A7 Passing lanes

A7.1 Introduction

Introduction

This appendix contains procedures to evaluate the benefits of providing passing lanes, typically through the provision of passing lanes, climbing lanes, slow vehicle bays, and increases in the natural passing opportunities from improved alignments.

Benefits of providing increased passing lanes

A wide range of vehicle types travel on New Zealand highways each day and inevitably some slower vehicles impede other faster vehicles. In order to overtake these slower vehicles on two lane highways, drivers must use the opposing traffic lane. However this is not always possible or safe. Suitable gaps in the opposing traffic may be limited and the road alignment may restrict the forward sight distance. The result is increased travel times as well as increases in driver frustration. Research suggests that the latter may lead to an increase in unsafe passing manoeuvres and accidents (Thrush, 1996).

In this appendix

This appendix contains the following topics:

A7.1 Introduction, continued

Passing lanes

Passing lanes (and climbing lanes) provide a relatively safe environment for vehicles to overtake other vehicles, allowing them to travel at their desired speed until such time as the platoons reform. As a consequence the benefits of passing lanes generally extend much farther than the physical length of the passing lane section itself, as shown in figure A7.1 below.

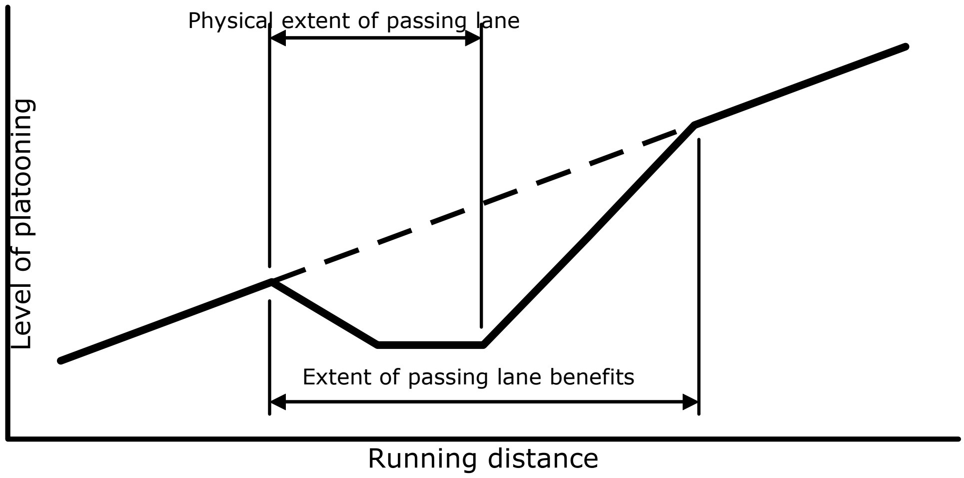


Figure A7.1 Benefit length of installing passing lanes

Passing lanes free impeded vehicles from slow moving platoons and in doing so they improve levels of service, reduce travel times and driver frustration. These benefits will be greatest at locations where road and traffic conditions result in significant passing demand.

Other improvement options

In hilly and mountainous terrain, passing lanes (and climbing lanes) may not be viable, particularly on lower volume roads. In such cases other improvement options such as slow vehicle bays and shoulder widening should be considered. The benefit of full length passing lanes in less severe terrain can also be low, when traffic volumes are low. In such cases improving sight lines through clearance of vegetation and vertical or horizontal realignment may increase the available passing opportunities and generate other safety benefits.

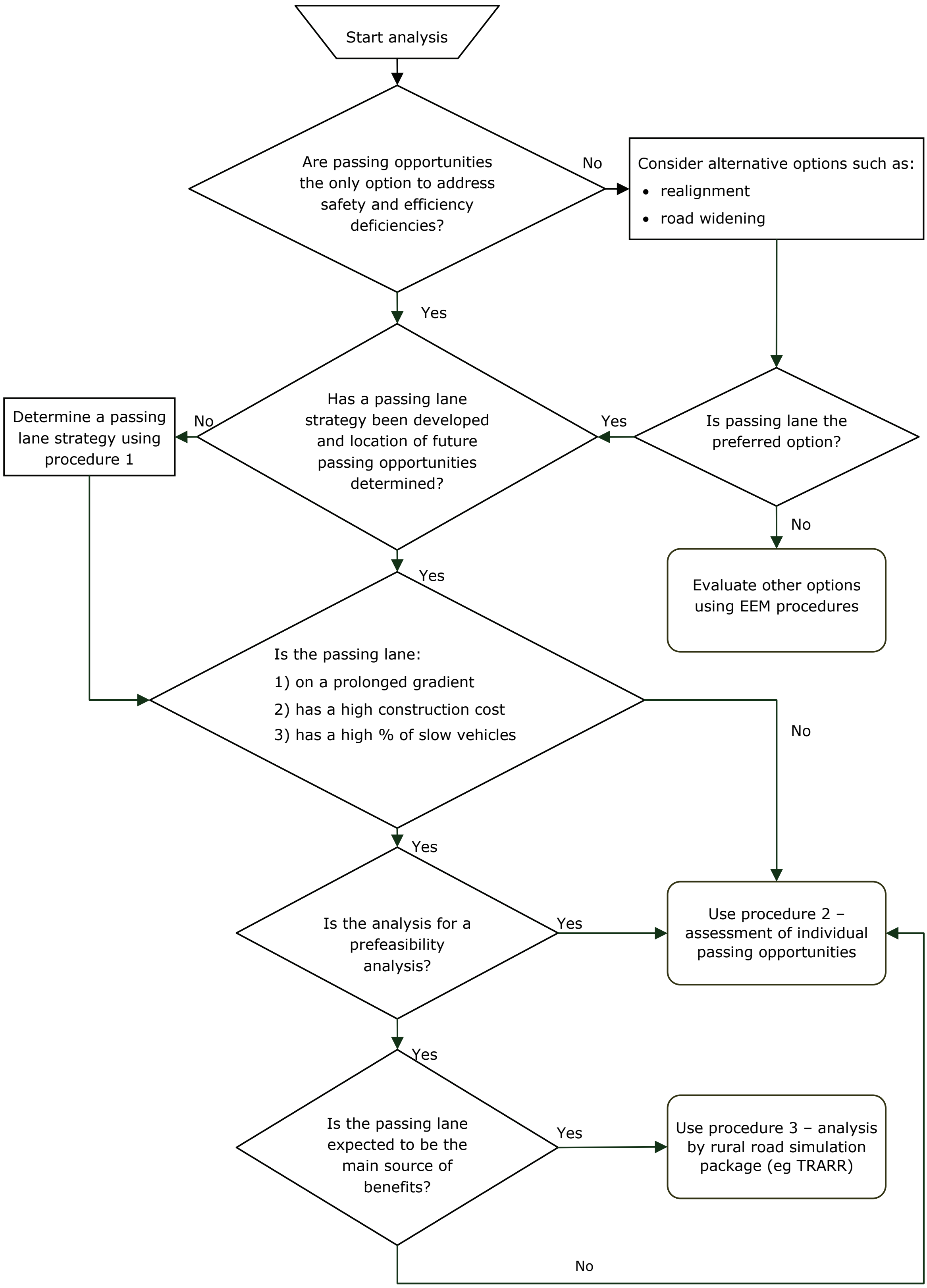
Passing lane evaluation procedures

There are three procedures in this appendix.

- passing lane strategy for determining the location of individual passing lanes (appendix A7.3).
- assessment of individual passing lanes identified as feasible from a passing lane strategy (appendix A7.4).
- detailed analysis of passing lane projects using rural traffic simulation software, such as TRARR (appendix A7.5).
- Figure A7.2 should be used to determine the appropriate procedure.

A7.1 Introduction, continued

Figure A7.2 Selection of passing lane analysis procedure



A7.2 Background

Travel time and driver frustration savings

Travel time and driver frustration benefits are generated when passing lanes reduce the amount of time drivers spend travelling in platoons. The demand for passing and consequently the benefits, are a function of a number of parameters including:

Traffic variables

- traffic volume
- percentage of HCVs
- initial platooning
- directional split of traffic
- vehicle speed distributions

Road variables

- terrain/alignment
- grades
- available passing lanes (sight distance)
- passing lane lengths and frequency

The downstream distance over which road user benefits accrue reduces as traffic volumes, the proportion of slower vehicles (HCVs), and the speed differential between fast and slow vehicles increases. Features that re-platoon the traffic stream, such as urban areas and major intersections, may limit the available benefits. While passing lanes also have an impact on the passing opportunities available to traffic travelling in the opposite direction (where passing is not prohibited), these impacts are typically quite small and are ignored.

These procedures provide graphs of travel time and driver frustration benefits, which are used or incorporated into graphs of BCR for different input parameters. These graphs were developed from a simulation model, which simulates two traffic streams (fast and slow vehicles) travelling along sections of highway. The simulations are used to determine the demand for passing lanes. The travel time benefits of passing lanes are then assessed using the Unified Passing Model developed by Werner and Morrall (1984). The changes observed in the level of platooning determine the driver frustration benefits, while the reduction in travel time is a benefit in its own right, it is also used to determine the change in mean travel speed and the subsequent change in vehicle operating costs.

A7.2 Background, continued

Accident rates

An accident rate analysis has been undertaken to produce the accident reduction benefit graphs shown in figures A7.9 to A7.12. The typical accident rate by terrain type is taken from table A6.12(a). The accident rate at the passing lane and downstream of the passing lane is less than the typical rate and varies depending on proximity to the passing lane. The maximum reduction is along the passing lane where the reduction in the typical rate is 25%. The reduction in the accident rate reduces linearly to zero from the end of the passing lane to either the location where vehicle platooning returns to normal (generally 5 to 10 km downstream), or where another passing lane begins.

Table A7.1 shows the accident rate before the installation of a passing site. The typical accident rates for hilly terrain have been interpolated as mid-way between the accident rates for rolling and mountainous terrain.

If the passing lane forms part of a rural realignment or there are 5 or more injury accidents or two or more serious and fatal accidents in any 1 kilometre section (up to 10 kilometres downstream of the passing lane) then accident-by accident analysis may be suitable. To determine if such an analysis is appropriate refer to section A6.2.

For accident by accident analysis, table A6.18(d) provides accident reductions for up to 10 km downstream of the passing lane. In the majority of cases however accident benefits should only be claimed up to 5 km downstream of a passing lane unless a rural simulation analysis indicates that vehicle platooning will not return to normal until more than 5 km downstream. No upstream accident benefits can be included unless international or local research is produced to justify such benefits.

Passing lane length

A standard passing lane length of 1 km is assumed in these procedures. When evaluating passing lanes with a length greater or shorter than 1 km, the appropriate factors in table A7.8 should be applied to the road user benefits.

Table A7.1 Accident rates for rural mid-block locations (/10^8 veh-km)

Terrain type	Typical accident rate – no passing lane
Flat	16
Rolling	20
Hilly	24 (interpolated from rolling and mountainous accident rates)
Mountainous	28

A7.2 Background, continued

Proportion of heavy traffic

Two traffic streams, 'cars' (passenger cars and light commercial vehicles) and 'trucks' (medium/heavy commercial vehicles and buses) are assumed. The relative proportions are based on the All periods composition for a rural strategic road, which is 88 percent light vehicles and 12 percent heavy vehicles (refer table A2.1). This assumption impacts on both the level of travel time benefits and on the value of these benefits. The adjustment in equation 1 (appendix A7.4) can be applied when the percentage of heavy vehicles is above or below 12%.

Traffic flow profile

The benefits of passing lanes are a function of the traffic using the road during a particular period (vehicles/hour). To express the benefits of passing lanes as a function of AADT, it is necessary to assume a traffic flow profile and the number of hours per year that this particular level of traffic flow (percentage of AADT) occurs. The traffic flow profile assumed for these procedures is based on that recorded for rural State Highways that do not carry high volumes of seasonal holiday or recreational traffic.

Although it may be expected that additional benefits will accrue to passing lanes on roads that do carry high volumes of recreational traffic, the differences have been found to be insignificant. The exceptional peaks of the roads with high volumes of recreational traffic are offset by a reduction in the proportion of time the road operates at around 7 percent of AADT (refer table A7.2 below).

The relationship between the benefits and the flow profile is relatively robust. In situations where the traffic flow profile differs significantly from the above, the simplified procedure may not be applicable, and more detailed analysis using ruralsimulation (eg, TRARR) may be required.

Table A7.2 Traffic flow profiles

Hourly flow as % of AADT	Roads with low volumes of recreational traffic			Roads with high volumes of recreational traffic		
	hours/year	**% hours**	**% AADT**	**hours/yr**	**% hours**	**% AADT**
0.9	3,979	45.42	9.7%	3,797	43.35	9.3%
3.5	933	10.65	8.9%	2,062	23.54	19.8%
7.0	3,210	36.64	61.6%	1,819	20.76	34.9%
10.5	541	6.18	15.6%	822	9.38	23.6%
14.0	97	1.11	3.7%	96	1.10	3.7%
17.5	10	0.11	0.5%	120	1.37	5.8%
21.0	-	-	-	6	0.07	0.4%
25.0	-	-	-	38	0.43	2.6%
Total	**8,760**	**100%**	**100%**	**8,760**	**100%**	**100%**

A7.2 Background, continued

Traffic growth

The procedures have been developed using a traffic growth of 2%. Adjustment factors are produced to modify benefit graphs when the traffic growth is 1%, 3% and 4%. Where the traffic growth does not correspond to these values an appropriate adjustment factor can be calculated using interpolation or extrapolation.

Speed

The variation in traffic speed of individual vehicles within each traffic stream is expressed in terms of the coefficient of variation (standard deviation divided by the mean) of all vehicle speeds. The procedure assumes the coefficient of variation (COV) to be 13.5 percent for both traffic streams.

In situations where road geometry or terrain type has a significant impact on the speeds of particular vehicle types, it is likely that the coefficient of variation will increase. In such cases the simplified model will under predict the benefits of releasing faster vehicles from platoons. Similarly on long flat straights where there is likely to be less variation in speed the model can be expected to over predict the travel time benefits. The adjustment in equation 2 (appendix A7.4) can be applied when the COV is above or below 13.5%.

Construction costs

The construction costs presented here, and used in the analysis for determining the appropriate passing lane strategy, are based on the average costs of constructing a 1 km passing lane in each of the terrain categories. These average costs are generally weighted to the lower end of the reported range, as in most instances passing lanes are located to avoid costly items, such as bridges.

Table A7.3 Classification of passing lane costs

Category	Cost/m ($2005)	Typically had some or all of the following features:	Assumed cost/m ($2005)
Easy	$120 to $250	• Flat, straight road and terrain, • Very good ground conditions, • 2 or 3 passing lanes projects in one contract, • Existing road 10 metres seal width, new passing lanes on both sides of road, and • No expensive special features	$170
Average	$250 to $500	• Flat or gently rolling terrain, • Straight or curved alignment, • Good or average ground conditions (soft material encountered on some projects), • Typically one passing lane per contract, and • Some special features on some projects	$320
Difficult	≥ $500	• Poor ground requiring removal and replacement, • Curved or straight alignment, • Awkward or hilly terrain, • Short length of passing lane in one contract, • High traffic count and control costs, and • Often expensive special features such as rehabilitation and intersection improvements	$800 (Estimates in this category were as high as $1,700 per linear metre)

A7.2 Background, continued

Construction costs, continued

Average construction and maintenance costs have been calculated for each of the terrain types, using real costs from a number of projects and from data collected for passing lane research. The construction costs per linear metre from these projects determined the cost categories shown in table 10.3. Table A7.4 relates each of the four terrain types to the cost categories, together with the unit and total construction costs used in the analysis.

Where the estimated cost of construction differs significantly from that assumed in table A7.4, an adjustment to the BCR could be made using equation 3 (appendix A7.4):

Be aware that analysis of data from selected passing lane sites indicated that:

- passing lanes generally cost between $120 and $800 per linear metre, but can cost up to $1700 in some cases. Specific cost estimates should be prepared for each site under consideration
- significant savings in both design and construction costs are possible if two or three projects are combined into one contract.

Special features can be very expensive and should be avoided where possible, and local knowledge is important to achieving accurate estimates. Special features include:

swamps/soft ground

significant earthworks quantities

large culvert and/or drain extensions

intersection improvements

expensive service relocations

Construction period

The procedures outlined in this appendix assume that the construction of the passing lane is completed within the first year.

Update factors

Update factors for user benefits and constructions costs should be used with these procedures. These can be found in table A12.1 and A12.2. When applying an update factor to the combined travel time and vehicle operating costs, the adjustment factor for travel time costs should be used.

Table A7.4 Passing lane average costs ($2005)

Terrain type	Cost category	Unit cost (per m)	Total cost (for 1 km)
Flat	Easy/average	$250	$250,000
Rolling	Average	$320	$320,000
Hilly	Average/difficult	$500	$500,000
Mountainous	Difficult	$800	$800,000

Note: Construction cost estimates vary widely depending on site-specific factors. Use caution with these costs for other applications. All costs include the end tapers.

A7.3 Passing lane strategies

Introduction

This section provides a procedure for assessing passing lane strategies and is divided into two sections. Firstly a coarse analysis to identify passing lane spacing strategies and when increased passing lane frequency may become economic. The second section is used for determining actual locations for passing lanes and approximate BCRs of individual projects. More detailed guidance on individual passing lanes can be found in appendix A7.4.

The assumptions made in this procedure are affected by local conditions (refer appendix A7.2).

Strategy identification procedure

This procedure is required as an initial step to evaluate strategies. It can also be used in isolation as a coarse analysis to identify the approximate BCR for each passing lane within a particular strategy.

This procedure can be used to determine the most appropriate passing lane spacing strategy for sections of strategic rural roads and by doing so identify when increased passing lane frequency may be required.

Step	Action
1	**Break the network into sections,** as specified in Transit New Zealand's state highway performance indicators and targets guidelines (or similar for local authority roads). Further classify these traffic sections into sub-sections with consistent traffic volume and terrain type. Sub-sections should start or finish at main urban centres (large towns and cities). Sub-sections should not be shorter than: • 10 kilometres for passing lanes at 5 kilometre spacing • 20 km for passing lanes at 10 kilometre spacing. When terrain and traffic volumes change frequently, then smaller sections should be combined and the average traffic volume used in the analysis. The predominant terrain type should also be used in the analysis. Where this procedure does not seem appropriate, such as where there is a steep grade on a route that has typically a rolling or flat alignment, analysts should use a simulation model such as TRARR to calculate the benefits.
2	**Classify the terrain**, terrain can be classified vertically by generalised gradient (sum of the absolute value of rises and falls expressed as m/km) and horizontally by generalised curvature (degrees/km). Combined terrain classifications of vertical and horizontal terrain are shown in table A7.5, and are a result of analysis of 500 metre lengths using a 1500 metre moving average of these parameters. The curvature, or degrees per kilometre specified in table A7.5, is estimated by summing the deviation angles of the horizontal curves from plans or aerial photography, and dividing by the road length. Rise and fall can be obtained from profile drawings or highway information sheets. Alternatively, this profile and curve data can be obtained from surveyed road geometry data.

A7.3 Passing lane strategies, continued

Strategy identification procedure, continued

Step	Action
3	**Determine percentage of road with passing sight distance** (% PSD), for each sub-section. The % PSD is the proportion of the section that has visibility greater than 450m. This can be calculated using surveyed gradient and horizontal curvature data. In the absence of survey data, each sub-section can be classified according to terrain type, based on average gradient and curvature. Terrain type sectioning can then be converted to percentage passing sight distance using table A7.6. Note that this method is not as accurate and may not be sufficient in situations where the benefits are sensitive to % PSD, especially where traffic volumes are higher. In table A7.6 PSD has been calculated as a moving average over 15 km, with the PSD ascribed to the centre five kilometres. This is the basis of the BCR graphs and should be observed when applying the method. The curvature can be estimated as in step 2.

Table A7.5 Combined terrain classification

<table>
<tr><td></td><td colspan="4">Horizontal terrain (degrees/km)</td></tr>
<tr><td>Vertical terrain (rise and fall, m/km)</td><td>Straight (0-50)</td><td>Curved (50-150)</td><td>Winding (150-300)</td><td>Tortuous (>300)</td></tr>
<tr><td>Flat (0-20)</td><td rowspan="2">Flat</td><td rowspan="2">Rolling</td><td rowspan="3">Hilly</td><td rowspan="4">Mountainous</td></tr>
<tr><td>Rolling (20-45)</td></tr>
<tr><td>Hilly (45-60)</td><td rowspan="2">Rolling</td><td rowspan="2">Hilly</td></tr>
<tr><td>Mountainous (>60)</td><td>Mountainous</td></tr>
</table>

Table A7.6 Terrain relationship to passing sight distance

Measure	**Vertical terrain**			
	Straight	**Curved**	**Windy**	**Tortuous**
Curvature, degrees per km	0-50	50-150	150-300	>300
Number of curves per km	<1.0	1.0 – 3.0	3.0 – 6.0	>6.0
Average % passing sight distance	35	15	10	5
Percentage of road length with:				
less than 25% sight distance	45	85	95	98
25 to 50% sight distance	30	15	5	2
50 to 75% sight distance	15	-	-	-
over 75% sight distance	-	-	-	-

A7.3 Passing lane strategies, continued

Strategy identification procedure, continued

Step	Action
4	**Use the analysis year AADT, and % PSD, to calculate a BCR**, using the figures A7.3 to A7.6. If traffic growth is not 2% per year, multiply the BCR by the correction factors in table A7.7. If the traffic growth is not in table A7.7, extrapolate or interpolate to obtain a correction factor. The analysis is carried out in both directions, generally with a stagger between opposing passing lanes where the terrain and available width allows.
5	Repeat step 4 using the predicted AADT for future years in increments of 5 years from the analysis year, to identify when it may be worthwhile to adopt a strategy that involves more frequent passing lanes.

Table A7.7 Traffic growth correction factors for BCR graphs

AADT	Traffic growth			
	1%	2%	3%	4%
2000	0.90	1.00	1.10	1.21
3000	0.91	1.00	1.09	1.18
4000	0.92	1.00	1.08	1.16
6000	0.92	1.00	1.08	1.16
8000	0.92	1.00	1.08	1.15
10000	0.93	1.00	1.07	1.15

Refinement of strategy

The following steps determine the location of passing lanes before evaluating individual passing lanes (appendix A7.4).

Step	Action

6	**Identify existing and planned passing lanes** for each section where passing lanes can be justified.
	
	If existing passing lanes spacing ≤ calculated, then
	
	No new passing lanes required
	
	If existing passing lanes spacing > calculated, then
	
	Identify potential new sites at the calculated interval
	
	Older sites are unlikely to be at set intervals (as part of a strategy) and judgement is required in determining whether new sites are justified. Where relevant, identify possible sites for future years.

A7.3 Passing lane strategies, continued

Refinement of strategy, continued

Step	Action
7	**Identify suitable sites**. Sites should be within 1 km of either side of the calculated spacing. Construction cost, land availability and forward visibility at the exit merge are important factors for site selection. Site spacing or length may be adjusted to balance passing demand and opportunities. For wider spacing it will be necessary to combine each of the sub-sections identified in step 1. Where the strategy results in similar site spacing for each sub-section, this spacing must be maintained over sub-section boundaries. If the optimal spacing for each sub-section results in different desired site spacing for each sub-section, the overall strategy should be based on the largest spacing, ie where the spacing changes from 5 km in sub-section one to 10 km in sub-section two, then the spacing should be increased to the higher values (10 km) over the boundary. Any inbound sites in the vicinity of towns should commence at least 5 km from the urban speed limit, unless reasons for a closer facility can be justified. This normally requires modelling using TRARR. Use the following guidance to maximise passing lane benefits: • select locations where large numbers of vehicles are observed travelling in slow moving platoons • select locations where there is the greatest speed differential between slow and fast vehicles (for example, on steep grades) • locate sites leading away from congestion (such as urban areas) • where possible locate sites on sections with existing no-overtaking lines to maximise the increase in net passing opportunities • avoid significant intersections (particularly right-turn bays) • consider site lengths of between 800m and 1500m in most rural areas – shorter lengths are unlikely to release all platooned vehicles and little benefit is gained from excessively long lengths • do not locate the merge area at the end of the sites where there is limited forward sight distance or where there is a sudden reduction in the desired speed, eg at a tight horizontal curve • the termination of sites in opposing directions should not be adjacent to each other • ensure that sufficient shoulder width and merge space are provided, otherwise an increase in lost-control and merging accidents could occur • avoid costly physical restraints such as narrow bridges and culverts that require widening. Refer to Austroads (2003) 'Rural road design' for further information.

A7.3 Passing lane strategies, continued

Refinement of strategy, continued

Step	Action
8	**Sections of prolonged gradient should be identified,** as possible opportunities for climbing lanes (or slow vehicle bays) using table A7.8 below, which is adapted from Austroads (2003) 'Rural road design' and considers the length of sustained gradient necessary to reduce the speed of a heavy commercial vehicle to 40 km/h. To assess the benefits of such sites a more detailed analysis is required using rural simulation software (see section A7.5).

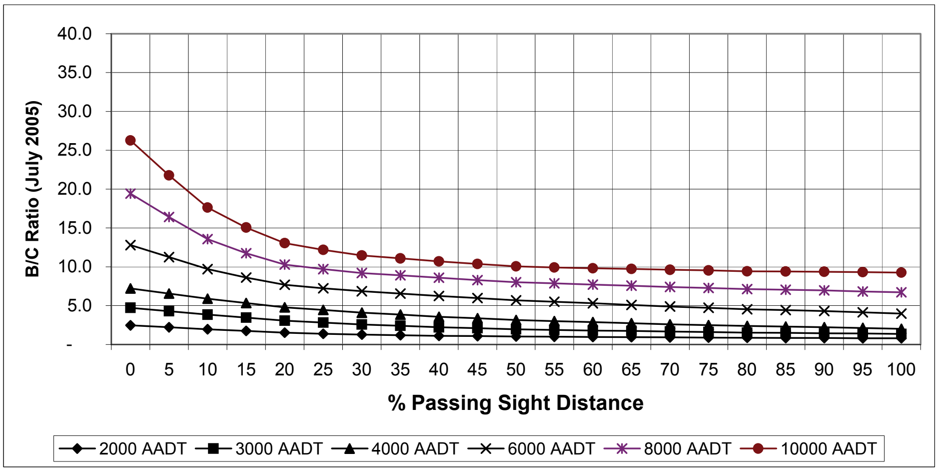
Table A7.8 Limiting lengths m for consideration of climbing lanes

Gradient %	Approach speed (km/h)		
	60	**80**	**100**
10	100	200	450
9	100	250	550
8	100	300	650
7	150	300	800
6	150	350	1000
5	200	450	
4	300	650	

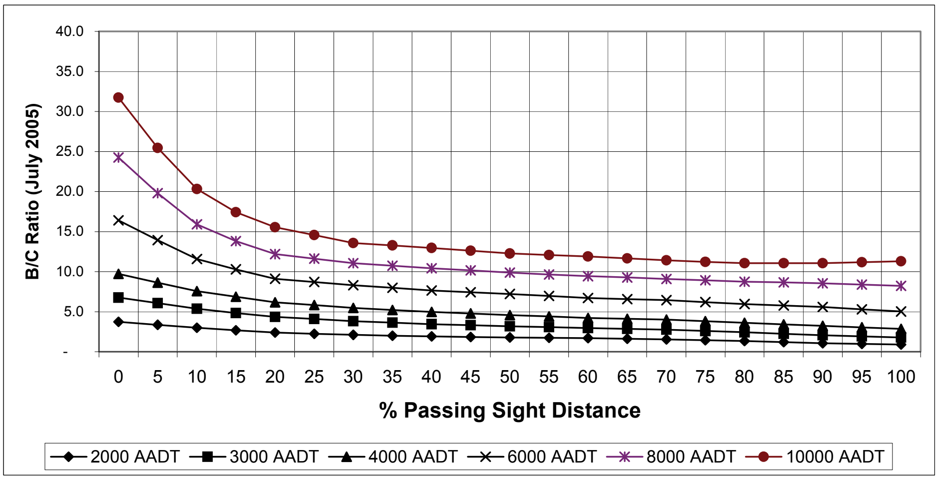
A7.3 Passing lane strategies, continued

Figure A7.3 Graphs of strategy BCR for flat terrain

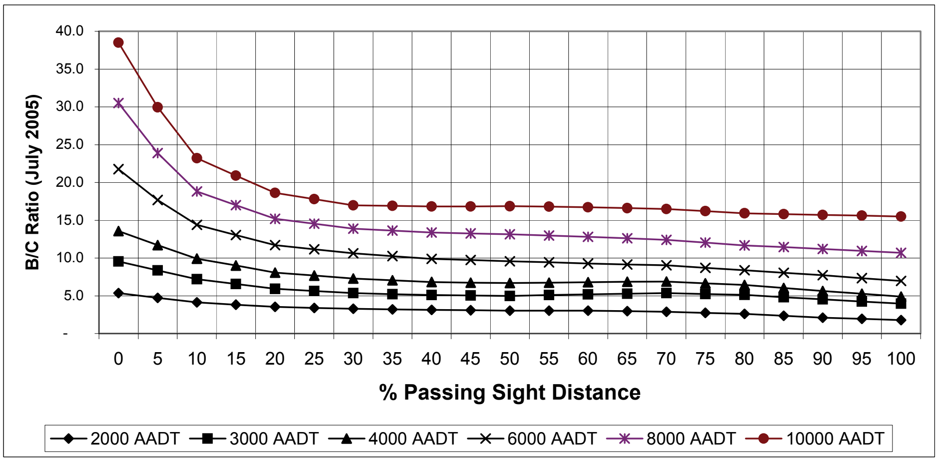
Flat terrain - 5 km spacing – 2% traffic growth



Flat terrain - 10 km spacing – 2% traffic growth



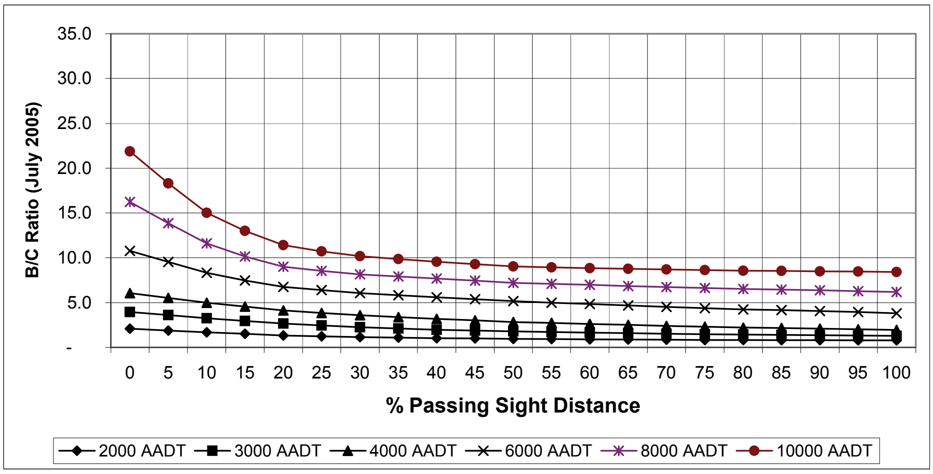
Flat terrain - 20 km spacing – 2% traffic growth



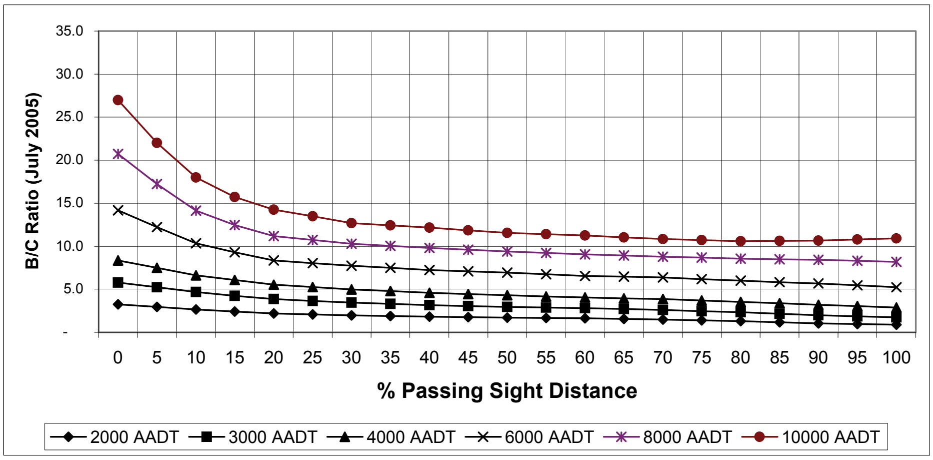
A7.3 Passing lane strategies, continued

Figure A7.4 Graphs of strategy BCR for rolling terrain

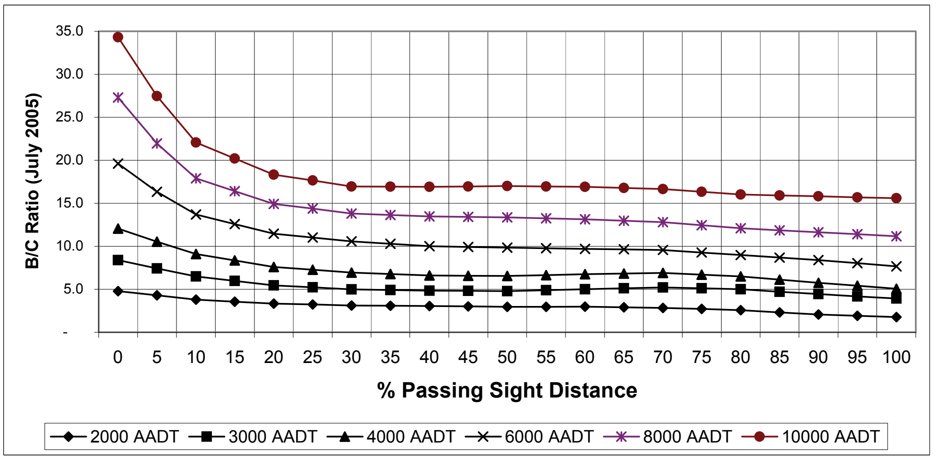
Rolling terrain - 5 km spacing – 2% traffic growth



Rolling terrain - 10 km spacing – 2% traffic growth



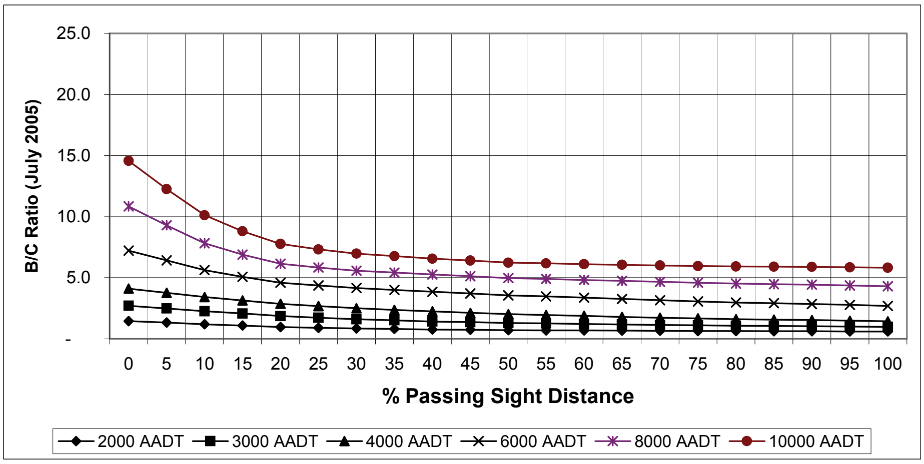
Rolling terrain - 20 km spacing – 2% traffic growth



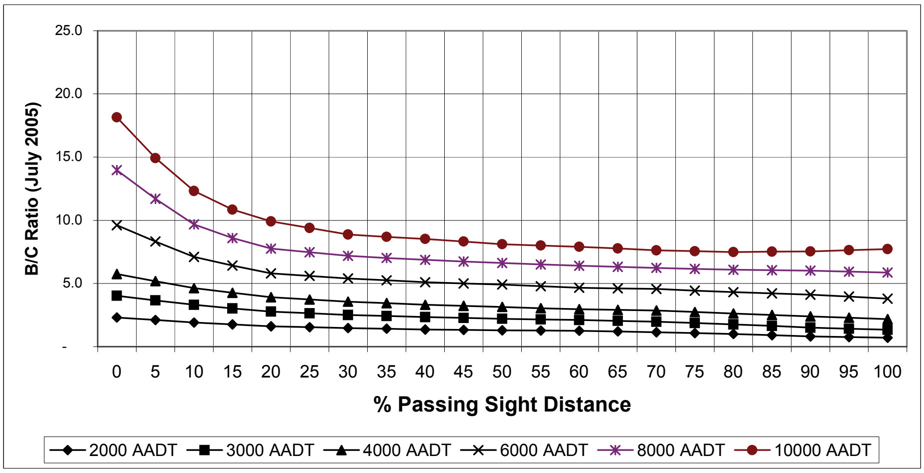
A7.3 Passing lane strategies, continued

Figure A7.5 Graphs of strategy BCR for hilly terrain

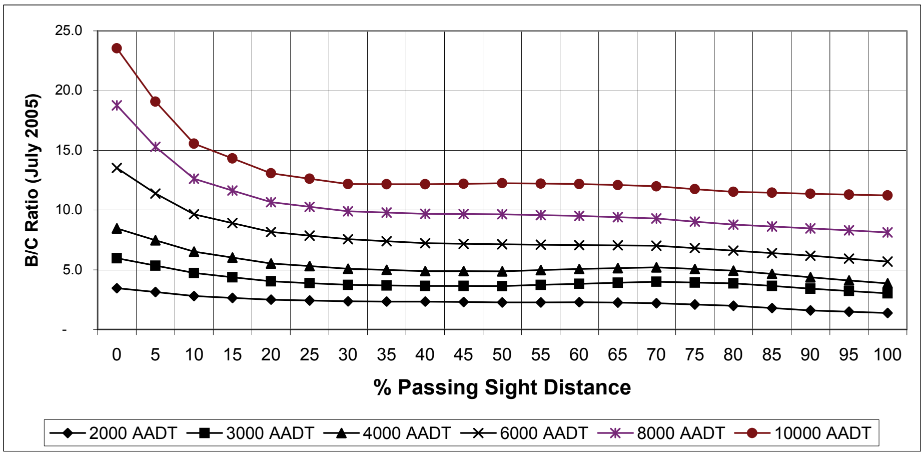
Hilly terrain - 5 km spacing – 2% traffic growth



Hilly terrain - 10 km spacing – 2% traffic growth



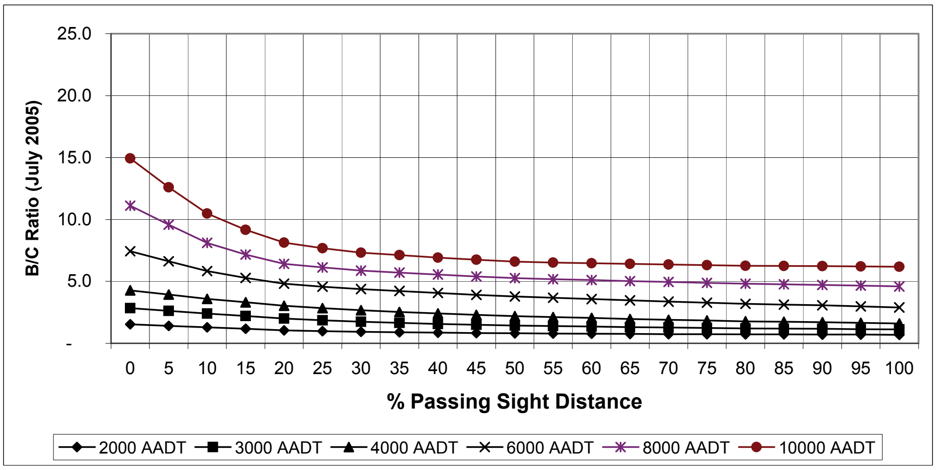
Hilly terrain - 20 km spacing – 2% traffic growth



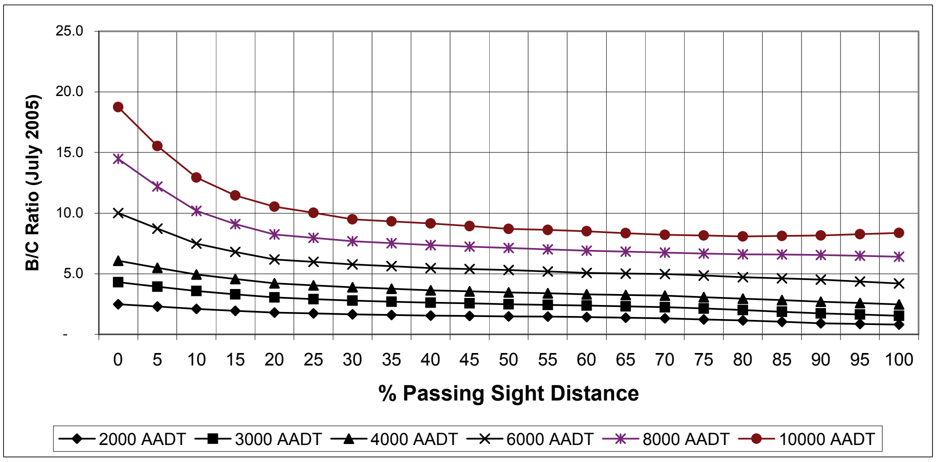
A7.3 Passing lane strategies, continued

Figure A7.5 Graphs of strategy BCR for mountainous terrain

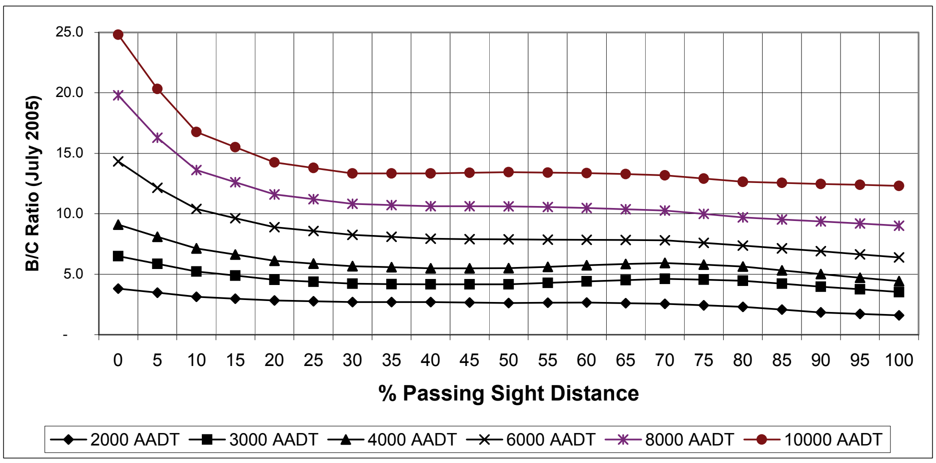
Mountainous terrain - 5 km spacing – 2% traffic growth



Mountainous terrain - 10 km spacing – 2% traffic growth



Mountainous terrain - 20 km spacing – 2% traffic growth



A7.4 Assessment of individual passing lanes

Introduction

This procedure this section is suitable for establishing the benefits of individual passing lane projects. This method is not suitable for:

- slow vehicle bays and crawling lanes at the scheme assessment stage
- locations where there are a large proportion of slow vehicles such as campervans, coaches, or slow heavily loaded commercial vehicles
- passing lanes with significant construction costs or significant construction and preconstruction periods.

For locations where one or more of the above factors apply, a rural traffic simulation model is required to assess the benefits (see appendix A7.5).

It is assumed that before using this procedure that an appropriate passing lane strategy has been developed using the method in appendix A7.3 and individual passing lanes are being investigated. This procedure is used to calculate the benefits of passing lanes in one direction only. For dual passing lanes (passing lanes in both directions), the procedure needs to be undertaken for both directions separately.

To use the procedure in this section, the BCR graphs in figures A7.3 to A7.6 are not to be used. Instead, separate graphs for each category of road user benefits are used (figures A7.7 to A7.12), and these can be adjusted where necessary to account for local conditions.

Procedure for individual passing lanes

Step	Action
1	**Calculate the travel time and vehicle operating savings,** using graphs in figure A7.7. If necessary multiply by the traffic growth correction factor in table A7.9 and the travel time update factor in table A12.2. The inputs to the graphs are: • passing lane spacing (either 5, 10 or 20 km - for isolated passing lanes use 20 km spacing) • analysis year AADT • % PSD (to calculate see appendix A7.3)

Table A7.9 Traffic growth correction factors for travel time and VOC graphs

AADT	Traffic Growth			
	1%	2%	3%	4%
2000	0.83	1.00	1.18	1.39
3000	0.85	1.00	1.17	1.34
4000	0.86	1.00	1.14	1.27
6000	0.90	1.00	1.10	1.20
8000	0.91	1.00	1.09	1.18
10000	0.91	1.00	1.09	1.17

A7.4 Assessment of individual passing lanes, continued

Procedure for individual passing lanes, continued

Step	Action
2	**Calculate the driver frustration savings,** using graphs in figure A7.8. If necessary multiply by the traffic growth correction factor in table A7.10 and the driver frustration update factor in table A12.2.
3	**Sum the road user benefits from steps 1 and 2.** These are the road user benefits that need to be adjusted to account for the site specific characteristics such as passing lane length, speed distribution and proportion of heavy traffic.
4	**Adjustment for the passing lane length.** The benefits calculated in the previous steps are based on passing lanes of 1 km in length. Where individual passing lanes are less than 1 km in length, the benefits are reduced because a lesser number of platooned vehicles will be released. Where the proposed passing lane is longer than 1 km, additional benefits may result. The formation of platoons depends on the spacing between passing lanes, therefore an adjustment to the benefits is calculated based on the combined effect of passing lane length and spacing, as provided in table A7.11 below (intermediate values may be interpolated).

Table A7.10 Traffic growth correction factors for driver frustration graphs

AADT	Traffic growth			
	1%	2%	3%	4%
2000	0.82	1.00	1.19	1.40
3000	0.85	1.00	1.15	1.30
4000	0.88	1.00	1.11	1.22
6000	0.92	1.00	1.08	1.15
8000	0.93	1.00	1.07	1.15
10000	0.93	1.00	1.07	1.15

Table A7.11 Factors for passing lane length

Spacing	750m	1,000m	1,250m	1,500m	2,000m
5 km	0.76	1.00	1.15	1.25	1.40
10 km	0.74	1.00	1.10	1.24	1.46
20 km	0.81	1.00	1.14	1.23	1.47

A7.4 Assessment of individual passing lanes, continued

Procedure for individual passing lanes, continued

Step	Action
5	**Adjustment for the proportion of heavy traffic,** by comparing the medium plus heavy vehicle component of the traffic flow at the site with the component for rural strategic roads identified in appendix A2. For every percentage above the assumed 12 percent proportion of heavy vehicles (rural strategic), increase the road user benefits by 1 percent. Similarly for every percentage point below the assumed 12 percent of heavy vehicles decrease the road user benefits by 1 percent. **Equation 1** Road user benefits (adjusted) = Road user benefits (unadjusted) × (1 + [prop heavy vehicles - 0.12])
6	**Adjustment for differences in the speed distribution**. This adjustment of road user benefits (from step 5)) is performed if the speed distribution at the site varies from the assumed 13.5 percent. A current sample of vehicle speeds over the road sections being analysed is required. The adjustment is to increase the road user benefits by 2.5 percent for each percentage point above the assumed coefficient of variation (COV) of speed of 13.5 percent. Similarly reduce the road user benefits for a lower COV. **Equation 2** Road user benefits (adjusted) = Road user benefits (unadjusted) × (1 + [COV - 0.135] × 2.5)
7	**Calculate accident costs savings**, using graphs in figures A7.9 to A7.12 (interpolate or extrapolate if necessary) and multiply with the appropriate traffic growth correction factors in table A7.12. If the passing lane forms part of a rural realignment, or there are either 5 or more injury accidents, or 2 or more serious and fatal accidents in any 1 km section (up to 10 km downstream of the passing lane) then accident-by accident analysis can be used. To determine if such an analysis is appropriate, refer to figure A6.1

Table A7.12 Traffic growth correction factors for accident savings graphs

AADT	Traffic growth			
	1%	2%	3%	4%
2000	0.92	1.00	1.08	1.15
3000	0.94	1.00	1.04	1.07
4000	0.99	1.00	1.02	1.05
6000	0.94	1.00	1.06	1.12
8000	0.94	1.00	1.06	1.12
10000	0.94	1.00	1.06	1.12

A7.4 Assessment of individual passing lanes, continued

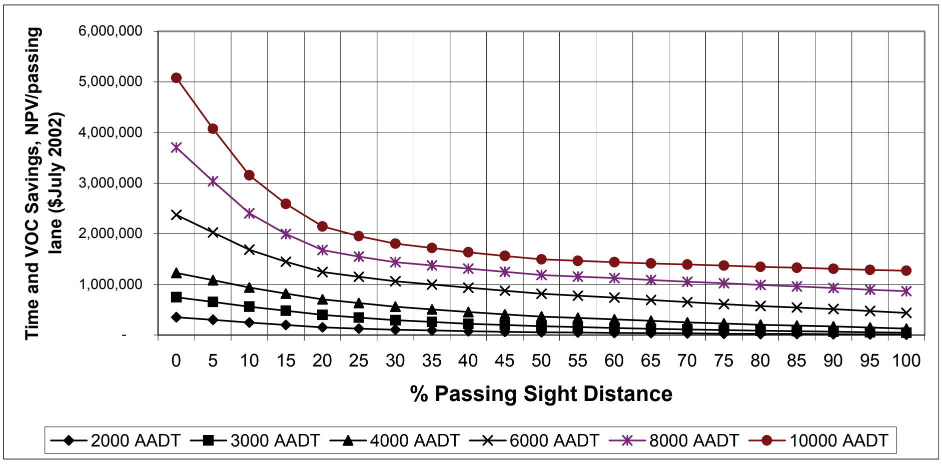
Procedure for individual passing lanes, continued

Step	Action
8	**Calculate the BCR,** for the individual passing lanes using the cost estimates for the site and the benefits calculated in the preceding steps. The BCR can be recalculated using the following formula (if the unit costs are taken from table A7.4). **Equation 3** $\text{BCR (adjusted)} = \dfrac{\text{BCR (calculated above) x table A7.4 unit cost}}{\text{Local unit cost (per m)}}$

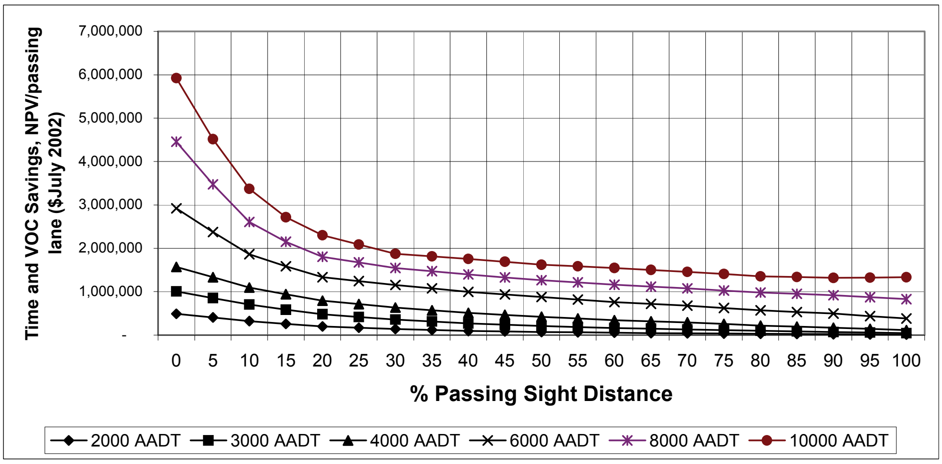
A7.4 Assessment of individual passing lanes, continued

Figure A7.7 Graphs of vehicle operating cost and delay savings for all terrain

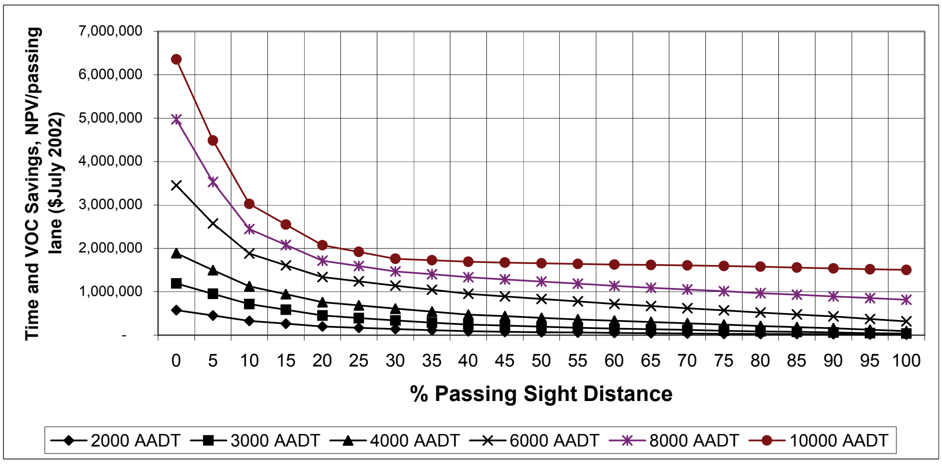
5 km spacing – 2% traffic growth



10 km spacing – 2% traffic growth



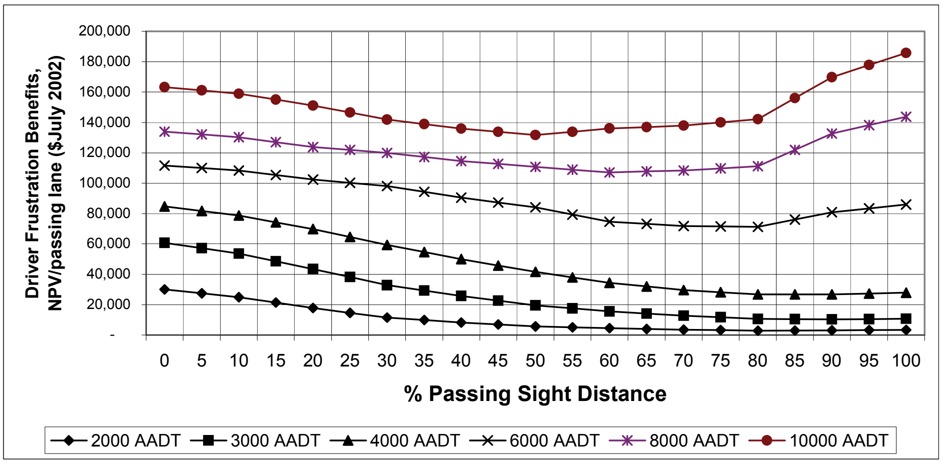
20 km spacing – 2% traffic growth



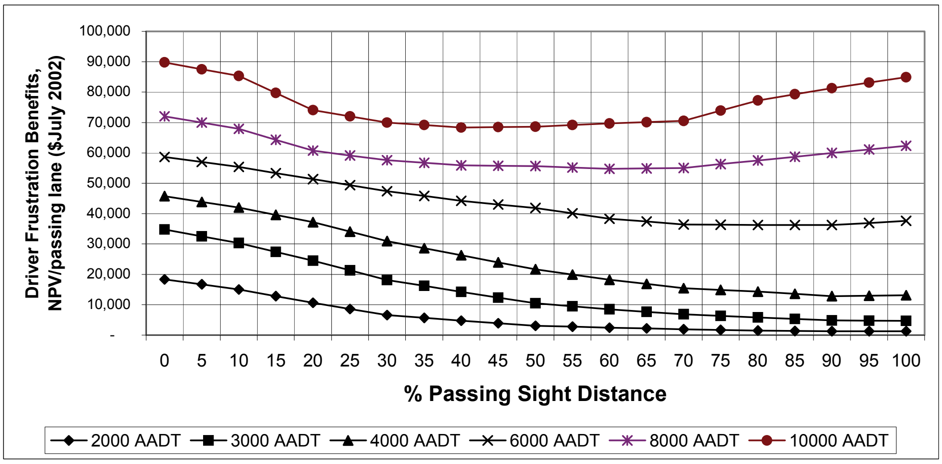
A7.4 Assessment of individual passing lanes, continued

Figure A7.8 Graphs of driver frustration benefits for all terrain

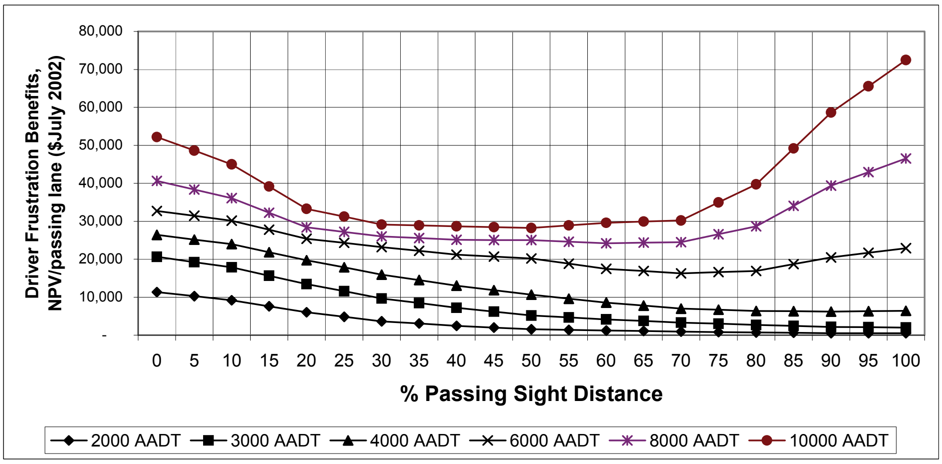
5 km spacing – 2% traffic growth



10 km spacing – 2% traffic growth



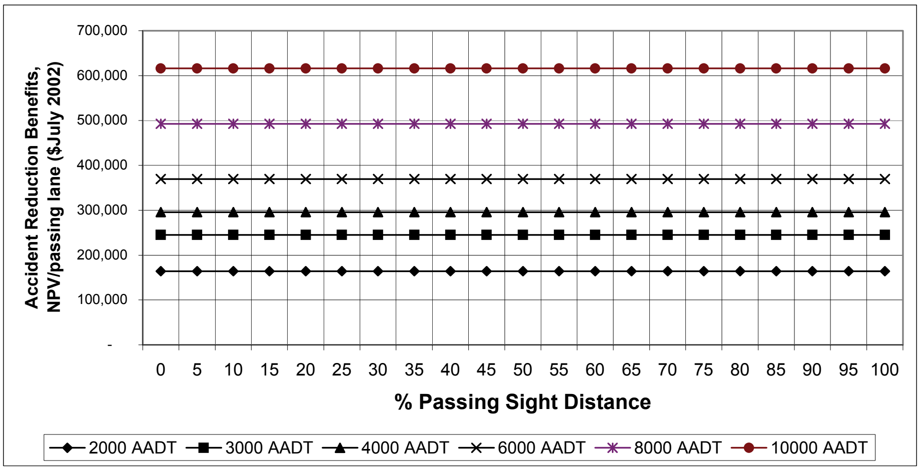
20 km spacing – 2% traffic growth



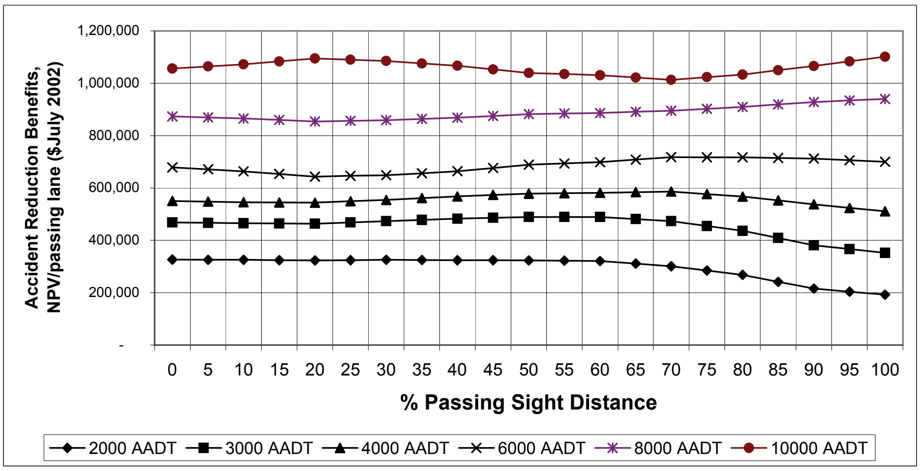
A7.4 Assessment of individual passing lanes, continued

Figure A7.9 Graphs of accident savings for flat terrain

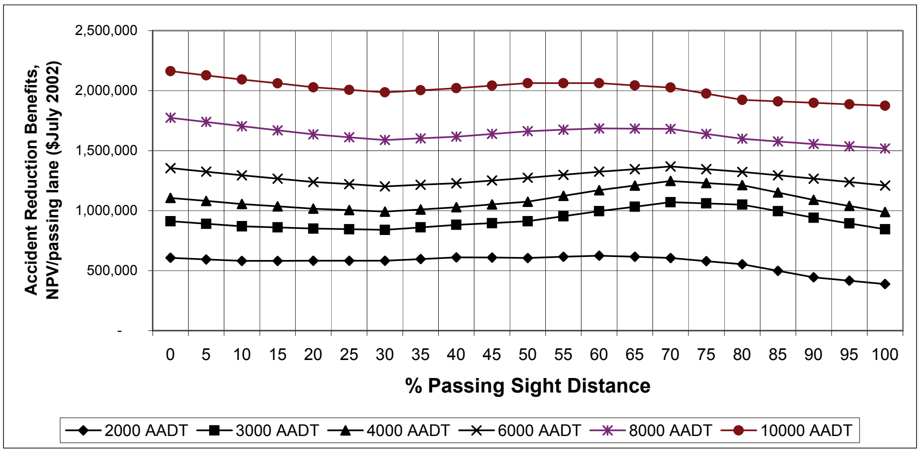
Flat terrain - 5 km spacing – 2% traffic growth



Flat terrain - 10 km spacing – 2% traffic growth



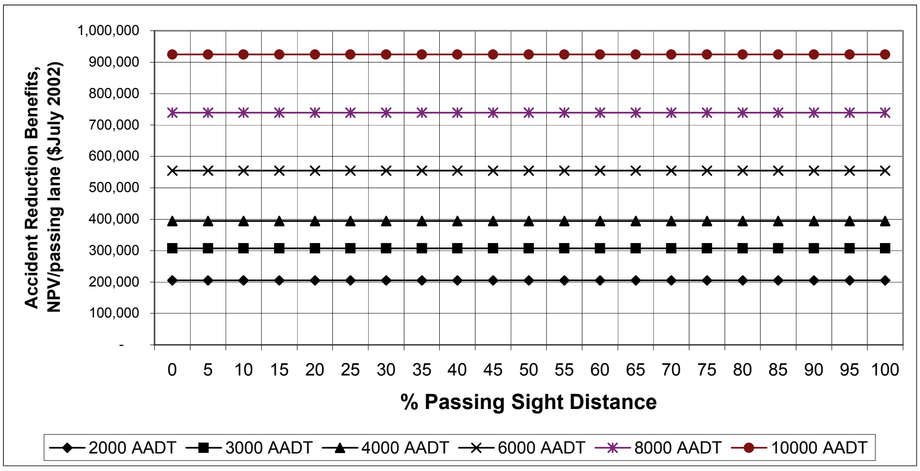
Flat terrain - 20 km spacing – 2% traffic growth



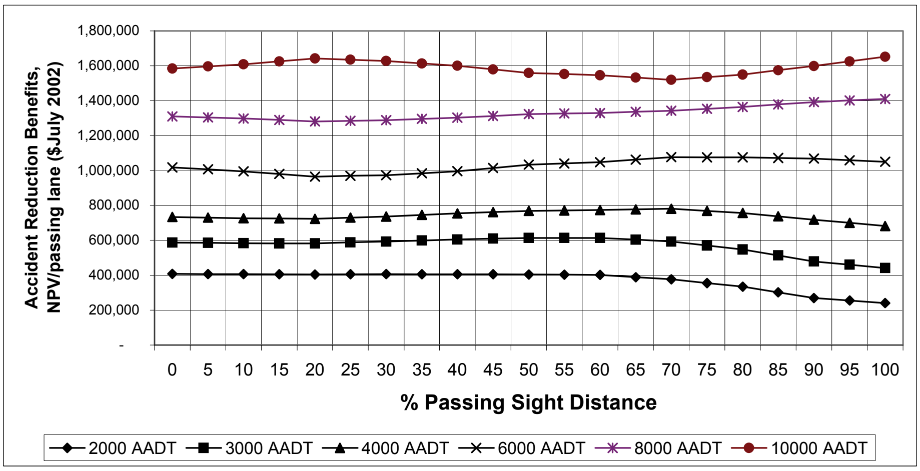
A7.4 Assessment of individual passing lanes, continued

Figure A7.10 Graphs of accident savings for rolling terrain

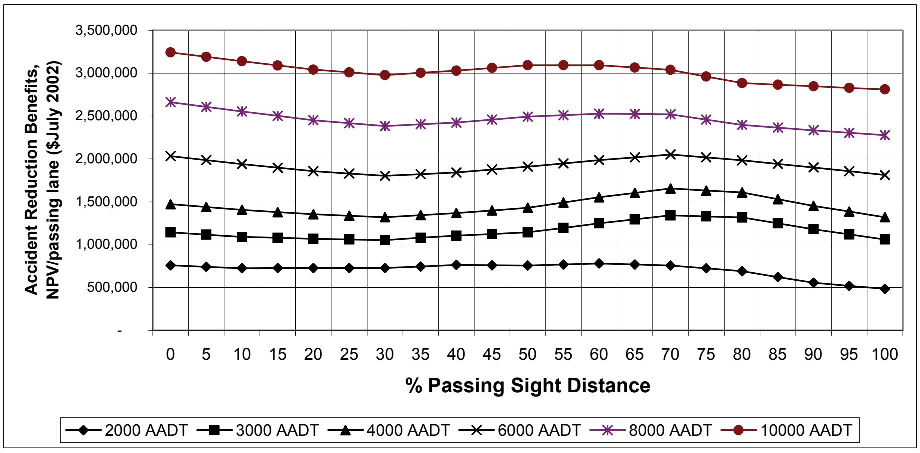
Rolling terrain - 5 km spacing – 2% traffic growth



Rolling terrain - 10 km spacing – 2% traffic growth



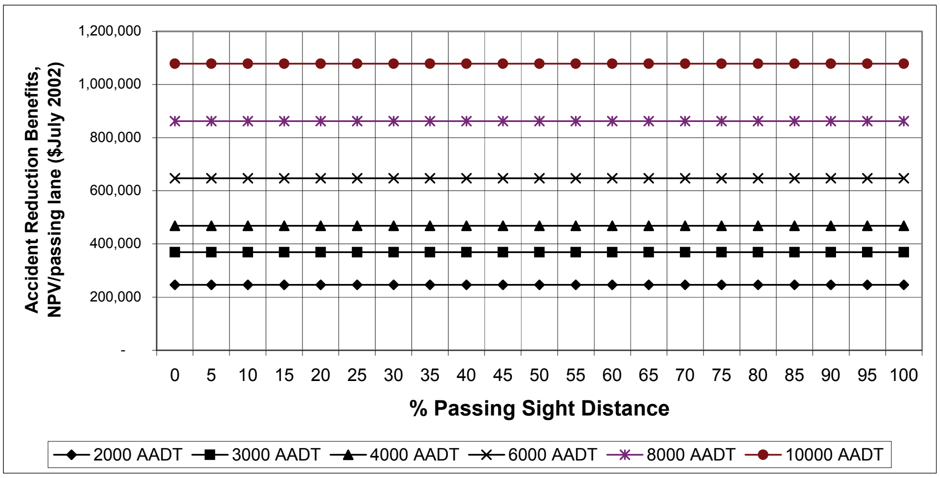
Rolling terrain - 20 km spacing – 2% traffic growth



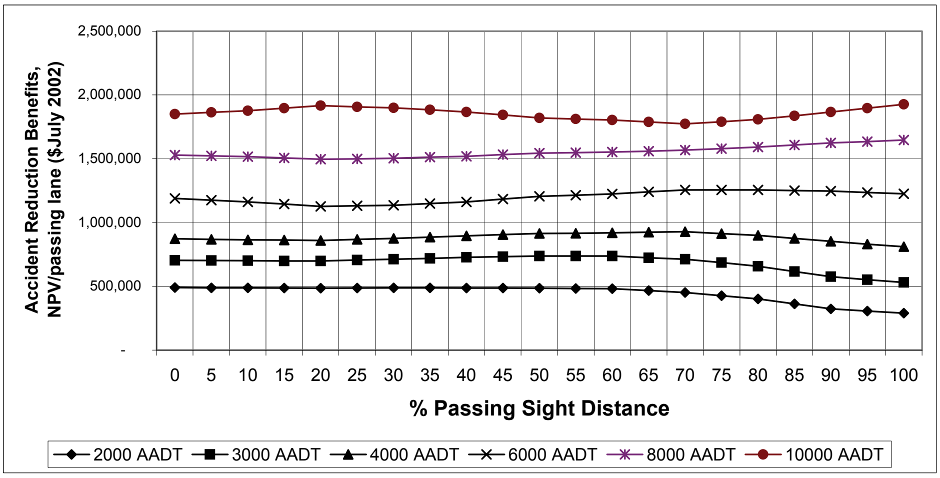
A7.4 Assessment of individual passing lanes, continued

Figure A7.11 Graphs of accident savings for hilly terrain

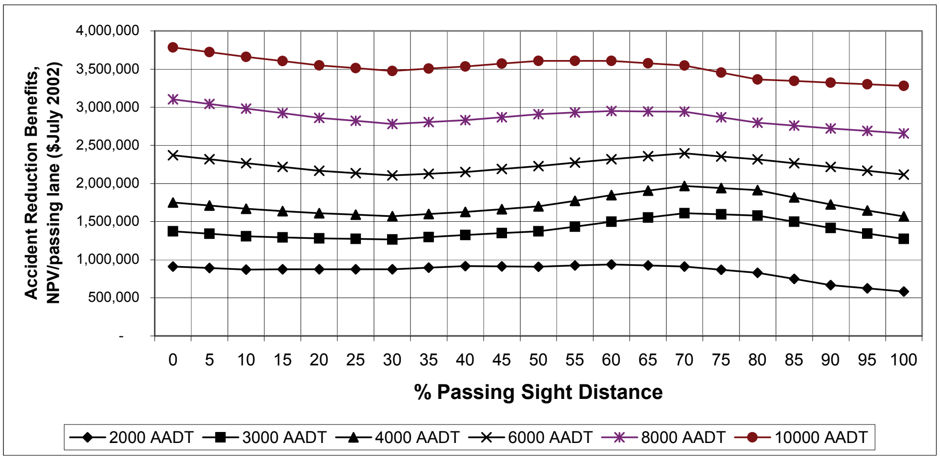
Hilly terrain - 5 km spacing – 2% traffic growth



Hilly terrain - 10 km spacing – 2% traffic growth



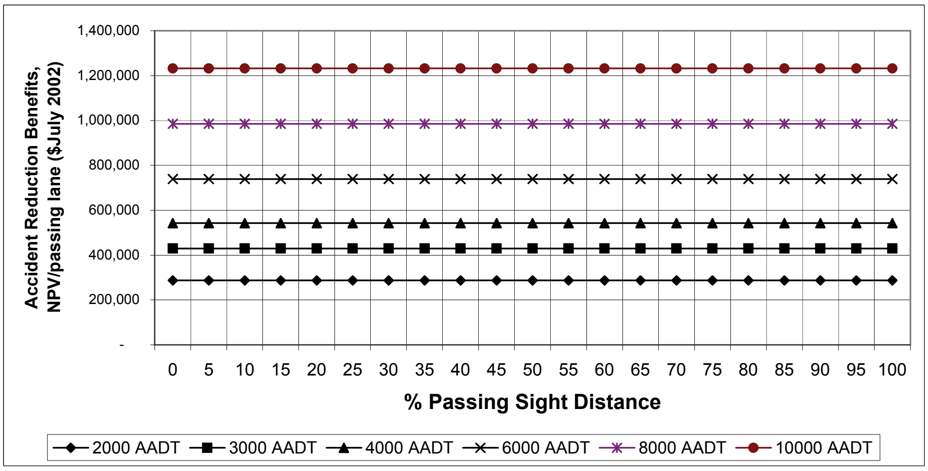
Hilly terrain - 20 km spacing – 2% traffic growth



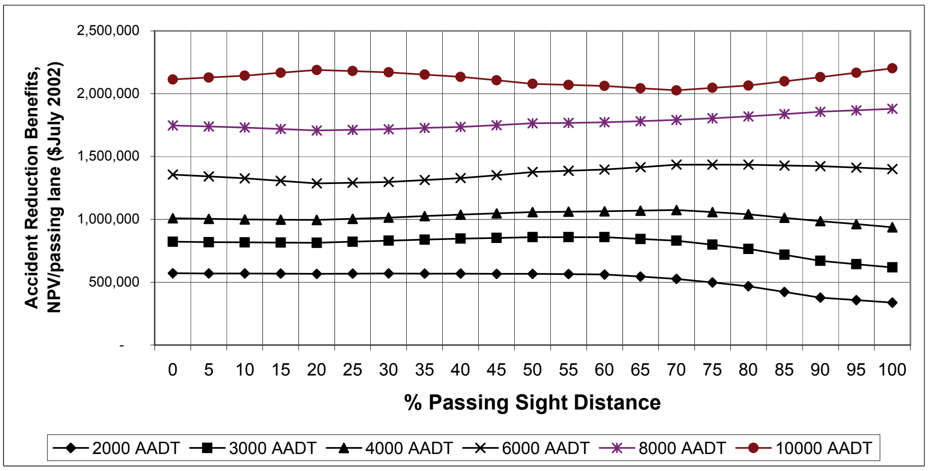
A7.4 Assessment of individual passing lanes, continued

Figure A7.12 Graphs of accident savings for mountainous terrain

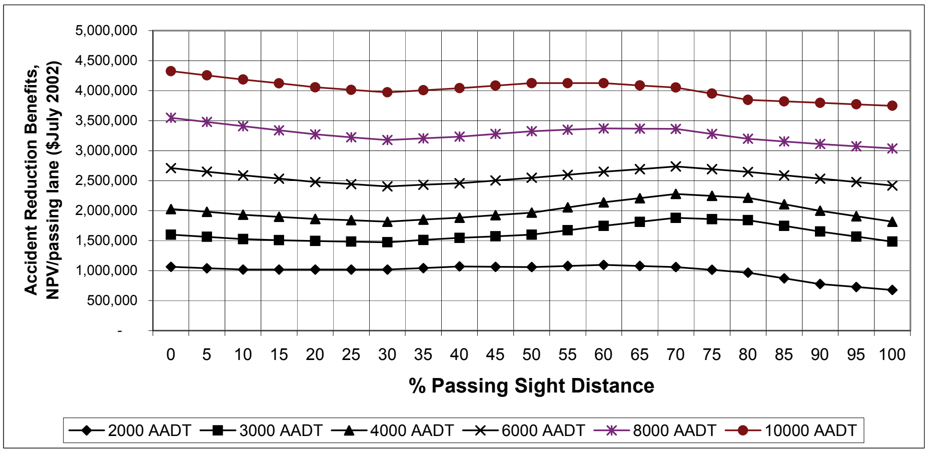
Mountainous terrain - 5 km spacing – 2% traffic growth



Mountainous terrain - 10 km spacing – 2% traffic growth



Mountainous terrain - 20 km spacing – 2% traffic growth



A7.5 Rural simulation for assessing passing lanes

Introduction

Due to the complex nature of vehicle interactions on two lane rural roads, traffic simulation programmes such as TRARR (or TWOPASS) should be used where a more detailed analysis is required or the costs of a passing lane project are very high. Rural road simulation should be used for:

- slow vehicle bays and climbing lanes at the scheme assessment stage
- locations where there are a large proportion of slow vehicles such as campervans, coaches or slow moving heavy vehicles.

Rural simulation can be used to obtain a more precise calculation of travel time and vehicle operating cost benefits resulting from passing lanes, particularly when the sites are constructed as part of road realignments. For strategic assessment of road links, rural simulation can also be used to evaluate the relative benefits of passing lanes at various spacing or where local circumstances suggest that these procedures may not be appropriate or the assumptions have been violated.

TRARR has traditionally been the rural simulation package used for evaluating passing lanes, however, other packages are also available and can be used. Koorey, (2003) discusses some of the advantages and disadvantages of TRARR and other packages. The following sub-sections describe analysis by TRARR as well as model calibration and validation.

Analysis using TRARR

TRARR requires particular care to accurately model traffic flows for both existing and proposed highway layouts. The following notes are provided as a guide. Refer to Hoban *et al* (1991) for further details about the TRARR model.

- The modelled road section should include 2 km of road upstream of the actual passing site(s). The modelled road section shall, where appropriate, start and end at points where significant changes in the nature of the traffic stream occur, such as restricted speed zones (as in urban areas) and major intersections. The length of the road modelled downstream of the project end point shall be sufficient to ensure that traffic platooning differences between the do minimum and the passing lane option will have tapered out over this length. Depending upon the traffic volume, terrain and passing lanes downstream of the project section, this may be up to 10 kms.
- A sufficient range of traffic volumes should be modelled to adequately represent all existing and predicted traffic flows. The proportion of trucks to be modelled should be checked from traffic data, as it may vary with time of day or volume. For traffic flows of less than 50 veh/hr the benefits can be assumed to be negligible and not included if desired.
- Select a sufficient settling-down period to enable traffic (including the slowest vehicles) to fully traverse the modelled section.

A7.5 Rural simulation for assessing passing lanes, continued

Analysis using TRARR, continued

- A New Zealand-based set of vehicle classes and parameters (as specified in VEHS & TRAF files) should be used for accurate representation of the traffic stream. Refer to Tate (1995) for examples.
- Suitable intermediate observation points should be specified to enable an accurate assessment of vehicle operating costs. The same points should be used for all options (except where realignments preclude this).
- Driver frustration benefits are derived from the 'Time spent following' information (given in the TRARR OUT file). Research by Koorey *et al* (1999) established a willingness to pay value for the provision of passing lanes of 3.5 cents per vehicle per kilometre of constructed passing lane (this is in addition to other benefits such as travel time savings). This benefit is applied to all vehicles that are freed from a platoon at the passing lane over the length they remain free from a platoon. The value of 3.5 cents/veh/km shall only apply to vehicles travelling in the direction of the passing site. The vehicle-km to apply the willingness to pay factor to shall be determined by multiplying the traffic volume by the analysis length and the change in time spent following.

  Example: TRARR is used to analyse 12 km of highway.

  For a traffic volume of 200 veh/hr, the do minimum option gives 50% of time spent following.

  A passing lane option gives 35% of time spent following. The resulting veh-km to apply the willingness to pay value to, is: 200 × 12 × (50% - 35%) = 360 veh-km/hr

- Accident benefits should be considered up to 10 km downstream of the passing lane depending on where the traffic platooning differences between the do minimum and the option have tapered out.

A7.5 Rural simulation for assessing passing lanes, continued

Calibration/ validation of TRARR

TRARR modelling requires care to ensure that it accurately models the actual highway flows. Although Tate (1995) found that the relative changes were typically not as sensitive as the absolute values, it is desirable to match the two where possible. To this end, sufficient field data must be obtained to verify the models.

- The same random traffic generation shall be used for both the do-minimum and project options. Likewise, for each traffic volume, an equal number of vehicles (at least 1000) shall be simulated for each option.
- Field data must be collected on typical travel times along the modelled section, including intermediate points, for both cars and trucks in each direction. These should be used to calibrate the do minimum model, adjusting the TRARR desired vehicle speeds to replicate the observed travel time under the given volume. Overall modelled travel times should match to within 5%, while intermediate times should be within 10%.
- The proportion of bunching at the start and end of the modelled section should be collected, along with any desired intermediate points. This data should be calibrated against the do minimum model for the particular traffic volume by adjusting the TRARR initial bunching parameters and intermediate passing lanes. Modelled bunching values should be within 5% (absolute value) of the field data.
- Once calibrated the models may then be validated by assessing their performance against outputs measured under different traffic conditions. So if for example, calibration data was collected when the average traffic flow was 100 vehicles per hour, the models may be validated by comparing the model outputs against field measurements taken when traffic volumes were 200 vehicle per hour.

Refer to chapter 3 for further information on checking traffic models.

A7.6 Definitions

Bunching	The proportion of vehicles travelling behind others in platoons. Calculated as the ratio of following vehicles over total vehicles.
Climbing lane	An additional lane provided on steep grades where large and heavy vehicles travel at reduced speeds.
Desired speed	The speed that drivers would like to travel when not constrained by other traffic. This is largely dependent on the road alignment. Also known as free speed or unimpeded speed.
Following vehicles	Vehicles that are sufficiently close to the vehicle in front to be affected by the speed of the front vehicle. Vehicles with headways of less than 6 seconds are usually considered to be following.
Free vehicles	Vehicles able to travel at their desired speed. This includes vehicles on their own, ie, not part of a multi-vehicle platoon, and leading vehicles. Vehicles with headways of more than 6 seconds are usually considered to be free.
Headway	The amount of space between successive vehicles. Can be measured either by distance or time. Usually measured from the front of one vehicle to the front of the next.
Leading vehicles	The vehicle at the head of a multi-vehicle platoon. Leading vehicles are able to travel at their desired speed.
Merge area	The zone at the end of the passing lane where the two lanes taper into one.
Overtaking	An equivalent term for passing.
Passing lane	An additional lane, providing two lanes in one direction. A common form of passing lane. Typically 400m to 2km in length. Also known as auxiliary lanes or climbing lanes (on grades). For the purposes of analysis, the length of the passing lane does not include the end tapers.
Passing opportunity	Any measure designed to improve the likelihood of vehicles passing safely. These include passing lanes, slow vehicle bays, shoulder widening, and improved passing sight distance (eg, realignments).
Platoon	A group of vehicles clustered together (ie, small headways) and all travelling at approximately the same speed as the leading vehicle. Also known as queues or bunches. The size of the platoon is defined by the number of vehicles. A vehicle on its own is considered a platoon of size one.

A7.6 Definitions, continued

Sight distance	The road distance ahead of the driver that is visible. This enables the driver to assess whether it is safe to pass. Refer to Austroads (2003) 'Rural road design' for further information, especially with regard to object and eye heights.
Slow vehicle bay	A short section of shoulder marked as a lane for slow vehicles to move over and let other vehicles pass. Typically up to 400m in length. Slow vehicles have to give way to the main traffic flow at the end of the bay.
TRARR	A rural road simulation package from ARRB transport research in Australia - the latest version is TRARR 4 (Shepherd, 1994). The name 'TRARR' is a contraction of 'TRAffic on Rural Roads'. TRARR uses various vehicle performance models together with highway terrain data to establish, in detail, the speeds of vehicles at each location along the road. This establishes the demand for passing and determines whether or not passing manoeuvres may be executed. The outputs, mean travel times and journey speeds are used to calculate the benefits of various project options.

A7.7 References

References

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