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2+1 Rural Highway Treatments in Queensland, Australia

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Limitations of Use

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

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

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Abstract

Two-lane highways in rural Australia perform an important task of conveying traffic across long distances. Some sections of rural two-lane highway are under ever increasing strain due to increasing traffic demand. Not all two-lane highways can be upgraded to a four lane carriageway due to cost.

The conventional way of optimising a two-lane highway in Australia is ensuring that there is a desirable amount of overtaking opportunities on the section of road. However, on some sections of road the traffic exceeds the capacity of the road but doesn't warrant the implementation of duplication.

The 2 plus 1 (2+1) treatment can be used on the busier sections of road that contain large percentages of heavy or slow vehicles. This treatment is essentially providing continual overtaking lanes in both directions. The use of a 2+1 treatment has generally been used in Europe to improve safety, but little research reported the traffic performance improvements or disadvantages.

A literature review was performed including the compilation of existing literature on 2+1 treatments to provide insight into how the treatment was implemented differently in each case. A concept design & strategy on a typical section of road was created. Analysis in HCS2010, which is endorsed by the Transportation Research Board (2010a), was then performed to find the existing segment of road performance and then the 2+1 treatment was analysed to find the improvement in performance over the section of road.

From research it was obvious that no case study had implemented the 2+1 treatment the same. No guideline for this treatment has been detailed. The 2+1 treatment is an effective alternative to duplication.

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Chapter 1

1. Introduction

1.1 Project Background

The Bruce Highway is one of many rural highways in Australia struggling with capacity issues due to economic activity associated with the mining industry and tourism. Congestion and lack of capacity is a concern for the Department of Transport and Main Roads (2012) as stated in the Bruce Highway Action Plan (BHAP) (2012), specifically around town centres including Rockhampton, Sarina, Mackay, Townsville and Cairns. This is all due to extension of residential and industrial development (Department of Transport and Main Roads 2012).

The capacity initiatives provided in the BHAP are overtaking lanes, two to four lane upgrades and possibly even six lane upgrades. However, Austroads Limited (2016) Guide to Road Design shows that an excellent standard of overtaking lane provision ranges from 4330-5670 AADT whilst 12,000 vpd is the triggering factor for four lanes in the BHAP (Department of Transport and Main Roads 2012).

This gap in traffic volumes causes a challenge for a decision on the appropriate treatment – whether to maintain existing road or progress to four lanes – for the section of road. It also poses ‘gold plating’ concerns in regards to the funding of the project. Is this of most benefit to the community? Or could it have been spent elsewhere with more benefit?

The 2+1 treatment has been successful in several countries in Europe as discussed in the literature review. The facilities of rural highways in Europe differ to those in rural Australia. Europe have access control and major intersections such as interchanges which will optimise the 2+1 treatment. The implementation of the 2+1 treatment in Australia may present the communities with small inconveniences – such as access control of properties and intersection control on minor intersections – but can provide a great benefit to the wider community.

1.2 Project Aim

The project seeks to research and deliver results on how the 2+1 treatment operates under realistic conditions on a rural two-lane highway using Queensland industry standards. The project will also provide a case study into how a typical, desirable rural two-lane highway in Queensland will change with a 2+1 treatment implemented. The project aims to give an indicative guide on where and how a 2+1 treatment should be implemented in regards to traffic performance and level of service.

1.3 Specific Objectives

The objective of this project is to provide an assessment of how the 2+1 treatment provides benefit when for different traffic parameters, particularly when parameters don't warrant the implementation of four lane duplication. The main objective for a site based analysis is:

1.3.1.1 Compare a section of desirable tow-lane rural highway with the same section upgraded to a 2+1 treatment. The comparison will be based on the following scope:

- The comparison will be based on traffic performance parameters.
- There will be no benefit cost analysis undertaken.

1.3.1.2 Further refinement of the 2+1 configuration by adjusting input parameter to find the limits of the treatment.

This will allow fair comparison and a decision to be made about whether the 2+1 treatment is suitable for use on this type of two-lane highway section in Queensland.

1.4 Expected Outcomes

This analysis will provide will provide a real world analysis of the 2+1 treatment. This project should provide general parameters about when the 2+1 treatment can be implemented.

The main outcome for this project is providing the situation where the 2+1 treatment parameters and inputs have been compiled together from previous studies and having a discussion about how it may be implemented and how it performs in Queensland.

The expected outcome for the comparison is that the 2+1 treatment will have a range of traffic parameters that it will perform well under with rural highways in Australia.

Chapter 2

2. Literature Review

This literature review was undertaken to consolidate on knowledge on two-lane highways and also provide findings in relation to the 2+1 treatment implemented around the world.

Two-lane highways are conventional transport project solutions which have had substantive research over time and standards have gathered this information and compiled what is appropriate for different road environments. Two-lane highways are not the focus of the dissertation, however, they must be investigated to provide criteria for analysis.

2.1 Roadway System Elements

2.1.1 Points

Points are places within a facility that provide one of the following points of interest. A point may be where traffic streams cross, a merge or diverge; a single traffic stream is controlled by a device, i.e. signals; there is a significant change in the segment capacity i.e. a lane drop or addition, narrow bridge, significant upgrade or start or end of a ramp influence area (Transportation Research Board 2010a) .

2.1.2 Segments

A segment of road comprises of a start and end point, traffic volumes and typical characteristics are similar along the segment, although small variations may occur. Segments may be directional if they do not affect one another, i.e. freeway facilities (Transportation Research Board 2010a).

2.1.3 Facilities

Facilities are a connected series of points and segments which may be a roadway, bicycle paths and pedestrian paths. The HCM separately defines freeway facilities, multilane highways, two-lane highways, urban street, pedestrian and bicycle facilities (Transportation Research Board 2010a).

2.1.4 Corridors

A corridor is generally a set of parallel transportation facilities intended to provide transportation in possible multiple modes between two locations (Transportation Research Board 2010a). For example, a corridor for a two-lane highway in rural Queensland would generally convey automobiles and bicycle activities.

2.2 Uninterrupted Facilities

An uninterrupted flow facility is ‘uninterrupted’ in that there are no external impacts on the traffic stream (Transportation Research Board 2010a). Facilities such as freeways under the purest uninterrupted flow condition with no intersections, access control and limited ramp locations.

Multilane and two-lane highways also operate under uninterrupted conditions between points of fixed interruptions, i.e. roundabouts and traffic signals.

2.3 Traffic Concepts for Uninterrupted Facilities

2.3.1 Volume

Volume is the total number of vehicle to pass a given point on a section of road per interval of time. Volumes are generally expressed in terms of annual, daily, hourly or sub-hourly periods (Transportation Research Board 2010a). The analysis of two-lane highways requires directional volumes in hourly terms. The directional volume for a two-lane highway facility is simply a split of the entire volume depending on the directional split – the percentage of vehicles travelling in each direction.

2.3.2 Flow Rate

The flow rate of traffic is distinctly different than volume as the flow rate is measured as vehicles pass a given point in a time interval less than an hour and is expressed as an equivalent hourly rate. The Transportation Research Board (2010a) explains 'For example, a volume of 100 veh observed in a 15-min period implies a flow rate of 100 veh divided by 0.25 h, or 400 veh/h'.

2.3.3 Peak Hour Factor (PHF)

The peak hour factor is used by the Highway Capacity Manual (Transportation Research Board 2010a) to convert hourly demands into a peak 15 minute flow rate. The PHF is a ratio of the hourly volume and peak flow rate as shown in Equation 2-1 and can be used to find peak or off-peak 15 minute periods.

Equation 2-1 - Peak Hour Factor (PHF) (Transportation Research Board 2010a)

$$PHF = \frac{Hourly\ volume}{Peak\ \ flow\ rate\ (within\ an\ hour)}$$

2.3.4 Base Conditions

The Transportation Research Board (2010b) explains that base conditions for two-lane highways represent the ideal, unrestricted geometric, traffic or environmental conditions which is different to the typical or default conditions of a specific site. Base conditions are universal for any two-lane highways and are defined by geometric conditions as follows:

2.3.4.1 Traffic lane width of 3.66m (12ft)

2.3.4.2 Clear shoulders equal to or greater than 1.83m (6ft)

2.3.4.3 No no-passing zones

2.3.4.4 All vehicles are passenger cars

2.3.4.5 Level terrain

2.3.4.6 No hindrance to through traffic (intersection, turning vehicles etc.)

The above points are all factors that affect the operation of two-lane highways. Lane widths and shoulder narrow than specified has been shown to reduce speed sand increase percent time spent following (PTSF).

2.3.5 Level of Service (LOS)

Austroads Limited (2013a) describes level of service (LOS) as a qualitative measure of operational conditions in a traffic stream, and their perception by motorists. LOS is generally measured, depending on the environment, as speed and travel time, delay density, freedom to manoeuvre, traffic interruptions, comfort, convenience and safety. There are six levels of service ranging from A to F which are described for uninterrupted flow in Table 2-1.

For appropriate analysis and comparison there are quantitative measures that vary from jurisdiction that need to be applied to determine LOS and performance, depending on the road flow and type. Austroads Limited (2013a) has summarised that measures recommended for use to adequately assess roads in Table 2-2.

Table 2-1 - Level of Service Descriptions (Austroads Limited 2013b)

Level of Service	Conditions
A	A condition of free-flow in which individual drivers are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to manoeuvre within the traffic stream is extremely high, and the general level of comfort and convenience provided is excellent.
B	In the zone of stable flow where drivers still have reasonable freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience is a little less than with level of service A.
C	Also in the zone of stable flow, but most drivers are restricted to some extent in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience declines noticeably at this level.
D	All drivers are severely restricted in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience is poor, and small increases in traffic flow will generally cause operational problems.
E	Traffic volumes are at or close to capacity, and there is virtually no freedom to select desired speeds or to manoeuvre within the traffic stream. Flow is unstable and minor disturbances within the traffic stream will cause breakdown.
F	In the zone of forced flow, where the amount of traffic approaching the point under consideration exceeds that which can pass it. Flow breakdown occurs, and queuing and delays result.

Table 2-2 – Two-Lane Highway LOS Measures (Austroads Limited 2013b)

Element	Level of service measure	Performance measure used
Two-Lane Highway	Speed, per cent time spent following	Speed

2.3.6 Access Management

Access management, or access control, is related to access-point density. Access control is management of all access points onto a roadway. It is necessary to ensure safe access and to allow the road to perform well. The current practice for access management may include the following measures to optimise and improve safety on particular segment.

Regulatory bodies can plan to provide access management to control access to abutting developments. These may partly or fully restrict driveways, local roads and paths from having access to the major roadway. A common measure provided by regulatory bodies is land zoning controls, i.e. planning for a vegetation reserve adjacent to the road corridor (Austroads Limited 2017). Conditions in planning permits can also prove effective for planning authorities.

Geometric design can incorporate access management using elements such as service roads, raised medians, or by providing constrained vertical geometry, i.e. a road in a cutting. This method of management focuses the access at major intersections and governs more suitable locations for access by service roads or local roads (Austroads Limited 2017).

Traffic regulation is also an effective way of managing access control by erecting road furniture, i.e. signs, islands and barriers (Austroads Limited 2017). This may be a common way of rectifying an access management concern after the fact of implementation of a project.

2.3.7 Intersection Treatments

A variety of turn treatments are used on Australian roads. These include basic, auxiliary and channelized turn treatments, all of these types have both left and right turn options. The basic turn treatments implement pavement widening that allows through vehicles to slow but pass the propped vehicle that wishes to turn (Austroads Limited 2016). The axillary treatment provides pavement widening and delineation to improve safety further from the basic turn treatments. Whilst auxiliary turn treatments are common and used widely, they are not as safe as a channelized turn treatment. A channelized turn treatment is considered the safest at grade turn treatment in use on two-lane highways in Australia. The use of a median island – painted or raised concrete – is generally used and deflects the trough traffic away from turning vehicles (Austroads Limited 2016).

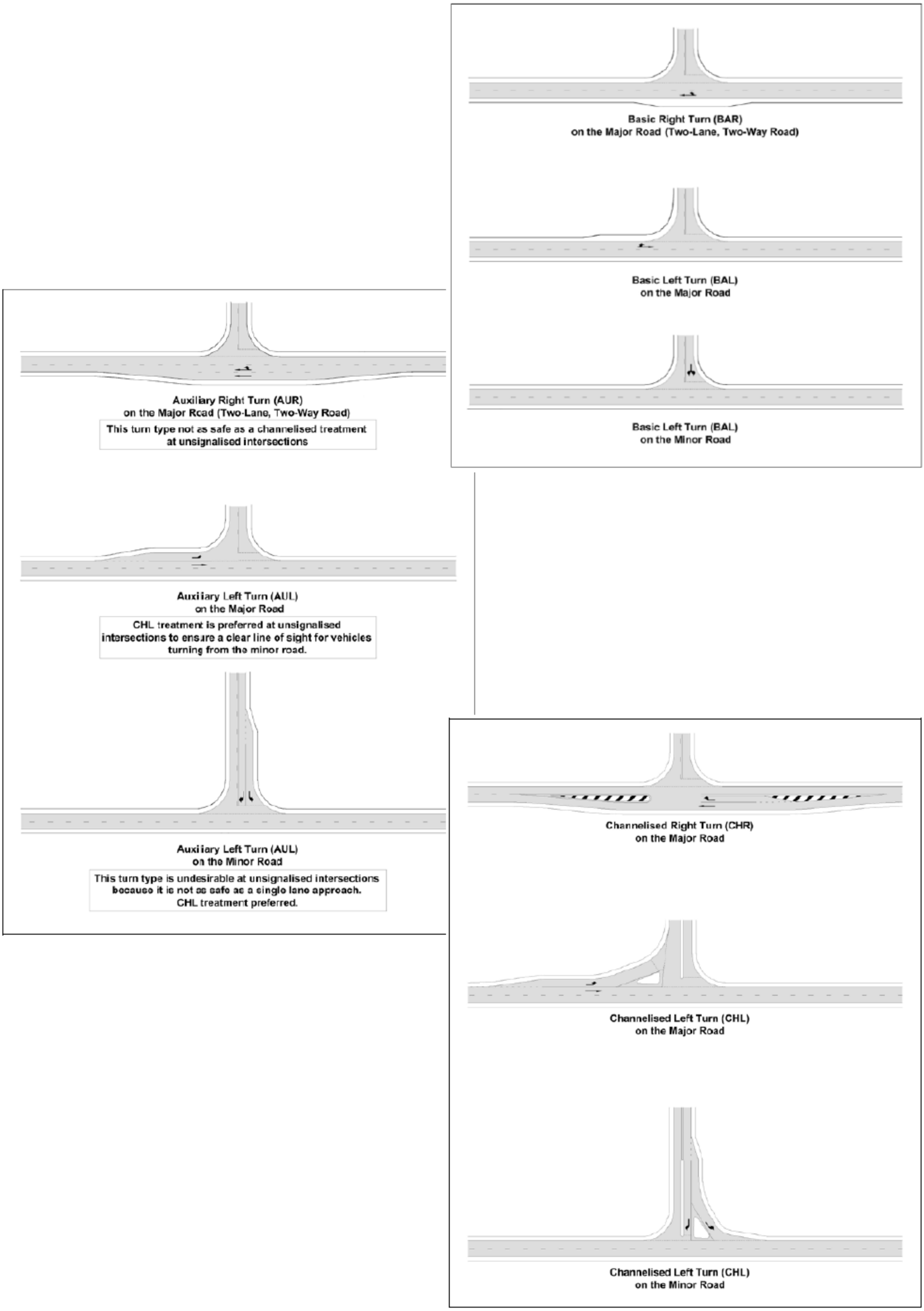


Figure 2-1 - Rural Turn Treatments in Australia

A turn treatment is warranted for implementation on a road based on the traffic volumes the intersection experiences (Austroads Limited 2016). High speed rural roads (>100km/hr design speed) and lower speed or urban roads have different warrants due to the increase in accident severity. It is recommended that an adoption of a higher order turn treatment is used to prevent compounding design minima.

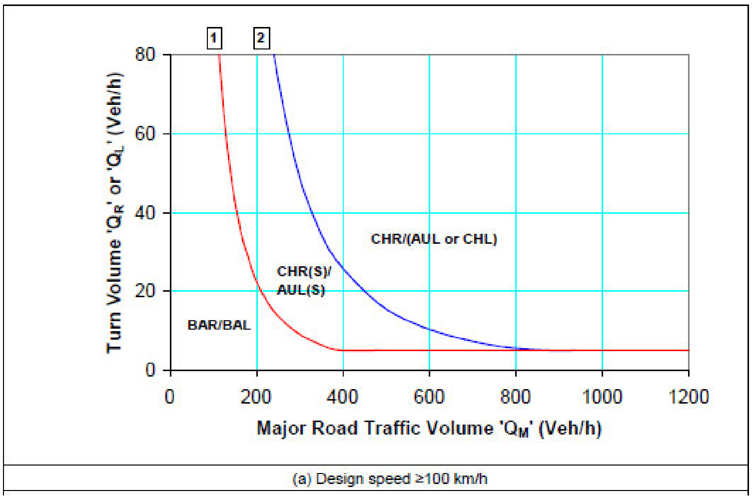


Figure 2-2 - Turn Warrants for High Speed Environments

2.4 Two-Lane Highways

Two-Lane highways are roads which provide one carriageway with a lane in each direction for vehicles. The principal characteristics that separates two-lane highways from other uninterrupted flow facilities – such as freeway and multilane facilities - is that vehicles utilise the opposing lane to pass slower vehicles (Transportation Research Board 2010b).

Two-lane highways are utilised all over the world and serve an integral part in transportation networks by connecting major trip generators and primary links to state and national highway networks. Mainly long distance commercial and recreational travellers, particularly in less built up, rural areas. Some rural two-lane highways also provide a scenic route for tourists which are meant to enjoyed by traffic without interruption by traffic or delays(Transportation Research Board 2010b).

2.4.1 Classification of Two-Lane Highways

There are three classes of two-lane highways that differentiate the purpose of the route, for example, long distance trips, commuter trips, scenic routes etc. Class I and II address rural two-lane highways and class III address two-lane highways in developed areas. The analysis approach differs between class I, II and III (Transportation Research Board 2010b).

2.4.1.1 Class I Two-Lane Highways

2.4.1.2 Class I two-lane highways are assigned to major commuter, major intercity routes, major links in state and national highway networks or primary connectors of major traffic generators, mainly for long distance trips or providing connections between facilities that provide long distance trips. Driver expectation for this classification is to travel at relatively high speeds(Transportation Research Board 2010b).

2.4.1.3 . Class II Two-Lane Highways

2.4.1.4 Class II two-lane highways are assigned to scenic or recreational routes where the expectation of high speed is not possible due to mountainous terrain. Trip length is short in comparison to class I facilities and class II facilities may provide connection to Class I facilities(Transportation Research Board 2010b).

2.4.1.5 Class III Two-Lane Highways

2.4.1.6 Class III two-lane highways serve as moderately developed areas class III may contain portions of class I and II when passing through small towns and developed recreational areas. In these segments through traffic may interact with local traffic and there is a higher density of un-signalised roadside access points which are noticeably higher than in a purely rural area. Class III segments may be longer passing through spread-out recreational areas and may be accompanied by reduced speed limits due to the high activity level (Transportation Research Board 2010b).

The definition of two-lane highways is based on their function or network priority. Arterials or trunk roads and generally class I highways, whilst collectors or local roads are generally Class II or III highways. However, the determination of a facility is the motorist's expectation of the facility (Transportation Research Board 2010b).

Transportation Research Board (2010b) provides an example of this conflicting situation 'For example, a major intercity route passing through a rugged mountainous area might be described as Class II if drivers recognize that high-speed operation is not feasible due to the terrain, but the route could still be considered to be in Class I'.

2.4.2 Passing Lanes

A passing lane is an additional lane provided in one (or two, simultaneously) directions of travel on a typical two-lane highway to definite passing opportunities to motorists (Hardwood 1987). The common definition of a passing lane is recognised by the HCM (Transportation Research Board 2010a) and Hardwood (1987) includes passing lanes in rolling or level terrain, short four lane sections and climbing lanes in mountainous terrain.

Most of the problems associated with two-lane highways result from a lack of passing opportunities. The can be due to limited sight distance of the oncoming traffic, and also heavy oncoming traffic volumes. Passing lanes are an effective solution to providing definite passing opportunities for motorists to reduce congestion and driver frustration without having to implement a four-lane highway (Hardwood 1987).

Passing lanes perform two functions which are reduction in delays at specific bottleneck locations such as mountainous terrain and slow vehicles; and improvement of overall traffic operations cause by insufficient passing opportunities on longer segments of two-lane highways (Hardwood 1987).

Hardwood (1987) stated that the original use of passing lanes were as climbing lanes in the bottleneck type locations. This then evolved into passing lanes due to a lack of funds for improvements and major upgrades. In practice, passing lanes may provide both functions and it may be difficult to draw a distinct line between which function a specific passing lane may be serving (Hardwood 1987).

The analysis of a climbing lane considers only the bottle neck location which, once a passing lane is implemented, shoulder provide the same level of service as the adjacent two-lane highway. A passing lane should consider an extensive length of highway in which improvements will be made, typically from five to 50 miles (Hardwood 1987).

2.4.3 Average Travel Speed

Average travel speed (ATS) is length of a segment of road divided by the time it takes all vehicles to traverse the segment. Average travel speed is a level of service indicator for Class I and II two-lane highways, it represents the mobility (Transportation Research Board 2010b). The closer the ATS is to the operating speed of the segment the better level of service.

2.4.4 Percent Time Spent Following

Percent time spent following (PTSF) is the average percentage of time vehicles platoon behind a vehicle before performing a passing manoeuvre. In regards to level of service, PTSF represents the freedom to manoeuvre, the comfort and convenience of travel. Due to the difficulty to measure in the field PTSF is measured as the percentage of vehicles travelling with less than three seconds headway. PTSF also represents the percentage of vehicles travelling in platoons (Transportation Research Board 2010b).

The 2+1 treatment is a series of overtaking lanes and PTSF is changed when an overtaking lane is implemented on a section of road. The effective length of the passing lane is considered as the passing lane as well as the downstream section which has an improved PTSF(Transportation Research Board 2010b).

The concept of effective length is required for analysis purposes to determine the downstream benefits of the passing lane. The effective length may vary from 3-8 miles depending on length, traffic flow and downstream passing opportunities (Hardwood 1987). The effective length of passing lanes may be constrained by downstream features such as small towns, four lane sections, or additional passing lanes. In this case the effective length will be reduced to the start point of the downstream constraint if it continues past that start point (Hardwood 1987).

2.4.5 Relationships between Flow Rate, PTSF & ATS

2.4.5.1 Passing Capacity

Due to the need of vehicles to pass in the opposing direction of flow on two-lane highways the opposing flow rate and distribution of gaps limits the passing capacity (Transportation Research Board 2010b)

2.4.5.2 Passing Demand

An increase in passing demand is due to vehicles platooning behind slower vehicles in a given direction. As more drivers add to the platoon the passing demand increases (Transportation Research Board 2010b).

2.4.5.3 Capacity

Base conditions result in a capacity of 1700 passenger cars per hour (pc/h) in one direction. However, this capacity cannot be maintained in both directions. For one direction to maintain capacity the opposing lane must stay below 1500pc/h. This is due to passing capacity and demand. From this theory Figure 2-3 illustrates the effect on LOS parameters below.

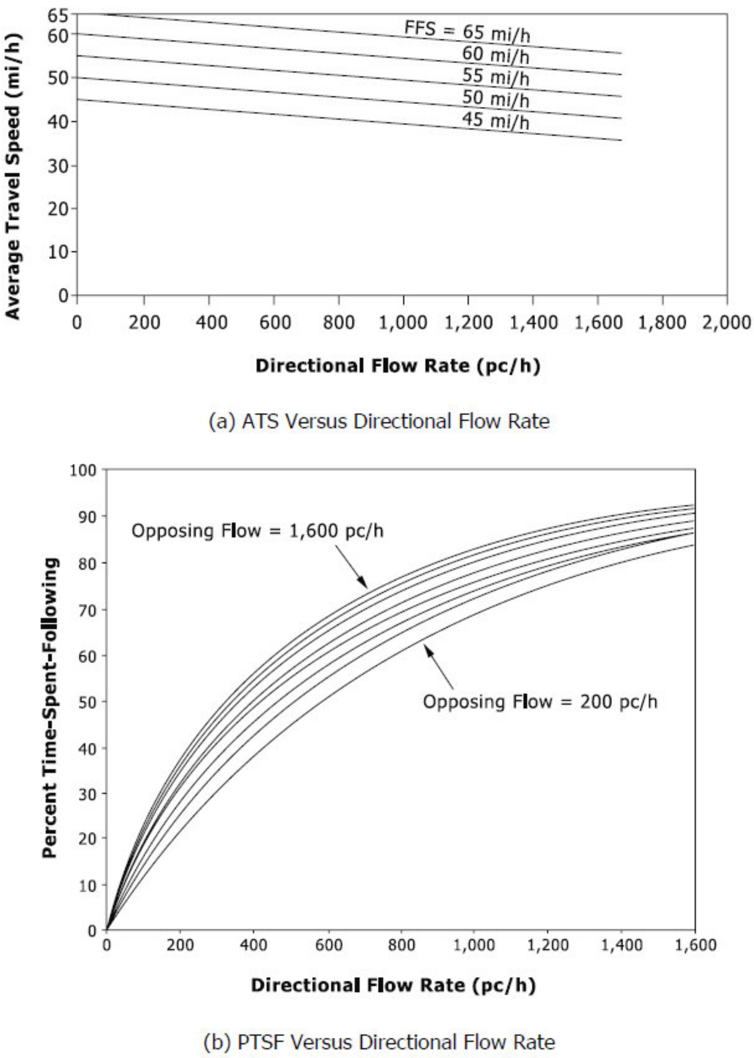


Figure 2-3 - Speed-flow and PTSF Relationships for Directional Segments with Base Conditions

2.5 2+1 Treatment

The 2+1 treatment is a three lane highway design where the centre lane is used as a passing lane, or overtaking lane as it's referred to in Australia. The 2+1 treatment is an attractive alternative to rural highways in Europe but is yet to gain traction in Australia. The treatment has been shown to provide significant safety improvements and brief section of the literature has shown improvements in the level of service on the roads (Derr 2003).


2.5.1 Cross Section

Table 2-3 shows the different cross sections adopted across the literature and any additional commentary shown below. Refer to Figure 2-4 for an illustration on cross sectional dimensions.

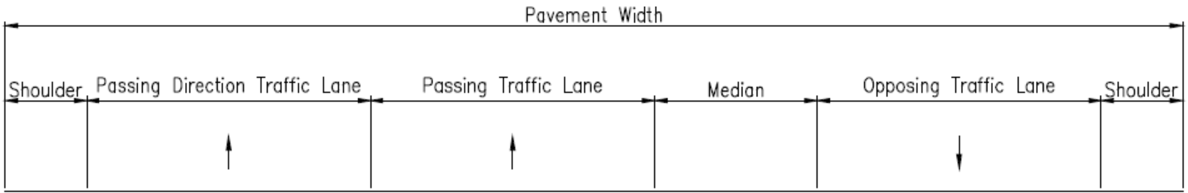


Figure 2-4 - Cross Section Dimensions

Table 2-3 - Literature Review Cross Section Summary

Elements	Sweden[1] (Bergh et al. 2016)	Ireland[2] (Gazzini 2008)		Germany[3] (Derr 2003)			Finland[4] (Derr 2003)	
Existing Pavement Width	13.0m	NA		12.0m	11.5m	11.0m	13m	14.35m
2+1 Pavement Width	13.5m	14.0m	13.0m	12.0m	11.5m	11.0m	13m	14.35m
Median	2.0m	2.0m	1.25m	0.5m			Nil	1.7m
Median Barrier[5]	Yes	Yes		No			No	Yes
Opposing Traffic Lane	3.5m	3.5m		4.25m	3.75m	3.5m	3.75m	
Passing Direction Traffic Lane	3.25m	3.5m		3.5m	3.5m	3.25m	3.25m	3.5m
Passing Traffic Lane	3.25m	3.5m	3.25m	3.25m			3.5m	3.25m
Shoulder	0.75m	1.0m		0.25m			1.25m	
Passing Direction Shoulder	0.75m	0.5m		0.25m			1.25m	0.9m

1. Sweden's implementation of the 2+1 treatment involved modifying existing carriageway which challenged conventional road design at the time. Little or no widening was implemented to re-configure the highways (Bergh et al. 2016).
2. Gazzini (2008) Discusses that a wide lane, wide shoulder, two-lane highway was planned in Ireland where passing manoeuvres are made using the sealed shoulders. This carriageway configuration provides an AADT of 13,800. However, the decision to change the planning

scheme was made in an aim to reduce fatal head-on accidents on single carriageway roads and the construction of the two provided cross sections was green field design.

3. Derr (2003) Discusses Germany’s previous adopted two-lane highway was also a wide carriageway configuration similar to Ireland’s conventional highway. The safety performance was not satisfactory as many drivers did not use them in accordance with the intended use. Driver’s used the roadway as a four lane configuration with slower vehicles used the shoulder and passenger cars used the through lanes. Simple re-configuration of pavement marking was required due to sufficient pavement width.

4. Derr (2003) reports that Finland had to provide pavement widening on some sections and strip pavement marking to implement the 2+1 treatment. The Finnish Road Administration considered this as a relatively inexpensive way of address the need to improve traffic flows without providing four lanes.

5. The issue that arises with the use of median barriers use is the available width of the median and deflection for the barrier product. The vehicle may enter the opposing lane if errant and come to stop in the opposing traffic lane (Derr 2003). This creates a higher maintenance cost while the barrier doesn’t provide the solution intended. There may be some associated deterrence or shy line that may keep drivers alert. Another issue is the provision for maintenance and emergency vehicle access at intervals.

2.5.2 Segment Configuration & Performance

The significant elements of pavement marking of a 2+1 treatment are the changeovers. This is where a lane is dropped or gained. The two types are known as critical and non-critical (Derr 2003). A non-critical changeover is a lane-gaining situation where both directions are diverging. A critical transition is where both directions of traffic are merging, this is known as critical due to the risk of the manoeuvre.

Derr (2003) reported that the desirable length of 2+1 treatment is from 4-6km, however, sections up to 15km have been considered successful. Consideration needs to be made on the length of overtaking segments as the then traffic increases the passing lane will need to increase. Optimal passing lane length is reliant on the flow rate of vehicles.

Table 2-4 - 2+1 Treatment Configuration

Elements	**Sweden[1] (Bergh et al. 2016)**	**Ireland[2] (Gazzini 2008)**	**Germany[3] (Derr 2003)**	**Finland[4] (Derr 2003)**
One Lane Segment	2-11km	Not reported	Not reported	1-1.5km
Subcritical Buffer	Not reported	0m	0m	0m
Diverge	Not reported	25m	30m (50m max)	25m
Passing Lane (including tapers)	0.8-2km	0.95-1.5km	1-1.4km (2km max)	1.5km
Overtaking Lane Percentage	15-40%	36%	Not reported	Not reported
Merge	150m	150m	45 degrees	200m
Critical Buffer	0m	0m	0m	100m

1. Bergh et al. (2016) discusses that overhead lane configuration signs to improve clarity around transitions have been trialled and have found that the benefit is not significantly more than traditional signage of passing lanes.
2. Ireland (Gazzini 2008) have adopted their traditional climbing lane configuration as well as an equal overtaking opportunity for each direction. Ideally climbing lanes are on upgrades where the differential speed between vehicle types is greater.
3. Germany utilise a 45 degree merge taper which provides a very short merge style pavement marking. The Germans consider the 2+1 treatment adaptable to all terrain (Derr 2003).
4. Derr (2003) reports that the improved PTSF ends approximately 3.3km downstream and the increased travel speed diminishes 2.7km downstream.

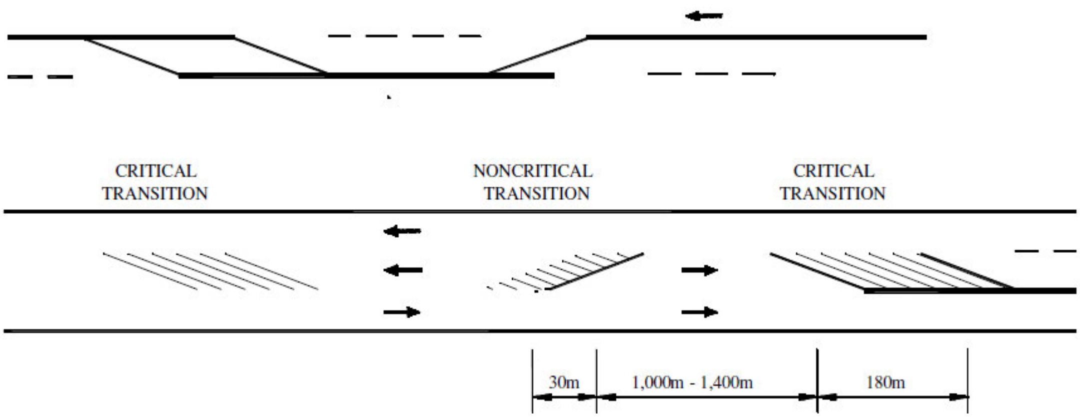


Figure 2-5 - End of Passing Lane Configurations

2.5.3 Intersection Treatments

Germany, Finland and Sweden adopt the use of grade separated intersections for new construction to optimise efficiency of the 2+1 treatment. Finland adopts a loop turn for any at grade intersections. A loop turn is a facility where to turn right the vehicle leaves the through carriageway via a left turn lane, then loops around and cross the major road perpendicularly which provides no disturbance to the through traffic and provide optimal sight distance to the major road (Derr 2003).

2.5.4 Safety

The accident rates are all reportedly significantly lower than conventional two-lane highways (Derr 2003). Germany was found to have a reduction in accidents of 36% on their 2+1 treatments over 360km. Finland has estimated that the two-lane highways with the 2+1 treatment (48km) implemented resulted in a 22-46% reduction in accident rates. Sweden observed a 55% reduction in fatal and injury accidents after implementation of 400km worth of 2+1 treatments (Derr 2003).

2.5.5 Speed Environment

The posted speed limit adopted in Germany, Finland and Sweden on 2+1 roads is 100km/hr. Finland enforce an 80km/hr speed limit for trucks (Derr 2003). Germany also reduces the speed limit down to 70km/hr at intersection and interchanges.

Derr (2003) mentions that before and after studies concluded in Finland that the amount of passing increased 20-40% in day time traffic and more than doubled in the weekend period. However, the passing at the downstream ends of the 2+1 decreased which is positive from a safety point of view.

2.5.6 Community Acceptance

A survey was conducted in Germany between 1983 and 1988 Figure 8 shows the results of driver's opinions. A survey in Finland also yielded positive results indicating 80% of drivers prefer the 2+1 treatment over a two lane road. Police in Finland and Sweden report that drivers adapted quickly to the 2+1 roads (Derr 2003).

The use of heavy vehicles is briefly discussed by Derr (2003) in that the 2+1 treatment has a wide range of uses and is considered effective even with a high percentage of heavy vehicles. Derr (2003) reports that Danish drivers had positive experiences. Heavy vehicle usage in Denmark was up to 12% heavy vehicles on the route.

Question	Percentage of responses
How do 2+1 roads compare to normal rural roads?	
Better	92
Worse	5
No difference	3
On 2+1 roads, one can pass much better than on normal rural roads.	
Agree	92
Disagree	6
No opinion	2
2+1 roads are dangerous.	
Agree	22
Disagree	75
No opinion	3
On 2+1 roads, one can travel faster.	
Agree	80
Disagree	15
No opinion	5

NOTE: Survey is based on driver survey results conducted at five 2+1 road sites between 1983 and 1988.

Figure 2-6 - Denmark survey results (Derr 2003)

2.6 Highway Analysis Methods

2.6.1 Two-Lane Highway Analysis

The HCM (Transportation Research Board 2010b) states that the methodology for operational analysis of two-lane highways is mostly directed at finding a LOS of uniform directional segments of two-lane highways by estimating PTSF and ATS. Whilst the two directions of flow interact with passing manoeuvres in the opposing traffic lane, analysis must be made in each direction separately. The HCM states that all segments in mountainous terrain and any grades steep than 3% must be analysed independently due to the nature of a climbing lane (Transportation Research Board 2010b).

Limitations of the methodology as described in the HCM (Transportation Research Board 2010b) does not have the capability to analyse any signalized intersections or any segments between signalised sections less than 2 miles long. These segments are classified as urban streets and shoulder be analysed as such.

Figure 2-7 Illustrates the computational steps required to complete analysis as described in the HCM (Transportation Research Board 2010b).

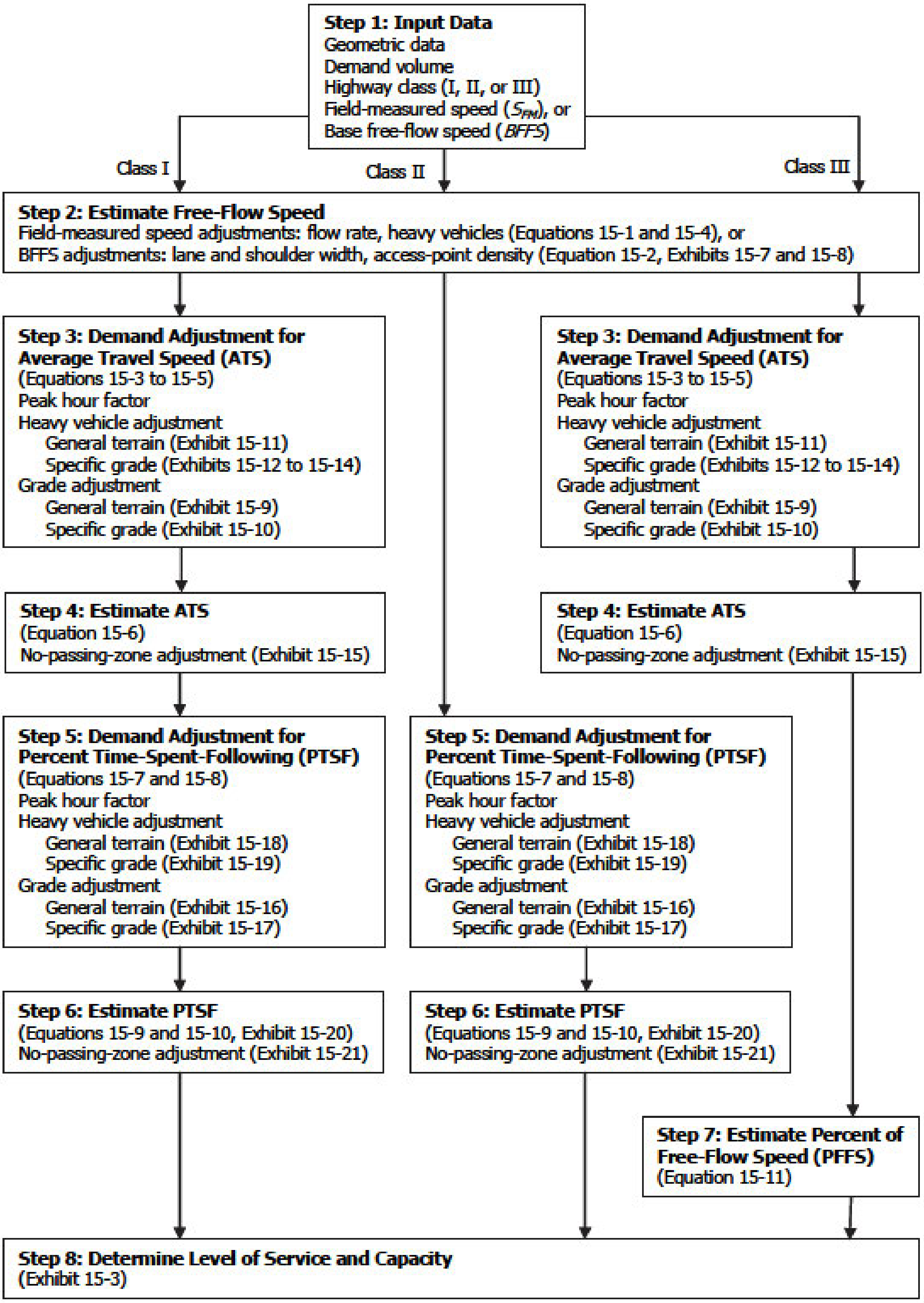


Figure 2-7 - Two-Lane Analysis Methodology (Transportation Research Board 2010b)

2.6.2 Passing Lane Analysis

The HCM (Transportation Research Board 2010b) describes a procedure to estimate the effect that a passing lane will have on a two-lane highway in level and rolling terrain. On specific grades, passing lanes are considered as climbing lanes which are addressed differently. Figure 2-8 illustrates the effect a passing lane will have on a passing lane. It is important to note that the length of segment is critical in that an analysis segment that only contains the passing lane will have seemingly larger benefits than a segment that runs between two points of similar characteristics (Transportation Research Board 2010b). It is critical to choose start and end points of the analysis segment correctly and sensibly. The HCM discussed that the four regions of a passing lane – the upstream length, passing lane length, effective downstream length and the downstream length must add up to the total length of the segment. Refer to Figure 2-8 for illustration of the four regions.

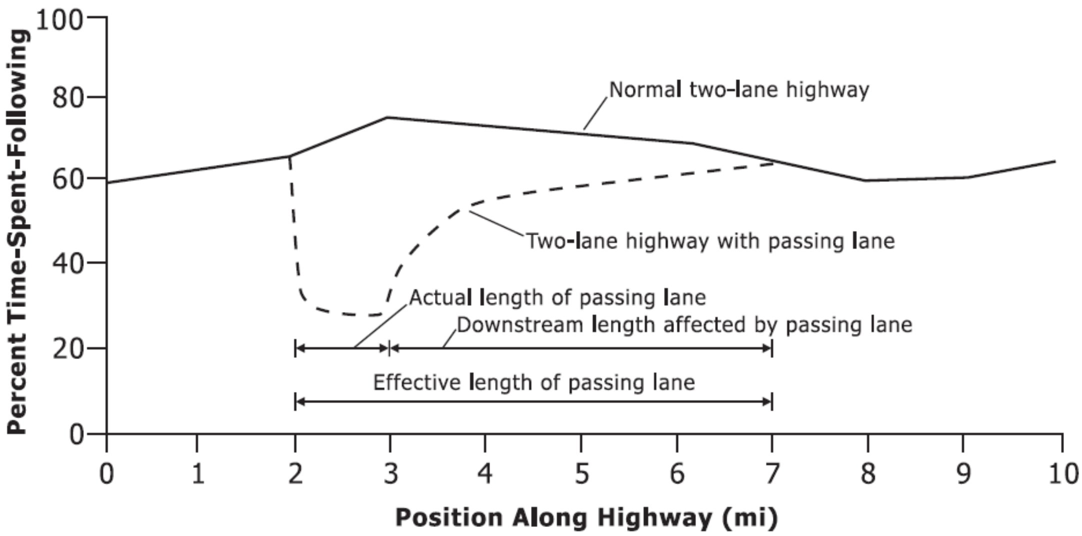


Figure 2-8 - Effect of Passing Lanes on PTSF (Transportation Research Board 2010b)

Figure 2-8 shows the solid lines is the PTSF on the segment of road before a passing lane was added, the dashed line shows the PTSF changing when the passing lane is added. The addition of a passing lane reduces the PTSF by allowing vehicles to safely carrying out a passing manoeuvre. It falls dramatically over the length of the passing lane and also has an effective length downstream of the passing lane. Installation of passing lane can affect the whole segment, depending on the length of the segment (Hardwood 1987).

To undertake an analysis of a passing lane the analysis of the segment must be conducted without the passing lane to get the base PTSF and ATS. The HCM (Transportation Research Board 2010b) that the downstream effective length of a passing lane may be required to return to region four at the following locations:

- The highway environment radically changes, such as entering a small town
- A major unsignalised intersection
- A signalised intersection affects the performance of the two-lane segment
- The terrain changes significantly
- Lane or shoulder widths change dramatically

Hardwood (1987) agrees with the above definition of extents for the effective length of the passing lane with one addition, that the effective length of the passing lane returns to region four values when another passing lane is encountered. This is especially important when the 2+1 treatment has multiple passing lanes close together within a segment.

The limitations of the HCM is that for the purpose of analysis the effective length of downstream benefit from passing lanes is not seen as the passing lane analysis requires the effective length to be cropped to the start of the obstruction, in this case the passing lane. The benefit of the 2+1 treatment isn't seen using this methodology.

2.6.3 2+1 Treatment Analysis

Luttinen (2001) acknowledges that the HCM (2000) does not have a procedure to analyse the 2+1 treatment – or three-lane highway. This is still the case with the latest HCM (Transportation Research Board 2010b). The results as described by Luttinen (2001) are only tentative and further research is required to develop a firm methodology for the analysis of 2+1 treatments.

The HCM (2000) can be applied with some modifications, to analyse 2+1 highways. The modified method is based on previous simulation results acknowledged by (Luttinen 2001).

The methodology as presented by Luttinen (2001) uses this notation:

- Flowrate (q_d) in observed direction
- Distance (d_U) upstream of the first passing lane
- Lengths ($d_{L,i}$) of the passing lanes
- The effective length ($d_{D,i}$) downstream of the effective length of each passing lane
- ATS ($v_{s,\,U}$) on a passing lane section outside the effects of the passing lane

This methodology provides equations for the calculation of the ATS of the downstream effective length of the passing lane (Equation 2-2), the ATS between the passing lane and the next passing lane (Equation 2-3) and an equation that provides an ATS if the effective length of the passing lane is longer than the distance to the next passing lane (Equation 2-4) (Luttinen 2001). The methodology also provides an equation to find the ATS across the 2+1 segment (Equation 2-5).

Equation 2-2

$$\bar{v}_{\mathrm{s,E}} = \frac{\bar{v}_{\mathrm{s,U}}(1 + f_{\mathrm{L}})}{2}.$$

Equation 2-3

$$\bar{v}_{\mathrm{s,B},i} = \frac{\bar{v}_{\mathrm{s,U}}}{2}\left(2f_{\mathrm{L}} - (f_{\mathrm{L}} - 1)\frac{d_{\mathrm{B},i}}{d_{\mathrm{E}}}\right).$$

Equation 2-4

$$\bar{v}_{\mathrm{s,B},i} = \frac{d_{\mathrm{B},i}}{\dfrac{d_{\mathrm{E}}}{\bar{v}_{\mathrm{s,E}}} + \dfrac{d_{\mathrm{D},i}}{\bar{v}_{\mathrm{s,U}}}}.$$

Equation 2-5

$$\bar{v}_{\mathrm{s,T}} = d_{\mathrm{T}}\left[\frac{d_{\mathrm{U}}}{\bar{v}_{\mathrm{s,U}}} + \sum_{i=1}^{n}\left(\frac{d_{\mathrm{L},i}}{\bar{v}_{\mathrm{s,L}}} + \frac{d_{\mathrm{B,i}}}{\bar{v}_{\mathrm{s,B},i}}\right)\right]^{-1},$$

The methodology also tentatively provides equations for the calculation of PTSF on 2+1 segments. The equations provided are for the calculation of PTSF of the downstream effective length of the passing lane (Equation 2-6), the PTSF between the passing lane and the next passing lane (Equation 2-7) and an equation that provides an PTSF if the effective length of the passing lane is longer than the distance to the next passing lane (Equation 2-8) (Luttinen 2001). The methodology also provides an equation to find the PTSF across the 2+1 segment (Equation 2-9).

The methodology provided by Luttinen (2001) requires validation as reported, this methodology needs to be acknowledged but due to the nature of the methodology not being sound it will not be utilised in the calculation of any values for this project.

Equation 2-6

$$P_{W,\mathrm{E}} = \frac{P_{W,\mathrm{U}}(1 + f_{\mathrm{L}})}{2}.$$

Equation 2-7

$$P_{W,\mathrm{B},i} = \frac{d_{\mathrm{E}}\, P_{W,\mathrm{E}} + d_{\mathrm{D},i}\, P_{W,\mathrm{U}}}{d_{\mathrm{B},i}}.$$

Equation 2-8

$$P_{W,\mathrm{B},i} = P_{W,\mathrm{U}} \left(f_{\mathrm{L}} + \frac{(1 - f_{\mathrm{L}})d_{\mathrm{B},i}}{2d_{\mathrm{E}}} \right).$$

Equation 2-9

$$P_{W,\mathrm{T}} = \frac{1}{d_{\mathrm{T}}} \left[d_{\mathrm{U}}\, P_{W\mathrm{s},\mathrm{U}} + \sum_{i=1}^{n} \left(d_{\mathrm{L},i}\, P_{W,\mathrm{L}} + d_{\mathrm{B,i}}\, P_{W,\mathrm{B},i} \right) \right].$$

Chapter 3

3. Methodology

This project seeks to provide a comparison between a rural two lane highway and a 2+1 treatment suited to Australian driver's expectations. . A comparative analysis of a segment of existing highway against a 2+1 treatment will be undertaken using standards discussed in Chapter 2.

3.1 Research

The process of gathering information was undertaken in the literature review in Chapter 2. This involved gathering literature on 2+1 treatment implementations as well as investigating current Australian industry standards for two-lane highways and analysis methods. For the purpose of this dissertation the Australian industry standards are not being questioned, assessed or interrogated.

Conflicts between the findings from foreign literature and Australian industry standards may be a point of discussion for the outcomes of this dissertation, however implementation in Australia will most likely result in the adoption of industry standards to maintain consistency. However, the literature is crucial in forming a knowledge base and how conditions and solutions are different in Australia.

3.2 Data Sources & Current Standards

The documents considered as industry standards for use in this dissertation are:

3.2.1.1 Austroads Guide to Road Design (Austroads Limited 2016)

3.2.1.2 Austroads Guide to Traffic Management (Austroads Limited 2013a)

3.2.1.3 Highway Capacity Manual (Transportation Research Board 2010a)

All data sources explored in the literature review will be compiled and considered along with the above mentioned industry standards to provide a basis for implementation and guidance in application of the 2+1 treatment in Queensland, Australia.

Traffic and road data has been obtained from the Department of Transport and Main Roads which will be used in the computer software Highway Capacity Software (HCS) (McTrans 2010) which is endorsed by the Transportation Research Board (2010a) as it performs calculations as specified in the Highway Capacity Manual (2010). Austroads Limited (2013a) refers to the HCM in regards to traffic analysis and calculations. The data received from TMR is as follows:

3.2.1.4 AADT segment reports (Appendix A)

3.2.1.5 Classified vehicle reports (Appendix B)

3.2.1.6 Weekly volume reports (Appendix C)

3.2.1.7 Intersection Traffic Counts (Appendix D)

3.3 Evaluation of Traffic Performance

The analysis undertaken as part of this dissertation will provide outcomes of the traffic performance when the 2+1 treatment has been implemented (theoretically) compared to the existing highway on a segment of road suited to possibly implementation of the 2+1 treatment.

3.4 Case Study & Analysis Method

A case study will be undertaken on a segment of road depending on the area of data supplied by TMR. The location will be limited by the supply of this data. TMR recommended that the use of data from Sarina to Hay Point. This will require use of the Australian industry standards as mentioned above.

A basic desktop survey using publicly available GIS information will be required to establish start and end points of segments, intersection locations, existing passing opportunities and private accesses. This information will be supplied as a schematic for viewing and use in analysis.

Using this information the parameters required for input into HCS (McTrans 2010). In order to undertake analysis on the segment of highway various parameters need to be adopted and calculated. Some further calculation may be required to finalise the values as well as converting into imperial measurements for use in the software. The software requires multiples runs to add a passing lane into the segment.

Depending on results a growth factor is to be applied to the traffic for a period into the future, i.e. a 10 year prediction of traffic demand to see the breakdown in performance of the two-lane highway and the performance of the 2+1 treatment. If there is no apparent difference in the traffic performance between the two scenarios an inflated traffic volume will be adopted to provide insight into future requirements for the segment of road.

3.4.1 Location

The location chosen for the analysis was based on advice from a spokesperson of the Department of Transport and Main Roads Queensland. The location was the segment of two-lane highway between Sarina and Hay Point situated south of Mackay. Figure 3-1 Figure 3-1 – Sarina to Hay Point Road (Bruce Highway)illustrates the segment, the segment starts after Bells Creek as the township of Sarina extends to the bridge as well as the intersection of Sarina-Homebush Road. The location between major town centres is shown in Figure 3-2. Both Mackay and Sarina are major traffic generators which require commuter, heavy vehicles and commercial vehicles to travel on the Bruce Highway for a wide range of activities.

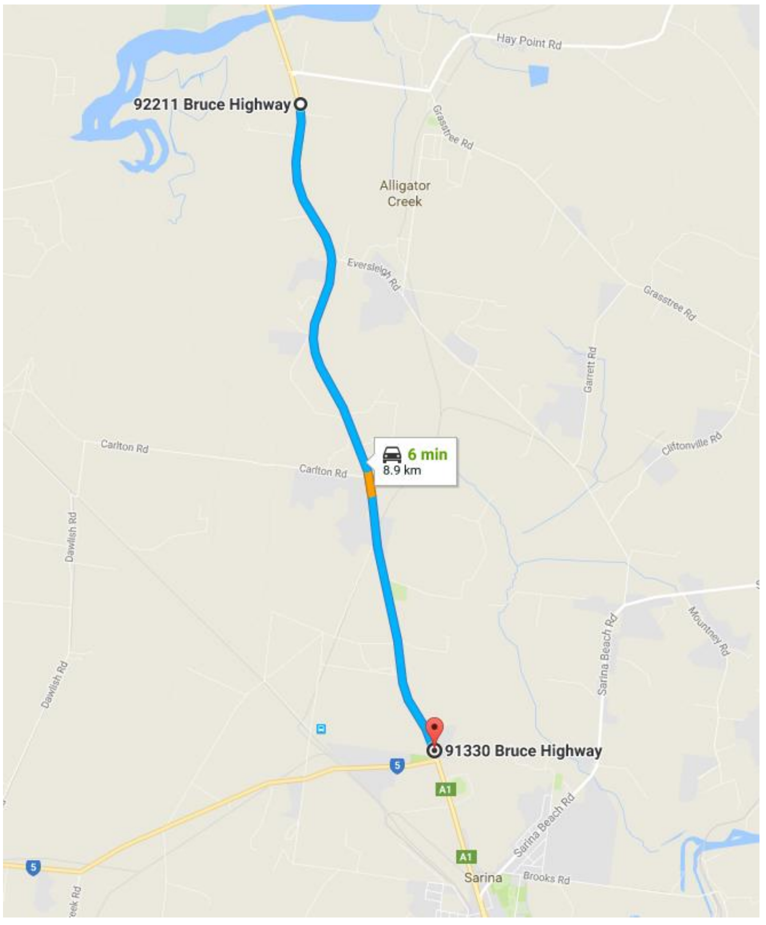


Figure 3-1 – Sarina to Hay Point Road (Bruce Highway)

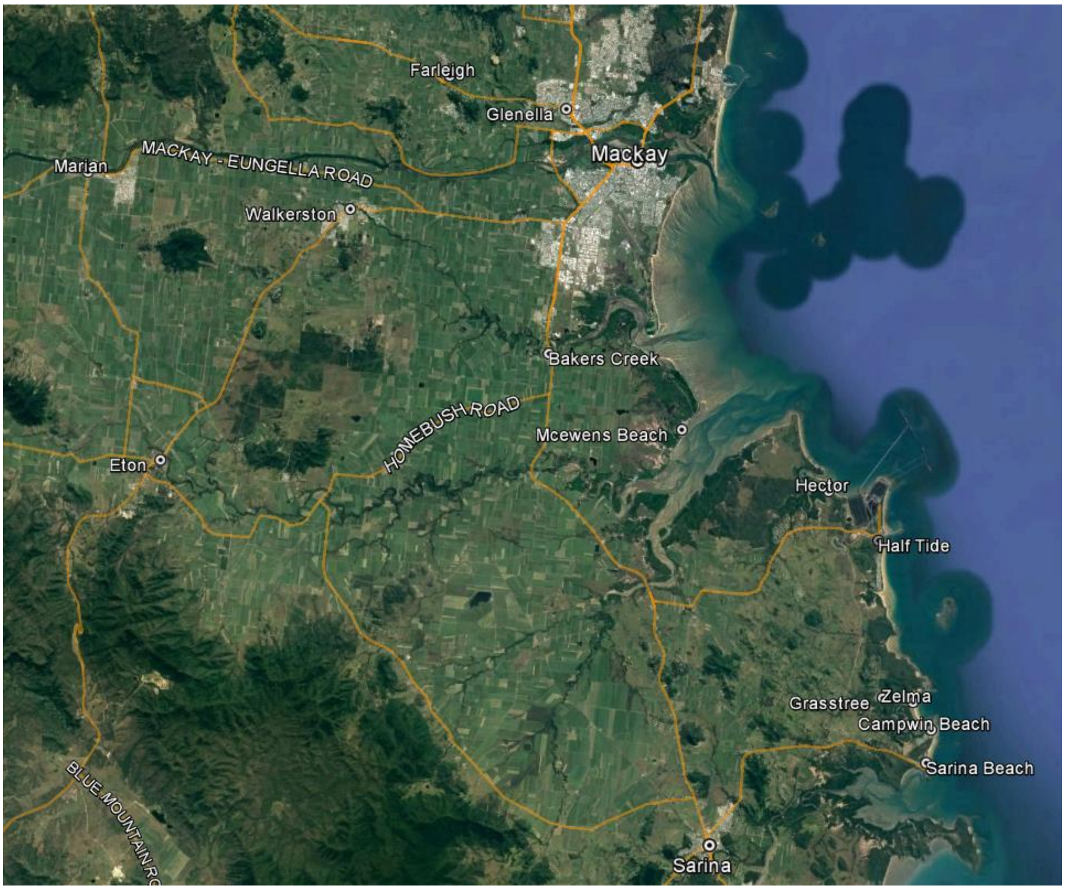


Figure 3-2 - Locality - Mackay to Sarina

3.4.2 Input Data

3.4.2.1 Terrain

The terrain from Sarina to Hay Point Road is considered as rolling due to slight grades in both directions. These grades were observed affect heavy vehicles during several drive throughs. Unfortunately exact grades were not attainable in the data provided by TMR.

3.4.2.2 Shoulder & Lane Width

Lane width and shoulder width shall be adopted from the Guide to Road Design Part 3 (Austroads Limited 2016) as specified in Table 4.5 for single carriageway rural road widths. The guide recommends lane width of 3.5m. The same table recommends a total shoulder width of 2.5m which satisfies bicycle demand requirements of Table 4.7 of 2.0/3.0m. The width of 2.5m along the whole segment will be assumed due to frequent private accesses which will allow a car to stay in its lane to manoeuvre around the vehicle entering private property.

Table 3-1 – Traffic Lane & Shoulder Width

Traffic Lane Width	3.5m
Shoulder Width	2.5m

3.4.2.3 Segment Length

The segment length is from Bell's Creek to the speed reduction zone prior to the roundabout at Hay Point Road. This segment is necessary to be analysed as one segment to get a base ATS, PTSF and LOS. The need for different segment lengths for passing lanes are discussed below and summarised in Table 3-2.

Table 3-2 - Segment Length

Whole Segment Length	8.86km

3.4.2.4 Highway Class

Highway class I has been adopted for all analyses the segment is a major link in the national highway network that serves long distance trips as well as daily commuter routes to places of employment.

Table 3-3 - Highway Class

Highway Class	I

3.4.2.5 Directional Volumes

The analysis direction volume for each part of the analyses will be the same. The 2016 Weekly Volume Report (Appendix B). Each direction of analyses will have different traffic volumes. Each scenario will require with travel and against travel analysis which may have different peak hour volumes. The average weekday peak hour volume will be adopted for the analysis. Table 3-3 reports the volumes in each direction.

The peak volume for the northbound average weekday was the AM peak for the hour ending at 1000, the corresponding AM weekday average from 0900-1000 was taken from the southbound measurements. The southbound peak was the PM hour ending at 1700 and corresponding values were chosen.

Table 3-4 - Directional Volumes

Northbound Peak Hour Volumes	
Northbound	269vph
Southbound	177vph
Southbound Peak Hour Volumes	
Southbound	283vph
Northbound	248vph

3.4.2.6 Peak Hour Factor

The data provided was in hourly measurements and to compute PHF shorter time intervals are required to find the 15 minute peak flow peak rate. The recommended default PHF used in the analysis is shown in Table 3-5.

Table 3-5 - Peak Hour Factor

Peak Hour Factor	0.88

3.4.2.7 Heavy Vehicle (Trucks and Buses)

The heavy vehicle percentages were adopted from the 2015 AADT Segment Analysis Report (Appendix C) as the 2016 Segment Analysis Report (Appendix B) was observed to be inconsistent with previous years. It is assumed that there was an unusual disruption to the traffic at the time of measurement.

Table 3-6 - Heavy Vehicle Percentages

Northbound HV	13.5%
Southbound HV	13.3%

3.4.2.8 Recreational Vehicles

Recreational vehicles are all vehicles in classification 2B which are defined as ‘short vehicles towing’. These vehicles may not necessarily be ‘recreational’ in nature but generally won’t perform as well as vehicles not towing. The values shown in Table 3-7 were adopted from the 2015 Segment Analysis Report (Appendix C) as, once again, the 2016 Segment Analysis Report appeared inconsistent with previous years of measurement.

Table 3-7 - Recreational Vehicle Percentages

Northbound RV	4.7%
Southbound RV	4.2%

3.4.2.9 Percent No-passing Zones

The percent no-passing zones are assumed to be 100% as the base case requires any passing lanes to be removed and there are no broken lane line sections to overtake in the opposing direction traffic lane. This will be applied for both the existing section and the 2+1 treatment section.

Table 3-8 - Percent No-Passing Zones

Percent No Passing Zones	100%

3.4.2.10 Access-Point Density

The access-point density is required to be calculated for each side. This will also be the case for the 2+1 treatment as left in, left out access would most likely be implemented due to the use of central barriers or pavement marking. The northbound direction has 6 intersections and 8 private accesses. The southbound direction has 2 intersections and 11 private accesses. Table 3-9 shows the calculated access-point density.

Table 3-9 - Access-Point Density

Northbound	2.5/mile
Southbound	2.4/mile

3.4.2.11 Passenger-Car Equivalent for Trucks & RVs

Passenger-car equivalent for trucks and RVs is provided in Exhibit 15-11 (Transportation Research Board 2010b). Using the adopted directional volumes provided in Table 3-6 and Table 3-7Table 3-10 the equivalent trucks and RVs were interpolated to the nearest 0.1, as recommended. The adopted figures are shown in Table 3-10.

Table 3-10 - Passenger-Car Equivalents

Northbound HV equivalent	2.2
Northbound RV equivalent	1.1
Southbound HV equivalent	2.2
Southbound RV equivalent	1.1

3.4.2.12 Base Free-Flow Speed

Due to no speed data being provided by TMR the base free flow speed (BFFS) was taken as the design speed of the segment of road which is typically the posted speed plus 10km/hr. The adopted value is shown in Table 3-11.

Table 3-11 - Base Free Flow Speed

BFFS	110km/hr

3.4.2.13 Adjustment for Lane, Shoulder Width & Access-Point Density

To attain the free-flow speed (FFS) of the road adjustments must be made for the road cross section and access-point density. Exhibit 15-7 and 15-8 in the HCM2010 (Transportation Research Board 2010b) contain the adjustment factors which must be subtracted off the BFFS. The adjustment factors are shown in Table 3-12below.

Table 3-12 - Adjustment Factors

Adjustment for Lane and Shoulder Width	3.0
Adjustment for Access-point Density	1.2

3.4.2.14 Adjustment for No-Passing Zones

To attain the adjustment factor for no-passing zones the FFS must be calculated as discussed in the literature review. Interpolation of Exhibit 15-15 in HCM2010 (Transportation Research Board 2010b) is to the nearest 0.1 using the calculated FFS, percent no-passing zones & direction volume.

Table 3-13 - Adjustment for No-Passing Zones

Existing Segment	
Northbound	3.5
Southbound	3.6
2+1 Treatment	
Northbound	3.3
Southbound	3.6

3.4.2.15 Length of Two-Lane Highway Upstream of the Passing Lane & Passing Lane

The length of two-lane highway upstream of passing lanes is assumed to start at Bell's Creek due to the township of Sarina preceding the bridge. The length of the analysis segment needs to finish at the start of the next passing lane or at the end of the analysis segment. The length of existing and 2+1 treatment overtaking lanes are shown in Appendix F . Table 3-14 summarises the dimensions required for passing lane analysis in HCS2010. The passing lanes were labelled from one onwards from South to North.

Table 3-14 - Passing Lane Dimensions

Passing Lane	Upstream Length (km)	Passing Lane Length (km)
	Existing Segment	
	Northbound	
OT-NB1	0.59	1.79
OT-NB2	2.65	1.25
	Southbound	
OT-SB2	4.82	1.08
OT-SB1	2.99	1.29
	2+1 Treatment	
	Northbound	
2P1-NB1	0.00	0.97
2P1-NB2	1.42	1.15
2P1-NB3	1.67	1.29
2P1-NB4	1.37	0.91
	Southbound	
2P1-SB3	1.76	1.07
2P1-SB2	1.58	1.36
2P1-SB1	0.91	1.13

3.5 Consequential Effects

The result anticipated by this dissertation is that there will be a greater awareness of the 2+1 treatment in Australia and that there are environments where this treatment may be implemented to benefit road users in Australia. The comparison between a two-lane highway and the treatment will be able to be made.

The dissertation will determine whether this segment of road will benefit from implementation of the 2+1 treatment now and into the future. Recommendations of changes to implementation of the treatment to potentially optimise will be provided for research in the future.

Literature has already established that this treatment is also an appropriate safety measure for rural highways and that is an aspect that will benefit the community. Generally speaking the public's perception of the implementation of the 2+1 treatment would be positive due to the anticipated improvements in traffic performance and likely improvement in safety.

3.6 Resource Requirements

This project is predominantly research based, to complete this projects usage of internet and contact with industry professionals is required. The project will require the following resources:

- Traffic data supplied by TMR
- Australian industry standards
- CAD software
- HCS software (McTrans 2010)
- General office software
- Camera

3.7 Risk Assessment

A personal and project based risk assessment is produced below aligning with Australian Center of Healthcare Governance (2013). The risk matrix used for the assessment is documented below along with likelihood descriptions. There a minimal personal safety issues to deal with if due care is taken around roads and whilst driving. The major project risk is obtaining relevant standards as well as obtaining relevant software for desired analysis, this has a monetary constraint if hazard occurs.

Table 3-15 - Risk Matrix, adopted from Australian Center of Healthcare Governance (2013)

	CONSEQUENCE				
LIKELIHOOD	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Extreme (5)
Rare (1)	Low	Low	Low	Low	Low
Unlikely (2)	Low	Low	Low	Medium	Medium
Possible (3)	Low	Low	Medium	Medium	Medium
Likely (4)	Low	Medium	Medium	High	High
Almost certain (5)	Low	Medium	Medium	High	Extreme

Table 3-16 - Likelihood Descriptions, adopted from Australian Center of Healthcare Governance (2013)

Level	Likelihood	Expected or actual frequency experienced
1	Rare	May only occur in exceptional circumstances; simple process; no previous incidence of non-compliance
2	Unlikely	Could occur at some time; less than 25% chance of occurring; non-complex process &/or existence of checks and balances
3	Possible	Might occur at some time; 25 – 50% chance of occurring; previous audits/reports indicate non-compliance; complex process with extensive checks & balances; impacting factors outside control of organisation
4	Likely	Will probably occur in most circumstances; 50-75% chance of occurring; complex process with some checks & balances; impacting factors outside control of organisation
5	Almost certain	Can be expected to occur in most circumstances; more than 75% chance of occurring; complex process with minimal checks & balances; impacting factors outside control of organisation

Table 3-17 - Personal Risk Assessment

Hazard	Risk	Mitigation
Injury from being hit by car	Unlikely Major	• Maintain safe distance from roadway • Adhere to traffic regulations • Wear florescent clothing • Maintain awareness while crossing road • Make it clear to drivers your actions
Injury from car accident	Unlikely Extreme	• Don't perform other tasks while driving • Adhere to traffic regulations • Drive safely
Dehydration/Exhaustion /Sunburn	Likely Minor	• Drink water frequently throughout day • Apply sunscreen and wear hat and long sleeves • Have a helper in case of emergency

Table 3-18 - Project Risk Assessment

Hazard	Risk	Mitigation
Analysis scope creep	Possible Minor	1. Consult with project supervisor on minimising extra work. Only perform work relevant to project specification

Chapter 4

4. Discussion

The research and analysis was carried out according to the methodology described in Chapter 3 and the following observations, findings, constraints and opportunities were obtained.

4.1 General Observations

4.1.1 Literature Review

The cross section of all nations mentioned in the literature had varied dimensions and methods for implementation. Some countries implemented the 2+1 treatment with pavement marking only or pavement widening and marking.

In Australia for the implementation of the 2+1 treatment using typical existing pavement widths extended design domain or design exception documentation will most likely be required due to the minimal technical advice in prescribed standards. A standard two-lane highway in Queensland is typically 13 metres wide consisting of 2m shoulders, 3.5m traffic lanes and a 1m wide centre line treatment. The compromise in width when comparing with Australia is generally in the shoulder area. This would raise concerns in design for bicycle road users as well as vehicles turning into private property being unprotected.

The segment configurations across all four countries were relatively uniform. It was observed that the diverge for all reports were quite short compared to that specified in the Guide to Road Design (Austroads Limited 2016). The guide specifies 110m for a diverge in a 110km/hr design speed, it is recognised that some nations posted speed limits were lower but the 25-30m diverge tapers reported wouldn’t be suitable for implementation in high speed rural applications. The merge tapers reported are similar to what is recommended in Austroads Limited (2016). The passing lane lengths found in the literature review are similar but longer than generally prescribed in Australia. The desirable length of overtaking lane in Australia is 1360m including tapers.

The intersection treatments implemented throughout the literature are significantly different to what Australian road authorities implement. Rural two-lane highways in Australia generally don’t employ grade separated interchanges or loop turns. Loop turns may be a viable option in Australia for safety purposes and minimal disruption to traffic flow. However, this treatment will require a wider road corridor at intersections. The use of grade separated intersections in rural Australia is unrealistic unless the ultimate design of a divided carriageway is foreseen within a reasonable time frame. The use of interchanges and entry/exit ramps will generally not provide a high benefit-cost ratio.

The accident reductions reported in the literature is substantial. All countries reported large reduction in accidents ranging from 22-55%. The types of accidents weren’t discussed in the literature. The key accidents would be head-on and side-swipe type accidents. The use of wide two-lane highways in Germany and Ireland where passing manoeuvres were intended to be made on the sealed shoulders ultimately failed. This was due to increases in fatal head-on crashed in Ireland and driver misuse in Germany.

At first thought head-on crashes would be reduced due to the separation with a median and possible implementation of a barrier system which would keep the driver alert of the constant risk. Side swiping accidents may increase due to the increase in merging required with this style of treatment.

Driver behaviour on Australian roads may differ to that in Europe. Community acceptance in Denmark was overwhelming positive, with the routes having high heavy vehicle usage which is similar to the segment used in the case study for this dissertation.

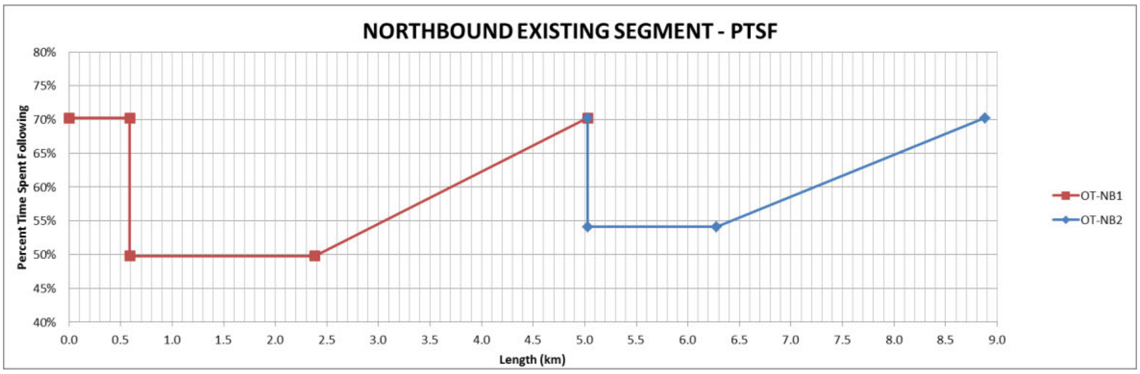
4.1.2 Case Study

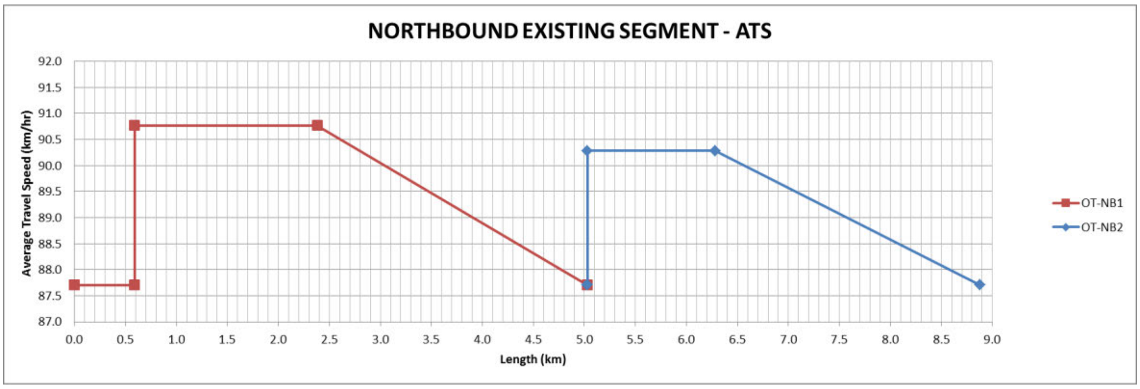
4.1.2.1 Existing Segment

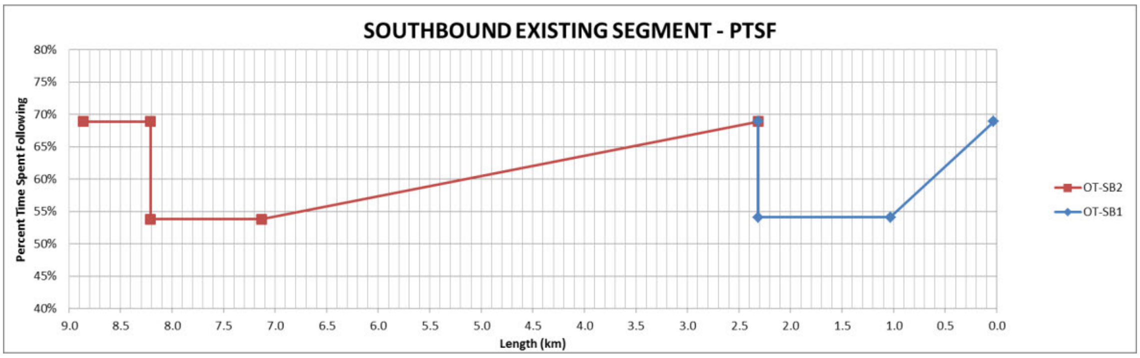
The existing segment analysis of the base case and two overtaking lanes was conducted and resulted in an average LOS of ‘C’ over the section in both directions. The base cases’ operated at LOS ‘D’. The two overtaking lanes in each direction provided significant improvement to the segment regarding PTSF reducing 11.4% (northbound) and 8.7% (southbound). The passing lanes were seen to have much more impact on PTSF than ATS.

Table 4-1 - Existing Segment Results

Feature	ATS (km/hr)	ATS Downstream Length (km)	PTSF	PTSF Downstream Length (km)	Level of Service
Northbound Base Case	87.7	-	70.2%	-	D
OT-NB1	90.8	2.7	49.8%	2.7 (12.7)	B
OT-NB2	90.3	2.6 (2.7)	54.1%	2.6 (12.7)	C
NB Average	**89.5**	-	**58.8%**	-	**C (A/C)**
Southbound Base Case	86.4	-	68.9%	-	D
OT-SB2	88.8	2.7	53.8%	4.8 (12.6)	C
OT-SB1	88.7	1.0 (2.7)	57.7%	1.0 (12.6)	C
SB Average	**87.5**	-	**60.2%**	-	**C (B/C)**







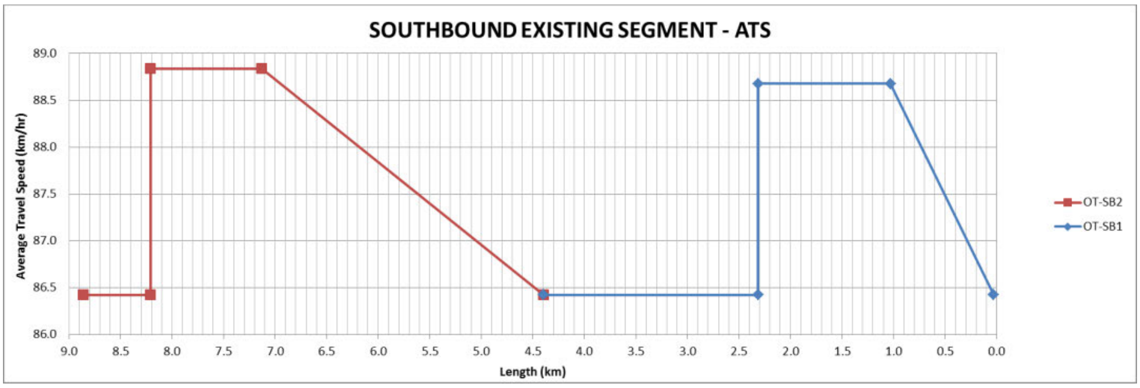


Figure 3- Existing Segment Results

4.1.2.2 2+1 Treatment Segment

The 2+1 segment analysis of the base case and passing lanes was conducted and resulted in an average LOS of 'C' over the section in both directions. The base cases' operated at LOS 'D'. The two overtaking lanes in each direction provided significant improvement to the segment regarding PTSF reducing 12.9% (northbound) and 11.1% (southbound). Once again, it is observed that the passing lanes were seen to have much more impact on PTSF than ATS.

Table 4-2 - 2+1 Segment Results

Feature	ATS (km/hr)	ATS Downstream Length (km)	PTSF	PTSF Downstream Length (km)	Level of Service
Northbound Base Case	87.7	-	70.2%	-	D
2P1-NB1	90.1	1.4 (2.7)	50.4%	1.4 (12.7)	B
2P1-NB2	90.1	1.7 (2.7)	52.1%	1.7 (12.7)	C
2P1-NB3	90.3	1.4 (2.7)	52.1%	1.4 (12.7)	C
2P1-NB4	90.3	0 (2.7)	52.3%	0 (12.7)	B
NB Average	**89.5**	-	**57.3%**	-	**C (A/C)**
Southbound Base Case	86.4	-	68.9%	-	D
OT-SB3	86.4	1.6 (2.7)	58.9%	1.6 (12.6)	B
OT-SB2	89.0	1.8 (2.7)	51.0%	1.8 (12.6)	C
OT-SB1	88.7	1.0 (2.7)	51.7%	1.0 (12.6)	C
SB Average	**87.91**	-	**57.8%**	-	**C (B/C)**

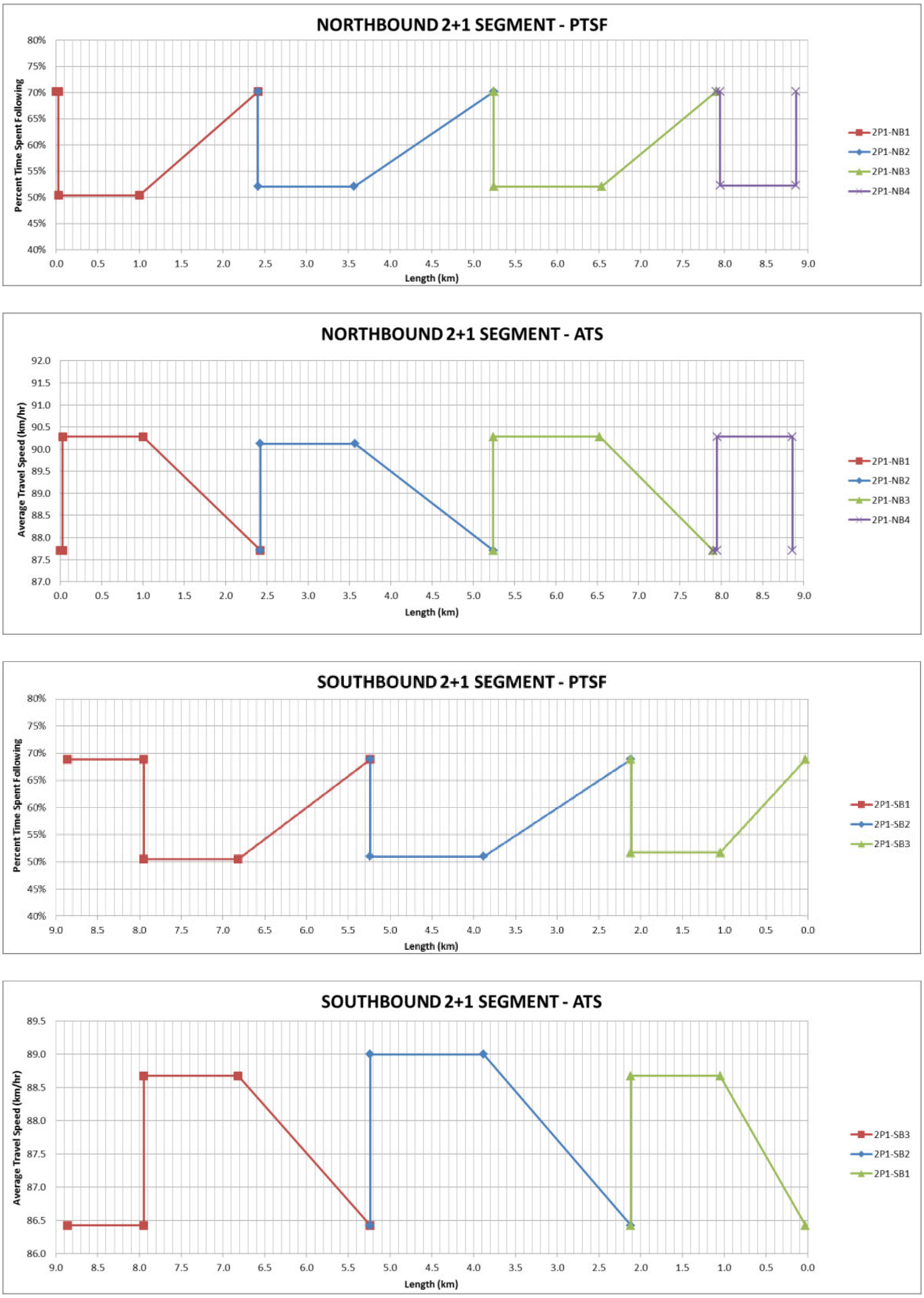


Figure 4 - 2+1 Segment Results

4.1.2.3 Limitations

A major constraint that may limit the results of the analysis of the results is that the methodology generally used when analysing passing lanes as discussed in the literature review was that the effective length of passing lane for the purposes of analysis finishes at the start of the next passing lane or feature. This may be true for a fixed interruption such as a roundabout or traffic signals, however, PTSF and ATS are returning to existing conditions and a passing lane start then there may be a compounding effect on the downstream passing lanes. This limits the effectiveness of the 2+1 treatment when comparing results.

Chapter 5

5. Conclusions

From the literature review and case study the following conclusions can be made.

Australian industry standards can be used for majority of the design required for implementation of the 2+1 treatment. A cross section comprising of common dimensions would be suitable for different jurisdictions to keep drivers familiar with the geometry and environment. Some technical direction from authorities on elements of the 2+1 treatment is required. The central median usage, implementation of a barrier system and the changeovers of passing lanes are the elements that need technical advice to provide a uniform configuration for drivers to familiarise themselves with.

Intersection treatments in Australia will most likely be the standard turn treatments – BA, AU and CH – as discussed in the literature review due to the cost of implementation of loop turns, interchanges and entry/exit ramps. There is opportunity to use turn treatments as start and termination points of passing lanes. The use of loop turns may need to be considered as location specific issues arise from the implementation of the 2+1 treatment.

The safety improvements seen in the reported nations are significant across the board. The reduction in crashed in Australia may be significant also but it may be beneficial to provide the 2+1 treatment in known black spots across Australia for the most benefit to the community.

The traffic performance shown in the case study was beneficial. . The existing segment has two passing lanes in each direction which provided an overtaking lane provision between 30-70% which is regard as ‘Good’ by Austroads Limited (2016). The decision to include them in the analysis was beneficial as it let us compare three scenarios – a two-lane rural highway with no overtaking lane provision, a two-lane highway with good overtaking lane provision and a 2+1 treatment. Ultimately the existing segment was improved by one LOS by the 2+1 treatment. However, the implementation of regular overtaking lane provisions may also provide the desired effect.

5.1 Recommendations

The 2+1 treatment is an effective engineering solution to problems seen on two-lane highways all around the world. The treatment must be predominantly regarded as a safety improvement treatment but also has level of service improvements. If traffic performance is the desired outcome than a regular provision of overtaking lanes may solve the problem.

The use of the treatment for safety improvement is evident and will reduce severe to fatal crashes in Australia based on the literature reviewed. Overtaking manoeuvres performed on increasingly busy roads is becoming common due to more heavy vehicles and increased driver frustration.

If road authorities are looking to implement the 2+1 treatment in their jurisdiction than a uniform set of standards are required as they are currently not present and even vary across Europe. Each country applied relatively uniform cross sections and configurations.

5.2 Further Work

Further work is required on many different aspects to create a suitable implementation of the treatment by engineering professionals with sufficient knowledge and advice to enable it. Investigation into the calculation of traffic performance measures to challenge or validate the use of the method specified by the Highway Capacity Manual (Transportation Research Board 2010a) for passing lanes in close succession as typical in a 2+1 treatment.

Development of a meaningful guideline is required, satisfying safety, traffic performance and geometric details. The guidelines should advise what safety and accident history would trigger the treatment to determine suitable locations for the use of the treatment.

More specific aspects to develop a guideline are crash types and percent time spent following. Crash types are crucial to ensuring the treatment is effective. For example, the 2+1 treatment can address head-on crashes where a vehicle is trying to perform a passing manoeuvre and collides with a car travelling in opposing traffic lanes. This can be caused out of poor sight distance or driver frustration with no passing opportunities along the segment. PTSF may be a good secondary indicator as to where the treatment should be implemented; it will relate to driver frustration and become measureable as opposed to anecdotal.

Field surveys could be conducted to challenge or validate HCM’s downstream PTSF and ATS predictions. The HCM will most likely be accurate when passing lanes don’t interact with each other in regards to PTSF and ATS. However, traffic performance when the traffic has knowledge of passing opportunities are coming up may be different.

An Investigation into the use of an alternative method of modelling the 2+1 treatment may be required. The use of HCS2010 may not be accurate due to the simplified nature of the calculation.

Validation of alternative models would be beneficial against 2+1 treatments or passing lanes in close succession, particularly where the effective length downstream for PTSF and ATS is limited to the next passing lane. Alternative modelling software or calculations may include the use of microsimulation software such as VISSUM. Validation of the tentative formulas provided by Luttinen (2001) may also be beneficial.

Location specific benefit-cost ratios of relevant locations would be the next major step to providing evidence against implementing the 2+1 treatment. The benefits and costs associated with the treatment and the community in Australia may be quite different to that in Europe.

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Appendix A – Project Specification

University of Southern Queensland
FACULTY OF ENGINEERING AND SURVEYING

ENG4111 & ENG4112 Research Project

PROJECT SPECIFICATION

FOR:	Jack BARTOLO ([redacted])
TITLE:	Performance of a 2 Plus 1 Highway Treatment on a rural highway in Australia
MAJOR:	Civil Engineering (Transport)
SUPERVISORS:	USQ – Trevor Drysdale (Lecturer) AECOM – Andrew Barrie (Senior Engineer - Transport)
SPONSORSHIP:	AECOM Australia Pty Ltd
CONFIDENTIALITY:	
ENROLMENT:	ENG4111 – Semester 1, 2017 ENG4112 – Semester 2, 2017
PROJECT AIM	This project seeks to discover the improvement in performance of rural highways in Qld with the implementation of a 2 Plus 1 treatment on a typical rural highway section.
PROGRAMME:	Revision A – March 15, 2017

1) Research industry standards such as AUSTROADS, Department of Transport and Main Roads (Queensland) & the Highway Capacity Manual relevant to rural highway performance in Queensland.
   a. Determine parameters suitable for rural highways in Queensland.
   b. Research and Determine appropriate calculation methods (modelling software and/or manual calculations).
2) Research the current performance of a typical section of rural highway in Queensland using parameters and analysis method defined in step 1).
   a. Typical section will be based on availability of data to enable evaluation and comparison.
3) Research the change in performance if a 2 Plus 1 treatment was to be implemented over the section of rural highway using parameters and analysis method defined in step 1).
   a. Evaluate (3) options of the 2 Plus 1 treatment with different concepts/strategies to optimise the treatment.
4) Write a dissertation on the findings of the project in the required format.

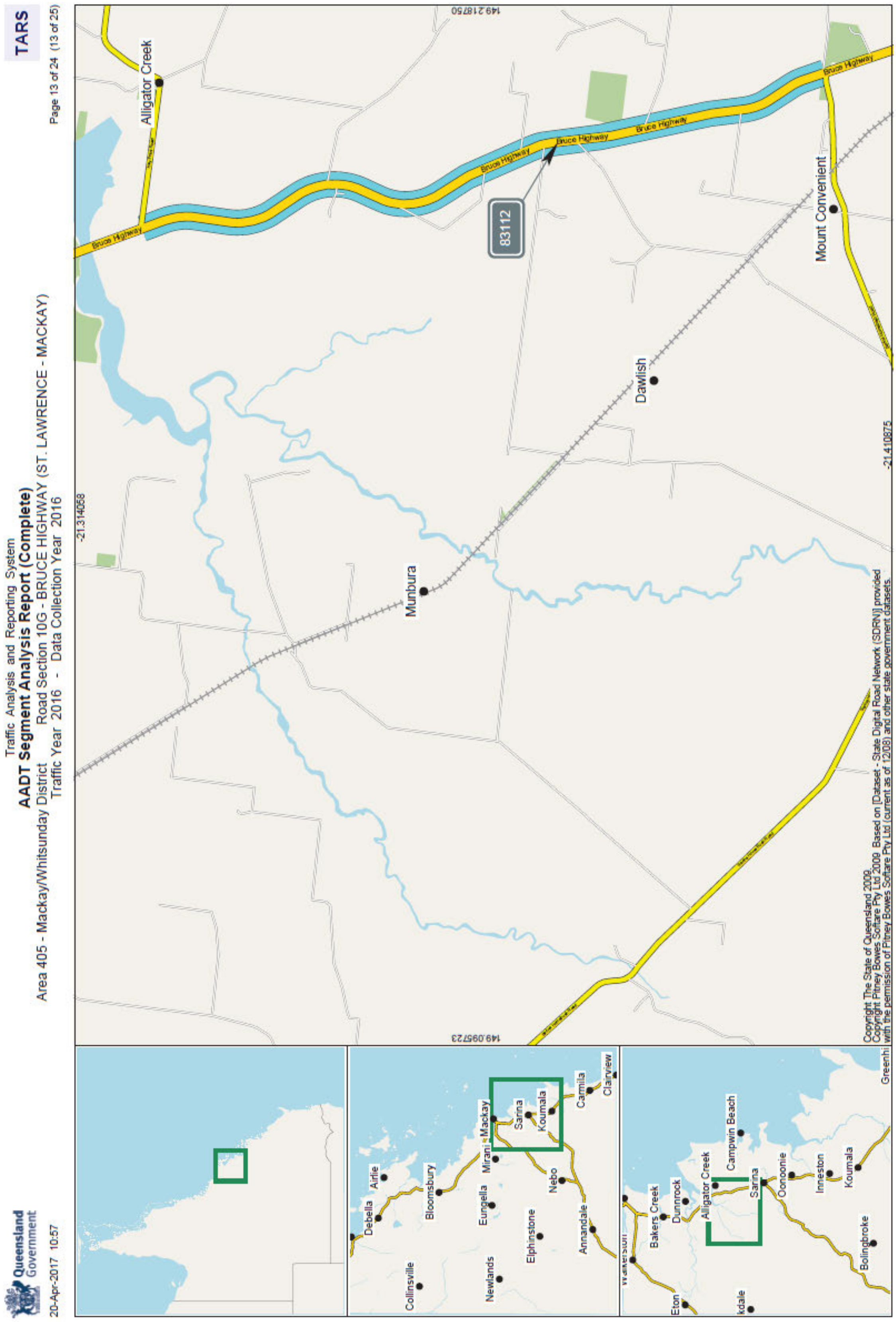
AGREED

[redacted] (J. Bartolo) Date: 14 / 3 / 2017

Acknowledged
_____________ (T. Drysdale)
21/05/2017
Date: ___ / ___ / 2017

[redacted] (A. Barrie) Date: 14 / 03 / 2017

Appendix B – AADT Segment Report 2016



Queensland Government

20-Apr-2017 10:57

Traffic Analysis and Reporting System

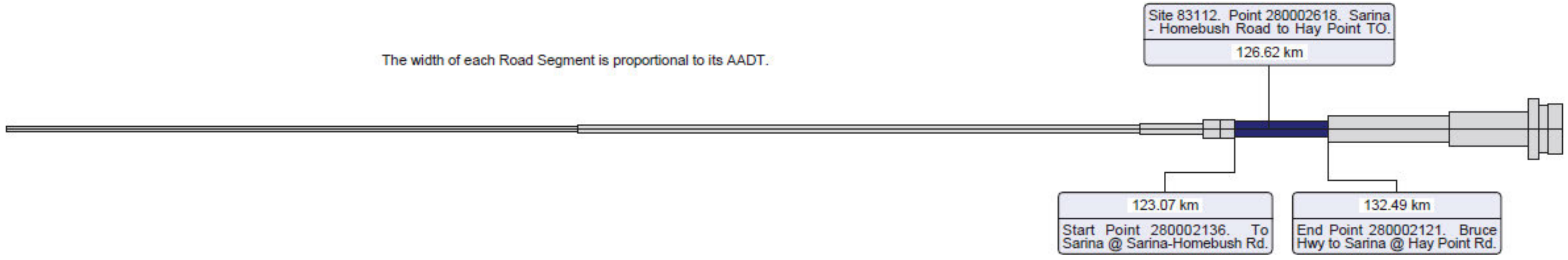
AADT Segment Analysis Report (Complete)

Area 405 - Mackay/Whitsunday District Road Section 10G - BRUCE HIGHWAY (ST. LAWRENCE - MACKAY)

Traffic Year 2016 - Data Collection Year 2016

TARS

The width of each Road Segment is proportional to its AADT.



This report shows Annual Average Daily Traffic values (AADTs). Because the AADT values are converted to whole numbers, there will be occasional inaccuracies due to rounding. These inaccuracies are statistically insignificant.

	Annual Segment Growth		
	Based on 1 year's data	Based on 5 years' data	Based on 10 years' data
G	-9.64%	-5.06%	-1.47%
A	-3.07%	-3.19%	-0.88%
B	-6.41%	-4.13%	-1.17%

All Vehicles (00)

G	3,204	100%
A	3,342	100%
B	6,546	100%

Light Vehicles (0A)

G	2,875	89.73%
A	2,431	72.74%
B	5,306	81.06%

Heavy Vehicles (0B)

G	330	10.30%
A	910	27.23%
B	1,240	18.94%

Short Vehicles (1A)

G	2,875	89.73%
A	2,431	72.74%
B	5,306	81.06%

Trucks and Buses (1B)

G	129	4.03%
A	648	19.39%
B	777	11.87%

Articulated Vehicles (1C)

G	90	2.81%
A	153	4.58%
B	243	3.71%

Road Trains (1D)

G	111	3.46%
A	109	3.26%
B	220	3.36%

Short 2-Axle Vehicles (2A)

G	2,677	83.55%
A	2,298	68.76%
B	4,975	76.00%

Short Vehicles Towing (2B)

G	198	6.18%
A	133	3.98%
B	331	5.06%

2-Axle Trucks and Buses (2C)

G	93	2.90%
A	612	18.31%
B	705	10.77%

3-Axle Trucks and Buses (2D)

G	29	0.91%
A	30	0.90%
B	59	0.90%

4-Axle Trucks (2E)

G	7	0.22%
A	6	0.18%
B	13	0.20%

3-Axle Articulated (2F)

G	4	0.12%
A	41	1.23%
B	45	0.69%

4-Axle Articulated (2G)

G	11	0.34%
A	36	1.08%
B	47	0.72%

5-Axle Articulated (2H)

G	17	0.53%
A	18	0.54%
B	35	0.53%

6-Axle Articulated (2I)

G	58	1.81%
A	58	1.74%
B	116	1.77%

B Double (2J)

G	111	3.46%
A	108	3.23%
B	219	3.35%

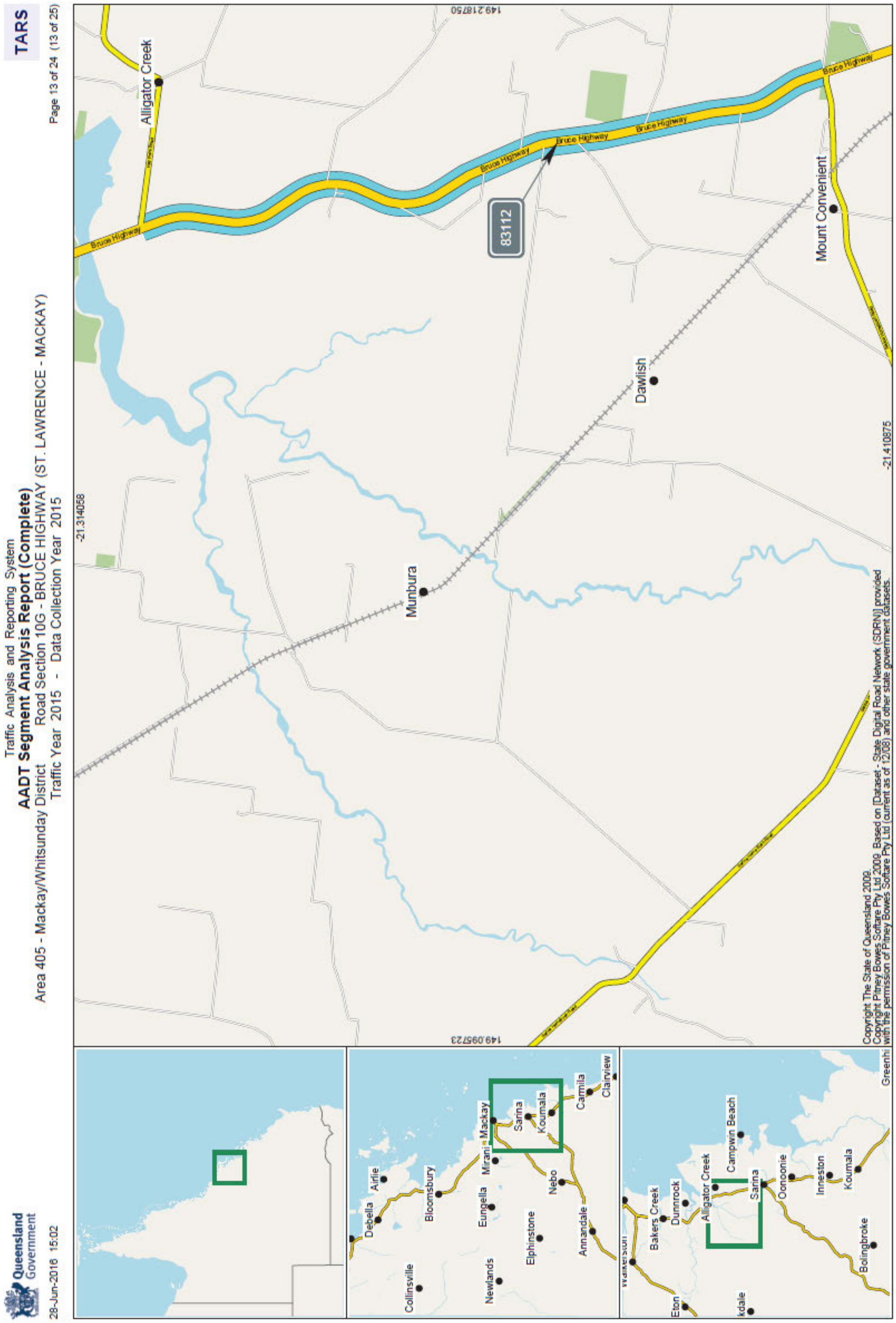
Double Road Trains (2K)

G	0	0.00%
A	1	0.03%
B	1	0.02%

Triple Road Trains (2L)

G	0	0%
A	0	0%
B	0	0%

Appendix C – AADT Segment Report 2015



Queensland Government

28-Jun-2016 15:02

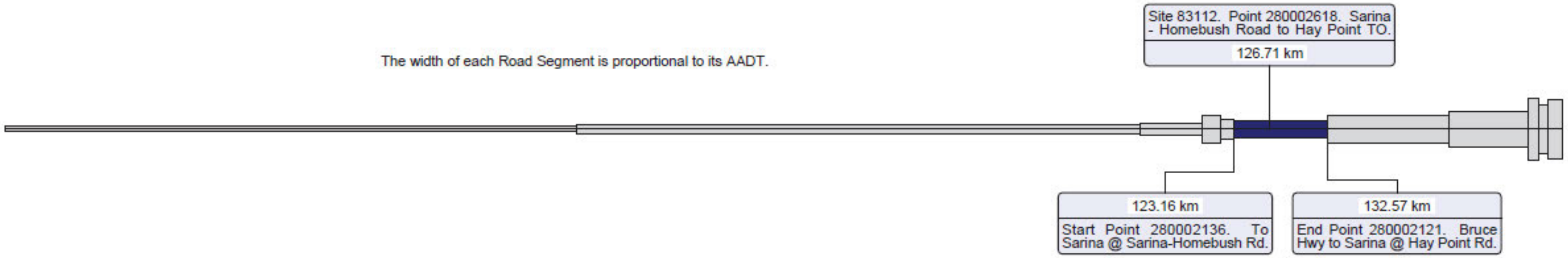
Traffic Analysis and Reporting System

AADT Segment Analysis Report (Complete)

Area 405 - Mackay/Whitsunday District Road Section 10G - BRUCE HIGHWAY (ST. LAWRENCE - MACKAY)

Traffic Year 2015 - Data Collection Year 2015

The width of each Road Segment is proportional to its AADT.



This report shows Annual Average Daily Traffic values (AADTs). Because the AADT values are converted to whole numbers, there will be occasional inaccuracies due to rounding. These inaccuracies are statistically insignificant.

	Annual Segment Growth		
	Based on 1 year's data	Based on 5 years' data	Based on 10 years' data
G	2.93%	-2.54%	0.39%
A	2.28%	-2.46%	-0.20%
B	2.61%	-2.50%	0.09%

All Vehicles (00)
- G 3,546 100%
- A 3,448 100%
- B 6,994 100%

Light Vehicles (0A)
- G 3,068 86.52%
- A 2,990 86.72%
- B 6,058 86.62%

Heavy Vehicles (0B)
- G 478 13.48%
- A 458 13.28%
- B 936 13.38%

Short Vehicles (1A)
- G 3,068 86.52%
- A 2,990 86.72%
- B 6,058 86.62%

Trucks and Buses (1B)
- G 220 6.20%
- A 212 6.15%
- B 432 6.18%

Articulated Vehicles (1C)
- G 126 3.55%
- A 122 3.54%
- B 248 3.55%

Road Trains (1D)
- G 132 3.72%
- A 124 3.60%
- B 256 3.66%

Short 2-Axle Vehicles (2A)
- G 2,903 81.87%
- A 2,847 82.57%
- B 5,750 82.21%

Short Vehicles Towing (2B)
- G 165 4.65%
- A 143 4.15%
- B 308 4.40%

2-Axle Trucks and Buses (2C)
- G 171 4.82%
- A 163 4.73%
- B 334 4.78%

3-Axle Trucks and Buses (2D)
- G 40 1.13%
- A 40 1.16%
- B 80 1.14%

4-Axle Trucks (2E)
- G 9 0.25%
- A 9 0.26%
- B 18 0.26%

3-Axle Articulated (2F)
- G 8 0.23%
- A 8 0.23%
- B 16 0.23%

4-Axle Articulated (2G)
- G 16 0.45%
- A 15 0.44%
- B 31 0.44%

5-Axle Articulated (2H)
- G 20 0.56%
- A 19 0.55%
- B 39 0.56%

6-Axle Articulated (2I)
- G 82 2.31%
- A 80 2.32%
- B 162 2.32%

B Double (2J)
- G 131 3.69%
- A 123 3.57%
- B 254 3.63%

Double Road Trains (2K)
- G 1 0.03%
- A 1 0.03%
- B 2 0.03%

Triple Road Trains (2L)
- G 0 0%
- A 0 0%
- B 0 0%

Queensland Government

17-Apr-2015 09:54

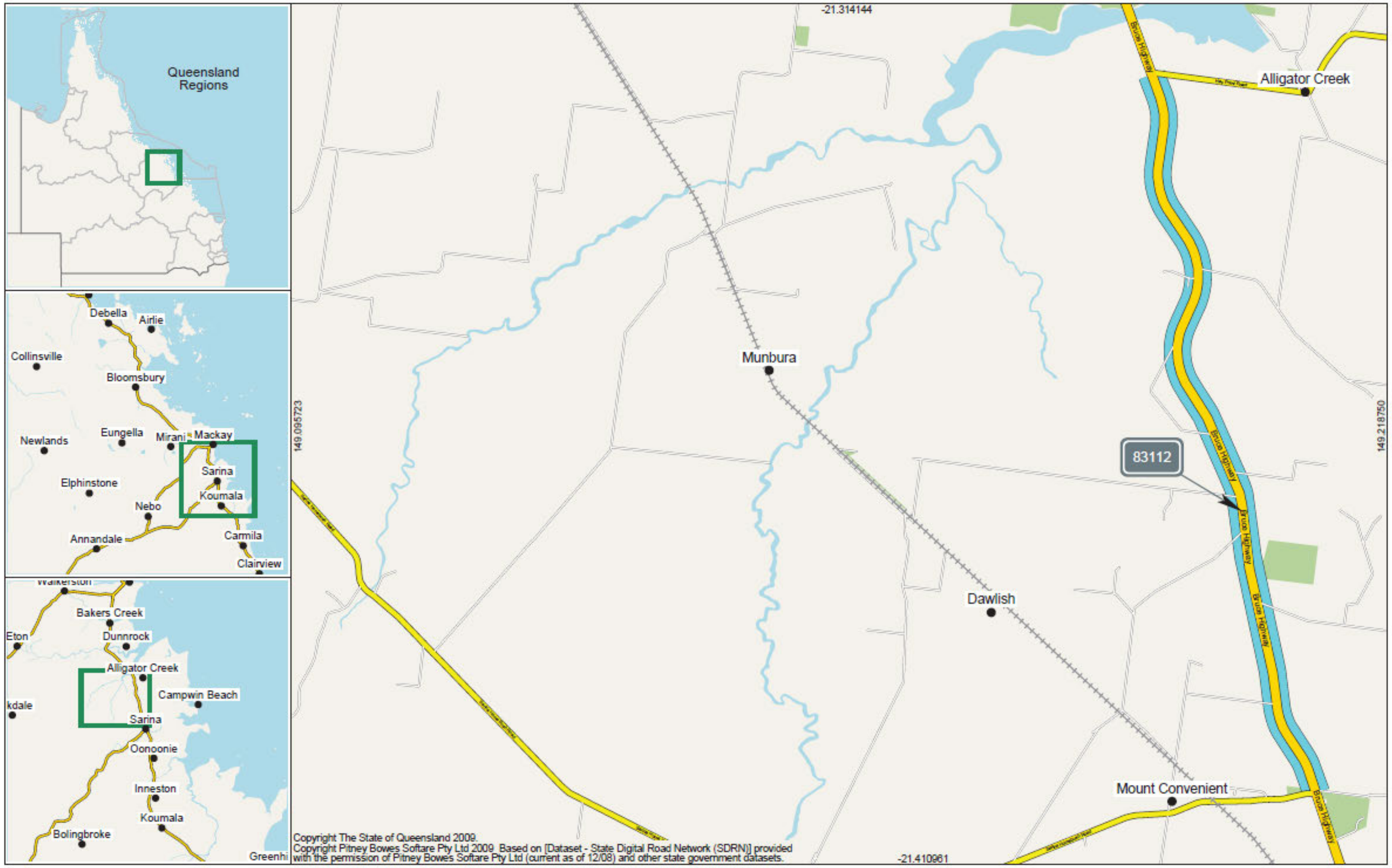
Traffic Analysis and Reporting System

AADT Segment Report

Region 405 - Mackay/Whitsunday District   Road Section 10G - Bruce Highway (St. Lawrence - Mackay)

Traffic Year 2014 - Data Collection Year 2014

TARS



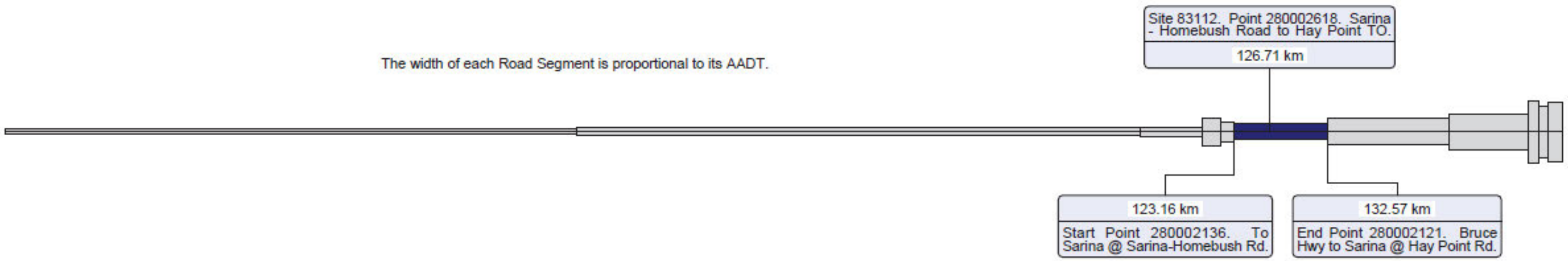
Traffic Analysis and Reporting System

AADT Segment Report

Region 405 - Mackay/Whitsunday District Road Section 10G - Bruce Highway (St. Lawrence - Mackay)

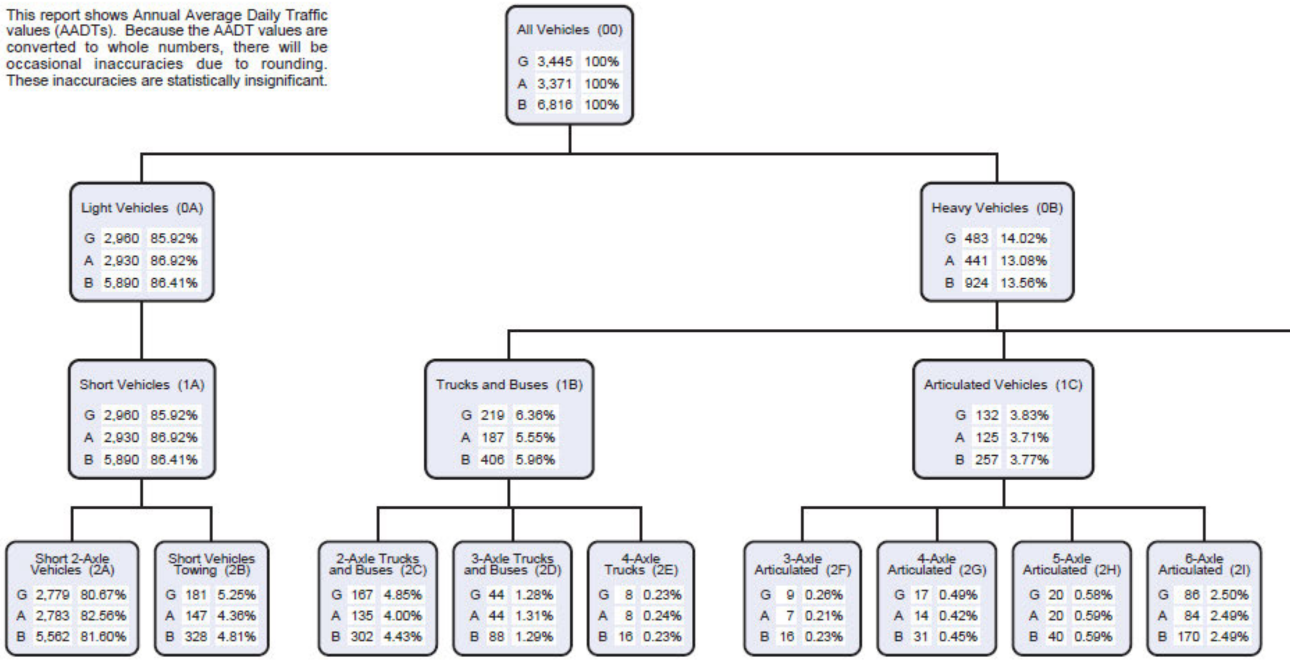
Traffic Year 2014 - Data Collection Year 2014

The width of each Road Segment is proportional to its AADT.



This report shows Annual Average Daily Traffic values (AADTs). Because the AADT values are converted to whole numbers, there will be occasional inaccuracies due to rounding. These inaccuracies are statistically insignificant.

	Annual Segment Growth		
	Based on 1 year's data	Based on 5 years' data	Based on 10 years' data
G	-7.42%	-2.70%	0.43%
A	-5.34%	-2.59%	-0.03%
B	-6.40%	-2.65%	0.20%



Appendix D – Classified Vehicle Report

Queensland Government

28-Apr-2017 12:52

Traffic Analysis and Reporting System

Classified Vehicle Report

Area 405 - Mackay/Whitsunday District Road Section 10G - BRUCE HIGHWAY (ST. LAWRENCE - MACKAY)
Site 83112 - Sarina - Homebush Road to Hay Point TO TDist 126.615km Speed Limit 100
Site Stream T1 - Thru traffic in Lane 1 -in gazettal dirn Gazettal Direction G
Date Range Friday 01-Jan-2016 - Saturday 31-Dec-2016

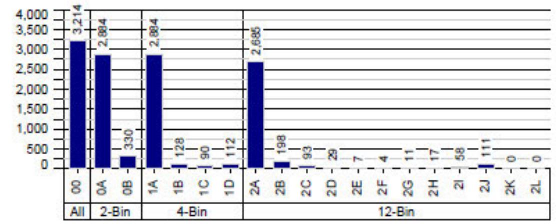
Average Daily Volumes

	Total	2-Bin		4-Bin				12-Bin											
	00	0A	0B	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L
Avg Volume	3,214	2,884	330	2,884	128	90	112	2,685	198	93	29	7	4	11	17	58	111	0	0
Class %	100%	89.7%	10.3%	89.7%	4.0%	2.8%	3.5%	83.6%	6.2%	2.9%	0.9%	0.2%	0.1%	0.3%	0.5%	1.8%	3.5%	0.0%	0.0%

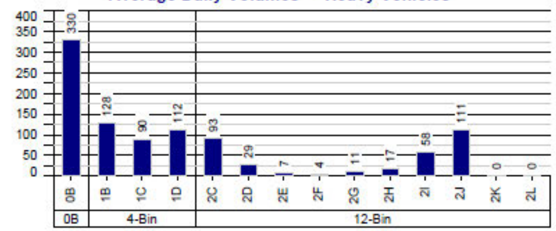
Average Hourly Volumes

	Total	2-Bin		4-Bin				12-Bin											
Hour	00	0A	0B	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L
00-01	24	16	8	16	1	2	5	15	1	1	0	0	0	0	0	2	5	0	0
01-02	20	11	9	11	1	2	6	10	1	1	1	0	0	0	0	1	6	0	0
02-03	20	12	7	12	2	2	4	12	0	2	0	0	0	0	1	1	4	0	0
03-04	19	14	5	14	1	1	3	13	1	1	0	0	0	0	0	1	3	0	0
04-05	37	29	8	29	2	2	4	28	1	1	1	0	0	0	0	2	4	0	0
05-06	87	77	10	77	2	3	5	74	2	2	1	0	0	0	0	2	5	0	0
06-07	123	106	17	106	7	4	6	102	4	4	3	0	0	0	0	3	6	0	0
07-08	173	152	21	152	9	6	6	146	6	6	2	0	0	0	1	4	6	0	0
08-09	214	194	21	194	7	6	8	181	13	4	2	0	0	1	1	5	8	0	0
09-10	247	225	22	225	10	6	6	209	16	7	2	1	0	1	1	4	6	0	0
10-11	240	219	20	219	10	5	5	202	17	8	2	0	0	1	1	3	5	0	0
11-12	263	242	22	242	11	6	5	220	21	8	2	1	0	1	1	4	5	0	0
12-13	243	223	20	223	9	5	6	203	19	7	1	1	0	1	1	4	6	0	0
13-14	229	205	23	205	12	6	5	186	19	10	2	1	0	1	1	4	5	0	0
14-15	223	202	21	202	11	4	5	185	17	8	2	0	1	1	1	2	5	0	0
15-16	240	222	18	222	9	4	4	206	16	6	2	1	0	1	1	2	4	0	0
16-17	228	210	18	210	8	5	5	196	15	6	2	0	0	1	2	2	5	0	0
17-18	195	181	14	181	7	3	4	171	10	4	2	0	0	0	1	2	4	0	0
18-19	133	122	11	122	4	4	3	115	6	3	1	0	0	0	1	2	3	0	0
19-20	81	73	8	73	2	3	3	67	6	2	0	0	0	0	1	2	3	0	0
20-21	61	54	6	54	1	3	2	51	3	1	0	0	0	0	1	1	2	0	0
21-22	50	44	7	44	1	3	3	41	2	1	0	0	0	1	0	2	3	0	0
22-23	38	30	7	30	1	3	3	29	1	1	0	0	0	1	1	2	3	0	0
23-00	30	22	7	22	1	2	4	21	1	1	0	0	0	0	0	2	4	0	0

Average Daily Volumes - All Vehicles



Average Daily Volumes - Heavy Vehicles



Queensland Government

28-Apr-2017 12:52

Traffic Analysis and Reporting System

Classified Vehicle Report

Area 405 - Mackay/Whitsunday District Road Section 10G - BRUCE HIGHWAY (ST. LAWRENCE - MACKAY)
Site 83112 - Sarina - Homebush Road to Hay Point TO TDist 126.615km Speed Limit 100
Site Stream T2 - Thru traffic in Lane 2 -against gazettal Gazettal Direction A
Date Range Friday 01-Jan-2016 - Saturday 31-Dec-2016

TARS

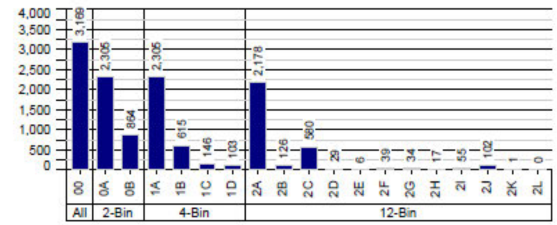
Average Daily Volumes

	Total	2-Bin		4-Bin				12-Bin											
	00	0A	0B	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L
Avg Volume	3,169	2,305	864	2,305	615	146	103	2,178	126	580	29	6	39	34	17	55	102	1	0
Class %	100%	72.7%	27.3%	72.7%	19.4%	4.6%	3.3%	68.8%	4.0%	18.3%	0.9%	0.2%	1.2%	1.1%	0.5%	1.7%	3.2%	0.0%	0.0%

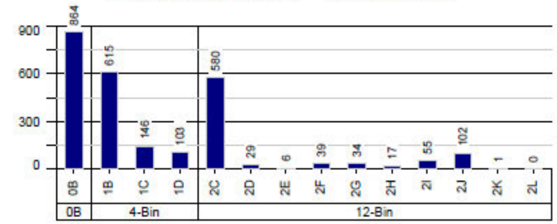
Average Hourly Volumes

	Total	2-Bin		4-Bin				12-Bin											
Hour	00	0A	0B	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2I	2J	2K	2L
00-01	19	12	7	12	4	1	2	12	0	3	1	0	0	0	0	1	2	0	0
01-02	18	10	8	10	4	1	2	9	0	4	0	0	0	0	0	1	2	0	0
02-03	17	11	6	11	3	1	2	10	0	3	0	0	0	0	0	0	2	0	0
03-04	20	12	8	12	4	2	2	11	1	4	0	0	0	0	1	0	2	0	0
04-05	40	25	15	25	10	2	2	23	2	9	1	0	1	0	0	1	2	0	0
05-06	93	62	31	62	25	4	2	60	3	23	1	0	1	1	1	1	2	0	0
06-07	129	85	44	85	34	7	4	79	6	31	2	0	2	2	1	2	3	0	0
07-08	155	105	50	105	37	9	4	97	8	34	2	1	3	2	1	3	4	0	0
08-09	201	144	57	144	42	10	5	135	9	39	2	1	3	2	1	4	5	0	0
09-10	218	158	59	158	43	12	5	147	11	41	2	0	4	3	1	4	4	0	0
10-11	229	169	60	169	43	11	6	156	13	40	2	1	3	3	1	3	6	0	0
11-12	240	176	64	176	47	11	6	164	12	45	2	0	4	3	1	3	6	0	0
12-13	247	181	66	181	48	11	7	169	12	46	2	1	3	3	1	4	7	0	0
13-14	233	173	60	173	44	10	6	164	10	42	2	0	3	3	1	3	6	0	0
14-15	227	169	59	169	44	9	5	160	9	41	2	1	2	2	1	4	5	0	0
15-16	238	181	57	181	42	9	6	174	8	40	1	0	2	2	2	3	6	0	0
16-17	230	174	56	174	42	8	6	167	8	41	1	0	2	2	1	3	6	0	0
17-18	208	159	50	159	37	8	5	153	6	35	2	0	2	1	1	3	5	0	0
18-19	138	104	34	104	22	6	6	101	3	22	1	0	1	1	1	3	6	0	0
19-20	76	57	18	57	10	4	5	55	2	10	0	0	1	1	0	2	5	0	0
20-21	67	48	19	48	11	4	5	47	1	10	1	0	1	0	1	2	5	0	0
21-22	54	38	16	38	8	3	4	37	1	8	0	0	0	1	0	2	4	0	0
22-23	41	30	11	30	6	2	3	29	0	5	1	0	0	0	0	1	3	0	0
23-00	31	21	9	21	5	1	3	21	1	4	0	0	0	0	0	1	3	0	0

Average Daily Volumes - All Vehicles



Average Daily Volumes - Heavy Vehicles



Classified Vehicle Report

Displays volume data in the Austroads Vehicle Classification categories by Site and Stream in the following manner:

- In tabular and graph format
- For the selected date range
- Averaged by Day and Hour

Please Note: Part or missing days are excluded from the calculations.

Important Information

The figures in this report are an Average Daily Traffic (ADT) for the date range chosen and not an Annual Average Daily Traffic (AADT).

Annual Average Daily Traffic (AADT)

Annual Average Daily Traffic (AADT) is the number of vehicles passing a point on a road in a 24 hour period, averaged over a calendar year.

Average Daily Traffic (ADT)

Is determined by summing the total traffic flow, at Stream level, for the days within a date range, divided by the number of days collected. Missing days or incomplete days are excluded from the calculation.

Date Range

The period for which the report was run.

Gazettal Direction

The Gazettal Direction is the direction of the traffic flow. It can be easily recognised by referring to the name of the road eg. Road Section: 10A Brisbane - Gympie denotes that the gazettal direction is from Brisbane to Gympie.

G	Traffic flowing in Gazettal Direction
A	Traffic flowing against Gazettal Direction
B	The combined traffic flow in both Directions

Region

For administration purposes from 1 February 2015 the Department of Transport and Main Roads has divided Queensland into 12 Districts. The Region field in TSDM reports displays the District Name and Number.

Central West District	401
Darling Downs District	402
Far North District	403
Fitzroy District	404
Mackay/Whitsunday District	405
Metropolitan District	406
North Coast District	407
North West District	409
Northern District	408
South Coast District	410
South West District	411
Wide Bay/Burnett District	412

Road Section

Is the Gazetted road from which the traffic data is collected. Each Road Section is given a code, allocated sequentially in Gazettal Direction. Larger roads are broken down into sections and identified by an ID code with a suffix for easier data collection and reporting (eg. 10A, 10B, 10C). Road Sections are then broken into AADT Segments which are determined by traffic volume.

Site

The physical location of a traffic counting device. Sites are located at a specified Through Distance along a Road Section.

Speed Limit

Maximum speed or posted speed limit at this point on the Road Section.

Stream or Site Stream

The flow of traffic or lane number in which the vehicles is travelling.

TB	Traffic flowing in both directions
TG	Traffic flowing in gazettal direction
TA	Traffic flowing against gazettal direction
T1, T3, T5, T7	Lanes with traffic flowing in gazettal direction
T2, T4, T6, T8	Lanes with traffic flowing against gazettal direction

TDist

TDist or Through Distance is the physical location of the traffic count site measured in kilometres from the beginning of the Road Section.

Traffic Class

Is the 12 Austroads vehicle categories or classes into which vehicles are placed or binned. Traffic classes are formed in a hierarchical format.

Volume or All Vehicles
00 = 0A + 0B

Light Vehicles
0A = 1A
1A = 2A + 2B

Heavy Vehicles
0B = 1B + 1C + 1D
1B = 2C + 2D + 2E
1C = 2F + 2G + 2H + 2I
1D = 2J + 2K + 2L

The following classes are the categories for which data can be captured:

Volume
00 All vehicles.

2-Bin
0A Light vehicles
0B Heavy vehicles

4-Bin
1A Short vehicles
1B Truck or bus
1C Articulated vehicles
1D Road train

12-Bin
2A Short 2 axle vehicles
2B Short vehicles towing
2C 2 axle truck or bus
2D 3 axle truck or bus
2E 4 axle truck
2F 3 axle articulated vehicle
2G 4 axle articulated vehicle
2H 5 axle articulated vehicle
2I 6 axle articulated vehicle
2J B double
2K Double road train
2L Triple road train

Appendix E – Weekly Volume Report

Traffic Analysis and Reporting System
Weekly Volume Report
Weeks 2016-W01 - 2016-W52 (52 weeks)

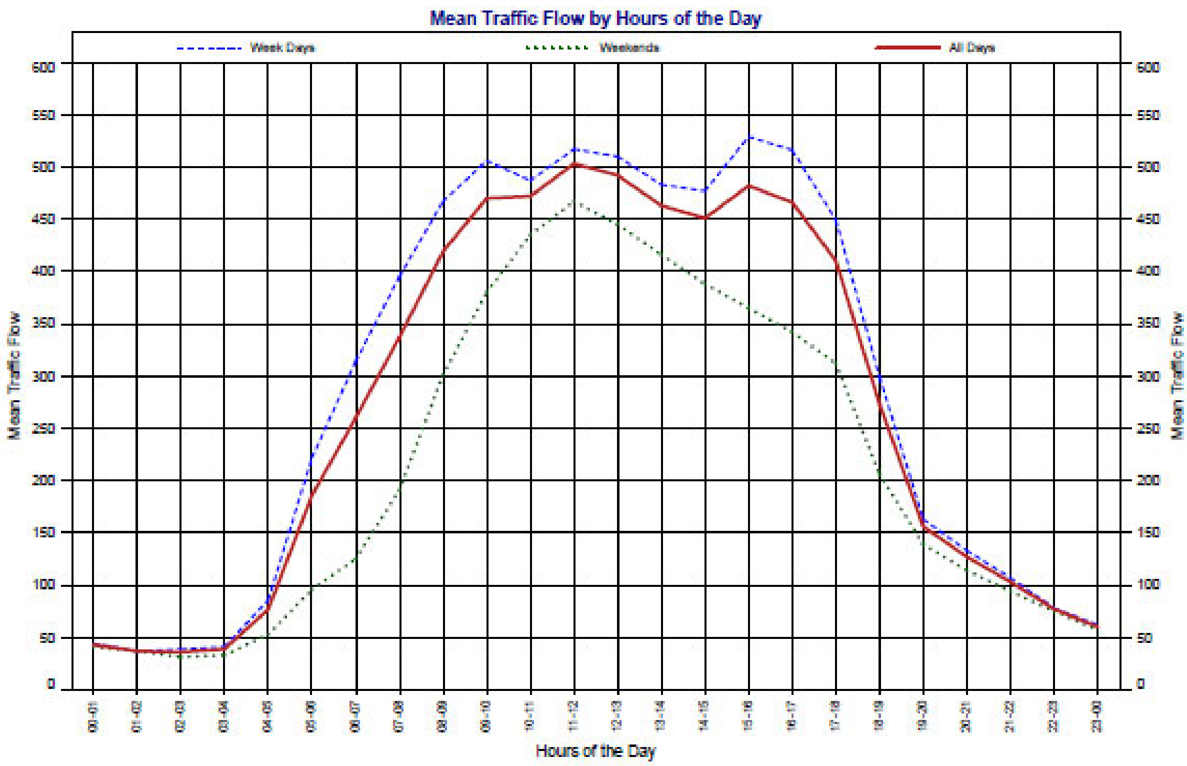
24-Apr-2017 16:11

TARS

Area	405 - Mackay/Whitsunday District
Road Section	10G - BRUCE HIGHWAY (ST. LAWRENCE - MACKAY)
Site	83112 - Sarina - Homebush Road to Hay Point TO
Thru Dist	126.615
Type	C - Coverage
Stream	TB - Bi-directional traffic flow
Traffic Class	00 - All Vehicles
Weeks	2016-W01 - 2016-W52 (52 weeks)
Date Range	Monday 04-Jan-2016 - Sunday 01-Jan-2017

Data Profile

	Mondays	Tuesdays	Wednesdays	Thursdays	Fridays	Saturdays	Sundays
Days in Date Range	52	52	52	52	52	52	52
Days Included	2	2	2	3	3	3	3
Calendar Events	5	2	0	0	1	1	3



Queensland Government

24-Apr-2017 16:11

Traffic Analysis and Reporting System
Weekly Volume Report
Weeks 2016-W01 - 2016-W52 (52 weeks)

TARS

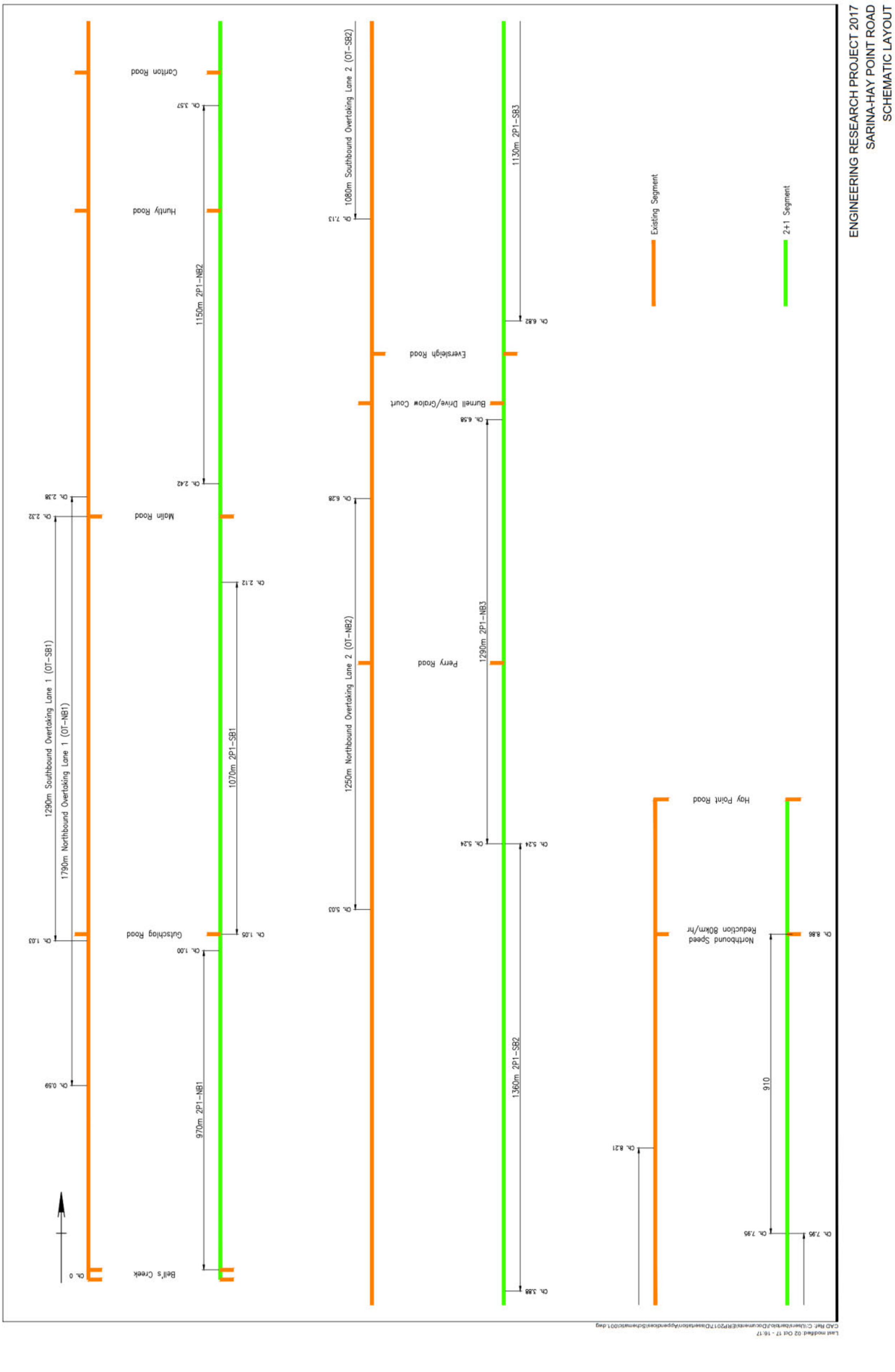
Hour	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday		Average Week Day		Average Weekend Day		Average Day	
00-01	41	0.6%	37	0.5%	42	0.6%	41	0.5%	58	0.8%	42	0.8%	39	0.8%	44	0.6%	41	0.8%	43	0.7%
01-02	35	0.6%	31	0.4%	33	0.5%	42	0.6%	44	0.6%	38	0.7%	35	0.7%	37	0.5%	37	0.7%	37	0.6%
02-03	34	0.5%	34	0.5%	35	0.5%	48	0.6%	42	0.6%	33	0.6%	28	0.6%	39	0.6%	31	0.6%	36	0.6%
03-04	36	0.6%	37	0.5%	36	0.5%	49	0.6%	47	0.7%	38	0.7%	28	0.6%	41	0.6%	33	0.6%	39	0.6%
04-05	67	1.1%	85	1.2%	85	1.2%	101	1.3%	94	1.4%	57	1.1%	49	1.0%	86	1.2%	53	1.0%	77	1.2%
05-06	152	2.4%	252	3.6%	262	3.7%	244	3.2%	202	2.9%	113	2.1%	79	1.6%	222	3.2%	96	1.9%	186	2.9%
06-07	226	3.6%	337	4.9%	355	5.0%	350	4.6%	302	4.4%	137	2.5%	112	2.3%	314	4.5%	125	2.4%	260	4.0%
07-08	289	4.6%	440	6.3%	435	6.2%	443	5.8%	369	5.4%	225	4.2%	157	3.2%	395	5.7%	191	3.7%	337	5.2%
08-09	385	6.1%	453	6.5%	487	6.9%	524	6.9%	485	7.0%	347	6.4%	254	5.2%	467	6.7%	301	5.9%	419	6.5%
09-10	465	7.3%	543	7.8%	497	7.1%	518	6.8%	506	7.3%	412	7.6%	348	7.2%	506	7.3%	380	7.4%	470	7.3%
10-11	524	8.3%	497	7.2%	455	6.5%	447	5.9%	514	7.5%	470	8.7%	399	8.2%	487	7.0%	435	8.5%	472	7.3%
11-12	532	8.4%	482	6.9%	488	6.9%	536	7.0%	547	7.9%	492	9.1%	442	9.1%	517	7.4%	467	9.1%	503	7.8%
12-13	509	8.0%	514	7.4%	494	7.0%	523	6.9%	512	7.4%	459	8.5%	430	8.9%	510	7.3%	445	8.7%	492	7.6%
13-14	507	8.0%	464	6.7%	444	6.3%	505	6.6%	493	7.2%	425	7.8%	406	8.4%	483	6.9%	416	8.1%	463	7.2%
14-15	478	7.5%	421	6.1%	480	6.8%	528	6.9%	476	6.9%	404	7.5%	372	7.7%	477	6.9%	388	7.5%	451	7.0%
15-16	470	7.4%	515	7.4%	534	7.6%	616	8.1%	509	7.4%	353	6.5%	377	7.8%	529	7.6%	365	7.1%	482	7.5%
16-17	461	7.3%	524	7.5%	544	7.7%	589	7.7%	460	6.7%	330	6.1%	353	7.3%	516	7.4%	342	6.6%	466	7.2%
17-18	407	6.4%	473	6.8%	474	6.7%	483	6.4%	409	5.9%	309	5.7%	314	6.5%	449	6.5%	312	6.1%	410	6.4%
18-19	251	4.0%	294	4.2%	309	4.4%	354	4.7%	289	4.2%	210	3.9%	201	4.1%	299	4.3%	206	4.0%	273	4.2%
19-20	150	2.4%	165	2.4%	152	2.2%	194	2.6%	156	2.3%	132	2.4%	145	3.0%	163	2.3%	139	2.7%	156	2.4%
20-21	107	1.7%	130	1.9%	133	1.9%	166	2.2%	127	1.8%	124	2.3%	104	2.1%	133	1.9%	114	2.2%	127	2.0%
21-22	80	1.3%	97	1.4%	118	1.7%	139	1.8%	102	1.5%	107	2.0%	80	1.6%	107	1.5%	94	1.8%	103	1.6%
22-23	70	1.1%	67	1.0%	73	1.0%	94	1.2%	87	1.3%	92	1.7%	58	1.2%	78	1.1%	75	1.5%	77	1.2%
23-24	60	0.9%	52	0.7%	65	0.9%	69	0.9%	62	0.9%	71	1.3%	42	0.9%	62	0.9%	57	1.1%	60	0.9%

Peaks	Hour End & Count		Hour End & Count		Hour End & Count		Hour End & Count		Hour End & Count		Hour End & Count		Hour End & Count		Hour End & Count		Hour End & Count		Hour End & Count	
AM	11:30	534	10:00	544	09:15	506	12:00	536	12:00	548	12:00	492	12:00	442	12:00	518	12:00	467	12:00	502
PM	13:00	510	16:30	592	16:45	569	16:15	627	13:00	513	13:00	459	13:00	430	16:30	546	13:00	444	13:00	490

12-Hour	5,278	83.3%	5,620	80.9%	5,641	80.2%	6,066	79.8%	5,569	80.8%	4,436	81.8%	4,053	83.5%	5,635	81.0%	4,248	82.6%	5,238	81.3%
16-Hour	5,841	92.2%	6,349	91.4%	6,399	91.0%	6,915	91.0%	6,256	90.8%	4,936	91.1%	4,494	92.6%	6,352	91.3%	4,720	91.8%	5,884	91.4%
18-Hour	5,971	94.2%	6,468	93.1%	6,537	93.0%	7,078	93.1%	6,405	92.9%	5,099	94.1%	4,594	94.7%	6,492	93.3%	4,852	94.3%	6,021	93.5%
24-Hour	6,336	100.0%	6,944	100.0%	7,030	100.0%	7,603	100.0%	6,892	100.0%	5,420	100.0%	4,852	100.0%	6,961	100.0%	5,143	100.0%	6,439	100.0%

Avg Week Day		91.0%		99.8%		101.0%		109.2%		99.0%						100.0%		73.9%		92.5%
Avg Weekend Day												105.4%		94.3%		135.3%		100.0%		125.2%
Avg Day		98.4%		107.8%		109.2%		118.1%		107.0%		84.2%		75.4%		108.1%		79.9%		100.0%

Appendix F – Case Study Schematic



Appendix G – Analysis Outputs

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                     HCS 2010: Two-Lane Highways Release 6.80




Phone:                                  Fax:
E-Mail:

_________________Directional Two-Lane Highway Segment Analysis________________

Analyst                 Jack Bartolo
Agency/Co.              USQ
Date Performed          29/08/17
Analysis Time Period    0900-1000
Highway                 Bruce Highway
From/To                 Sarina to Hay Point
Jurisdiction            MRC
Analysis Year           2017
Description  Existing Segment NB

__________________________________Input Data__________________________________

Highway class  Class 1              Peak hour factor, PHF     0.88
Shoulder width       8.2     ft     % Trucks and buses        14      %
Lane width           11.5    ft     % Trucks crawling         0.0     %
Segment length       5.5     mi     Truck crawl speed         0.0     mi/hr
Terrain type         Rolling        % Recreational vehicles   5       %
Grade:  Length       -       mi     % No-passing zones        100     %
        Up/down      -       %      Access point density      3       /mi

Analysis direction volume, Vd  269     veh/h
Opposing direction volume, Vo  177     veh/h

____________________________Average Travel Speed______________________________

Direction                                Analysis(d)         Opposing (o)
PCE for trucks, ET                           2.2*                2.2*
PCE for RVs, ER                              1.1                 1.1
Heavy-vehicle adj. factor,(note-5) fHV       0.853               0.853
Grade adj. factor,(note-1) fg                0.83                0.75
Directional flow rate,(note-2) vi            432     pc/h        314     pc/h

Free-Flow Speed from Field Measurement:
Field measured speed,(note-3) S FM                 -       mi/h
Observed total demand,(note-3) V                   -       veh/h
Estimated Free-Flow Speed:
Base free-flow speed,(note-3) BFFS                68.0     mi/h
Adj. for lane and shoulder width,(note-3) fLS     3.0*     mi/h
Adj. for access point density,(note-3) fA         1.2*     mi/h

Free-flow speed, FFSd                             63.8     mi/h

Adjustment for no-passing zones, fnp              3.5*     mi/h
Average travel speed, ATSd                        54.5     mi/h
Percent Free Flow Speed, PFFS                     85.4     %
```

```
_________________________Percent Time-Spent-Following________________________

Direction                                      Analysis(d)        Opposing (o)
PCE for trucks, ET                                 2.2*               2.2*
PCE for RVs, ER                                    1.1*               1.1*
Heavy-vehicle adjustment factor, fHV               0.853              0.853
Grade adjustment factor,(note-1) fg                0.85               0.80
Directional flow rate,(note-2) vi                  422    pc/h        295     pc/h
Base percent time-spent-following,(note-4) BPTSFd  42.8   %
Adjustment for no-passing zones, fnp                        46.6
Percent time-spent-following, PTSFd                         70.2   %

________________Level of Service and Other Performance Measures_______________

Level of service, LOS                                       D
Volume to capacity ratio, v/c                               0.25
Peak 15-min vehicle-miles of travel, VMT15                  420     veh-mi
Peak-hour vehicle-miles of travel, VMT60                    1480    veh-mi
Peak 15-min total travel time, TT15                         7.7     veh-h
Capacity from ATS, CdATS                                    1218    veh/h
Capacity from PTSF, CdPTSF                                  1316    veh/h
Directional Capacity                                        1218    veh/h

_____________________________Passing Lane Analysis____________________________

Total length of analysis segment, Lt                                  5.5     mi
Length of two-lane highway upstream of the passing lane, Lu           -       mi
Length of passing lane including tapers, Lpl                          -       mi
Average travel speed, ATSd (from above)                               54.5    mi/h
Percent time-spent-following, PTSFd (from above)                      70.2
Level of service, LOSd (from above)                                   D

___________________Average Travel Speed  with Passing Lane____________________

Downstream length of two-lane highway within effective
    length of passing lane for average travel speed, Lde              -       mi
Length of two-lane highway downstream of effective
    length of the passing lane for average travel speed, Ld           -       mi
Adj. factor for the effect of passing lane
    on average speed, fpl                                             -
Average travel speed including passing lane, ATSpl                    -
Percent free flow speed including passing lane, PFFSpl                0.0     %

________________Percent Time-Spent-Following with Passing Lane________________

Downstream length of two-lane highway within effective length
    of passing lane for percent time-spent-following, Lde             -       mi
Length of two-lane highway downstream of effective length of
    the passing lane for percent time-spent-following, Ld             -       mi
Adj. factor for the effect of passing lane
    on percent time-spent-following, fpl                              -
Percent time-spent-following
    including passing lane, PTSFpl                                    -       %

______Level of Service and Other Performance Measures with Passing Lane ______

Level of service including passing lane, LOSpl              E
Peak 15-min total travel time, TT15                         -       veh-h

__________________________ Bicycle Level of Service __________________________
```

Posted speed limit, Sp	55
Percent of segment with occupied on-highway parking	0
Pavement rating, P	3
Flow rate in outside lane, vOL	305.7
Effective width of outside lane, We	27.90
Effective speed factor, St	4.79
Bicycle LOS Score, BLOS	5.62
Bicycle LOS	F

Notes:

1. Note that the adjustment factor for level terrain is 1.00, as level terrain is one of the base conditions. For the purpose of grade adjustment, specific dewngrade segments are treated as level terrain.
2. If vi (vd or vo) >= 1,700 pc/h, terminate analysis-the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only.
5. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

* These items have been entered or edited to override calculated value

```
                    HCS 2010: Two-Lane Highways Release 6.80



Phone:                                  Fax:
E-Mail:

_________________Directional Two-Lane Highway Segment Analysis________________

Analyst                   Jack Bartolo
Agency/Co.                USQ
Date Performed            29/08/17
Analysis Time Period      0900-1000
Highway                   Bruce Highway
From/To                   Sarina to Hay Point
Jurisdiction              MRC
Analysis Year             2017
Description  Existing Segment NB OT-NB1

__________________________________Input Data__________________________________

Highway class  Class 1              Peak hour factor, PHF    0.88
Shoulder width       8.2     ft     % Trucks and buses       14       %
Lane width           11.5    ft     % Trucks crawling        0.0      %
Segment length       5.5     mi     Truck crawl speed        0.0      mi/hr
Terrain type         Rolling        % Recreational vehicles  5        %
Grade: Length        -       mi     % No-passing zones       100      %
       Up/down       -       %      Access point density     3        /mi

Analysis direction volume, Vd  269     veh/h
Opposing direction volume, Vo  177     veh/h

____________________________Average Travel Speed______________________________

Direction                             Analysis(d)         Opposing (o)
PCE for trucks, ET                        2.2*                2.2*
PCE for RVs, ER                           1.1                 1.1
Heavy-vehicle adj. factor,(note-5) fHV    0.853               0.853
Grade adj. factor,(note-1) fg             0.83                0.75
Directional flow rate,(note-2) vi         432      pc/h       314      pc/h

Free-Flow Speed from Field Measurement:
Field measured speed,(note-3) S FM                 -       mi/h
Observed total demand,(note-3) V                   -       veh/h
Estimated Free-Flow Speed:
Base free-flow speed,(note-3) BFFS                 68.0    mi/h
Adj. for lane and shoulder width,(note-3) fLS      3.0*    mi/h
Adj. for access point density,(note-3) fA          1.2*    mi/h

Free-flow speed, FFSd                              63.8    mi/h

Adjustment for no-passing zones, fnp               3.5*    mi/h
Average travel speed, ATSd                         54.5    mi/h
Percent Free Flow Speed, PFFS                      85.4    %
```

```
_________________________Percent Time-Spent-Following________________________

Direction                                 Analysis(d)         Opposing (o)
PCE for trucks, ET                            2.2*                2.2*
PCE for RVs, ER                               1.1*                1.1*
Heavy-vehicle adjustment factor, fHV          0.853               0.853
Grade adjustment factor,(note-1) fg           0.85                0.80
Directional flow rate,(note-2) vi             422    pc/h         295     pc/h
Base percent time-spent-following,(note-4) BPTSFd  42.8   %
Adjustment for no-passing zones, fnp               46.6
Percent time-spent-following, PTSFd                70.2   %

________________Level of Service and Other Performance Measures_______________

Level of service, LOS                              D
Volume to capacity ratio, v/c                      0.25
Peak 15-min vehicle-miles of travel, VMT15         420      veh-mi
Peak-hour vehicle-miles of travel, VMT60           1480     veh-mi
Peak 15-min total travel time, TT15                7.7      veh-h
Capacity from ATS, CdATS                           1218     veh/h
Capacity from PTSF, CdPTSF                         1316     veh/h
Directional Capacity                               1218     veh/h

_____________________________Passing Lane Analysis____________________________

Total length of analysis segment, Lt                          5.5      mi
Length of two-lane highway upstream of the passing lane, Lu   0.4      mi
Length of passing lane including tapers, Lpl                  1.1      mi
Average travel speed, ATSd (from above)                       54.5     mi/h
Percent time-spent-following, PTSFd (from above)              70.2
Level of service, LOSd (from above)                           D

___________________Average Travel Speed  with Passing Lane____________________

Downstream length of two-lane highway within effective
    length of passing lane for average travel speed, Lde      1.70     mi
Length of two-lane highway downstream of effective
    length of the passing lane for average travel speed, Ld   2.30     mi
Adj. factor for the effect of passing lane
    on average speed, fpl                                     1.10
Average travel speed including passing lane, ATSpl            56.4
Percent free flow speed including passing lane, PFFSpl        88.3     %

________________Percent Time-Spent-Following with Passing Lane________________

Downstream length of two-lane highway within effective length
    of passing lane for percent time-spent-following, Lde     7.92     mi
Length of two-lane highway downstream of effective length of
    the passing lane for percent time-spent-following, Ld     -3.92    mi
Adj. factor for the effect of passing lane
    on percent time-spent-following, fpl                      0.61
Percent time-spent-following
    including passing lane, PTSFpl                            49.8     %

______Level of Service and Other Performance Measures with Passing Lane ______

Level of service including passing lane, LOSpl     B
Peak 15-min total travel time, TT15                7.5      veh-h

__________________________ Bicycle Level of Service __________________________
```

Posted speed limit, Sp	55
Percent of segment with occupied on-highway parking	0
Pavement rating, P	3
Flow rate in outside lane, vOL	305.7
Effective width of outside lane, We	27.90
Effective speed factor, St	4.79
Bicycle LOS Score, BLOS	5.62
Bicycle LOS	F

Notes:
1. Note that the adjustment factor for level terrain is 1.00, as level terrain is one of the base conditions. For the purpose of grade adjustment, specific dewngrade segments are treated as level terrain.
2. If vi (vd or vo) >= 1,700 pc/h, terminate analysis-the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only.
5. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

* These items have been entered or edited to override calculated value

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Phone:                                      Fax:
E-Mail:

_________________Directional Two-Lane Highway Segment Analysis________________

Analyst                   Jack Bartolo
Agency/Co.                USQ
Date Performed            29/08/17
Analysis Time Period      0900-1000
Highway                   Bruce Highway
From/To                   Sarina to Hay Point
Jurisdiction              MRC
Analysis Year             2017
Description  Existing Segment NB OT-NB2

__________________________________Input Data__________________________________

Highway class  Class 1             Peak hour factor, PHF     0.88
Shoulder width       8.2     ft     % Trucks and buses        14       %
Lane width           11.5    ft     % Trucks crawling         0.0      %
Segment length       5.5     mi     Truck crawl speed         0.0      mi/hr
Terrain type         Rolling        % Recreational vehicles   5        %
Grade:  Length       -       mi     % No-passing zones        100      %
        Up/down      -       %      Access point density      3        /mi

Analysis direction volume, Vd  269     veh/h
Opposing direction volume, Vo  177     veh/h

____________________________Average Travel Speed______________________________

Direction                                      Analysis(d)        Opposing (o)
PCE for trucks, ET                                 2.2*               2.2*
PCE for RVs, ER                                    1.1                1.1
Heavy-vehicle adj. factor,(note-5) fHV             0.853              0.853
Grade adj. factor,(note-1) fg                      0.83               0.75
Directional flow rate,(note-2) vi                  432     pc/h       314     pc/h

Free-Flow Speed from Field Measurement:
Field measured speed,(note-3) S FM                      -       mi/h
Observed total demand,(note-3) V                        -       veh/h
Estimated Free-Flow Speed:
Base free-flow speed,(note-3) BFFS                     68.0     mi/h
Adj. for lane and shoulder width,(note-3) fLS          3.0*     mi/h
Adj. for access point density,(note-3) fA              1.2*     mi/h

Free-flow speed, FFSd                                  63.8     mi/h

Adjustment for no-passing zones, fnp                   3.5*     mi/h
Average travel speed, ATSd                             54.5     mi/h
Percent Free Flow Speed, PFFS                          85.4     %
```

```
_________________________Percent Time-Spent-Following_________________________

Direction                                      Analysis(d)        Opposing (o)
PCE for trucks, ET                                 2.2*               2.2*
PCE for RVs, ER                                    1.1*               1.1*
Heavy-vehicle adjustment factor, fHV               0.853              0.853
Grade adjustment factor,(note-1) fg                0.85               0.80
Directional flow rate,(note-2) vi                  422    pc/h        295     pc/h
Base percent time-spent-following,(note-4) BPTSFd  42.8   %
Adjustment for no-passing zones, fnp                       46.6
Percent time-spent-following, PTSFd                        70.2   %

________________Level of Service and Other Performance Measures_______________

Level of service, LOS                                      D
Volume to capacity ratio, v/c                              0.25
Peak 15-min vehicle-miles of travel, VMT15                 420      veh-mi
Peak-hour vehicle-miles of travel, VMT60                   1480     veh-mi
Peak 15-min total travel time, TT15                        7.7      veh-h
Capacity from ATS, CdATS                                   1218     veh/h
Capacity from PTSF, CdPTSF                                 1316     veh/h
Directional Capacity                                       1218     veh/h

_____________________________Passing Lane Analysis____________________________

Total length of analysis segment, Lt                                 5.5     mi
Length of two-lane highway upstream of the passing lane, Lu          1.7     mi
Length of passing lane including tapers, Lpl                         0.8     mi
Average travel speed, ATSd (from above)                              54.5    mi/h
Percent time-spent-following, PTSFd (from above)                     70.2
Level of service, LOSd (from above)                                  D

___________________Average Travel Speed  with Passing Lane____________________

Downstream length of two-lane highway within effective
    length of passing lane for average travel speed, Lde     1.70    mi
Length of two-lane highway downstream of effective
    length of the passing lane for average travel speed, Ld  1.30    mi
Adj. factor for the effect of passing lane
    on average speed, fpl                                    1.10
Average travel speed including passing lane, ATSpl           56.1
Percent free flow speed including passing lane, PFFSpl       87.9    %

________________Percent Time-Spent-Following with Passing Lane________________

Downstream length of two-lane highway within effective length
    of passing lane for percent time-spent-following, Lde    7.92    mi
Length of two-lane highway downstream of effective length of
    the passing lane for percent time-spent-following, Ld    -4.92   mi
Adj. factor for the effect of passing lane
    on percent time-spent-following, fpl                     0.61
Percent time-spent-following
    including passing lane, PTSFpl                           54.1    %

______Level of Service and Other Performance Measures with Passing Lane ______

Level of service including passing lane, LOSpl     C
Peak 15-min total travel time, TT15                7.5      veh-h

__________________________ Bicycle Level of Service __________________________
```

Posted speed limit, Sp	55
Percent of segment with occupied on-highway parking	0
Pavement rating, P	3
Flow rate in outside lane, vOL	305.7
Effective width of outside lane, We	27.90
Effective speed factor, St	4.79
Bicycle LOS Score, BLOS	5.62
Bicycle LOS	F

Notes:
1. Note that the adjustment factor for level terrain is 1.00, as level terrain is one of the base conditions. For the purpose of grade adjustment, specific dewngrade segments are treated as level terrain.
2. If vi (vd or vo) >= 1,700 pc/h, terminate analysis-the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only.
5. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

* These items have been entered or edited to override calculated value

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Phone:                                  Fax:
E-Mail:

_________________Directional Two-Lane Highway Segment Analysis________________

Analyst                   Jack Bartolo
Agency/Co.                USQ
Date Performed            29/08/17
Analysis Time Period      1600-1700
Highway                   Bruce Highway
From/To                   Sarina to Hay Point
Jurisdiction              MRC
Analysis Year             2017
Description  Existing Segment SB

__________________________________Input Data__________________________________

Highway class  Class 1                Peak hour factor, PHF    0.88
Shoulder width       8.2     ft       % Trucks and buses       13      %
Lane width           11.5    ft       % Trucks crawling        0.0     %
Segment length       5.5     mi       Truck crawl speed        0.0     mi/hr
Terrain type         Rolling          % Recreational vehicles  4       %
Grade:  Length       -       mi       % No-passing zones       100     %
        Up/down      -       %        Access point density     2       /mi

Analysis direction volume, Vd  283     veh/h
Opposing direction volume, Vo  248     veh/h

____________________________Average Travel Speed______________________________

Direction                             Analysis(d)         Opposing (o)
PCE for trucks, ET                        2.2*                2.2*
PCE for RVs, ER                           1.1                 1.1
Heavy-vehicle adj. factor,(note-5) fHV    0.862               0.862
Grade adj. factor,(note-1) fg             0.85                0.82
Directional flow rate,(note-2) vi         439     pc/h        399     pc/h

Free-Flow Speed from Field Measurement:
Field measured speed,(note-3) S FM             -       mi/h
Observed total demand,(note-3) V               -       veh/h
Estimated Free-Flow Speed:
Base free-flow speed,(note-3) BFFS             68.0    mi/h
Adj. for lane and shoulder width,(note-3) fLS  3.0*    mi/h
Adj. for access point density,(note-3) fA      1.2*    mi/h

Free-flow speed, FFSd                          63.8    mi/h

Adjustment for no-passing zones, fnp           3.6*    mi/h
Average travel speed, ATSd                     53.7    mi/h
Percent Free Flow Speed, PFFS                  84.2    %
```

```
_________________________Percent Time-Spent-Following________________________

Direction                                     Analysis(d)        Opposing (o)
PCE for trucks, ET                                2.2*               2.2*
PCE for RVs, ER                                   1.1*               1.1*
Heavy-vehicle adjustment factor, fHV              0.862              0.862
Grade adjustment factor,(note-1) fg               0.86               0.84
Directional flow rate,(note-2) vi                 434    pc/h        389     pc/h
Base percent time-spent-following,(note-4) BPTSFd  45.6   %
Adjustment for no-passing zones, fnp                 44.2
Percent time-spent-following, PTSFd                  68.9   %

________________Level of Service and Other Performance Measures_______________

Level of service, LOS                                D
Volume to capacity ratio, v/c                        0.26
Peak 15-min vehicle-miles of travel, VMT15           442     veh-mi
Peak-hour vehicle-miles of travel, VMT60             1557    veh-mi
Peak 15-min total travel time, TT15                  8.2     veh-h
Capacity from ATS, CdATS                             1334    veh/h
Capacity from PTSF, CdPTSF                           1404    veh/h
Directional Capacity                                 1334    veh/h

_____________________________Passing Lane Analysis____________________________

Total length of analysis segment, Lt                           5.5     mi
Length of two-lane highway upstream of the passing lane, Lu   -       mi
Length of passing lane including tapers, Lpl                   -       mi
Average travel speed, ATSd (from above)                        53.7    mi/h
Percent time-spent-following, PTSFd (from above)               68.9
Level of service, LOSd (from above)                            D

___________________Average Travel Speed  with Passing Lane____________________

Downstream length of two-lane highway within effective
    length of passing lane for average travel speed, Lde      -       mi
Length of two-lane highway downstream of effective
    length of the passing lane for average travel speed, Ld   -       mi
Adj. factor for the effect of passing lane
    on average speed, fpl                                      -
Average travel speed including passing lane, ATSpl             -
Percent free flow speed including passing lane, PFFSpl         0.0     %

________________Percent Time-Spent-Following with Passing Lane________________

Downstream length of two-lane highway within effective length
    of passing lane for percent time-spent-following, Lde     -       mi
Length of two-lane highway downstream of effective length of
    the passing lane for percent time-spent-following, Ld     -       mi
Adj. factor for the effect of passing lane
    on percent time-spent-following, fpl                       -
Percent time-spent-following
    including passing lane, PTSFpl                             -       %

______Level of Service and Other Performance Measures with Passing Lane ______

Level of service including passing lane, LOSpl      E
Peak 15-min total travel time, TT15                  -       veh-h

__________________________ Bicycle Level of Service __________________________
```

Posted speed limit, Sp	55
Percent of segment with occupied on-highway parking	0
Pavement rating, P	3
Flow rate in outside lane, vOL	321.6
Effective width of outside lane, We	27.90
Effective speed factor, St	4.79
Bicycle LOS Score, BLOS	5.17
Bicycle LOS	E

Notes:

1. Note that the adjustment factor for level terrain is 1.00, as level terrain is one of the base conditions. For the purpose of grade adjustment, specific dewngrade segments are treated as level terrain.
2. If vi (vd or vo) >= 1,700 pc/h, terminate analysis-the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only.
5. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

* These items have been entered or edited to override calculated value

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Phone:                                  Fax:
E-Mail:

_________________Directional Two-Lane Highway Segment Analysis________________

Analyst                   Jack Bartolo
Agency/Co.                USQ
Date Performed            29/08/17
Analysis Time Period      1600-1700
Highway                   Bruce Highway
From/To                   Sarina to Hay Point
Jurisdiction              MRC
Analysis Year             2017
Description  Existing Segment SB OT-NB2

__________________________________Input Data__________________________________

Highway class  Class 1              Peak hour factor, PHF    0.88
Shoulder width       8.2     ft     % Trucks and buses       13       %
Lane width           11.5    ft     % Trucks crawling        0.0      %
Segment length       5.5     mi     Truck crawl speed        0.0      mi/hr
Terrain type         Rolling        % Recreational vehicles  4        %
Grade: Length        -       mi     % No-passing zones       100      %
       Up/down       -       %      Access point density     2        /mi

Analysis direction volume, Vd  283     veh/h
Opposing direction volume, Vo  248     veh/h

____________________________Average Travel Speed______________________________

Direction                                     Analysis(d)         Opposing (o)
PCE for trucks, ET                                2.2*                2.2*
PCE for RVs, ER                                   1.1                 1.1
Heavy-vehicle adj. factor,(note-5) fHV            0.862               0.862
Grade adj. factor,(note-1) fg                     0.85                0.82
Directional flow rate,(note-2) vi                 439      pc/h       399      pc/h

Free-Flow Speed from Field Measurement:
Field measured speed,(note-3) S FM                     -       mi/h
Observed total demand,(note-3) V                       -       veh/h
Estimated Free-Flow Speed:
Base free-flow speed,(note-3) BFFS                     68.0    mi/h
Adj. for lane and shoulder width,(note-3) fLS          3.0*    mi/h
Adj. for access point density,(note-3) fA              1.2*    mi/h

Free-flow speed, FFSd                                  63.8    mi/h

Adjustment for no-passing zones, fnp                   3.6*    mi/h
Average travel speed, ATSd                             53.7    mi/h
Percent Free Flow Speed, PFFS                          84.2    %
```

```
_________________________Percent Time-Spent-Following_________________________

Direction                                     Analysis(d)        Opposing (o)
PCE for trucks, ET                                2.2*               2.2*
PCE for RVs, ER                                   1.1*               1.1*
Heavy-vehicle adjustment factor, fHV              0.862              0.862
Grade adjustment factor,(note-1) fg               0.86               0.84
Directional flow rate,(note-2) vi                 434    pc/h        389     pc/h
Base percent time-spent-following,(note-4) BPTSFd  45.6   %
Adjustment for no-passing zones, fnp               44.2
Percent time-spent-following, PTSFd                68.9   %

________________Level of Service and Other Performance Measures_______________

Level of service, LOS                              D
Volume to capacity ratio, v/c                      0.26
Peak 15-min vehicle-miles of travel, VMT15         442      veh-mi
Peak-hour vehicle-miles of travel, VMT60           1557     veh-mi
Peak 15-min total travel time, TT15                8.2      veh-h
Capacity from ATS, CdATS                           1334     veh/h
Capacity from PTSF, CdPTSF                         1404     veh/h
Directional Capacity                               1334     veh/h

_____________________________Passing Lane Analysis____________________________

Total length of analysis segment, Lt                          5.5      mi
Length of two-lane highway upstream of the passing lane, Lu   1.9      mi
Length of passing lane including tapers, Lpl                  0.8      mi
Average travel speed, ATSd (from above)                       53.7     mi/h
Percent time-spent-following, PTSFd (from above)              68.9
Level of service, LOSd (from above)                           D

___________________Average Travel Speed  with Passing Lane____________________

Downstream length of two-lane highway within effective
    length of passing lane for average travel speed, Lde     1.70     mi
Length of two-lane highway downstream of effective
    length of the passing lane for average travel speed, Ld  1.10     mi
Adj. factor for the effect of passing lane
    on average speed, fpl                                     1.10
Average travel speed including passing lane, ATSpl            55.2
Percent free flow speed including passing lane, PFFSpl        86.6     %

________________Percent Time-Spent-Following with Passing Lane________________

Downstream length of two-lane highway within effective length
    of passing lane for percent time-spent-following, Lde    7.83     mi
Length of two-lane highway downstream of effective length of
    the passing lane for percent time-spent-following, Ld    -5.03    mi
Adj. factor for the effect of passing lane
    on percent time-spent-following, fpl                      0.61
Percent time-spent-following
    including passing lane, PTSFpl                            53.8     %

______Level of Service and Other Performance Measures with Passing Lane ______

Level of service including passing lane, LOSpl     C
Peak 15-min total travel time, TT15                8.0      veh-h

__________________________ Bicycle Level of Service __________________________
```

Posted speed limit, Sp	55
Percent of segment with occupied on-highway parking	0
Pavement rating, P	3
Flow rate in outside lane, vOL	321.6
Effective width of outside lane, We	27.90
Effective speed factor, St	4.79
Bicycle LOS Score, BLOS	5.17
Bicycle LOS	E

Notes:
1. Note that the adjustment factor for level terrain is 1.00, as level terrain is one of the base conditions. For the purpose of grade adjustment, specific dewngrade segments are treated as level terrain.
2. If vi (vd or vo) >= 1,700 pc/h, terminate analysis-the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only.
5. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

* These items have been entered or edited to override calculated value

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Phone: Fax:
E-Mail:

Directional Two-Lane Highway Segment Analysis

Analyst	Jack Bartolo
Agency/Co.	USQ
Date Performed	29/08/17
Analysis Time Period	1600-1700
Highway	Bruce Highway
From/To	Sarina to Hay Point
Jurisdiction	MRC
Analysis Year	2017
Description	Existing Segment SB OT-SB1

Input Data

Highway class	Class 1		Peak hour factor, PHF	0.88	
Shoulder width	8.2	ft	% Trucks and buses	13	%
Lane width	11.5	ft	% Trucks crawling	0.0	%
Segment length	5.5	mi	Truck crawl speed	0.0	mi/hr
Terrain type	Rolling		% Recreational vehicles	4	%
Grade: Length	-	mi	% No-passing zones	100	%
Up/down	-	%	Access point density	2	/mi

Analysis direction volume, Vd	283	veh/h
Opposing direction volume, Vo	248	veh/h

Average Travel Speed

Direction	Analysis(d)		Opposing (o)	
PCE for trucks, ET	2.2*		2.2*	
PCE for RVs, ER	1.1		1.1	
Heavy-vehicle adj. factor,(note-5) fHV	0.862		0.862	
Grade adj. factor,(note-1) fg	0.85		0.82	
Directional flow rate,(note-2) vi	439	pc/h	399	pc/h

Free-Flow Speed from Field Measurement:		
Field measured speed,(note-3) S FM	-	mi/h
Observed total demand,(note-3) V	-	veh/h
Estimated Free-Flow Speed:		
Base free-flow speed,(note-3) BFFS	68.0	mi/h
Adj. for lane and shoulder width,(note-3) fLS	3.0*	mi/h
Adj. for access point density,(note-3) fA	1.2*	mi/h
Free-flow speed, FFSd	63.8	mi/h
Adjustment for no-passing zones, fnp	3.6*	mi/h
Average travel speed, ATSd	53.7	mi/h
Percent Free Flow Speed, PFFS	84.2	%

Percent Time-Spent-Following

Direction	Analysis(d)		Opposing (o)	
PCE for trucks, ET	2.2*		2.2*	
PCE for RVs, ER	1.1*		1.1*	
Heavy-vehicle adjustment factor, fHV	0.862		0.862	
Grade adjustment factor,(note-1) fg	0.86		0.84	
Directional flow rate,(note-2) vi	434	pc/h	389	pc/h
Base percent time-spent-following,(note-4) BPTSFd	45.6	%		
Adjustment for no-passing zones, fnp	44.2			
Percent time-spent-following, PTSFd	68.9	%		

Level of Service and Other Performance Measures

Level of service, LOS	D	
Volume to capacity ratio, v/c	0.26	
Peak 15-min vehicle-miles of travel, VMT15	442	veh-mi
Peak-hour vehicle-miles of travel, VMT60	1557	veh-mi
Peak 15-min total travel time, TT15	8.2	veh-h
Capacity from ATS, CdATS	1334	veh/h
Capacity from PTSF, CdPTSF	1404	veh/h
Directional Capacity	1334	veh/h

Passing Lane Analysis

Total length of analysis segment, Lt	5.5	mi
Length of two-lane highway upstream of the passing lane, Lu	3.0	mi
Length of passing lane including tapers, Lpl	0.7	mi
Average travel speed, ATSd (from above)	53.7	mi/h
Percent time-spent-following, PTSFd (from above)	68.9	
Level of service, LOSd (from above)	D	

Average Travel Speed with Passing Lane

Downstream length of two-lane highway within effective length of passing lane for average travel speed, Lde	1.70	mi
Length of two-lane highway downstream of effective length of the passing lane for average travel speed, Ld	0.10	mi
Adj. factor for the effect of passing lane on average speed, fpl	1.10	
Average travel speed including passing lane, ATSpl	55.1	
Percent free flow speed including passing lane, PFFSpl	86.4	%

Percent Time-Spent-Following with Passing Lane

Downstream length of two-lane highway within effective length of passing lane for percent time-spent-following, Lde	7.83	mi
Length of two-lane highway downstream of effective length of the passing lane for percent time-spent-following, Ld	-6.03	mi
Adj. factor for the effect of passing lane on percent time-spent-following, fpl	0.61	
Percent time-spent-following including passing lane, PTSFpl	57.7	%

Level of Service and Other Performance Measures with Passing Lane

Level of service including passing lane, LOSpl	C	
Peak 15-min total travel time, TT15	8.0	veh-h

Bicycle Level of Service

```
Posted speed limit, Sp                                     55
Percent of segment with occupied on-highway parking        0
Pavement rating, P                                         3
Flow rate in outside lane, vOL                             321.6
Effective width of outside lane, We                        27.90
Effective speed factor, St                                 4.79
Bicycle LOS Score, BLOS                                    5.17
Bicycle LOS                                                E
```

Notes:
1. Note that the adjustment factor for level terrain is 1.00, as level terrain is one of the base conditions. For the purpose of grade adjustment, specific dewngrade segments are treated as level terrain.
2. If vi (vd or vo) >= 1,700 pc/h, terminate analysis-the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only.
5. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

* These items have been entered or edited to override calculated value

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Phone:                                  Fax:
E-Mail:

_________________Directional Two-Lane Highway Segment Analysis________________

Analyst                 Jack Bartolo
Agency/Co.              USQ
Date Performed          29/08/17
Analysis Time Period    0900-1000
Highway                 Bruce Highway
From/To                 Sarina to Hay Point
Jurisdiction            MRC
Analysis Year           2017
Description  2+1 Segment NB

__________________________________Input Data__________________________________

Highway class  Class 1              Peak hour factor, PHF    0.88
Shoulder width        8.2     ft    % Trucks and buses       14      %
Lane width            11.5    ft    % Trucks crawling        0.0     %
Segment length        5.5     mi    Truck crawl speed        0.0     mi/hr
Terrain type          Rolling       % Recreational vehicles  5       %
Grade:  Length        -       mi    % No-passing zones       100     %
        Up/down       -       %     Access point density     3       /mi

Analysis direction volume, Vd  269     veh/h
Opposing direction volume, Vo  177     veh/h

____________________________Average Travel Speed______________________________

Direction                                Analysis(d)        Opposing (o)
PCE for trucks, ET                           2.2*               2.2*
PCE for RVs, ER                              1.1                1.1
Heavy-vehicle adj. factor,(note-5) fHV       0.853              0.853
Grade adj. factor,(note-1) fg                0.83               0.75
Directional flow rate,(note-2) vi            432     pc/h       314     pc/h

Free-Flow Speed from Field Measurement:
Field measured speed,(note-3) S FM                -       mi/h
Observed total demand,(note-3) V                  -       veh/h
Estimated Free-Flow Speed:
Base free-flow speed,(note-3) BFFS               68.0     mi/h
Adj. for lane and shoulder width,(note-3) fLS    3.0*     mi/h
Adj. for access point density,(note-3) fA        1.2*     mi/h

Free-flow speed, FFSd                            63.8     mi/h

Adjustment for no-passing zones, fnp             3.3*     mi/h
Average travel speed, ATSd                       54.7     mi/h
Percent Free Flow Speed, PFFS                    85.8     %
```

```
_________________________Percent Time-Spent-Following________________________

Direction                                    Analysis(d)         Opposing (o)
PCE for trucks, ET                               2.2*                2.2*
PCE for RVs, ER                                  1.1*                1.1*
Heavy-vehicle adjustment factor, fHV             0.853               0.853
Grade adjustment factor,(note-1) fg              0.85                0.80
Directional flow rate,(note-2) vi                422    pc/h         295     pc/h
Base percent time-spent-following,(note-4) BPTSFd  42.8   %
Adjustment for no-passing zones, fnp                      46.6
Percent time-spent-following, PTSFd                       70.2   %

________________Level of Service and Other Performance Measures_______________

Level of service, LOS                                     D
Volume to capacity ratio, v/c                             0.25
Peak 15-min vehicle-miles of travel, VMT15                420     veh-mi
Peak-hour vehicle-miles of travel, VMT60                  1480    veh-mi
Peak 15-min total travel time, TT15                       7.7     veh-h
Capacity from ATS, CdATS                                  1218    veh/h
Capacity from PTSF, CdPTSF                                1316    veh/h
Directional Capacity                                      1218    veh/h

_____________________________Passing Lane Analysis____________________________

Total length of analysis segment, Lt                                5.5     mi
Length of two-lane highway upstream of the passing lane, Lu         -       mi
Length of passing lane including tapers, Lpl                        -       mi
Average travel speed, ATSd (from above)                             54.7    mi/h
Percent time-spent-following, PTSFd (from above)                    70.2
Level of service, LOSd (from above)                                 D

___________________Average Travel Speed  with Passing Lane____________________

Downstream length of two-lane highway within effective
    length of passing lane for average travel speed, Lde            -       mi
Length of two-lane highway downstream of effective
    length of the passing lane for average travel speed, Ld         -       mi
Adj. factor for the effect of passing lane
    on average speed, fpl                                           -
Average travel speed including passing lane, ATSpl                  -
Percent free flow speed including passing lane, PFFSpl              0.0     %

________________Percent Time-Spent-Following with Passing Lane________________

Downstream length of two-lane highway within effective length
    of passing lane for percent time-spent-following, Lde           -       mi
Length of two-lane highway downstream of effective length of
    the passing lane for percent time-spent-following, Ld           -       mi
Adj. factor for the effect of passing lane
    on percent time-spent-following, fpl                            -
Percent time-spent-following
    including passing lane, PTSFpl                                  -       %

______Level of Service and Other Performance Measures with Passing Lane ______

Level of service including passing lane, LOSpl            E
Peak 15-min total travel time, TT15                       -       veh-h

__________________________ Bicycle Level of Service __________________________
```

Posted speed limit, Sp	55
Percent of segment with occupied on-highway parking	0
Pavement rating, P	3
Flow rate in outside lane, vOL	305.7
Effective width of outside lane, We	27.90
Effective speed factor, St	4.79
Bicycle LOS Score, BLOS	5.62
Bicycle LOS	F

Notes:

1. Note that the adjustment factor for level terrain is 1.00, as level terrain is one of the base conditions. For the purpose of grade adjustment, specific dewngrade segments are treated as level terrain.
2. If vi (vd or vo) >= 1,700 pc/h, terminate analysis-the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only.
5. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

* These items have been entered or edited to override calculated value

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Phone:                                   Fax:
E-Mail:

_________________Directional Two-Lane Highway Segment Analysis________________

Analyst                  Jack Bartolo
Agency/Co.               USQ
Date Performed           29/08/17
Analysis Time Period     0900-1000
Highway                  Bruce Highway
From/To                  Sarina to Hay Point
Jurisdiction             MRC
Analysis Year            2017
Description  2+1 Segment 2P1-NB1

__________________________________Input Data__________________________________

Highway class  Class 1               Peak hour factor, PHF     0.88
Shoulder width       8.2     ft      % Trucks and buses        14       %
Lane width           11.5    ft      % Trucks crawling         0.0      %
Segment length       5.5     mi      Truck crawl speed         0.0      mi/hr
Terrain type         Rolling         % Recreational vehicles   5        %
Grade: Length        -       mi      % No-passing zones        100      %
       Up/down       -       %       Access point density      3        /mi

Analysis direction volume, Vd  269     veh/h
Opposing direction volume, Vo  177     veh/h

____________________________Average Travel Speed______________________________

Direction                               Analysis(d)         Opposing (o)
PCE for trucks, ET                          2.2*                2.2*
PCE for RVs, ER                             1.1                 1.1
Heavy-vehicle adj. factor,(note-5) fHV      0.853               0.853
Grade adj. factor,(note-1) fg               0.83                0.75
Directional flow rate,(note-2) vi           432     pc/h        314     pc/h

Free-Flow Speed from Field Measurement:
Field measured speed,(note-3) S FM                 -       mi/h
Observed total demand,(note-3) V                   -       veh/h
Estimated Free-Flow Speed:
Base free-flow speed,(note-3) BFFS                 68.0    mi/h
Adj. for lane and shoulder width,(note-3) fLS      3.0*    mi/h
Adj. for access point density,(note-3) fA          1.2*    mi/h

Free-flow speed, FFSd                              63.8    mi/h

Adjustment for no-passing zones, fnp               3.3*    mi/h
Average travel speed, ATSd                         54.7    mi/h
Percent Free Flow Speed, PFFS                      85.8    %
```

```
_________________________Percent Time-Spent-Following_________________________

Direction                                     Analysis(d)        Opposing (o)
PCE for trucks, ET                                2.2*               2.2*
PCE for RVs, ER                                   1.1*               1.1*
Heavy-vehicle adjustment factor, fHV              0.853              0.853
Grade adjustment factor,(note-1) fg               0.85               0.80
Directional flow rate,(note-2) vi                 422    pc/h        295      pc/h
Base percent time-spent-following,(note-4) BPTSFd  42.8   %
Adjustment for no-passing zones, fnp                       46.6
Percent time-spent-following, PTSFd                        70.2   %

________________Level of Service and Other Performance Measures_______________

Level of service, LOS                                      D
Volume to capacity ratio, v/c                              0.25
Peak 15-min vehicle-miles of travel, VMT15                 420      veh-mi
Peak-hour vehicle-miles of travel, VMT60                   1480     veh-mi
Peak 15-min total travel time, TT15                        7.7      veh-h
Capacity from ATS, CdATS                                   1218     veh/h
Capacity from PTSF, CdPTSF                                 1316     veh/h
Directional Capacity                                       1218     veh/h

_____________________________Passing Lane Analysis____________________________

Total length of analysis segment, Lt                                  5.5      mi
Length of two-lane highway upstream of the passing lane, Lu           0.0      mi
Length of passing lane including tapers, Lpl                          0.6      mi
Average travel speed, ATSd (from above)                               54.7     mi/h
Percent time-spent-following, PTSFd (from above)                      70.2
Level of service, LOSd (from above)                                   D

___________________Average Travel Speed  with Passing Lane____________________

Downstream length of two-lane highway within effective
    length of passing lane for average travel speed, Lde     1.70     mi
Length of two-lane highway downstream of effective
    length of the passing lane for average travel speed, Ld  3.20     mi
Adj. factor for the effect of passing lane
    on average speed, fpl                                    1.10
Average travel speed including passing lane, ATSpl           56.1
Percent free flow speed including passing lane, PFFSpl       87.9     %

________________Percent Time-Spent-Following with Passing Lane________________

Downstream length of two-lane highway within effective length
    of passing lane for percent time-spent-following, Lde    7.92     mi
Length of two-lane highway downstream of effective length of
    the passing lane for percent time-spent-following, Ld    -3.02    mi
Adj. factor for the effect of passing lane
    on percent time-spent-following, fpl                     0.61
Percent time-spent-following
    including passing lane, PTSFpl                           50.4     %

______Level of Service and Other Performance Measures with Passing Lane ______

Level of service including passing lane, LOSpl      C
Peak 15-min total travel time, TT15                 7.5      veh-h

__________________________ Bicycle Level of Service __________________________
```

Posted speed limit, Sp	55
Percent of segment with occupied on-highway parking	0
Pavement rating, P	3
Flow rate in outside lane, vOL	305.7
Effective width of outside lane, We	27.90
Effective speed factor, St	4.79
Bicycle LOS Score, BLOS	5.62
Bicycle LOS	F

Notes:
1. Note that the adjustment factor for level terrain is 1.00, as level terrain is one of the base conditions. For the purpose of grade adjustment, specific dewngrade segments are treated as level terrain.
2. If vi (vd or vo) >= 1,700 pc/h, terminate analysis-the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only.
5. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

* These items have been entered or edited to override calculated value

HCS 2010: Two-Lane Highways Release 6.80

Phone: Fax:
E-Mail:

Directional Two-Lane Highway Segment Analysis

Analyst	Jack Bartolo
Agency/Co.	USQ
Date Performed	29/08/17
Analysis Time Period	0900-1000
Highway	Bruce Highway
From/To	Sarina to Hay Point
Jurisdiction	MRC
Analysis Year	2017
Description	2+1 Segment 2P1-NB2

Input Data

Highway class	Class 1		Peak hour factor, PHF	0.88	
Shoulder width	8.2	ft	% Trucks and buses	14	%
Lane width	11.5	ft	% Trucks crawling	0.0	%
Segment length	5.5	mi	Truck crawl speed	0.0	mi/hr
Terrain type	Rolling		% Recreational vehicles	5	%
Grade: Length	-	mi	% No-passing zones	100	%
Up/down	-	%	Access point density	3	/mi

Analysis direction volume, Vd	269	veh/h
Opposing direction volume, Vo	177	veh/h

Average Travel Speed

Direction	Analysis(d)		Opposing (o)	
PCE for trucks, ET	2.2*		2.2*	
PCE for RVs, ER	1.1		1.1	
Heavy-vehicle adj. factor,(note-5) fHV	0.853		0.853	
Grade adj. factor,(note-1) fg	0.83		0.75	
Directional flow rate,(note-2) vi	432	pc/h	314	pc/h

Free-Flow Speed from Field Measurement:		
Field measured speed,(note-3) S FM	-	mi/h
Observed total demand,(note-3) V	-	veh/h
Estimated Free-Flow Speed:		
Base free-flow speed,(note-3) BFFS	68.0	mi/h
Adj. for lane and shoulder width,(note-3) fLS	3.0*	mi/h
Adj. for access point density,(note-3) fA	1.2*	mi/h
Free-flow speed, FFSd	63.8	mi/h
Adjustment for no-passing zones, fnp	3.5*	mi/h
Average travel speed, ATSd	54.5	mi/h
Percent Free Flow Speed, PFFS	85.4	%

```
_________________________Percent Time-Spent-Following________________________

Direction                                     Analysis(d)          Opposing (o)
PCE for trucks, ET                                2.2*                 2.2*
PCE for RVs, ER                                   1.1*                 1.1*
Heavy-vehicle adjustment factor, fHV              0.853                0.853
Grade adjustment factor,(note-1) fg               0.85                 0.80
Directional flow rate,(note-2) vi                 422    pc/h          295      pc/h
Base percent time-spent-following,(note-4) BPTSFd 42.8   %
Adjustment for no-passing zones, fnp                       46.6
Percent time-spent-following, PTSFd                        70.2   %

________________Level of Service and Other Performance Measures_______________

Level of service, LOS                                      D
Volume to capacity ratio, v/c                              0.25
Peak 15-min vehicle-miles of travel, VMT15                 420     veh-mi
Peak-hour vehicle-miles of travel, VMT60                   1480    veh-mi
Peak 15-min total travel time, TT15                        7.7     veh-h
Capacity from ATS, CdATS                                   1218    veh/h
Capacity from PTSF, CdPTSF                                 1316    veh/h
Directional Capacity                                       1218    veh/h

_____________________________Passing Lane Analysis____________________________

Total length of analysis segment, Lt                                 5.5      mi
Length of two-lane highway upstream of the passing lane, Lu          0.9      mi
Length of passing lane including tapers, Lpl                         0.7      mi
Average travel speed, ATSd (from above)                              54.5     mi/h
Percent time-spent-following, PTSFd (from above)                     70.2
Level of service, LOSd (from above)                                  D

___________________Average Travel Speed  with Passing Lane____________________

Downstream length of two-lane highway within effective
    length of passing lane for average travel speed, Lde             1.70     mi
Length of two-lane highway downstream of effective
    length of the passing lane for average travel speed, Ld          2.20     mi
Adj. factor for the effect of passing lane
    on average speed, fpl                                            1.10
Average travel speed including passing lane, ATSpl                   56.0
Percent free flow speed including passing lane, PFFSpl               87.7     %

________________Percent Time-Spent-Following with Passing Lane_______________

Downstream length of two-lane highway within effective length
    of passing lane for percent time-spent-following, Lde            7.92     mi
Length of two-lane highway downstream of effective length of
    the passing lane for percent time-spent-following, Ld            -4.02    mi
Adj. factor for the effect of passing lane
    on percent time-spent-following, fpl                             0.61
Percent time-spent-following
    including passing lane, PTSFpl                                   52.1     %

______Level of Service and Other Performance Measures with Passing Lane ______

Level of service including passing lane, LOSpl             C
Peak 15-min total travel time, TT15                        7.5     veh-h

__________________________ Bicycle Level of Service __________________________
```

Posted speed limit, Sp	55
Percent of segment with occupied on-highway parking	0
Pavement rating, P	3
Flow rate in outside lane, vOL	305.7
Effective width of outside lane, We	27.90
Effective speed factor, St	4.79
Bicycle LOS Score, BLOS	5.62
Bicycle LOS	F

Notes:

1. Note that the adjustment factor for level terrain is 1.00, as level terrain is one of the base conditions. For the purpose of grade adjustment, specific dewngrade segments are treated as level terrain.
2. If vi (vd or vo) >= 1,700 pc/h, terminate analysis-the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only.
5. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

* These items have been entered or edited to override calculated value

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Phone: Fax:
E-Mail:

_________________Directional Two-Lane Highway Segment Analysis________________

```
Analyst                  Jack Bartolo
Agency/Co.               USQ
Date Performed           29/08/17
Analysis Time Period     0900-1000
Highway                  Bruce Highway
From/To                  Sarina to Hay Point
Jurisdiction             MRC
Analysis Year            2017
Description  2+1 Segment 2P1-NB3
```

__________________________________Input Data__________________________________

```
Highway class  Class 1            Peak hour factor, PHF    0.88
Shoulder width       8.2     ft   % Trucks and buses       14       %
Lane width           11.5    ft   % Trucks crawling        0.0      %
Segment length       5.5     mi   Truck crawl speed        0.0      mi/hr
Terrain type         Rolling      % Recreational vehicles  5        %
Grade:  Length       -       mi   % No-passing zones       100      %
        Up/down      -       %    Access point density     3        /mi

Analysis direction volume, Vd  269     veh/h
Opposing direction volume, Vo  177     veh/h
```

____________________________Average Travel Speed______________________________

```
Direction                                  Analysis(d)         Opposing (o)
PCE for trucks, ET                             2.2*                2.2*
PCE for RVs, ER                                1.1                 1.1
Heavy-vehicle adj. factor,(note-5) fHV         0.853               0.853
Grade adj. factor,(note-1) fg                  0.83                0.75
Directional flow rate,(note-2) vi              432     pc/h        314     pc/h

Free-Flow Speed from Field Measurement:
Field measured speed,(note-3) S FM                  -       mi/h
Observed total demand,(note-3) V                    -       veh/h
Estimated Free-Flow Speed:
Base free-flow speed,(note-3) BFFS                  68.0    mi/h
Adj. for lane and shoulder width,(note-3) fLS       3.0*    mi/h
Adj. for access point density,(note-3) fA           1.2*    mi/h

Free-flow speed, FFSd                               63.8    mi/h

Adjustment for no-passing zones, fnp                3.3*    mi/h
Average travel speed, ATSd                          54.7    mi/h
Percent Free Flow Speed, PFFS                       85.8    %
```

```
_________________________Percent Time-Spent-Following_________________________

Direction                                    Analysis(d)         Opposing (o)
PCE for trucks, ET                               2.2*                2.2*
PCE for RVs, ER                                  1.1*                1.1*
Heavy-vehicle adjustment factor, fHV             0.853               0.853
Grade adjustment factor,(note-1) fg              0.85                0.80
Directional flow rate,(note-2) vi                422    pc/h         295     pc/h
Base percent time-spent-following,(note-4) BPTSFd  42.8   %
Adjustment for no-passing zones, fnp                      46.6
Percent time-spent-following, PTSFd                       70.2   %

________________Level of Service and Other Performance Measures_______________

Level of service, LOS                                     D
Volume to capacity ratio, v/c                             0.25
Peak 15-min vehicle-miles of travel, VMT15                420     veh-mi
Peak-hour vehicle-miles of travel, VMT60                  1480    veh-mi
Peak 15-min total travel time, TT15                       7.7     veh-h
Capacity from ATS, CdATS                                  1218    veh/h
Capacity from PTSF, CdPTSF                                1316    veh/h
Directional Capacity                                      1218    veh/h

_____________________________Passing Lane Analysis____________________________

Total length of analysis segment, Lt                                5.5     mi
Length of two-lane highway upstream of the passing lane, Lu         1.0     mi
Length of passing lane including tapers, Lpl                        0.8     mi
Average travel speed, ATSd (from above)                             54.7    mi/h
Percent time-spent-following, PTSFd (from above)                    70.2
Level of service, LOSd (from above)                                 D

___________________Average Travel Speed  with Passing Lane____________________

Downstream length of two-lane highway within effective
    length of passing lane for average travel speed, Lde            1.70    mi
Length of two-lane highway downstream of effective
    length of the passing lane for average travel speed, Ld         2.00    mi
Adj. factor for the effect of passing lane
    on average speed, fpl                                           1.10
Average travel speed including passing lane, ATSpl                  56.3
Percent free flow speed including passing lane, PFFSpl              88.2    %

________________Percent Time-Spent-Following with Passing Lane________________

Downstream length of two-lane highway within effective length
    of passing lane for percent time-spent-following, Lde           7.92    mi
Length of two-lane highway downstream of effective length of
    the passing lane for percent time-spent-following, Ld           -4.22   mi
Adj. factor for the effect of passing lane
    on percent time-spent-following, fpl                            0.61
Percent time-spent-following
    including passing lane, PTSFpl                                  52.1    %

______Level of Service and Other Performance Measures with Passing Lane ______

Level of service including passing lane, LOSpl            C
Peak 15-min total travel time, TT15                       7.5     veh-h

__________________________ Bicycle Level of Service __________________________
```

Posted speed limit, Sp	55
Percent of segment with occupied on-highway parking	0
Pavement rating, P	3
Flow rate in outside lane, vOL	305.7
Effective width of outside lane, We	27.90
Effective speed factor, St	4.79
Bicycle LOS Score, BLOS	5.62
Bicycle LOS	F

Notes:
1. Note that the adjustment factor for level terrain is 1.00, as level terrain is one of the base conditions. For the purpose of grade adjustment, specific dewngrade segments are treated as level terrain.
2. If vi (vd or vo) >= 1,700 pc/h, terminate analysis-the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only.
5. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

* These items have been entered or edited to override calculated value

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Phone:                                  Fax:
E-Mail:

_________________Directional Two-Lane Highway Segment Analysis________________

Analyst                  Jack Bartolo
Agency/Co.               USQ
Date Performed           29/08/17
Analysis Time Period     0900-1000
Highway                  Bruce Highway
From/To                  Sarina to Hay Point
Jurisdiction             MRC
Analysis Year            2017
Description  2+1 Segment 2P1-NB4

__________________________________Input Data__________________________________

Highway class  Class 1              Peak hour factor, PHF    0.88
Shoulder width        8.2     ft    % Trucks and buses       14       %
Lane width            11.5    ft    % Trucks crawling        0.0      %
Segment length        5.5     mi    Truck crawl speed        0.0      mi/hr
Terrain type          Rolling       % Recreational vehicles  5        %
Grade:  Length        -       mi    % No-passing zones       100      %
        Up/down       -       %     Access point density     3        /mi

Analysis direction volume, Vd  269     veh/h
Opposing direction volume, Vo  177     veh/h

____________________________Average Travel Speed______________________________

Direction                                Analysis(d)         Opposing (o)
PCE for trucks, ET                           2.2*                2.2*
PCE for RVs, ER                              1.1                 1.1
Heavy-vehicle adj. factor,(note-5) fHV       0.853               0.853
Grade adj. factor,(note-1) fg                0.83                0.75
Directional flow rate,(note-2) vi            432     pc/h        314     pc/h

Free-Flow Speed from Field Measurement:
Field measured speed,(note-3) S FM                -      mi/h
Observed total demand,(note-3) V                  -      veh/h
Estimated Free-Flow Speed:
Base free-flow speed,(note-3) BFFS              68.0     mi/h
Adj. for lane and shoulder width,(note-3) fLS   3.0*     mi/h
Adj. for access point density,(note-3) fA       1.2*     mi/h

Free-flow speed, FFSd                           63.8     mi/h

Adjustment for no-passing zones, fnp            3.3*     mi/h
Average travel speed, ATSd                      54.7     mi/h
Percent Free Flow Speed, PFFS                   85.8     %
```

```
_________________________Percent Time-Spent-Following_________________________

Direction                                    Analysis(d)         Opposing (o)
PCE for trucks, ET                               2.2*                2.2*
PCE for RVs, ER                                  1.1*                1.1*
Heavy-vehicle adjustment factor, fHV             0.853               0.853
Grade adjustment factor,(note-1) fg              0.85                0.80
Directional flow rate,(note-2) vi                422    pc/h         295     pc/h
Base percent time-spent-following,(note-4) BPTSFd  42.8   %
Adjustment for no-passing zones, fnp                      46.6
Percent time-spent-following, PTSFd                       70.2   %

________________Level of Service and Other Performance Measures_______________

Level of service, LOS                                     D
Volume to capacity ratio, v/c                             0.25
Peak 15-min vehicle-miles of travel, VMT15                420     veh-mi
Peak-hour vehicle-miles of travel, VMT60                  1480    veh-mi
Peak 15-min total travel time, TT15                       7.7     veh-h
Capacity from ATS, CdATS                                  1218    veh/h
Capacity from PTSF, CdPTSF                                1316    veh/h
Directional Capacity                                      1218    veh/h

_____________________________Passing Lane Analysis____________________________

Total length of analysis segment, Lt                                5.5     mi
Length of two-lane highway upstream of the passing lane, Lu        0.9     mi
Length of passing lane including tapers, Lpl                        0.6     mi
Average travel speed, ATSd (from above)                             54.7    mi/h
Percent time-spent-following, PTSFd (from above)                    70.2
Level of service, LOSd (from above)                                 D

___________________Average Travel Speed  with Passing Lane____________________

Downstream length of two-lane highway within effective
    length of passing lane for average travel speed, Lde      1.70    mi
Length of two-lane highway downstream of effective
    length of the passing lane for average travel speed, Ld   2.30    mi
Adj. factor for the effect of passing lane
    on average speed, fpl                                     1.10
Average travel speed including passing lane, ATSpl            56.1
Percent free flow speed including passing lane, PFFSpl        87.9    %

________________Percent Time-Spent-Following with Passing Lane________________

Downstream length of two-lane highway within effective length
    of passing lane for percent time-spent-following, Lde     7.92    mi
Length of two-lane highway downstream of effective length of
    the passing lane for percent time-spent-following, Ld     -3.92   mi
Adj. factor for the effect of passing lane
    on percent time-spent-following, fpl                      0.61
Percent time-spent-following
    including passing lane, PTSFpl                            52.3    %

______Level of Service and Other Performance Measures with Passing Lane ______

Level of service including passing lane, LOSpl            C
Peak 15-min total travel time, TT15                       7.5     veh-h

__________________________ Bicycle Level of Service __________________________
```

Posted speed limit, Sp	55
Percent of segment with occupied on-highway parking	0
Pavement rating, P	3
Flow rate in outside lane, vOL	305.7
Effective width of outside lane, We	27.90
Effective speed factor, St	4.79
Bicycle LOS Score, BLOS	5.62
Bicycle LOS	F

Notes:
1. Note that the adjustment factor for level terrain is 1.00, as level terrain is one of the base conditions. For the purpose of grade adjustment, specific dewngrade segments are treated as level terrain.
2. If vi (vd or vo) >= 1,700 pc/h, terminate analysis-the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only.
5. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

* These items have been entered or edited to override calculated value

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Phone: Fax:
E-Mail:

Directional Two-Lane Highway Segment Analysis

Analyst	Jack Bartolo
Agency/Co.	USQ
Date Performed	29/08/17
Analysis Time Period	1600-1700
Highway	Bruce Highway
From/To	Sarina to Hay Point
Jurisdiction	MRC
Analysis Year	2017
Description	2+1 Segment SB

Input Data

Highway class	Class 1		Peak hour factor, PHF	0.88	
Shoulder width	8.2	ft	% Trucks and buses	13	%
Lane width	11.5	ft	% Trucks crawling	0.0	%
Segment length	5.5	mi	Truck crawl speed	0.0	mi/hr
Terrain type	Rolling		% Recreational vehicles	4	%
Grade: Length	-	mi	% No-passing zones	100	%
Up/down	-	%	Access point density	2	/mi

Analysis direction volume, Vd	283	veh/h
Opposing direction volume, Vo	248	veh/h

Average Travel Speed

Direction	Analysis(d)		Opposing (o)	
PCE for trucks, ET	2.2*		2.2*	
PCE for RVs, ER	1.1		1.1	
Heavy-vehicle adj. factor,(note-5) fHV	0.862		0.862	
Grade adj. factor,(note-1) fg	0.85		0.82	
Directional flow rate,(note-2) vi	439	pc/h	399	pc/h

Free-Flow Speed from Field Measurement:		
Field measured speed,(note-3) S FM	-	mi/h
Observed total demand,(note-3) V	-	veh/h
Estimated Free-Flow Speed:		
Base free-flow speed,(note-3) BFFS	68.0	mi/h
Adj. for lane and shoulder width,(note-3) fLS	3.0*	mi/h
Adj. for access point density,(note-3) fA	1.2*	mi/h
Free-flow speed, FFSd	63.8	mi/h
Adjustment for no-passing zones, fnp	3.6*	mi/h
Average travel speed, ATSd	53.7	mi/h
Percent Free Flow Speed, PFFS	84.2	%

```
_________________________Percent Time-Spent-Following_________________________

Direction                                   Analysis(d)        Opposing (o)
PCE for trucks, ET                              2.2*                2.2*
PCE for RVs, ER                                 1.1*                1.1*
Heavy-vehicle adjustment factor, fHV            0.862               0.862
Grade adjustment factor,(note-1) fg             0.86                0.84
Directional flow rate,(note-2) vi               434    pc/h         389     pc/h
Base percent time-spent-following,(note-4) BPTSFd  45.6   %
Adjustment for no-passing zones, fnp               44.2
Percent time-spent-following, PTSFd                68.9   %

________________Level of Service and Other Performance Measures_______________

Level of service, LOS                              D
Volume to capacity ratio, v/c                      0.26
Peak 15-min vehicle-miles of travel, VMT15         442     veh-mi
Peak-hour vehicle-miles of travel, VMT60           1557    veh-mi
Peak 15-min total travel time, TT15                8.2     veh-h
Capacity from ATS, CdATS                           1334    veh/h
Capacity from PTSF, CdPTSF                         1404    veh/h
Directional Capacity                               1334    veh/h

_____________________________Passing Lane Analysis____________________________

Total length of analysis segment, Lt                         5.5      mi
Length of two-lane highway upstream of the passing lane, Lu  -        mi
Length of passing lane including tapers, Lpl                 -        mi
Average travel speed, ATSd (from above)                      53.7     mi/h
Percent time-spent-following, PTSFd (from above)             68.9
Level of service, LOSd (from above)                          D

___________________Average Travel Speed  with Passing Lane____________________

Downstream length of two-lane highway within effective
    length of passing lane for average travel speed, Lde     -        mi
Length of two-lane highway downstream of effective
    length of the passing lane for average travel speed, Ld  -        mi
Adj. factor for the effect of passing lane
    on average speed, fpl                                    -
Average travel speed including passing lane, ATSpl           -
Percent free flow speed including passing lane, PFFSpl       0.0      %

________________Percent Time-Spent-Following with Passing Lane________________

Downstream length of two-lane highway within effective length
    of passing lane for percent time-spent-following, Lde    -        mi
Length of two-lane highway downstream of effective length of
    the passing lane for percent time-spent-following, Ld    -        mi
Adj. factor for the effect of passing lane
    on percent time-spent-following, fpl                     -
Percent time-spent-following
    including passing lane, PTSFpl                           -        %

______Level of Service and Other Performance Measures with Passing Lane ______

Level of service including passing lane, LOSpl     E
Peak 15-min total travel time, TT15                -       veh-h

__________________________ Bicycle Level of Service __________________________
```

Posted speed limit, Sp	55
Percent of segment with occupied on-highway parking	0
Pavement rating, P	3
Flow rate in outside lane, vOL	321.6
Effective width of outside lane, We	27.90
Effective speed factor, St	4.79
Bicycle LOS Score, BLOS	5.17
Bicycle LOS	E

Notes:
1. Note that the adjustment factor for level terrain is 1.00, as level terrain is one of the base conditions. For the purpose of grade adjustment, specific dewngrade segments are treated as level terrain.
2. If vi (vd or vo) >= 1,700 pc/h, terminate analysis-the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only.
5. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

* These items have been entered or edited to override calculated value

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Phone:                                 Fax:
E-Mail:

_________________Directional Two-Lane Highway Segment Analysis________________

Analyst                 Jack Bartolo
Agency/Co.              USQ
Date Performed          29/08/17
Analysis Time Period    1600-1700
Highway                 Bruce Highway
From/To                 Sarina to Hay Point
Jurisdiction            MRC
Analysis Year           2017
Description  2+1 Segment 2P1-SB3

__________________________________Input Data__________________________________

Highway class  Class 1              Peak hour factor, PHF    0.88
Shoulder width       8.2     ft     % Trucks and buses       13       %
Lane width           11.5    ft     % Trucks crawling        0.0      %
Segment length       5.5     mi     Truck crawl speed        0.0      mi/hr
Terrain type         Rolling        % Recreational vehicles  4        %
Grade: Length        -       mi     % No-passing zones       100      %
       Up/down       -       %      Access point density     2        /mi

Analysis direction volume, Vd  283     veh/h
Opposing direction volume, Vo  248     veh/h

____________________________Average Travel Speed______________________________

Direction                                  Analysis(d)        Opposing (o)
PCE for trucks, ET                             2.2*               2.2*
PCE for RVs, ER                                1.1                1.1
Heavy-vehicle adj. factor,(note-5) fHV         0.862              0.862
Grade adj. factor,(note-1) fg                  0.85               0.82
Directional flow rate,(note-2) vi              439     pc/h       399     pc/h

Free-Flow Speed from Field Measurement:
Field measured speed,(note-3) S FM                  -       mi/h
Observed total demand,(note-3) V                    -       veh/h
Estimated Free-Flow Speed:
Base free-flow speed,(note-3) BFFS                  68.0    mi/h
Adj. for lane and shoulder width,(note-3) fLS       3.0*    mi/h
Adj. for access point density,(note-3) fA           1.2*    mi/h

Free-flow speed, FFSd                               63.8    mi/h

Adjustment for no-passing zones, fnp                3.6*    mi/h
Average travel speed, ATSd                          53.7    mi/h
Percent Free Flow Speed, PFFS                       84.2    %
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_________________________Percent Time-Spent-Following________________________

Direction                                    Analysis(d)        Opposing (o)
PCE for trucks, ET                               2.2*               2.2*
PCE for RVs, ER                                  1.1*               1.1*
Heavy-vehicle adjustment factor, fHV             0.862              0.862
Grade adjustment factor,(note-1) fg              0.86               0.84
Directional flow rate,(note-2) vi                434    pc/h        389     pc/h
Base percent time-spent-following,(note-4) BPTSFd 45.6   %
Adjustment for no-passing zones, fnp                      44.2
Percent time-spent-following, PTSFd                       68.9   %

________________Level of Service and Other Performance Measures______________

Level of service, LOS                                     D
Volume to capacity ratio, v/c                             0.26
Peak 15-min vehicle-miles of travel, VMT15                442     veh-mi
Peak-hour vehicle-miles of travel, VMT60                  1557    veh-mi
Peak 15-min total travel time, TT15                       8.2     veh-h
Capacity from ATS, CdATS                                  1334    veh/h
Capacity from PTSF, CdPTSF                                1404    veh/h
Directional Capacity                                      1334    veh/h

_____________________________Passing Lane Analysis____________________________

Total length of analysis segment, Lt                                5.5     mi
Length of two-lane highway upstream of the passing lane, Lu         0.6     mi
Length of passing lane including tapers, Lpl                        0.7     mi
Average travel speed, ATSd (from above)                             53.7    mi/h
Percent time-spent-following, PTSFd (from above)                    68.9
Level of service, LOSd (from above)                                 D

___________________Average Travel Speed  with Passing Lane____________________

Downstream length of two-lane highway within effective
    length of passing lane for average travel speed, Lde            1.70    mi
Length of two-lane highway downstream of effective
    length of the passing lane for average travel speed, Ld         2.50    mi
Adj. factor for the effect of passing lane
    on average speed, fpl                                           1.10
Average travel speed including passing lane, ATSpl                  55.1
Percent free flow speed including passing lane, PFFSpl              86.4    %

________________Percent Time-Spent-Following with Passing Lane________________

Downstream length of two-lane highway within effective length
    of passing lane for percent time-spent-following, Lde           7.83    mi
Length of two-lane highway downstream of effective length of
    the passing lane for percent time-spent-following, Ld           -3.63   mi
Adj. factor for the effect of passing lane
    on percent time-spent-following, fpl                            0.61
Percent time-spent-following
    including passing lane, PTSFpl                                  50.5    %

______Level of Service and Other Performance Measures with Passing Lane ______

Level of service including passing lane, LOSpl            C
Peak 15-min total travel time, TT15                       8.0     veh-h

__________________________ Bicycle Level of Service __________________________
```

Posted speed limit, Sp	55
Percent of segment with occupied on-highway parking	0
Pavement rating, P	3
Flow rate in outside lane, vOL	321.6
Effective width of outside lane, We	27.90
Effective speed factor, St	4.79
Bicycle LOS Score, BLOS	5.17
Bicycle LOS	E

Notes:
1. Note that the adjustment factor for level terrain is 1.00, as level terrain is one of the base conditions. For the purpose of grade adjustment, specific dewngrade segments are treated as level terrain.
2. If vi (vd or vo) >= 1,700 pc/h, terminate analysis-the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only.
5. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

* These items have been entered or edited to override calculated value

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Phone:                                  Fax:
E-Mail:

_________________Directional Two-Lane Highway Segment Analysis________________

Analyst                  Jack Bartolo
Agency/Co.               USQ
Date Performed           29/08/17
Analysis Time Period     1600-1700
Highway                  Bruce Highway
From/To                  Sarina to Hay Point
Jurisdiction             MRC
Analysis Year            2017
Description  2+1 Segment 2P1-SB2

__________________________________Input Data___________________________________

Highway class  Class 1             Peak hour factor, PHF    0.88
Shoulder width        8.2     ft     % Trucks and buses       13       %
Lane width            11.5    ft     % Trucks crawling        0.0      %
Segment length        5.5     mi     Truck crawl speed        0.0      mi/hr
Terrain type          Rolling        % Recreational vehicles  4        %
Grade:  Length        -       mi     % No-passing zones       100      %
        Up/down       -       %      Access point density     2        /mi

Analysis direction volume, Vd  283     veh/h
Opposing direction volume, Vo  248     veh/h

____________________________Average Travel Speed______________________________

Direction                              Analysis(d)         Opposing (o)
PCE for trucks, ET                         2.2*                2.2*
PCE for RVs, ER                            1.1                 1.1
Heavy-vehicle adj. factor,(note-5) fHV     0.862               0.862
Grade adj. factor,(note-1) fg              0.85                0.82
Directional flow rate,(note-2) vi          439      pc/h       399      pc/h

Free-Flow Speed from Field Measurement:
Field measured speed,(note-3) S FM                -       mi/h
Observed total demand,(note-3) V                  -       veh/h
Estimated Free-Flow Speed:
Base free-flow speed,(note-3) BFFS              68.0     mi/h
Adj. for lane and shoulder width,(note-3) fLS   3.0*     mi/h
Adj. for access point density,(note-3) fA       1.2*     mi/h

Free-flow speed, FFSd                           63.8     mi/h

Adjustment for no-passing zones, fnp            3.6*     mi/h
Average travel speed, ATSd                      53.7     mi/h
Percent Free Flow Speed, PFFS                   84.2     %
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```
_________________________Percent Time-Spent-Following________________________

Direction                                     Analysis(d)         Opposing (o)
PCE for trucks, ET                                2.2*                2.2*
PCE for RVs, ER                                   1.1*                1.1*
Heavy-vehicle adjustment factor, fHV              0.862               0.862
Grade adjustment factor,(note-1) fg               0.86                0.84
Directional flow rate,(note-2) vi                 434    pc/h         389     pc/h
Base percent time-spent-following,(note-4) BPTSFd  45.6   %
Adjustment for no-passing zones, fnp                       44.2
Percent time-spent-following, PTSFd                        68.9   %

________________Level of Service and Other Performance Measures_______________

Level of service, LOS                                      D
Volume to capacity ratio, v/c                              0.26
Peak 15-min vehicle-miles of travel, VMT15                 442     veh-mi
Peak-hour vehicle-miles of travel, VMT60                   1557    veh-mi
Peak 15-min total travel time, TT15                        8.2     veh-h
Capacity from ATS, CdATS                                   1334    veh/h
Capacity from PTSF, CdPTSF                                 1404    veh/h
Directional Capacity                                       1334    veh/h

_____________________________Passing Lane Analysis____________________________

Total length of analysis segment, Lt                                5.5     mi
Length of two-lane highway upstream of the passing lane, Lu         1.0     mi
Length of passing lane including tapers, Lpl                        0.9     mi
Average travel speed, ATSd (from above)                             53.7    mi/h
Percent time-spent-following, PTSFd (from above)                    68.9
Level of service, LOSd (from above)                                 D

___________________Average Travel Speed  with Passing Lane____________________

Downstream length of two-lane highway within effective
    length of passing lane for average travel speed, Lde            1.70    mi
Length of two-lane highway downstream of effective
    length of the passing lane for average travel speed, Ld         1.90    mi
Adj. factor for the effect of passing lane
    on average speed, fpl                                           1.10
Average travel speed including passing lane, ATSpl                  55.3
Percent free flow speed including passing lane, PFFSpl              86.7     %

________________Percent Time-Spent-Following with Passing Lane________________

Downstream length of two-lane highway within effective length
    of passing lane for percent time-spent-following, Lde           7.83    mi
Length of two-lane highway downstream of effective length of
    the passing lane for percent time-spent-following, Ld           -4.23   mi
Adj. factor for the effect of passing lane
    on percent time-spent-following, fpl                            0.61
Percent time-spent-following
    including passing lane, PTSFpl                                  51.0     %

______Level of Service and Other Performance Measures with Passing Lane ______

Level of service including passing lane, LOSpl             C
Peak 15-min total travel time, TT15                        8.0     veh-h

__________________________ Bicycle Level of Service __________________________
```

Posted speed limit, Sp	55
Percent of segment with occupied on-highway parking	0
Pavement rating, P	3
Flow rate in outside lane, vOL	321.6
Effective width of outside lane, We	27.90
Effective speed factor, St	4.79
Bicycle LOS Score, BLOS	5.17
Bicycle LOS	E

Notes:
1. Note that the adjustment factor for level terrain is 1.00, as level terrain is one of the base conditions. For the purpose of grade adjustment, specific dewngrade segments are treated as level terrain.
2. If vi (vd or vo) >= 1,700 pc/h, terminate analysis-the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only.
5. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

* These items have been entered or edited to override calculated value

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Phone:                                  Fax:
E-Mail:

_________________Directional Two-Lane Highway Segment Analysis________________

Analyst                  Jack Bartolo
Agency/Co.               USQ
Date Performed           29/08/17
Analysis Time Period     1600-1700
Highway                  Bruce Highway
From/To                  Sarina to Hay Point
Jurisdiction             MRC
Analysis Year            2017
Description  2+1 Segment 2P1-SB1

__________________________________Input Data__________________________________

Highway class  Class 1               Peak hour factor, PHF    0.88
Shoulder width       8.2     ft      % Trucks and buses       13       %
Lane width           11.5    ft      % Trucks crawling        0.0      %
Segment length       5.5     mi      Truck crawl speed        0.0      mi/hr
Terrain type         Rolling         % Recreational vehicles  4        %
Grade:  Length       -       mi      % No-passing zones       100      %
        Up/down      -       %       Access point density     2        /mi

Analysis direction volume, Vd  283     veh/h
Opposing direction volume, Vo  248     veh/h

____________________________Average Travel Speed______________________________

Direction                                Analysis(d)         Opposing (o)
PCE for trucks, ET                           2.2*                2.2*
PCE for RVs, ER                              1.1                 1.1
Heavy-vehicle adj. factor,(note-5) fHV       0.862               0.862
Grade adj. factor,(note-1) fg                0.85                0.82
Directional flow rate,(note-2) vi            439      pc/h       399      pc/h

Free-Flow Speed from Field Measurement:
Field measured speed,(note-3) S FM                 -       mi/h
Observed total demand,(note-3) V                   -       veh/h
Estimated Free-Flow Speed:
Base free-flow speed,(note-3) BFFS                68.0     mi/h
Adj. for lane and shoulder width,(note-3) fLS     3.0*     mi/h
Adj. for access point density,(note-3) fA         1.2*     mi/h

Free-flow speed, FFSd                             63.8     mi/h

Adjustment for no-passing zones, fnp              3.6*     mi/h
Average travel speed, ATSd                        53.7     mi/h
Percent Free Flow Speed, PFFS                     84.2     %
```

```
_________________________Percent Time-Spent-Following________________________

Direction                                      Analysis(d)        Opposing (o)
PCE for trucks, ET                                 2.2*               2.2*
PCE for RVs, ER                                    1.1*               1.1*
Heavy-vehicle adjustment factor, fHV               0.862              0.862
Grade adjustment factor,(note-1) fg                0.86               0.84
Directional flow rate,(note-2) vi                  434    pc/h        389     pc/h
Base percent time-spent-following,(note-4) BPTSFd  45.6   %
Adjustment for no-passing zones, fnp                        44.2
Percent time-spent-following, PTSFd                         68.9   %

________________Level of Service and Other Performance Measures_______________

Level of service, LOS                                       D
Volume to capacity ratio, v/c                               0.26
Peak 15-min vehicle-miles of travel, VMT15                  442     veh-mi
Peak-hour vehicle-miles of travel, VMT60                    1557    veh-mi
Peak 15-min total travel time, TT15                         8.2     veh-h
Capacity from ATS, CdATS                                    1334    veh/h
Capacity from PTSF, CdPTSF                                  1404    veh/h
Directional Capacity                                        1334    veh/h

_____________________________Passing Lane Analysis____________________________

Total length of analysis segment, Lt                                  5.5     mi
Length of two-lane highway upstream of the passing lane, Lu          1.1     mi
Length of passing lane including tapers, Lpl                         0.7     mi
Average travel speed, ATSd (from above)                              53.7    mi/h
Percent time-spent-following, PTSFd (from above)                     68.9
Level of service, LOSd (from above)                                  D

___________________Average Travel Speed  with Passing Lane____________________

Downstream length of two-lane highway within effective
    length of passing lane for average travel speed, Lde     1.70    mi
Length of two-lane highway downstream of effective
    length of the passing lane for average travel speed, Ld  2.00    mi
Adj. factor for the effect of passing lane
    on average speed, fpl                                    1.10
Average travel speed including passing lane, ATSpl           55.1
Percent free flow speed including passing lane, PFFSpl       86.4    %

________________Percent Time-Spent-Following with Passing Lane________________

Downstream length of two-lane highway within effective length
    of passing lane for percent time-spent-following, Lde    7.83    mi
Length of two-lane highway downstream of effective length of
    the passing lane for percent time-spent-following, Ld    -4.13   mi
Adj. factor for the effect of passing lane
    on percent time-spent-following, fpl                     0.61
Percent time-spent-following
    including passing lane, PTSFpl                           51.7    %

______Level of Service and Other Performance Measures with Passing Lane ______

Level of service including passing lane, LOSpl      C
Peak 15-min total travel time, TT15                 8.0      veh-h

__________________________ Bicycle Level of Service __________________________
```

Posted speed limit, Sp	55
Percent of segment with occupied on-highway parking	0
Pavement rating, P	3
Flow rate in outside lane, vOL	321.6
Effective width of outside lane, We	27.90
Effective speed factor, St	4.79
Bicycle LOS Score, BLOS	5.17
Bicycle LOS	E

Notes:
1. Note that the adjustment factor for level terrain is 1.00, as level terrain is one of the base conditions. For the purpose of grade adjustment, specific dewngrade segments are treated as level terrain.
2. If vi (vd or vo) >= 1,700 pc/h, terminate analysis-the LOS is F.
3. For the analysis direction only and for v>200 veh/h.
4. For the analysis direction only.
5. Use alternative Exhibit 15-14 if some trucks operate at crawl speeds on a specific downgrade.

* These items have been entered or edited to override calculated value