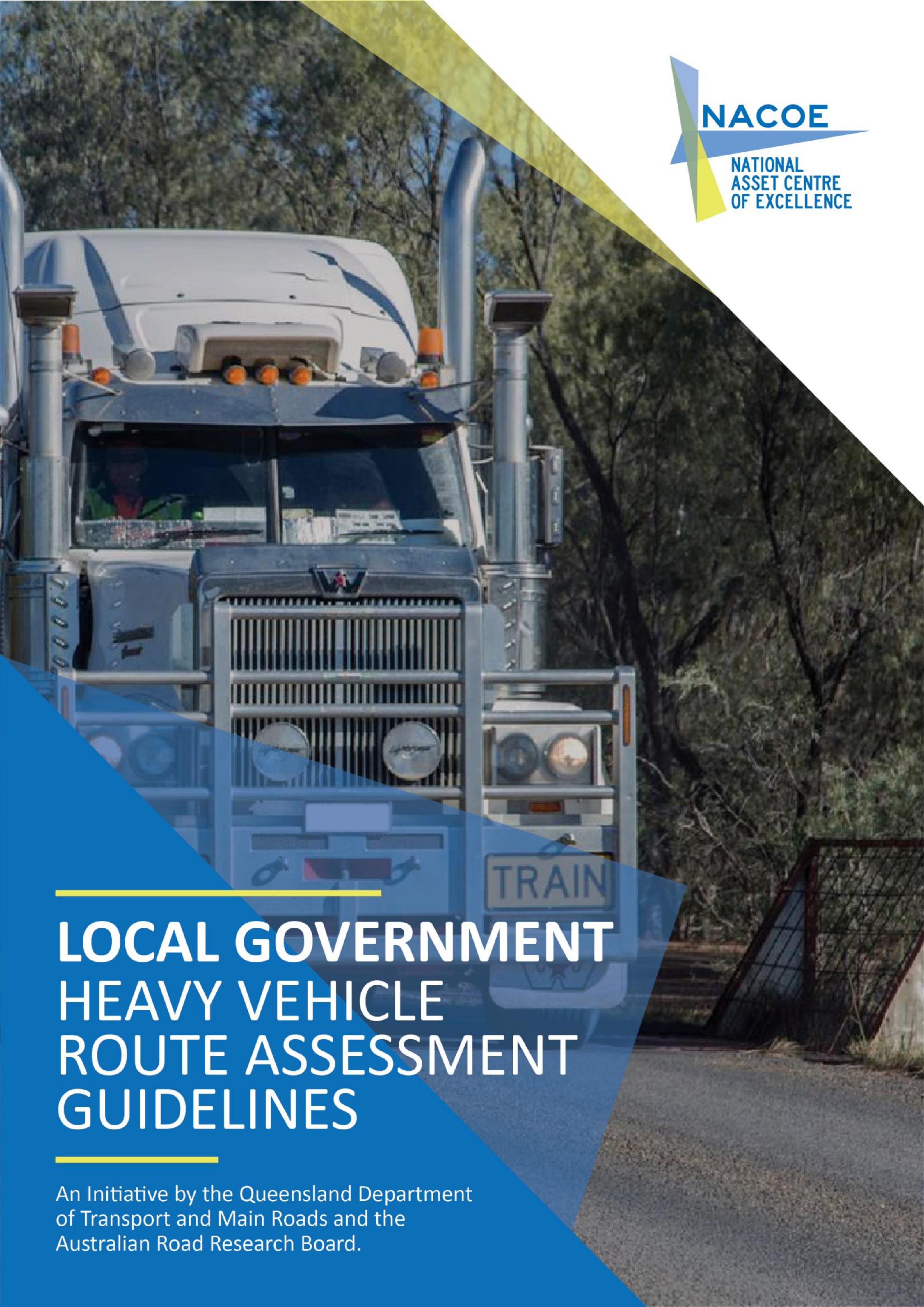

NACOE
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LOCAL GOVERNMENT HEAVY VEHICLE ROUTE ASSESSMENT GUIDELINES

An Initiative by the Queensland Department of Transport and Main Roads and the Australian Road Research Board.

SUMMARY

These guidelines have been prepared by the Australian Road Research Board (ARRB) as part of the National Asset Centre of Excellence (NACOE) program, this project however was initially instigated by the Local Government Association of Queensland (LGAQ). The guidelines were developed to assist Local Government (LG) road managers or consultants to assess the suitability of prescriptive heavy freight vehicles and Performance Based Standards (PBS) vehicles accessing LG routes under the Heavy Vehicle National Law and within Queensland.

Under the Heavy Vehicle National Law, local government road managers and/or consultants assess the suitability of local government routes for access by Class 3 prescriptive or PBS heavy vehicles. The guidelines have been developed to assist with that assessment.

The guidelines aim to ensure that all the key factors have been considered during the route assessment process. The guidelines provide suggested procedures for determining access and should be used in conjunction with local experience. An excel-based route assessment form is provided to assist an assessor in identifying which attributes on a route should be assessed and provides high-level assessment results to identify which assessment criteria meets the guidelines or may require further investigation to developing mitigation measures.

The contents of this document have been prepared to serve as a guide only and should not be referred to as a specification. Engineering judgement must be exercised by the assessor to make an access decision. An assessor should apply suitable risk management practices when reviewing route applications and making access decisions.

The guidelines allow for road managers to approve access if a route does not meet the guidelines, however a risk management process has been followed and/or access is granted under permit with operating conditions.

These guidelines are based on existing heavy vehicle route assessment criteria and road engineering practice from each relevant engineering discipline. The information within the guidelines was collated from existing state road authority heavy vehicle route assessment guidelines throughout Australia, Austroads guides, reports and research, and practical experience within road agencies and local government.

Project Title:	Local Government Heavy Vehicle Route Assessment Guidelines
ARRB Project No:	PRJ17105
Author/s:	David Milling, Anthony Germanchev, Hanson Ngo, Lory Noya and Lincoln Latter
Client:	Queensland Department of Transport and Main Roads
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1 PURPOSE

The *Local government heavy vehicle route assessment guidelines* have been prepared by the Australian Road Research Board (ARRB) to assist local government (LG) road managers or consultants assess the suitability of prescriptive heavy freight vehicles and performance based standards (PBS) vehicles accessing LG routes under the Heavy Vehicle National Law (HVNL) and within Queensland.

The guidelines focus on heavy freight vehicles and do not provide guidance on route assessment for over-size overmass vehicles or special purpose vehicles such as mobile cranes, low loaders, or platforms.

The guidelines are intended to ensure that relevant factors have been considered during the route assessment process. This includes assessing:

- geometric performance
- road safety implications
- structural capacities
- pavement impact
- amenity considerations.

Where quantitative limits are recommended, the guidelines provide guidance in determining access and should be used in conjunction with local experience. Should any aspect of a route clearly fail to conform to these guidelines in a manner which cannot be suitably addressed, resulting in a compromise of road safety and unreasonable risk, the route should be considered unsuitable for heavy vehicle access.

It is emphasised that this document should be used as a guide only and should not be referred to as a specification. Engineering judgement must be exercised by the assessor to make an access decision. In addition, users of this guide need to apply suitable risk management practices when making decisions on route applications.

The guidelines will also allow for road managers to provide approval in certain cases where routes that do not meet the requirements can be permitted by imposing additional access conditions such as speed restrictions, curfews etc.

The information used in the preparation of this document has been obtained from sources such as Austroads reports and research and years of practical experience within road agencies and local government and incorporates the latest reference material currently available.

The assessment of a potential heavy vehicle route should initially be undertaken using these guidelines in conjunction with other information such as maps and technical reports or other assessment tools available, if necessary.

Particular aspects of the route may require physical inspection and consultation with third parties, such as where the route intersects an asset owned by other parties, for example power lines or railway level crossings. As such, the guidelines are a resource for completing assessments that in some cases can be undertaken using this document alone but also provide guidance on other available assessment resources.

Appendix A contains a glossary of terms used throughout the guidelines.

2 THE AUSTRALIAN HEAVY VEHICLE FLEET

Australia has a long history of supporting the use of innovative vehicles including the introduction of the B-double, increases in length and mass of truck and dog trailers, and widespread use of innovative multi-combination vehicles such as B-triples, AB-triples and quad road trains.

Today Australia has a productive and diverse range of specialised heavy vehicles delivering the nation's freight task. These innovative vehicles often have unique requirements and access conditions to ensure the safe, efficient and most amenable transportation of goods to their destinations. The uptake of these vehicles is intrinsically linked to the levels of access they have to the road network. Traditionally this has been achieved by way of road managers issuing permits or notices granting restricted access to these vehicles. The incremental gains in vehicle productivity achieved by permitting access to various innovative vehicle configurations ultimately led to the introduction of the PBS scheme. The PBS scheme aimed to grant heavy vehicles access to the road network based on their performance rather than their mass and dimensions.

3 VEHICLE TYPES AND PRODUCTIVITY

This section describes the classes used in heavy vehicle regulation and lists common the vehicle types and attributes that are important to consider when making access decisions.

3.1 National Heavy Vehicle Classes

A heavy vehicle is defined in legislation as a vehicle with a gross vehicle mass (GVM) exceeding 4.5 t and includes trailers. The NHVR is Australia's independent regulator for all vehicles over 4.5 t GVM. It also administers the HVNL. The national law applies in Queensland as well as the Australian Capital Territory, New South Wales, South Australia, Tasmania and Victoria.

The system employed in the HVNL includes three vehicle classes: Class 1, Class 2 and Class 3, that cover all the heavy vehicles in operation on the network.

Class 1 vehicles include special purpose vehicles, agricultural vehicles, and oversize overmass (OSOM) vehicles such as a prime mover and low loader combination.

Class 2 vehicles are freight carrying vehicles that are longer than 19 m and require specific networks that are capable of handling these larger vehicles. There are a number of common class 2 heavy vehicle combinations, including B-doubles, road trains, PBS vehicles and buses.

Class 3 vehicles are those which, together with their load, do not comply with prescribed mass or dimension requirements and are not a class 1 heavy vehicle. A truck and dog trailer combination consisting of a rigid truck with 3 or 4 axles towing a dog trailer with 3 or 4 axles weighing more than 42.5 t is an example of a class 3 heavy vehicle. Other examples might include a B-double or road train transporting a load wider than 2.5 m.

While the vehicle classes provide a means for applying the HVNL, it is more common to describe vehicles by their configuration.

3.2 Common Heavy Vehicle Configurations

The NHVR has produced a list of common heavy freight vehicle configurations to assist industry and road managers by providing common terminology. Terminology varies between states. In Queensland, the term multi-combination vehicle (MCV) defines an articulated vehicle with two or more trailers. MCVs generally exceed 19.0 m in length or 42.5 t GCM and include B-doubles and road trains. It should be noted that PBS vehicles include 12.5 m rigid trucks, 20 m semi-trailers and both 19 and 26 m truck and trailer combinations; all these vehicles are highly productive but are not MCVs.

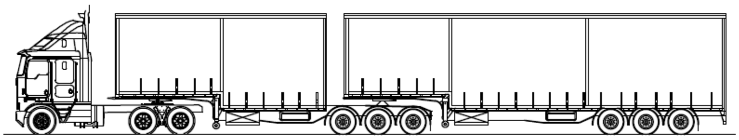
These guidelines refer to common MCVs including:

- B-doubles
- Type 1 road trains
    - A-doubles
    - B-triples
- Type 2 road trains
    - AB-triples
    - A-triples
    - quad combinations.

3.3 B-doubles

A B-double comprises a prime mover and two semi-trailers connected by a fifth wheel coupling, as shown in Figure 3.1. B-doubles are more productive than standard semi-trailers as they are longer and have an extra axle group. Common freight carried by B-doubles includes palletised freight, commodities such as grain, bulk liquid, car transport and livestock.

Figure 3.1: General freight 26 m B-double



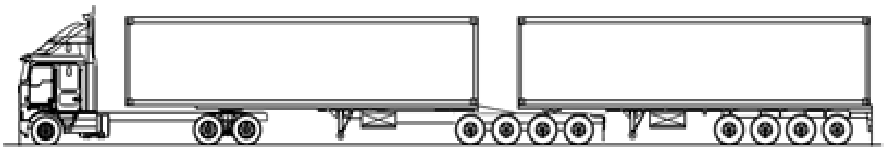
Source: TMR (2018a) (Note that TMR sources are listed in the references under Queensland Department of Transport and Main Roads).

The Heavy Vehicle National Law (HVNL) permits B-doubles to be up to 26 m in length, with a gross mass of up to 62.5 t in accordance with the mass, dimensions and loading (MDL) regulations under general mass limits (GML). The minimum axle group spacings are specified within the HVNL to limit bridge impacts. In Queensland, mass regulations allow B-doubles fitted with certified road-friendly suspension (RFS), and participating in the intelligent access program (IAP) to operate at higher mass limits (HML) axle loads. Thus, allowing up to 68.5 t gross mass (with a 6.5 t steer axle and tandem drive).

Queensland has gazetted networks for 23 m and 25 m B-doubles, and HML vehicles.

Through the PBS scheme, B-double-combinations generally fall into PBS Level 2. They are not restricted in overall length, however are limited to a length of 30 m if requesting PBS Level 2B access. PBS also allows for twin-steer, tri-drive prime movers and quad-axle trailers. A commonly used configuration near the Port of Brisbane is a 30 m B-double fitted with quad-axle groups, as shown in Figure 3.2.

Figure 3.2: General freight 30 m B-double (PBS combination)



Source: TMR (2018a).

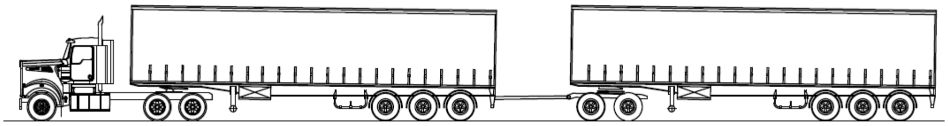
This PBS combination has on-road performance that is equivalent to or better than conventional 26 m B-doubles, except for their low-speed manoeuvrability and bridge loading impacts on certain span bridges. PBS requires that quad-axle groups include at least one steerable axle. This improves low-speed manoeuvrability and reduces horizontal loading of the pavement.

3.4 Type 1 Road Trains

3.4.1 A-doubles

A-doubles, also referred to as 'conventional type 1 road trains' or 'double road trains', comprise a prime mover and two semi-trailers connected by a converter dolly, as shown in Figure 3.3. They are more productive than B-doubles as they have an extra axle group and, in most cases, increased payload length.

Figure 3.3: General freight 36.5 m A-double



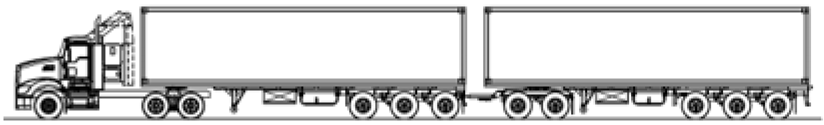
Source: TMR (2018a).

The HVNL classes A-doubles as a 'Type 1 road train', allowing up to 36.5 m in length with a gross mass of up to 79 t under GML. Current regulations applicable in Queensland permit A-doubles fitted with certified RFS and participating in the IAP, to operate at HML axle loads, allowing up to 85.5 t gross mass (with 6.5-t steer axle and tandem drive). Queensland has gazetted networks for 36.5 m Type 1 road trains.

Through the PBS scheme, innovative A-double designs have emerged with various axle configurations, and overall lengths ranging between 26 m and 30 m. This reduction in length (from 36.5 m) is in most cases due to the use of a shorter wheelbase prime mover and shorter dolly, thus reducing the overall length of the combination while maintaining a large payload length. An example of a 30 m A-double is shown in Figure 3.4.

The reason these A-doubles are limited to 30 m is because the length limit for PBS Level 2B access is capped at 30 m. Compliance with Level 2B allows these A-doubles wider access including to urban parts of the road network that were previously restricted to truck and dog trailer combinations or B-doubles. Although a shorter 30 metre A-double does not offer a greater payload capacity compared with a 36.5 m road train, when compared to truck and dog trailer combinations and B-doubles on Level 2B roads there is a considerable benefit. Longer 30 m combinations gained popularity in shipping container transport, as the additional length allows for two 40 ft containers to be carried. This has proved popular on the route between the Port of Brisbane and Toowoomba. The effect of a shorter overall length negatively impacts bridge loading which can be quantified through bridge assessments required under the PBS process.

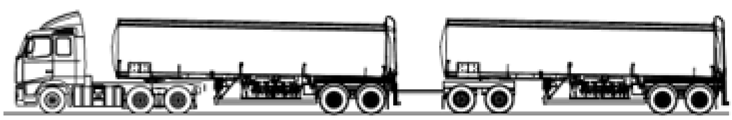
Figure 3.4: General freight 30 m A-double (PBS combination)



Source: TMR (2018a).

The 26-metre A-doubles, as shown in Figure 3.5, have been adopted by bulk liquid transporters; they have better low-speed manoeuvrability than equivalent B-doubles and the potential to reach a higher gross combination mass (because of the additional axle group). In some cases, for example for the transportation of milk from farms, this combination is preferred, despite not offering any increased capacity, because of the flexibility to de-couple trailers and operate as either a semi-trailer or road train, offering efficiency gains.

Figure 3.5: A 26 m A-double



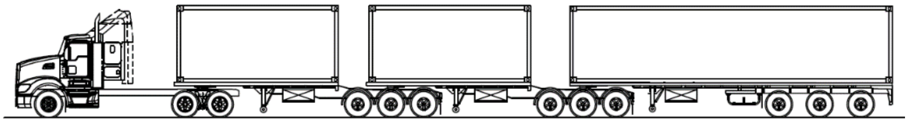
Source: TMR (2018a).

In general, PBS Level 2B A-doubles perform equivalent to or better than conventional 26-metre B-doubles, with the exception of high-speed dynamic performance, and bridge loading impacts. To counteract this, load height restrictions may be used to reduce trailer centre-of-gravity height and limit gross mass to reduce bridge loading impacts. Queensland has existing networks for 26 m and 30 m PBS A-doubles, which are the PBS Level 2A and 2B networks, respectively.

3.4.2 B-triples

B-triple combinations comprise a prime mover, two lead trailers, and a semi-trailer connected by fifth wheel couplings as shown in Figure 3.6. They are more productive than B-doubles and A-doubles due to their extra length and when compared against a B-double, their additional axle group. They can carry more freight volume than an A-double of equivalent overall length. Due to the additional axle group, B-triples are generally the reference (worst-case) vehicle used in structural assessments for volumetric access.

Figure 3.6: General freight B-triple



Source: TMR (2018a).

B-triples are also classed as a 'Type 1 road trains' in accordance with HVNL. B-triple combinations can be up to 36.5 m in length with a gross mass of up to 82.5 t under GML. Current regulations applicable in Queensland allow B-triples fitted with RFS and participating in the IAP, to operate at HML, allowing up to 91.5 t gross mass (with 6.5 t steer axle and tandem drive).

Under PBS, B-triples are not restricted in overall length, but would be typically limited to 36.5 m because of the length limit for PBS Level 3A access.

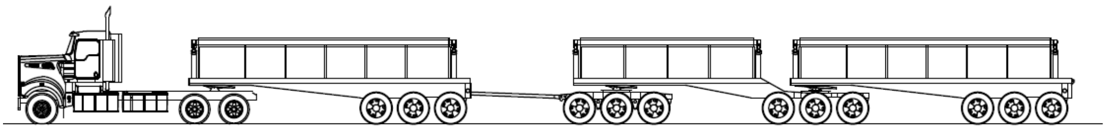
PBS Level 3A B-triples perform equivalent to or better than conventional 36.5-metre A-triples, except for low-speed manoeuvrability. The 36.5 m PBS B-triples would operate in Queensland on the PBS Level 3A network.

3.5 Type 2 Road Trains

3.5.1 AB-triples

AB-triples comprise of a prime mover and semi-trailer, towing a B-double trailer set connected to the first trailer by a converter dolly, as shown in Figure 3.7. AB-triples can be fitted with either tandem or triaxle groups on the trailers and converter dolly, but the most common scenarios are tandem dollies and triaxle trailers, or triaxle groups throughout. Common freight includes mined ore and livestock.

Figure 3.7: 36.5 m side tipping AB-triple



Source: TMR (2018a).

AB-triples are classed as either a Type 1 or a Type 2 road train in HVNL (2015), depending on their overall length. AB-triples within 36.5 m are classed as a Type 1 road train, while longer

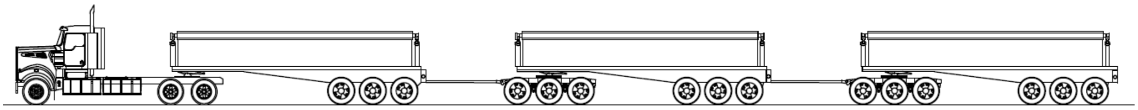
AB-triples, up to 44 m long, are classed as Type 2 road trains. AB-triples can have a gross mass of up to 103 t under GML. Current regulations applicable in Queensland allow AB-triples fitted with RFS and participating in the IAP, to operate at HML axle loads, allowing up to 108 t gross mass (with 6.5 t steer axle and tandem drive).

Through the PBS scheme, AB-triples are not restricted in overall length, however they would be typically limited to 36.5 m or 42 m because of the length limit for PBS Level 3A and 3B access. PBS-approved AB-triples can include a twin-steer, tandem drive, or tri-drive prime mover, and trailers can be fitted with quad-axle groups.

3.5.2 A-triples

A-triples comprise of a prime mover and three semi-trailers connected by converter dollies, as shown in Figure 3.8. A-triples can be fitted with either tandem or triaxle groups on the trailers and converter dolly, but the most common scenarios are tandem dollies and triaxle trailers, or triaxle groups throughout. Freight commonly transported by A-triples includes aggregate and livestock.

Figure 3.8: Side tipping A-triple



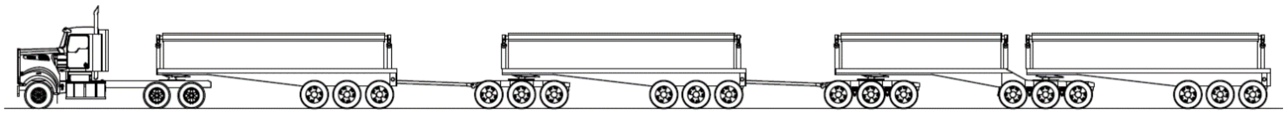
Source: TMR (2018a).

A-triples are classed as a Type 2 road train under the *National class 2 heavy vehicle road train authorisation (notice) 2015 (no.1)* in HVNL. A-triples can be up to 53.5 m in length and have a gross mass of up to 115.5 t under GML. Current regulations applicable in Queensland allow A-triples fitted with RFS to operate at HML, allowing up to 125 t gross mass (with 6.5 t steer axle, tandem drive, and tandem axle dollies). Under PBS, A-triples are not restricted in overall length, but would be typically limited to 53.5 m because of the length limit for PBS Level 4A access.

3.5.3 Quad Combinations

Quad combinations are Type 2 roads trains that comprise A- and B-double trailer sets and converter dollies to create various configurations, including ABB-quad, BAB-quad and the AAB-quad combinations shown in Figure 3.9. These combinations are typically used by the mining industry and have on-road performance equivalent to or better than conventional A-triples.

Figure 3.9: 48-metre side tipping AAB-quad



Source: TMR (2018a).

Quad combinations can be up to 53.5 m long, with varying gross masses depending on their axle group configuration. Under PBS, quad combinations are not restricted in overall length, but would be typically limited to 53.5 or 60 m because of the length limit for PBS Level 4A and 4B access, respectively.

3.6 PBS Vehicles

A PBS vehicle is any vehicle approved under the PBS scheme. It will require assessment under the scheme as some aspect of its design will not comply with the prescriptive regulations or notices. A PBS vehicle will satisfy the required safety and performance criteria for a set level. The performance of the vehicle is then matched to an appropriate level of access, as summarised in Table 3.1.

Table 3.1: Vehicle levels according to the PBS scheme

Vehicle performance	PBS road access level		Example	PBS vehicle length limit	
				A	B
Level 1	1		Semi-trailer, truck and trailer, short B-double	20 m	
Level 2	2A	2B	Long B-double, short A-double, short B-triple	26 m	30 m
Level 3	3A	3B	AB-triple, long A-double	36.5 m	42 m
Level 4	4A	4B	A-triple, quad road train	53.5 m	60 m

4 ENCOURAGING INNOVATIVE VEHICLE DESIGNS

The PBS scheme is an alternative regulatory scheme (to existing prescriptive vehicle notices and permits) and provides a method for assessing the suitability of any vehicle design compared with the requirements of a road network. The PBS allows for greater flexibility in vehicle design than offered by prescriptive mass and dimension limits while offering greater certainty and transparency on the performance of these vehicles. All vehicles applying under the PBS regulatory scheme must meet the requirements of the 20 performance standards (NHVR 2008), of which 16 are related to safety and 4 are related to infrastructure (pavement and bridge loading).

4.1 Understanding the Aims and Benefits of PBS

It is important to understand that PBS vehicles are restricted to the same axle group mass limits as the prescriptive vehicles. The PBS pavement standards require that all individual axle groups must comply with either general mass limits (GML), higher mass limits (HML) or concessional mass limits (CML). This does not limit the total gross mass of the vehicle but upholds the existing prescriptive axle mass limits.

The contrary belief is one of many misconceptions regarding PBS. Despite the development of training materials, the scheme remains highly reliant on the advice provided by subject matter experts, typically experienced PBS assessors, who under the scheme are accredited to submit applications to the NHVR as a consulting service. The lack of knowledge and understanding of the PBS scheme has been identified by Austroads (2018) as a barrier to the uptake of vehicles under the scheme. From this, the following topics were listed as being misunderstood by many road managers:

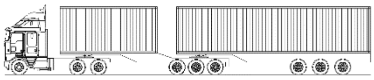
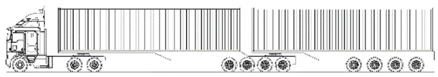
- the finite nature of the freight task
- perceived risks to safety
- perceived impacts on infrastructure
- what is a PBS vehicle
- the difference between existing networks and PBS networks
- the requirements of a PBS vehicle approval, conditions and vehicle specifications.

4.1.1 Understanding there is a finite freight task

Excluding special-purpose vehicles such as garbage trucks, the purpose of heavy vehicles is to move freight. The amount of work required is defined by the size of the freight task, which could be general freight such as groceries being delivered to a local supermarket or the hauling of bulk commodities such as grain during harvest periods. Regardless of the freight task it is the size that defines the number of trips; if vehicles with a greater carrying capacity are used this will result in less trips. The local community, other road users and road owners will benefit from the most productive vehicle that can perform the task without detriment to safety or infrastructure. The PBS scheme and vehicle approval process, in general, helps to achieve this balance for mutual benefit.

Austroads (2017c) adopted the approach of viewing truck movements as a requirement to deliver a defined freight task when proposing a method for quantifying the benefits of high-productivity PBS vehicles. Sixteen use cases were explored comparing PBS vehicles with an alternative conventional vehicle. The example shown in Table 4.1 compares a prescriptive 26.0 m, 62.5 t B-double with tri-axle groups with a PBS 30 m, 76.5 t B-double with quad-axle groups.

Table 4.1: Comparison between a prescriptive and a PBS B-double

	Prescriptive	PBS
Configuration/load (t)	 6.0 16.5 20.0 20.0	 6.0 16.5 24.0 24.0
Vehicle length	26.0 m	30.0 m
Gross combination mass	62.5 t	70.5 t
Number of axles	9	11
Maximum payload mass	40.2 t	52.7 t
Maximum payload volume	132.7 m^3	176.9 m^3

Source: Adapted from Austroads (2017c).

The characteristics of these two vehicles as a means for delivering a defined freight task is highlighted through this example. The PBS B-double is 8 tonnes heavier and 4.0 metres longer than the prescriptive B-doulbe however, it is to carry an additional 6.5 tonnes of payload and has an additional 44.2 m^3 of payload capacity.

Table 4.2 shows that the freight task delivered by the PBS vehicle with quad-axle groups, rather than the prescriptive B-double could result in 13.9% less trips (based on volume) or 25.0% less trips (based on mass).

Table 4.2 B-double trip efficiency comparison

Basis of comparison	Prescriptive	PBS	Efficiency gain
Trips per 1000 t of payload moved	24.88	21.41	13.9%
Trips per 1000 m^3 of payload moved	7.54	5.65	25.0%

4.1.2 Perceived risks to safety

Austroads (2018) found through stakeholder engagement that there is a perception that PBS vehicles, by definition, bring with them an increased risk to public safety, infrastructure and amenity and therefore must be contained, monitored, compensated for, or avoided altogether. However, the intent of the PBS scheme is the opposite and aims to improve safety and minimise the impact on infrastructure. The PBS scheme achieves this as the performance requirements were set at a level higher than the performance of the average conventional heavy vehicle. The quantification of the safety benefits is often debated due to the lack of crash data, however, research reported in Austroads (2014) has indicated that considerable savings are possible with PBS vehicles having 66% fewer crashes than conventional vehicles per unit of distance travelled.

Subsequent to this research, the method proposed by Austroads (2017c) can be used to quantify the benefits of PBS vehicles in the area of safety, based on reduced exposure.

4.1.3 Perceived impacts on infrastructure

The most common misunderstanding is the belief that PBS vehicles impart higher loads on the pavement causing an increased rate of wear. As discussed in Section 4.1, the maximum mass permitted to be carried by each axle or axle group is the same for both PBS and prescriptive vehicles. This is explored through the case study (as shown in Table 4.2) and the introduction of the metrics standard axle repetitions (SAR) and equivalent standard axles (ESA).

The SAR definition and calculations on which they are based are provided in Section 13. The SAR is a unit of measure that allows the loads imparted by a heavy vehicle to be estimated. It is the basis for calculating the damage caused by a single passage of an axle group type with a load. As the amount of damage varies depending on the type of pavement, a SAR is required for each pavement type. ESA is the terminology used to describe the SAR for a sprayed seal on an unbound granular pavement. This pavement is the most common in Australia and in particular for local roads. When referring to these types of roads, ESA is the correct term, but ESA and SAR are often used interchangeably.

The ESAs for a sealed unbound granular pavement for each axle group are shown in Table 4.3.

Table 4.3 ESA values for different axle group types

Group type	Axle group load (t)	ESA
Single axle with single tyre	6	1.52
Tandem axle with dual tyres	16.5	2.06
Tri-axle with dual tyres	20	1.38
Quad-axle with dual tyres	20	0.62
Quad-axle with dual tyres	24	1.29
Quad-axle with dual tyres	27	2.06

The ESA values shown in Table 4.3 are less for axle groups comprising more axles but carrying less load. The advantage of a quad-axle group is demonstrated as when loaded to 20 t this represents 0.62 ESA and when loaded to 27 tonnes this represents 2.06 ESA (equivalent to a tandem group at 16.5 t).

Figure 4.1 shows a prescriptive 26 metre B-double and Figure 4.2, Figure 4.3, and Figure 4.4 show an alternative PBS quad-quad B-double with quad-axle groups loaded at 20 t, 24 t and 27 t respectively.

Figure 4.1: Prescriptive 26 m (tri-tri) B-double

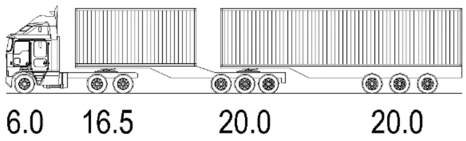


Figure 4.2: PBS 30 m (quad-quad at 20 t) B-double

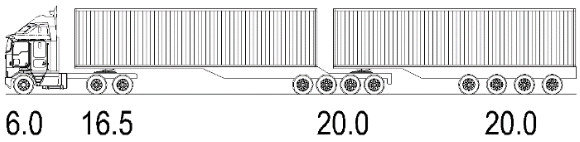


Figure 4.3: PBS 30 m (quad-quad at 24 t) B-double

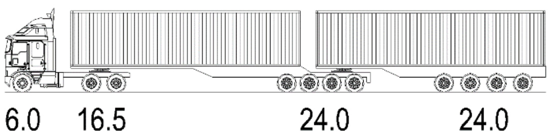
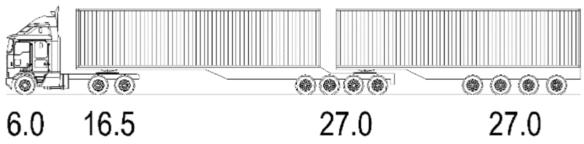


Figure 4.4: PBS 30 m (quad-quad at 27 t) B-double



The productivity of these vehicles can be quantified relative to their impact on the pavement using the ESA values shown in Table 4.4.

Table 4.4 Comparison of pavement impacts for B-doubles

Vehicle	ESA	Tare mass (t)	Payload mass (t)	Payload mass (t) per ESA	Trips per 1000 t of payload moved	Total ESAs to move 1,000 t	Reduction of ESAs compared to prescriptive 26 m B-double
Prescriptive 26-metre B-double (tri-tri)	6.34	22.3	40.2	6.34	24.9	157.7	Baseline (0%)
PBS 30-metre B-double (quad-quad at 20 t)	4.83	23.8	38.7	8.02	25.8	124.8	20%
PBS 30-metre B-double (quad-quad at 24 t)	6.16	23.8	46.7	7.59	21.4	131.9	16%
PBS 30-metre B-double (quad-quad at 27 t)	7.70	23.8	52.7	6.84	19.0	146.1	7%

The efficiency gain shown in Table 4.4 is expressed as a percentage improvement in the number of trips required to move the same amount of payload compared with the prescriptive B-double. This example shows that despite the PBS 30-metre (quad-quad at 27 t) B-double being a heavier vehicle that imparts more ESAs than the other three options, when the amount of payload is considered it is 7.36% more efficient per unit of pavement wear, and with 23.7% fewer trips for the same freight task there is a considerable reduction in pollution and crash exposure.

Heavy vehicles apply loads both vertically and horizontally. Vertical loading can be quantified by ESA as discussed above. The horizontal loading of PBS vehicles is restricted by the same prescriptive limits that apply to all heavy vehicles. Horizontal forces are generated by all vehicles in the longitudinal direction when accelerating and climbing grades. The maximum gross combination mass of a vehicle is limited in the PBS scheme depending on whether the vehicle has a single or two drive axles.

The maximum total GCM permitted for PBS Level 4 vehicles with tandem drive groups is 150 tonnes, which is consistent with prescriptive limits. There may be occasions where operators of PBS Level 3 and 4 vehicles will request approval to operate at a higher GCM than conventional vehicles. Such requests should consider the previously permitted vehicle's GCM and the presence of steep grades on the route. Similarly, the horizontal forces generated from tyre scrubbing during tight turns are limited by restricting the maximum spacings of an axle group and requiring a steerable axle to be fitted to quad axle groups.

The PBS rules prevent the vertical and horizontal loading of pavements from exceeding those generated by prescriptive vehicles.

4.1.4 PBS design and approval process

A PBS vehicle is any freight vehicle that has been approved under the PBS scheme. This means that it can refer to any type of vehicle e.g. a rigid truck, truck and dog, or a multi-combination vehicle. The vehicle must be assessed and approved through the PBS design and vehicle approval process. This process ensures that the vehicle has been designed and built to operate as productively and safely as possible on the road networks appropriate for its level of performance. The steps in this process are:

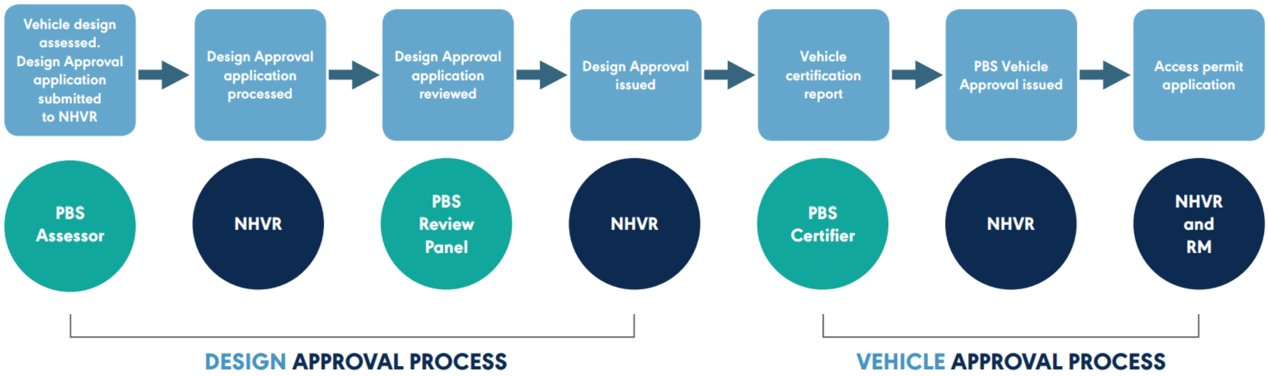
1. Authorised PBS assessor assesses the proposed vehicle design against standards.
2. An application for design approval is submitted to the NHVR (by an assessor on behalf of the applicant).
3. NHVR reviews and refers the application to PBS review panel.

4. PBS design approval is issued by the NHVR.
5. Authorised certifier inspects as-built vehicle against design approval and provides certification report to the NHVR.
6. NHVR issues vehicle approval, provided as-built combination complies with design parameters.

If there is no notice under which the PBS vehicle can operate, operator submits access permit application via the NHVR customer portal.

This is a thorough and stringent process which involves detailed assessments and approvals by a number of contributors as shown in Figure 4.5.

Figure 4.5: PBS design and vehicle approval process



Source: NHVR (2018).

There are two approval documents received during this process:

The PBS design approval – this defines the vehicle specifications for a PBS approved design. The applicant can build to this specification knowing it will comply with the approved performance level.

The PBS vehicle approval – this is similar to the design approval but is specific to a vehicle and includes a vehicle identification number (VIN) issued after the vehicle has been built and inspected by a PBS certifier. This serves as evidence that the vehicle is compliant with its PBS design.

Following the approval process the applicant can apply for a PBS vehicle access permit through the NHVR online portal. Unless the vehicle can operate under an existing notice, it will require an access permit for the operation on the road. The application is received by road managers.

The key contributors to the process are:

NHVR – administers the process, receives applications, seeks consent from road managers and issues permits.

PBS assessor – authorised by the NHVR to perform computer simulations of vehicles against the PBS standards. Only authorised assessors can submit an application to the NHVR for a design approval.

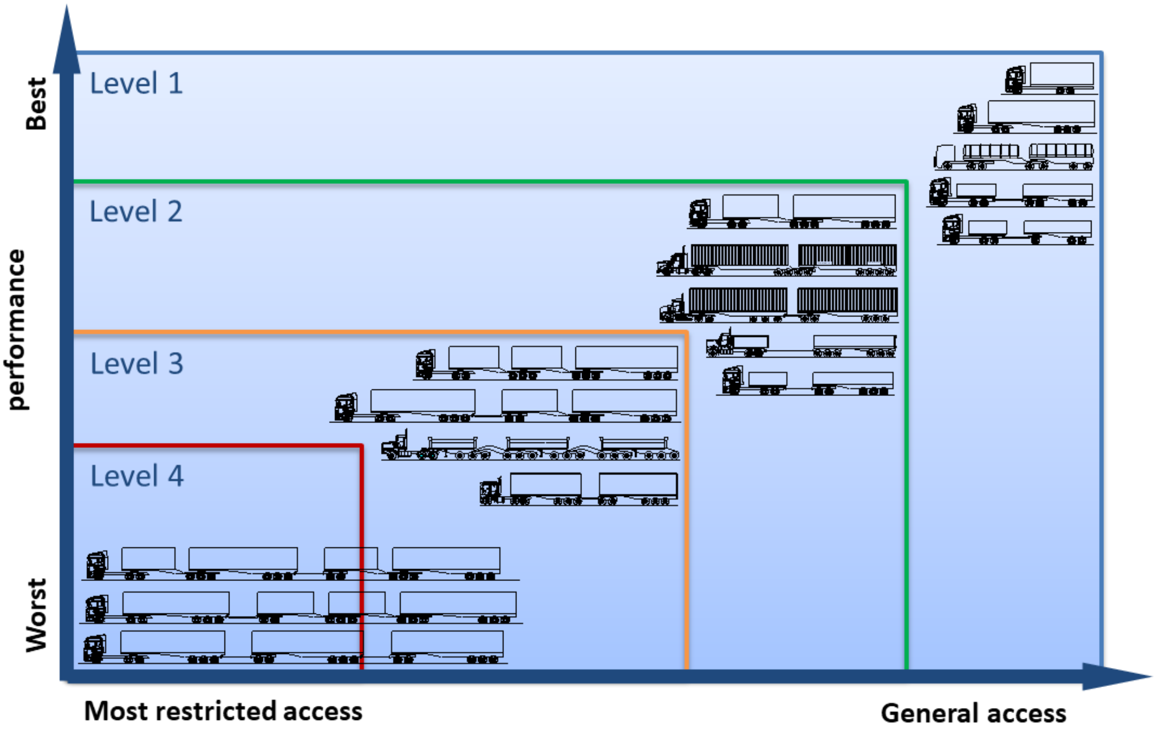
PBS certifier – authorised by the NHVR to certify and inspect as-built combinations against the design approval specifications. Only certifiers can submit an application for a PBS vehicle approval.

Road manager – issues the PBS vehicle access consent to the NHVR and may restrict axle masses and/or stipulate additional operating conditions to suit particular roads or bridges.

4.1.5 Access tailored to performance level

Figure 4.6 shows the four PBS levels of network access and the types of vehicles that comply with each. There are four levels of PBS access. Level 1 requires the highest level of performance and is equivalent to general access. These vehicles include rigid trucks, semi-trailers, some B-doubles and truck and trailers with either three or four axles. Level 4 is the most restrictive level of access for vehicles such as quad road trains.

Figure 4.6: PBS network access levels



A detailed comparison between the existing road network and the PBS road classes is provided in Section 6.

4.1.6 The requirements for a PBS vehicle approval

The requirements for a PBS vehicle are often more detailed than those for a prescriptive vehicle. A PBS vehicle must comply with the specifications listed in Part B of its specific PBS assessment documents. A PBS vehicle approval contains the following information:

- mass limits
- operating conditions
- exemptions from Australian Design Rules and National Regulations
- combination layout drawing
- VINs and relevant technical specifications
- tyres fitted to the vehicle at inspection and those that may replace them in the future.

The PBS vehicle approval serves as evidence that the vehicle has been accepted into the PBS scheme and is used to apply for an access permit.

5 THE PARTIES INVOLVED IN HEAVY VEHICLE ACCESS

The Heavy Vehicle National Law (HVNL) defines the roles and responsibilities of the National Heavy Vehicle Regulator (NHVR), transport operators and road managers. This section summarises the roles and responsibilities of the stakeholder agencies. Further information may be found in *Performance based standards – a guide for road managers* (NHVR 2019).

5.1 National Heavy Vehicle Regulator

The role of the NHVR is to review and facilitate the heavy vehicle access consent request process by way of notices or permits. One of the primary objectives of the NHVR is the safe operations of heavy vehicles on the road network. In accordance with the HVNL, heavy vehicle access under a notice or permit may only be granted by the NHVR if:

1. It is satisfied that the use of the heavy vehicle under the authority will not pose a significant risk to other road users, other vehicles and persons and property in the vicinity of roads.
2. Each relevant road manager has consented to the access approval.

Any other consents required by law have been obtained or given.

The NHVR may decide not to grant access under a notice or a permit despite the road manager consenting to grant access if the NHVR is not satisfied the heavy vehicle can be used safely. The road manager does not have the power to overrule the NHVR and allow a heavy vehicle to use a road.

Furthermore, the NHVR may grant heavy vehicle access under a notice or permit subject to conditions that may not be initially requested by the road manager. However, the road manager’s consent will still be required for the NHVR to grant access.

5.2 Road Managers

Road managers include state and territory road transport authorities, local governments (LGs) and some other road owners, such as port or forestry agencies. Road managers are responsible for making heavy vehicle access decisions for their road network and for determining appropriate access conditions.

Key information applicable to road managers, in accordance with the HVNL, are as follows:

1. A decision to grant access should not be made on the basis that further consent must be obtained before the restricted access vehicle may operate on a road. Consents from road managers must be obtained before the access is granted. Furthermore, where required by law, consent from other entities (such as utilities) must also be obtained before access is granted.
2. Road managers have legislated requirements/responsibilities placed upon them by the HVNL for making heavy vehicle access decisions for their road network and for determining appropriate access conditions. A decision by a Road Manager may be subject to judicial review or may be referred to an ombudsman. Further, s163 provides that if a Road Manager is a public authority (i.e. a Local Government, a Port Authority, or any government department) and refuses consent, the NHVR may ask a Road Authority to grant consent instead of the Road Manager. This allows a Road Authority to make a substitute decision on behalf of the road manager. If access is denied by a road manager, the HVNL stipulates that the relevant road manager must provide reasons, backed with all relevant documents relied upon.

3. Road managers are subject to time limits on how long they may take to make an access decision, being a default 28 days, or 14 days for the expedited approval procedure (extensions are possible in some cases up to 6 months). Within the allocated time, a road manager must decide to give or not to give the requested access consent. It should be noted that the earliest practicable response is desirable. Besides, under the expedited procedure for road manager's consent for renewal of mass or dimension authority(s167 of the HVNL) a shorter 14-day period applies.
4. The road manager is allowed to require travel conditions and road conditions and the NHVR must impose these conditions. The road manager may also ask the NHVR to impose a stated vehicle condition. However, while the NHVR must consider these conditions, it is not required to impose those conditions if the proposed conditions are deemed to be invalid or inappropriate. Strictly, the NHVR could disregard any invalid conditions that did not meet the precise requirements of Part 4.7 of the HVNL. Should the NHVR choose to disregard any conditions which it deems to be invalid, it must not issue a permit without the disregarded conditions, but must request that the road manager grant approval for the issue of a permit with an amended set of conditions.

Decisions by a road manager to not grant consent or to impose travel or road conditions can only be overridden by the road authority and not by the NHVR. The road authority may only override such decisions at the request of the NHVR using the process specified in the HVNL.

The responsibility of the road manager for providing a decision on consent applies to both accesses granted by notices and permits. As outlined in Section 163 of the HVNL, the road manager may decide not to give consent if it is determined that the heavy vehicle may:

- pose significant risks to public safety arising from heavy vehicle use that is incompatible with the geometry of the road infrastructure, traffic conditions or structural capacities
- cause damage to road infrastructure
- have an adverse effect on the community.

However, before deciding not to give consent, the road manager must give consideration to granting access subject to road or travel conditions that may avoid or significantly mitigate identified risks.

Heavy vehicle access conditions exist for many reasons, including maintaining the highest levels of safety and reducing the impacts on roads and structures that were not designed for these new-generation heavy vehicles. Currently, these access conditions are applied by road agencies and enforced by the police and/or roadside transport inspectors.

Traditional enforcement methods include visual inspections and roadside weighing (either using portable scales or a weighbridge). However, new technologies are now being used, including automatic number plate recognition (ANPR), vehicle length scanning and weigh-in-motion (WIM). While vehicle-based technology is more commonly utilised by transport operators to better manage their vehicle fleet and drivers, these technologies also offer benefits to road managers, particularly to assist with identifying where problematic areas exist on the network. It is possible that currently available geographic information system (GIS) datasets can provide data which will enable the movements of a heavy vehicle along the network to be monitored with a greater level of accuracy.

The enforcement of heavy vehicle compliance with permit conditions remains the responsibility of the road manager, whether that be the local council or state and territory road agency.

5.3 Queensland Department of Transport and Main Roads

TMR is the road authority in Queensland responsible for transport regulation. As the agency responsible for State-controlled roads, it is also a road manager in accordance with the HVNL.

6 APPLICATION OF THESE GUIDELINES

While any road can be assessed using these guidelines, the extent of the assessment varies for roads that are part of different existing networks. In the case where road networks have been previously assessed using the TMR *Route Assessment Guidelines for Multi-Combination Vehicles in Queensland*, only a sub-set of the assessment tasks may be required.

For the purpose of determining the level of assessment required, heavy vehicle networks can be grouped as follows:

- general access/PBS Level 1 roads
- prescriptive vehicle access (B-double route, Type 1 road train route, Type 2 road train route)
- PBS vehicle access (Level 1, Level 2A/2B, Level 3A/3B and Level 4A/4B routes).

Sections 6.1 to 6.3 provide tables identifying the assessment criteria to be reviewed when considering access to new heavy vehicles. While these provide an indication of the criteria to be reviewed, the Excel-based route assessment form (nacoe.com.au) provides a further detailed breakdown of the assessment criteria to be assessed. The route assessment form provides high-level results to identify which assessment criteria may require further investigation so that access decisions can be made.

A checklist for the assessment of the following criteria considerations is provided in Appendix H:

- traffic considerations
- road geometry
- amenities
- structures
- pavements.

6.1 General Access/PBS Level 1 Roads

General access roads in Queensland allow regulation vehicles to be up to 19 metres in length, and 50.5 tonnes gross mass.

In 2007, with agreement from all road managers, all general access roads were also classified as PBS Level 1 for PBS vehicles up to 20 metres in length, and 50.5 tonnes gross mass (TMR 2017c). This was done on the basis that vehicles achieving PBS Level 1 standards have no greater geometric or infrastructure impacts, or reduced safety performance than existing as-of-right general access vehicles.

Road managers may receive requests to reclassify the general access/PBS Level 1 road. The most common request will be to reclassify the road to a B-double road or PBS Level 2A road.

B-doubles or vehicles achieving PBS Level 2 standards and being up to 26 m in length (i.e. Level 2A vehicles) may have greater infrastructure impacts than existing as-of-right general access vehicles. Table 6.1 provides guidance on the required assessment tasks, depending on the level of access requested. The Excel-based upgrade table (nacoe.com.au) provides a breakdown of the assessment criteria to be reviewed.

Table 6.1: Current general access networks, potential new classifications, and required assessment

Current classification (mass and length limits)	Potential new classification (mass and length limits)	Required assessment criteria to be reviewed
General access (19.0 metres, 50.5 tonnes)	PBS Level 1 (20.0 metres, 50.5 tonnes)	No assessment required
	B-double (26.0 metres, 62.5 t and volumetric)	▪ Traffic interactions* ▪ Road geometry ▪ Amenities* ▪ Structures – including for a volumetric B-double ▪ Pavements
	PBS Level 2A (26.0 metres, 85.0 tonnes)	▪ Traffic interactions* ▪ Road geometry ▪ Amenities* ▪ Structures ▪ Pavements

Note: *Traffic interactions and amenities should be considered for access of any new heavy vehicle, including of the same class.

Source: TMR (2018a).

It should be noted that the PBS pavement horizontal loading standard sets the maximum allowable mass for a vehicle with one or two driven axles (refer to Table 6.5). There may be occasions where PBS Level 3 and 4 vehicles will be requested to operate at a higher GCM than conventional vehicles. Many routes will be unable to support this increase in mass due to structural constraints, and gross mass limits will need to be imposed. The route assessment process will address geometric, pavement and structural considerations, including the presence of steep grades where the tractive forces can be high.

6.2 B-double, Type 1 and Type 2 Road Train Routes

In Queensland, the following prescriptive heavy vehicle routes exist:

- B-double routes: 23 and 26 metre B-doubles to operate at up to 68.5 tonnes
- Type 1 road train routes: 36.5 metre Type 1 road trains to operate at up to 113.0 tonnes
- Type 2 road train routes: 53.5 metre Type 2 road trains to operate at up to 158.5 tonnes.

In 2007, with consent from all road managers, all B-double roads were also classified as PBS Level 2A roads, all Type 1 road train roads were also classified as PBS Level 3A roads, and all Type 2 road train roads were also classified as PBS Level 4A roads.

Road managers may receive requests to reclassify these routes to higher level prescriptive routes or PBS routes. Table 6.2 provides guidance on the required assessment tasks, depending on the level of access requested.

Table 6.2: Current restricted access networks, potential new classifications, and required assessment

Current classification (mass and length limits)	Potential new classification (mass and length limits)	Required assessment criteria to be reviewed
B-double route (23.0 metres, 68.5 tonnes)	B-double route (26.0 metres, 68.5 t and volumetric)	▪ Traffic considerations* ▪ Road geometry ▪ Amenities* ▪ Structures – including for a volumetric B-double ▪ Pavements
	PBS Level 2A (26 metres, 85.0 tonnes)	
	PBS Level 2B (30 metres, 85.0 tonnes)	
	PBS Level 3A (36.5 metres, 110.0 tonnes)	
B-double route (25.0 metres, 68.5 tonnes)	PBS Level 2A (26 metres, 85.0 tonnes)	No assessment required
	PBS Level 2B (30 metres, 85.0 tonnes)	▪ Traffic considerations* ▪ Road geometry ▪ Amenities* ▪ Structures – including for a volumetric Type 1 road train ▪ Pavements
	Type 1 road train route (36.5 metres, 113 tonnes (volumetric))	
	PBS Level 3A (36.5 metres, 110.0 tonnes)	
Type 1 road train route (36.5 metres, 113 tonnes)	PBS Level 3A (36.5 metres, 110.0 tonnes)	No assessment required
	PBS Level 3B (42.0 metres, 110.0 tonnes)	▪ Traffic considerations* ▪ Road geometry ▪ Amenities* ▪ Structures – including for a volumetric Type 2 road train ▪ Pavements
	Type 2 road train route (53.5 metres, 158.5 tonnes and volumetric)	
	PBS Level 4A (53.5 metres, 150.0 tonnes)	
Type 2 road train route (53.5 metres, 158.5 tonnes)	PBS Level 4A (53.5 metres, 150.0 tonnes)	No assessment required
	PBS Level 4B (60 metres,150.0 tonnes)	▪ Traffic considerations* ▪ Road geometry ▪ Amenities* ▪ Structures ▪ Pavements

Note:

*Traffic interactions and amenities should be considered for access of any new heavy vehicle, including of the same class.

Source: TMR (2017d).

It should be noted that the PBS pavement horizontal loading standard sets the maximum allowable mass for a vehicle with one or two driven axles (refer to Table 6.5) . Many routes will be unable to support this mass due to structural constraints, and gross mass limits will need to be imposed. The route assessment process will address geometric, pavement and structural considerations.

6.3 PBS-classified Roads

PBS-classified roads in Queensland were transitioned from previous general access, B-double, Type 1 road train and Type 2 road train networks, or assessed using prior guidelines (e.g. TMR 2013a, 2014). Examples of assessed networks are the PBS Level 2B route between Toowoomba and the Port of Brisbane, and various PBS Level 2B roads around Townsville that connect the Port of Townsville with nearby industrial areas.

PBS roads are classified as Level 1, Level 2A, Level 2B, Level 3A, Level 3B, Level 4A and Level 4B. Class B vehicles are longer than Class A for the equivalent level, but meet the same PBS safety standards, hence only aspects related to increased length are required to be assessed.

The provision of upper bounds for vehicle lengths for each road level provides road managers with a performance envelope within which to classify vehicles. Table 6.3 provides the equivalent maximum vehicle length for each road level.

Table 6.3: Equivalent maximum vehicle length

Vehicle performance level	Network access by vehicle length, L (m)	
	Access Class A	Access Class B
PBS Level 1	L ≤ 20 (general access*)	
PBS Level 2	L ≤ 26	26 < L ≤ 30
PBS Level 3	L ≤ 36.5	36.5 < L ≤ 42
PBS Level 4	L ≤ 53.5	53.5 < L ≤ 60

Note:

*General access is subject to a 50.5 t gross mass limit, posted local restrictions and restrictions or limitations specified by the jurisdiction.

The level of assessment effort differs if a PBS road is being assessed to determine whether a new access level, or access class, is required. That is, if a road is currently classified as PBS Level 2A, fewer assessment criteria are required if the assessment seeks to determine whether the road can be reclassified as PBS Level 2B, than would be required to determine whether it can be reclassified as PBS Level 3A.

Basically, if reclassifying from Class A to B, the length-related aspects to consider include (but may not be limited to), overtaking provision, clearance times, stacking distance, parking and structures. Again, it is good practice to consider traffic interaction, amenity, and freight issues. If reclassifying to a higher road level, then all aspects in this guideline should be considered.

Table 6.4 provides guidance on the required assessment task, depending on the access requested. The Excel-based upgrade table (nacoe.com.au) provides a breakdown of the assessment criteria to be reviewed.

Table 6.4 Current PBS networks, potential new classifications, and required assessment

Current classification (mass and length limits)	Potential new classification (mass and length limits)	Required assessment criteria to be reviewed
PBS Level 1 (20.0 metres, 50.5 tonnes)	PBS Level 2A (26.0 metres, 85.0 tonnes) PBS Level 2B (30.0 metres, 85.0 tonnes)	▪ Traffic considerations ▪ Road geometry ▪ Amenities ▪ Structures ▪ Pavements
PBS Level 2A (26.0 metres, 85.0 tonnes)	PBS Level 2B (30.0 metres, 85.0 tonnes)	▪ Traffic considerations ▪ Road geometry ▪ Amenities ▪ Structures ▪ Pavements
	PBS Level 3A (36.5 metres, 110.0 tonnes)	▪ Traffic considerations ▪ Road Geometry ▪ Amenities ▪ Structures ▪ Pavements
PBS Level 2B (30 metres, 85.0 tonnes)	PBS Level 3A (36.5 metres, 110.0 tonnes) PBS Level 3B (42.0 metres, 110.0 tonnes)	▪ Traffic considerations ▪ Road geometry ▪ Amenities ▪ Structures ▪ Pavements
PBS Level 3A (36.5 metres, 110.0 tonnes)	PBS Level 3B (42.0 metres, 110.0 tonnes)	▪ Traffic considerations ▪ Road geometry ▪ Amenities ▪ Structures ▪ Pavements
	PBS Level 4A (53.5 metres, 150.0 tonnes)	▪ Traffic considerations ▪ Road geometry ▪ Amenities ▪ Structures ▪ Pavements
PBS Level 3B (42.0 metres, 110.0 tonnes)	PBS Level 4A (53.5 metres, 150.0 tonnes) PBS Level 4B (60.0 metres, 150.0 tonnes)	▪ Traffic considerations ▪ Road geometry ▪ Amenities ▪ Structures ▪ Pavements
PBS Level 4A (53.5 metres, 150.0 tonnes)	PBS Level 4B (60.0 metres, 150.0 tonnes)	▪ Traffic considerations ▪ Road geometry ▪ Amenities ▪ Structures ▪ Pavements

It should be noted that the maximum gross mass limits that apply to each PBS level and that are shown in Table 6.2 and Table 6.4 (e.g. 85 tonnes for Level 2, 110 tonnes for Level 3 and 150 tonnes for Level 4) are based on the PBS pavement horizontal loading standard which sets the maximum allowable mass for a vehicle with either one or two driven axles. These limits are designed to limit the tractive forces particularly when accelerating on a steep grade to not exceed those generated by conventional vehicles. Table 6.5 shows the maximum gross mass permitted for the different PBS road classes based on the vehicle having either one to two driving axles, applicable for sealed and unsealed roads.

Table 6.5: Gross mass limits based on number of drive axles

PBS road class	Maximum gross mass for one driving axle (tonnes)	Maximum gross mass for two driving axles (tonnes)
PBS Level 1	35	70
PBS Level 2	45	85
PBS Level 3	45	110
PBS Level 4	45	150

7 GRANTING ACCESS TO THE ROAD NETWORK

The successful uptake of innovative heavy vehicles in Australia is dependent on road managers granting access to the road network. The decision is made by road managers based on the suitability of the road network to accommodate these longer and heavier combinations and is made to serve the public by providing benefits to the local community as well as broader economic and environment considerations.

7.1 Reasons for Restrictions

The reasons for heavy vehicle access restrictions can be distilled into three main areas as discussed below.

7.1.1 Safety

Safety is paramount, and the PBS scheme was introduced in 2007 to improve the safety of the Australian heavy vehicle fleet. Safety benefits arise from:

- reduced crash rates associated with less trips
- benefits of advanced technologies fitted to new and modern vehicles
- reduced crash risk associated with PBS-compliant vehicles.

7.1.2 Infrastructure preservation

Pavements deteriorate depending on the volume and mass of the vehicles traversing them. The rate of deterioration can increase exponentially with load. As a result, encouraging the use of heavy vehicles with a lower impact on pavements can increase the life of the pavement and reduce the costs associated with road maintenance.

The well accepted understanding that lower standard axle repetitions (SAR) result in less pavement wear provides evidence to assist road managers with making access decisions; however, in the case when these are higher it is necessary to quantify the other benefits that longer and heavier heavy vehicles provide and to compare these to the pavement impacts.

In the case of horizontal pavement loading caused by tyre scrubbing while turning or tractive forces during acceleration or when climbing steep grades, the approach has traditionally been to manage this risk by limiting the mass of the vehicle to suit the mass limits of the drive axles whether it be a single, tandem or tridem. In most instances this will be sufficient to avoid damage to the road surface. However, for heavy vehicles (typically PBS Level 4) climbing steep grades in cases where the drive axles are lightly loaded, or where there is no friction (particularly unsealed roads) it can result in surface wear from high shear forces.

Vehicle assessments can determine when a vehicle will be limited in its ability to climb grades based on the available friction, as opposed to being limited by the clutch engagement torque, and this information can assist road managers with access decisions. Conversely, the limitations of the pavement can be determined by applying known loads using heavy-duty truck tyre pavement-test equipment.

Granting access based on pavement loading and restricting access to vulnerable roads or bridges from loads for which they may not have been designed will have the overall positive effect of increasing the life of the road network and reducing the need for premature renewal and reconstruction works.

7.1.3 Amenity

Access restrictions are used to preserve location amenity, most commonly by keeping longer and heavier restricted-access vehicles out of suburban community-focused areas. Factors that affect amenity include their overall length and mass and their effects on traffic flow as well as the noise generated from these vehicles. For example, the use of engine brakes, or audible reversing warnings, especially at night, are often cited as the undesirable impacts heavy vehicles might have on a locality.

Realising the benefits of using longer and heavier vehicles to move freight is intrinsically linked to the roads on which the vehicles operate. To achieve the maximum benefits, the vehicles should be utilised to the network's full capacity but restricted from roads not deemed suitable.

The mass and dimensions of a heavy vehicle can become a safety consideration if permitted to travel along routes not designed to accommodate them. A simple example of this is high vehicles travelling on roads with low-lying overhead structures such as bridges. Impacts with these structures can damage the vehicle, cause traffic disruptions and, in the worst case, damage the structure. Typically, heavy vehicles are restricted to an overall height of 4.3 m, except for livestock vehicles at 4.6 m. The inclusion of heavy vehicle access conditions as part of the vehicle access permit is an important mechanism for managing risk and maximising benefits.

7.2 Heavy Vehicle Access Conditions

Road managers have the right to apply conditions when granting access to heavy vehicles. Three types of conditions are applied: vehicle, road and travel, as defined by the HVNL. Road and travel conditions are primarily the responsibility of the road managers. Access conditions (vehicle conditions) are primarily the responsibility of the NHVR. This is based on the responsibilities of each organisation.

Road conditions are intended to minimise risks associated with road infrastructure, the community and public safety. NHVR (2016) lists the following examples of road conditions:

- do not use particular bridges or sections of the otherwise-approved route
- only carry particular loads
- be limited to a particular speed
- travel at a speed under the posted speed limit
- operate in a specified position on the road, e.g. travel in certain lanes may be restricted
- require the operator to participate in an intelligent access program.

Travel conditions may require that the movement of exempt heavy vehicles is undertaken at stated times or in a stated direction. NHVR (2016) lists standard conditions that can be applied by road managers.

Vehicle conditions include:

- how the vehicle should be configured (e.g. trailer type)
- general requirements to mitigate risks subject to mass or dimension
- installation and use of certain components (including safety features or other equipment)
- limiting the vehicle to a particular speed.

NHVR (2016) lists considerations to minimise risks, as listed in Table 7.1.

Table 7.1: Considerations for managing risks

NHVR (vehicle considerations)	Road manager (travel and road considerations)
Size and mass of the vehicle	Vehicle's ability to interact with surrounding traffic
Security of couplings	Vehicle's ability to interact with the infrastructure and road
Distribution of mass	Suitability of the dimensions (length and width) of the road
Dynamic stability and tracking characteristics	Location of infrastructure on or near the road
Acceleration and braking characteristics	Traffic conditions
Manoeuvrability	Use of properties near the road
Visibility to other road users	Sight distance for other road users
Suitability of the vehicle to the task	Clearance zones for the road
Load restraint	Results of road safety audits
Rollover risk	Suitability of the road for transport of dangerous goods

Source: NHVR (2016).

8 RISK ASSESSMENT PROCESS

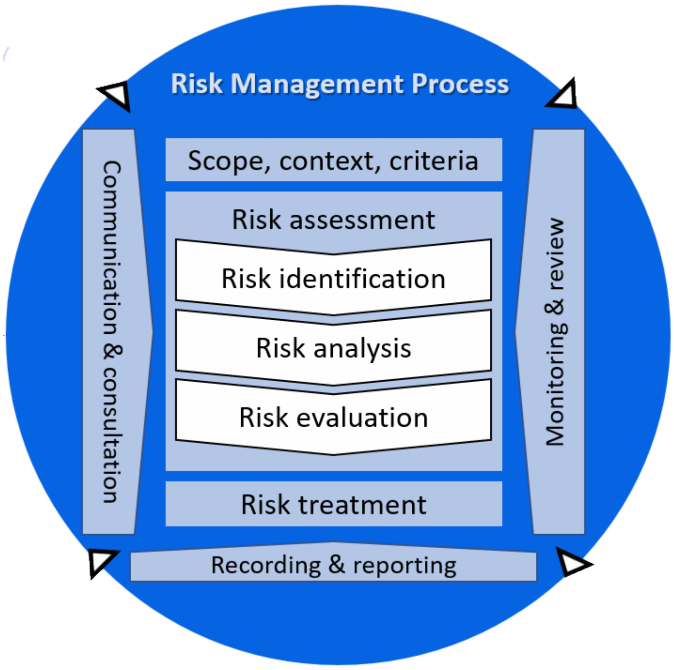
This section presents a risk assessment process that provides a framework and procedures to identify, assess and manage risk associated with granting non-as-of-right access to heavy freight vehicles on local government controlled roads.

8.1 Risk Management Process

From the perspective of a local government as an asset owner and road manager, the risk management process aims at both minimising the potential for damage, loss, injury and death and maximising positive outcomes in terms of movement efficiency, safety, productivity and public acceptance. According to Austroads (2006), examples of risk for a road authority include crashes and injuries on the road network, public concerns, road or structure failure, political influence and legal action.

ISO 31000:2018 describes the principles, framework and process for managing risk in order to increase the likelihood of achieving the required objectives. Figure 8.1 shows the cyclical process of risk management. At its core, the tasks of identifying, analysing and evaluating risks are referred to as risk assessment.

Figure 8.1: ISO 31000 risk management process



Source: ISO 31000:2018.

Other stages identified in the international risk management process are:

- scope, context, criteria
- risk treatment
- communication and consultation
- recording and reporting
- monitoring and review.

8.2 Risk Management Framework for Heavy Vehicle Route Evaluation

This section describes an overarching risk management framework that can be used by road managers to assess risks in the processing of heavy vehicle access requests.

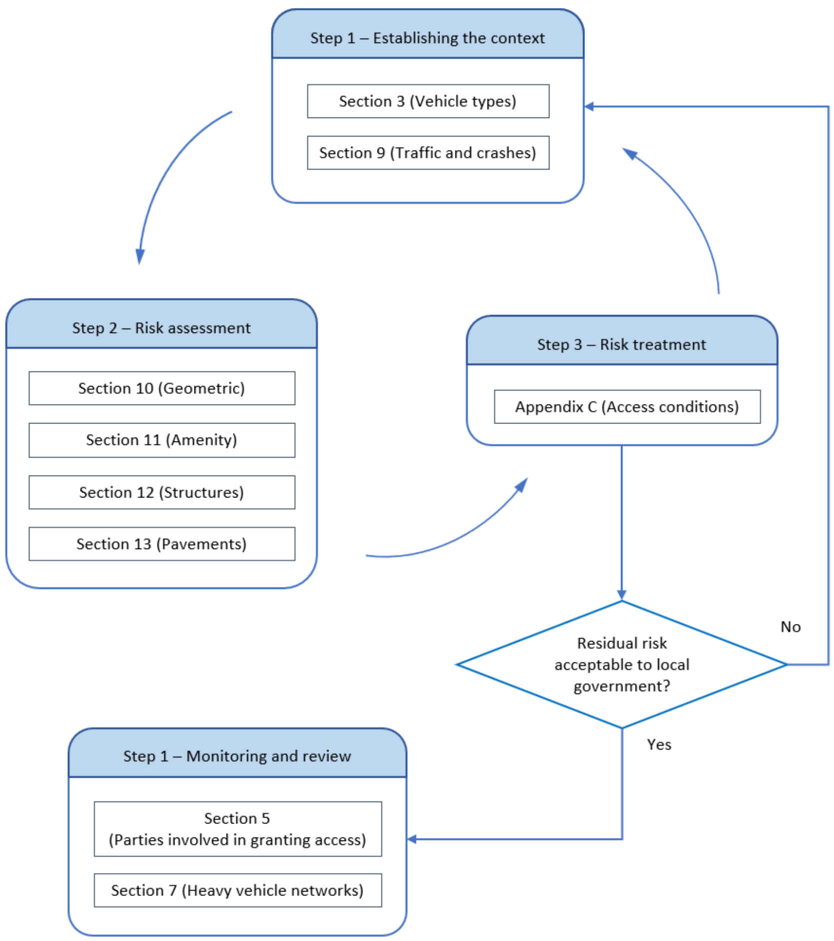
8.2.1 Overview

The main objective of the framework is to provide a road manager and/or assessor with a consistent and methodological approach for assessing access requests. The framework has been developed to support the risk-based decision making of the route assessment process which, in turn, would:

- remove ambiguity in the risk assessment component of a route evaluation process
- enable a balanced approach for improved heavy vehicle productivity by recognising and quantifying safety, infrastructure, amenity and public community risk to local government
- provide a risk evaluation method to prioritise risk treatment options primarily through access conditions relating to vehicle and travel characteristics and/or infrastructure upgrades
- provide a mechanism for local councils to evaluate what is an acceptable level of risk.

Figure 8.2 illustrates the assessment and decision-making process.

Figure 8.2: Risk management framework for heavy vehicle route evaluation



There are four steps proposed in the risk management framework with the first three forming an iterative process. The first step is to establish the context by defining the objectives and scope of route assessment activities. A risk assessment is undertaken in the second step where risks associated with road geometric attributes and structures, and pavement and amenity considerations are identified, analysed and evaluated.

The third step of risk treatment, primarily through the conditions of consent, is followed by a point of decision to determine whether the residual risk as a result of treatment implementation can be tolerated by the road manager. Deciding whether to accept the residual risk should take account of the wider context of potential mitigation measures and benefits of high-productivity vehicles. Such benefits include not only productivity gains, but also improved safety through fatality and injury reduction as well as fuel and environmental savings (Austroads 2014).

The following two options are identified for the decision about the risk tolerance:

- The residual risk *is not acceptable* to the road manager. The process, involving modification to vehicle and route selection, starts again from the first step should the application continue or, otherwise, discontinues with the access request declined.
- The residual risk *is acceptable* to the road manager. The process proceeds to the final step that involves the ongoing monitoring and review of the roles and responsibilities and the suitability of approved heavy vehicle routes and networks.

8.2.2 Establishing the Context

As the first step of the framework, the objective and scope of assessing a heavy vehicle for a particular length of road(s) needs to be clearly defined. The understanding of traffic composition, crash history and the variation in traffic volumes will provide the context for the risk assessment in the second step. Table 8.1 identifies contextual factors in the risk assessment process.

Table 8.1: Contextual factors in the risk assessment process

Key consideration	Contextual factor	Value
Basic information	Assessment of route description and location	Assessment reference
		Local government area
		Road name(s)
		Road classification (e.g. arterial, regional and local roads)
		Location / address / distance
		Surrounding land use (e.g. urban, fringe and rural)
Vehicle types and productivity (Section 3)	Vehicle characteristics	Class / category
		Length / width / height
		Restrictions
Traffic interaction considerations (Section 9)	Traffic composition	Percentage of heavy vehicles
		A school bus route?
	Crash history	Number of fatal and serious injury crashes
		Number of total crashes
	Traffic volume data	AADT
		Peak and seasonal volumes

8.2.3 Risk Assessment

It is important for an overall risk assessment process to consider the road, traffic and crash risk characteristics of a heavy vehicle route under consideration. Elaborated in Section 8.3, the risk assessment process, which incorporates risk identification, analysis and evaluation, informs the next step of risk treatment.

8.2.4 Risk Treatment

Risk treatment involves the selection of one or more options to modify risks and the implementation of these options. The following principles are provided to assist the road manager in treating the identified risks:

- Balance the costs and requirements of treatment implementation to select the most appropriate option(s) against the benefits obtained.
- Prioritise the treatment of the more severe risks based on a risk analysis matrix and a treatment evaluation model, outlined in Sections 8.3.1 and 8.3.3, respectively.
- Involve and communicate with key stakeholders in the decision when risk treatment options impact risk elsewhere in the organisation and/or community (e.g. a partial road closure during access hours would have an impact on the network operation team and local community).
- Recognise that risk treatment can also introduce secondary risks, which should be assessed, treated, monitored and reviewed.

Imposing the conditions of consent relating to vehicle and travel characteristics, coupled with infrastructure upgrade requirements, is considered a primary measure to mitigate the recognised risks. Examples of consent conditions are included in Appendix B.

8.2.5 Monitoring and Review

The key objective of the last step in the risk management framework is to ensure the control measures used to modify risk (e.g. risk transfer and reduction options) are effective and efficient in both design and operation. Understanding the role and responsibility of the key parties (Section 5) and the extent of the heavy vehicle networks helps determine the changes and trends in the external and internal context as well as identifying lessons learnt and emerging risks.

8.3 Risk Assessment Process for Heavy Vehicle Route Evaluation

This section presents detailed risk assessment procedures, which collectively constitute the second step of the risk management framework for the evaluation of heavy vehicle routes.

8.3.1 Risk Identification

The aim of risk identification is to generate a comprehensive list of risks or hazards based on events that might affect the local government in its ability (including perceived ones) to deliver a safe, efficient and reliable local road network if the heavy vehicle access request was approved without mitigation treatments. The following aspects of risk should be identified:

- sources of risk
- area of impacts
- their causes and potential consequences.

It is important to identify risks comprehensively as a risk not identified at this stage will not be included in further analysis. Knock-on effects of significant consequences (e.g. traffic disruption as a cascade effect from pavement or bridge failure due to additional loads) should also be considered. Identifying risks will also require relevant and up-to-date information and people with appropriate knowledge.

Table 8.2 outlines how the key considerations of road geometry, structures, pavement and amenity (as discussed in Sections 6 to 9) contribute to a comprehensive risk identification process.

Table 8.2: Risk identification in relation to road geometry, amenity, structures, and pavements

Key consideration	Risk overview	Criteria for identification	Reference
Road geometry (Section 10)	▪ Road geometry not suitable for a heavy vehicle under consideration, resulting in a reduction in safety and efficiency	▪ Geometric design elements, e.g. horizontal and vertical alignments, cross-section attributes, intersections, crossings and sight distances	▪ Section 10 for the geometric route assessment considerations
Amenity considerations (Section 11)	▪ Environmental amenity deteriorating, resulting in discontent from local community and businesses	▪ Surrounding land use and the level of noise, exhaust emissions and airborne dust	▪ Section 11 for amenity considerations
Structures assessment (Section 12)	▪ A structure along the route incapable of carrying the specific vehicle and/or loads, resulting in damage, loss, injury or death	▪ Load rating assessment criteria for relevant tier assessments, including design loading and load effect of the design vehicle	▪ Figure 12.2 for a framework to assess structures on the assessment route
Pavement impact assessment (Section 13)	▪ Pavement conditions unable to be maintained at the same level of service provided before the impact period, resulting in deficiency, loss of productivity and public outcry	▪ Marginal cost of road wear, which is dependent on: – traffic loading and duration of additional load – pavement strength and condition information – typical maintenance practices and costs	▪ Figure 13.1 for a pavement impact assessment process ▪ Austroads (2015b, 2015c) for the FAMLIT to quantify the marginal cost ▪ AGPT Part 2 (Austroads (2012a) for updated pavement structural design parameters

8.3.2 Risk Analysis

Risk analysis is the consideration of the nature of the identified risks, their positive and negative consequences and the likelihood that these consequences can occur. The interdependence of different risks and their sources should also be considered. A risk analysis matrix is proposed in Table 8.3 to quantify the level of risk based on:

- likelihood of the risk: almost certain, likely, unlikely and rare
- severity of the consequences: insignificant, minor, major and catastrophic.

Table 8.3: Risk analysis and evaluation matrix

Likelihood	Severity of consequence			
	Insignificant	Minor	Major	Catastrophic
Almost certain	L	H	E	E
Likely	L	M	H	E
Unlikely	L	L	M	H
Rare	L	L	M	M

Through the qualitative risk analysis, a risk can be classified as follows:

- Extreme risk (E) – critical concern that must be addressed and requires changes to avoid serious consequences (e.g. death, life-threatening and complete failure).
- High risk (H) – significant concern that should be addressed and requires changes to avoid major consequences (e.g. injury, damage, financial loss and public concerns).
- Moderate risk (M) – moderate concern that should be addressed via planned action.
- Low risk (L) – minor concern that should be addressed by routine procedures.

8.3.3 Risk Evaluation

Risk evaluation involves the determination of which risks need treatment and the priority for treatment implementation based on the risk rating. Table 8.4 outlines the treatment approaches of risk avoidance, transfer, mitigation and acceptance and the treatment options identified in the ISO 31000 standard with respect to the risk-rating outcomes.

Table 8.4: Risk evaluation model to determine treatment approaches and options

Risk rating	Treatment approach	Treatment option (ISO 31000)
E	Risk avoidance	▪ Remove the risk source
		▪ Avoid the risk by deciding not to start or continue with the activity that gives rise to the risk
H	Risk transfer	▪ Share the risk with another party or parties (including contracts and risk financing)
M	Risk mitigation	▪ Change the likelihood
		▪ Change the consequences
L	Risk acceptance	▪ Take or increase the risk in order to pursue an opportunity
		▪ Retain the risk by informed decision

With the presence of a risk considered extreme, the road manager is to adopt the risk avoidance approach, which means the consideration of an alternative route or the proposed route is unlikely to be approved.

Risk transfer and mitigation approaches are suitable for high and moderate risks where conditions of consent (including financial contributions) can be imposed to reduce the level of risk carried by the road manager or asset owner i.e. local government jurisdiction. While risk transfer involves shifting the responsibility or the burden for loss through, for example, legislation, contract and insurance, risk mitigation aims at reducing the likelihood of an event occurring and/or the severity of such an event should it occur.

By an informed decision, low risks can be accepted, particularly when the treatment costs are higher than the estimated costs of the risk occurring. Without risk treatment, a low risk becomes a residual risk which, as shown in Figure 8.2, is still subject to the final decision of whether the residual risk is acceptable to the road manager. Often, standard consent conditions that control and restrict heavy vehicle access to the local road network, further reduce adverse effects even when the risk is deemed acceptable based on this approach.

9 TRAFFIC INTERACTION CONSIDERATIONS

The interaction between heavy vehicles and other road users is an important road safety consideration. While aspects of traffic interaction are covered in other areas of these guidelines (e.g. speed differential when merging, requirements for cycling lanes, etc.) the traffic volume, composition and crash history of a route should be considered.

The daily and annual variation in traffic volumes on a proposed road (and the projected variation) should be considered. It is reasonable to impose as a condition of access that heavy vehicle operations can be restricted during peak traffic hours in urban areas, or during certain periods of the year to accommodate seasonal fluctuations in traffic. On the other hand, higher heavy vehicle traffic may be permitted during certain periods of the year, for example, to cater for the grain carting season.

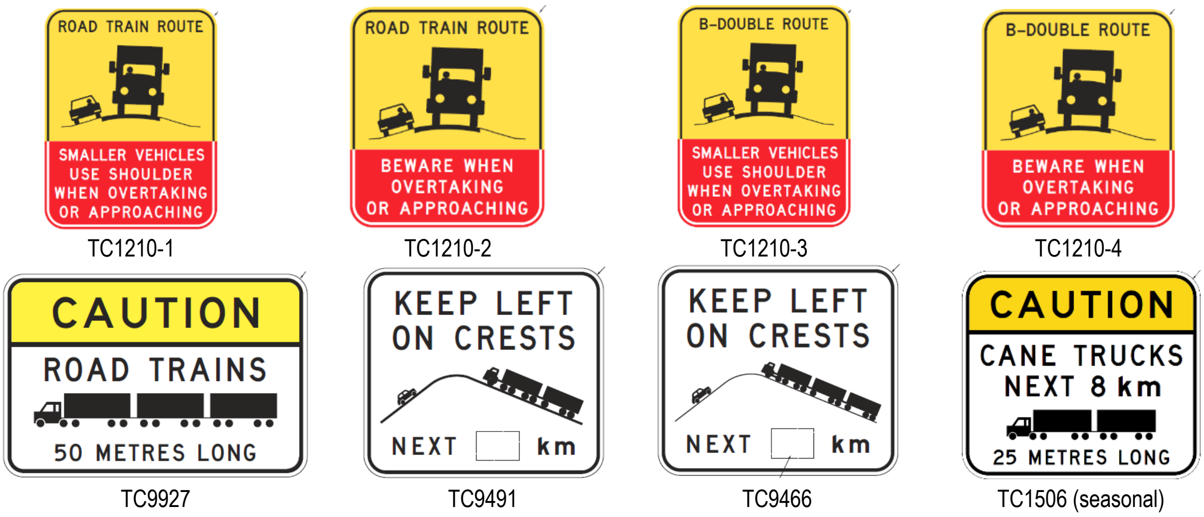
9.1 Traffic Composition

The current vehicle composition of the proposed route should be quantified and considered. The ability of typical drivers and road users to safely integrate with the multi-combination vehicles may influence the acceptance of the route.

On a route where there is a high proportion of heavy vehicles, or where local drivers are already familiar with the heavy vehicles operating in the area, there is a greater likelihood of route acceptance.

However, on a route where there is a high tourist content, vehicles towing caravans, or drivers not familiar with the area and inexperienced in encountering heavy vehicles, the possible safety risk to other road users needs to be considered. Due caution should be exercised in allowing the requested access application. Appropriate signage advising motorists of heavy vehicle operations should be considered where significant amounts of tourist traffic are likely to be encountered, with some examples shown in Figure 9.1.

Figure 9.1: Examples of heavy vehicle route signage



Note: Installed as per AS 1742.2 (2009).

Source: TMR traffic control (TC) signage.

9.2 Crash History

The crash history of the proposed route should be assessed to determine whether crash rates are worse than other roads of a comparable class within the council. The analysis should determine if the crash data exhibits any patterns including time of day, crash types and impact on other road users. It is useful to investigate whether certain times of the day have particular risks, while at other times the risk is significantly lower. In these cases, it may be appropriate to consider time restrictions as a condition of access that heavy vehicles use the route during the low-risk hours. Metrics of crash rates include:

- crashes per vehicle kilometres travelled (VKT) (individual crash risk)
- crashes per kilometre (collective risk).

If fatal and serious injury crash data is available, it is possible to determine the crash risk and compare it against baseline data. If a route is considered to have a higher crash risk than expected, it is prudent to undertake a road safety audit to identify safety deficiencies and mitigation measures.

Consultation with the police should also be conducted to ascertain whether the introduction of heavy vehicles to the route would exacerbate existing hazards associated with typical road users interacting with heavy vehicles. Other road users/vehicles to be considered include:

- pedestrians (particularly at or in close proximity to schools)
- cyclists (including school age, recreational and commuting)
- tourists (who would be unfamiliar with the conditions, including cars towing caravans)
- motorcyclists (commuting on weekdays and recreational riding on weekends)
- school buses (where the frequent stopping and turning by buses, and the presence of children on or adjacent to the road can pose potential hazards)
- cattle and other stock
- farm machinery and implements.

To address any safety concerns, the road manager can impose traffic or operation conditions, such as the use of headlights when travelling through town sites, reduced speeds or curfew times. Where alternative routes exist, consideration should be given to directing the vehicles to the route with the lower crash risk.

9.3 Proactive Risk Assessment

In addition to considering the criteria outlined in Section 10, a proactive assessment can be undertaken to identify and mitigate crash risk and possible increases in risk resulting from heavy vehicle access. A high-level assessment is discussed in Section 9.3.1 however more detailed studies can be undertaken. Often the information required for a risk assessment may not be available until the geometric route assessment considerations have been analysed; however, this should not preclude a route from being assessed should the assessor have all the relevant information. A proactive assessment can be revisited after the geometric criteria have been assessed.

9.3.1 Identifying and Mitigating Crash Risk

The presence of heavy vehicles on a road comes with an inherent safety risk. While these guidelines provide some criteria to determine if a heavy vehicle should be given access based on the road infrastructure, an assessor should also consider if granting access will increase the likelihood of a crash involving (or caused by) a heavy vehicle. Due to the mass of a heavy vehicle a collision with a passenger vehicle is likely to have a high crash severity.

A Safe System assessment framework (SSAF) provides a method to identify and record the safety risks on the road. The SSAF assessment considers crash history, and how the features of a road influence crash likelihood and severity for run-off-road, head-on, intersection, and vulnerable road user crashes. The risks identified in the assessment should be treated or placed within a program of works to be treated at a later date. High-risk issues, particularly those related to heavy vehicles should be treated before access is granted. Refer to Austroads (2016b) for information on the SSAF, with case studies provided in Appendix C of that report. Some safety issues may warrant further safety investigation, e.g. a road safety audit or inspection by an experienced road safety engineer.

An example of treatments for head-on crashes and their influence on the exposure, likelihood or severity of each treatment is shown in Table 9.1.

Table 9.1: Examples of Safe System treatments for head-on crashes

Hierarchy	Treatment	Influence (E = exposure, L = likelihood S = severity)
Safe System options ('primary' or 'transformational' treatments)	▪ One-way traffic	L
	▪ Divided carriageway	L, S
	▪ Flexible median barrier	S
	▪ Very wide median	L, S
	▪ Very low speed environment/speed limit.	L, S
Supporting treatments (compatible with future implementation of Safe System options)	▪ Wide median	L
	▪ Painted median/wide centrelines.	L
Supporting treatments (does not affect future implementation of Safe System options)	▪ Non-flexible barrier provision	S
	▪ Lower speed environment/speed limit	L, S
	▪ Ban overtaking	L
	▪ Skid resistance improvement	L
	▪ Audio-tactile centreline	L
	▪ Audio-tactile edgeline	L
	▪ Roadside barriers	S
	▪ Consistent design along the route (i.e. no out-of-context curves)	L
	▪ Consistent delineation for route	L
	▪ Overtaking lanes	L
	▪ Improved superelevation	L
	▪ Vehicle activated signs	L
	▪ Heavy-vehicle-specific special warning signs, heavy vehicle warning signs.	L

Hierarchy	Treatment	Influence (E = exposure, L = likelihood S = severity)
Other considerations	▪ Speed enforcement and/or monitoring ▪ Rest area provision ▪ Lane marking compatible with vehicle lane-keeping technology.	L, S L L

Source: Adapted from Austroads (2016b).

9.4 Traffic Volume Data

In order to determine the suitability of a road for access, it is essential to obtain current traffic data for the road under assessment, and this should include intersection turning volumes. Higher volumes during seasonal periods such as agricultural activity (e.g. cane harvesting) or commercial activity (in the months leading to Christmas) should be considered; this could include but is not limited to:

- higher vehicle per day volumes on low-volume roads (agriculture)
- higher heavy vehicle turning volumes through intersections to adjoining industrial areas (seasonal commercial activity).

The traffic counts must be accurately identified to assess for appropriate road widths, potential congestion issues and relevant operating conditions as outlined in Section 10.

9.4.1 Average Annual Daily Traffic (AADT) or Vehicles per Day (VPD)

Throughout Section 10 the assessment criteria provide an option to assess an attribute with AADT and VPD.

AADT

AADT is a suitable measure to use for most roads as traffic volumes are typically consistent. In its most simplistic form, AADT is calculated as per formula 1.

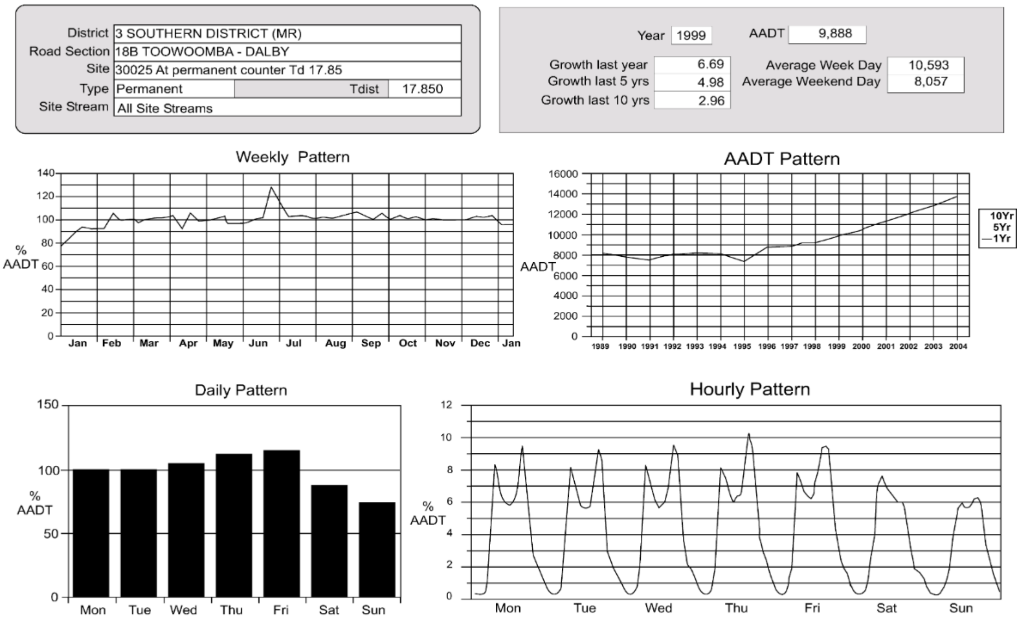
$$AADT = \frac{\text{estimate total volume of vehicle traffic for 1 year}}{\text{365 days}} \qquad 1$$

AADT is not able to identify increases or decrease due to seasonal traffic (e.g. tourist season), days of the week or hours during each day. Should a road have clear seasonal or day of the week fluctuations in traffic, or access is being considered by permit VPD can be explored.

VPD

VPD can be extracted from traffic volume reports to identify seasonal traffic, or days of the week or even hours during a day that may have higher or lower volumes than the AADT. VPD can be used to more accurately identify suitable times for access under permits or even identify times of the year where access is not suitable or safety risks may have to be mitigated.

Figure 9.2: Example of traffic volume data report



10 ROAD GEOMETRY ASSESSMENT CONSIDERATIONS

The geometric attributes of a road should cater for the performance characteristics of the vehicles using it. This includes heavy vehicles, particularly if they regularly use the road or if the function of the road is to provide heavy vehicle access.

The relationship between the design and condition of a road can influence the performance characteristics of heavy vehicles. This can in turn influence the safe operation of the vehicles.

The following sections provide assessment criteria to guide an assessor to determine if the road geometry is suitable for a heavy vehicle. In certain cases, routes which do not meet the requirements outlined can be accepted as heavy vehicle routes by providing mitigation treatments, and/or imposing additional conditions, such as speed restrictions, curfews etc.

Should any aspect of a route clearly fail to conform to these guidelines in a manner which cannot be suitably addressed, resulting in a compromise of road safety, the route should be considered unsuitable for the heavy vehicles.

Route assessments should be undertaken (or as a minimum reviewed) by a person or team that has the experience and substantial knowledge of road design and road safety engineering principles and how these influence heavy vehicle performance and interaction with infrastructure and road users.

10.1 Assessing a Road in Sections

The road may be composed of a number of sections that vary in their standard and that would fall into different categories of heavy vehicle suitability or require different operating conditions (e.g. for low-volume roads). Width variation is a typical example of this principle. Where differing sections are reasonably long, it is beneficial to separately assess each section as to its category of heavy vehicle access and any applicable operating conditions. Assessors should only consider applying this method of assessment where there is a likely benefit and a practical start and finish point.

10.2 Consideration of Geometric Attributes

An attribute when assessed using the geometric assessment criteria in Section 10.4 to Section 10.15 may be identified to ‘pass’ or ‘fail’. Where a pass is not demonstrated, the implementation of mitigation measures may be considered. If an attribute does not pass the residual risk (including if a mitigation measure is provided) it will be captured in the risk assessment process (as described in Section 8.1).

Section 10.4 to Section 10.15 provide assessment criteria for geometric attributes. Only the attributes on a route require assessment. The attributes that may require assessment are summarised in Figure 10.1.

The geometric attributes to be considered for assessment and some key inputs to the assessment criteria are summarised in Figure 10.2 to Figure 10.4.

Figure 10.1: Geometric attributes to be considered for assessment

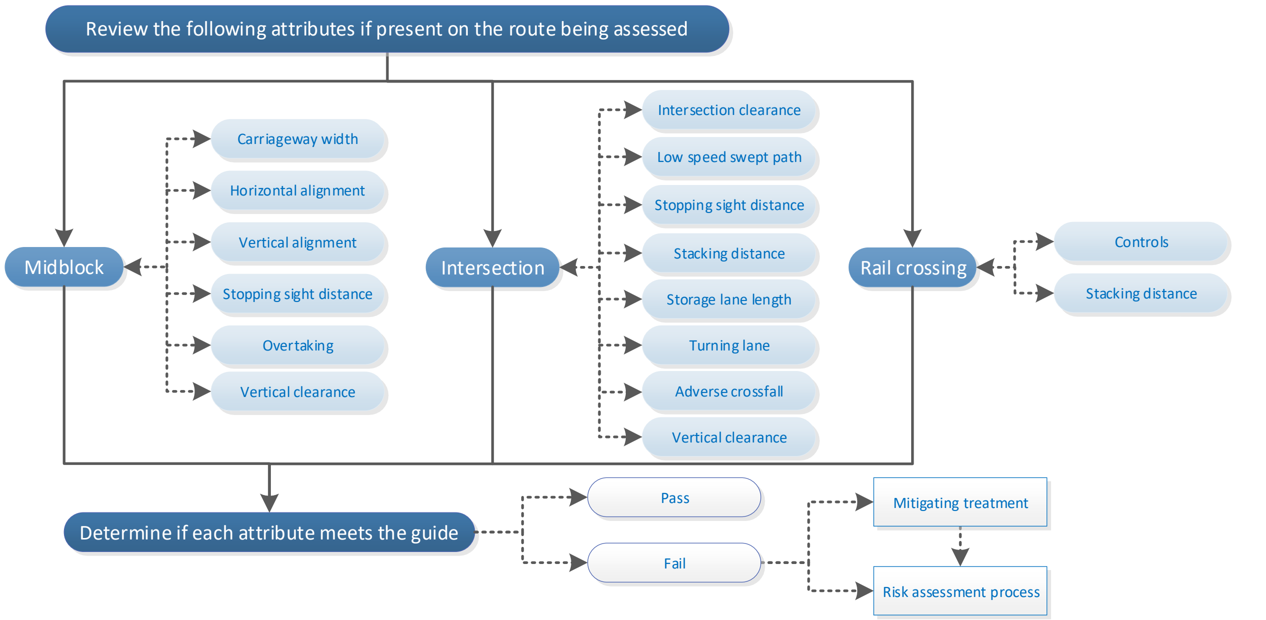


Figure 10.2: Midblock attributes to be considered for assessment

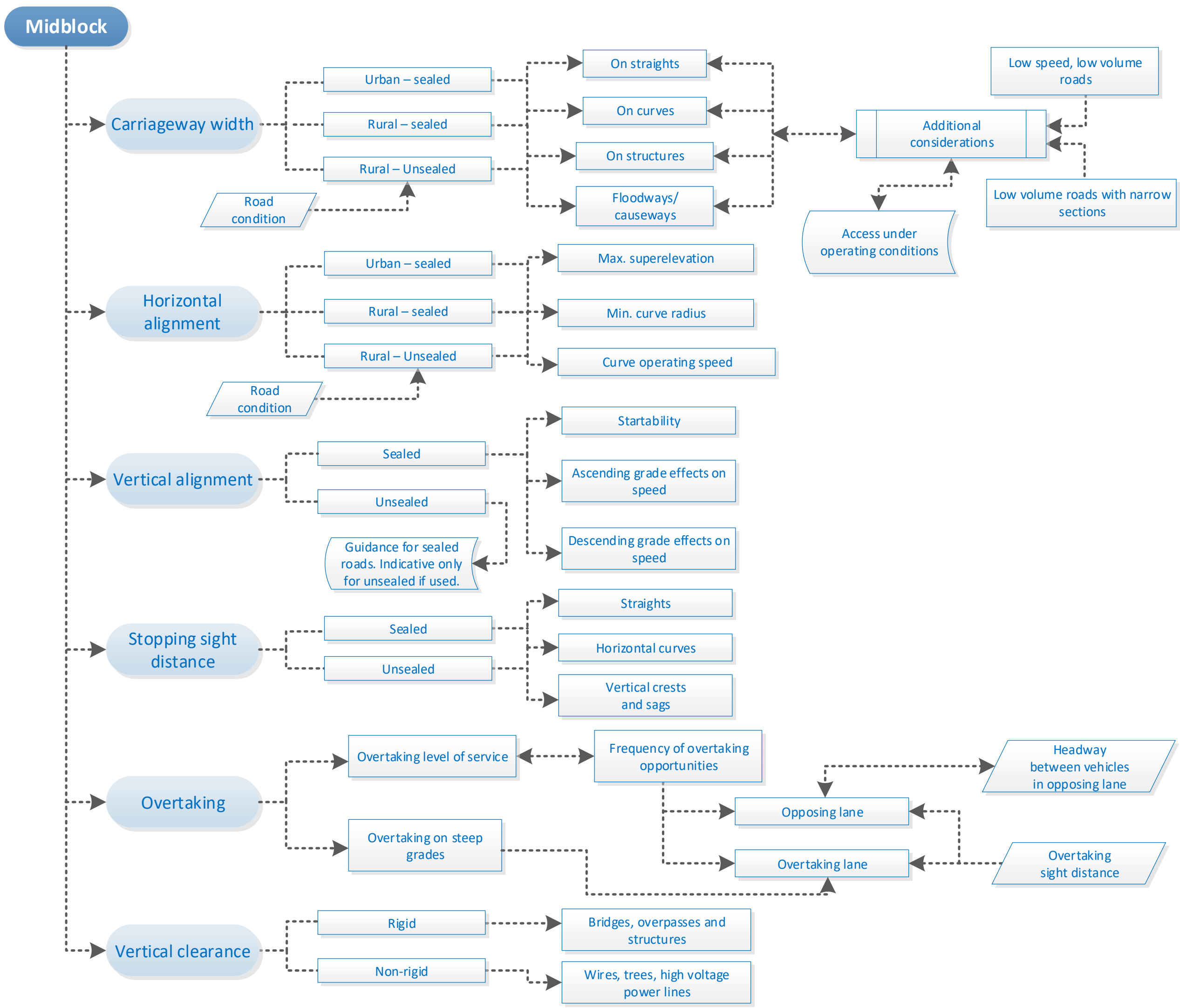


Figure 10.3: Intersection attributes to be considered for assessment

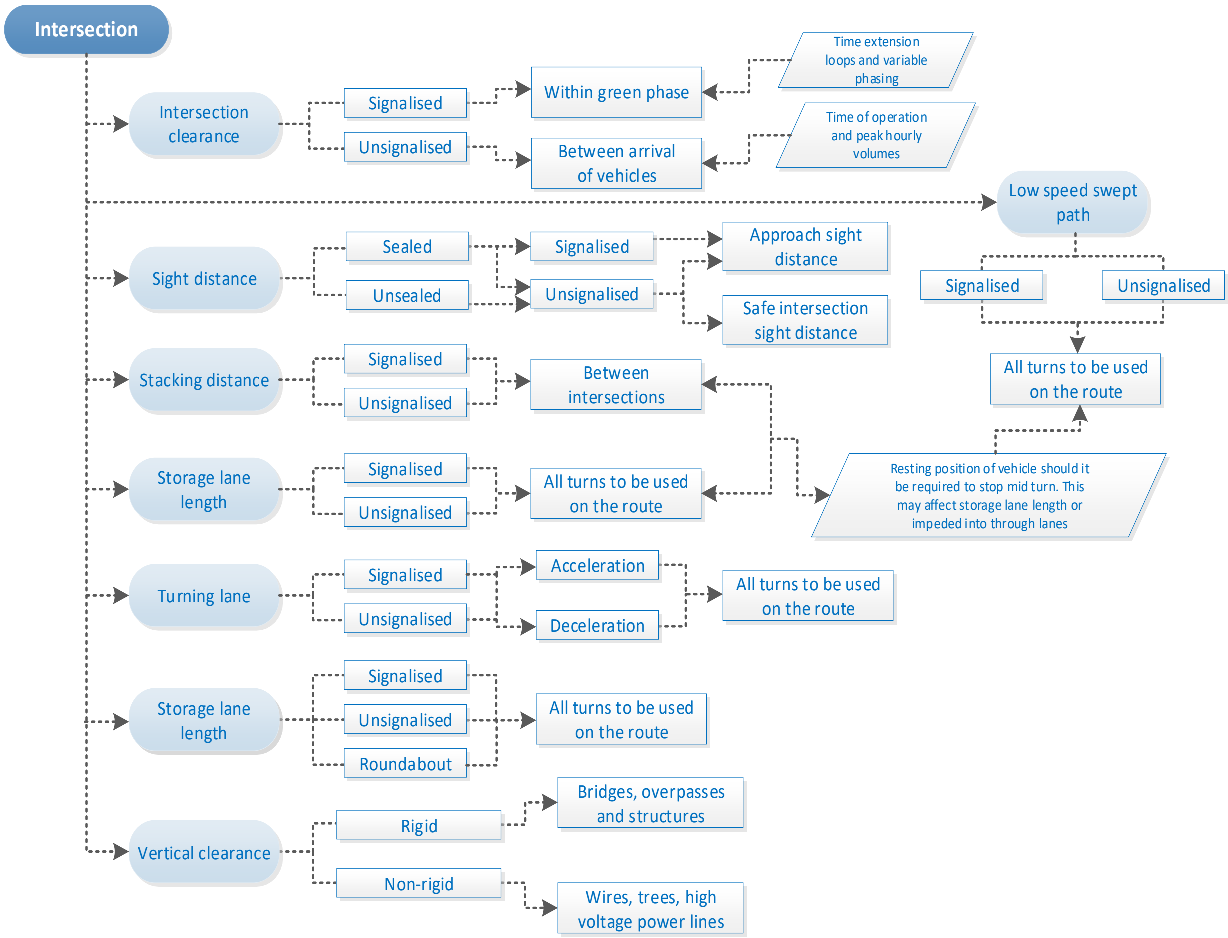
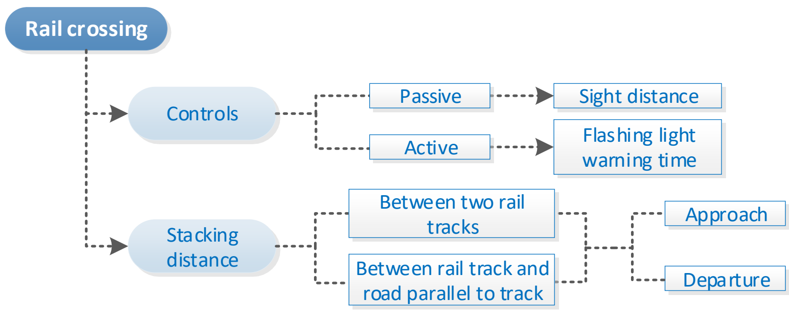


Figure 10.4: Rail crossing attributes to be considered for assessment



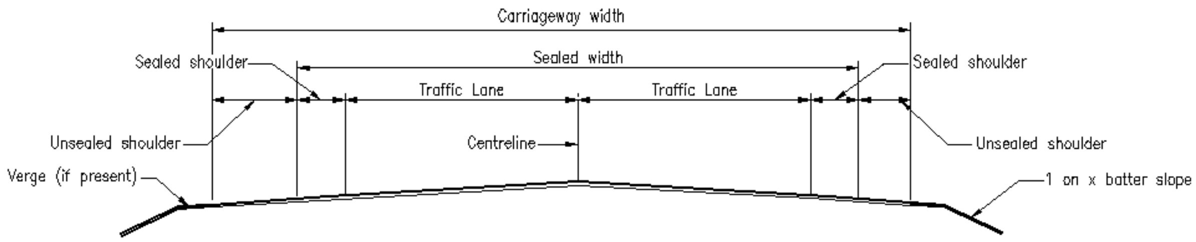
10.3 Posted speeds and operating speeds

Speed (km/h) is referenced throughout Section 10. This is typically referencing the posted speed limit or the prevailing speed limit. If the operating speed for a section of road (e.g. curvilinear alignments) has been determined by on-site data collection or through an operating speed model the operating speeds could be used.

10.4 Carriageway Widths on Straight Sections

The assessment of carriageway width (Figure 10.5) addresses operational road safety and infrastructure risks. The risks increase if sufficient width is not available for heavy vehicles. Haldane (2002) noted that heavy vehicles that require more lane width than is available risk crossing either the centre or edge line of the road. Crossing the centreline presents a considerable safety risk as it could lead to head-on or sideswipe crashes. Crossing the edge line can have various impacts ranging from damage to the edge of the pavement seal, to the initiation of a rollover, if tyres on one side of one trailing unit leave the sealed surface.

Figure 10.5: Example of carriageway width: undivided road



The ability of the trailers of a multi-unit heavy vehicle combination to remain within the path tracked by the prime mover is referred to as the vehicle's tracking ability on a straight path (TASP). As shown in Table 10.1, the tracking ability of a vehicle (including all trailers) depends on many road, environment, and driver-related factors (NHVR 2007).

The risks associated with insufficient lane and carriageway widths differ with the road environment (i.e. urban or rural) or a feature on the road (e.g. bridge, culvert or curve); the preferred road widths are outlined in Section 10.4.3 to Section 10.7.

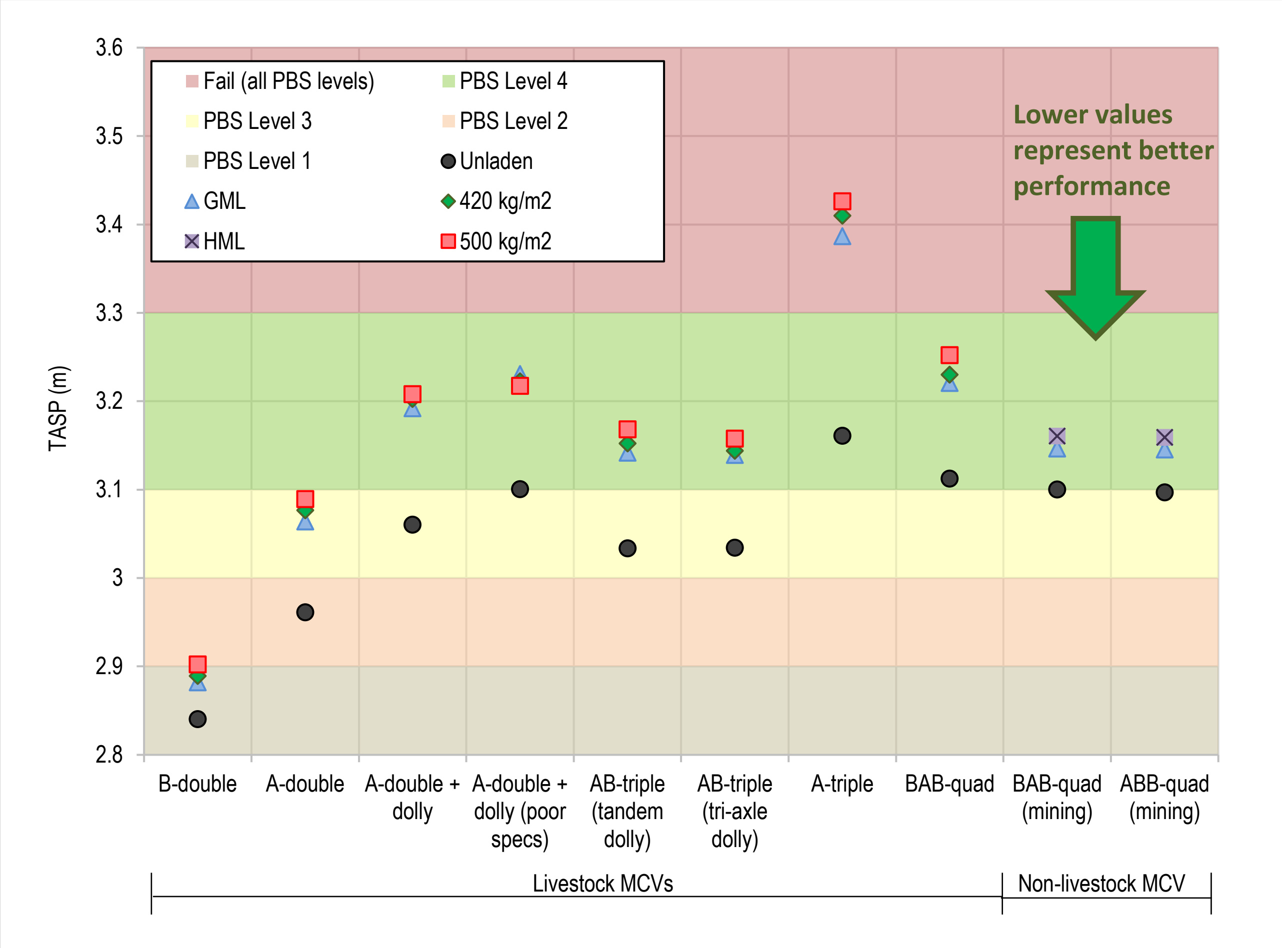
The carriageway width criteria are inclusive of the lane and shoulder width. However, the consideration of what is included within the assessed carriageway width varies depending on whether the section of road being assessed is identified as urban or rural.

Table 10.1: Predominant factors influencing TASP

Heavy vehicle configuration	Road design and condition	Driver behaviour
▪ The number of trailers ▪ The vehicle's overall length ▪ The number of articulation points ▪ The type of coupling(s) between trailers ▪ Suspension characteristics ▪ Tyre characteristics ▪ Load type and centre of gravity	▪ Road roughness (IRI) ▪ Crossfall on straights or superelevation on curves ▪ Sideloading from wind gusts	▪ Vehicle speed ▪ The degree of steering input and path correction by the driver

TASP is adversely affected by the factors in Table 10.1 on some non-PBS heavy vehicles. For example (Figure 10.6), the A-triple carrying livestock has a greater TASP than the AB-triple carrying livestock due to the A-type couplings. Whereas the BAB-quad carrying livestock has a greater TASP than the BAB-quad carrying mining product, this is due to the high centre of gravity (COG) of the livestock combination. An assessor should be aware of the TASP of a vehicle and if it can be contained within the lane widths provided. A PBS vehicle will have a TASP no greater than 2.9 m (Level 1), 3.0 m (Level 2), 3.1 m (Level 3) and 3.3 m (Level 4).

Figure 10.6: Examples of the TASP (m) of multi-combination vehicles against the TASP (m) range for each PBS level



Note:

These simulations were conducted using a road with an International Roughness Index (IRI) of 4.1 and cross-slope of 4.5% at a travel speed of 90 km/h.

Source: Milling et al. (2017).

10.4.1 Road Condition

The International Roughness Index (IRI) of a road will affect the TASP of a heavy vehicle. The TASP width requirements in the PBS were based on a road profile with an IRI of 4.1. This road profile was selected for use in the PBS as it is representative of a typical rough road that would provide enough lateral movement to quantify the differences in performance between vehicles. It is important to understand that, for example, if a Level 2B 30 m B-double would achieve a result of 3.0 m lateral movement on this TASP road when travelling at 80 km/h, then it has satisfied the requirement to gain access to the Level 2 network and the result is not an indication of the maximum roughness permitted for this or any PBS vehicle. A road with an IRI greater than 4.1 (105 NAASRA count) is likely to result in a higher lateral displacement while tracking in a straight path, and conversely, the lateral displacement of the vehicle will be less on a smoother road. Consideration should be given to the condition of the road, both IRI, profile and crossfall, as well as the expected changes in condition due to deterioration should heavy vehicles be granted access and what effects this will have on TASP performance and how this relates to the widths discussed in Section 10.4.3 to Section 10.7.

On lower-volume rural roads (less than 150 VPD or AADT) if the road width criteria are met, but isolated sections of rough surfaces are present, signage as shown in Figure 10.7 could be provided.

IRIs on an unsealed road is expected to be greater than 4.1, however, the traffic volumes and speeds are typically lower. The risks associated with greater heavy vehicle TASP widths and providing access should be considered in association with the reduced width guidance in Section 10.4.4.

As a rough surface can increase the lateral movement of an articulated vehicle the minimum length of a section with a rough surface should be as per the minimum length and sight distance criteria in Table 10.7.

Figure 10.7: Examples of warning signage for sections with a rough surface or a rough surface and reduced sight lines

Warning signage on immediate approaches [1]	Special warning signage in advance of the approach [2]
 TC1391	 TC1798

Notes:
1 Installed as per AS 1742.2 (2009), maximum distances for Dimension A and B are recommended.
2 Installed at a distance that allows the relevant heavy vehicle or passenger vehicle to reduce to the appropriate speed before the hazard.

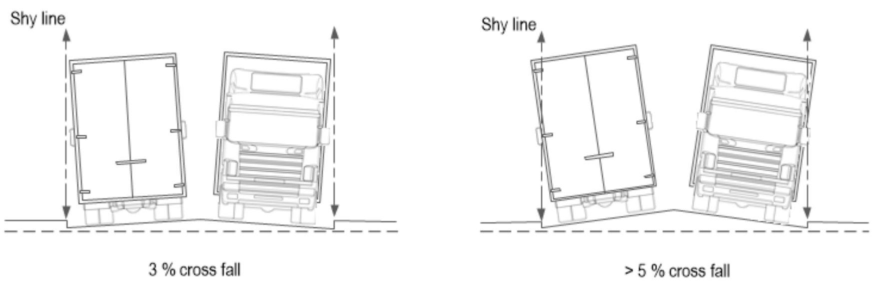
Source: TMR TC signage.

10.4.2 Turn Lane and Kerbside Lane Widths

Sufficient width should be provided to prevent the vehicle from striking a roadside object behind the shy line.

The crossfall of the lane, shoulder or intersection may result in the side mirrors or top half of the prime mover or trailing units to cross the shy line (Figure 10.8). Sufficient width should be provided between a vehicle in the through lane and an object on the shoulder or median (e.g. signals, power poles, signs and buildings).

Figure 10.8: Crossfall and heavy vehicles encroaching the shoulder or footpath



Note:

Drawing not to scale, for illustration purposes only.

When roadside objects are present, the widths as per Table 10.2 should be provided as a minimum. Note that these widths are independent of AADT or speed and are intended to prevent a vehicle striking a roadside object that is close to the shy line. This may result in the required width being greater than what would be identified in Section 10.4.

Table 10.2: Minimum width between vehicle and roadside objects

Crossfall	Minimum width between centreline and object (m)	
	Through lane	Turn lane
-3 to -4 %	3.7	3.5
-5 to -6 %	3.8	3.6
-7 to -8 %	3.9	3.7

Notes:
- Crossfall is negative, i.e. resulting in the vehicle leaning towards an object on the shoulder or median.
- Caters for vehicles up to 4.6 m in height.

10.4.3 Urban Roads

Urban environments include some crash risks which are typically not expected on rural roads. These include crash risk with parked/parking vehicles, cyclists and pedestrians. Urban roads require an assessment of width on both kerbside and non-kerbside lanes, including consideration of the shoulder function.

In urban areas, it is preferable for at least two continuous through lanes to be available in the direction of travel, though some short sections of single through lane may be acceptable. The through lane furthest from the passenger-side shoulder provides travel with less interaction with parked vehicles, cyclists or stationary turning queues.

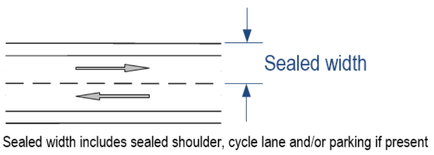
The urban width criteria may also be applicable to townships or remote industrial areas with roadside land-use activities where roadside parking may occur due to accessing a business, schools or community buildings (sports grounds, parks, forestry trails, pools etc.).

Table 10.3 presents the preferred minimum sealed widths in urban areas.

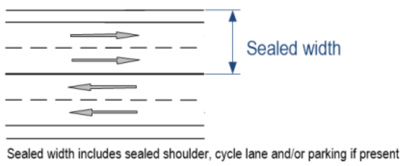
Table 10.3: Urban carriageways: minimum road widths

	60 – 70 km/h			80-100 km/h		
	B-double / PBS level 2	Type 1 RT / PBS level 3	Type 2 RT / PBS level 4	B-double / PBS level 2	Type 1 RT / PBS level 3	Type 2 RT / PBS level 4
Undivided carriageway						
One lane (2 Way)**	Required width between sealed edge and road centre for each direction of travel (m)					
Basic	3.2	3.3	3.6	3.5	3.7	4.1
with marked separation line	3.5	3.6	3.9	3.8	4.0	4.4
with dedicated cycle lane	4.7	4.8	5.1	5.5	5.7	6.1
with parallel parking	5.7	5.8	6.1	N/A	N/A	N/A
with angle (45º) parking	9.2	9.3	9.6	N/A	N/A	N/A
Two lane (2 way)	Required width between sealed edge and road centre for each direction of travel (m)					
Basic	6.6	6.7	7.0	7.0	7.1	7.5
with dedicated cycle lane	8.1	8.2	8.5	9.0	9.1	9.5
with parallel parking	9.1	9.2	9.5	N/A	N/A	N/A
Divided carriageway						
One lane (1 way)	Required width between sealed edge and edge of median or traffic island for each direction of travel (m)					
Basic	3.5	3.6	3.9	3.8	4.0	4.4
with dedicated cycle lane	5.0	5.1	5.4	5.8	6.0	6.4
with parallel parking	6.0	6.1	6.4	N/A	N/A	N/A
with angle (45º) parking	9.5	9.6	9.9	N/A	N/A	N/A
Two lanes (1 way)	Required width between sealed edge and edge of median or traffic island for each direction of travel (m)					
Basic	6.6	6.7	7.0	7.0	7.1	7.5
with dedicated cycle lane	8.1	8.2	8.5	9.0	9.1	9.5
with parallel parking	9.1	9.2	9.5	N/A	N/A	N/A
Three or more lanes (1 way)	Required width of additional through lane for each direction of travel (m)					
Basic	3.2	3.3	3.4	3.4	3.5	3.6
Carriageway descriptions						

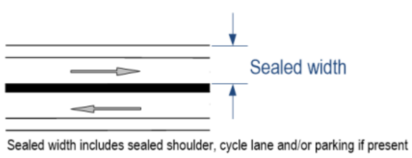
Undivided:
One lane
(2 way)



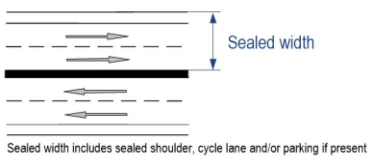
Undivided:
Two lane
(2 way)



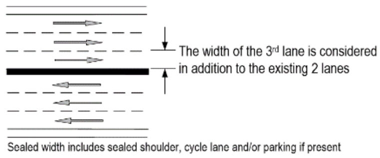
Divided: One lane (1 way)



Divided : Two lane (1 way)



Divided: Three or more lanes (1 way)



Note: If a centre line is not present. The width is the sealed width divided by the number of lanes.

Source: TMR (2013a).

10.4.4 Rural Roads

Table 10.4 presents the preferred minimum sealed and carriageway widths in rural areas; this includes carriageway widths over floodways. The minimum sealed and carriageway width should also be considered in conjunction with the roadside design, i.e. embankments and table drains, non-frangible hazards etc.

On medium to high-volume roads (AADT > 500), the AADT will usually be a suitable measure of traffic volume. On low to medium-traffic roads, (AADT 150 to 500), higher seasonal traffic volume may be a more appropriate measure of traffic volume.

Despite a road's width demonstrating that it meets the minimum width criteria, factors in addition to width should be considered. These factors may result in the application of additional heavy vehicle operating conditions, or in extreme cases, the road may not be suitable for heavy vehicle access. The factors to consider in conjunction with road width criteria are:

- reduced sight distances (Section 10.11)
  - 'blind' corners (curves)
  - crests
- crossfall and superelevation (Section 10.9)
- poor shoulder condition (edge drop, edge break, roughness, rutting, texture)
- poor road condition (roughness, rutting, texture)
- surface roughness (Section 10.4.1)
- vulnerable road users (cyclists, horse riders, motorcycles, pedestrians/school bus stops)
- presence of school buses stopping on the shoulder at property access.

The rural road width criteria do not specifically cater for the presence of vulnerable road users such as cyclists or motorcyclists; if these road users are present additional consideration as in the cycling guidance in the *Guide to road design part 3: geometric road design* (Austroads 2016a) and *Infrastructure treatments to reduce motorcycle casualties* (Austroads 2016c) should be considered.

Minor width deficiencies may be acceptable, particularly if it is only for a small portion of the road. If width requirements are relaxed, consideration should be given to other factors (as noted above and in Section 9.3.1) which may adversely affect the safe operation of a heavy vehicle on the section. Guidance for sections with deficient width is provided in the notes to Table 10.4.

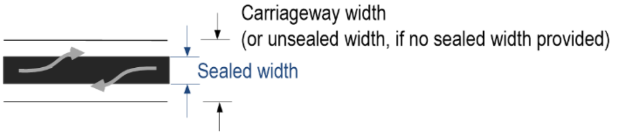
Minimum seal widths may also be reduced on roads where all other users are familiar with the operation of multi-combination vehicles, e.g. farm and mine access roads. These are typically low-volume roads or roads where the volumes are low and signage has been provided to identify the presence of heavy vehicles as discussed in Section 9.1.

The likely traffic composition of the proposed route should be considered. It may be appropriate to provide signage as in Section 9.1 to identify the operation of heavy vehicles on the route.

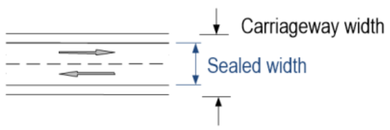
Table 10.4: Rural carriageway: single lane and one lane (2 way) road widths

	60 – 70 km/h			80-100 km/h		
	B-double / PBS level 2	**Type 1 RT / PBS level 3**	**Type 2 RT / PBS level 4**	**B-double / PBS level 2**	**Type 1 RT / PBS level 3**	**Type 2 RT / PBS level 4**
Undivided carriageway: Single lane (roadside conditions apply [3])						
0 – 150 AADT or VPD						
Sealed width (m)[1]	3.3	3.4	3.8	3.4	3.5	3.9
Carriageway width (m)[2]	7.6	7.7	8.2	7.9	8.0	8.6
Undivided carriageway: One lane (2 way) (roadside conditions apply [4])						
150 – 500 AADT or VPD						
Sealed width (m)[1]	5.6	5.7	6.1	5.9	6.0	6.4
Carriageway width (m)[2]	7.6	7.7	8.2	7.9	8.0	8.6
500 – 1000 AADT						
Sealed width (m)[1]	6.1	6.2	6.6	6.4	6.5	6.9
Carriageway width (m)[2]	7.9	8	8.6	8.2	8.3	9.0
More than 1000 AADT						
Sealed width (m)[1]	6.8	6.9	7.6	7.1	7.2	8
Carriageway width (m)[2]	9.6	9.7	10.6	9.9	10.0	11.0

Undivided carriageway single lane



One lane (2 way)



Notes:
1 Sealed width should be provided if the AADT is > 150 and annual freight tonnage > 300 000 tonnes per annum. In the absence of AADT and load data, a sealed width should be provided if:
   - uniform annual loaded heavy vehicle traffic volume is more than 10 vehicles per day; or
   - loaded heavy vehicle traffic volume is more than 60 vehicles per day over a seasonal two-month period.
2 Carriageway width can be used to assess unsealed roads.
3 If the carriageway width of an undivided carriageway single lane is < 10 m, the embankment or table drain should be 1:6 or flatter, this will allow smaller vehicles to move clear of an oncoming heavy vehicle that stays on the seal:
   - If the sealed width is less than 5.5 m then signage to identify heavy vehicles are operating on the route should be provided.
   - Some short sections are acceptable where sight distance in both directions (between opposing vehicles) is > 250 m and the sight distance allows the smaller vehicle to stop at a section with adequate width and the embankment or table drains are 1:6 or flatter.

Source: MRWA (2017).

10.4.5 Rural Roads – Low Volume (< 75 VPD or AADT < 75), Low Speed (< 60 km/h)

Table 10.5 presents the preferred minimum carriageway widths for low-volume, low-speed rural roads based on stopping sight distance (SSD). The table also provides criteria for embankments and table drains.

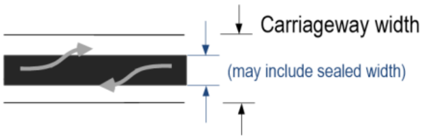
For low-volume roads, where AADT is < 75, but may have higher seasonal variations, obtaining the best estimate of higher daily volumes (VPD) during seasonal activities is recommended. Table 10.5 only applies if AADT or any higher seasonal traffic volumes (VPD) are less than 75, otherwise, Table 10.4 must be used.

The likely traffic composition of the proposed route should be considered. It may be appropriate to provide signage as in Section 9.1 to identify the operation of heavy vehicles on the route. Consideration should also be given to the notes to Table 10.5 as operating conditions as in Section 10.5 may be applicable.

Table 10.5: Rural low-volume (< 75 VPD or AADT < 75), low-speed roads: single carriageway 2-way road widths

	40 km/h			60 km/h		
	B-double / PBS level 2	**Type 1 RT / PBS level 3**	**Type 2 RT / PBS level 4**	**B-double / PBS level 2**	**Type 1 RT / PBS level 3**	**Type 2 RT / PBS level 4**
Local access road 0 – 75 AADT or VPD [1, 2, 3]: 2-way heavy vehicle traffic, roadside conditions apply [6, 7]						
Carriageway width (m) with SSD > 250 m	5.8		5.9	6.1[1]		6.3[1]
Carriageway width (m) with SSD < 250 m	6.1		6.2	6.4[1]		6.6[1]
Formed track 0 – 75 AADT or VPD [1, 4]: 1-way heavy vehicle traffic only restrictions apply [5], roadside conditions apply [6, 7]						
Carriageway width (m) with SSD < 250 m	3.5		3.5			

Low volume single carriageway (2 way)



Notes:
1. AADT should consider traffic growth and include consideration of seasonal volumes. If seasonal volumes exceed 75 VPD or an AADT of 75 Table 10.4 is to be used
2. Operating conditions 1, 2, 3, 4, 5, 7 and 8 will apply automatically as a condition of permit (Section 10.5). These are not required if the widths meet the requirements in Table 10.4.
3. If a road is at least 1.0 m wider than these widths, an 80 km/h speed restriction should be considered. A speed restriction above 80 km/h should only be considered if the road is sealed as per 0–150 AADT or VPD criteria in Table 10.4, has good sight distance and presents no significant safety concern.
4. Operating conditions 1, 2, 3, 4, 5, 6, 7 and 8 will apply automatically as a condition of permit (Section 10.5). These are not required if the widths meet the 0–150 AADT criteria requirements in Table 10.4.
5. Formed tracks assessed with this width criteria are only suitable for one-way heavy vehicle traffic. However, the approval is dependent on the traffic volume and road length as shown in Table 10.6.
6. If the carriageway width of a low-volume single carriageway (2 way) road is < 10 m the embankment and table drains should be 1:6 (or flatter), this will allow smaller vehicles to move clear of an oncoming heavy vehicle that stays on the seal.
7. If the carriageway width of a low-volume single carriageway (2 way) road is < 7 m, where heavy vehicles may be required to move off the carriageway when giving way to oncoming heavy vehicles, the embankments and table drains should be 1:10 (or flatter) for at least the first 1.5 m to 2 m.

- Some short sections are acceptable where sight distance in both directions (between opposing vehicles) is > 250 m and the sight distance allows the smaller vehicle to stop at a section with adequate width and embankment or table drains are 1:6 (or flatter).
- All widths in the table are not suitable for truck and 2 x dog combinations (use the widths as per Table 10.4).
- Speed refers to the prevailing speed limit for the road. The operating speed could be used (based on operating speed model/simulation or historical speed data).

Source: MRWA (2017).

Table 10.6: Formed track maximum length based on traffic volume

Daily traffic volume	0 to 15 VPD	16 to 30 VPD	31 to 50 VPD	51 to 75 VPD
Max. road length	5.0 km	2.0 km	1.5 km	1.0 km

Note: These criteria are for one-way heavy vehicle traffic only. Two-way heavy vehicle traffic is not eligible to run on a formed track when using the widths as per 0–75 VPD or AADT criteria in Table 10.5.

10.4.6 Rural Roads – Narrow Sections with Lower Volumes (0 - 75 and 75 - 150 VPD or AADT)

On lower-volume rural roads (0 - 75 and 75 - 150 VPD or AADT) short sections can have reduced width if the criteria in Table 10.7 are met. Similar principles may logically be applied to higher-volume rural roads; however, the width deficiencies should be assessed on a case by case basis. Table 10.7 should be considered in parallel with the operating conditions as in Section 10.5.

Consideration should also be given to whether signage as in Section 9.1 and/or location-specific warning signage should be provided.

Table 10.7: Rural road (low volume) short lengths with reduced width criteria

Traffic volume	Road type and width requirement reference	Width requirements [2,3]	Road section length criteria			
			Maximum length of narrow section [4]	Concurrent sections of narrow length	Sight distance on each approach and departure to the narrow section [5]	Combined length of sections [6]
0–75 VPD or AADT[1]	Low-volume roads assessed according to Table 10.5.	Not less than 3.5 m	100 m	Two adjacent sections must not be within 150 m of each other.	150 m [7]	No more than 10% of the road length being assessed.
75–150 VPD or AADT	Medium-volume roads assessed according to Table 10.4.	Carriageway width not less than 1.3 m, or a sealed width not less than 0.2 m of the values in Table 10.4.	2 km		250 m [7]	No more than 15% of the road length being assessed.

Notes:
1 The criteria for 0–75 VPD only apply to roads that do not meet the criteria in Table 10.5. Operating conditions as in Section 10.5 apply.
2 If a single point does not meet the required minimum widths the route shall be considered unsuitable for heavy vehicle access.
3 For 0–75 VPD, if the minimum 3.5 m width criterion is met but one or more of the other criteria are not met the route shall be considered unsuitable for heavy vehicle access. However, the route may be suitable for one-way heavy vehicle traffic only, provided the operating conditions for a formed track in Table 10.5, the volume and length limits in Table 10.6 are met and the operating conditions as in Section 10.5 are applied.
4 For 0–75 VPD, the total length of narrow points within a 100 m section can be combined to provide one length.
5 Continuous and unbroken sight distance (Section 10.11) must be provided in advance, during and beyond the narrow section for each direction of travel.
6 For assessment purposes, a single narrow point or section will be classified to have a minimum length of 50 m.
7 Refer to Table 10.7 for examples of good, medium or poor sight line criteria.

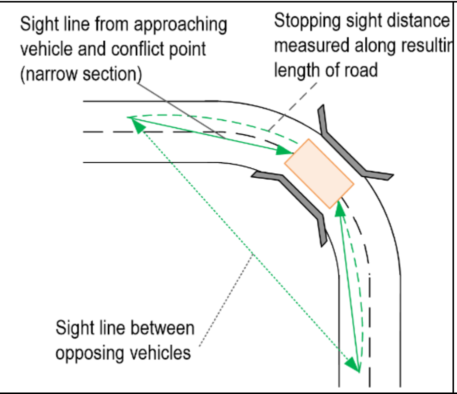
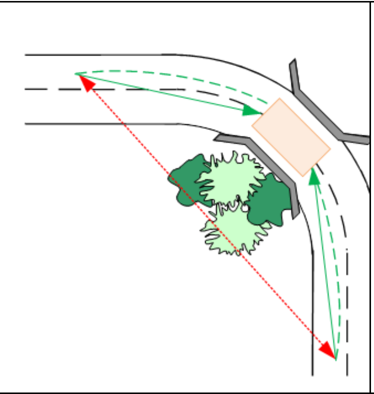
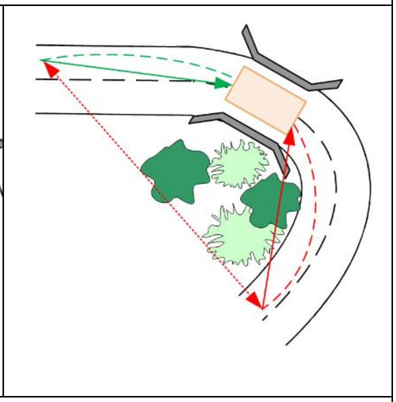
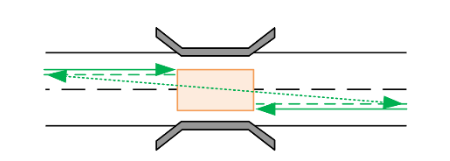
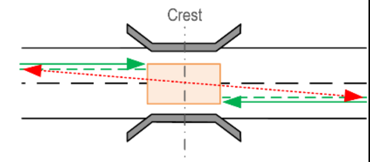
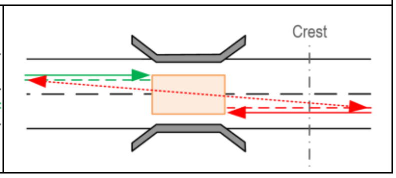
Source: Adapted from MRWA (2017).

The minimum sight distances on the approach and departure of a narrow section (as in Table 10.7) should be provided. These sight distances should be as in the 'good' criteria in Table 10.8. Where the good criteria cannot be met, signage is recommended to be provided if an assessor determines it will affectively mitigate the risk resulting from both width and sight distance deficiencies.

Examples of signage that could be used are provided in Figure 10.9. It should be recognised that providing signage is only a supplement to ensuring that sight lines are provided to achieve the required stopping sight distances.

Signage can also be provided for sections with a rough surface (refer to Section 10.4.1), or structures with reduced widths (refer to Section 10.7). The sight lines and sight distances available at these locations should also be considered as in Table 10.7 and Table 10.8.

Table 10.8: Narrow widths (small structure, lane or carriageway) and sightline criteria

Good	Medium	Poor
Horizontal sight line examples		
		
Vertical sight line examples		
		

Notes:

- These diagrams depict a narrow small structure; however, the principles also apply to floodways or narrow carriageway sections.
- Green indicates the sight line/stopping sight distance is achieved, Red indicates it is not.
- In addition to achieving SSD the presence of the structure and any carriageway narrowing must be clearly signed.
- Where SSD is not achieved, the presence of the structure and any carriageway narrowing must be clearly signed on the approach and at the structure/carriageway narrowing.

Source: Based on guidance in NHVR (2007).

Figure 10.9: Examples of heavy vehicle warning signage for sections with narrow widths or narrow widths and reduced sight lines

Warning signage on immediate approaches [1]		Special warning signage in advance of the approach [2]	
TC1033 TC2058 W8-2 	TC1033 TC2058 W8-2 	 TC1429	 TC9762*

Notes:

1 Installed as in AS 1742.2 (2009), maximum distances for Dimension A and B are recommended.

2 Installed at a distance that allows the relevant heavy vehicle or passenger vehicle to reduce to appropriate speed before the hazard.

* Sign to be modified to suit section.

Source: TMR TC signage.

10.5 Operating Conditions for Low-volume (< 75 VPD or AADT < 75) Roads with Reduced Width

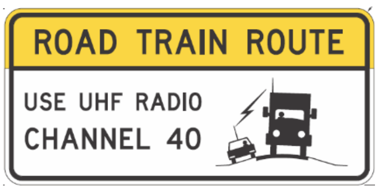
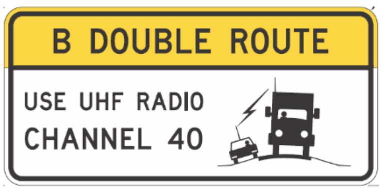
MRWA (2017) provides guidance for operating conditions for low-volume roads. It is provided as a basis for operating conditions for low-volume roads; however, these can be modified by a road owner when suitable.

Where a road does not meet the minimum requirements as in Section 10.4.4 but the road has very low volumes (< 75 VPD or AADT < 75) and low speeds (< 60 km/h) and also meets the conditions for narrower sections on low-volume rural roads (Section 10.4.5), access under operating conditions may be considered. Where the assessor feels a risk is present and could be mitigated through one or more of the following operating conditions, these and other conditions may be applied:

1. When travelling at night, the heavy vehicle must travel at a maximum speed of 40 km/h and display an amber flashing warning light in the prime mover.
2. No operation is to be permitted on an unsealed road segment when visibly wet, without the road owner's approval.
3. Headlights must be switched on at all times.
4. Speed restrictions of 40 km/h or 60 km/h as in Table 10.5 apply.
5. Direct radio contact must be maintained with other heavy vehicles to establish their position on or near the road (suggested UHF Ch. 40), and signage as in Figure 10.10 is to be installed.
6. For a single-lane road, the road must not be entered until the driver has established via radio contact that there is no other heavy vehicle on the road travelling in the oncoming direction.
7. Operation is not permitted while a school bus is operating on the road. Operators must contact the relevant schools and obtain school bus timetables; where direct contact can be made with the school bus driver, operation is permitted once the driver confirms all school drop-offs/pick-ups have been completed on the road.

Current written approval from the road owner, endorsing the use of the road, must be obtained, carried in the vehicle and produced upon request.

Figure 10.10: Examples of heavy vehicle warning signage for intersections with reduced sight distance/unexpected heavy vehicle movements

Warning signage on immediate approaches [1]	
	
TC1654-1	TC1654-2

Source: TMR TC signage.

Refer to Appendix B for further examples and templates for Access Conditions.

10.6 Lane Widths on Curved Sections

Heavy vehicles require wider lanes on horizontal curves to cater for the tracking of trailing units through a curve. The lane width recommended on a curve is the total of the required lane width on a straight (Section 10.4) and the additional width per lane in Table 10.9. An example is as follows:

B-double access on a sealed rural road, AADT 150-500, operating speed 60- 70 km/h:		
Sealed width on a straight (Section 10.4) = 5.6 m (2.8 m sealed lane width, this can include the sealed shoulder)	Additional sealed lane width for a 70 m radius curve (Table 10.9) = 1.31 m	Total lane width on curve = 2.8 m + 1.31 m = 4.11m

As the width on a straight is based on traffic volume and speed this method to determine the total width required on a curve will result in varying clearances to the shoulder and centreline. As such the resulting total lane width on curves is regarded as an absolute minimum requirement.

If the total width on a curve cannot be achieved the available sightlines between vehicles approaching the curve (Table 10.8), condition and usability of the shoulder, batter slopes on the shoulder and presence of roadside hazards should be considered. The risk assessment process (Section 8) can be used to evaluate these considerations and assist in determining if access should be granted on a section of road where the lane width on a curve does not meet the total width requirements on curve sections.

Table 10.9: Curve widening per lane in metres

Curve radius (m)	B-doubles and PBS Level 2 vehicle	Type 1 road trains and PBS Level 3 vehicles	Type 2 road trains and PBS Level 4 vehicles
30		Use of Austroads turning templates or software such as TMR's VPath is recommended.	
40			
50			
60			
70	1.31		
80	1.16	1.62	
90	1.03	1.44	
100	0.90	1.26	1.80
120	0.80	1.13	1.61
140	0.71	1.00	1.43
160	0.62	0.87	1.25
180	0.53	0.74	1.07
200	0.45	0.62	0.89
250	0.37	0.51	0.74
300	0.30	0.41	0.59
350	0.26	0.35	0.51
400	0.22	0.30	0.44
450	No curve widening required	0.27	0.39
500		0.25	0.35
600		0.21	0.30
700			0.25
800			0.22

Notes:
* Sealed width can include sealed shoulders.

- Curve widening for a given carriageway will be the widening width per lane, multiplied by the number of lanes. This value is rounded to the nearest 0.25 m.
- Curve widening is not required if the calculated curve widening value is less than 0.25 m per lane or the total for multiple lane roads is less than 1.0 m.
- Stopping sight distance should be maintained at all times, refer to Section 10.11.
- Consideration should be given to the presence of cyclists; additional width for a cycling lane outside of the lane/shoulder may be suitable.

Source: TMR (2013a).

10.7 Carriageway Width over Structures

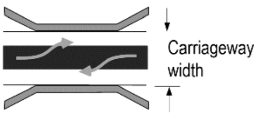
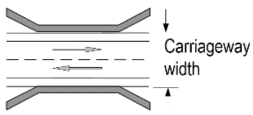
Structures such as bridges and culverts typically have the narrowest carriageway widths. To minimise the risk of collisions between vehicles and structures, it is desirable to have adequate width along all structures to provide sufficient lateral clearance between two opposing vehicles, as well as appropriate clearance to the structure or rails.

The minimum carriageway widths over structures are shown in Table 10.10 and Table 10.11.

Sight distance between vehicles approaching from either side of the structure and stopping sight distance (SSD) to the narrow section (over the structure) should be provided; this is crucial for lower-volume roads where the structure width criteria is less than the adjoining road width criteria.

Maintaining a sight line between approaching vehicles should reduce the approach speeds of each vehicle and maintaining SSD to the narrow section will allow an approaching vehicle to stop before the narrow section, should the opposing vehicle be encroaching into the opposing lane. Signage should be provided at the structure to identify a reduction in width; should sight distance to the structure be restricted, signage should also be placed on the approach. Refer to Section 10.11 for examples of sight line and SSD criteria and required distances.

Table 10.10: Undivided carriageway (2 way traffic): bridge and culvert widths

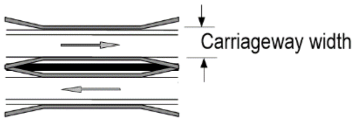
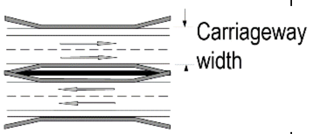
<table>
<tr><th rowspan="2"></th><th colspan="6">AADT</th></tr>
<tr><th>< 75</th><th>75 to 150</th><th>150 to 500</th><th>500 to 1,000</th><th>1,000 to 2,000</th><th>> 2,000</th></tr>
<tr><td colspan="7">Undivided Single lane + unsealed shoulders (shared bi-directional)</td></tr>
<tr><td>Any length (Adequate SSD and signage[1, 2])</td><td>3.5[3]</td><td>5.3</td><td>5.8</td><td>7.2</td><td colspan="2" rowspan="2">Not applicable AADT expected to be < 1,000</td></tr>
<tr><td>Any length (Inadequate SSD and signage [3])</td><td>7.0</td><td>7.0</td><td>7.2</td><td>-</td></tr>
<tr><td colspan="7">Undivided One lane (2 Way)</td></tr>
<tr><td>Any length (Adequate SSD and signage [2])</td><td colspan="3">5.8</td><td>7.2</td><td colspan="2" rowspan="2">Dependent on structure length see below</td></tr>
<tr><td>Any length (Inadequate SSD and signage [3])</td><td colspan="4">7.2</td></tr>
<tr><td colspan="5">Length < 20 m (Adequate SSD and signage [2])</td><td>9.5</td><td>11.0</td></tr>
<tr><td colspan="5">Length > 20 m (Adequate SSD and signage [2])</td><td>8.5</td><td>9.0</td></tr>
<tr><td colspan="7">Carriageway descriptions</td></tr>
<tr><td colspan="3">Undivided
Single lane + unsealed
shoulders (shared bi-directional)

</td><td colspan="4">Undivided
One lane (2 Way)

</td></tr>
</table>

Notes:
1 Section 10.5 operating conditions will apply as a condition of permit. This may be dismissed if the road widths meet the criteria in Table 10.4.
2 In addition to achieving SSD the presence of the structure and any carriageway narrowing must be clearly signed.
3 Where SSD is not achieved, the presence of the structure and any carriageway narrowing must be clearly signed on the approach and at the structure/carriageway narrowing.

- Required sealed width (m) is between the sealed edges/kerbs on the structure.
- The width of the carriageway on the approach and over the structure should be sealed with line-marking and delineation provided.
- The approaches to a structure should be smooth, i.e. not have depressions or rises between the road and structure that will affect the tail swing of a heavy vehicle.
- If a structure is part of a cycling route, adequate sight distance and lane widths as per urban width requirements must be provided.
- If a structure is in a built-up area, lane widths as per urban width requirements must be provided.
- AADT should consider traffic growth and seasonal volumes.

Source: MRWA (2017) for AADT < 1,000 and TMR (2013a) for AADT > 1,000

Table 10.11: Divided carriageway (1 way traffic): bridge and culvert widths

	AADT					
	< 75	75 to 150	150 to 500	500 to 1,000	1,000 to 2,000	> 2,000
Divided or single direction One lane (1 Way)						
Any length (Adequate SSD and signage [1])	4.2 (0.6,3.0,0.6) [2]	6.0 (2.0,3.0,1.0) [2]		6.25 (2.0,3.25,1.0) [2]		6.5 (2.0,3.5,1.0) [2]
Divided Two lanes (1 Way)						
Length < 20 m (Adequate SSD and signage [1])	Not applicable, AADT expected to be > 2,000					10.0 (2.0,7.0,1.0) [2]
Length > 20 m (Adequate SSD and signage [1])						9.0 (1.0,7.0,1.0) [2]
Carriageway description						
Divided One lane (1 way) (also suitable for one-way roads)				Divided Two lanes (1 Way)		

Notes:
1 In addition to achieving SSD, the presence of the structure and any carriageway narrowing must be clearly signed.
2 Indicates passenger shoulder, lane width and driver shoulder (m) respectively.
- Required sealed width (m) is between the sealed edges/kerbs on the structure.
- The width of the carriageway on the approach and over the structure should be sealed with line-marking and delineation provided.
- The approaches to a structure should be smooth, i.e. not have depressions or rises between the road and structure that will affect the tail swing of a heavy vehicle.
- If a structure is part of a cycling route, adequate sight distance and lane widths as per urban width requirements must be provided.
- If a structure is a built-up area, lane widths as per urban width requirements must be provided.
  AADT should consider traffic growth and seasonal volumes.

Source: MRWA (2017) and TMR (2013a).

10.7.1 Narrow Width over Structures on Lower-volume Rural Roads (< 150 VPD or AADT)

Narrow widths over structures on lower-volume roads (< 150 VPD or AADT) are not as per the suggested widths a road manager may mitigate this with signage or operating conditions (Figure 10.11), consideration of the sight lines to the narrow structure should also be considered (refer to Table 10.8).

Figure 10.11: Examples of heavy vehicle warning signage for structures with narrow widths or narrow widths and reduced sight lines

Warning signage on immediate approaches [1]	Special warning signage in advance of the approach [2]			
TC1033 TC1346 W8-2 	 TC1494	 TC1862-2	 TC1862-1	 TC1874

Notes:
1 Installed as per AS 1742.2 (2009), maximum distances for Dimension A and B are recommended.
2 Installed at a distance that allows the relevant heavy vehicle or passenger vehicle to reduce to appropriate speed before the hazard.

Source: TMR TC signage.

10.8 Floodways and Causeways

Consideration of floodways and causeways is required to ensure that road safety and network operations are not compromised by routes that contain flood-prone sections.

When assessing a route that contains sections subject to flooding or is crossing floodways, the detours and alternative routes should be examined to determine whether they are suitable for the heavy vehicles in question. Consideration should be given to permanent flood traffic management schemes where available, and how they can accommodate such vehicles. Off-street parking areas, rest areas and lane closures can be used to address road closures due to flooding. In cases where alternative provisions cannot accommodate the heavy vehicles, a risk assessment should be conducted and used to guide the access decision.

Floodways and causeways should be assessed using the road width criteria as in Section 10.4.4 or Section 10.4.5.

10.9 Horizontal Alignment

Rollover stability is the most significant safety issue and arguably the most important performance measure for heavy vehicles because it has been strongly linked to rollover crashes. Crashes that involve heavy vehicle rollover are strongly associated with severe injury and fatalities (NHVR 2007).

Both crossfall and superelevation (on curves) are important considerations relating to the rollover risk posed to heavy vehicles. Crossfall on a straight section and superelevation on a curve causes a heavy vehicle to lean to the edge of the road on a straight or to the edge of the road or centre of the road on a curve (depending on the direction of travel). The lean resulting from crossfall or superelevation is likely to increase the heavy vehicle tracking ability on a straight path (Section 10.4), which is likely to require additional lane width to maintain safe distances to opposing vehicles and ensure a heavy vehicle stays within the sealed width.

10.9.1 Requirements to Assess Crossfall and Superelevation for PBS Vehicles

Due to the static rollover threshold (SRT) performance requirement in the PBS scheme (NHVR 2008) PBS vehicles are expected to demonstrate a rollover performance in most cases better than existing, as-of-right vehicles. The minimum SRT requirements for all PBS vehicles, regardless of length or mass, are the same (excluding buses and dangerous goods vehicles which have a higher standard to meet). This means that a PBS approved Level 4A vehicle (i.e. 53.5 m quad road train) will comply with the same minimum rollover threshold as a Level 1 rigid truck.

This means that when assessing a route for a PBS vehicle, superelevation may not be required to be assessed if the route:

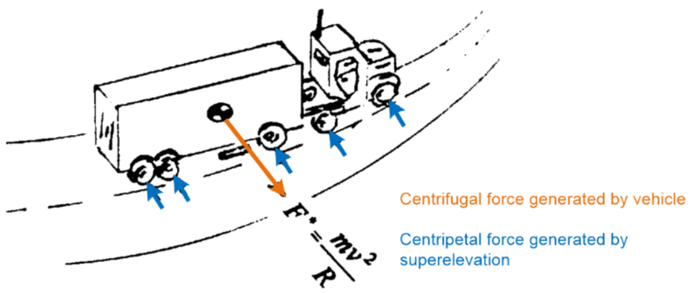
- has been previously assessed and is providing access for an equivalent non-PBS vehicle
- has been previously assessed and is providing access for a PBS vehicle (of any class, mass or length).

10.9.2 Curves and Superelevation

A heavy vehicle travelling through a curve generates a centrifugal force (Figure 10.12), acting laterally on the vehicle units. When travelling at low speeds or on curves with large radii, the effects of centrifugal force are low. However, when travelling at higher speeds and/or around curves with smaller radii, the centrifugal force increases. Excessive speeds generating high centrifugal forces may cause lateral movement of the turning prime mover and trailing units towards the outside of the curve and increase the risk of rollover as illustrated in Figure 10.13. If the static rollover threshold of the vehicle is exceeded, the vehicle will rollover. Superelevation provides a positive camber that counteracts the centrifugal forces, thus reducing the likelihood of a rollover.

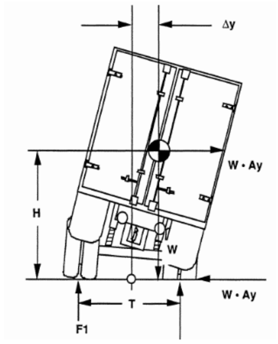
As heavy vehicles carry more mass and have a higher centre of gravity than passenger vehicles, the side friction demand threshold is much lower than that used in horizontal curve design for passenger cars. This results in curves with larger radii, higher superelevation values or lower operating speeds being required for heavy vehicles.

Figure 10.12: Lateral forces acting on a heavy vehicle on a curve



Source: Adapted from TNZ (2005).

Figure 10.13: Effect of lateral forces on heavy vehicle rollover risk on a curve



Source: NHTSA (1992).

10.9.3 Maximum values of superelevation

The maximum values of superelevation for heavy vehicles are provided in Table 10.12.

Table 10.12: Maximum values of superelevation for heavy vehicles

Road surface	Operating speed (km/h)	Rural roads		Urban roads
		Number of heavy vehicles		
		≥ 20 VPD	< 20 VPD	
Sealed	> 70	6%	6%	5%
	≤ 70	7%	10%*	
Unsealed**	> 70	6%	6%	
	≤ 70	4%	6%***	

Notes:
* Higher values (up to 10%) may be used in special cases such as rural roads in mountainous terrain or the reuse of existing pavement or kerb lines. To be used with caution, heavy vehicles with a high centre of gravity may be susceptible to becoming unstable when at low speeds on curves with high superelevation.
** A minimum of 4% superelevation on unsealed roads is recommended to maintain drainage (Giummarra 2009).
*** A maximum of 6% superelevation on unsealed roads is recommended as the greatest superelevation value; it should be recognised that a value > 4% (Giummarra 2009) may increase the risk of slow-moving heavy vehicles deviating into the inside of a curve (crossing into the opposing lane on right curves, and the shoulder on left curves).

Source: Adapted from TMR (2002), Giummarra (2009) and TMR (2016a).

10.9.4 Adverse Crossfall

Adverse crossfall (where superelevation is not provided on a curve) should be avoided where practicable on heavy vehicle routes. A curve with adverse crossfall should be reviewed in detail, particularly if the heavy vehicle has a high centre of gravity and/or the operating speed is greater than 70 km/h.

10.9.5 Assessing Horizontal Curve Suitability

The suitability of a curve for heavy vehicles can be undertaken with the recommended minimum curve radius. If the curve being assessed is:

- larger in radius than the relevant minimum curve radius for the posted speed limit or the expected approach speed to the curve, then this curve radius is considered suitable.
- smaller in radius than the relevant minimum curve radius for the posted speed limit or expected approach speed to the curve, then this curve radius is considered unsuitable and mitigation treatments should be considered or access restricted.

The minimum curve radius value is based on:

- Curve operating speed: this is the speed a heavy vehicle is expected to travel based on the alignment on the approach. Information regarding operating speeds and how to estimate heavy vehicle operating speeds can be found in Austroads (2016a); alternatively, if an existing road is being assessed and a similar class heavy vehicle is operating on the road a speed survey can be undertaken.
- Superelevation: this is the percentage crossfall of the road from the edgeline of the outside of the curve (high-side) to the edgeline on the inside (low-side) of the curve.
- Side friction factor: this is the friction value required to balance centripetal and centrifugal forces and maintain vehicle stability and reduce rollover risk.

The minimum curve radii values for various curve operating speeds and superelevation values that will result in suitable side friction factors to provide vehicle stability are as follows:

- Sealed roads (desirable): Table 10.13 provides the desirable minimum curve radii for sealed roads. These minimum curve values are based on road design principles to provide comfort and are not expected to be associated with poor safety performance.
- Sealed roads (absolute minimum): Table 10.14 provides the absolute minimum curve radii values for sealed roads. These values accept a side friction value that is closer to the rollover threshold, thus increasing the likelihood of a rollover or loss-of-control crash. If these values are used there should be a high level of confidence that curve operating speeds will not be exceeded. It is recommended that vehicle-specific analyses are undertaken for vehicles with a high centre of gravity (COG).
- Unsealed roads (road condition dependent): Table 10.15 provides the absolute minimum curve radii values for unsealed roads. These minimum curve values are considered indicative only and relevant for dry roads in good condition. Changes in surface profile (superelevation due to re-sheeting) need to be considered, as well as changes to the road surface condition (potholes, rutting, delamination, surface gravel) as these are likely to influence vehicle stability and/or the surface friction to provide a centripetal force (Figure 10.12).

Conversely to the rollover risk resulting from a vehicle’s centrifugal force towards the outside of a curve (Figure 10.12), combinations of superelevation > 4% on small radius curves with low curve operating speeds may result in an increased likelihood of a vehicle rollover to the inside of the circular path. The heavy vehicles most at risk are those with a high COG (e.g. double-deck livestock).

It is advised that broken-back, reverse and compound curves should be reviewed in detail, i.e. the approach speeds, superelevation development lengths, and the length of straights. Sight distance and lane width requirements should be provided on these curve types.

Worked examples of how to assess the curve radius for suitability and consider mitigation treatments are provided in Appendix F.

Table 10.13: Sealed road: desirable minimum curve radius (m)

Curve operating speed (km/h)	Minimum curve radius (m) for urban and rural roads			
	Superelevation			
	3%	4%	5%	6%
20	13	13	12	12
30	30	28	27	26
40	52	50	48	47
50	82	79	76	73
60	142	135	129	123
70	227	214	203	193
80	315	296	280	265
90	425	399	375	354
100	525	492	463	437
110	635	595	560	529

Notes:

- Minimum curve radii determined using minimum curve radius formula and desirable maximum side friction values for trucks (Austroads 2016a).
- Shaded orange: According to guidelines in TMR (2018a) heavy vehicles, particularly those with a high centre of gravity (COG), may be susceptible to becoming unstable when at low speeds on curves with superelevation > 4%. A high level of confidence that free-flow traffic will be maintained is required; this will allow a heavy vehicle to maintain the required operating speed through the curve. As absolute minimum values are already being used if a heavy vehicle with a high COG is expected to operate on a curve that is at or slightly greater than the absolute minimum curve radius, a vehicle-specific rollover assessment is advised.

Source: Adapted from Austroads (2016a).

Table 10.14: Sealed road: absolute minimum curve radius (m) (low operating speeds (≤ 70 km/h))

Curve operating speed (km/h)	Minimum curve radius (m)							
	Rural roads in mountainous terrain Urban roads			Rural roads in mountainous terrain Urban roads – interchange ramps only				
	Superelevation			Superelevation				
	3%	4%	5%	6%	7%	8%	9%	10%
20	*11*	*11*	*10*	*10*	*10*	*10*	*9*	*9*
30	*25*	*24*	*24*	*23*	*22*	*21*	*21*	*20*
40	*45*	*43*	*42*	*41*	*39*	*38*	*37*	*36*
50	*70*	*68*	*66*	*64*	*62*	*60*	*58*	*56*
60	*105*	*101*	*98*	94	91	89	86	83
70	*148*	*143*	*138*	133	129	124	121	117

Notes:

- Minimum curve radii determined using minimum curve radius formula and absolute maximum side friction values for trucks (Austroads 2016a).
- Shaded orange: As per Table 10.13.
- Shaded red: These minimum curve radii are the absolute minimum values; these minimum curve radii inherently increase the likelihood of a loss-of-control, run-off-road or rollover crash occurring. A high level of confidence in the operating speeds is required; curve warning signage and advisory speeds should be provided if the required curve operating speed is > 10 km/h less than the approach operating speed. Ideally the minimum curve radii as in Table 10.13 should be provided.

Source: Adapted from Austroads (2016a).

Table 10.15: Unsealed road: minimum curve radius (m)

Curve operating speed (km/h)	Minimum curve radius (m) for superelevation							
	3%	4%	5%	6%	7%	8%	9%	10%
20	21	20	*19*	*17*	*17*	*16*	*15*	*14*
30	47	44	*42*	*39*	*37*	*35*	*34*	*32*
40	84	79	*74*	*70*	*66*	*63*	*60*	*57*
50	131	123	*116*	*109*	*104*	*98*	*94*	*89*
60	202	189	177	167	157	149	142	135
70	297	276	257	241	227	214	203	193
80	388	360	336	315	296	280	265	252
90	531	491	456	425	399	375	354	-
100	656	606	562	525	-	-	-	-
110	866	794	733	681	-	-	-	-

Notes:
- Based on the minimum curve radius formula (Austroads 2016a) and truck side friction values for unsealed roads (TMR 2016a).
- These minimum curve values are considered as indicative only for dry roads in good condition. Changes in unsealed road surface condition (potholes, rutting, delamination, surface gravel) are likely to influence the vehicle stability and/or the resulting rate of side friction, thus larger curve radii may be required.
- Shaded orange: As per Table 10.13.

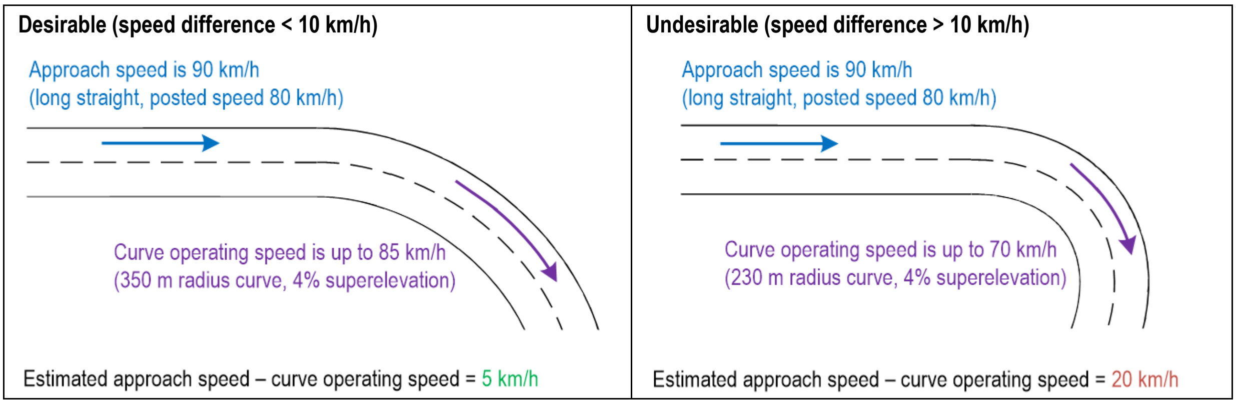
10.9.6 Horizontal Curve Perception Sight Distance and Operating Speed Reductions when Entering Curves

On high-speed roads a driver should have enough visibility into a curve from the approach (horizontal curve perception sight distance (Austroads 2016a)) to be able to clearly identify the curve direction and radius so as they can select appropriate curve operating speed (close to the curve operating speeds as per Section 10.9.5) and decelerate to that speed in a controlled manner.

In addition to horizontal curve perception sight distance, a driver should not be required to reduce their approach speed by more than 10 km/h when slowing to a speed that is safe to traverse the curve (curve operating speeds as per Section 10.9.5). An example demonstrating this is provided in Figure 10.14.

Where the reduction in speed is greater than 10 km/h and/or horizontal curve perception sight distance is not provided, the installation of curve warning signage and advisory speeds should be considered. The excel based Route Assessment Form will assist in identifying if a reduction of more than 10 km/h is likely to be required when entering a curve.

Figure 10.14: Reductions in operating speed to curve operating speed



Should a curve or section of curves be identified to present as a risk a formal onsite assessment should be carried out as per Clause 4.4.7.10 in TMR's supplement to AS1742.2 (TMR 2018b) and appropriate signage provided. Examples of advisory speed signs that could be provided to mitigate risk are provided in Table 10.16 and an example of the application of these signs to reduce approach speeds is provided in Figure 10.15.

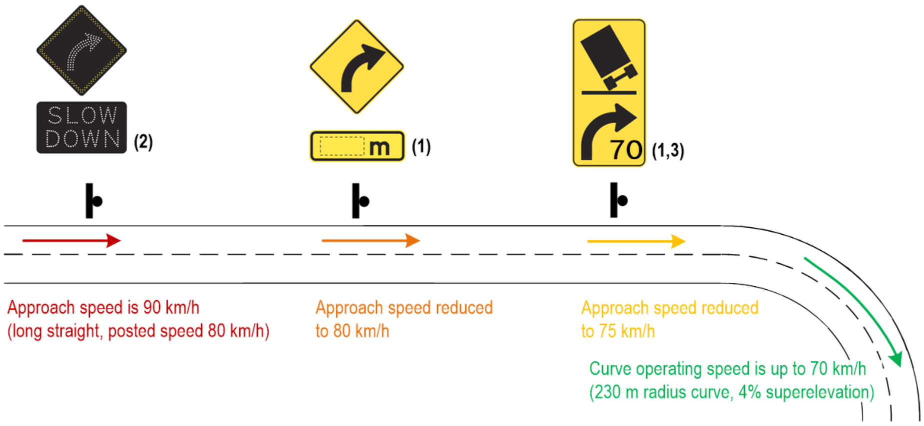
Table 10.16: Curve warning signage for curves which are substandard for heavy vehicles

Warning signage on immediate approaches [1,3]			
 Tilting Truck Curve warning (W1-8)	 Tilting Truck Turn warning (W1-8)	 Tilting Truck Hairpin warning (W1-8)	 TC1777 [(4)]
Special warning signage in advance of the approach [2]			
 TC1790 (vehicle activated LED sign)	 TC1790 (vehicle activated LED sign)	 TC1790 (vehicle activated LED sign)	

Notes:
1 Installed as per and AS 1742.2 (2009).
2 Installed at a distance that allows the relevant heavy vehicle or passenger vehicle to reduce to appropriate speed before the hazard.
3 Advisory speeds should not be provided on unsealed roads as changes in surface condition may reduce the safe curve operating speed to a speed lower than the advisory speed.
4 Curve tightens supplementary plate may be used for any curve type where the radius of the curve reduces (compound curve).

Source: TMR TC signs and TMR MUTCD Part 2

Figure 10.15: Reducing approach speed through curve warning signage



Estimated approach speed without signage treatment – curve operating speed = 90 – 70 = 20 km/h

Estimated approach speed with signage treatment – curve operating speed = 75 – 70 = 5 km/h

Notes:
- Examples use sealed road, desirable minimum curve radius (m) values.
- Examples estimate speed reductions which will depend on signage placement, driver alertness and vehicle braking performance.

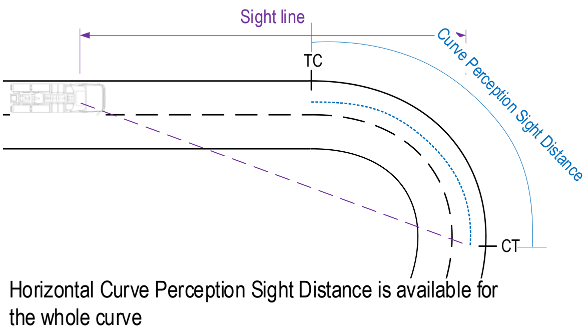
1 Recommended if sight line to the curve is restricted. Installed as per AS 1742.2 (2009), maximum distances for Dimension A and B are recommended.
2 Recommended if sight line to curve warning sign with distance plate and tilting truck curve warning (vehicle activated LED) sign is restricted. Installed at a distance that allows the relevant heavy vehicle or passenger vehicle to reduce to appropriate speed before the hazard.
3 Advisory speeds should not be provided on unsealed roads as changes in surface condition may reduce the safe curve operating speed to a speed lower than the advisory speed.

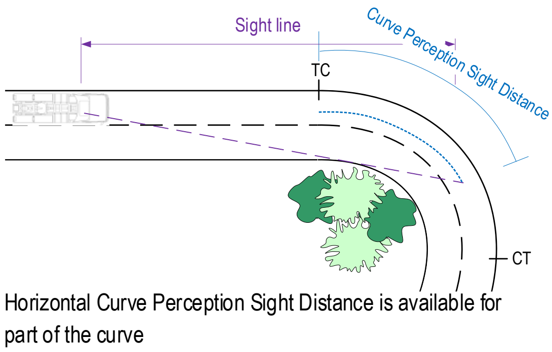
Source: Based on AS 1742.2 (2009) and TMR (2017b).

10.9.7 Determination of Horizontal Curve Perception Sight Distance and Approach Speeds

The horizontal curve perception sight distance is the length of the curve that is visible from the approach to the curve, some examples are provided in Figure 10.16. To determine if the available horizontal curve perception sight distance is suitable a number of criteria should be considered, refer to AGRD Part 3 for more detailed information.

Figure 10.16: Horizontal Curve Perception Sight Distance examples





10.10 Vertical Alignment

10.10.1 Maximum Grades

A route should not have grades that exceed those in Table 10.17. Where a maximum grade is exceeded, the length of the grade should be considered, a site trial or simulation should be considered.

Table 10.17: Grade limits for heavy vehicles

Vehicle	Sealed roads	Unsealed roads
B-doubles and PBS Level 2 vehicles	8%	5%
Type 1 road trains and PBS Level 3 vehicles	6%	4%
Type 2 road trains and PBS Level 4 vehicles	5%	3%

Source: MRWA (2017).

10.10.2 Ascending Grade Effects on Speed

The speed of heavy vehicles ascending long, steep grades can be reduced to the extent that the speed differential can present a hazard for approaching upstream vehicles. In some cases, the drivers of such vehicles may become frustrated and attempt unsafe overtaking manoeuvres. To mitigate this, steep ascending grades should have overtaking lanes where possible. A forced speed reduction to 40 km/h is considered the threshold point at which drivers will seek to overtake a slower vehicle, regardless of whether adequate sight distance is available.

The distances required for heavy vehicles on grades to slow to 40 km/h were previously investigated via simulation (TMR 2013a). The results of that investigation are applicable to current as-of-right combinations and PBS vehicles, as the power-to-weight ratios are similar, with the exception of quad-trailer road trains, which are expected to have low acceleration performance, particularly for combinations with gross masses above 120 tonnes. Table 10.18 shows the maximum distances of uphill travel before speeds are reduced to 40 km/h. Where no value is given, this indicates that the vehicle can maintain a speed higher than 40 km/h on that grade.

Table 10.18: Maximum distances (m) of uphill travel before speeds are reduced to 40 km/h

Grade (per cent)	B-doubles and PBS Level 2 vehicles		Type 1 road trains and PBS Level 3 vehicles		Type 2 road trains and PBS Level 4 vehicles	
	80 km/h approach speed	100 km/h approach speed	80 km/h approach speed	100 km/h approach speed	80 km/h approach speed	100 km/h approach speed
3	-	-	-	-	1,080	1,650
4	950	1,410	900	1,350	690	1,110
5	640	980	610	960	520	840
6	480	760	470	750	410	680
7	390	630	380	620	340	570
8	330	530	320	530	290	490

Source: TMR (2013a).

10.10.3 Descending Grade Effects on Braking

Long, steep downgrades can result in heavy vehicles losing control. Measures should be taken to prevent the occurrence and limit the consequences of runaway heavy vehicles. An out-of-control heavy vehicle may result from brakes overheating and a failure to change down gears at the appropriate time or mechanical failure.

It should be noted that longer and heavier vehicles that comprise more multi-axle groups will have a higher braking power-to-mass ratio. For example, when comparing a tri-axle group which carries less mass per axle than a tandem axle, it will have the same braking power as the tandem but less mass to stop and therefore be more effective at decelerating the vehicle and less likely to suffer from brakes overheating. In addition, all heavy-duty prime movers that are required to haul heavy vehicles will be equipped with auxiliary brakes (Austroads 2017c). An auxiliary brake provides controlled retardation that is separate from the service brakes, most commonly from the engine or exhaust and requires the transmission to be engaged, and therefore is less vulnerable to brake fade when used continuously (Austroads 2017c). The correct use of the auxiliary brake including the selection of an appropriate gear is critical to its effectiveness.

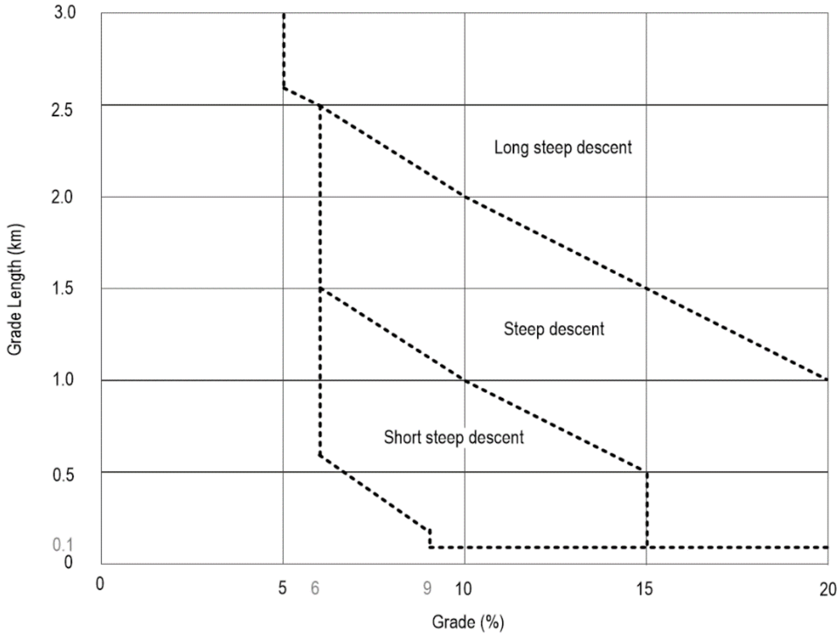
The following measures aimed at managing errant vehicles on steep descents should be provided:

- Appropriate signage as per AS 1742.2 (2009) to alert heavy vehicle drivers of a steep descent should be provided on the approach to the downgrade so that they can descend at a controlled speed. Figure 10.17 identifies the descent percentage and lengths that require signage treatments.
- Regulating the use of a low enough gear to control the descent speed of heavy vehicles should be implemented. Refer to Figure 10.17 to identify appropriate signage.
- Containment facilities for runaway vehicles should be provided. Table 10.19 outlines grades over continuous lengths that warrant an investigation (as in Austroads 2010a) to determine if a runaway vehicle is possible and containment facilities such as safety ramps or arrester beds should be provided.

When upgrading a road classification, consideration should be given to the fact that a larger runaway vehicle with more mass is likely to require more braking power to maintain a safe speed when descending a grade.

The length, depth and grade or material of an arrester bed should be evaluated to determine if it is still suitable.

Figure 10.17: Guide for signage treatment of steep descents



Note:

Refer to AS 1742.2 (2009) for signage schemes relevant to each descent type and safety ramps. Vehicle activated signs could also be included in the signage (refer to TMR TC1790 sign).

Source: Based on AS 1742.2 (2009).

Table 10.19: Typical warrants for analysis of runaway vehicles

Grade (%)	Minimum continuous length (km)
- 3	8.0
- 5	3.1
- 7	1.9
- 9	1.4
- 12	1.0

Note:

On-road distances may depend on design considerations of site topography, horizontal curvature and costs.

Source: Austroads (2010a).

10.10.4 Combinations of Steep Descents and Tight Horizontal Curves

Steep descents with horizontal curvature, particularly closely spaced curves (reverse curves, broken-back curves) should be reviewed to ensure that the heavy vehicle speed on the descent will not exceed the safe curve speed. As discussed in Section 10.10.3, longer and heavier vehicles with more axles will typically have greater braking capacity, however the presence of tight horizontal combined with a steep descent can pose a risk to a vehicle due to excessive braking causing high brake temperatures which may lead to brake fade.

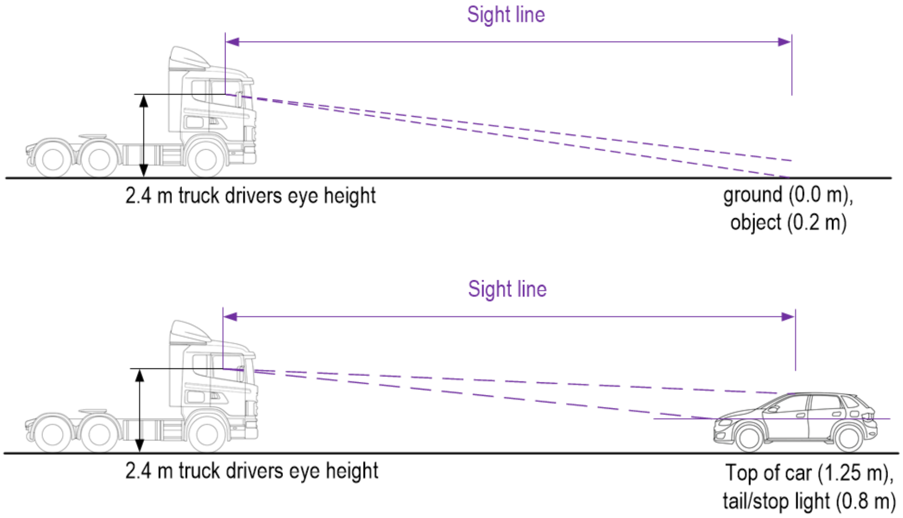
A vehicle should be assessed to understand its braking capacity compared to existing vehicles currently accessing the same road section, and if required ensure that if braking is required to maintain a safe speed on the approach to curves that this does not increase the likelihood of brake fade.

10.11 Sight Distance

10.11.1 Stopping Sight Distance (SSD)

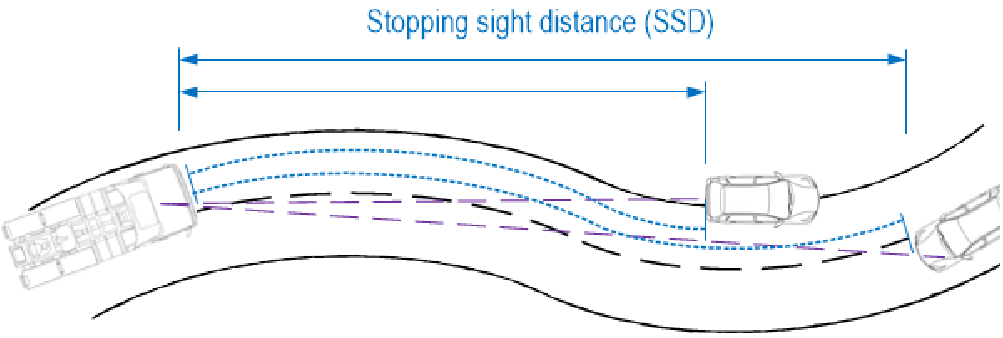
SSD is the distance required for a heavy vehicle to stop before a potential hazard or conflict point. The SSD that is available on a road is determined by the sight line from the truck driver's eye height to the road surface, an object, a vehicle or between two drivers (Figure 10.18). Once the sight line is established through a curve or over a crest, the resulting distance in the travel lane is measured to establish the available SSD (Figure 10.19).

Figure 10.18: Sight lines and the resulting stopping sight distance



Note: Sightlines are dependent on what is intended to be identified by the driver; refer to Table G 1 in Appendix G for all vertical height parameters.

Figure 10.19: Stopping sight distance



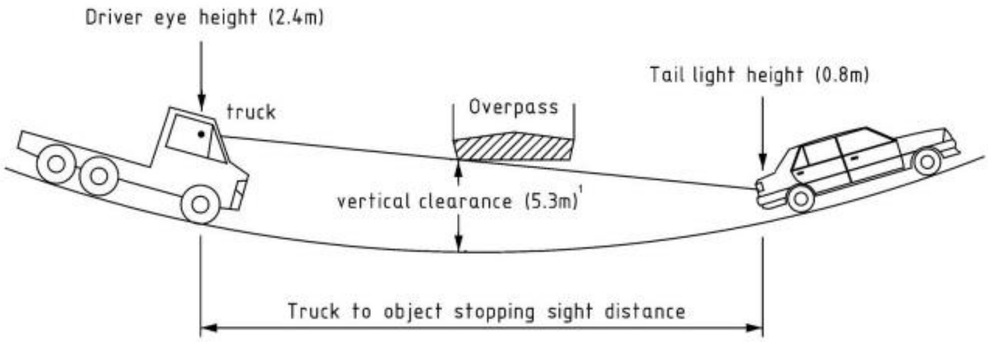
While ensuring SSD for heavy vehicles is provided on a road, it should be recognised that heavy vehicles do have longer stopping distances than passenger vehicles and therefore are more reliant on adequate sight lines (and adequate SSD) to undertake controlled stops, deceleration and/or lane-changing manoeuvres. Some scenarios may require a heavy vehicle to stop unexpectedly. While SSD may not be able to be provided along the length of each route, it should be provided at locations where higher-risk scenarios may arise, some examples of are provided in Table 10.20.

The required SSDs for heavy vehicles on sealed and unsealed roads are provided in Table 10.21 and Table 10.22 respectively. SSD is subject to several variables, should the on-site distances vary from the SSD in the tables expert judgement should be exercised in determining if the onsite sightlines are suitable, this may include the provision of providing mitigation measures.

Table 10.20: Higher-risk scenarios that require SSD for heavy vehicles

Vehicle may be stopped on the through lane	Deceleration is required	Braking on curves	Other
▪ Back of queues (at traffic lights, commercial property accesses) ▪ Vehicle/s waiting to turn right ▪ Vehicle on a shoulder which has insufficient width for the vehicle to stop clear of the through lane ▪ Bus stops and pick-up/drop-off locations (on rural routes these may change dependent on student requirements). This should also consider SSD for passenger cars and pedestrian crossing sight distance for school children and parents	▪ Curve-tangent-curve points on compound curves ▪ Deceleration lanes and exit ramp noses ▪ On the approaches to areas where merging is required, such as lane drops ▪ On the approaches to surface changes, e.g. from sealed to unsealed	Heavy vehicles are required to brake on low-radius horizontal curves, e.g. at intersections, as large vehicles require additional distance for braking, especially when considering truck stability during turns within intersections. Refer to Table 10.21 and Table 10.22 notes	▪ On the approaches to surface changes, e.g. from sealed to unsealed ▪ Sight distance through underpasses, particularly when the truck driver eye height is high (e.g. 2.4 m) to car tail light (0.8 m) (see Figure 10.20) ▪ Bus lanes on freeways adjacent to safety barriers

Figure 10.20: SSD through underpasses



Note: The vertical clearance of 5.3 m is a nominal figure only and should not be used as an acceptable vertical clearance for all structures. Refer to relevant road agency for vertical clearance requirements.

Source: Austroads (2016a).

Table 10.21: SSD for sealed roads

Operating speed (km/h)	Downhill			Level	Uphill		
	-9%	*-6%*	*-3%*	*0%*	*3%*	*6%*	*9%*
B-double / PBS Level 2							
50	100 *	90 *	80	75	70	70	65
60	135 *	120 *	110	100	95	90	85
70	175 *	155 *	140	130	120	115	105
80	225 *	195 *	175	160	150	140	130
90	275 *	240 *	215	195	180	170	160
100	330 *	290 *	255	235	215	200	190
110	395 *	340 *	305	275	255	235	220
Type 1 RT / PBS Level 3							
50	115 *	105 *	95	85	80	75	75
60	160 *	140 *	125	115	105	100	95
70	205 *	180 *	160	145	135	125	120
80	260 *	225 *	200	180	165	155	150
90	320 *	275 *	245	220	205	190	180
100	385 *	330 *	290 *	260	240	225	210
110	460 *	390 *	340 *	310	280	260	245
Type 2 RT / PBS Level 4							
50	140 *	120 *	105	100	90	85	85
60	185 *	160 *	140	130	120	115	105
70	245 *	205 *	180	165	150	140	135
80	305 *	260 *	225 *	205	185	175	165
90	375 *	315 *	275 *	245	225	210	195
100	455 *	380 *	330 *	295	270	250	235
110	540 *	445 *	385 *	345	315	290	270

Notes:
*On extended lengths of this grade, heavy vehicles would need to descend in low gear to prevent overrun. Signage treatments as per AS 1742.2 (2009) should be provided. These should be appropriate for the decent type (i.e. short steep descent, steep descent, long steep descent), which may include detour signage. Steep descents with horizontal curvature should be reviewed as presented in Section 10.10.3.

- Stopping distances on curves with a radius < 400 m should be increased by 10% (Austroads 2016a).
- Stopping distances on curves where the approach is 15 km/h greater than the relevant curve operating speed (Table 10.14) should be calculated with the relevant deceleration rate being reduced by 0.05 g (adapted from Austroads 2016a); these values are provided in Appendix G.2.
- The above SSD values have been derived using the formula given in Austroads (2016a) with the following variables (MRWA 2017).

	B-double / PBS level 2	Type 1 RT / PBS level 3	Type 2 RT / PBS level 4
Reaction time	2.5 s	3.0 s	3.5 s
Deceleration rate (d)	0.24 g	0.22 g	0.20 g

Source: Adapted from Austroads (2016a) and MRWA (2017).

Table 10.22: SSD for unsealed roads

Operating speed (km/h)	Downhill			Level	Uphill		
	-9%	-6%	-3%	0%	3%	6%	9%
B-double / PBS Level 2							
50	110 *	100 *	90	80	75	70	70
60	155 *	135 *	120	110	100	95	90
70	200 *	175 *	155	145	130	125	115
80	255 *	220 *	195	180	165	155	145
90	315 *	275 *	240	220	200	190	175
100	380 *	330 *	290	265	240	225	210
110	455 *	390 *	345	310	285	265	245
Type 1 RT / PBS Level 3							
50	130 *	115 *	100	95	85	80	75
60	180 *	155 *	135	125	115	110	100
70	235 *	200 *	180	160	150	140	130
80	295 *	255 *	225	200	185	170	160
90	365 *	310 *	275	245	225	210	195
100	445 *	375 *	330 *	295	270	250	235
110	530 *	445 *	390 *	350	320	295	275
Type 2 RT / PBS Level 4							
50	155 *	130 *	115	105	100	90	85
60	210 *	175 *	155	140	130	120	115
70	275 *	230 *	200	180	165	155	145
80	350 *	290 *	255 *	225	205	190	180
90	435 *	360 *	310 *	275	250	230	215
100	525 *	430 *	375 *	330	300	275	260
110	625 *	515 *	440 *	390	355	325	300

Notes:

- *On extended lengths of this grade, heavy vehicles would need to descend in low gear to prevent overrun. Signage treatments as per AS 1742.2 (2009) should be provided. These should be appropriate for the decent type (i.e. short steep descent, steep descent, long steep descent), which may include detour signage. Steep descents with horizontal curvature should be reviewed as presented in Section 10.10.3.
- These SSD values are considered as indicative only for dry roads in good condition. Changes in unsealed road surface conditions (potholes, rutting, delamination, surface gravel) are likely to influence the ability of a vehicle to achieve the rates of deceleration to develop these SSD values, thus longer distances may be required.
- Stopping distances on curves with a radius < 400 m should be increased by 10% (Austroads 2016a).
- Stopping distances on curves where the approach is 15 km/h greater than the relevant curve operating speed (Table 10.14) should be calculated with the relevant deceleration rate being reduced by 0.05 g (adapted from Austroads 2016a); these values are provided in Appendix G.2.
- The above SSD values have been derived using the formula given in Austroads (2016a) with the following variables (MRWA 2017). A gavel correction factor as in Austroads (2009) was applied to determine the SSD on an unsealed surface.

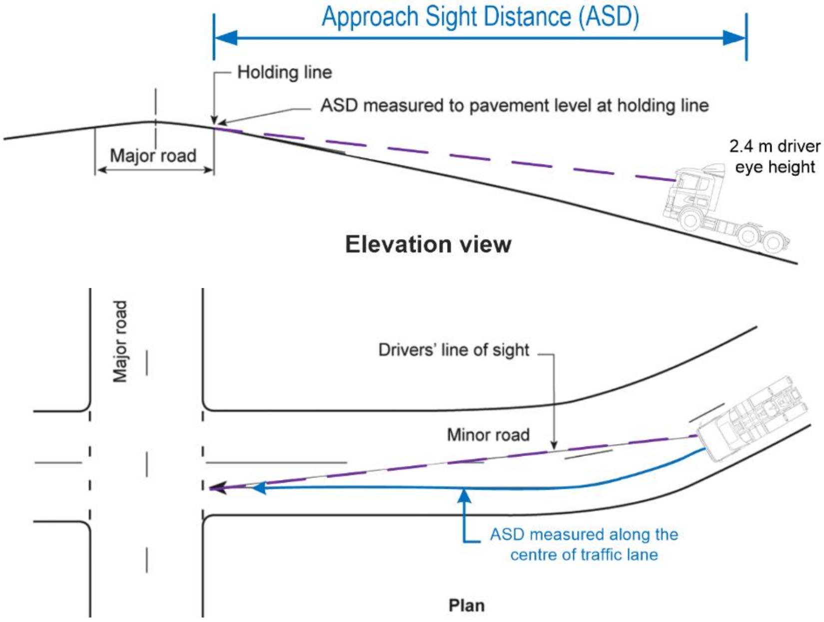
	B-double / PBS level 2	Type 1 RT / PBS level 3	Type 2 RT / PBS level 4
Reaction time	2.5 s	3.0 s	3.5 s
Deceleration rate (d)	0.24 g	0.22 g	0.20 g

Source: Adapted from Austroads (2009), Austroads (2016a), MRWA (2017).

10.11.2 Approach Sight Distance (ASD)

Approach sight distance (ASD) is the distance required on a minor road (or traffic control device over a bridge or for a narrow section of road) which allows a heavy vehicle to stop safely before the intersection point with the major road (or two-way carriageway). ASD for trucks on intersection approaches should be measured from truck driver eye height (2.4 m) to pavement level at the stop or holding line (0.0 m) (Figure 10.21). If the ASD cannot be achieved from driver eye height to the stop or holding line, a raised centre island with a hazard marker visible for at least the last 10 m of ASD may be used in place of the stop or holding line.

Figure 10.21: Sight lines and resulting ASD



Note:

Sight lines are dependent on what is intended to be identified by the driver, refer to Table G 1 in Appendix G for all vertical height parameters.

Source: Adapted from Austroads (2017a).

ASD for trucks is numerically the same as the SSD values provided in Section 10.11.1. Reduced ASD (based on quicker reaction times) may be used in constrained, low-speed environments, as explained in Table 10.23. The resulting values are provided for sealed and unsealed roads in Table 10.24 and Table 10.8 respectively.

Table 10.23: Constrained, low-speed environments

Reaction time R_T (s)	Typical road conditions	Typical use
Reduced reaction time (values in Table G 2 and Table G 3)	Alert driving conditions e.g.: ▪ high expectancy of stopping due to traffic signals ▪ consistently tight alignments, for example mountainous roads ▪ restricted low-speed urban areas ▪ built-up areas – high traffic volumes ▪ interchange ramps when sighting over or around barriers	▪ Only to be used in very constrained situations where drivers will be alert ▪ Should not be used where other assessment criteria are not met (e.g. horizontal or vertical alignment or carriageway width) ▪ Can be considered only where the maximum operating speed is ≤ 70 km/h ▪ Only to be used where approach speeds are unlikely to physically be able to exceed 70 km/h (e.g. turning from side road, curve on approach, exiting a property and cannot accelerate to 70 km/h before intersection)

Source: Adapted from Austroads (2016a).

Table 10.24: ASD for sealed roads in constrained low-speed environments

Operating speed (km/h)	Downhill			Level	Uphill		
	-9%	-6%	-3%	0%	3%	6%	9%
B-double / PBS Level 2							
50	95 *	80 *	75	70	65	60	60
60	130 *	110 *	100	90	85	80	75
70	165 *	145 *	130	120	110	105	95
Type 1 RT / PBS Level 3							
50	110 *	95 *	85	80	75	70	65
60	150 *	130 *	115	105	100	90	85
70	195 *	170 *	150	135	125	120	110
Type 2 RT / PBS Level 4							
50	130 *	110 *	100	90	85	80	75
60	180 *	150 *	135	120	110	105	100
70	235 *	195 *	170	155	140	135	125

Notes:

- * On extended lengths of this grade, heavy vehicles would need to descend in low gear to prevent overrun. Signage treatments as per AS 1742.2 (2009) should be provided. These should be appropriate for the decent type (i.e. short steep descent, steep descent, long steep descent), which may include detour signage. Steep descents with horizontal curvature should be reviewed as presented in Section 10.10.3.
- Stopping distances on curves with a radius < 400 m should be increased by 10% (Austroads 2016a).
- Stopping distances on curves where the approach is 15 km/h greater than the relevant curve operating speed (Table 10.14) should be calculated with the relevant deceleration rate being reduced by 0.05 g (adapted from Austroads 2016a); these values are provided in Appendix G.2.
- Reaction and deceleration rates as in Table 10.25.

Table 10.25: ASD for unsealed roads in constrained low-speed environments

Operating speed (km/h)	Downhill			Level	Uphill		
	-9%	-6%	-3%	0%	3%	6%	9%
B-double / PBS Level 2							
50	105 *	90 *	80	75	70	65	60
60	145 *	125 *	110	100	95	90	80
70	190 *	165 *	145	135	120	115	105
Type 1 RT / PBS Level 3							
50	125 *	105 *	95	85	80	75	70
60	170 *	145 *	130	115	105	100	95
70	225 *	190 *	170	150	140	130	120
Type 2 RT / PBS Level 4							
50	145 *	125 *	110	100	90	85	80
60	200 *	170 *	150	135	120	115	105
70	265 *	220 *	190	170	155	145	135

Notes:

- * On extended lengths of this grade, heavy vehicles would need to descend in low gear to prevent overrun. Signage treatments as per AS 1742.2 (2009) should be provided. These should be appropriate for the decent type (i.e. short steep descent, steep descent, long steep descent), which may include detour signage. Steep descents with horizontal curvature should be reviewed as indicated in Section 10.10.3.
- Stopping distances on curves with a radius < 400 m should be increased by 10% (Austroads 2016a).
- Stopping distances on curves where the approach is 15 km/h greater than the relevant curve operating speed (Table 10.14) should be calculated with the relevant deceleration rate being reduced by 0.05 g (adapted from Austroads 2016a); these values are provided in Appendix G.2.
- The above values have been derived using the formula given in Austroads (2016a) with the following factors.

	B-double / PBS level 2	Type 1 RT / PBS level 3	Type 2 RT / PBS level 4
Reaction time	2.0 s	2.5 s	3.0 s
Deceleration rate (d)	0.24 g	0.22 g	0.20 g

Note:

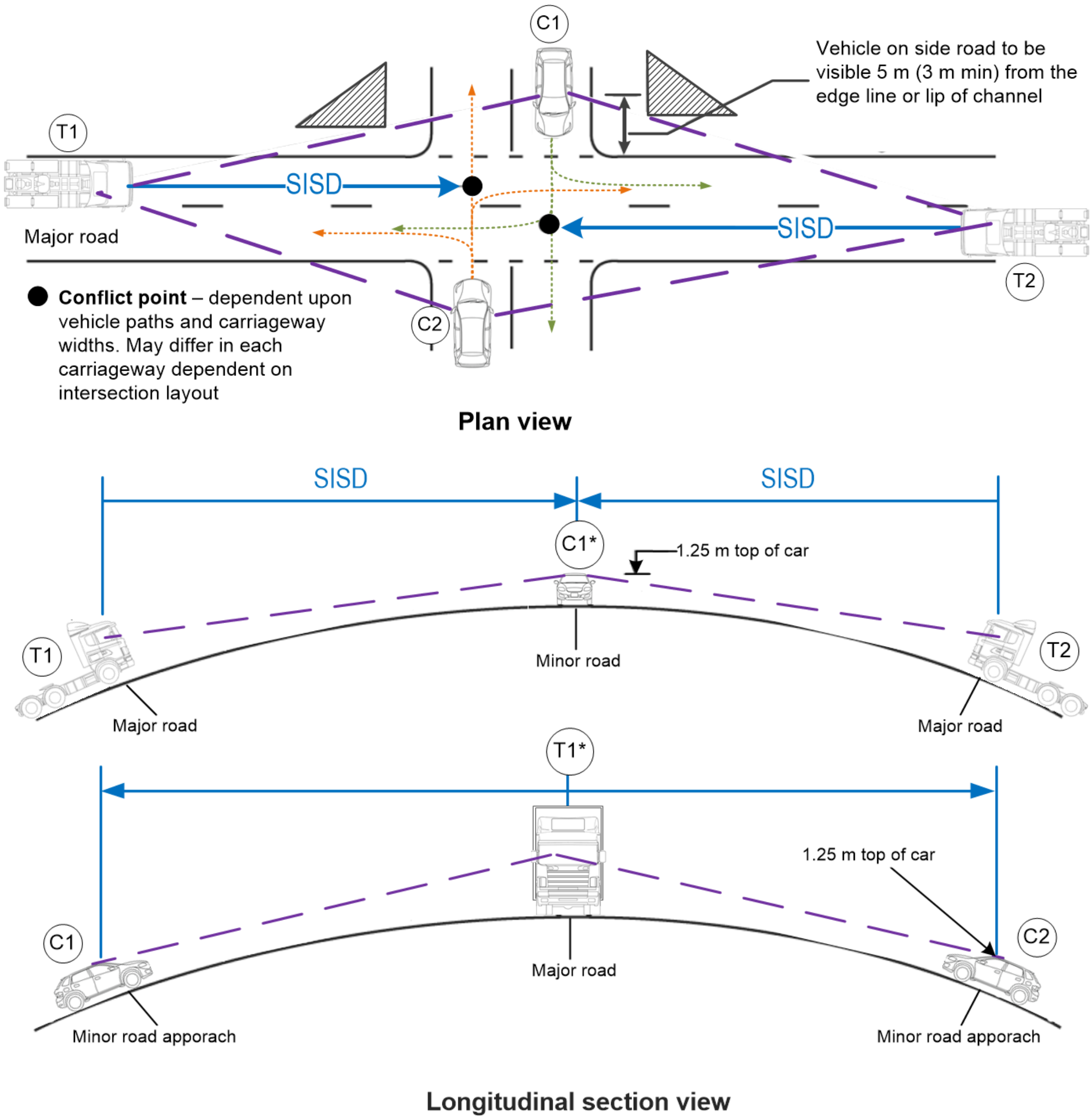
Gravel correction factor as per Austroads (2009) has been applied.

Source: Based on MRWA (2017).

10.11.3 Safe Intersection Sight Distance (SISD)

Safe intersection sight distance (SISD) is the distance required on a major road for a heavy vehicle to stop safely before a potential conflict point with a vehicle turning into, or from the minor road (Figure 10.22). The sight lines to determine SISD for trucks should be measured from truck driver eye height (2.4 m) to the top of a vehicle on the through road waiting to turn right or a vehicle on the minor road waiting to enter the intersection (1.25 m).

Figure 10.22: Sight lines and the resulting SISD for heavy vehicle on major road



Note:

* C1 would be replaced with C2 when assessing SISD to the opposite minor road. T1 would be replaced with T2 when assessing the opposing approach on the major road.

Source: Adapted from Austroads (2017a).

The required SISDs for heavy vehicles on sealed and unsealed roads are provided in Table 10.26 and Table 10.27 respectively.

Table 10.26: SISD for sealed roads

Operating speed (km/h)	Downhill			Level	Uphill		
	-9%	*-6%*	*-3%*	*0%*	*3%*	*6%*	*9%*
B-double / PBS Level 2							
50	135 *	125 *	120	115	115	110	110
60	170 *	160 *	155	150	145	140	135
70	215 *	200 *	190	185	175	170	165
80	260 *	245 *	230	220	210	205	200
90	310 *	290 *	275	260	250	240	235
100	375 *	345 *	325	305	295	280	275
110	465 *	420 *	390	365	350	330	320
Type 1 RT / PBS Level 3							
50	140 *	135 *	130	125	120	120	115
60	180 *	170 *	165	155	155	150	145
70	225 *	210 *	200	195	185	180	175
80	270 *	255 *	240	230	225	215	210
90	320 *	300 *	285	270	260	255	245
100	390 *	360 *	340 *	320	310	295	285
110	480 *	435 *	405 *	380	365	345	335
Type 2 RT / PBS Level 4							
50	145 *	140 *	135	130	130	125	125
60	190 *	180 *	170	165	160	155	155
70	235 *	220 *	210	205	195	190	185
80	280 *	265 *	250 *	240	235	230	220
90	335 *	315 *	300 *	285	275	265	260
100	400 *	375 *	350 *	335	320	310	300
110	495 *	450 *	420 *	395	380	365	350

Notes:

- * On extended lengths of this grade, heavy vehicles would need to descend in low gear to prevent overrun. Signage treatments as per AS 1742.2 (2009) should be provided. These should be appropriate for the decent type (i.e. short steep descent, steep descent, long steep descent), which may include detour signage. Steep descents with horizontal curvature should be reviewed as per Section 10.10.3.
- Stopping distances on curves with a radius < 400 m should be increased by 10% (Austroads 2016a).
- Stopping distances on curves where the approach is 15 km/h greater than the relevant curve operating speed (Table 10.14) should be calculated with the relevant deceleration rate being reduced by 0.05 g (adapted from Austroads 2016a); these values are provided in Appendix G.2.
- The above SSD values have been derived using the formula given in Austroads (2016a) with the following variables (MRWA 2017).

	B-double / PBS level 2	Type 1 RT / PBS level 3	Type 2 RT / PBS level 4
Reaction time	2.0 s	2.0 s	2.0 s
Observation time	3.0 s	3.0 s	3.0 s
Brake lag	1.0 s	1.5 s	2.0 s
Deceleration rate (d)	0.29 g up to 90 km/h, 0.28 g at 100 km/h and 0.26 g at 110 km/h		

Source: Adapted from Austroads (2016a) and MRWA (2017).

Table 10.27: SISD for unsealed roads

Operating Speed (km/h)	Downhill			Level	Uphill		
	-9%	*-6%*	*-3%*	*0%*	*3%*	*6%*	*9%*
B-double / PBS Level 2							
50	140 *	130 *	125	120	120	115	110
60	185 *	170 *	165	155	150	145	140
70	230 *	215 *	205	195	185	180	175
80	280 *	260 *	245	235	225	215	210
90	340 *	315 *	295	280	265	255	250
100	415 *	380 *	355	335	315	305	290
110	480 *	440 *	410	385	365	350	335
Type 1 RT / PBS Level 3							
50	145 *	140 *	135	130	125	120	120
60	190 *	180 *	170	165	160	155	150
70	240 *	225 *	215	205	195	190	185
80	295 *	275 *	260	245	235	230	220
90	350 *	325 *	305	290	280	270	260
100	425 *	395 *	365	345	330	315	305
110	495 *	455 *	425 *	400	380	365	350
Type 2 RT / PBS Level 4							
50	155 *	145 *	140	135	130	130	125
60	200 *	190 *	180	175	165	165	160
70	250 *	235 *	225	215	205	200	195
80	305 *	285 *	270 *	255	250	240	235
90	365 *	340 *	320 *	305	290	280	275
100	440 *	405 *	380 *	360	345	330	320
110	510 *	470 *	440 *	415	395	380	365

Notes:

- * On extended lengths of this grade, heavy vehicles would need to descend in low gear to prevent overrun. Signage treatments as per AS 1742.2 (2009) should be provided. These should be appropriate for the decent type (i.e. short steep descent, steep descent, long steep descent), which may include detour signage. Steep descents with horizontal curvature should be reviewed as indicated in Section 10.10.3.
- These SISD values are considered as indicative only for dry roads in good condition. Changes in unsealed road surface conditions (potholes, rutting, delamination, surface gravel) are likely to influence the ability of a vehicle to achieve the rates of deceleration to develop these SISD values, thus longer distances may be required.
- Stopping distances on curves with a radius < 400 m should be increased by 10% (Austroads 2016a).
- Stopping distances on curves where the approach is 15 km/h greater than the relevant curve operating speed (Table 10.14) should be calculated with the relevant deceleration rate being reduced by 0.05 g (adapted from Austroads 2016a); these values are provided in Appendix G.2.
- The above SSD values have been derived using the formula given in Austroads (2016a) with the following variables (MRWA 2017). A gravel correction factor as per Austroads (2009) was applied to determine the SSD on an unsealed surface.

	B-double / PBS level 2	Type 1 RT / PBS level 3	Type 2 RT / PBS level 4
Reaction time	2.5 s	3.0 s	3.5 s
Deceleration rate (d)	0.24 g	0.22 g	0.20 g

Source: Adapted from Austroads (2009), Austroads (2016a) and MRWA (2017).

10.11.4 Minimum Gap Sight Distance

Minimum gap sight distance (MGSD) is based on distances corresponding to the critical acceptance gap that drivers are prepared to accept when undertaking a crossing or turning manoeuvre at intersections. As heavy vehicles take a longer time to accelerate and therefore complete a turn movement compared to passenger vehicles, consideration should be given to whether an introduced heavy vehicle can complete movements from property accesses and unsignalised intersections between vehicles arriving.

Cox et al. (2015) proposed heavy-vehicle-specific sight distance time-gaps based on field trials and a model and explained the method and proposed values.

10.11.5 Overtaking Sight Distance

Guidance on overtaking sight distances is provided in Section 10.14.

10.12 Intersections

10.12.1 Clearance Times

A heavy vehicle should be able to clear the relevant through or turn manoeuvre (Figure 10.25) within the green time at a signalised intersection and between vehicles arriving at an unsignalised intersection.

At a signalised intersection insufficient clearance time can increase the safety risks, as vehicles may still be completing either turning or through manoeuvres at the start of the green phase of an opposing traffic stream. Signal phases may have to be modified to allow a vehicle to clear the manoeuvre within the signal phase, and detector loops may have to be modified or installed to allow additional green time when a heavy vehicle is present.

At an unsignalised intersection other vehicles may have to slow down or stop to allow a manoeuvre to be completed; this increases the risk of a collision with the heavy vehicle and a rear-end collision for the vehicle/s required to slow or stop. SISD should be available to the heavy vehicle undertaking the turning manoeuvre and to the back of a queue that may result from cars slowing or stopping to allow a heavy vehicle to complete a manoeuvre. SSD should be available from the heavy vehicle turning from the minor or major road to any other vehicle in the lane or lanes it will cross. Should the time required for a heavy vehicle to complete a manoeuvre and clear an intersection be greater than the average arrival time between vehicles on the major road, resulting in multiple vehicles having to slow or stop in the through lane to allow a manoeuvre to be completed, mitigation treatments should be installed. Mitigation measure(s) should be appropriate for the intersection location and traffic volumes during the likely times of heavy vehicle operation.

Indicative clearance times for normal and cautious acceleration are provided in Table 10.28 and Table 10.29 respectively; these times are for a vehicle starting from a stopped position with a reaction time of 2.5 seconds (from green light (or decision to start the manoeuvre) to vehicle starts forward momentum). Cautious acceleration times may be used for routes with frequent livestock and explosives load movements.

Table 10.28: Clearance times (seconds): using normal acceleration

Clearance distance (m)	Downhill			Level	Uphill		
	-6%	-4%	-2%	0%	2%	4%	6%
B-double / PBS Level 2							
5	12.5	13.5	14.5	16.5	18.5	21.5	26.5
15	13.5	15.0	16.0	18.0	20.5	24.0	29.5
25	14.5	16.0	17.5	19.5	22.5	26.0	33.0
35	15.5	17.0	19.0	21.0	24.0	28.5	35.5
Type 1 RT / PBS Level 3							
5	14.0	15.0	17.0	19.0	21.5	25.5	32.0
15	15.0	16.5	18.0	20.5	23.5	28.0	35.5
25	16.0	17.5	19.5	22.0	25.0	30.0	39.0
35	17.0	18.5	20.5	23.0	26.5	32.0	42.0
Type 2 RT / PBS Level 4							
5	16.5	18.0	20.0	22.0	25.5	31.5	52.0
15	17.5	19.0	21.0	23.5	27.5	35.0	57.5
25	18.5	20.0	22.5	25.0	29.0	36.0	63.0
35	19.5	21.0	23.5	26.5	30.5	38.5	68.5

Source: Adapted from Austroads (2009).

Table 10.29: Clearance times (seconds): using cautious acceleration

Clearance distance (m)	Downhill			Level	Uphill		
	-6%	-4%	-2%	0%	2%	4%	6%
B-double / PBS Level 2							
5	15.0	15.0	16.0	17.5	20.5	24.0	28.0
15	16.5	17.0	18.0	20.0	23.0	27.0	32.0
25	18.0	18.5	20.0	22.5	25.5	30.0	35.5
35	19.0	20.0	21.5	24.0	28.0	32.5	38.0
Type 1 RT / PBS Level 3							
5	15.5	17.5	20.5	24.5	29.0	35.0	42.0
15	17.0	19.0	22.5	26.5	32.0	38.0	45.5
25	18.0	20.5	24.0	28.5	34.0	40.5	48.0
35	19.0	21.5	25.0	30.0	35.5	42.0	49.5
Type 2 RT / PBS Level 4							
5	21.5	20.5	22.5	27.5	35.5	46.0	60.0
15	22.5	21.5	23.5	29.0	37.5	49.0	63.0
25	23.0	22.0	24.5	30.0	39.0	50.5	65.5
35	23.0	22.5	25.0	31.0	40.0	51.5	66.5

Source: Adapted from Austroads (2009).

10.12.2 Stacking Distance

The distance between two intersecting roads (stacking distance) should be long enough to contain the length of the vehicle being assessed + 3.5 m when a heavy vehicle is stopped at the intersection of an intersecting through road. Stacking distance should be provided on the approach and departure of an intersection (if heavy vehicles operate in both directions) for the heavy vehicle that operates in that direction (e.g. a PBS Level 2B may operate in one direction and a PBS Level 3A in the other direction).

The required stacking distance is dependent on the length of the vehicle being assessed. The required staking distances are shown in Table 10.30.

Adequate stacking distance (Figure 10.23) will not result in a heavy vehicle encroaching into a through lane whereas inadequate stacking distance (Figure 10.24) will result in the vehicle encroaching into the through lane resulting in a safety hazard and/or traffic-flow hazard.

Assessors should use their judgement to determine whether greater stacking distances or margins are appropriate given the expected traffic volumes and impacts on traffic flow. Where the required stacking distance is not met the treatments as provided in Section 10.13.2 could be considered; the use of these treatments should be considered within the context of the site and traffic volumes.

Table 10.30: Stacking distances between intersections

Vehicle	Max. vehicle length (m)	Required stacking distance (m)
General access (19 m semi) and PBS Level 1	20.0	23.5
B-double (26 m), PBS Level 2A	26.0	29.5
PBS Level 2B	30.0	33.5
Type 1 road train (e.g. A-double, B-triple, AB-triple), PBS Level 3A	36.5	40
PBS Level 3B	42.0	45.5
Type 2 road train (e.g. A-triple, quad combinations) PBS Level 4A	53.5	57
PBS Level 4B	60.0	63.5

Note:
The total stacking distance length is based on the length of the vehicle + 3.5 m (NHVR 2007).

Figure 10.23: Adequate stacking distance between intersections

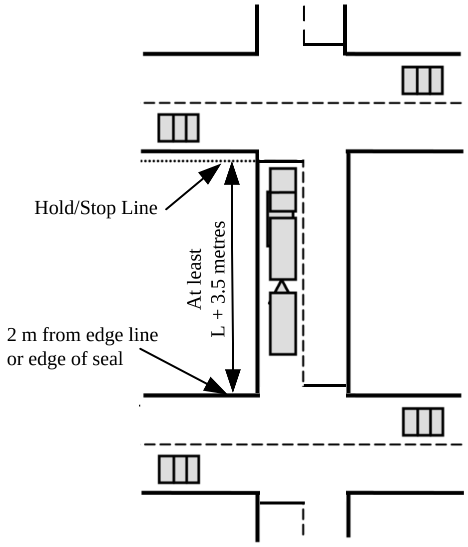
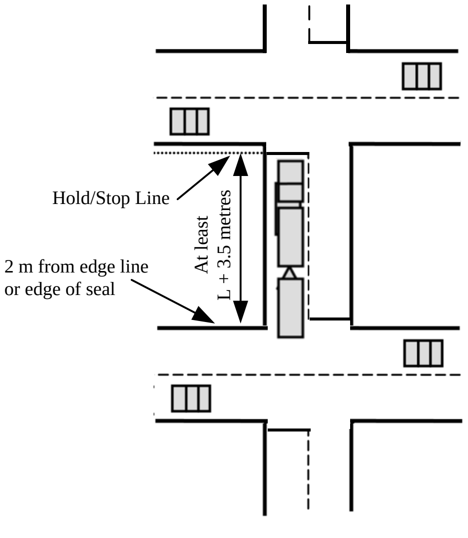


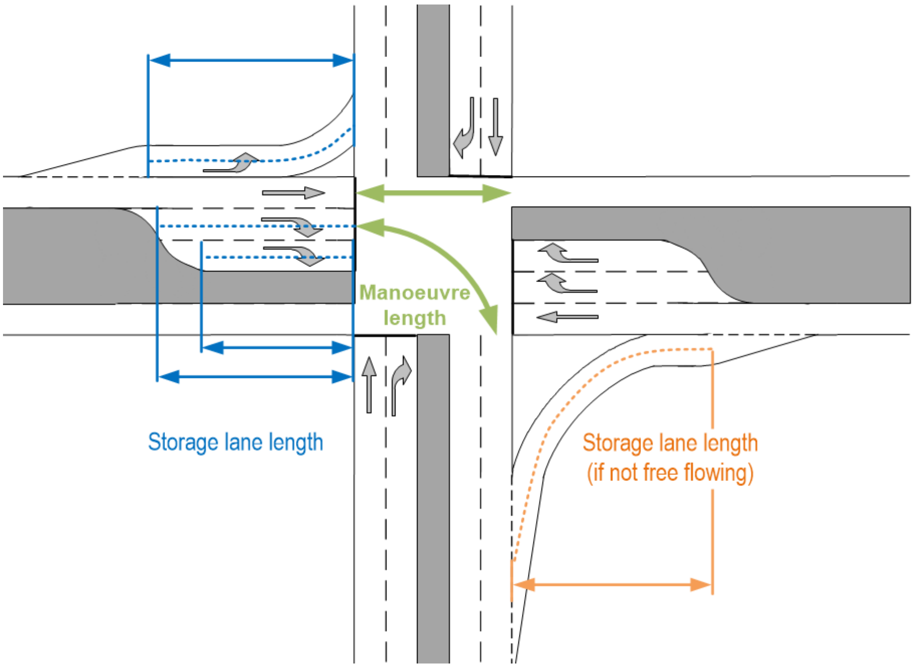
Figure 10.24: Inadequate stacking distance between intersections



10.12.3 Storage Lane Length

Storage lanes should at a minimum be the same lengths as the stacking distance (Table 10.30). Additional length may be required when considering the effect that the heavy vehicle stacking distance may have on queue lengths. All vehicles queueing to make the relevant turn (including the heavy vehicle) should remain stored within the turn lane length (Figure 10.25). Any vehicle (including the heavy vehicle) that cannot be stored within the storage lane length is likely to mount the kerb adjacent to the through lane damaging the shoulder or median or be stopped in the through lane becoming susceptible to a rear-end or side-swipe collision.

Figure 10.25: Measuring storage lane and intersection manoeuvre lengths



Notes:
1 An intersection manoeuvre should be measured along the centre of the likely vehicle path. The end of the manoeuvre should be clear of the intersection so that proceeding pedestrian or vehicle movements are not restricted.
2 A free-flowing turn lane (identified in orange) may need to be assessed should any changes or peaks in traffic volumes during the likely heavy vehicle times of operation result in a vehicle needing to stop in the turn lane.

10.12.4 Low Speed Swept Path

A heavy vehicle's low speed swept path (LSSP) for any intersection manoeuvre should be able to fit within the intersection. The steer path radius of these swept paths should be as shown in Table 10.31.

Table 10.31: Maximum turn speeds and minimum turning radii

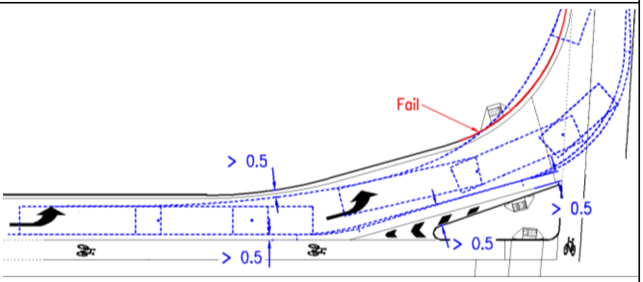
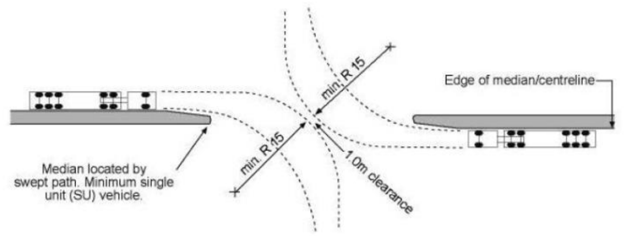
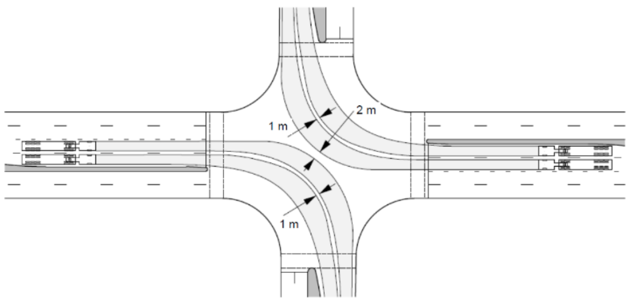
Maximum turn speed	Minimum turn/steer path radius (r_0)
5 km/h	12.5 m
15 km/h	15 m
20 km/h	20 m
30 km/h	30 m

Notes:
- Only to be used when a stop provision is present, or if traffic flow will result in a vehicle being required to stop at a give-way provision or in a turn lane, a traffic flow analysis should be undertaken.

The outside of the LSSP should maintain a 0.5 m clearance to the edge of pavement, kerb, centreline, cycle lane and roadside object (including safety barriers). The LSSP of opposing turns should also be separated by 1.0 to 2.0 m. Examples of the required clearances from the extremities of the LSSP are provided in Table 10.32. When making left turns the LSSP (Section 10.12.4) must not cross into the path of oncoming traffic (encroachment over the centreline may be acceptable where traffic volumes are very low, i.e. less than 250 vehicles per day oncoming traffic).

If an assessor is unsure of the tracking due to an unusual vehicle design or an unusual road geometry, a field trial could be used to test the vehicle.

Table 10.32: Required distances from LSSP extremities

Description	Required distance	
Distance from vehicle to edge of pavement, kerb, centreline, cycle lanes and roadside objects: Applicable at signalised and unsignalised intersections types. Applicable on the left and right side of LSSP. Mountable kerbs are excluded.	0.5 m	
Unsignalised intersection: Opposing turns – two single vehicles.	1.0 m	
Signalised intersection: Opposing turns – two dual vehicles (applicable for dual vehicles from one direction with only a single vehicle from the opposing direction, and any combination of heavy vehicle and passenger car in left or right lanes).	2.0 m	

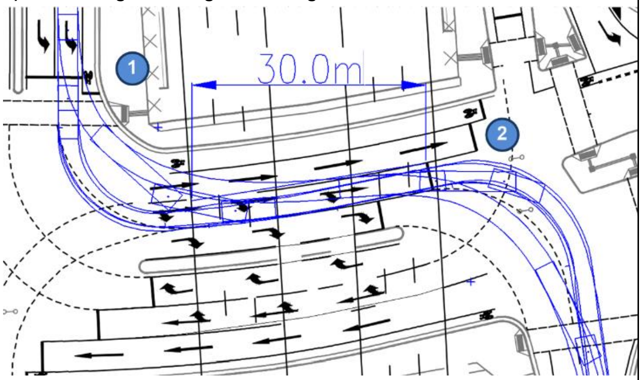
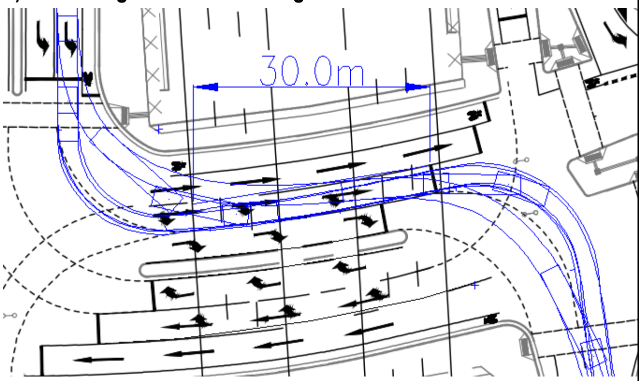
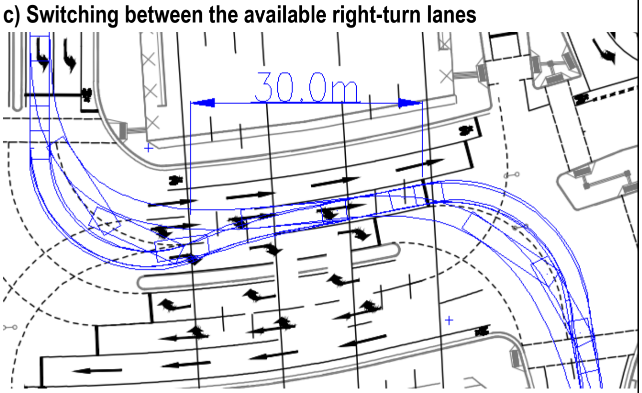
Source: Adapted from Austroads (2017a).

While swept paths are mostly used to identify if a swept path fits through an intersection geometrically, the effects of a vehicle's swept path on intersection function and efficiency should also be considered. Some examples are as follows:

- When stationary, will the vehicle's trailing units effect intersection capacity e.g. store across adjacent through or turn lanes.
- Can it legally turn from the through lane.
- Can it turn from the centre of multiple turn lanes.
- When turning from the outside turn lane might it encroach on the adjacent turn lane.
- Could the rear unit/s impede storage capacity or through lanes.

Table 10.33 shows a number of potential movements a heavy vehicle could undertake to achieve a complex manoeuvre through two closely spaced intersections at an interchange. Commentary on the positives and negatives of each manoeuvre and possible solutions are provided.

Table 10.33: Complex intersection manoeuvres

<table>
<tr><td colspan="2">These examples show a 30 m PBS Level 2B vehicle using a 12.5 m steer path radius manoeuvring through an underpass to access a motorway on-ramp. These examples show a number of issues with regard to LSSP clearances; however, they also demonstrate that while a heavy vehicle can legally turn from the through lane or the middle of the two turn lanes, the capacity of the intersection will be reduced due to the vehicle being stored across either turn lane or the through lane when the vehicle is required to stop at the second stop line.</td></tr>
<tr><td>Other issues with these LSSPs are as follows:
a) When stopped at the second stop line the LSSP stores across both turn lanes when at the stop line. When exiting from the second stop line, the vehicle is required to cross into the outside turn lane to complete the manoeuvre without striking the central island.</td><td>a) Remaining in the right-most right-turn lanes

</td></tr>
<tr><td>b) At the first stop line the LSSP encroaches into the cycling lane. When stopped at the second stop line, the LSSP stores in the through lane. When exiting from the second stop line, the vehicle is required to cross into the inside turn lane to complete the manoeuvre to avoid striking the kerb on the outside of the on-ramp.</td><td>b) Remaining in the left-most right-turn lanes

</td></tr>
<tr><td>c) When stopped at the second stop line the LSSP stores in the through lane. When exiting from the second stop line, the vehicle is required to cross into the inside turn lane to complete the manoeuvre to avoid striking the kerb on the outside of the on-ramp.</td><td>c) Switching between the available right-turn lanes

</td></tr>
<tr><td colspan="2">Possible solution:
Consideration could be given to the time-of-day that access could be granted.
If gazetted access is desired, various signal phasing configurations could be investigated that allow one continual movement through both intersections (triggered by detector loops on the approach to the first stop line).</td></tr>
</table>

10.12.5 Turning Lanes

Acceleration lanes

Heavy vehicles should maintain appropriate speeds when they merge into mainstream traffic from an entry lane to avoid causing a hazard or obstruction. The length of an entry lane should allow a vehicle, when fully loaded, to accelerate to approximately 70% of the traffic speed at the point where the lane joins with the through road. The acceleration lane should also allow a heavy vehicle to travel for 4 seconds when parallel to the adjacent lane so that the driver can select an appropriate gap to merge into.

The required acceleration lane length to allow a heavy vehicle to accelerate to the appropriate merge speed is dependent on the curve/entry speed (refer to Austroads (2017a) or if the heavy vehicle is starting from a stopped position. The required acceleration lane distances based on a stopped position are provided in Table 10.34.

Drivers on the adjacent through road should also be able to visually identify a heavy vehicle on the acceleration lane and the location of the merge point so that they have adequate time to safely slow down or change lanes. Signage should also be placed on the through road to warn traffic of the presence of entering heavy vehicles that may be moving slowly.

Acceleration lane lengths can be relaxed in scenarios where traffic volume is lower, or the through road is not a main road. On roads with an AADT less than 1000 passenger car equivalents (PCE) (as in Table 10.41) consideration may be given to providing access if the acceleration lane length is not provided but stopping sight distance is available to all vehicles (including heavy vehicles if operating on the through road) to stop before reaching a merging heavy vehicle. Signage must be placed on the through road to warn traffic of the presence of entering heavy vehicles that may be moving slowly.

Table 10.34: Minimum length (m) of acceleration lane from a stop/start

Vehicle classification	Average grade of the acceleration lane					
	Downhill			Level	Uphill	
	-4%	-2%	-1%	0%	1%	2%
Through road speed limit = 80 km/h (i.e. heavy vehicle entry speed = 56 km/h)						
B-double, Level 2 PBS vehicle	190	270	350	510	1090	*
Type 1 road train, Level 3 PBS vehicle	200	280	370	570	1500	*
Type 2 road train, Level 4 PBS vehicle up to 120 tonnes	220	330	460	790	*	*
Through road speed limit = 110 km/h (i.e. heavy vehicle entry speed = 77 km/h)						
B-double, Level 2 PBS vehicle	410	630	910	1620	*	*
Type 1 road train, Level 3 PBS vehicle	420	670	970	1870	*	*
Type 2 road train, Level 4 PBS vehicle up to 120 tonnes	470	760	1180	*	*	*

Notes:

- * It is not possible to accelerate from rest up to the required speed within 2000 m.
- These distances are based on a stop/start. A shorter distance will be required if the vehicle enters the acceleration lane at speed; the distance should be calculated based on the distance required to reach 80 km/h from the entry speed (typically controlled by an entry curve radius and resulting speed).

Source: MRWA (2017).

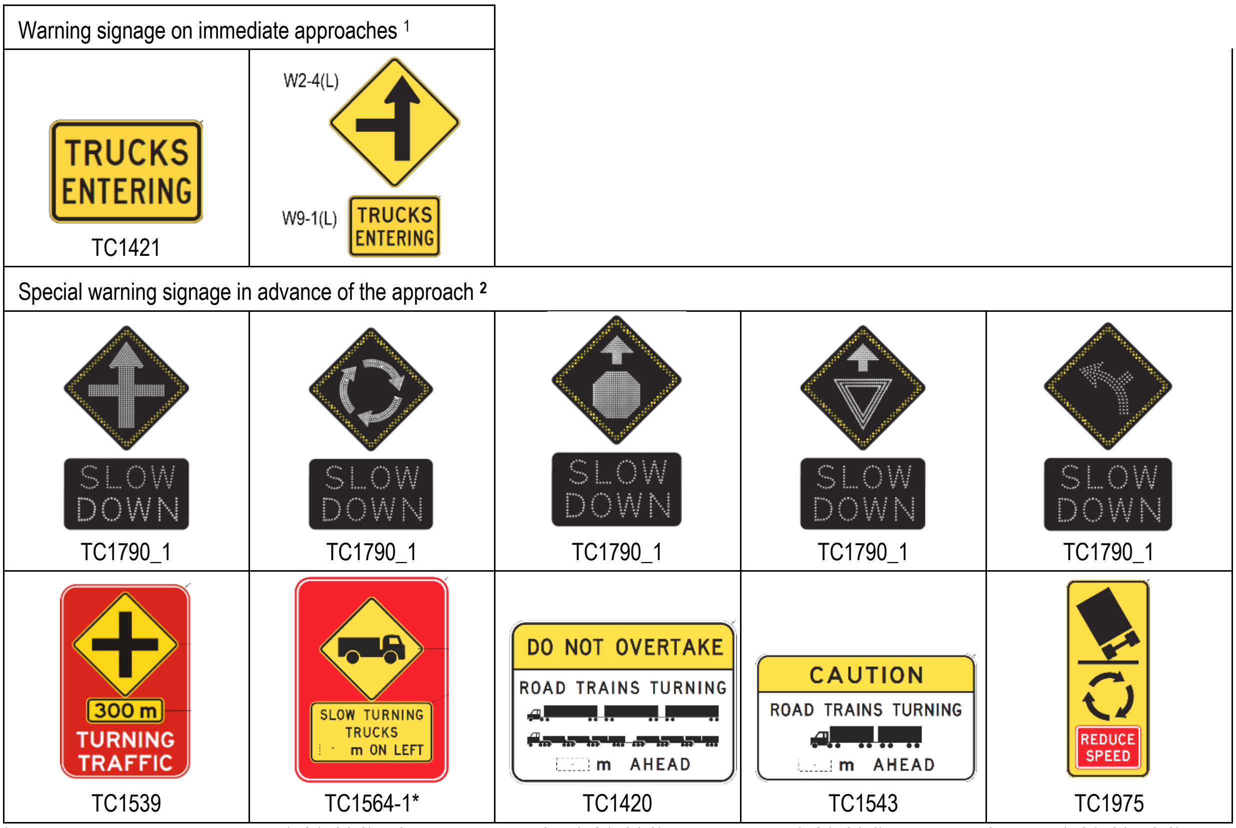
Deceleration lanes

Deceleration lanes should be considered where AADT is high and/or stopping distance to left turn or right turn onto a side road (or median) is restricted. For example, this would be most applicable if a heavy vehicle is required to turn left from a high-volume, high-speed road.

10.12.6 Intersection Sight Distance

ASD should be provided on a side road and SISD on the major road (refer to Section 10.11). Where a sightline is not available to provide the required ASD, SISD or MGSD, or a clear view of an approaching heavy vehicle may be reduced due to heat haze, misleading road layouts or lighting, warning signage should be provided. It is important to provide a heavy vehicle driver with warning of an upcoming intersection so that there is adequate time to select a safe speed to negotiate a stop or give-way control, negotiate a roundabout or when on a through road anticipate the potential need to stop to avoid a collision. Some examples of warning signage for the through road and side roads to warn all drivers of the presence of heavy vehicles and give warning to heavy vehicle drivers are provided in Figure 10.26.

Figure 10.26: Examples of heavy vehicle warning signage for intersections with reduced sight distance/unexpected heavy vehicle movements



* Additional signs available: on right (TC1564-2), left or right not specified (TC1564-3), merging ahead (TC1564-4), quarry on left or right (TC1564-5 & 6).

Notes:

1 Installed as per AS 1742.2 (2009), maximum distances for Dimension A and B are recommended.

2 Installed at a distance that allows the relevant heavy vehicle or passenger vehicle to reduce to appropriate speed before the hazard.

- TC190 signs are vehicle activated based on their approach speed; these are to be used in combination with equivalent W series warning signage on the immediate approaches.

Source: TMR (2017b).

10.12.7 Adverse Crossfall

Adverse crossfall is also a consideration at intersections and roundabouts. Intersections (including roundabouts) may have adverse crossfall of up to 3%. As the adverse crossfall exceeds 3% the potential for trucks to overturn increases (Austroads 2009). It should be noted that all PBS vehicles must meet the minimum performance requirements for static rollover threshold. In the case of a heavy vehicle with a high risk of rollover, a safe speed analysis compared with the static rollover threshold of the vehicle should be considered, particularly for movements through intersections or roundabouts with adverse crossfall greater than 3%, or if the crossfall is less than 3% but the vehicle has a high COG or 'live load' e.g. liquids or livestock.

10.12.8 Roundabouts and Complex Horizontal Geometry

Vehicle Stability

The geometry on the approach to a roundabout (reverse curves) and on the circulating carriageway may increase the risk of a heavy vehicle rollover or loss-of-control crash, this also applies to an alignment with small radius curves and no or short lengths of straight between reverse curves. A roundabout with changes in horizontal curve direction and reducing radius on the approach (reversed curves to reduce approach/entry speeds) or curvilinear alignment with reverse curves may affect the stability of a heavy vehicle. A Load Transfer Ratio (LTR) analysis should be considered, particularly if the vehicle has a high COG or live load e.g. liquids or livestock and/or the approach speeds to the first curve or curve operating speeds through the roundabout or alignment or may be high. A particular speed cannot provide as a guide for a 'high speed' as this is dependent on the curve radius, curve length and deflection angle between the entry and exit of each curve. This is why a LTR analysis is recommended.

Low Speed Swept Paths

The following issues should be considered in addition to Section 10.12.4. Heavy vehicles may encroach on the central or splitter island if the island has an apron of sufficient width to cater for the LSSP and the kerb to the apron is mountable (or semi-mountable for constrained low-speed turns). A 0.5 m clearance to light poles, signage or other structures on the central, splitter island or outside of the roundabout must be maintained. Where the number of heavy vehicle movements per day is expected to be low (by permit or historical and future movement estimates) and a roundabout has multiple lanes, a heavy vehicle may marginally encroach into the adjacent lane as long as the encroachment width does not force the other vehicle off the circulating carriageway.

Consideration of the interaction between heavy vehicle LSSP and pedestrians and cyclists should also be considered. Further guidance on providing separation between vehicles and cyclists can be found in *Technical note 128: selection and design of cycle tracks* (TMR 2015).

10.13 Railway Level Crossings

In all cases involving level crossings, the assessor is required to liaise with the appropriate rail owner and road owner/manager. The assessor should also refer to the requirements of the *Australian standard manual of uniform traffic control devices, part 7, railway crossings* (AS 1742.7:2016) and the TMR supplement. Contact details for the relevant authorities are as follows:

Queensland Rail (ODRL Coordinator) – phone: (07) 3072 1719, email: roadloads@qr.com.au

Aurizon Rail Network (ODRL Team) – phone: (07) 3019 2331.

10.13.1 Sight Distance and Signage on Approaches to Railway Level Crossings

The approach to a railway crossing should provide the appropriate sight lines and sight distance (dependent on the crossing control type) and appropriate warning signage/ pavement markings on the approaches to crossings, and regulatory signage at crossings as indicated in AS 1742.7:2016 and the TMR supplement (example in Figure 10.27). Consideration should be given to providing adequate warning signage to ensure heavy vehicles have ample time to come to a controlled stop.

Figure 10.27: Example of truck-specific railway level crossing warning signage

TC1496

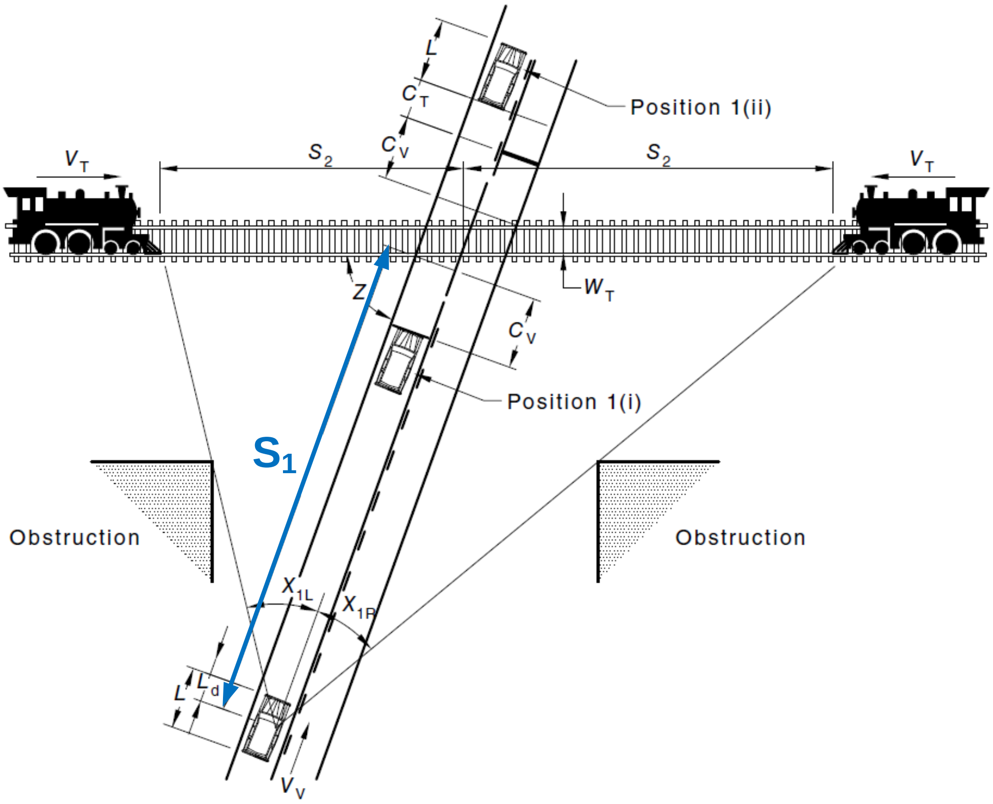
Passive Control Crossings (give-way and stop signs)

When a heavy vehicle is approaching a railway crossing controlled by a give-way or stop sign, the driver must have sufficient time to decide to either clear the crossing before a train arrives, without substantially altering the travelling speed, or decelerate to the stop at the hold line (ASD as in Section 10.11.2).

The distance required for a driver to determine if the crossing can be cleared before a train arrives is established by the available sight lines between the heavy vehicle and a train approaching from either direction as indicated by S1 in Figure 10.28.

The required S1 distance is dependent on the travel speed of the heavy vehicle and the speed of the train; the resulting distance that should be available to the heavy vehicle driver is provided in Table 10.35.

Figure 10.28: Establishing a sight distance to a passive railway level crossing



Source: AS 1742.7-2016.

Table 10.35: Sight distance required on approach to a passive level railway crossing to clear the crossing at speed (S1)

Heavy vehicle type	Grade (per cent)	Sight distance (m) for vehicle speed of 60 km/h			Sight distance (m) for vehicle speed of 80 km/h			Sight distance (m) for vehicle speed of 100 km/h		
		80 km/h train	*100 km/h train*	*120 km/h train*	*80 km/h train*	*100 km/h train*	*120 km/h train*	*80 km/h train*	*100 km/h train*	*120 km/h train*
B-doubles and Level 2A PBS vehicles	-4	209	261	313	222	277	333	240	300	360
	0	194	242	291	203	254	305	218	272	327
	+4	183	229	274	189	237	284	201	251	302
Level 2B PBS vehicles	-4	223	279	335	235	294	353	253	317	380
	0	207	259	310	215	269	323	229	286	344
	+4	195	243	292	200	250	300	211	264	317
Type 1 road trains and Level 3A PBS vehicles	-4	231	289	346	240	301	361	257	321	385
	0	215	268	322	221	276	331	233	291	350
	+4	203	254	304	206	257	309	216	269	323
Type 2 road trains and Level 3B PBS vehicles	-4	237	296	355	244	305	367	260	324	389
	0	221	276	331	225	281	337	236	295	354
	+4	209	261	314	210	263	315	219	274	328
PBS Level 4A vehicles	-4	258	322	387	259	324	389	270	337	405
	0	242	303	363	241	301	361	248	310	372
	+4	230	288	345	226	283	340	231	289	347
PBS Level 4B vehicles	-4	274	342	410	275	344	413	287	358	430
	0	256	320	384	254	317	381	261	327	392
	+4	242	303	364	238	297	357	243	303	364

Notes:

- The distances in this table represent distance S1.
- The distances in this table are greater than stopping sight distance/approach sight distance (SSD/ASD) as they allow for a vehicle to clear the railway level crossing. SSD and ASD allow enough distance for the heavy vehicle to stop before the crossing. If the distances in this table are provided, SSD/ASD will be provided by default.
- SSD/ASD are not required to factor in the train speed as the SSD/ASD should allow a heavy vehicle to stop before the crossing.

Active control crossings (flashing lights and/or crossing gates)

The visibility of the primary flashing lights and advance flashing yellow warning sign displays on the approach to crossings must allow a driver to react and safely stop if required. The sight distance to the flashing lights, or alternatively the advance flashing yellow warning signs must meet the ASD requirements as indicated in Section 10.11.2.

The timing delay between the flashing lights activating and the gate arms activating (to descend) must be long enough to allow a heavy vehicle to pass through the crossing from a stopped position before the gates close. The warning times in Table 10.36 are required for the flashing lights to be active to allow the heavy vehicle to clear a single-track crossing before the gate arms are activated; for crossings with multiple crossings or wider boom gate locations the distances and resulting clearance times in Section 10.12.1 may be used to determine an appropriate flashing light warning time duration. If the delay is not long enough, the railway access provider should be advised, and the provider must concur that the heavy vehicle operation will meet the safety requirement.

Table 10.36: Railway level crossing warning times on flat grades over a single track

Vehicle	Minimum warning time * (s)
General access (19 m semi) and PBS Level 1	8
B-double (26 m), PBS Level 2A	11
PBS Level 2B	12
Type 1 road train (e.g. A-double, B-triple, AB-triple), PBS Level 3A	14
PBS Level 3B	16
Type 2 road train (e.g. A-triple, quad combinations) PBS Level 4A	21
PBS Level 4B	22

Note: *Assumes a driver reaction time of 0.5 s.

Source: NHVR (2007).

10.13.2 Stacking Distance at Level Crossings

The distance between an intersecting road and railway level crossing (stacking distance) should be long enough to contain the length of the vehicle being assessed + 5.0 m when a heavy vehicle is stopped at the intersection of an intersecting through road or railway crossing. Stacking distance should be provided on the approach and departure of a crossing (if heavy vehicles operate in both directions) for the vehicle that operates in that direction (e.g. a PBS Level 2B may operate in one direction and a PBS Level 3A in the other direction).

The stacking distance requirements are dependent on the length of the vehicle being assessed; the required stacking distances are shown in Table 10.37.

Adequate stacking distance (Figure 10.29) will ensure that a heavy vehicle does not encroach into a through lane or store across a crossing, therefore preventing a safety and/or traffic-flow hazard, or possible train to heavy vehicle crash.

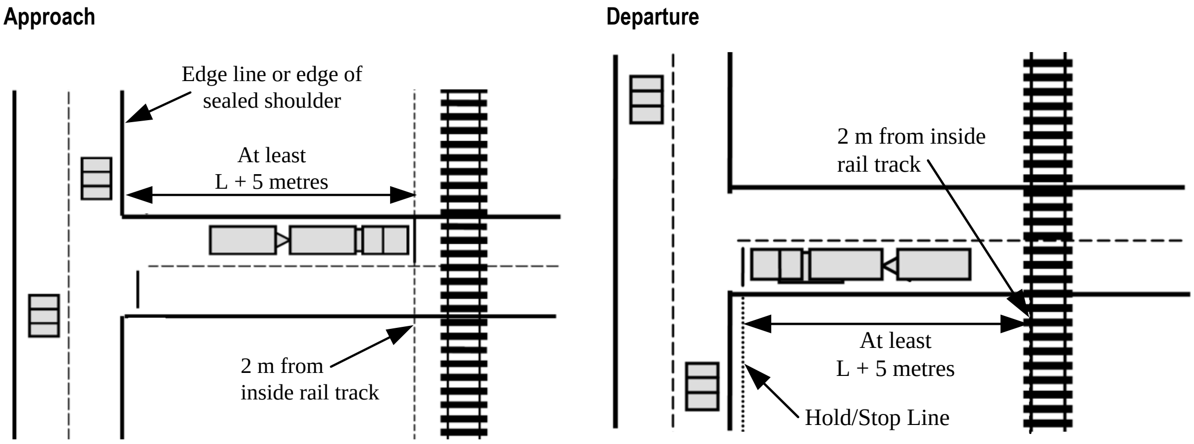
Table 10.37: Stacking distances between an intersection and railway level crossing

Vehicle	Max. vehicle length (m)	Required stacking distance (m)
General access (19 m semi) and PBS Level 1	20.0	25.0
B-double (26 m), PBS Level 2A	26.0	31.0
PBS Level 2B	30.0	35.0
Type 1 road train (e.g. A-double, B-triple, AB-triple), PBS Level 3A	36.5	41.5
PBS Level 3B	42.0	47.0
Type 2 road train (e.g. A-triple, quad combinations) PBS Level 4A	53.5	58.5
PBS Level 4B	60.0	65.0

Note:

The total stacking distance length is based on the length of the vehicle + 5 m (AS 1742.7-2016).

Figure 10.29: Adequate stacking distance between an intersection and railway level crossing



Notes:

- The diagrams represent a vehicle approaching and departing a railway crossing, however the crossing could be an intersecting road.
- The distance requirements are the same between the two intersections. The railway line in the crossing is also representative of an intersecting road.
- Where a stop or hold line is not present at an intersection, the distance should be measured 2 m back from the edge of the shoulder of the intersecting road.
- Where line-marking is not present at a level crossing, the distance should be measured 3.5 m back from the first rail line.

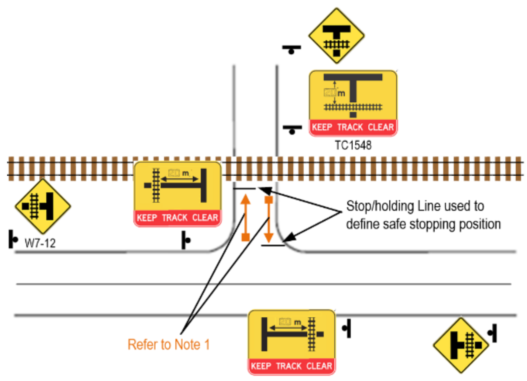
Source: Adapted from NHVR (2007).

At railway level crossing sites where the stacking distances are insufficient, consideration could be given to the volume of train movements and main road traffic. If the number of train movements is less than or equal to 10 per day and the AADT is less than 500 vehicles, the stacking distance requirements may be waived if the following steps are undertaken:

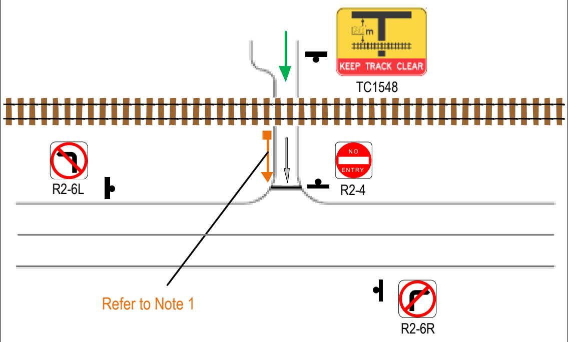
- A site inspection and formal analysis are conducted to identify that heavy vehicles will be able to clear a manoeuvre without being required to stop in the stacking distance and queue across the rail level crossing.
- Warning signage is provided to clearly identify the stacking distance hazard and the available length of the distance.
- Treatments are applied to the turn movements that are likely to have greater than 500 vehicles per day e.g. the movement turning from the through road or into a side road.

A number of suggested signage and turn treatments for stacking distances that marginally fail the distance requirements, or fail the requirements and have low train and/or vehicle volumes are provided in Figure 10.30 and Figure 10.31 but for consideration only; variants of these may also be applicable. All treatments, including those suggested, should be designed within the context of the site and provide the adequate turning path for the vehicle requiring access. The design should be approved and signed off by the appropriate person in the road authority, for example, a section manager and/or Registered Professional Engineer of Queensland (RPEQ).

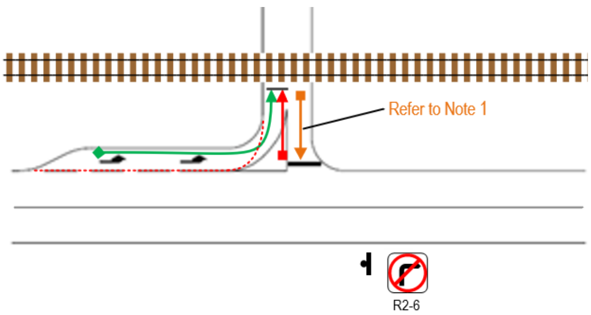
Figure 10.30: Possible treatments for short or marginally failing stacking distances at low-volume crossings



Advisory Signs and Stop/Hold Lines



Partial Closure



Left Turn Lane and Right Turn Prohibition

Unsuitable for crossings under passive control (as train may approach from behind driver in left or right-turn lanes) unless adequate width is provided and the vehicle has stopped at the hold line with an approach angle of between 70-90 degrees to the intersecting road or rail line.

Notes:

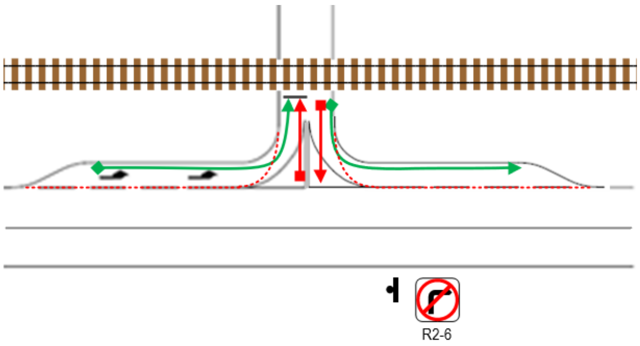
- A minimum vehicle length of + 3.5 m should ideally be provided. If this is not provided, Note 1 should be considered for approach and departure movements.
- These treatments are only relevant for railway level crossings with less than 10 train movements per day and traffic volumes of less than 500 vehicles per day.

1 If the same vehicle is to operate in both directions, when the approach stacking distance fails, the departure stacking distance will also fail. The probability of a vehicle completing the movement without any part of it being required to stop within 3.5 m of the track (due to vehicle queues or insufficient headways on the through road) should be considered. Adequate sight lines must also be available between the side road and through road.

Stacking distance met, no treatment required	Stacking distance met if this treatment is applied	Stacking distance not met however access may be granted if criteria met	If stacking distance not met, access not granted unless turn lane provided

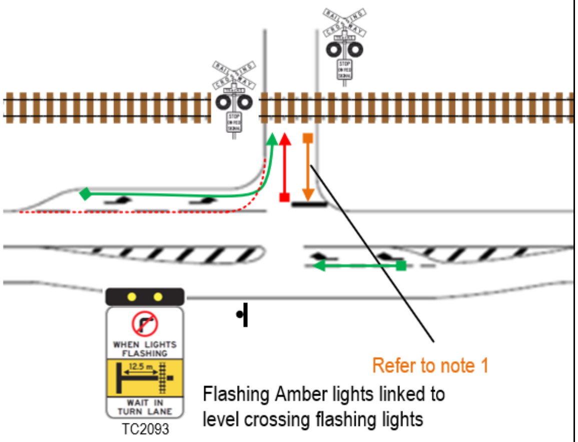
Source: Adapted from TMR (2017b).

Figure 10.31: Possible treatments for inadequate stacking distances at high-volume crossings



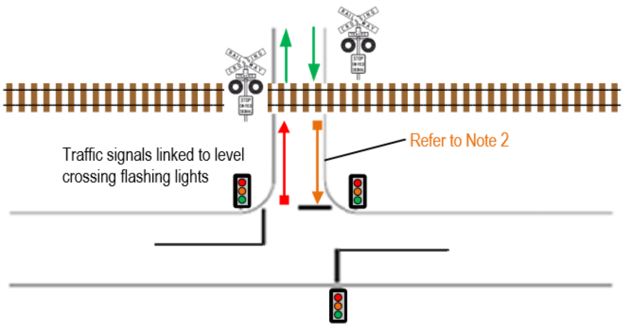
Provide Left in/Left out with auxiliary lanes

Unsuitable for crossings under passive control as train may approach from behind driver in left or right-turn lanes, unless adequate width is provided and the vehicle has stopped at the hold line with an approach angle of between 70-90 degrees to the intersecting road or rail line.



Provide Left and Right Turn Lanes on through road

Unsuitable for crossings under passive control as train may approach from behind driver in left or right-turn lanes, unless adequate width is provided and the vehicle has stopped at the hold line with an approach angle of between 70-90 degrees to the intersecting road or rail line. TC2093 is optional but is recommended.



Traffic Signals

For very short stacking distances, the stop line and signal display on the departure side of the crossing may be relocated to the approach side of the crossing.

Notes:

1 If the same vehicle is to operate in both directions, when the approach stacking distance fails, the departure stacking distance will also fail. The probability of a vehicle completing the movement without any part of the vehicle being required to stop within 3.5 m of the track (due to vehicle queues or insufficient headways on the through road) should be considered. Adequate sightlines must be available between the side road and through road.

2 This departure leg should be given priority to ensure vehicles are not stacked across tracks. Consideration should be given to ensuring that queue lengths on the through road do not restrict this leg from clearing during a green phase. In high volume or urban areas, the active crossing treatment should be accompanied with signals to ensure queuing does not occur across tracks.

Stacking distance met, no treatment required	Stacking distance met if this treatment is applied	Stacking distance not met however access may be granted if criteria met	If stacking distance not met, access not granted unless turn lane provided

Source: Adapted from TMR (2017b).

10.14 Overtaking

Overtaking opportunities are provided so that a specified level of service (LOS) is available for all vehicles using the route (Table 10.38). The LOS defines the quality of traffic flow as related to a number of road and traffic attributes which affect flow performance. Heavy vehicles operating on a route should not impede or delay other traffic beyond the current/expected LOS. TRARR (TRAffic on Rural Roads) is a software package which can be used to calculate the number of vehicles following a heavy vehicle based on the overtaking opportunities. Subsequently, the outputs of a TRARR assessment can be used to determine the LOS as shown in Table 10.39.

Six LOS are designated, from A to F, with A corresponding to free-flow conditions and F corresponding to full capacity. Level of service C expresses user expectations for flow conditions on the intermediate to high volume two-lane roads and this level of service is used as the performance level for L1 and L2 class roads see Table 7. Similarly, LOS B is recommended for L3 and L4 class roads as it denotes user expectations for flow conditions on low to intermediate volume two-lane roads.

Heavy vehicles tend to operate at lower average speeds along the length of a route compared to light vehicles. If sufficient overtaking opportunities are not provided, drivers of light vehicles may experience delays and, in some cases may form queues of vehicles waiting to overtake. This may result in driver frustration and increase the risk of drivers attempting to overtake when it is not safe. Therefore, it is essential from a road safety perspective to have adequate overtaking opportunities on a heavy vehicle route. Existing overtaking opportunities when using the opposing lane, or designated overtaking lanes, may not provide sufficient length to overtake the heavy vehicle being considered for access.

Table 10.38: Recommended LOS for desired heavy vehicle access

Performance standard	Performance measure	Required performance level when providing access for heavy vehicle				Test specification
		General access / Level 1	B-double / PBS Level 2	Type 1 RT / PBS Level 3	Type 2 RT / PBS Level 4	
Overtaking provision	The time taken for another vehicle to safely overtake the subject heavy vehicle related to the available overtaking opportunities and a target traffic flow level of service.	Level of service C	Level of service C	Level of service B	Level of service B	Specific to road and traffic conditions.

Source: Adapted from NHVR (2007).

Table 10.39: Relationship between LOS and percent time delayed, and LOS and percent time following

Level of service	% time delayed (Austroads 1998c)	% time following as per TRARR assessment
A	< 30	< 30
B	< 45	< 55
C	< 60	< 70
D	< 75	< 80
E	> 75	> 80
F	100	100

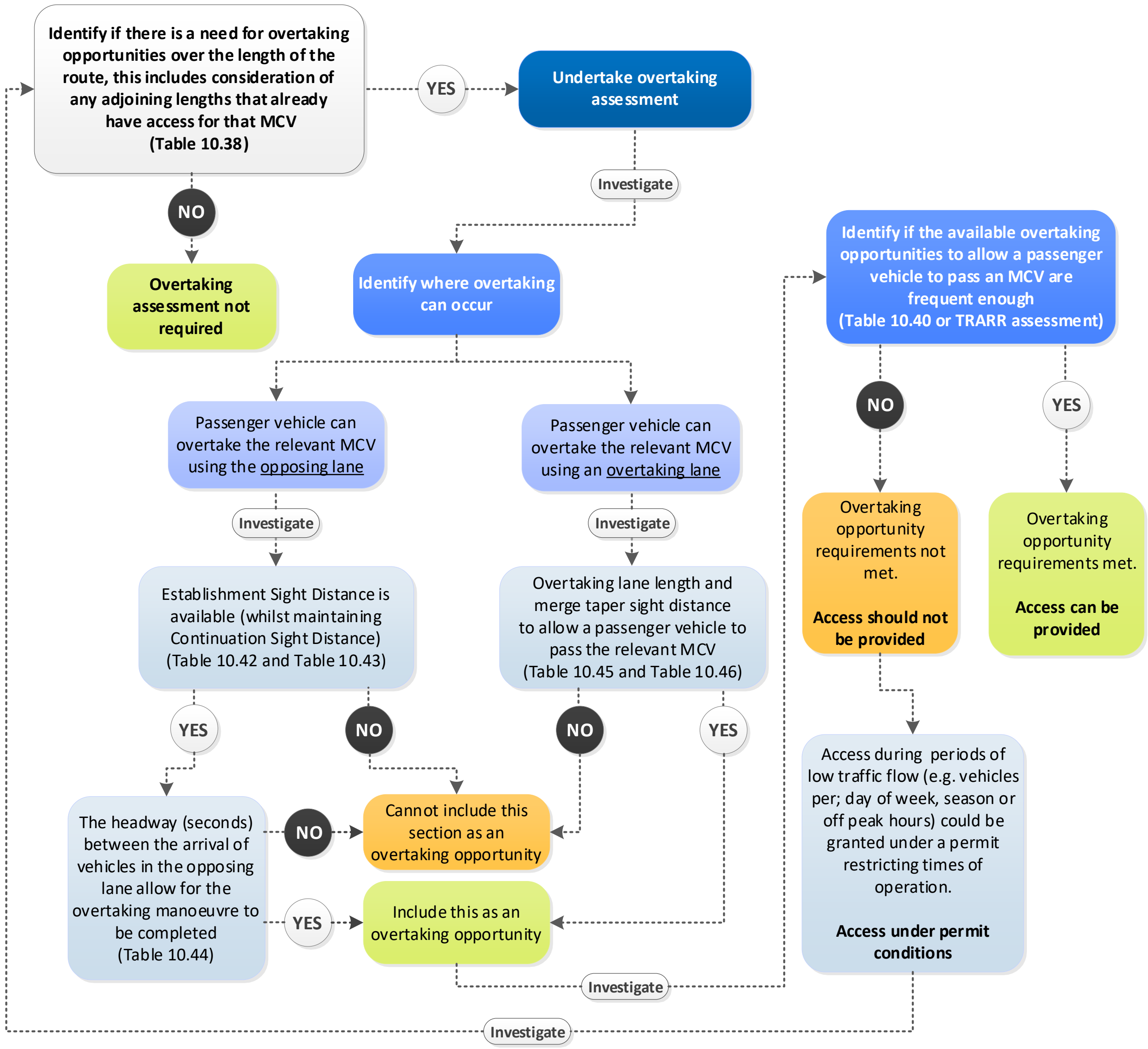
Source: TMR (2002).

When assessing overtaking, the following issues should be considered to determine if an appropriate level of service will be maintained/provided if a heavy vehicle is granted access:

- a sufficient number of overtaking opportunities are provided (Section 10.14.1)
- each overtaking opportunity (using the opposing lane) has sufficient overtaking sight distance and gaps between the arrival of vehicles in the opposing lane to pass the heavy vehicle to be granted access (Section 10.14.2)
- each overtaking lane has sufficient lane and merge length to pass the heavy vehicle to be granted access (Section 10.14.3).

An illustration of the process to assess overtaking is provided in Figure 10.32.

Figure 10.32: Overtaking provision assessment process



10.14.1 Overtaking opportunities

The suitability criteria for provision of overtaking opportunities are shown in Table 10.40. In all cases, the assessment of steep ascending grades in Section 10.10 must be performed separately.

It is recommended that AADT figures are used to assess overtaking opportunities, however the assessor should consider the impact of seasonal traffic during the assessment, as the AADT could be less than seasonal peak traffic volume.

The volume of traffic and the percentage of heavy vehicles on the route affects the requirement for overtaking opportunities. To assess the suitability of overtaking, an AADT derived using the PCE factors (Table 10.41) should be used. PCE factors represent the equivalent number of light vehicles for a particular type of heavy vehicle. The use of PCE factors provides a derived AADT value that can then be used to better assess overtaking opportunities.

If the route does not meet the criteria in Table 10.40, consideration needs to be given to whether access could be granted under a permit with restricted times of operation such as off-peak hours, days of week with low volumes, particular times of the year when the traffic volumes are lower etc.

For sections of road to be suitable for overtaking, the criteria as discussed in Section 10.14.2 and Section 10.14.3 should first be met.

Table 10.40: Suitability criteria for frequency of overtaking opportunities

AADT (derived using PCE factors)	Average distance between overtaking opportunities (km)	Maximum distance between overtaking opportunities (km)	Notes
< 100	N/A	N/A	Provision of additional opportunities is usually not justified.
101 to 500	30	50	-
501 to 1000	15	30	-
1001 to 1800	8	15	-
1801 and above	5	10	At AADT > 2700, additional opportunities that exceed the criteria may be necessary.

Note:

The distance requirements can be relaxed (a shift of one AADT range in the table is considered appropriate) when heavy vehicles represent less than 5% of total traffic and where other users can be expected to be familiar with the operation of multi-combination vehicles and/or appropriate signage as indicated in Section 9.1 is provided.

Source: NHVR (2007).

Table 10.41: Passenger car equivalent (PCE) factors for heavy vehicles

Vehicle types	PCE factors on flat terrain	PCE factors on rolling terrain
Austroads Class 2	1	1.3
Austroads Class 3 to 5	2	3.5
Austroads Class 6 to 9	2.5	5
Austroads Class 10 (B-double / PBS Level 2)	4	10
Austroads Class 11 (Type 1 RT / PBS Level 3)	4	10
Austroads Class 12 (Type 2 RT / PBS Level 4)	9	22

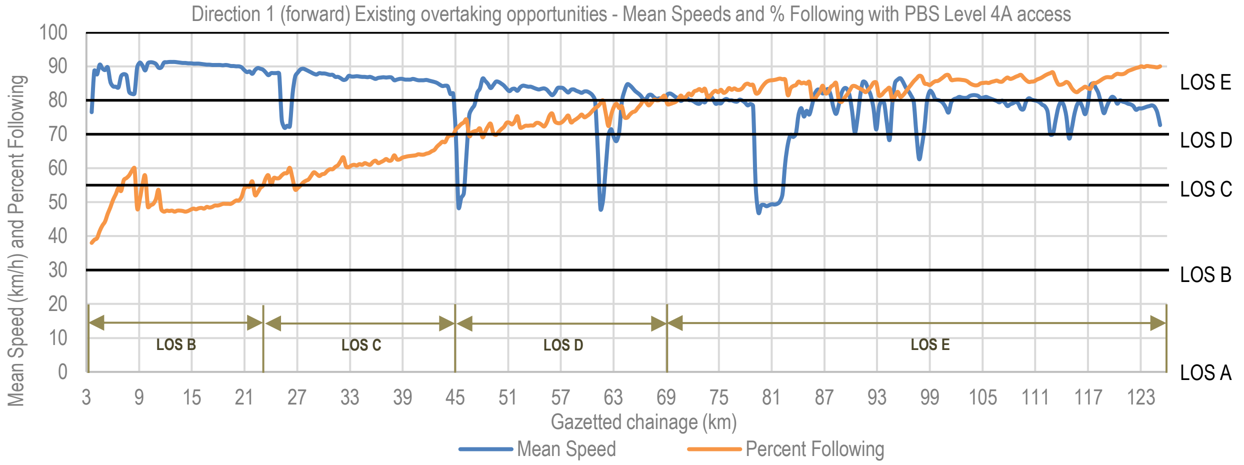
Source: MRWA (2017).

TRARR assessment

TRARR (TRAffic on Rural Roads) is a software package developed by ARRB which calculates the percentage of vehicles following a heavy vehicle and can be used to determine the LOS. TRARR provides an alternative method to using the criteria as given in Table 10.40. TRARR can be used to model the relationship between the number of and location of overtaking opportunities that meet the criteria in Section 10.14.2 and Section 10.14.3, traffic performance based on horizontal and vertical terrain using the heavy vehicle that is being considered for access and existing (or forecast) AADT and traffic composition. As such, it can assess traffic performance on a specific road and determine if the existing overtaking opportunities will result in the appropriate level of service. TRARR can be used to model the potential improvements in LOS by extending the lengths of existing overtaking lanes or providing additional overtaking lanes. For further information, refer to ARRB (2016) and the TRARR user manual.

An example of a TRARR assessment showing the LOS when providing access to a heavy vehicle with existing overtaking opportunities and then with additional overtaking opportunities is shown in Figure 10.33 and Figure 10.34 respectively.

Figure 10.33: TRARR results for existing overtaking opportunities if PBS Level 4A is granted access

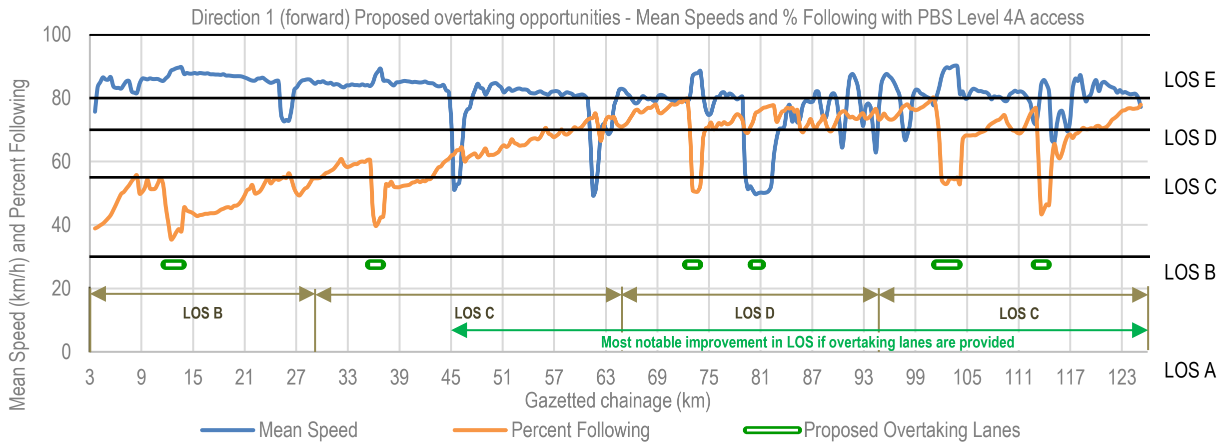


Note:

- The LOS for a section of road is determined by the average percent following over the section e.g. Ch. 69–123 has a LOS E.

Source: Milling et al. (2017).

Figure 10.34: TRARR results for proposed overtaking lanes if PBS Level 4A is granted access



Notes:

- The LOS for a section of road is determined by the average percent following over the section e.g. Ch. 66–94 has a LOS D and Ch. 94–123 LOS C
- Overtaking lane locations and lengths are selected based on suitable topography and available funding.

Source: Milling et al. (2017).

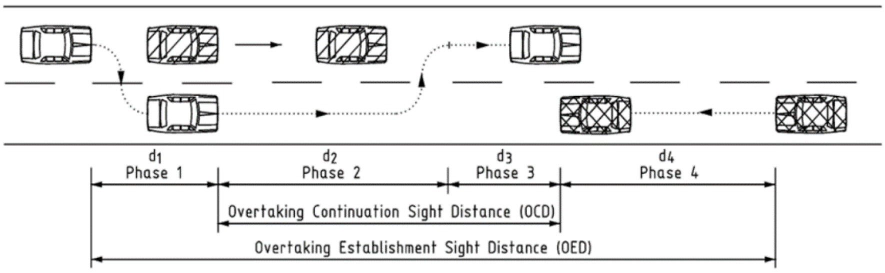
10.14.2 Overtaking in the opposing lane

An overtaking opportunity where a passenger vehicle can overtake a heavy vehicle when using the opposing lane should have sufficient overtaking sight distance and time between oncoming vehicles to complete the overtaking manoeuvre.

The overtaking sight distances to overtake a heavy vehicle in the opposing lane are the establishment sight distance (ESD) and continuation sight distance (CSD) (Figure 10.35). The passenger vehicle overtaking the heavy vehicle should be provided with ESD (Table 10.42) at the start of the manoeuvre and be able to maintain CSD (Table 10.43) while in the opposing lane. The arrival of vehicles in the opposing lane (headway) should be greater than the time it will take for a passenger vehicle to complete the overtaking manoeuvre (Table 10.44).

These overtaking sight distances and times required to complete an overtaking manoeuvre were calculated based on a number of assumptions regarding the proportion of drivers who will accept an overtaking opportunity and overtaken and overtaking vehicle speeds. In practice, there is considerable variation in the distances required for overtaking manoeuvres and in driver preparedness to initiate the manoeuvre or the selected overtaking speed. Hence, the information in Table 10.42 to Table 10.44 is a general indication of the requirements for an overtaking opportunity and provides estimates of available sight distance requirements for most route assessment purposes. An assessor should consider the context of the site, heavy vehicle and passenger vehicle operating speeds, if road users can be expected to be familiar with the operation of heavy vehicles, and/or appropriate signage as in Section 9.1 is provided to warn of the length of heavy vehicles operating on the route when considering if sight distance requirements are met.

Figure 10.35: Overtaking manoeuvre (in the opposing lane)



Source: Austroads (2016a).

Table 10.42: Minimum establishment sight distances for overtaking in the opposing lane

Road section operating speed (km/h)	Overtaken vehicle speed (km/h)		Establishment sight distance (m)				
	Semi-trailer, B-double, PBS Level 2	Type 1 and 2 road train, PBS Level 3/4	Semi-trailer, PBS Level 1	B-double, PBS Level 2A	Type 1 road train, PBS Level 2B, 3A	Type 2 road train, PBS Level 3B, 4A	PBS Level 4B
70	60	60	570	600	640	690	720
80	69	69	710	740	790	860	900
90	77	77	850	890	950	1,040 *	1,080 *
100	86	84	1,020 *	1,070 *	1,130 *	1,240 *	1,290 *
110	94	84	1,230 *	1,290 *	1,200 *	1,310 *	1,360 *

Note:

*It is expected that given their relatively low eye height (i.e. approximately 1.15 m), most passenger vehicle drivers would not be able to distinguish differences in sight distance of about 1000 metres. Hence, the listed sight distance values above 1000 m can be regarded as met when the actual sight distance exceeds 1000 m.

Source: SMEC (2015).

Table 10.43: Minimum continuation sight distance for overtaking in the opposing lane

Road section operating speed (km/h)	Overtaken vehicle speed (km/h)		Continuation sight distance (m)				
	Semi-trailer, B-double, PBS Level 2	Type 1 and 2 road train, PBS Level 3/4	Semi-trailer, PBS Level 1	B-double, PBS Level 2A	Type 1 road train, PBS Level 2B, 3A	Type 2 road train, PBS Level 3B, 4A	PBS Level 4B
70	60	60	300	320	360	420	450
80	69	69	370	400	450	510	550
90	77	77	440	470	530	620	660
100	86	84	530	560	630	740	790
110	94	84	620	680	660	770	820

Source: SMEC (2015).

Table 10.44: Overtaking vehicle classifications based on average headway between vehicles in opposing lane

Road section operating speed (km/h)	Overtaken vehicle speed (km/h)		Time required between the arrival of vehicles in the opposing lane for passenger vehicle to overtake a heavy vehicle based on ESD (seconds)				
	Semi-trailer, B-double, PBS Level 2	Type 1 and 2 road train, PBS Level 3/4	Semi-trailer, PBS Level 1	B-double, PBS Level 2A	Type 1 road train, PBS Level 2B, 3A	Type 2 road train, PBS Level 3B, 4A	PBS Level 4B
70	60	60	29	31	33	35	37
80	69	69	32	33	36	39	41
90	77	77	34	36	38	42	43
100	86	84	37	39	41	45	46
110	94	84	40	42	39	43	45

Notes:

- These times are indicative only, however if not met further analysis should be undertaken. A TRARR analysis is one method that can be used.
- If sight distance is available, the longest vehicle that can be overtaken based on the minimum time required to overtake (within the available average headway) becomes the classification.

10.14.3 Overtaking using an overtaking lane

An overtaking opportunity where a passenger vehicle can overtake a heavy vehicle when using an overtaking lane should have sufficient lane length (Table 10.45) and merge sight distance (Table 10.46).

Table 10.45: Overtaking lane lengths

Road section operating speed (km/h)	Overtaking lane lengths (excluding taper lengths (m) [1,2,3]	
	Minimum	Desirable
80	400	650
90	475	775
100	550	950
110	620	1070

Notes:
1. Derived from Table VI (Hoban & Morrall 1986).
2. Refer to Table 9.8 in Austroads Guide to Road Design Part 3 for diverge and merge taper lengths.
3. For road train routes, lengths should be 1.5 times the desirable.

Source: Austroads (2016a).

Table 10.46: Merge sight distance at the end of the overtaking lane for cars overtaking heavy vehicles

Road section operating speed (km/h)	Multi-combination vehicles			
	Car and prime mover semi-trailer	B-double	Type 1 road train	Type 2 road train
50	110	120	130	145
60	135	145	160	180
70	165	180	195	225
80	200	220	245	285
90	250	270	305	355
100	300	330	345	400
110	375	410	410	435
120	430	430	430	435
130	450	450	450	450

Source: Austroads (2016a).

10.14.4 Speed Differential Due to Grades

A slow-moving vehicle on an incline may result in an unreasonable percentage of other road users being platooned behind the vehicle, thus affecting the LOS on the road.

If the number of vehicles following a slow-moving vehicle on an incline or decline are determined to be unreasonable and an overtaking opportunity is not provided on the grade or after the grade, the LOS is likely to decrease; this may result in driver frustration and increase the risk of drivers attempting to overtake when it is not safe.

An overtaking lane on, or in proximity to an incline or decline may be required if the heavy vehicle travel speeds reduce to 40 km/h. Guidance regarding estimating heavy vehicle speeds on inclines is provided in Section 10.10 estimations of heavy vehicle speeds on declines may be determined from local knowledge or via a heavy vehicle simulation.

10.15 Vertical (Overhead) Clearance

Heavy vehicles, particularly those with high loads, are more likely to strike overhead objects or structures. Assessors should confirm that adequate overhead clearances as in the guidance in Table 10.47 are available along the entire length of the proposed route. The overhead clearance is the distance from the top of the vehicle to the overhead obstruction. The maximum heights for some vehicles are provided in Table 10.48, however the height of the vehicle should always be confirmed.

Table 10.47: Vertical (overhead) clearance requirements

Overhead obstruction type	Overhead clearance height between heavy vehicle and obstruction	Notes
Rigid	0.4 m	▪ Includes overhead obstructions such as bridges and overpasses ▪ Structures with less than 5 m clearance (from the road surface) should be signed to show the clearance level to the nearest 0.1 m
Non-rigid	0.5 m	▪ Includes overhead obstructions such as wires and trees ▪ Where high voltage power lines cross the route, the minimum overhead clearance requirements must be checked with the local electricity authority: – Origin Energy: website: https://www.essentialenergy.com.au/partners/high-load-permit – Ergon Energy – phone: 13 74 66, e-mail: highloads2@ergon.com.au, website: https://www.ergon.com.au/network/safety/industry-safety/high-loads-and-powerlines – Energex – e-mail: HighLoadEscort@energex.com.au website: https://www.energex.com.au/contractors-And-service-providers/document-library/forms ▪ Where electric overhead wiring exists at level crossings, height clearance requirements need to be checked with the relevant rail authority, refer to Section 10.13 for contact details

Source: Adapted from HVNL

Table 10.48: Heavy vehicle maximum vehicle heights

Vehicle type	Maximum overall height (m)
Vehicles carrying livestock (cattle, horses, pigs or sheep)	4.6
Built with at least two decks for carrying vehicles	4.6
Double-decker buses	4.4
All other vehicles	4.3

Source: Adapted from HVNL

11 AMENITY CONSIDERATIONS

Assessors determining route suitability need to consider the impacts that increased heavy freight traffic will have on the community. The primary considerations are noise, exhaust emissions and airborne dust. Furthermore, it is good practice to consider the lane use adjacent to heavy vehicle routes, to minimise the likelihood of amenity impacts on businesses or facilities on or near the routes.

11.1 Adjacent Land Use

It is desirable for heavy vehicle routes to have minimal conflicts with other road users for safety and amenity reasons, especially when adjacent to special land use types. These include schools, hospitals, aged care facilities, wildlife corridors and shopping centres.

Land use planning seeks to order and regulate land users to choose options that prevent conflicts, increase productivity, meet social needs and are sustainable. The Queensland Department of Infrastructure, Local Government and Planning (DILGP) is responsible for coordinating lane use planning within Queensland, working with other state government agencies, and the federal and local governments.

Regional land use planning and the production of planning schemes outlining future developments is primarily undertaken by local government. Therefore, the assessor may liaise with DILGP to understand the impacts heavy vehicle movements may have on current and future businesses and facilities present on or near the roads under assessment.

11.2 Noise

Heavy vehicles generate more traffic noise than other vehicles, particularly when braking, accelerating, and travelling over rough roads. The assessor needs to consider whether the increase in the number of heavy vehicles on the route has the potential to cause a significant noise impact by considering the following:

- areas sensitive to road traffic noise (dwellings, schools, hospitals)
- factors contributing to noise generated by heavy vehicles, such as
  - intersections/grades and other acceleration/deceleration areas (higher engine speeds, gear changing or use of engine braking); these should be at least 1500 m from noise-sensitive areas
  - road segments that contain high proportions of roughness and/or irregularities; these should be at least 300 m away from noise-sensitive areas
- factors mitigating the impact of noise from heavy vehicle traffic, such as the distance to noise-sensitive areas and the presence of natural noise barriers such as hills and vegetation, which should be confirmed by site inspection.

In some cases, the noise generated by heavy vehicles is unavoidable and may be acceptable for buildings located within the specified distances and could be confirmed via further investigation and consultation. If warranted, the assessor could engage a suitably qualified consultant to conduct a traffic noise assessment.

If noise impacts are expected to be significant, the assessor needs to consider options for mitigation, such as:

- signs advising drivers to avoid using engine brakes
- a curfew for heavy vehicles to prohibit operation during night-time hours

- alternative routes
- noise certification of heavy vehicles as a condition of access
- the installation of noise barriers along the sides of the road
- the construction of noise attenuation treatments
- speed restrictions.

The main criterion for noise impact assessment is the change in the number of trucks (three or more axles) on the route. Doubling the number of heavy vehicles can be considered as the start of a significant noise change while quadrupling can be considered a very significant change. However, on very low volume roads, approving the route may significantly increase the number of large trucks, but overall truck numbers may remain low enough so as not to cause a significant noise impact.

It should be noted that the noise emissions from existing as-of-right and PBS vehicles are similar to those from the conventional rigid and articulated vehicles. Therefore, the use of longer and heavier vehicles can decrease total noise emissions over a set period, as fewer heavy vehicles are required for a given freight task.

11.3 Emissions and Odours

Heavy vehicles are considerable producers of exhaust emissions, and in the case of vehicles carrying livestock, can produce undesirable odours. This may be of concern to the occupants of sensitive facilities such as dwellings and schools, especially when vehicles remain in the vicinity while on the route, such as when held up at intersections. The potential amenity impacts should be investigated. The route should not be recommended for approval if there are known problems caused by odours and fumes, or if the assessor judges that such problems are likely to be created by allowing specific vehicles to access the route.

11.4 Airborne Dust and Water Splash/Spray

The effects of airborne dust and the potential for splash and spray of rainwater from the pavement by heavy vehicles should be considered. These factors can adversely impact other vehicles, pedestrians, and cyclists where the route passes close to abutting developments, especially when the route is unsealed.

TMR (2013a) indicates that splash and spray emanating from a heavy vehicle is related to the number of wheels and becomes significant above 80 km/h. National guidelines (NHVR 2007) provide advice regarding the likelihood that dust, splash and spray can become problematic, relating to the speed limit, AADT, and the types of vehicles operating on the road, as shown in Table 11.1. The listed preferred provisions should be considered.

The assessor needs to consider whether the introduction of heavy vehicles onto the route has the potential to cause significant dust, splash or spray impact by considering:

- distance to buildings and their use
- likely numbers of heavy vehicles
- likelihood of significant amounts of dust, splash or spray
- mitigation options, including spray suppression equipment, alternative routes, speed restrictions and sealing sections of the route.

Note that while spray suppression equipment has a moderate effect, it does not stop all the spray being thrown out the sides and rear of the vehicle.

Table 11.1: Dust, splash and spray guidance

Vehicle type	Posted speed limit (km/h)	AADT	Preferred provisions to reduce dust, splash and spray
B-double or PBS level 2 vehicle	< 80	No limit	The road should be sealed, preferably with a sealed shoulder, though an unsealed shoulder is acceptable
	> 80	< 10 000	
	> 80	> 10 000	The road should be sealed with a sealed shoulder
Type 1 road train or PBS Level 3 vehicle	< 80	No limit	The road should be sealed. Unsealed shoulders are acceptable
	> 80	< 1 000	
	> 80	> 1 000	The road should be sealed with a sealed shoulder
Type 2 road train or PBS Level 4 vehicle	< 80	Any	Unsealed roads are acceptable; however, speeds should not exceed 80 km/h
	> 80	Any	The road should be sealed with a sealed shoulder

Source: NHVR (2007).

11.5 Seasonality

Seasonal fluctuations in traffic flow are expected throughout certain sections of the road network during peak holiday periods (e.g. Easter and Christmas) and harvest seasons. For routes that experience high seasonal traffic volumes, it may be undesirable to approve heavy vehicle access at that time of year.

The assessor needs to consider whether the introduction of heavy vehicles onto the route has the potential to significantly disrupt regular operation, considering:

- economic benefits of approval (such as during grain harvest season)
- likely number of heavy vehicles using the route and the risks posed to general traffic not expecting heavy vehicles
- mitigation options, including temporary permits to satisfy seasonal access requirements and curfews on operational hours.

11.6 Off-street parking

Guidance on off-street parking is not included in these guidelines. Information can be sourced from NHVR (2007), MRWA (2017) and TMR (2018a).

12 STRUCTURES ASSESSMENT

12.1 Introduction

As an asset owner and road manager, local councils are often called upon to assess applications for heavy vehicle access to a particular route and confirm that the structures on the route are capable of carrying the specific vehicles (or other) loads. These assessments arise when the vehicle does not comply with existing load limits for the requested route. The assessment of an application is referred to as a load rating assessment and involves the comparison of the requested vehicle to the known/calculated capacity of the structure. This assessment typically requires experienced practitioners who may not be readily available in-house in local councils. In most cases, a consultant is engaged to carry out such tasks.

It should be noted that most state road agencies currently have in-house capability for undertaking the load rating assessment. Within TMR all structural assessments are undertaken by the Structures Management section.

This section discusses what information is required to undertake a load rating assessment, what processes are involved and a hierarchal approach to completing an assessment. The intent is to ensure that on granting consent for a vehicle to travel, the road manager can be confident and understand what risks and impact the vehicle may have on the structures on the route. The following issues are discussed below:

- guidance on how to identify, assess and prioritise at-risk structures on a route
- descriptions of the hierarchical approach to the load rating assessment of bridges
- general guidance outlining the decision-making process, including a flowchart illustrating the hierarchical approach recommended.

12.2 Hierarchical Approach to Bridge Load Rating Assessment

A hierarchical approach can provide the road manager with a tailored, fit-for-purpose and hence cost-effective methodology to achieve the desired outcomes. This approach includes the following stages (which are further described in the section):

- desktop review, to establish/improve the knowledgebase of the structure assets
- load rating assessments (Tiers 0, 1 and 2), to improve the understanding of the current load carrying capacity of the structures on a particular route.

12.2.1 Establish the Knowledge-base of the Structure Assets

When preparing to undertake the assessment of structures on a requested route, the following information is critical to the assessment process:

- Structure location – how many structures require assessment and where are they.
- Design loading – what design standard/vehicle was each structure designed to. Very often structures may have a loading panel installed identifying the age of construction and design loading.
- As-built records – whether as-built drawings are available. This is not so critical for timber or steel superstructures or a Tier 0 assessment, however, it is essential for reinforced and prestressed concrete structures when structural capacity is assessed (refer to Section 12.3), as otherwise intrusive techniques may be required to determine the presence and location of reinforcement bars, strands or tendons.
- Geometry – how many spans, span lengths, carriageway widths/line markings are present.

- Articulation – whether spans are simply supported or continuous.
- Age – how old the structures are.
- Condition – what condition are the structures currently in. Structural condition is typically documented in the form of a Level 2 condition report which comprehensively identifies the condition of each component on the structure. Current condition would be considered as the most recent Level 2 inspection report that has been conducted in accordance with the time frames outlined in the TMR *Structures inspection manual*.
- Current/historic usage – what are the current levels of service.
- Structural modification – whether there have been major structural rehabilitation/strengthening works conducted on the structure. What design standard/vehicle was used for the works.
- Previous load rating assessment – whether the structure has previously been assessed, if so:
    - when was it performed
    - to what tier
    - what was the outcome
    - has the structure subsequently been refurbished/strengthened to address any deficiency identified by the assessment i.e. is the previous assessment still current.
- Existing restrictions – whether there are any current restrictions imposed on the structure that will impact on capacity or indicate deficiencies (e.g. posted mass limits, speed restrictions etc.).

Industry best practice would ensure that this information should be readily available and captured in the organisation's bridge (structure) information system. If this is not the case, then it is recommended that efforts be directed toward capturing this information.

The condition of all structures on the network should be readily available based on a program of inspection developed and undertaken in accordance with the procedures and frequencies outlined in the inspection policy. Typically, within Queensland and in the absence of any council inspection manual, this would be in accordance with the TMR *Structures inspection manual* and involve a prioritised program of Level 1 and Level 2 inspections undertaken by qualified/experienced personnel.

All information outlined above can be captured, if available, by undertaking:

- a Level 2 inspection of the structure (including geometric survey)
- reviewing existing drawings, construction records or contract documents to identify remaining information.

Given the limited time frames involved in responding to an application, these activities should be conducted as a priority for the structures on the network to ensure this information is on hand prior to receiving an application.

12.3 Tiers of Load Rating Assessment

While this document is not intended to provide guidance on the analysis techniques to be employed when undertaking a load rating assessment, some background on how the assessment of bridges is approached in Australia is presented below.

12.3.1 Background

Load rating assessments in Australia are typically undertaken in accordance with the requirements set out in AS 5100-2017. AS 5100.7 – *Bridge design: bridge assessment* is included in this set and provides specific guidance for the assessment of existing structures as distinct from the design of new structures, which typically needs to consider an extensive design life. The 2017 standard provides more detailed guidance than previous revisions. Furthermore, it recognises the hierarchical approach adopted by most jurisdictions.

AS 5100.7 notes that current assessment and load rating methods include:

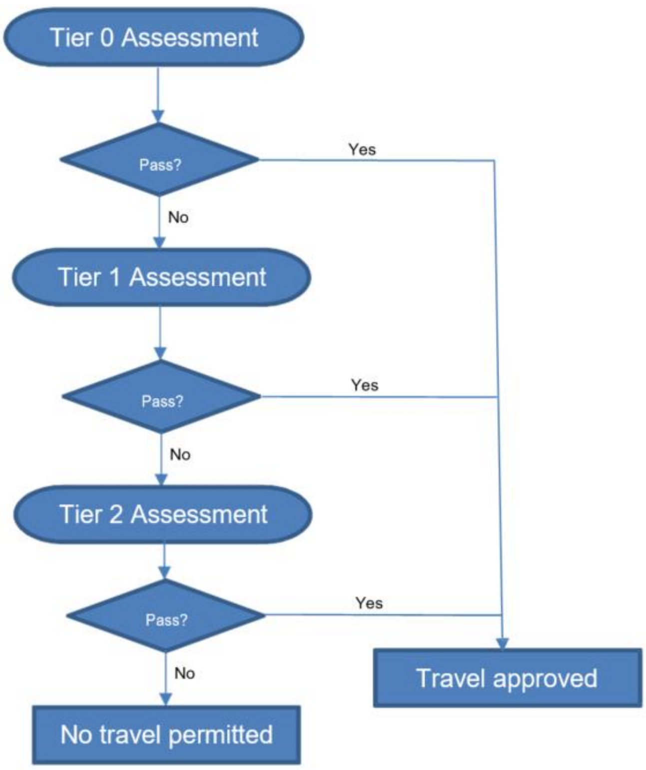
(a) a comparison check with the original design loading
(b) theoretical analysis/computer modelling based on the parameters in AS 5100.7
(c) more sophisticated theoretical analysis using techniques such as finite element or other advanced analysis methods
(d) analysis using the results of field investigation of material properties, bridge component dimensions, dead and traffic loads, foundation capacity and the like
(e) bridge-specific traffic load assessment
(f) field or laboratory test loading, e.g. proof, static and dynamic load testing
(g) structural health monitoring.

The above list typically correlates with the tier system outlined below, noting that the system is different from the Tier 1, 2 and 3 assessments set out in the PBS access guidelines:

- Tier 0 – Complete step (a) from AS 5100.7 load rating methods
- Tier 1 – Complete step (b) from AS 5100.7 load rating methods
- Tier 2 – Complete steps (c) to (g) from AS 5100.7 load rating methods.

The following section discusses the various levels or tiers of assessment typically undertaken when reviewing an application to travel across a structure. This hierarchical approach involves applying increasing levels of sophistication (and typically cost) to each tier to ensure that limited resources are focussed on the bridges identified as representing the greatest risk (Figure 12.1). The tiered approach described in this section aligns with the approach described in AS 5100.7 and the methodology adopted by TMR.

Figure 12.1: Simplified structures load rating assessment hierarchy



12.3.2 Tier 0 assessment

The Tier 0 assessment is considered the simplest form of assessment, consisting of a comparison of the load effects induced by the application vehicle with the original design vehicle for the structure. This is the simplest method which is conservative in most instances.

The assessment can be undertaken of both the superstructure and substructure as required and involves determining the peak effects for both application and design vehicles. The ratio of effects is then calculated as follows (Equation 1):

$$\text{Tier 0 assessment ratio} = \frac{\text{peak design vehicle effect}}{\text{peak application vehicle effect}} \qquad (1)$$

where

the vehicle effect should include bending moment, shear force and support reaction.

A ratio greater than 1.0 indicates the load effects of the application vehicle are less than those induced by the vehicle for which it was designed, and the vehicle may travel.

Load effects are typically determined using a simple line beam model and consequentially are quick and reliable to calculate. However, this method does not involve any calculation of structural capacities and assumes that the bridge was designed and constructed in accordance with the applicable design standard.

The Tier 0 approach can be applied across many structures in the network and provides a means of rapid assessment of the structures on a given route/network, however this approach requires knowledge of the design loading to which the bridge was originally designed. If design loading is unknown, but the age of the bridge is, then it may be possible to infer the design loading based on knowledge of the design standards (or local practice) in use at the time. However, it must be recognised that this approach may be non-conservative, and outputs should be treated with caution.

Similarly, if the bridge is currently operating with no restrictions (i.e. to current mass limits or other approved higher limits), then the application vehicle effects can be compared with existing legally loaded GML or HML vehicles travelling on the route.

It should be recognised that because no calculation of structural capacity is undertaken, Tier 0 assessments do not consider the condition of the structure and it is imperative that a review of structure condition be undertaken prior to accepting the results of an assessment. Tier 0 assessments should not be used where evidence of structural distress/deterioration is present in a Level 2 inspection report (defects or issues which could affect the capacity of the structure) until further investigation and higher-order assessments are completed to identify the capacity of the structure with consideration of the condition.

In the circumstances where the configuration of the design vehicles is significantly different from the assessment vehicles, engineering judgement is required to justify the lateral load distribution on the structural components and the assessment should typically be elevated to a higher tier.

An example of a Tier 0 load rating assessment is provided in Appendix E.1.

12.3.3 Tier 1 assessment

The Tier 1 assessment is essentially a load rating assessment based on the assessment criteria outlined in AS 5100.7. In this assessment, the structural capacity of a bridge component is compared with the vehicle load effect. This assessment requires bridge design/assessment experience and appropriate software and is more accurate than a Tier 0 assessment.

Appropriate numerical modelling methods for the type of structure under consideration are employed to determine the residual ultimate limit state (ULS) live load capacity of any components or group of components that could be critical under live load effects. The critical effects may include bending moment, shear, torsion, direct force, bearing, foundation failure or an interaction of any of these. The residual live load capacity is then compared with the critical effects of the application vehicle to determine the assessment ratio (Equation 2):

$$\text{Tier 1 assessment ratio} = \frac{\text{available ULS capacity for live load effect}}{\text{ULS load effect by application and accompanying vehicles}} \quad (2)$$

where

available ULS capacity for the live load effect is the capacity of the structure less the dead load effect.

As for a Tier 0 assessment, assessment ratios greater than 1.0 indicate that the bridge is structurally adequate for the assessed loading scenario.

The fundamental difference between Tier 0 and Tier 1 assessments is the inclusion of the estimation of structural capacity in the assessment. This estimate is undertaken using design drawings and makes allowances for Level 2 or Level 3 inspection outcomes and the use of an analytical model (such as a grillage model).

Tier 1 assessments consider more variables than Tier 0 which can provide concessions, such as enforcing travel restrictions on the application vehicle. These can include specifying vehicle travel speeds, lateral positioning and other traffic restrictions so as to reduce load effects on critical components. The effectiveness of these restrictions can be evaluated during a Tier 1 assessment to identify if they would be sufficient to grant access to the application vehicle.

A Tier 1 bridge assessment typically includes:

- review of supplied drawings and Level 2 inspection reports
- preparation of analytical models of the bridge (typically a grillage analysis or a line model analysis with appropriate girder distribution factors is used)
- determination of load effects for a range of predetermined assessment vehicles and travel restrictions
- determination of bridge component capacities
- calculation of residual live load capacity and comparison with application vehicle load effects
- preparation of an assessment report.

While a Tier 1 assessment would not typically be undertaken unless a Tier 0 assessment identifies a structure as being at risk, it should be recognised that, once analytical models have been prepared for a structure, these can then be used for any future assessments. The additional cost (above a Tier 0 analysis) of undertaking the initial analysis is offset by the ability to undertake future application assessments in a more cost-effective manner.

Furthermore, the assessment ratios calculated can allow for rapid assessment of application vehicles.

An example of a Tier 1 load rating assessment is provided in Appendix E.2.

12.3.4 Tier 2 assessment

Tier 2 assessments are advanced processes undertaken when a Tier 1 assessment indicates that a bridge has a theoretical structural deficiency yet observed performance of the bridge (condition of the deficient components) does not confirm this. Tier 2 assessments are rarely performed at the local jurisdiction level due to the complexity, costs, and technical oversight required to conduct them.

Tier 2 assessments typically involve:

- more sophisticated theoretical analysis using techniques such as finite element or other advanced analysis methods
- analysis using the results of field investigation of material properties, bridge component dimensions, dead and traffic loads, foundation capacity and the like
- bridge-specific traffic load assessment
- field or laboratory test loading, e.g. proof, static and dynamic load testing
- structural health monitoring
- reference to other recognised codes and standards, subject to the approval of the relevant authority.

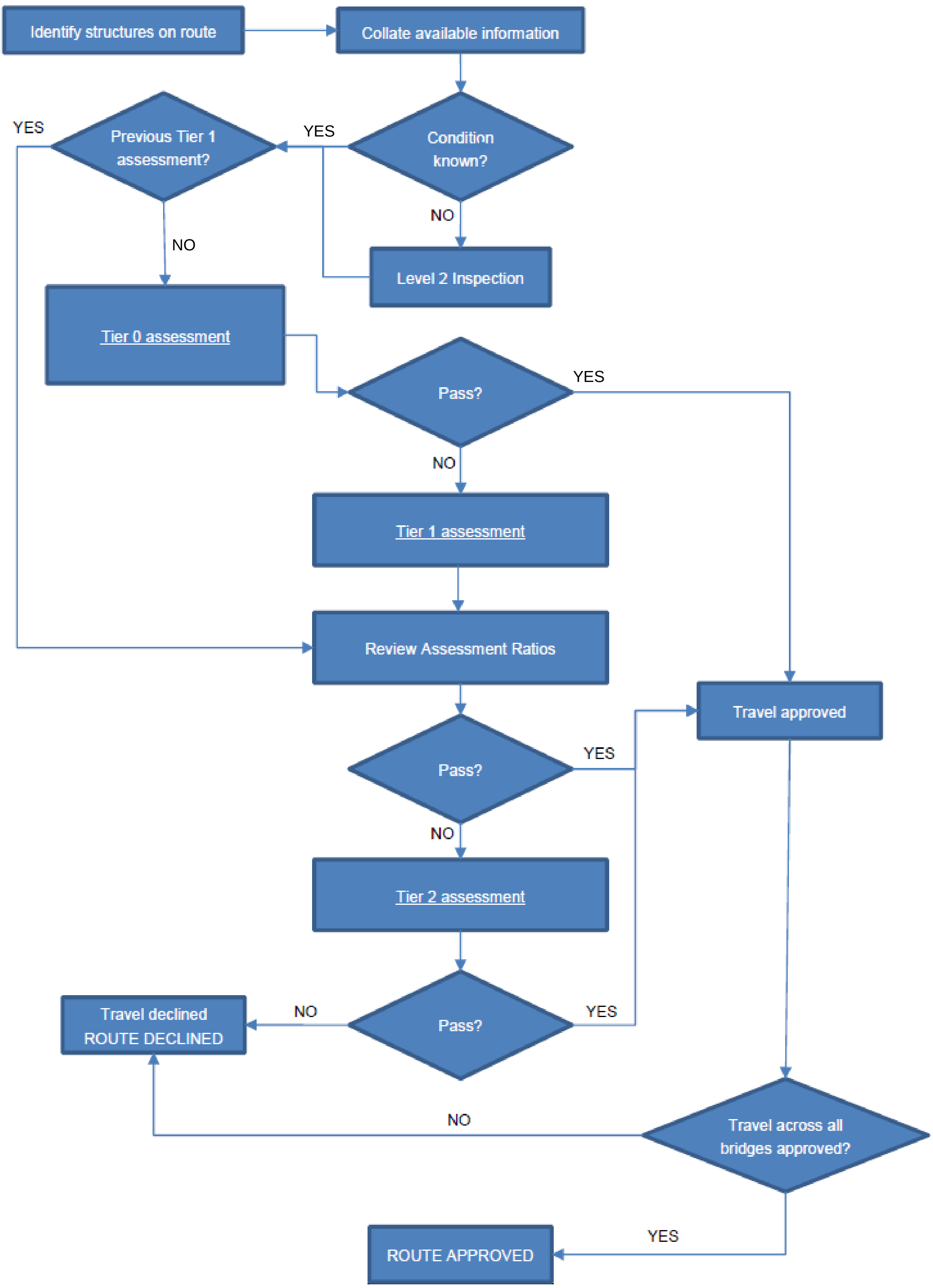
It is essential that, whatever methodology is adopted for a Tier 2 assessment, it is robust and based on sound engineering principles. Generally, a peer review process is required to confirm the methodology is technically sound.

12.4 Structural Assessment Process

12.4.1 Framework

Based on the methodologies discussed above, a suggested framework to assessing structures located on a particular route is outlined in Figure 12.2.

Figure 12.2: Simplified route assessment framework for structures



12.4.2 Granting/Denying Access

Access decision making is based on the load rating assessment outcomes as well as the following parameters that are assumed to have been undertaken as part of the road safety and geometry assessment (Section 10):

- bridge alignment
- sight distances
- restricted widths
- restricted heights
- barrier safety
- speed environment.

While, in theory, a structure could be subjected to three tiers of assessment when assessing a route, it is not compulsory or necessary in every instance and is very much dependent on the financial capacity of the assessing road authority/council and the strategic importance of the application route. There are cases where a vehicle operator is willing to pay for a higher-tier assessment by an eligible consultant, and if the results are favourable, submit the results to the road manager for consideration. A higher-tier assessment, however, does not always guarantee a favourable outcome.

If the vehicle passes a Tier 0 assessment, the road manager should be satisfied that the vehicle can travel with consideration of the assumptions outlined in Section 12.3. The same is true of Tier 1 assessments.

If at any stage of the process it becomes apparent that escalation to the next tier of assessment will likely not yield sufficient gains in capacity, then it is reasonable to cease assessment. Specifically, the costs and benefits of Tier 2 assessments must be considered against the marginal gains likely to be realised. Furthermore, where multiple structures on a route are being assessed, if one or more structures are found to be deficient, careful consideration should be given to continuing with the assessment of the remaining structures.

12.4.3 Documentation

For each structure assessed, a brief report should be prepared containing at least a record of:

- the purpose of the assessment
- any assumptions made
- assessment methodology
- copies or reference to drawings used for the assessment
- copy of the inspection report used to assess condition
- assessment findings.

A copy of the report should be kept in the structure file and relevant information extracted and added to the road manager’s bridge information system.

12.4.4 Change in Conditions

Route and structure assessments are a continuous process that must recognise that the condition of infrastructure changes over time. Should any of the conditions that the assessment is based on change at any time following the assessment then the findings must be revisited. These include:

- any proposed increase in loading
- change of purpose
- change in condition of the structure.

As noted previously, the condition of the structure is fundamental to the assessment process. Consequentially it should be recognised that regular inspection of all structures as part of a prioritised program should be undertaken. Any change in condition of the structure must be investigated and the impact on any previous assessment reviewed.

12.5 Establishment of a Structures Capacity Database

12.5.1 Network Classification

To provide input into the bridge load rating assessment process, a desktop review should be undertaken for all structures on the network as the first step to establish the network classification. This is a worthwhile exercise, as it provides the road manager with a good knowledge of its structure assets and forms the basis for determining fit-for-purpose and cost-effective solutions to the development of a structures capacity database. The specific purpose of the desktop review is to:

- find all the available plans and records, and review them for design classification information
- identify gaps in the network database and prioritise classification activities, i.e. Level 2 inspections and tier assessments. These activities should be focused on high-priority routes which are subject to frequent applications.

Potentially, the network classification can minimise the number of structures requiring a higher-tier assessment which is usually more expensive. As such, the structures capacity database can lower the overall costs associated with route approvals.

12.5.2 Development of Databases

In addition to the knowledge of structures (including information discussed in Section 12.2.1), the following information should be included in a structures capacity assessment database:

- Tier 0 assessment
- Tier 1 assessment
- Higher-tier assessment.

For each assessment undertaken, the information required in Section 12.4.3 should be included.

13 PAVEMENT CONSIDERATIONS

Consideration of pavement loading is required to ensure that the loads imparted by heavy vehicles to the pavement surface and underlying layers will not cause damage or premature wear.

Two types of pavement loading are of concern:

- Horizontal loading: the shear forces imparted when accelerating and braking, and ‘scrubbing’ forces resulting when turning. Horizontal loading typically impacts the surface itself, and can result in aggregate stripping, and in extreme cases, surface layer shifting. This occurs mostly at intersections and on grades. Refer to Section 13.1 for further information.
- Vertical loading: the forces applied by the vehicle’s mass, and their dynamic effects. Vertical loading typically impacts the underlying layers and causes damage such as rutting. This occurs mostly on midblock sections. Refer to Section 13.2 for further information.

13.1 Intersections and Grades

Intersections and grades are susceptible to wear and damage due to high horizontal loading. The tractive force exerted on the pavement by each drive tyre increases with vehicle mass, as heavier vehicles need extra tractive effort when starting and accelerating to overcome resistive forces of rolling resistance and gravity. This places additional shear/horizontal stresses on surfaces and the upper 100 mm pavement layers, and is most likely to be observed at intersections, on upgrades, and on new seals or reseals.

TMR (2018a) recommends that chip seals are acceptable for short sections of grades of less than 2%, whereas for grades greater than 5% an asphalt surface should be present. In some areas of low traffic, chip seal surfaces with polymer-modified binders may endure shear forces.

Assessors should ensure that the pavement design considers the proportion and composition of traffic for climbing lanes.

Assessment of the suitability of surfacings at intersections should consider the potential for the increase in shear forces likely to result from heavy vehicles turning (Section 10.12.4). In some instances, the effect of those forces may be beyond the capacity of a sprayed seal. Alternative seal types are listed below, in order from least to most effective at withstanding the effects of high horizontal forces (TMR 2018a):

- Single-coat seal with polymer modification
- two-coat seal
- two-coat seal with polymer modification
- dense graded asphalt
- dense graded asphalt with polymer modification.

13.2 Pavement Impact Assessment

Roads are designed to carry a certain level of load over an expected time frame. The load is expressed in the number of standard axle repetitions (SAR), a way to define the cumulative damaging effect to the pavement. Any additional heavy vehicle traffic or freight task placed on the road will therefore see a reduction of the pavement intended life.

The significance of the impact of heavy loads on pavements is related to the magnitude of the additional freight task (axle loads and vehicle trips) as well as the current capacity of the road to withstand the load. It is often the case for pavements in rural areas that they are not designed to carry significant amounts of heavy vehicle traffic.

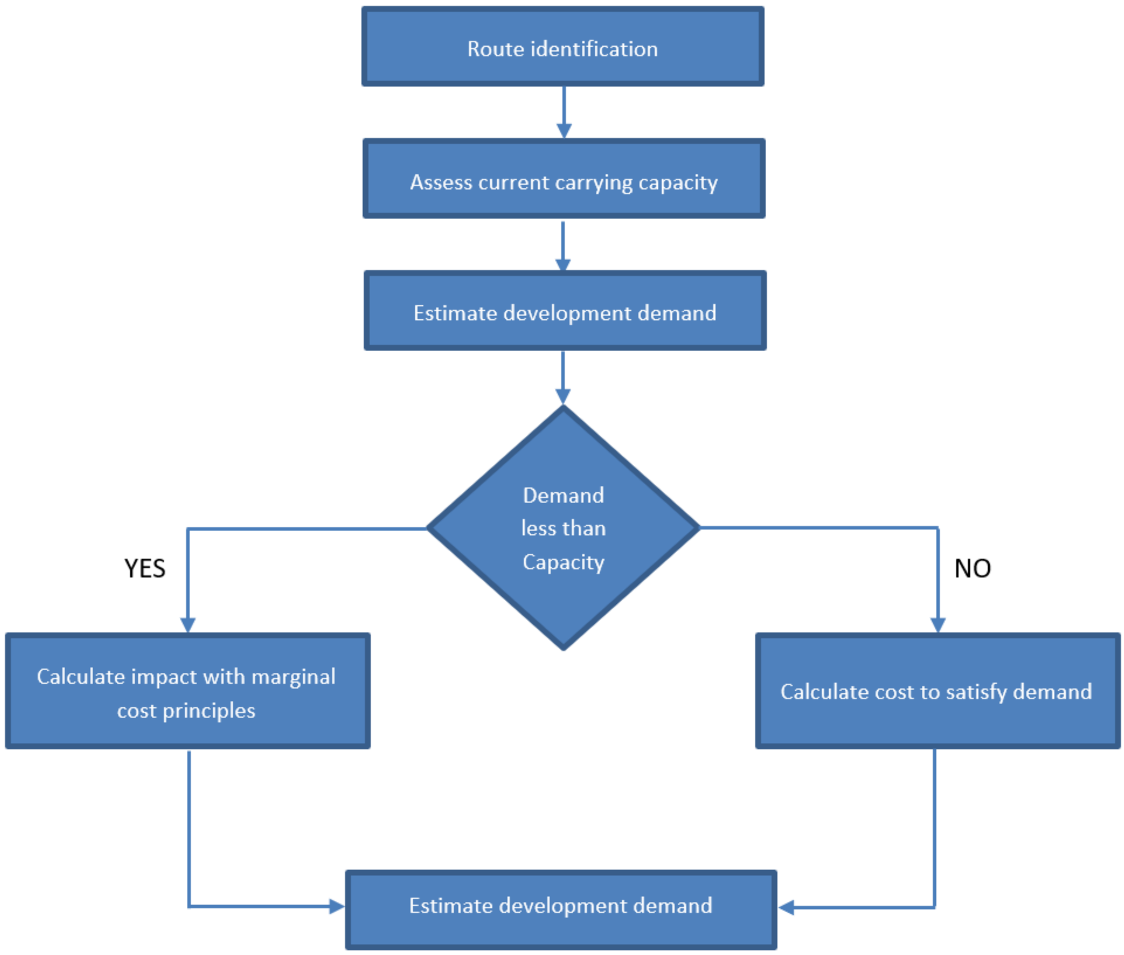
A method of quantifying the impact of heavy vehicles on pavement loading is presented in the following sections. The underlying principles, the calculation tool and the supporting information is also described.

It is important to note that in 2017, a new version of the *Guide to pavement technology part 2: pavement structural design* (Austroads 2012a) was published. One of the changes included in the new version is the way traffic input parameters are considered in the design of bound pavement layers. Each different axle type and load is assumed to cause a different strain at the bottom of bound pavement layers, rather than being converted to a standard axle and translated into an equivalent number of repetitions of this axle (SARs). However, the marginal cost calculator described in the following sections is based on the 2012 version of Part 2.

13.2.1 Pavement Impact Assessment Process

The process of determining the impact of development traffic on pavements is provided in Figure 13.1.

Figure 13.1: Impact assessment process on pavements



The first step in assessing the impact is identifying the route which is often made up of affected road segments. In the case where potential routes or traffic volumes are not known, the councils should utilise local knowledge, traffic modelling or information from previous applications with similar conditions. Once determined, the remaining task of assessing the impact is comparing the road user demand against the current capacity of the route.

The demand resulting from development-generated traffic for each road segment should be determined based on the principles outlined in *Sections 3 and 4* of the *Guide to traffic impact assessment* (TMR 2017a). SARs are calculated for each segment considering the volume and configuration of the additional heavy vehicle traffic, as well as the period of impact.

The use of SARs is aligned with the pavement structural design method (Austroads 2012a) to determine the ability of certain pavement configurations to withstand loading from a reference axle group.

The two most common methods of calculating the remaining life of a pavement are:

1. The empirical method using design charts for overlays from Austroads (2011).

The mechanical method of back-calculating the moduli of the pavement layers with further calculation using a computerised pavement design package to determine the remaining life.

Both methods will require the following information:

- pavement strength data, obtained by one of the survey methods described in Austroads (2008)
- traffic data
- pavement configuration and thicknesses.

If the SARs generated by the proposed heavy vehicle trips are greater than those generated by current traffic volumes then the remaining pavement life will be reduced, potentially requiring more frequent reseals or an earlier than scheduled rehabilitation on the affected roads. Any extra maintenance costs can be calculated using the marginal cost principles.

This section describes a method for road managers to quantify the impact on pavements in financial terms. It provides them with the information to make a decision to grant access to the network with respect to its ability to restore or maintain the same level of service provided before the impact period. The assessment results can be presented as:

- a percentage of the council’s total program maintenance for pavement; or
- a percentage of the typical annualised maintenance cost for the route.

Each council can then determine a viable threshold in accordance with its financial capacity.

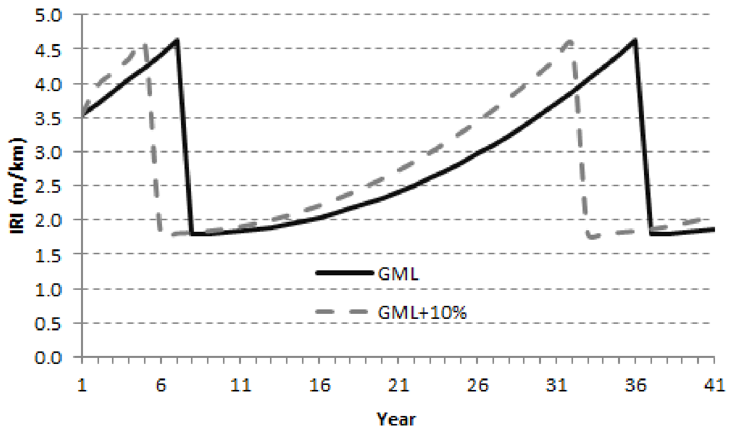
13.2.2 Marginal Cost Principles

Definition

Quantifying pavement impacts can be expressed with marginal cost principles. This is widely accepted as a reasonable basis for cost attribution (Austroads 2012b).

The impacts on performance are observed over a full life-cycle of a network or a route by comparing the costs of maintaining and rehabilitating road infrastructure over an extended period as illustrated in Figure 13.2. In this example the additional freight task of 10% over the general mass limit brings forward the need to rehabilitate the road by up to 6 years.

Figure 13.2: Impact of increasing axle load on road rehabilitation timing



Note:

This method has the limitation of only being applicable for unbound pavements with data available only up to certain design traffic loading.

IRI = International Roughness Index, a measure of the accumulated displacement of the simulated suspension.

Source: Austroads (2012a).

The marginal cost of road wear is defined as the difference in the cost of maintaining a road in a serviceable condition arising from an increase in traffic loading above the current or base traffic. It is mostly dependent on the magnitude and duration of the additional load, the structural strength of the road and its variation, and the additional cost of road maintenance activities to fulfil performance requirements.

Marginal Cost Database

The built-for-purpose Freight Axle Mass Limits Investigation Tool (FAMLIT) developed by ARRB (Austroads 2015b, 2015c) was used to perform the analysis in quantifying the marginal cost.

FAMLIT is a pavement life-cycle costing analysis tool tailored to produce load-wear cost relationships suitable for estimating the marginal cost of road wear with increased axle loads. It assists asset managers in assessing the wear and cost implications of changes in traffic loading at a route or network level.

It requires pavement condition information, traffic loading, typical maintenance practices and maintenance costs. It then uses this information to generate a simulated works program for the segment over 50 years using Austroads pavement deterioration and works effects models (Austroads 2010b, 2010c) for each loading scenario. A road pavement maintenance cost per SAR-km is then derived from the cost of the simulated works program.

The process is sensitive to the pavement structural information considering that many rural roads have relatively weak structures in relation to the additional traffic loads they may be subjected to, whereas freeways and highways, which are designed, built and maintained to higher standards, possess significantly higher strengths. The level of accuracy therefore depends on the extent of the structural data used in the calculation. In the past, obtaining extensive strength information was not a common practice due to the cost and time constraints.

However, in recent years, a new rapid way of collecting strength information has been introduced using the intelligent pavement assessment vehicle (iPave) (Figure 13.3), allowing several road agencies including TMR to complete an annual network-wide collection of pavement strength data.

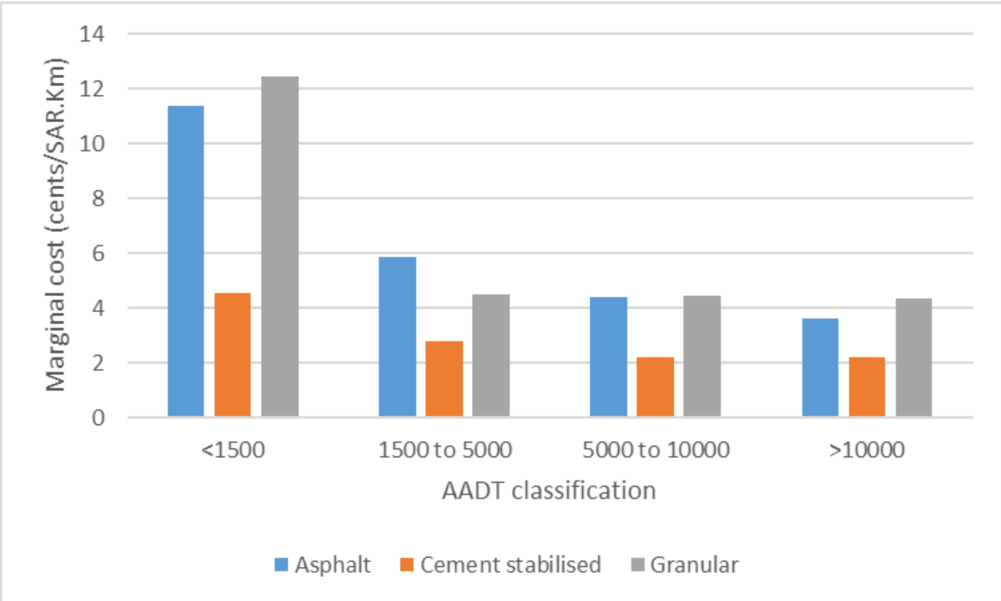
Figure 13.3: ARRB iPAVe

A study for TMR in 2017 (Toole et al. 2017) utilised the strength data from iPAVe to produce a comprehensive database of marginal cost covering all the sealed road network. It covered roads with different functionality, pavement type, traffic levels and climatic conditions, some of which are comparable to typical local government roads.

For the purpose of calculating the marginal cost for local government roads, this database is used to correlate the locality of each local government area to the relevant TMR district. The assumption is, being in the same geographical area, the unit rates for maintenance works, material quality and climatic condition are similar.

An illustration of the findings from the study is provided in Figure 13.4 which shows a general trend for the marginal cost for different pavement base materials grouped in four traffic classifications. The high marginal cost of roads carrying low levels of traffic compared to those with high levels highlights the underlying distinction between rural roads not designed to carry heavy vehicles and the roads designed to do so.

Figure 13.4: Averaged marginal cost trends based on TMR's database



13.2.3 SAR Calculation for Assessment of Impact on Sealed Roads

The assessment provided in this framework accounts for the impact of additional freight tasks by converting them to SARs following the equation from Austroads (2012a) below:

$$SARm_{ij} = \left(\frac{L_{ij}}{SL_i}\right)^m \qquad 3$$

where

$SARm_{ij}$	=	number of standard axle repetitions which causes the same amount of damage as a single passage of axle group type i with load Lij, where the load damage exponent is m
SL_i	=	standard load for axle group type *i* (from Table 13.1)
L_{ij}	=	j^{th} load magnitude on the axle group type *i* (an example shown in Table 13.2)
m	=	load damage exponent for the damage type (from Table 13.3)

The use of SARs allows the additional freight task to be expressed as a ratio to the standard load per axle group in accordance with Austroads pavement design method. Table 13.1 lists the standard axle group types as the denominator (SL_i). For loading information for axle group types other than those shown in the table refer to Table 7.6 of Austroads (2012a).

Table 13.1: Loads on axle group types which cause the same damage as a standard axle

Axle group type	Nominal tyre section width	Load (kN)
Single axle with single tyres (SAST)*	< 375 mm	53
	> 375 mm < 450 mm	58
	> 450 mm	71
Single axle with dual tyres (SADT)	N/A	80
Tandem axle with single tyres (TAST)*	< 375 mm	90
	> 375 mm < 450 mm	98
	> 450 mm	120
Tandem axle with dual tyres (TADT)	N/A	135
Triaxle with dual tyres (TRDT)	N/A	181
Quad-axle with dual tyres (QADT)	N/A	221

Note:

*Axle with single tyres with nominal tyre section width of less than 375 mm.

The numerator from Equation 3, the (L_{ij}), is the actual load magnitude by axle group of additional freight task under consideration. This varies depending on the permit request.

A typical approach adopted to calculate the magnitude of the pavement loading is to assume the current heavy vehicle fleet is imposing a level of damage equivalent to operating at GML. This represents a conservative estimate of the level of service road managers would have to provide in servicing transport industry's freight movements. Table 13.2 shows loading, maximum allowable loads per axle group, at GML as in the Mass Dimension Loading Regulation (NHVR 2018).

Table 13.2: Axle mass limits for axle groups in Queensland

Axle group type	Load (t)	Load (kN)
Steer single axle, 2 tyres	6	59
Single trailer axle, 2 tyres	8	78
Single trailer axle, 4 tyres	9	88
Tandem axle, 8 tyres	16.5	162
Tri axle, 12 tyres	20	196

The three most common types of pavement base material are typically considered; each behaves differently with respect to the applied load and is represented by the load damage exponent in Table 13.3.

Table 13.3: Load damage exponent (m)

Pavement type	Load damage exponent (m)
Granular	4
Asphalt	5
Cemented	12

13.2.4 Marginal Cost Calculation for Sealed Roads

To calculate the impact on pavement in terms of marginal cost, the following information is needed for each road segment within the route,:

1. length of road
2. AADT
3. the pavement base type of either asphalt (AC), cement stabilised (CS) or granular pavement
4. the traffic volumes (trips per day) classified by the type of heavy vehicle

annual operation days (to include both construction and operation periods).

SARs for each road segment and each heavy vehicle type are calculated, then the marginal cost is calculated using Equation 4.

The outcome of the calculation is the annual additional cost in maintenance.

$$\text{Pavement contribution} = \sum_{i=1}^{n} [(C + O)_i \times MC_i \times L_i] \qquad 4$$

where

i = each road segment triggered

C = construction period in SARs (the period during construction where higher volumes of heavy vehicles may have been experienced)

O = operational period in SARs for the impact mitigation period

MC = the relevant marginal cost rate in cents per SAR-km, adopted from TMR database for each LGA (Appendix D.1)

L = the length of road section in km

n = the number of road segments triggered in the impact assessment area

Calculation examples are provided in Appendix D.

13.2.5 Assessment of Impact on Unsealed Roads and from turning vehicle

During the development of this guide, marginal cost rates were not available for unsealed roads. However, further research could be undertaken to develop these to enable assessments of the impacts on unsealed roads to be undertaken.

This framework does not address the specific impact on road surfacing as a result of horizontal shear from turning vehicle. However, TMR provides guidance in selecting a suitable surfacing option (TMR 2018a) to withstand high horizontal stress.

14 RELATED RESOURCES

Route assessment guidelines used by other jurisdictions are listed in Table 14.1.

Table 14.1: Route assessment guidelines used by other jurisdictions

Jurisdiction	Documents
Queensland	*Route assessment guidelines for multi-combination vehicles in Queensland* (TMR 2018a)
New South Wales	*NSW route assessment guide – 4.6 metre high vehicle routes* (RMS 2013) *NSW route assessment guide for restricted access vehicles* (RMS 2012a) *Freight route investigation levels for restricted access vehicles* (RMS 2012b)
South Australia	*DTEI route assessment for restricted access vehicles* (DTEI 2008)
Tasmania	*Review of gazetted high productivity vehicle route network* (DIER 2011)
Victoria	*Victoria freight planning and assessment toolbox* (MAV, MFAC & DTPLI 2014)
Western Australia	*Standard restricted access vehicle route assessment guidelines* (MRWA 2017)
National Heavy Vehicle Regulator	*Performance-Based Standards Scheme – Network Classification Guidelines* (NHVR 2007)

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APPENDIX A GLOSSARY OF TERMS

AADT	Annual average daily traffic. A measure of the daily number of vehicles travelling on a road, averaged over one year.
A-double	A prime mover towing a semi-trailer towing another semitrailer connected by a converter dolly.
AB-triple	A prime mover towing three semitrailers. The second semitrailer is connected by a converter dolly and the third trailer is connected by a fifth wheel located towards the rear of the preceding semitrailer. Can also be described as a semitrailer towing a B-double using a converter dolly.
Arrester bed	Commonly found on severely descending grades, an arrester bed is a type of escape exit that decelerates out-of-control heavy vehicles. Often gravel and sand is used.
ARMIS	TMR's road management and data information system.
As-of-right vehicles	Heavy vehicle combinations that are permitted to operate through gazettes or notices.
A-triple	A prime mover towing three semitrailers. The second and third semitrailers are each connected by a converter dolly.
Approach sight distance (ASD)	The distance required on a minor road for a heavy vehicle to stop safely before the intersection point with the major road.
Austroads	The association of Australian and New Zealand road agencies.
B-double	A combination consisting of a prime mover towing two semitrailers, with the first semitrailer being attached directly to the prime mover by a fifth wheel coupling and the second semitrailer being mounted on the rear of the first semitrailer by a fifth wheel coupling on the first semitrailer.
B-triple	A prime mover towing three semitrailers. The second and third semitrailers are connected by a fifth wheel located towards the rear of the preceding semitrailer.
Bridge	A structure (with the exception of gantries) having a clear opening in any span of greater than 3 metres measured between the faces of piers and/or abutments or structures of a lesser span with a deck supported on timber stringers.
Carriageway width	The width between the outer shoulder edges (sealed and unsealed portions) or between the kerb faces, of undivided carriageways.
Crossfall	The slope, measured at right angles to the alignment, of the surface of any part of a carriageway.
Culvert	A structure under a road having only clear openings of less than or equal to 3 metres measured between the faces of piers and/or abutments or a pipe-shaped structure of any diameter.
General mass limits (GML)	The allowable mass for all types of heavy vehicle axle groups unless the vehicle is operating under an accreditation or an exemption under the HVNL.
Heavy Vehicle National Law (HVNL)	An Australian law with the purpose of regulating the heavy vehicle industry including registration, driver fatigue, vehicle standards, mass dimensions and loading, compliance and enforcement and access. Applicable to heavy vehicle combinations above 4.5 tonnes, adopted by the Australian Capital Territory, New South Wales, Queensland, South Australia, Tasmania and Victoria.
High-speed off tracking	The degree to which the rear unit of a combination vehicle tracks outboard of the hauling unit during high-speed turns or when travelling straight under the influence of pavement crossfall.
Higher mass limits (HML)	Additional mass entitlements are provided to heavy vehicles under the following conditions: vehicles are fitted with certified road friendly suspension, operators running HML on tri-axle groups are accredited under the National Heavy Vehicle Accreditation Scheme, vehicles are on an authorised HML route.
International Roughness Index (IRI)	Used to define a characteristic of the longitudinal profile of a travelled wheel path and constitutes a standardised roughness measurement. The commonly recommended units are metres per kilometre (m/km) or millimetres per metre (mm/m).
Lane	A portion of the paved carriageway marked out by kerbs, painted lines or barriers, which carries a single line of vehicles in one direction.

Low-speed swept path (LSSP)	The maximum width of the swept path in a prescribed 90° low-speed turn.
Minimum gap sight distance (MGSD)	The sight distance acceptable to a driver to enter or cross a conflicting traffic stream.
Multi-combination vehicle (MCV)	All articulated combinations of vehicles with two or more trailers generally exceeding 19.0 metres in length or 42.5 tonnes GCM, including B-doubles and road trains.
National Transport Commission (NTC)	The entity established by the *National Transport Commission Act 2003* of the Commonwealth. An inter-governmental agency charged with improving the productivity, safety and environmental performance of Australia's road, rail and intermodal transport systems.
One-way road	A road or street on which all vehicular traffic travels in the same direction.
Overtaking lane	An auxiliary lane provided to allow for slower vehicles to be overtaken. It is lined-marked so that all traffic is initially directed into the left lane, with the inner lane being used to overtake.
Passenger car equivalence	Passenger car equivalence (PCE) factors are a relative measure of the traffic flow impedance effects of different vehicle types. The PCE factor for a particular vehicle type is the equivalent number of passenger cars (Austroads Vehicle Class 1) that would have the same impedance effect as a single vehicle of that type.
Pavement	The portion of a road designed for the support of, and to form the running surface for, vehicular traffic.
Performance based standard (PBS)	An alternative regulatory scheme for heavy vehicles which sets minimum performance levels for safe and efficient operation (as opposed to standard prescriptive rules). Greater access is generally afforded for higher performance.
Remote road	A general term for a main arterial road carrying mostly long-distance traffic.
Restricted access vehicles (RAV)	A vehicle that is not a general access vehicle. RAV is an umbrella term for Class 1, 2 and 3 vehicles and those operating at HML. RAVs operate under a notice or permit issued by or on behalf of the regulator. Examples are B-doubles, road trains, cranes, etc.
Road friendly suspension	Vehicle suspensions that comply with the performance standard described in Vehicle Standards Bulletin No. 11 (Certification of Road Friendly Suspensions).
Road furniture	A general term covering all signs, street lights and protective devices for the control, guidance and safety of traffic, and the convenience of road users.
Rural road	All roads that provide a secondary network of national, state and local government roads connecting cities and towns.
Safe intersection sight distance (SISD)	The distance required on a major road for a heavy vehicle to stop safely before a potential conflict point with a vehicle turning into, or from the minor road.
Safe System assessment framework (SSAF)	Assessment considering crash history, and how the features of a road influence crash likelihood and severity for run-off-road, head-on, intersection, and vulnerable road users crashes.
Seal width	Width between edges of a sealed surface or between edge lines (where installed on undivided carriageways), whichever is less.
Shoulder	The portion of formed carriageway that is adjacent to the traffic lane and flush with the surface of the pavement.
Sight distance	The distance measured along the road over which visibility occurs between a driver or rider and an object or between two drivers at specific heights above the carriageway in their lane of travel. There are many specific types of sight distance (e.g. approach sight distance, stopping sight distance).
Stopping sight distance (SSD)	The sight distance required by an average driver or rider (car or truck depending on design requirements), travelling at a given speed, to react and stop before striking an object on the road.
Structure	A bridge, culvert or floodway.

Superelevation	A slope on a curved pavement, selected to increase forces assisting a vehicle to maintain a circular path.
Swept path	The area bounded by lines traced by the extremities of the bodywork of a vehicle or combination while turning.
Swept width	The radial distance between the innermost and outermost turning paths of a vehicle or combination.
Tracking ability on a straight path (TASP)	The ability of the trailers of a multi-unit heavy vehicle combination to remain within the path tracked by the prime mover. One of the performance measures assessed in PBS.
Type 1 road train	A combination, other than a B-double, consisting of a motor vehicle towing 2 trailers, connected by a converter dolly. Also commonly referred to as an A-double.
Type 2 road train	A combination, other than a B-triple or AB-triple, consisting of a motor vehicle towing 3 trailers, connected by a converter dolly. Also commonly referred to as a triple road train.
Urban and townsite road	All roads within a populated area of established dwellings, a central place of trade and recognised as a distinct place. Generally, the area will act as a central hub of activity for the community.
Vehicles per day (VPD)	The number of vehicles observed passing a point on a road in both directions for 24 hours. (It is a measure of daily traffic volume, often more relevant to low volume, local government roads, typically rural roads in these guidelines. VPD can differ from AADT in being a better measure of traffic volume during periods of more intensive heavy vehicle usage or seasonal tourist traffic.).

APPENDIX B ACCESS CONDITIONS

The operating conditions outlined in Table B 1 to Table B 4 may apply as conditions of permits to mitigate a specific risk that has been identified in the route access assessment.

Table B 1: Standard speed-related access operating conditions

Issue	Speed
S1	The maximum allowable speed under this permit is <XX> km/h.
	Reason/circumstance: This condition may be used to mitigate a public safety, infrastructure or vehicle safety issue. Generally, not a condition to mitigate public amenity (dust on unsealed roads) (see S2).
S2	The maximum allowable speed under this permit is <XX> km/h along <ZZ road>.
	Reason/circumstance: This condition may be used to mitigate a public amenity risk (i.e. dust on unsealed roads) or public safety risk (high tourist route). Can also be used where infrastructure risks exist (narrow bridges and narrow roads).
S3	The maximum allowable speed under this permit is <XX> km/h on unsealed roads.
	Reason/circumstance This condition can be used to mitigate an amenity risk (dust reduction) and/or public safety. Condition may also reduce infrastructure degradation.
Issue	**Speed (low-speed crossings)**
S4	Vehicle speed is restricted to <XX> km/h over <YY bridge> on <ZZ Road>.
	Reason/circumstance This condition can be used to mitigate an infrastructure risk associated with an overmass heavy vehicle. May also be applied to over-dimensional loads where low clearance infrastructure is involved. This condition will not mitigate any public safety or amenity risks.
S5	The vehicle shall not travel at a speed exceeding <XX> km/h over the following structure/s:
	Reason/circumstance This condition can be used to mitigate an infrastructure risk associated with an overmass heavy vehicle. May also be applied to over-dimensional loads where low clearance infrastructure is involved. This condition will not mitigate any public safety or amenity risks.
S6	The vehicle shall not travel at a speed exceeding <XX> km/h down the centreline over the following structure/s: 1) <EXAMPLE: RICHMOND BRIDGE> 2) <EXAMPLE: ALBERT BRIDGE>
	Reason/circumstance This condition can be used to mitigate an infrastructure risk associated with an overmass heavy vehicle. May also be applied to over-dimensional loads where low clearance infrastructure is involved. This condition will not mitigate any public safety or amenity risks but may increase safety risks to other road users and increase traffic congestion.
S7	<EXAMPLE: RIGHT HAND LANE> lane must be used at maximum speed of <XX> km/h over the following structure/s: 1) <EXAMPLE: RICHMOND BRIDGE> 2) <EXAMPLE: ALBERT BRIDGE>
	Reason/circumstance This condition can be used to mitigate an infrastructure risk associated with an over mass heavy vehicle. May also be applied to over-dimensional loads where low clearance infrastructure is involved. This condition will not mitigate any public safety or amenity risks but may increase safety risks to other road users and increase traffic congestion.

Source: NHVR (2016).

Table B 2: Standard notification-related access operating conditions

Issue	Notification
N1	<ENTITY TO BE CONTACTED> must be contacted <XX> hours prior to travel on <PHONE NUMBER>. Note: If there are changes to the time of arrival, operator must notify <ENTITY> of change.
	Reason/circumstance Condition can be applied to over-dimensional loads to mitigate infrastructure-related risks. Could also be applied to minimise public safety risks. Could be applied where road works are occurring (escorts – traffic control).
N2	Where any part of the vehicle, including its load or any equipment, exceeds <XX>m in height, approval must be obtained in writing from the following third parties before travel commences: 1. <EXAMPLE: ELECTRICITY PROVIDER> 2. <EXAMPLE: COMMUNICATIONS PROVIDER> 3. <EXAMPLE: RAIL CROSSING PROVIDER> This approval must be obtained and complied with in addition to any other clearance requirements in force along the route.
	Reason/circumstance Condition can be applied where a road manager is aware of a third party.
N3	All residential properties along the route are to be notified of the planned vehicle movements at least <XX> working days before commencement.
	Reason/circumstance Condition only applicable to over-dimensional loads likely to interfere with parked vehicles. Condition should not be applied to special purpose vehicles, as condition should be covered by council street parking permit.

Source: NHVR (2016).

Table B 3: Standard general access operating conditions

Issue	General
G1	The vehicle must remain on the sealed section of carriageway for the entirety of its journey when practical.
	Reason/circumstance Condition could be applied to mitigate infrastructure-related risks when wet weather occurs (risks related to soft shoulders or steep shoulders). May be applied to reduce safety risks.
G2	Vehicles are not to be coupled or uncoupled on council local roads at any time.
	Reason/circumstance Condition applicable to mitigate amenity risks (noise). Condition used to mitigate public safety risks.
G3	The vehicle is permitted a maximum of <XX> travel movements per <WEEK/DAY>.
	Reason/circumstance This condition can be imposed to address infrastructure and public amenity risks. Can also be applied to trial permits or to a specific freight task. Condition not to be applied to a single trip class 1.
G4	Unless in emergency, or as directed by an authorised officer, or otherwise permitted by law, a vehicle must not be loaded or unloaded while on a road or street that is part of the permitted route. Examples of instances permitted by law include: 1. designated loading bays/areas 2. designated truck stops 3. properly authorised lane closures at a construction site.
	Reason/circumstance Condition aimed at reducing risks associated with public amenity and public safety.
G5	Trucks must enter and leave the property in a forward direction only.
	Reason/circumstance Condition applied to reduce public safety risks.

<table>
<tr><th>Issue</th><th>General</th></tr>
<tr><td rowspan="2">G6</td><td>Vehicles must not traverse unsealed roads when they are visibly wet without approval of the road manager.</td></tr>
<tr><td>Reason/circumstance
Condition applied to reduce infrastructure risks.</td></tr>
<tr><td rowspan="2">G7</td><td>Exhaust brakes should not be used in built-up areas.</td></tr>
<tr><td>Reason/circumstance
Condition applied to reduce public amenity risks.</td></tr>
<tr><td rowspan="2">G8</td><td><ONE|TWO) <1|2> additional pilot vehicle/s to accompany the permit vehicle from <POINT A> to <POINT B>.</td></tr>
<tr><td>Reason/circumstance
Condition applied to reduce public safety risk. It should be noted that NHVR/state road authorities will apply a number of pilots based on the general risk of the vehicle and that any additional pilots should only be required where significant public safety risks occur such as mountainous terrain, etc.</td></tr>
<tr><td rowspan="2">G9</td><td>Combination to be lowered to <X.Xm> under <bridge/structure>.</td></tr>
<tr><td>Reason/circumstance
Condition applied where an oversize wide load may impinge on bridge/structure.</td></tr>
<tr><td rowspan="2">G10</td><td>Combination to be raised to <X.Xm> over <bridge/structure>.</td></tr>
<tr><td>Reason/circumstance
Condition applied where an oversize wide load may impinge on bridge/structure.</td></tr>
<tr><td rowspan="2">G11</td><td>Load to have a minimum of <X.Xm> of ground clearance to clear bridge handrails, etc.</td></tr>
<tr><td>Reason/circumstance
Condition applied where an oversize wide load may impinge on bridge/structure.</td></tr>
<tr><td rowspan="2">G12</td><td>Vehicle headlights must be switched on at all times.</td></tr>
<tr><td>Reason/circumstance
Condition applied to reduce public safety risks.</td></tr>
<tr><td rowspan="2">G13</td><td>Direct radio contact must be maintained with other heavy vehicles to establish their position on or near the road.</td></tr>
<tr><td>Reason/circumstance
This condition may be used to mitigate public safety, infrastructure or a vehicle safety issue.</td></tr>
<tr><td rowspan="2">G14</td><td>On single-lane roads, the road must not be entered until the driver has established, via radio contact, that there are no other heavy vehicles on the road travelling in the oncoming direction.</td></tr>
<tr><td>Reason/circumstance
This condition may be used to mitigate public safety, infrastructure or a vehicle safety issue.</td></tr>
</table>

Source: NHVR (2016).

Table B 4: Standard travel-related access operating conditions

Issue	Travel
T1	Travel is only permitted during the <daytime/night time>.
	Reason/circumstance This condition can be used to mitigate public safety and public amenity risks. Daytime-only condition can be applied for vehicle safety reasons (insufficient lighting). Consultation with other road managers is recommended when considering this condition as conflicting conditions may render the permit invalid.
T2	Travel is only permitted on <xxx road or area> between the <start time> and <end time> [and <day> and <day>…].
	Reason/circumstance This condition can be used to mitigate public safety and public amenity risks.
T3	Travel is not permitted on <xxx road or area> from (<start time> and <end time> and <start time> and <end time> (day to day)
	Reason/circumstance This condition can be used to mitigate public safety and public amenity risks (used for peak periods or sensitive areas).
T4	No travel permitted from <DATE> to<DATE> and on public holidays.
	Reason/circumstance This condition can be used to mitigate public safety and public amenity risks.
T5	The vehicle may not travel at a speed exceeding <XX> km/h when travelling during the night-time, and must display an amber flashing warning light on the prime mover.
	Reason/circumstance This condition can be used to mitigate public safety and public amenity risks.

Source: NHVR (2016).

APPENDIX C RISK ASSESSMENT EXAMPLE

A simplified example demonstrates how the risk assessment framework for a vehicle route evaluation can be undertaken. The example is based primarily on case studies documented in both Austroads (2018) and DTEI (2008).

C.1 Establishing the Context (Step 1)

The issues concern access for a unique PBS tanker with adjustable combinations on a specific route within a local road network. Some of the contextual information on road and traffic characteristics is as follows:

- PBS combination scenarios include a maximum mass limit of 67.5 tonnes and a maximum length of 26 metres.
- The route consists predominantly of two-lane, sealed roads with a typical carriageway width of 7 metres and narrow shoulders (< 1 metre in width).
- The speed limit environment is 80 km/h with an AADT of 1000 vehicles and 5% heavy vehicle composition.

There is no crash pattern based on reported crash data that suggests the proposed route is a high-risk location, with lower-than-average fatal crashes based on the Queensland Road Crash Database.

C.2 Risk Assessment (Step 2)

As shown in Table C 1, safety hazards and concerns are identified and analysed in line with the risk assessment process for each of the key considerations.

Table C 1: Risk identification and analysis

Key consideration	Safety hazard/risk	Description	Risk rating		
			Likelihood	Severity	Outcome
Geometry	▪ Unsafe turning at an intersection	▪ Possibility of an over-dimensional vehicle damaging roadside infrastructure and increasing crash risk to other road users	Likely	Minor	M
Structure	▪ Risk of bridge damage or failure	▪ A bridge is identified as at risk of being unable to carry the increased mass. A Tier 1 assessment confirms bridge integrity, but with recommendations to restrict travel speeds and load effects on critical elements	Unlikely	Major	M
Pavement	▪ Risk of pavement damage or failure	▪ Following a pavement impact assessment, the demand is less than the remaining pavement standard axle repetition capacity. The marginal cost of road wear is calculated for cost attribution	Unlikely	Minor	L
Amenity	▪ Risk of PBS operator not adhering to approved route(s)	▪ This is a compliance issue for a road manager, especially when there are multiple parallel routes	Likely	Major	H

C.3 Risk Treatment (Step 3) and Residual Risk Consideration

In recognition of the improved road safety and efficiency performance of PBS combinations and after assessing the risk rating outcome and treatment options for the key assessment considerations, the local road manager decided to accept the residual risk, thereby granting consent for the proposed PBS vehicle to access the road network. As deemed necessary, specific access conditions relating to speed and mass restrictions when travelling over the bridge and the application of an intelligent access program, were imposed. Table C 2 lists the treatments and residual risk.

Table C 2: Treatment options and residual risk

Key consideration	Safety hazard/risk	Treatment	Risk rating		
			Likelihood	Severity	Outcome
Geometry	▪ Unsafe turning at an intersection	▪ A swept path analysis is performed to confirm the extent of intersection modifications to ensure safe turning	Unlikely	Major	**M**
Structure	▪ Risk of bridge damage or failure	▪ Imposing an access condition to restrict vehicle speed to 50 km/h with the maximum mass of 60 tonnes when travelling over the bridge	Rare	Major	**L**
Pavement	▪ Risk of pavement damage or failure	▪ Cost attribution based on the marginal cost principles	Unlikely	Minor	**L**
Amenity	▪ PBS operator not adhering to approved route(s)	▪ Imposing an access condition for the consent holder to enrol in the intelligent access program, which provides position-tracking and record-keeping information to road manager	Rare	Major	**L**

C.4 Monitoring and Review (Step 4)

The local manager in collaboration with the NHVR and TMR initiate a process to developing a monitoring and review framework to better understand the effectiveness of the treatment measures in minimising the risk as well as the efficiency of the route assessment process against established objectives. The outcome of a performance evaluation based on the monitoring and review framework not only helps to identify changes and trends required in the process, but also facilitates ongoing improvement and collaboration.

APPENDIX D MARGINAL COST CALCULATION EXAMPLE

Example 1. Assess the impact of adding five 9-axle B-doubles travelling on a 10 km segment of road in Logan City Council doing 12 trips in a day for 200 days of the year at GML loading. The impacted road is of granular pavement base usually carrying a low traffic volume of 1000 AADT.

To calculate the marginal cost for a new heavy vehicle as shown in Table D 3 the following steps are used:

1. Break-up the heavy vehicle configuration into individual axle groups and enter the type into the ‘Axle group’ column and axle load (t) into the ‘Axle load (t)’ column. In this case, the 9-axle B-double consists of four axle groups which are; one steer axle with single tyre (SAST), one tandem axle with dual tyre (TADT), and two tri-axle with dual tyre (TRDT).
2. Determine the load standard for each axle group using Table 13.1 and enter these values into the ‘load standard (kN)’ column.
3. Determine the load actual for each axle group and enter these values into the ‘load actual (kN)’ column. In this case a GML is considered as the load actual, so loads from Table 13.2 can be used. In cases where the load is not GML the axle load in tonnes can be multiplied by 9.81 (constant for gravity) to convert to kN.
4. Determine the Load Damage Exponent (LDE) for the applicable pavement type from Table 13.3 and enter the value into the ‘Load damage exponent (LDE)’ column.
5. Calculate the SAR for each axle group of the vehicle for each section of road under consideration (see Section 13.2.3 for more information). In this instance we are only assessing for one vehicle on one section of road, the resulting values can be entered into the ‘SAR’ column.
6. Use the TMR database (Table D 6) to determine the relevant marginal cost rate corresponding to Logan City Council, given the AADT and the type of pavement for the segment. The rate is 8.5 cents per SAR km.
7. Determine the vehicle trip information, including yearly number of trips and distance travelled on road sections.
8. Calculate the impact on annual maintenance cost (see Section 13.2.4 for more information) by multiplying the total SAR, the number of trips in a year, the distance travelled and the marginal cost rate together as shown in Table D 3. In this instance the estimated annual additional maintenance cost would be $64,974.

Table D 3: Example 1 Marginal cost calculation for 9-axle B-double

Axle group	Axle load (t)	Load standard (kN)	Load Actual (kN)	Load damage exponent (LDE)	SAR
SAST	6.0	53	59	4	1.54
Tandem 1	16.5	135	162		2.07
Tri-axle 1	20.0	181	196		1.38
Tri-axle 2	20.0	181	196		1.38
				Total SAR	6.37

Number of daily trips	60

Axle group	Axle load (t)	Load standard (kN)	Load Actual (kN)	Load damage exponent (LDE)	SAR
				Number of operating days in a year	200
				Distance (km)	10
				Current cost rate (cents per SAR km)	8.5
				Annual additional maintenance cost	$64,974

Example 2. Assess the impact of replacing the existing vehicles with proposed larger vehicles:

- **Existing** five 9-axle 26m B-doubles at 68.0t doing 12 trips in a day for 200 days
- **Proposed** four PBS Level 2B 11-axle 30m A-doubles at 68.0t doing 10 trips in a day for 200 days

This is assessed on a 10km segment of road in Logan City Council. The impacted road is of granular pavement base usually carrying a low traffic volume of 1000 AADT.

To calculate and compare the current cost of existing vehicles (Table D 4) against the marginal cost of new vehicles (Table D 5) the following steps are used:

1. Calculate the current cost of the existing 9-axle B-double vehicles (Table D 4) and the marginal cost of the new PBS Level 2B 30m 11-axle A-doubles vehicles (Table D 5) using the steps shown in **Example 1**. Note that the vehicles will use different load actual values and may need to be calculated manually due to not being GML masses on axles.
2. Compare the resulting current cost and marginal costs in Table D 4 and Table D 5. The difference is the expected change in marginal cost if access is granted to the proposed vehicle. In this instance the estimated savings on annual additional maintenance cost would be $50,048.

Table D 4: Example 2 Current cost calculation for 9-axle B-double at 68.0t

Axle group	Axle load (t)	Load standard (kN)	Load Actual (kN)	Load damage exponent (LDE)	SAR
SAST	6.0	53	59	4	1.54
Tandem 1	17.0	135	167		2.34
Tri-axle 1	22.5	181	221		2.22
Tri-axle 2	22.5	181	221		2.22
				Total SAR	8.32
				Number of daily trips	60
				Number of operating days in a year	200
				Distance (km)	10
				Current cost rate (cents per SAR km)	8.5
				Annual additional maintenance cost	$84,864

Table D 5: Example 2 Marginal cost calculation for PBS Level 2B 30m 11-axle A-double at 68.0t

Axle group	Axle load (t)	Load standard (kN)	Load Actual (kN)	Load damage exponent (LDE)	SAR
SAST	6.0	53	59	4	1.54
Tandem 1	13.6	135	134		0.97
Tri-axle 1	17.2	181	169		0.76
Tandem 2	14	135	138		1.09
Tri-axle 2	17.2	181	169		0.76
				Total SAR	5.12

Number of daily trips	40
Number of operating days in a year	200
Distance (km)	10
Current cost rate (cents per SAR km)	8.5
Annual additional maintenance cost	$34,816

D.1 Marginal Costs by TMR District

The marginal cost for the pavement type within a local government can based on the TMR marginal cost database in Table D 6. Identify the relevant TMR district to use for your local government area in Table D 7.

Table D 6: TMR 2017 Marginal Cost Database

TMR district number	TMR district name	Pavement type	AADT range	Marginal cost (Cents per SAR per Km)
401	Central Western	Asphalt	0 - 1,500	5.7
			1,500 - 5,000	4.2
			5,000 - 10,000	3.7
		Cement Stabilised	0 - 1,500	8.2
			1,500 - 5,000	1.7
			5,000 - 10,000	1.7
		Granular	0 - 1,500	11.7
			1,500 - 5,000	2.8
			5,000 - 10,000	2.8
402	Darling Downs	Asphalt	0 - 1,500	10.4
			1,500 - 5,000	5.9
			5,000 - 10,000	4.2
			>10,000	3.4
		Cement Stabilised	0 - 1,500	3.9
			1,500 - 5,000	3.2
			5,000 - 10,000	2.3
			>10,000	1.6
		Granular	0 - 1,500	13.4
			1,500 - 5,000	4

			5,000 - 10,000	4.2
			>10,000	3.4
403	Far North	Asphalt	0 - 1,500	15
			1,500 - 5,000	6.6
			5,000 - 10,000	4.2
			>10,000	3.1
		Cement Stabilised	0 - 1,500	5.7
			1,500 - 5,000	3.2
			5,000 - 10,000	1.9
			>10,000	2
		Granular	0 - 1,500	25.4
			1,500 - 5,000	7.7
			5,000 - 10,000	4.7
			>10,000	3
404	Fitzroy	Asphalt	0 - 1,500	9.1
			1,500 - 5,000	5.6
			5,000 - 10,000	5.2
			>10,000	4.5
		Cement Stabilised	0 - 1,500	3.6
			1,500 - 5,000	1.6
			5,000 - 10,000	1.5
			>10,000	3
		Granular	0 - 1,500	13.1
			1,500 - 5,000	3.6
			5,000 - 10,000	3.7
			>10,000	4.6
405	Mackay	Asphalt	0 - 1,500	20
			1,500 - 5,000	6.1
			5,000 - 10,000	5.3
			>10,000	5.4
		Cement Stabilised	0 - 1,500	3.9
			1,500 - 5,000	2.6
			5,000 - 10,000	2.5
			>10,000	3.3
		Granular	0 - 1,500	17.2
			1,500 - 5,000	6.5
			5,000 - 10,000	7
			>10,000	6.2
406	Metropolitan	Asphalt	0 - 1,500	29
			1,500 - 5,000	11.6
			5,000 - 10,000	4.1
			>10,000	3
		Cement Stabilised	0 - 1,500	1.7
			1,500 - 5,000	3.5

			5,000 - 10,000	3.1
			>10,000	2
		Granular	0 - 1,500	4.7
			1,500 - 5,000	8.8
			5,000 - 10,000	3
			>10,000	3.3
407	North Coast	Asphalt	0 - 1,500	15.8
			1,500 - 5,000	6.4
			5,000 - 10,000	4.6
			>10,000	3.5
		Cement Stabilised	0 - 1,500	4.3
			1,500 - 5,000	2.9
			5,000 - 10,000	2.2
			>10,000	1.8
		Granular	0 - 1,500	10.4
			1,500 - 5,000	7
			5,000 - 10,000	4.3
			>10,000	5.2
409	North Western	Asphalt	0 - 1,500	6.1
			1,500 - 5,000	5.7
			5,000 - 10,000	14.9
		Cement Stabilised	0 - 1,500	3.4
			1,500 - 5,000	1.9
			5,000 - 10,000	1.9
		Granular	0 - 1,500	10.3
			1,500 - 5,000	6.2
			5,000 - 10,000	5.7
408	Northern	Asphalt	0 - 1,500	10
			1,500 - 5,000	5.5
			5,000 - 10,000	4.4
			>10,000	5.2
		Cement Stabilised	0 - 1,500	4.5
			1,500 - 5,000	2.8
			5,000 - 10,000	2.4
			>10,000	3.2
		Granular	0 - 1,500	11.7
			1,500 - 5,000	4.1
			5,000 - 10,000	3.9
			>10,000	7.5
410	South Coast	Asphalt	0 - 1,500	7.6
			1,500 - 5,000	5
			5,000 - 10,000	4.3
			>10,000	3.8
		Cement Stabilised	0 - 1,500	3.8

			1,500 - 5,000	3.2
			5,000 - 10,000	2.2
			>10,000	1.9
		Granular	0 - 1,500	8.5
			1,500 - 5,000	6
			5,000 - 10,000	5.3
			>10,000	4.9
411	South Western	Asphalt	0 - 1,500	5.7
			1,500 - 5,000	3.5
			5,000 - 10,000	3.7
			>10,000	3.4
		Cement Stabilised	0 - 1,500	4.9
			1,500 - 5,000	1.7
			5,000 - 10,000	1.7
			>10,000	1.6
		Granular	0 - 1,500	8
			1,500 - 5,000	2.8
			5,000 - 10,000	2.8
			>10,000	3.4
412	Wide bay	Asphalt	0 - 1,500	6.6
			1,500 - 5,000	4.8
			5,000 - 10,000	4
			>10,000	4.5
		Cement Stabilised	0 - 1,500	2.2
			1,500 - 5,000	2.4
			5,000 - 10,000	2.2
			>10,000	2.7
		Granular	0 - 1,500	5.4
			1,500 - 5,000	4.1
			5,000 - 10,000	3.8
			>10,000	4.7

Table D 7: Local governments within TMR jurisdiction

TMR district number	TMR district name	LGA name
401	Central Western	Barcaldine Regional
		Barcoo Shire
		Blackall Tambo Regional
		Boulia Shire
		Diamantina Shire
		Longreach Regional
		Winton Shire
402	Darling Downs	Dalby Regional
		Goondiwindi Regional

TMR district number	TMR district name	LGA name
		Lockyer Valley Regional
		Southern Downs Regional
		Toowoomba Regional
403	Far North	Aurukun Shire
		Cairns Regional
		Cassowary Coast Regional
		Cook Shire
		Croydon Shire
		Etheridge Shire
		Hope Vale Shire
		Kowanyama Shire
		Lockhart River Shire
		Mapoon Shire
		Napranum Shire
		Northern Peninsula Area Regional
		Pormpuraaw Shire
		Tablelands Regional
		Torres Shire
		Torres Strait Island Regional
		Weipa Town
		Wujal Wujal Shire
		Yarrabah Shire
404	Fitzroy	Banana Shire
		Central Highlands Regional
		Gladstone Regional
		Rockhampton Regional
		Woorabinda Shire
405	Mackay	Isaac Regional
		Mackay Regional
		Whitsunday Regional
406	Metropolitan	Brisbane City
		Ipswich City
		Redland City
407	North Coast	Moreton Bay Regional
		Somerset Regional
		Sunshine Coast Regional
409	North Western	Burke Shire
		Carpentaria Shire
		Cloncurry Shire
		Doomadgee Shire
		Flinders Shire
		Mckinlay Shire

TMR district number	TMR district name	LGA name
		Mornington Shire
		Mount Isa City
		Richmond Shire
408	Northern	Burdekin Shire
		Charters Towers Regional
		Hinchinbrook Shire
		Palm Island Shire
		Townsville City
410	South Coast	Gold Coast City Logan City Scenic Rim Regional
411	South Western	Balonne Shire
		Bulloo Shire
		Murweh Shire
		Paroo Shire
		Quilpie Shire
		Roma Regional
412	Wide bay	Bundaberg Regional
		Cherbourg Shire
		Fraser Coast Regional
		Gympie Regional
		North Burnett Regional
		South Burnett Regional

APPENDIX E STRUCTURAL LOAD RATING EXAMPLES

E.1 Tier 0 Assessment

E.1.1 Requirements

Local City Council commissioned a consultant to undertake the assessment of applications by a heavy vehicle operator for movement of a number of vehicles on the council's two designated routes, Route No.1 and Route No.2. Three bridges were identified to be assessed, including Bridge No. 1 on Route No.1 and Bridge No.2 and Bridge No. 3 on Route No.2 (Table E 1).

The scope of this exercise is to undertake a simple assessment (Tier 0), using the line beam model, to compare the effects of the two groups of application vehicles with the recorded design loading for each affected structure. Group 1 comprising five vehicles (Veh1.1–Veh1.5) was assessed for Route No.1 only and Group 2 comprising two vehicles (Veh2.1–Veh2.2) was assessed for both routes. These vehicles differ in configurations, i.e. number of axles, axle masses and axle spacing. Full details of the application were supplied.

Based on the supplied drawings, the design loads of the affected structures included bridge design standards AS 5100 - SM1600 and '92 Austroads - T44/L44 (with the consideration of uniform load component).

Line beam model analyses were undertaken for each of the affected structures to compare the effects of the recorded design load (e.g. SM1600, including the uniform load component) with those of the application vehicles. For each structure, a bridge assessment typically includes:

- review of supplied drawings and available inspection reports
- determination of load effects for the design vehicle using the line beam model
- determination of load effects for each application vehicle using the line beam model
- comparison of the load effects by the design vehicle and the application vehicles for each structure.

E.1.2 Bridge Descriptions

Table E 1 lists the details of all bridges to be assessed.

Table E 1: Bridge details

Bridge detail	Bridge No. 1	Bridge No. 2	Bridge No. 3
Design year	2012	1994	1995
Span	24 m	13 m + 13 m + 13 m	19.85 m + 20 m + 19.85 m
Superstructure	One simply-supported 24 m non-skewed span of transversely stressed deck units	Three simply-supported 13 m non-skewed spans of transversely stressed deck units	Three simply-supported non-skewed spans of transversely stressed deck units
Substructure	RC abutments sitting on pile foundations	RC portal frame headstock and shallow foundation	RC headstock and piles
Width	Carriageway is 8.0 m plus a 2.0 m wide footpath	Carriageway width is 9.26 m	Carriageway width is 9.2 m
Design loading	AS 5100 - SM1600	92 Austroads - T44/ L44	92 Austroads - T44/ L44

Bridge detail	Bridge No. 1	Bridge No. 2	Bridge No. 3
Bridge condition	The most recent level 2 inspection undertaken in 2016 shows that the bridge is generally in good condition	The most recent level 2 inspection undertaken in 2015 shows that the bridge has minor pavement failure to approach 2. The bridge structure is generally in good condition	A recent level 2 inspection undertaken in 2016 shows that the bridge has minor scour around footings. The bridge structure is generally in good condition

E.1.3 Analysis Methodology

All three bridges were analysed as a simply-supported beam. Each vehicle moved along the bridge in a one metre increment until the vehicle was completely out of the bridge. For each vehicle position, load effects were determined at the sections spaced at L/20 along the span, where L is the length of the span. The maximum load effects due to each vehicle at these sections were recorded for comparison.

E.1.4 Summary of Load Rating Results

The load effects caused by the design load and application vehicles are represented by maximum moment M_{max} (kN m), maximum shear force V_{max} (kN) and maximum support reaction R_{max} (kN).

The maximum load effects caused by the design load are marked as **bold** in Table E 2. Therefore, the bridges designed to standard are expected to have capacity for these corresponding load effects.

Table E 3 shows the load effects due to the application vehicles, and comparison results for the assessed bridges. It is obvious that the load effects caused by all application vehicles are less than the maximum design load effects, therefore, it will be safe for all requested application vehicles to access the assessed bridges.

Table E 2: Load effects due to design load on the assessed bridges

Structure	Design load	M_{max} (kN m)	V_{max} (kN)	R_{max} (kN)
Bridge No. 1	S1600	**4142**	747	747
	M1600	4057	**760**	**760**
	W80	4800	80	80
	A160	960	160	160
Bridge No. 2	T44	681	345	401
	L44	568	247	329
	T44+L44	**1249**	**592**	**731**
Bridge No. 3	T44	1267	381	419
	L44	1001	299	424
	T44+L44	**2269**	**680**	**844**

Table E 3: Load effects due to application vehicles and comparison results for the assessed bridges

Structure	Application vehicle	M_{max} (kN m)	V_{max} (kN)	R_{max} (kN)
Bridge No. 1	Veh1.1	928	167	167
	Veh1.2	904	162	162
	Veh1.3	2179	399	399
	Veh1.4	2666	481	481
	Veh1.5	1523	282	282
	Veh2.1	2387	467	467
	Veh2.2	2016	359	359
	Max design load effects	4142	760	760
	Min assessment ratio	**1.55**	**1.58**	**1.58**
	Pass / fail	Pass	Pass	Pass
Bridge No. 2	Veh2.1	343	163	176
	Veh2.2	326	160	174
	Max design load effects	1249	592	731
	Min assessment ratio	**3.64**	**3.63**	**4.15**
	Pass / fail	Pass	Pass	Pass
Bridge No. 3	Veh2.1	591	170	180
	Veh2.2	572	167	179
	Max design load effects	2269	680	844
	Min assessment ratio	**3.84**	**4.00**	**4.69**
	Pass / fail	Pass	Pass	Pass

E.1.5 Recommendations

For each assessed route, the load effects caused by the requested application vehicles are all lower than the maximum load effects caused by the design vehicle loads for the affected bridges on the route. Therefore, it will be safe for the requested application vehicles to travel across the assessed bridges on the corresponding routes.

E.2 Tier 1 Assessment

E.2.1 Requirements

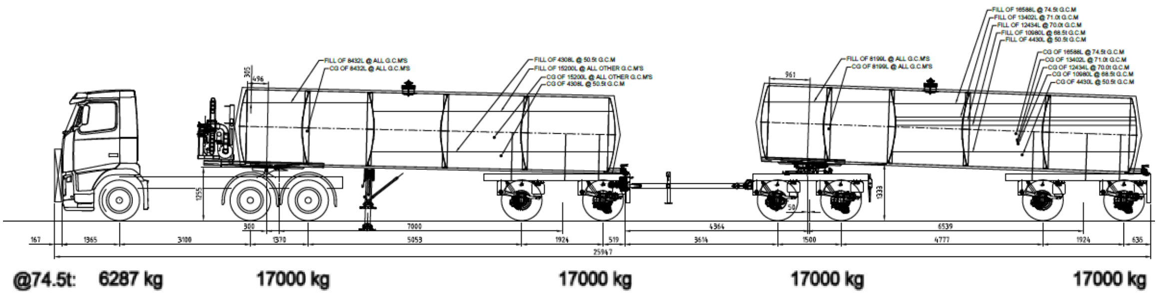
A council commissioned a consultant to undertake a bridge assessment of Bridge A over Creek B on Road C in order to make a decision on a heavy vehicle permit application.

The scope of the project is to undertake a capacity assessment of the bridge against the load effects due to the application vehicle as follows:

- bending and shear capacity assessment of superstructure components on the most critical span
- bending and shear capacity of the headstock of one portal-frame pier
- axial loading capacity of piles under vertical load effects where information about pile capacity is available in the original drawings.

The council requested that an assessment be undertaken for the following application vehicle configuration (Figure E 1). This vehicle is subsequently referred to as the application vehicle Veh_App.

Figure E 1: Application vehicle Veh_App (74.5 t)



E.2.2 Bridge Descriptions

Based on the supplied drawings, the bridge was constructed in 1978. The superstructure comprises three simply-supported 12 m straight spans of prestressed deck units (DU) with a skew angle of 10 degrees. These deck units have double circular hollow voids, 370 mm depth and 12.5 mm diameter straight strands (designed in 1977). The bridge travel width is 8.6 m.

The substructure comprises two portal frame piers and two spill-through abutments, all sitting on pile foundations. The piles are 400 diameter octagonal prestressed concrete piles with a maximum pile working load of 550 kN for piers and 570 kN for abutments.

Material properties of structural components were derived from the supplied drawings.

E.2.3 Analysis Methodology

Sectional capacity analysis

Section properties for the structural members (including deck units and headstocks) were calculated, where necessary, using elastic, uncracked sections and the material properties provided. For deck units, the ultimate bending capacity and ultimate shear capacity were calculated at various sections along the length of the span. For the headstocks, ultimate capacity for sag and hog bending moments, together with shear capacity of the sections near supports were calculated. For piles, the ultimate limit state method was used to assess the piles. The ultimate capacity of piles is derived based on the pile working load provided in the drawing.

Grillage modelling

The modelling approach adopted is in accordance with *S02 Annexure modelling deck unit bridge superstructure for tier 1 assessments* (TMR 2013b) and is summarised as follows:

- Two spans of the bridge are modelled to determine the reactions induced on piers and abutments.
- Since these bridges have a 10 degrees skew angle, the deck is approximated by a skew mesh consisting of longitudinal and transverse members.

- Longitudinal members: One member per deck unit, kerb unit (or deck unit acting compositely with cast-in situ kerb) positioned coincident with the centre of each unit. The area and moment of inertia of the cross-section are calculated based on uncracked section properties while the torsional constant is taken as 20% of the uncracked torsional constant of a deck unit.
- Transverse members: one row of transverse members is placed at midspan and coincident with each of the transverse stressing bars. Intermediate rows of transverse members are placed in between the above members. The spacing of transverse members provided near supports is smaller than that of the transverse members near midspan
  - the moment of inertia about the horizontal axis of the transverse member used in the model is taken as 3% of the moment of inertia of the deck unit, factored by the ratio of the spacing between transverse elements and the spacing between the longitudinal elements
  - the area and the moment of inertia about the vertical axis are taken based on the actual dimensions of the members
  - the torsional stiffness of the transverse member is taken as zero.
- Dummy transverse members: used to connect the points on the units at the supports to ensure the SpaceGass moving load generator applies wheel loads near the end of the structure. The stiffness of the dummy member is taken as 1% of the stiffness of the transverse members.
- Load factors and dynamic load allowance were taken in accordance with AS 5100.7.
- Load steps: step sizes less than span/50 are necessary to achieve shear forces and abutment reactions within 2% of the theoretical maximum. The moving vehicles are applied on the transverse elements.

E.2.4 Summary of Load Rating Results

The following travel restrictions were assessed:

(a) Adjacent to kerb, with a co-existing vehicle
(b) Adjacent to kerb, without a co-existing vehicle
(c) Centre of lane, with a co-existing vehicle
(d) Centre of lane, without a co-existing vehicle

Bridge centreline, without a co-existing vehicle.

The minimum (critical) assessment ratios for the assessed bridge components are listed Table E 4 for the application vehicle.

Table E 4: Critical assessment ratios

Travel restriction	Deck units		Headstock		Piles	
	Assessment ratio	Critical load effects	Assessment ratio	Critical load effects	Assessment ratio	Critical load effects
a	1.08	Bending	1.92	Shear	1.72	Axial
b	1.05	Bending	1.96	Shear	1.90	Axial
c	1.26	Bending	1.25	Shear	1.89	Axial
d	1.26	Bending	1.62	Shear	2.26	Axial
e	1.13	Bending	1.13	Shear	1.98	Axial

E.2.5 Recommendations

According to Table E 4, for the application vehicle (Veh_App), the assessment identified no potentially structurally deficient components. These results are based on the information supplied by the council and the assessed condition of the bridge components from the most recent level 2 inspections. Where critical information was not available, assumptions have been made based on historical properties.

Should conditions on site change, then further assessment may be required. Specifically, any change in the following should be followed up immediately:

- changes in the waterway resulting in exposure of piles
- evidence of compression of bearing strips
- evidence of distress in principal load bearing components of the superstructure (deck units, including transverse stressing bars) or substructure (headstock or piles).

APPENDIX F USING MINIMUM CURVE RADIUS TABLES

F.1 Identifying the Variables and Resulting Curve Operating Speed

An assessor will be required to identify the following two variables:

1. Superelevation: This can be taken on site with a smart level, and the measurement should be taken on the travel lane (shoulder may be different) near to the apex of the curve. In this instance the site measurements could be cross-checked with the superelevation provided in as-constructed plans (site changes may result in the superelevation changing over time, particularly on unsealed roads).
2. Existing curve radius. This can be done on scalable aerial images in AutoCAD or on web-based programs such as nearmap.com. Ideally though the radius should be identified as provided in the as-constructed drawings.

Estimate of the operating speed on the approach to the curve. Further information on how to estimate heavy vehicle operating speeds can be found in Austroads (2016a); alternatively, if an existing road is being assessed and a similar class heavy vehicle is operating on the road a speed survey can be undertaken.

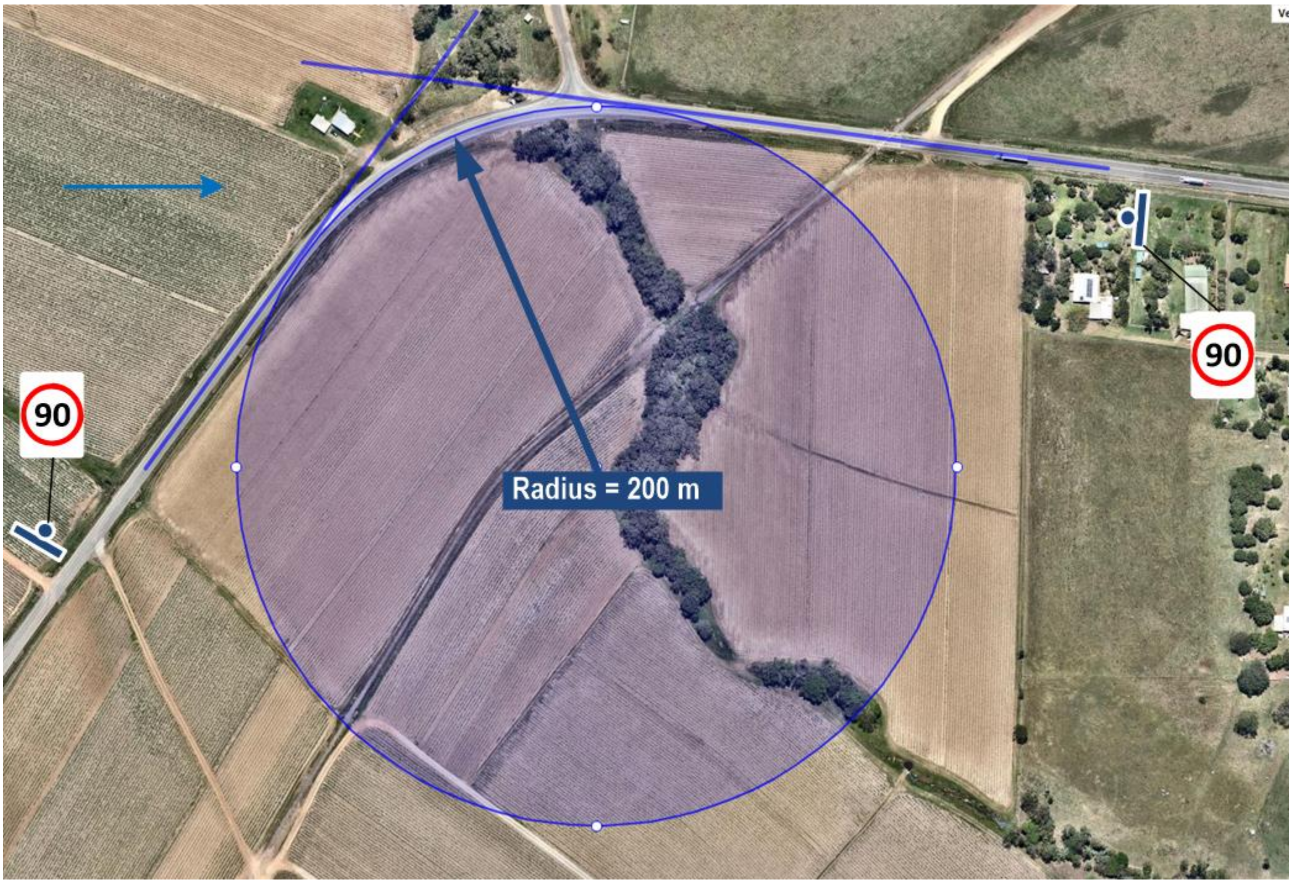
When these are identified they can be looked up in the relevant minimum curve radius table to identify the maximum curve operating speed. The speed reduction from the approach speed to the safe curve operating speed can then be calculated; this should not result in a reduction of more than 10 km/h. If the speed reduction is greater than 10 km/h appropriate mitigation measures must be in place to provide visual cues for a driver to reduce to an appropriate speed and be able to interpret the direction and size of the curve to reduce to an appropriate curve operating speed. Some mitigation measures may include those shown in Table G 1.

Table F 1: Sealed road: desirable minimum curve radius (m)

Curve operating speed (km/h)	Urban and rural roads			
	Superelevation			
	3%	4%	5%	6%
40	52	50	48	47
50	82	79	76	73
60	142	135	129	123
70	227	214	203	193
80	315	296	280	265
90	425	399	375	354
100	525	492	463	437
110	635	595	560	529

Note:
1 Minimum curve radii determined using minimum curve radius formula and desirable maximum side friction values for trucks (Austroads 2016a).
Source: Adapted from Austroads (2016a).

F.1.1 Worked Example A – Sealed road using desirable minimum curve radius (m) values



Source: nearmap.com.

Identify the variables

- 4% superelevation (measured on site, verified by as-constructed plans if available)
- 200 m radius (as in as-constructed plans or via aerial imagery)
- operating speed on the approach to the curve (speed survey of similar class vehicle or operating speed model).

Refer to relevant minimum curve radius table:

- go to the column for 4% superelevation
- find the curve radius that is ≤ 200 m (135 m in this instance)
- find the corresponding curve operating speed for that radius (60 km/h in this instance).

The resulting curve operating speed of 60 km/h is the recommended safe speed for a heavy vehicle on this curve. Vehicles with high COG may need to be assessed on a vehicle-specific basis, particularly if absolute minimum curve radius values are used.

The reduction in speed from the operating speed on the approach to the curve operating speed should not be more than 10 km/h. In this instance the reduction required is 40 km/h. This curve is not suitable for heavy vehicles based on horizontal geometry unless the following is provided:

- Curve perception sight distance: for a driver to clearly identify the curve direction and size so that speed can be reduced.

APPENDIX G SIGHT DISTANCE

G.1 Vertical Height Parameters

A description of object height and driver eye height can be found in Austroads (2016a). The object and driver heights to be used, along with typical applications are shown in Table G 1.

Table G 1: Vertical height parameters

Vertical height parameter[1]	Height (m)	Typical application
Height of eye of driver *h*1		
Passenger car	1.1	All car sight distance models.
Truck	2.4	All truck sight distance models where a truck is travelling in daylight hours and at night-time where the road is lit.
Bus	1.8	Specific case for bus-only facilities, e.g. busways.
Headlight height *h*1		
Passenger car	0.65	1. Headlight stopping sight distance in sags. 2. Check case for night-time stopping for cars (no road lighting).
Commercial vehicle	1.05	Check case for night-time stopping for trucks (no road lighting).
Object cut-off height *h*2		
Road surface	0.0	1. Approach sight distance at intersections. 2. Approach sight distance to taper at end of auxiliary lane. 3. Headlight sight distance in sags. 4. Horizontal curve perception distance. 5. Water surface at floodways.
Stationary object on road	0.2	Normal stopping sight distance for cars and trucks to hazard on roadway.
Front turn indicator	0.65	Minimum gap sight distance at intersections.
Car tail light/stop light/turn indicator	0.8	1. Car stopping sight distance to hazards over roadside safety barriers in constrained locations.[2] 2. Truck stopping sight distance to hazards over roadside safety barriers in constrained locations. 3. Stopping sight distance where there are overhead obstructions.
Top of car	1.25	1. Car stopping sight distance to hazards over roadside safety barriers on a horizontally curved bridge with road lighting.[2] 2. Truck stopping sight distance to hazards over roadside safety barriers in extremely constrained locations with road lighting.[2] 3. Intermediate sight distance. 4. Overtaking sight distance. 5. Safe intersection sight distance. 6. Mutual visibility at merges.

Notes:

1 Austroads (2016a), Commentary 10, discusses the degree to which some of the values of the vertical height parameters given in this table are representative of modern vehicles.

2 Where car stopping sight distance over roadside barriers is applied to an object height greater than 0.2 m, or truck stopping sight distance over roadside barriers is applied to an object height greater than 0.8 m, the minimum shoulder widths and manoeuvre times given in Table 5.7 apply.

Source: Austroads (2016a)

G.2 Stopping Distances for Curves where Curve Speed is 15 km/h Less than the Approach Speed

When the curve operating speed for a heavy vehicle (Table 10.13, Table 10.14 and Table 10.15) is less than 15 km/h (or > 15 km/h) compared to the approach speed, a heavy vehicle should have adequate sightlines on the approach through the curve and through the curve to identify the radius and direction of the curve, or a hazard.

Additional sight distance should result in a driver being able to reduce operating close to an appropriate curve speed to reduce the likelihood of a rollover (due to excessive speed), a collision with a hazard or vehicle on the carriageway/shoulder, or a vehicle (from the opposing lane) that has crossed the centreline.

G.2.1 SSD on substandard curves

Table G 2 and Table G 3 show the SSD for the instances where curve speed is 15 km/h less than the approach speed.

Table G 2: SSD for curves when curve speed is 15 km/h less than approach speed: sealed roads

Operating speed (km/h)	Downhill		Level	Uphill			
	-9%	*-6%*	*-3%*	*0%*	*3%*	*6%*	*9%*
B-double / PBS Level 2							
50	135 *	110 *	95	85	80	75	70
60	185 *	150 *	130	115	105	100	90
70	240 *	195 *	170	150	135	125	120
80	310 *	250 *	215	190	170	155	145
90	380 *	310 *	260	230	205	190	175
100	465 *	370 *	315	275	250	225	210
110	555 *	445 *	375	325	295	265	245
Type 1 RT / PBS Level 3							
50	165 *	130 *	110	100	90	85	80
60	225 *	180 *	150	135	120	110	105
70	300 *	235 *	195	170	155	140	135
80	380 *	295 *	245	215	195	175	165
90	475 *	365 *	305	265	235	215	200
100	575 *	440 *	365 *	315	280	255	235
110	685 *	525 *	430 *	370	330	300	275
Type 2 RT / PBS Level 4							
50	215 *	160 *	130	115	105	95	90
60	295 *	215 *	175	155	135	125	115
70	390 *	280 *	230	195	175	160	150
80	500 *	360 *	290 *	245	220	200	185
90	620 *	440 *	355 *	300	265	240	220
100	755 *	535 *	425 *	360	315	285	260
110	900 *	635 *	505 *	425	370	335	305

Notes:

- * On extended lengths of this grade, MCVs would need to descend in low gear to prevent overrun. Signage treatments as per AS 1742.2 (2009) should be provided. These should be appropriate for the decent type (i.e. short steep descent, steep descent, long steep descent), which may include detour signage. Steep descents with horizontal curvature should be reviewed as indicated in Section 10.10.3.
- Stopping distances on curves with a radius < 400 m should be increased by 10% (Austroads 2016a).
- The above values have been derived using the formula given in Austroads (2016a) with the following factors:

	B-double / PBS Level 2	Type 1 RT / PBS Level 3	Type 2 RT / PBS Level 4
Reaction time	2.5 s	3.0 s	3.5 s
Deceleration rate (d)	0.19 g *	0.17 g *	0.15 g *

Note: * Adapted from Austroads (2016a) to provide longer stopping distances on/through curves.

Source: Based on MRWA (2017).

Table G 3: SSD for curves when curve speed is 15 km/h less than approach speed: unsealed roads

Operating Speed (km/h)	Downhill			Level	Uphill		
	-9%	*-6%*	*-3%*	*0%*	*3%*	*6%*	*9%*
B-double / PBS Level 2							
50	150 *	125 *	105	95	85	80	75
60	210 *	170 *	145	130	115	105	100
70	280 *	225 *	190	170	150	140	130
80	355 *	285 *	240	210	190	175	160
90	445 *	355 *	300	260	235	215	195
100	540 *	430 *	360	315	280	255	235
110	645	515	430	375	335	305	280
Type 1 RT / PBS Level 3							
50	185 *	145 *	125	110	100	90	85
60	260 *	200 *	170	150	135	120	115
70	345 *	265 *	220	190	170	155	145
80	440 *	340 *	280	240	215	195	180
90	550 *	420 *	345	300	265	240	220
100	670 *	510 *	420 *	360	315	285	265
110	805 *	610 *	500 *	425	375	340	310
Type 2 RT / PBS Level 4							
50	245 *	175 *	145	125	110	100	95
60	340 *	245 *	200	170	150	135	125
70	450 *	325 *	260	220	195	175	160
80	580 *	410 *	325 *	275	245	220	200
90	725 *	510 *	405 *	340	300	265	245
100	880 *	620 *	490 *	410	355	320	290
110	1025 *	710 *	550 *	455	390	345	310

Notes:

- * On extended lengths of this grade, MCVs would need to descend in low gear to prevent overrun. Signage treatments as per AS 1742.2 (2009) should be provided. These should be appropriate for the decent type (i.e. short steep descent, steep descent, long steep descent), which may include detour signage. Steep descents with horizontal curvature should be reviewed as indicated in Section 10.10.3.
- Stopping distances on curves with a radius < 400 m should be increased by 10% (Austroads 2016a).
- The above values have been derived using the formula given in Austroads (2016a) with the following factors:

	B-double / PBS Level 2	Type 1 RT / PBS Level 3	Type 2 RT / PBS Level 4
Reaction time	2.5 s	3.0 s	3.5 s
Deceleration rate (d)	0.19 g *	0.17 g *	0.15 g *

Note: * Adapted from Austroads (2016a) to provide longer stopping distances on/through curves. Gravel correction factor as per Austroads (2009) applied
Source: Based on MRWA (2017).

G.2.2 SISD on substandard curves

Table G 2 and Table G 3 show the SSD for the instances where curve speed is 15 km/h less than the approach speed.

Table G 4: SISD: sealed roads on substandard curves

Operating Speed (km/h)	Downhill			Level	Uphill		
	-9 %	-6 %	-3 %	0 %	3 %	6 %	9 %
B-double / PBS Level 2							
50	150 *	140 *	130	125	120	115	115
60	195 *	180 *	165	160	150	145	145
70	245 *	225 *	210	195	190	180	175
80	300 *	275 *	255	240	225	215	210
90	365 *	325 *	300	285	270	255	245
100	450 *	400 *	365	340	320	300	290
110	580 *	500 *	450	410	380	360	340
Type 1 RT / PBS Level 3							
50	155 *	145 *	135	130	125	125	120
60	205 *	185 *	175	165	160	155	150
70	255 *	235 *	220	205	200	190	185
80	310 *	285 *	265	250	240	230	220
90	375 *	340 *	315	295	280	270	260
100	460 *	410 *	375 *	350	330	315	305
110	595 *	515 *	465 *	425	395	375	355
Type 2 RT / PBS Level 4							
50	165 *	150 *	145	140	135	130	125
60	210 *	195 *	185	175	170	165	160
70	265 *	245 *	230	215	210	200	195
80	325 *	295 *	275 *	260	250	240	230
90	390 *	350 *	325 *	310	295	280	270
100	475 *	425 *	390 *	365	345	330	315
110	610 *	530 *	480 *	440	410	390	375

Notes:

- * On extended lengths of this grade, MCVs would need to descend in low gear to prevent overrun. Signage treatments as per AS 1742.2 (2009) should be provided. These should be appropriate for the decent type (i.e. short steep descent, steep descent, long steep descent), which may include detour signage. Steep descents with horizontal curvature should be reviewed as indicated in Section 10.10.3.
- Stopping distances on curves with a radius < 400 m should be increased by 10% (Austroads 2016a).
- The above values have been derived using the formula given in Austroads (2016a) with the following factors:

	B-double / PBS Level 2	Type 1 RT / PBS Level 3	Type 2 RT / PBS Level 4
Reaction time	2.0 s	2.0 s	2.0 s
Observation time	3.0 s	3.0 s	3.0 s
Brake lag	1.0 s	1.5 s	2.0 s
Deceleration rate (d)	0.29 g up to 90 km/h, 0.28 g at 100 km/h and 0.26 g at 110 km/h		

Source: Based on MRWA (2017).

Table G 5: SISD: unsealed roads on substandard curves

Operating Speed (km/h)	Downhill			Level	Uphill		
	-9 %	*-6 %*	*-3 %*	*0 %*	*3 %*	*6 %*	*9 %*
B-double / PBS Level 2							
50	160 *	145 *	135	130	125	120	115
60	210 *	190 *	180	170	160	155	150
70	270 *	245 *	225	210	200	190	185
80	330 *	300 *	275	255	245	230	225
90	405 *	360 *	330	305	290	275	265
100	500 *	440 *	400	370	345	325	310
110	590 *	515 *	465	430	400	380	360
Type 1 RT / PBS Level 3							
50	165 *	155 *	145	135	130	125	125
60	220 *	200 *	185	175	170	165	155
70	280 *	255 *	235	220	210	200	195
80	345 *	310 *	285	270	255	245	235
90	415 *	375 *	340	320	300	290	275
100	515 *	455 *	415 *	385	360	340	325
110	605 *	530 *	480 *	445	415	395	375
Type 2 RT / PBS Level 4							
50	175 *	160 *	150	145	140	135	130
60	230 *	210 *	195	185	175	170	165
70	290 *	260 *	245	230	220	210	205
80	355 *	320 *	295 *	280	265	255	245
90	430 *	385 *	355 *	330	315	300	290
100	530 *	470 *	430 *	395	375	355	340
110	620 *	550 *	495 *	460	430	410	390

Notes:

- * On extended lengths of this grade, MCVs would need to descend in low gear to prevent overrun. Signage treatments as per AS 1742.2 (2009) should be provided. These should be appropriate for the decent type (i.e. short steep descent, steep descent, long steep descent), which may include detour signage. Steep descents with horizontal curvature should be reviewed as indicated in Section 10.10.3.
- Stopping distances on curves with a radius < 400 m should be increased by 10% (Austroads 2016a).
- The above values have been derived using the formula given in Austroads (2016a) with the following factors:

	B-double / PBS Level 2	Type 1 RT / PBS Level 3	Type 2 RT / PBS Level 4
Reaction time	2.0 s	2.0 s	2.0 s
Observation time	3.0 s	3.0 s	3.0 s
Brake lag	1.0 s	1.5 s	2.0 s
Deceleration rate (d)	0.29 g up to 90 km/h, 0.28 g at 100 km/h and 0.26 g at 110 km/h		

Note: Gravel correction factor as in Austroads (2009) applied.

Source: Based on MRWA (2017).

APPENDIX H CHECKLIST

Route name:	
Current vehicle authorisation:	
Requested vehicle authorisation:	
Date of completion:	

Item no. in the Guidelines	Description	Requirement	Data available	Assessed	Risk assessment	Comments
Section 10	**Geometric assessment conditions**					
Section 10.4	Carriageway widths on straight sections					
Section 10.4.1	Road condition	Road condition signage is in accordance with the guidance provided in Section 10.4.1	Yes / No	Yes / No	Yes / No	
Section 10.4.2	Turn lane and kerbside lane widths	Considered under Section 10.4.2.	Yes / No	Yes / No	Yes / No	
Section 10.4.3	Urban roads	Carriageway widths in urban areas are in accordance with the minimum requirements shown in Table 10.3 .	Yes / No	Yes / No	Yes / No	
Section 10.4.4	Rural roads	Sealed roads - carriageway sealed widths in rural areas are in accordance with the minimum requirements shown in Table 10.4.	Yes / No	Yes / No	Yes / No	
Section 10.4.5	Low-volume, low-speed roads	Carriageway widths in rural low-volume (< 75 vpd/AADT), low speed-areas (< 60 km/h) are in accordance with the minimum requirements shown in Table 10.5. Formed tracks are in accordance with maximum lengths shown in Table 10.6.	Yes / No	Yes / No	Yes / No	

Item no. in the Guidelines	Description	Requirement	Data available	Assessed	Risk assessment	Comments
Section 10.4.6	Narrow sections on lower-volume rural roads	Reduced width carriageways on lower-volume rural roads are in accordance with the requirements shown in Table 10.8.	Yes / No	Yes / No	Yes / No	
Section 10.5	Operating conditions for low-volume roads with reduced width					
		Where a road segment does not meet the minimum requirements as in Section 10.4.4 but meets the conditions of Section 10.4.5, has consideration of risk mitigation through one or more conditions outlined in section 10.5 been made.	Yes / No	Yes / No	Yes / No	
Section 10.6	Lane widths on curved sections					
		Lane widths on curved sections are in accordance with the minimum requirements shown in Table 10.9.	Yes / No	Yes / No	Yes / No	
Section 10.7	Carriageway width over structures					
		Undivided carriageway - carriageway widths on bridges and culverts are in accordance with the minimum requirements shown in Table 10.10. Divided carriageway - carriageway widths on bridges and culverts are in accordance with the minimum requirements shown in Table 10.11.	Yes / No	Yes / No	Yes / No	
Section 10.7.1	Narrow width over structures on-lower volume rural roads (< 150 VPD or AADT)	Has the risk of narrow widths over structures on lower-volume roads (< 150 VPD or AADT) been mitigated with signage or operating conditions.	Yes / No	Yes / No	Yes / No	
Section 10.8	Floodways and causeways					

Item no. in the Guidelines	Description	Requirement	Data available	Assessed	Risk assessment	Comments
		If the route contains sections subject to flooding or is crossing a floodway, have detours and alternative routes been assessed using road width criteria as Section 10.4.4 or Section 10.4.5.	Yes / No	Yes / No	Yes / No	
Section 10.9	Horizontal alignment					
Section 10.9.4	Adverse crossfall	Adverse crossfall has been reviewed in detail.	Yes / No	Yes / No	Yes / No	
Section 10.9.3	Maximum values of superelevation	Maximum curve superelevation, based on operating speed and road type, is in accordance with Table 10.12.	Yes / No	Yes / No	Yes / No	
Section 10.9.5	Assessing horizontal curve suitability	Sealed roads – desirable minimum curve radius, based on curve superelevation and operating speed, is in accordance with Table 10.13. If the desirable minimum curve radius is not met, is the absolute minimum curve radius in accordance with Table 10.14. Unsealed roads – minimum curve radius, based on curve superelevation and operating speed, is in accordance with Table 10.15.	Yes / No	Yes / No	Yes / No	
Section 10.9.6	Operating speed reductions when entering curves and horizontal curve perception of sight distance	Curve warning signage is in accordance with Section 10.9.6.	Yes / No	Yes / No	Yes / No	

Item no. in the Guidelines	Description	Requirement	Data available	Assessed	Risk assessment	Comments
Section 10.10	Vertical alignment					
Section 10.10.1	Startability	Maximum vehicle starting grades are in accordance with Table 10.17.	Yes / No	Yes / No	Yes / No	
Section 10.10.2	Ascending grade effects on speed	Maximum distance of uphill travel on sealed roads before speed reduces to 40 km/h, based on vehicle type and grade, is in accordance with Table 10.18.	Yes / No	Yes / No	Yes / No	
Section 10.10.3	Descending grade effects on braking	Warrant for runaway vehicle analysis is in accordance with Table 10.19.	Yes / No	Yes / No	Yes / No	
Section 10.10.4	Combinations of steep descents and tight horizontal curves	Steep descents with horizontal curvature have been revised in accordance with 10.10.4.	Yes / No	Yes / No	Yes / No	
Section 10.11	Sight distance					
Section 10.11.1	Stopping sight distance	Sealed roads - required stopping sight distance, based on operating speed, vehicle type and grade, is in accordance with Table 10.21. Unsealed roads - Required stopping sight distance, based on operating speed, vehicle type and grade, are in accordance with Table 10.22.	Yes / No	Yes / No	Yes / No	
Section 10.11.2	Approach sight distance (ASD)	Sealed Roads - required approach sight distance, based on operating speed, vehicle type and grade, is in accordance with Table 10.24. Unsealed roads - required approach sight distance, based on operating speed, vehicle type and grade, is in accordance with Table 10.25.	Yes / No	Yes / No	Yes / No	

Item no. in the Guidelines	Description	Requirement	Data available	Assessed	Risk assessment	Comments
Section 10.11.3	Safe intersection sight distance (SISD)	Sealed roads - required safe intersection sight distance, based on operating speed, vehicle type and grade, is in accordance with Table 10.26 of the Guidelines. Unsealed roads - required safe intersection sight distance, based on operating speed, vehicle type and grade, is in accordance with Table 10.27	Yes / No	Yes / No	Yes / No	
Section 10.11.5	Overtaking sight distance	Considered under Section 10.14.	Yes / No	Yes / No	Yes / No	
Section 10.12	Intersections					
Section 10.12.1	Clearance times	Intersection clearance times, based on clearance distance, vehicle type and grace, are in accordance with Table 10.28 and Table 10.29.	Yes / No	Yes / No	Yes / No	
Section 10.12.2	Stacking distance	Sufficient stacking distances between adjacent intersections in accordance with Table 10.30 allow an MCV to clear the first intersection before stopping at the second intersection.	Yes / No	Yes / No	Yes / No	
Section 10.12.3	Storage-lane length	The minimum storage lane length is in accordance Table 10.30. Consideration of the effects of the heavy vehicle stacking distance on queue lengths has been made	Yes / No	Yes / No	Yes / No	
Section 10.12.4	Low speed swept path	Low speed swept paths are adequate for turning manoeuvres based on maximum turn speeds and minimum turning radii shown in Table 10.31 and guidance provided in Section 10.12.4.	Yes / No	Yes / No	Yes / No	
Section 10.12.5	Turning lanes	Minimum lengths of turning acceleration lanes are in accordance with Table 10.34.	Yes / No	Yes / No	Yes / No	

Item no. in the Guidelines	Description	Requirement	Data available	Assessed	Risk assessment	Comments
Section 10.12.6	Intersection sight distance	Approach sight distance on a side road is in accordance with Section 10.11.	Yes / No	Yes / No	Yes / No	
Section 10.12.7	Adverse crossfall	Has an assessment of static rollover threshold through intersections with adverse crossfall greater than 3% been considered? Vehicles with a high centre of gravity of 'live load' may need to be assessed with adverse crossfall less than 3%.	Yes / No	Yes / No	Yes / No	
Section 10.12.8	Roundabouts	A static rollover threshold and/or load transfer ratio analysis may need be considered for heavy vehicles operating on roundabouts due to increased risk of rollover or loss of control.	Yes / No	Yes / No	Yes / No	
Section 10.13	Railway level crossings					
Section 10.13.1	Sight distance and signage on approaches to railway level crossings	Passive control crossings – sight distance required on approach to a passive control railway crossing is in accordance with Table 10.35. Active control crossings – active control crossing warning times are in accordance with Table 10.36.	Yes / No	Yes / No	Yes / No	
Section 10.13.2	Stacking distance at level crossings	Sufficient stacking distances between railway crossing and adjacent intersections are in accordance with Table 10.37 to allow an MCV to clear the railway crossing before stopping at the adjacent intersection.	Yes / No	Yes / No	Yes / No	
Section 10.14	Overtaking					
		The process for assessing overtaking provisions to ensure recommended level of service for desired heavy vehicle access is shown in Figure 10.32.	Yes / No	Yes / No	Yes / No	
Section 10.14.1	Overtaking opportunities	Overtaking opportunities are in accordance with Table 10.40.	Yes / No	Yes / No	Yes / No	

Item no. in the Guidelines	Description	Requirement	Data available	Assessed	Risk assessment	Comments
Section 10.14.2	Overtaking in the opposing lane	Overtaking conditions are in accordance with Table 10.42, Table 10.43 and Table 10.44.	Yes / No	Yes / No	Yes / No	
Section 10.14.3	Overtaking using an overtaking lane	Overtaking lanes lengths and merge sight distance are based on road section operating speed and should be in accordance with Table 10.45 and Table 10.46 respectively.	Yes / No	Yes / No	Yes / No	
Section 10.14.4	Speed differential due to grades	Overtaking lanes on or in proximity to an incline or decline where heavy vehicle travel speed reduces to 40 km/h are in accordance with Section 10.10.	Yes / No	Yes / No	Yes / No	
Section 10.15	Vertical (overhead) clearance					
		Rigid overhead obstruction – overhead clearance height between the heavy vehicle and obstruction is more than 0.4 m. Non-rigid overhead obstruction – overhead clearance height between the heavy vehicle and obstruction is more than 0.5 m.	Yes / No	Yes / No	Yes / No	
Section 11	**Amenity considerations**					
Section 11.1	Adjacent land use					
		Consideration has been given to adjacent land use to minimise conflicts with other road users for safety and amenity reasons. The assessor may liaise with the Queensland Department of Infrastructure, Local Government and Planning to understand the impacts of heavy vehicles.	Yes / No	Yes / No	Yes / No	
Section 11.2	Noise					
		Consideration has been given to impacts of increased noise on surrounding areas and use of noise impact mitigation techniques.	Yes / No	Yes / No	Yes / No	
Section 11.3	Emissions and odours					

Item no. in the Guidelines	Description	Requirement	Data available	Assessed	Risk assessment	Comments
		Consideration has been given to impacts of heavy vehicle emissions and odours on surrounding areas.	Yes / No	Yes / No	Yes / No	
Section 11.4	Airborne dust and water splash/spray					
		Consideration has been given to impacts of airborne dust and water splash/spray caused by heavy vehicles in accordance with Section 11.4.	Yes / No	Yes / No	Yes / No	
Section 11.5	Seasonality					
		Consideration has been given to heavy vehicle impacts on seasonal fluctuations in traffic flow expected during peak holiday and harvest periods.	Yes / No	Yes / No	Yes / No	
Section 11.6	Off-street parking					
		Consideration of off-street parking has been made in accordance with the guidelines in NTC (2007), MRWA (2017) and TMR (2018a).	Yes / No	Yes / No	Yes / No	
Section 12	**Structures assessment**					
Section 12.4	Structural assessment process					
		Consideration of structures has been undertaken in accordance with the framework in Figure 12.2.	Yes / No	Yes / No	Yes / No	
Section 13	**Pavement impact assessment**					
Section 13.2.1	Pavement impact assessment process					
		Consideration of pavements has been undertaken in accordance with the framework in Figure 13.1 and methods outlined in Section 13.2.1	Yes / No	Yes / No	Yes / No	

Item no. in the Guidelines	Description	Requirement	Data available	Assessed	Risk assessment	Comments
Section 8	**Risk assessment process**					
		If the route does not meet any of the desired criteria has the risk assessment processes been undertaken in accordance with Section 8.	Yes / No	Yes / No	Yes / No	