rural roads when AADT exceeds 1,000 • urban roads when AADT exceeds 10,000 • on multi-lane roads. In addition, consideration in the provision of raised pavement markers should be given to: • roads that have a crash problem that could be addressed through improved delineation (e.g. run-off-road crashes) • areas subject to poor environmental conditions such as excessive rain or fog • roads that are poorly lit • locations that have sharp curves (horizontal or vertical) that may not be expected by approaching drivers • roads that have special requirements (e.g. remote areas, high percentage of heavy vehicles).	–	–	–	–	–	–	Generally constructed of plastic in the form of domes approximately 100 mm in diameter or trapezoidal prisms about 100 mm wide. RRPMs contain a retroreflector that provides delineation under vehicle headlights at night.	–	Raised pavement markers provided for delineation purposes must have retroreflective properties in accordance with AS 1906.3.	–	–
Surface corrections													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Road safety barriers													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Skid resistance													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Flag lighting													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

A.15 US Department of Transportation Federal Highway Administration

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lane widening													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Longitudinal linemarking													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Audio-tactile linemarking													
Longitudinal rumble strips are milled or raised elements on the pavement intended to alert drivers through vibration and sound that their vehicle has left the travel lane. They can be installed on the shoulder, edge line, or at or near the centreline of an undivided roadway.	• 44% to 64% for centreline rumble strips. • 13% to 51% for shoulder rumble strips.	–	• Rumble strips are relatively low cost, and economic analyses have indicated benefit/cost ratios that exceed 100. • Where rumble strips cannot be placed due to noise concerns, agencies may consider a design using an oscillating sine wave pattern (also known as 'mumble strips') that reduces noise outside of the vehicle. However, the safety benefits of this design need more study.	–	–	–	–	Maintenance concerns: Where rumble strips are placed along a pavement joint, there are typically no issues with joint stability if the pavement structure and joint were already in good condition.	–	–	–	–	–
Speed limit review and zoning													
There is broad consensus among global roadway safety experts that speed control is one of the most important methods for reducing fatalities and serious injuries. Speed is an especially important factor on non-limited access roadways where vehicles and vulnerable road users mix.	26%	–	When setting a speed limit, agencies should consider a range of factors such as pedestrian and bicyclist activity, crash history, land use context, intersection spacing, driveway density, roadway geometry, roadside conditions, roadway functional classification, traffic volume and observed speeds.	–	–	To achieve desired speeds, agencies often implement other speed management strategies concurrently with setting speed limits, such as self-enforcing roadways, traffic calming and speed safety cameras.	–	–	–	–	–	–	–
Guide posts													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Curve warning signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Intersection warning signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Advisory speed signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Guide signs (i.e. CAMs)													
Enhanced delineation treatments can alert drivers to upcoming curves, the direction and sharpness of the curve.	• 25% in night-time crashes. • 16% in non-intersection fatal and injury crashes	–	Consistent practice for similar curves sets the appropriate driver expectancy.	–	–	–	–	–	–	–	–	–	–
Vehicle activated signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
RRPMs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Surface corrections													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Road safety barriers													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Skid resistance													
Friction is a critical characteristic of a pavement that affects how vehicles interact with the roadway, including the frequency of crashes. Measuring, monitoring, and maintaining pavement friction – especially at locations where vehicles are frequently turning, slowing and stopping – can prevent many roadway departure, intersection and pedestrian-related crashes.	–	• Horizontal curves. • Interchange ramps. • Intersection approaches. • Higher-speed signalised and stop-controlled intersections. • Steep downward grades. • Locations with a history of rear-end, failure to yield, wet-weather, or redlight-running crashes. • Crosswalk approaches.	• Is applied on existing pavement, so no new pavement is added. • If the underlying pavement structure is unstable, then the life cycle may be shortened, resulting in premature failure.	–	–	–	–	–	Consists of a layer of durable, anti-abrasion and polish-resistant aggregate over a thermosetting polymer resin binder that locks the aggregate in place to restore or enhance friction and skid resistance.	The automated installation method is preferred as it minimises issues often associated with manual installation: human error due to fatigue, inadequate binder mixing, improper and uneven binder thickness, delayed aggregate placement and inadequate aggregate coverage.	The cost can be reduced when bundling installations at multiple locations.	–	–
Flag lighting													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

A.16 Austroads (2023) Guideline (Not for Distribution to the Public)

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Shoulder sealing													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lane widening													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Longitudinal linemarking													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Audio-tactile linemarking													
Audio-tactile linemarking (ATLM) provides drivers with an audible and haptic response when traversed. They are commonly used along edge line and centreline markings to warn errant drivers before they deviate outside of their travel lane.	–	–	–	–	–	Design should consider use of audio-tactile linemarking in conjunction with the wide centreline and shoulder sealing.	Audio-tactile linemarking assists in minimising nuisance strikes on the barrier system.	–	–	–	–	–	–
Speed limit review and zoning													
The management of speed is an integral part of the Safe System. Speed is a particularly important issue in regional and remote areas as speed limits are often high and do not reflect the risks associated with travelling on roads with variable conditions and hazards. Over time, the population has become accustomed to driving at high speeds and negating this practice requires long-term, ongoing strategies.	25% to 40%	–	• Must be in accordance with guidelines for setting speed limits prepared by state road authorities. • Selection of the spatial limits of a speed limit review is a critically important step. Select spatial limits that include full road links or homogeneous segments within a road link. • Consider the benefits of a network-wide speed limit review program. A network-level review program supports the consistency and therefore credibility of speed limits. • Prior to commencing a speed limit review, ensure that adequate resources are allocated for data collection activities. • Ensure that a site visit is completed to identify existing risks that may not be captured in the speed setting process. Speed setting guidelines typically address setting speed limits at higher risk locations. • Consider the use of lower speed limits which are to be in place until improvements are made to provide a safer road. • Consider community consultation and public education required to support proposed speed limit changes. • Consider the ability to practically enforce lower speed limits, particularly over long distances.	–	–	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Guide posts													
To support road user recognition of road alignment	–	–	–	–	–	–	–	–	–	–	–	–	–
Curve warning signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Intersection warning signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Advisory speed signs													
Advisory speed signs supplementing alignment warning signs are typically not provided on unsealed roads.	–	–	–	–	–	–	–	–	–	–	–	–	–
Guide signs (i.e. CAMs)													
To support road user recognition of road alignment	–	–	–	–	–	–	–	–	–	–	–	–	–
Vehicle activated signs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
RRPMs													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Surface corrections													
–	–	–	–	–	–	–	–	–	–	–	–	–	–
Road safety barriers													
Road safety barriers are used to mitigate harm from lane-departure crashes that may otherwise have resulted in a more serious outcome, such as from a roll over or collision with a roadside hazard.	Up to 75%	Barriers are used along the roadside or as a median treatment between opposing direction lanes.	• Flexible barrier systems are preferred. • Continuous lengths of barriesr are preferred. • Audio-tactile linemarking assists in minimising nuisance strikes on the barrier system. • For high motorcycle routes consider flexible w-beam systems with motorcycle underrun protection. • Ensure barrier and barrier terminals are accepted for use by the jurisdiction in which the barrier products are proposed to be installed. • Minimising end terminals through connecting short lengths of barrier reduces risk. • Should median barriers restrict movements at access or side roads, appropriate alternative turn facilities should be provided. • Barrier choice and design is a complex multi-aspect process with detailed guidance provided by Austroads and jurisdictions.	–	–	–	–	–	–	–	–	Median and edge barrier: $1.5m to $5m per km Median barrier: $0.5m to $4m per km.	–
Skid resistance													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Flag lighting													
–	–	–	–	–	–	–	–	–	–	–	–	–	–

A.17 ARRB (2020) Road Materials Best Practice Guide 1

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Surface corrections													
The traffic load on a road pavement determines a range of pavement characteristics which in turn determine the purpose for which a chosen pavement material must be fit for purpose. These characteristics also influence whole-of-life cost implications. Pavement characteristics determined by traffic level include the following: • Pavement structural design. • Road importance. • Required performance criteria. • Functionality requirements.	–	–	–	–	–	–	–	–	–	–	–	–	–

A.18 ARRB (2020) Unsealed Roads Best Practice Guide 2

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Surface corrections													
–	–	–	–	–	–	Installing appropriate warning signs to alert drivers to changing road conditions.	Ride quality commensurate with the volume and type of traffic is maintained more consistently across the entire road network.	• The intervention criteria specified may not necessarily be the most economic treatment, because the root cause is a geometric or operating deficiency. • Unsealed road conditions do not remain constant.	–	–	–	–	Develop 5 and 10 year expected performance and condition predictions for each road group.

A.19 ARRB (2020) Sealed Roads Best Practice Guide 3

Description	Crash reduction factors for countermeasure	Potential locations	Considerations	Warrants	Hierarchy	Other supporting treatments	Pros	Cons	Types (material)	Installation methods	Installation considerations	Cost	Life
Surface corrections													
Correction of surface (pavement) defects: • cracking • potholes • flushing of bituminous surfaces • build-up of fines on unsealed surfaces • roughness • soft spots • oil spills.	–	–	At very lightly trafficked roads: Economics, maintenance strategies and community acceptance should be considered. Generally, aggregate quality requirements can be less stringent. Depending on operating conditions, fine-textured surfaces and low-cost treatments may be feasible, e.g. surface enrichment, slurry seals, small nominal size aggregate in sprayed seals or asphalt surfacing.	–	–	–	–	–	–	–	–	–	–

Appendix B Local Experience – Local Government Consultation

Email correspondence was distributed to 109 local governments to gain information on the use of these treatments, warrants/selection process, costs, etc.

Twenty responses were received from:

- Albany
- Augusta Margaret River
- Bruce Rock
- Cranbrook
- Cunderdin
- Dardanup
- Dumbleyung
- Esperance
- Gin Gin
- Goomalling
- Greater Geraldton
- Harvey
- Kalamunda
- Koorda
- Kulin
- Moora
- Plantagenet
- Waroona
- West Arthur
- Wyndham – East Kimberley.

Responses are summarised in the following table.

Low-cost safety treatments vs questions	Do you use any of these treatments? If so, was it easy to install? Were there administrative issues? Please provide an example location	How was the treatment selected, was it installed as part of a larger project? (e.g. larger maintenance or improvement project) Were there any warrants or guidelines applied to select the treatment?	What is the cost per unit for the material and installation budget?	Is there any other information you would like us to consider in the preparation of this guideline?
Audio-tactile linemarking	Audio-tactile linemarking (ATLM) has been implemented in various locations including Lower Denmark Road and Palmdale Road, but some administrative issues were encountered during installation. It was funded by the Regional Road Safety Package and not installed in some areas due to low traffic volumes. Installation on Clifton Road Brunswick and Forestry Road Harvey was easy but challenging on Woogenellup Road due to narrow shoulders. The cost of installation for 36 km was $1.8 million, which was federally funded for low-cost shoulder sealing work. Gingin Brook Road is another location where ATLM was installed.	ATLM was selected through the Regional Road Safety Program funding, crash history by Main Roads Western Australia and in the safety TRENCH system. The installation of ATLM is generally installed on roads where the sealed shoulder width is greater than 0.5 m and has sufficient width for vehicle recovery. Additionally, the speed environment, road alignment, traffic volume and roadside environment were considered before selecting ATLM treatment. The Main Roads Western Australia guidelines and Austroads Road Design Guideline Part 6 were applied to the ATLM treatment and can be installed as part of a Blackspot project. The installation is done only if the funding group advises that it needs to be installed or if a road safety audit recommends it as best practice. However, mostly low-volume roads do not warrant ATLM.	Range: $4,000 per lane km for only ATLM installation to $100,000 per km including shoulder sealing as part of works.	Widening or sealing of road shoulders on high-speed roads is considered for safety purposes. With funding specifically for safety improvements attributed to existing programmed works, Local Governments can prioritise in all works and make funding. However, the process of road widening as a pre-requisite for ATLM can be costly. Additionally, there is need for more clarity on low-volume roads as most currently policies refer to traffic with a count of 300 or more, whereas many local governments have traffic volume less than the specified. Main Roads Western Australia standards generally provide satisfactory installation guidelines, but performance requirements such as retro-reflectivity, adherence and integrity should be considered.
Speed limit review and zoning	Speed limit review and zoning are implemented in some areas like Bruce Rock and Packsaddle Road, but there can be long delays and administrative issues with Main Roads Western Australia responsibility. Main Roads Western Australia can also be rigid with speed limits and reluctant to add signage where there is ambiguity. Speed limit review and zoning are only monitored by Main Roads Western Australia and considered in urban or semi-urban areas.	The selection of the speed limit review and zoning treatment depends on various factors. It can be a result of community requests, road safety audits, or as part of a larger project. Main Roads Western Australia has policy and guidelines for speed limit zoning applications, but it is restrictive, and Main Roads Western Australia provides the final treatment decision. The decision to approve or decline the treatment depends on the local government's discretion, which can be influenced by community requests or safety improvements.	Main Roads Western Australia funded, but approximately $250 to $500 per sign including installation.	In areas where heavy vehicles and pedestrians coexist, the speed limit should be reviewed to improve safety. Roads managed by shires are currently experiencing an increase in heavy vehicles, including those that are not registered as approved vehicles. Main Roads Western Australia does not provide support in speed limit review and zoning matters. Managing speed signs is a regulatory responsibility that should be managed by Main Roads Western Australia. To expedite the outcome process from the governing authority, there should be measures in place to streamline the process.

Low-cost safety treatments vs questions	Do you use any of these treatments? If so, was it easy to install? Were there administrative issues? Please provide an example location	How was the treatment selected, was it installed as part of a larger project? (e.g. larger maintenance or improvement project) Were there any warrants or guidelines applied to select the treatment?	What is the cost per unit for the material and installation budget?	Is there any other information you would like us to consider in the preparation of this guideline?
Curve warning signs	Curve warning signs are commonly used on both gravel and sealed roads. They are installed in various locations throughout the shire, with easy installation and minimal administrative issues. They are used on the majority of substandard curves on many roads, such as Henty Road, Waterloo Road, McCatney Road, Mornington Road, Mt Barker Road and Weaber Plains Road.	Curve warning signs are selected based on factors such as community requests, road safety audits, or as part of larger maintenance and improvement projects, such as new road design or reconstruction. Austroads guidelines and AS 1742 series are often applied to select the treatment. Substandard curves are identified through road safety audits. Signs are also replaced when needed, and standard signage is used all over Australia.	Range: $50 to $1,200 per sign including installation. Average: $625 per sign including installation. $2,500 to $3,000 for Ball bank indicator.	Improving safety on windy sections in rural roads is to lower the speed limit rather than installing numerous curve warning signs.
Intersection warning signs	Intersection warning signs are used in various locations. Specific intersections such as Fisher/Halsey Road in Kendenup, Weaber Plains Road, and Williams Road/Nungulya Road in Pindar. Generally, intersection warning signs are easy to install, but administrative issues may arise if Main Roads Western Australia approval is required. Nonetheless, a number of roads have intersection warning signage to ensure safe driving conditions.	Intersection warning signs are selected based on various factors, such as road safety audits, community requests, and compliance with standards such as AS 1742 series and Austroads Guide to Road Design. Intersection warning signs may be installed as part of larger maintenance or improvement projects or to improve intersections with Blackspot funding. Standard signage is used all across Australia, and signs are replaced when required due to fading or damage.	Range: $50 to $1,200 per sign including installation. Average: $625 per sign including installation.	Include the road name and the distance to the intersection, which can help motorists to plan their route and adjust their speed accordingly. Additionally, having rumble strips can alert motorists of the approaching intersection and encourage them to reduce their speed.
Advisory speed signs	Advisory speed signs are used in various locations, mostly in 50 km/h zones where higher speeds are consistent. The installation process is easy with minimal administrative issues, e.g. Henty Road and Waterloo Road. While some areas have successfully implemented advisory speed signs, they are rarely used and Main Roads Western Australia has asked the signs to be removed. In general, advisory speed signs are used on all shire roads and are typically part of curve warning signage.	Advisory speed signs are selected based on various reasons such as community requests, road safety audits, compliance with standards, or maintenance. The AS 1742 series or Austroads Guide to Road Design may guide the selection. It is important to replace faded signs and install new ones only following qualified advice. Examples of installations include Henty Road, where Main Roads Western Australia provided safe speed data for substandard curves, and Waterloo Road, where Main Roads Western Australia conducted a safety review following a fatality.	Range: $120 to $1,000 per sign including installation. Average: $560 per sign including installation. $2,500 to $3,000 for Ball bank indicator.	Currently, there is no standard advisory speed sign for gravel roads in WA. Rather than having numerous warning and advisory speed signs, it may be more effective to lower the speed limit on windy rural roads. It is also important to note that the use of advisory speed signs can create legal implications.

Low-cost safety treatments vs questions	Do you use any of these treatments? If so, was it easy to install? Were there administrative issues? Please provide an example location	How was the treatment selected, was it installed as part of a larger project? (e.g. larger maintenance or improvement project) Were there any warrants or guidelines applied to select the treatment?	What is the cost per unit for the material and installation budget?	Is there any other information you would like us to consider in the preparation of this guideline?
Guide signs i.e. chevron/curve alignment markers (CAMs)	CAMs are used in various location, including Frenchman Bay Road and several sealed roads, with minimal use on unsealed roads. The installation of CAMs is easy, and when a road is upgraded, signs are also updated. For example, CAMs have been installed on Venn Road, Waterloo Road and Collie River Road. Installing guide signs is generally straightforward and only requires a review of Main Roads Western Australia guidelines.	The selection of guide signs such as CAMs can be based on various factors. CAMs may be retrofitted to existing roads when recommended in road safety audits, crash investigations, or following a community request. CAMs can also be replaced when required during maintenance and upgrade works that comply with standards such as the AS 1742 series or the Austroads Guide to Road Design Part 3.	Range: $165 to $390 per sign including installation. Average: $278 per sign including installation.	N/A
Vehicle activated signs	Vehicle activated signs are intermittently used in built-up areas where there is known speeding behaviour. The installation process and administrative issues may vary depending on the location. Example locations such as Wyndham Townsite on Victoria Highway, and at school zones.	Vehicle activated signs are selected either from traffic count data, strategic implementation, or community request, and installed as part of a larger project aimed at changing driver behaviour. The signs are placed in areas of high traffic volume with poor speed compliance. The selection of the signs is guided by Main Roads Western Australia Code of Practice, Austroads guidelines and AS 1742.3.	Range: $8,000 to $8,500 per sign including installation. Average: $8,250 per sign including installation.	Further guidance to be provided regarding installation of vehicle activated signs for Local Governments in WA.
Surface corrections	Surface corrections are not likely to be used, and instead, the surface would likely be resurfaced. However, there is an ongoing surface correction project in a Black Spot location on the Narembeen Road. When it comes to gravel roads, it is recommended to access them during a winter grading or re-sheeting program. On the other hand, sealed roads may require additional funds, and warning signs may need to be used until funding becomes available.	Surface corrections are selected based on various factors. In one instance, it was identified through a high-speed condition survey and another time during road upgrade works or reactive visual condition. Surface corrections can be completed as part of a larger project, or through maintenance requirements. Main Roads Western Australia and Austroads specifications as well as individual shire's construction specifications are applied as warrants or guidelines to select the treatment.	Road Reconstruction with double seal – $250,000 per km. Road gravel resheet – $40,000 per km Road reseal – $50,000 per km Maintenance grading – $12 per km	N/A

Low-cost safety treatments vs questions	Do you use any of these treatments? If so, was it easy to install? Were there administrative issues? Please provide an example location	How was the treatment selected, was it installed as part of a larger project? (e.g. larger maintenance or improvement project) Were there any warrants or guidelines applied to select the treatment?	What is the cost per unit for the material and installation budget?	Is there any other information you would like us to consider in the preparation of this guideline?
Road safety barriers	Road safety barriers have been used in various locations, with the installation process varying depending on the circumstances. The decision to install road safety barriers depends on various factors such as traffic volume, vehicle classification and speed limit of the road. In some cases, installation is done following a road safety audit or request from Main Roads Western Australia. Example of locations where road safety barriers have been installed include Forestry Road. The installation of road safety barriers is often carried out by contractors.	Road safety barriers are selected based on improved safety standards as a part of capital renewal projects. It can be selected as part of the outcomes through internal and external road safety audit of substandard curves. Additionally, road safety barriers are installed in compliance with Main Roads Western Australia, Austroads *Guide to Road Design Part 6: Roadside Design Safety and Barriers*, and Australian Standards.	Range: W-Beam Barrier – $150 to $290 per m Average: W-Beam Barrier – $220 per m	N/A
Surface treatment for skid resistance	Resurfacing may be the more appropriate solution given that most roads are low speed. Note that when there is only a small area of sealed roads, funding groups are working together to address any skid resistance matter by providing the appropriate treatment.	Surface treatment for skid resistance may be selected based on a high-speed condition survey, which can identify the need for improved skid resistance.	N/A	N/A
Flag lighting	Flag lighting is used in semi-urban areas at intersections such as Moore Road and Harris Road/Martin Pelusey Road intersection. The flag lighting at Moore Road was designed by the shire and installed by a contractor, while the solar flag lighting at Harris Road/Martin Pelusey Road intersection was designed and installed by a local contractor. However, there were many issues with the operation of the latter.	Flag lighting is typically installed at selected intersections/locations in new subdivisions, which are funded by the developer, and rarely retrofitted elsewhere. In the case of Moore Road in Dardanup West, it was installed as part of a project to widen the road as it serves as a heavy haulage route in an industrial area, and the project was funded by Regional Road Groups. The Harris Road/Martin Pelusey Road intersection had solar flag lighting installed as part of a black spot project based on recommendations from local government subdivisional development guidelines.	$12,000 per light	Consider using vehicle activated sensors for the lighting on low-volume rural roads to reduce energy costs.

Perth, Western Australia