

Managed Freeways

Handbook for:

- Lane Use Management
- Variable Speed Limits
- Traveller Information



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FOREWORD

Managed Freeways Handbook for:

- **Lane Use Management**
- **Variable Speed Limits**
- **Traveller Information**

This Handbook has been developed by VicRoads to provide the principles and standards for active freeway traffic management tools relating to lane use, variable speed limits and on-road information to motorists.

The tools documented in this Handbook assist in improving safety and operation, and keeping motorists informed about travelling conditions. They are particularly beneficial in relation to managing incidents and other events, roadworks and periods of congestion. The tools combine with access control using coordinated freeway ramp signals to manage freeway flow and achieve high levels of safety, efficiency and reliability.

Since 2006 VicRoads has been implementing an active managed freeway system that incorporates traffic management tools and operations which were initiated as part of the Monash-CityLink-West Gate (M1) Upgrade project. The installation of managed freeway operations included coordinated ramp signalling at freeway entry ramps and traveller information on the freeway and at interchanges over a distance of 75 km between Werribee and Berwick. A lane use management system with lane use / variable speed limit signs was installed over a distance of nearly 20 km between Williamstown and Malvern. The M80 Ring Road Upgrade project is providing further managed freeway facilities for Melbourne.

The Handbook is based on contemporary traffic management practice and state-of-the-art technologies including innovation associated with the design and operation of Melbourne's managed freeway projects.

This Handbook is one of a series of VicRoads guidelines relating to managed freeways, which include:

- Managed Freeway Guidelines;
- Managed Freeways: Freeway Ramp Signals Handbook; and
- Managed Freeways handbook for Lane Use Management, Variable Speed Limits and Traveller Information.

A standardised system is essential to ensure that drivers acquire the information necessary to enable them to comply with road rules and to use the road system in a safe and efficient manner. In the interests of uniformity, other Victorian road authorities are encouraged to apply the requirements of this Handbook to freeways / tollways under their control.

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Notations and Abbreviations

ARTIS	Advance real time information sign
CCTV	Closed circuit television
CMS	Changeable message sign
ESB	Emergency stopping bay
ESL	Emergency stopping lane
FCS	Freeway condition sign
LCS	Lane control signal
LED	Light emitting diode
LUMS	Lane use management system
LUS	Lane use sign
RC1	Sign reference number for the ramp entrance ramp control sign
RC2	Sign reference number for the on-ramp ramp signal warning sign
RC3	Sign reference number for the Real Time Information Sign (RTIS)
RTIS	Real Time Information Sign (sign reference No. RC3)
STREAMS	Freeway management system used by VicRoads
TCS	Trip condition sign
TIS	Trip information sign
TMC	Traffic management centre
VMS	Variable message sign
VSL	Variable speed limit

Chapter 1

Introduction and Overview

1. Introduction and Overview

1.1. Safe, Reliable and Efficient Freeway Operation

A managed freeway incorporates a number of 'active traffic management' tools which provide a range of road safety and traffic management benefits.

Active traffic management tools include lane use management, variable speed limits, traveller information and freeway ramp signals. These tools directly regulate or influence road user's behaviour, improve freeway flow and achieve high levels of freeway efficiency and reliability.

Melbourne's freeway and tollway network carries 30% of the arterial road traffic although comprising only 7% of the arterial road network¹. The efficient use of freeways and tollways is essential in providing a safe and reliable level of service that maximises the productivity of the asset and provides optimum operation in relation to safety, throughput and travel time.

1.2. Managing Traffic Flow Impacts

Under normal uninterrupted freeway flow conditions traffic is governed by vehicle interaction that determines operating characteristics. In normal circumstances on a managed freeway as traffic demands and density increase, coordinated ramp signals activate to manage flow and prevent or minimise flow breakdown and congestion.

However, when situations develop that affect the free flow of traffic, specific actions can assist in addressing safety concerns and returning the facility to free-flowing conditions. The traffic management systems and devices relating to lane use management, variable speeds and traveller information provide valuable tools to improve safety and manage situations involving incidents and congestion.

1.3. Managing Incidents

1.4. Traffic Flow Impacts

The impact of incidents on traffic operation can be significant. A Highways Agency (2002) study has reported that 25% of congestion on the UK trunk road network is due to incidents. It is likely that a similar situation could exist in Melbourne.

Figure 1-1 shows a time-distance-speed plot of an incident on Monash Freeway which resulted in significant delays. The results of an incident on traffic include:

- sudden reduction of flow;
- sudden reduction of speed; and
- rapid queue development.

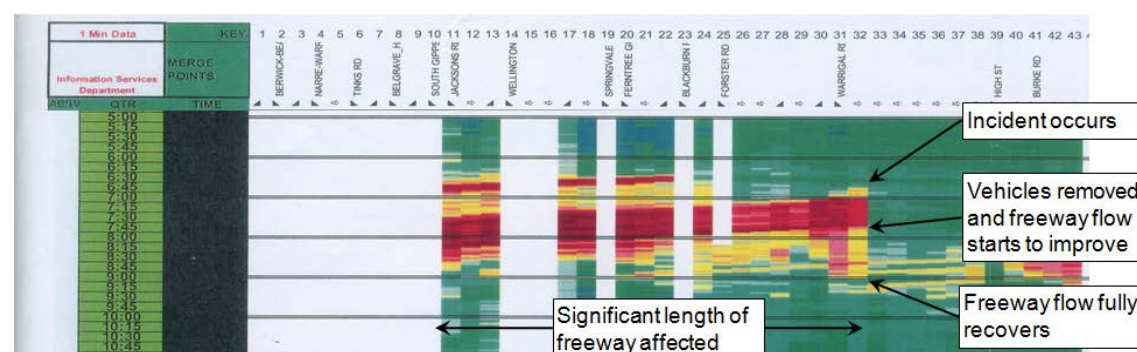


Figure 1-1: Time-Distance-Speed Plot of Monash Freeway Incident 20/6/2008

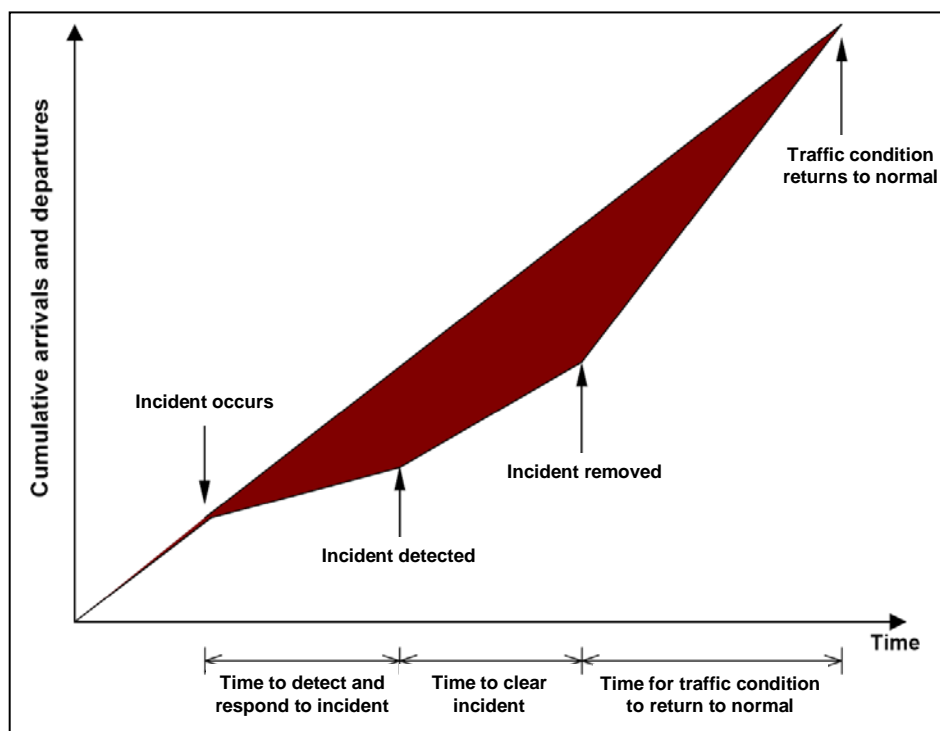
¹ Based on actual and estimated 2008 median midweek non-holiday 24 hour volumes for the Inner and Outer Metropolitan Statistical Division as defined by Australian Bureau of Statistics.

The traffic impacts of incidents result in economic, social and environmental impacts. An effective incident management system is essential to minimise these impacts. The early identification and effective management of an incident as well as initiation of actions to reduce freeway demand can assist in minimising the impact on traffic flow.

Figure 1-2 demonstrates incident delay with cumulative vehicle arrivals and departures plotted against time. The shaded area between the arrivals and departures represents the vehicle delay due to an incident. Before the incident, the vehicle arrival rate equals the rate of the departures. After the incident traffic is delayed and the departure rate decreases.

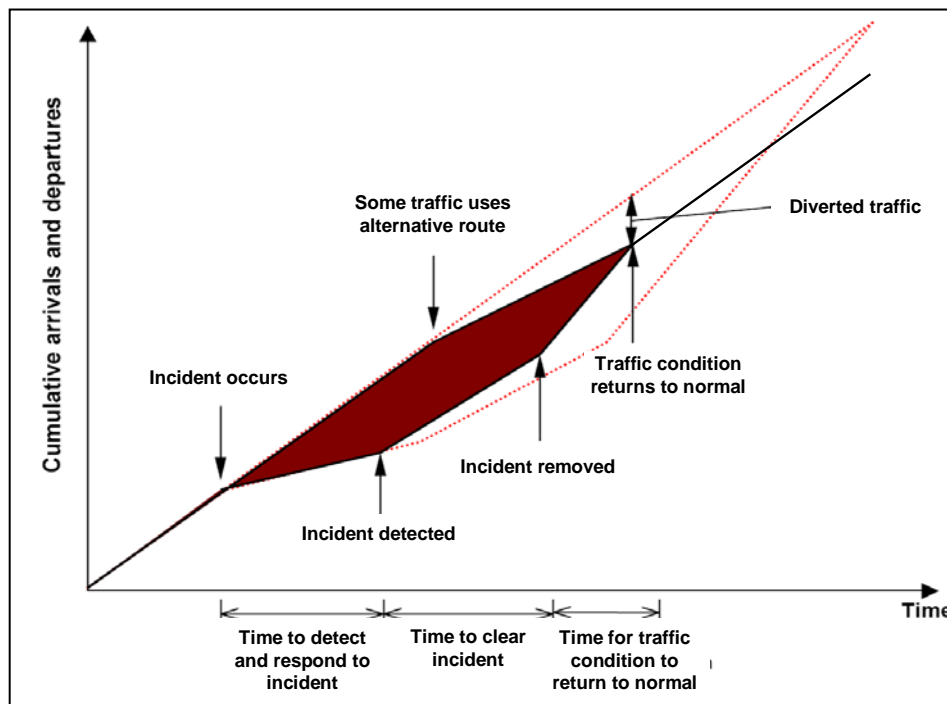
Figure 1-3 shows how an effective incident management system reduces the overall impact of an incident as well as the time for the freeway flow to return to normal. This is due to:

- faster incident detection and response that leads to earlier incident removal; and
- diverting traffic away from the incident.



Source: Based on Austroads AP-R298/07 Improving Traffic Incident Management: Evaluation Framework

Figure 1-2: Incident Clearance without an Incident Management System



Source: Based on Austroads AP-R298/07 Improving Traffic Incident Management: Evaluation Framework

Figure 1-3: Incident Clearance with an Incident Management System

1.5. Effective Incident Management

Austroads (2007b) defines a traffic incident as any event that can degrade safety and/or slow traffic, including disabled vehicles, crashes, maintenance activities, adverse weather conditions and debris on the roadway.

Traffic incident management involves a systematic, planned and coordinated use of human, institutional, mechanical and technical resources to reduce the impact of incidents and improve safety of motorists, crash victims and responders.

An effective incident management system reduces the traffic impact of an incident and the time for the freeway flow to return to normal. The system focuses on four key parts of the process.

- **Early detection and verification**
 - Identification and reporting of incidents may be by individuals, CCTV surveillance, automated incident detection, or in some instances, the reports may come via the media.
 - Verification is required, generally by CCTV cameras, to confirm the nature of the incident as well as an accurate identification of the incident location. At this stage a good understanding of incident needs is required relating to appropriate response personnel, including need for police or other emergency services personnel, as well as the resources required.
- **Efficient response to attend the incident site**
 - A fast and efficient response can be facilitated by prepared response teams operating from strategically located vehicles or compounds.
 - On reaching the incident site officers need to assess and clarify the incident severity, resources required (agencies, personnel and equipment).
- **Effective management at the incident site**
 - Initially the site must be made safe for workers, incident victims and the travelling public.

- Traffic management and control is needed to implement lane closures or traffic diversions, manage speed and manage site access, as required, and to minimise the potential for secondary incidents.
- Coordination at the incident site may need to consider the command structure, procedures, cooperation between the police, road agency, ambulance, fire brigade and special implications relating to information gathering for the crash investigation if the incident involves a fatality.
- Processes at the incident site should focus on safety and clearing the incident site as soon as possible.
- **Tools and actions to reduce freeway demand**
 - Traveller information is essential to divert freeway traffic away from the incident area. This can include as follows.
 - Media reports.
 - Advisory traveller information on upstream mainline VMS.
 - Travel time / traffic condition information on mainline signs.
 - Arterial road Real Time Information Signs displaying travel time and other incident traveller information.
 - Closure of ramps near an incident site may be necessary in some instances.
 - Coordinated ramp signals to reduce the volume of traffic entering the freeway.

1.6. Managing Congestion

The causes of freeway congestion can include incidents, roadworks or other events. In other situations the ramp signals may be unable to prevent flow breakdown, e.g., when there are uncontrolled entry flows. The reasons for congestion are generally capacity limitations and the oversupply of traffic at a bottleneck area.

When freeway congestion occurs, an integrated operational strategy is required to manage the congestion that will minimise the worsening of congestion and also assist in flow recovery. This focuses on the following traffic management actions which are complementary:

- Management of entry flows to assist in flow recovery. Freeway ramp signals limit entry ramp flows upstream of the incident or congestion by implementing a high cycle time to minimise the entry flow rate. This reduces the freeway flow and may also assist in diverting traffic.
- Traffic diversion by providing traveller information. Some motorists will use an alternative route if travel advice is available. This can be provided by the following.
 - Real Time Information Signs on the arterial road prior to the freeway entrance.
 - Mainline VMS to encourage motorists to leave the freeway before reaching the congested section.

Other supportive actions include traffic condition reports passed on to radio stations, particularly during peak periods.

1.7. An Integrated Managed Freeway System

VicRoads managed freeways with various traffic management tools operate within the road network management framework as shown in Figure 1-4. On-road operations and devices are managed within the STREAMS freeway management system. Toll-road operators use other systems for managing their roadways.

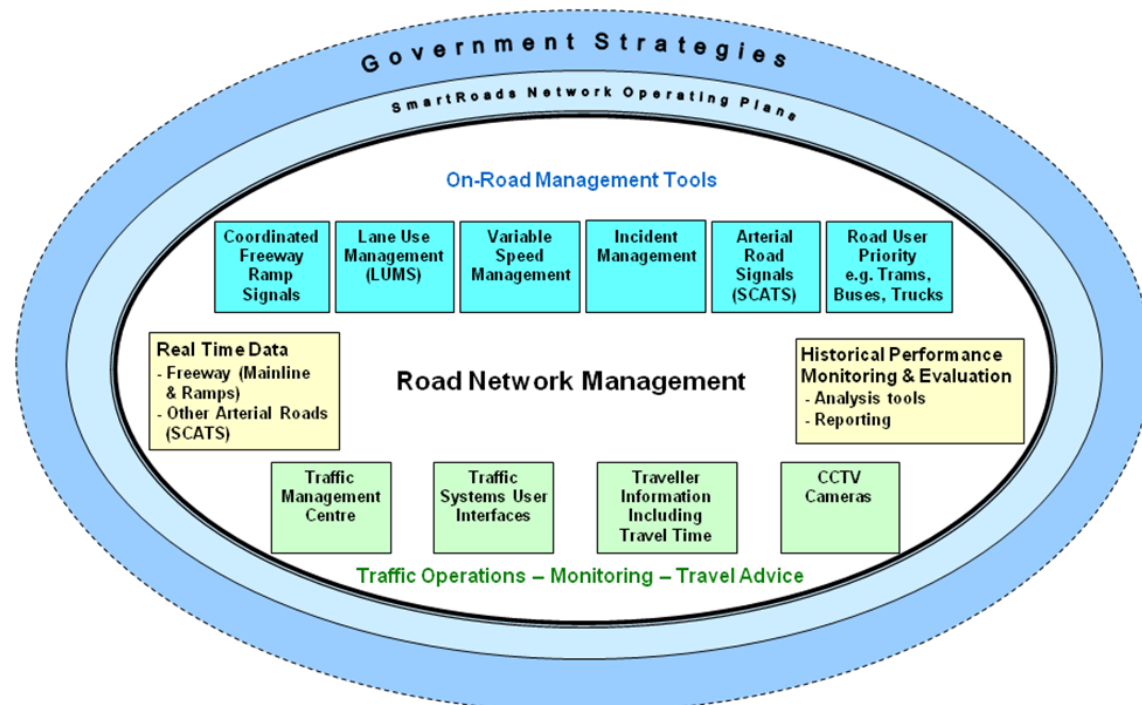


Figure 1-4: VicRoads Road Network Management

The STREAMS managed freeway system interfaces a number of real time on-road traffic management tools which need to be integrated including:

- coordinated freeway ramp signals system to manage freeway access and assist in preventing flow breakdown;
- traveller information that is provided in real-time on the freeway mainline as well as on the arterial roads leading to the freeway. This includes information about travel time and freeway traffic conditions to enable drivers to make informed decisions relating to route choice. Information may also relate to incidents or planned future events, e.g., roadworks;
- lane use management system to improve safety and assist in managing freeway incidents or events;
- variable speed limits to improve safety and assist in controlling vehicle speeds during incidents, events or adverse weather; and
- congestion management to supplement the overall freeway access management strategy. Restrictive ramp metering operation and traveller information combine to assist in preventing a worsening of congestion, to divert traffic away from the freeway and to assist in flow recovery.

The freeway management system is essential for consistency of information, integration of devices and consistency in traffic management for traffic operation (ramp signalling), event management (lane use management), variable speed limits and traveller advice to motorists. The system controls a number of traffic management devices that operate in default mode for general traffic management as well as providing special operation during incidents or congestion. The device standards are defined in the latest versions of VicRoads device specifications.

1.8. Legal Requirements for Installation of Devices

The electronic speed limit signs, lane control signals, lane use signs and variable message signs (mainline and real-time traveller information signs) described in this Handbook are Major Traffic Control Devices within the definition in the Road Safety (Traffic Management) Regulations 2009 – Schedule 1 item 1 (speed-limit sign), item 6 (traffic signals) and item 7 (devices that use lights or illuminated words or symbols to direct or warn road users).

Regulation 10 (1) indicates that responsible road authorities may erect, display, place, remove or alter a Major Traffic Control Device with the authority of VicRoads. Regulation 20 (2) states that a person who has erected, displayed or placed a traffic control device in accordance with the applicable or the previous regulations may maintain them.

1.9. Maintenance Regime and Reliability of Tools

On a managed freeway the correct functioning of devices, especially data detectors, is essential. This impacts the efficient use of freeways in providing safe and reliable travel that maximises use of the asset (throughput and travel speed), manages incidents efficiently and provides real-time traveller information. An appropriate maintenance regime, typically greater than 'normal' standards, is required to ensure a high standard of reliability and performance.

Real time monitoring by the system with manual checking represents best practice. Performance of devices should be regularly monitored for operations and maintenance needs with appropriate intervention levels that ensure a faulty device is repaired or brought back on line with minimal delay.

Chapter 2

Lane Use and Incident Management

2. Lane Use and Incident Management

2.1. Lane Use Management

A Lane Use Management System (LUMS) allocates and manages lane use across the roadway and is particularly useful during incidents and roadworks. The operation of lane use signs provides traffic management to improve safety during abnormal operation. LUMS includes speed management and should be supported by the use of mainline variable message signs.

Figure 2-1 and Figure 2-2 show schematics of typical lane use and speed management arrangements on a freeway and in an existing tunnel where headroom limitations do not allow installation of lane use signs. In new tunnels where adequate clearance is available, it is preferable to use integrated VSL / Lane Use Signs, i.e., the arrangement in Figure 2-1.

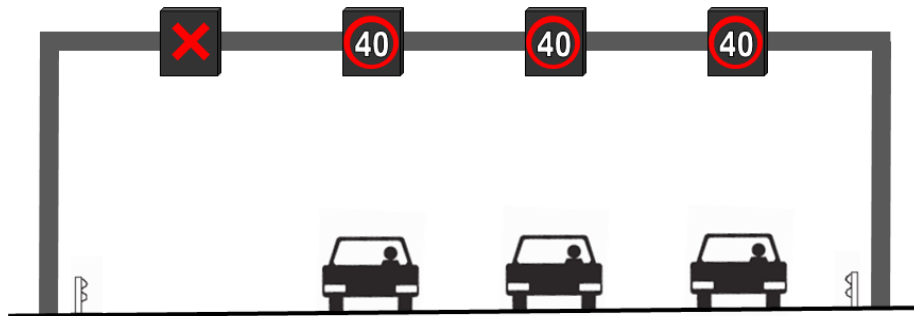


Figure 2-1: Integrated Speed and Lane Use Management Signs

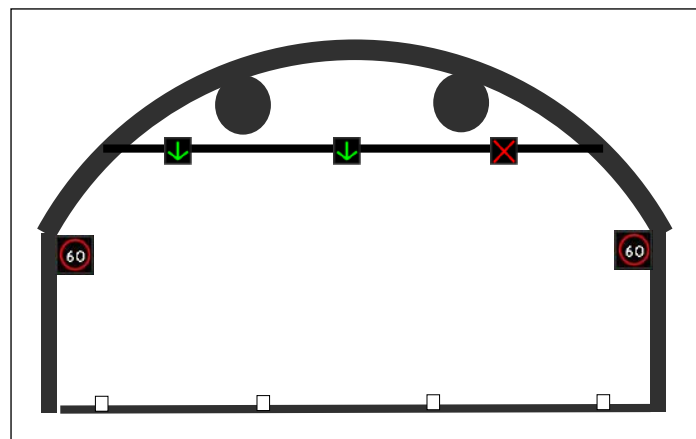


Figure 2-2: Lane Control Signals in an Existing Tunnel with Headroom Limitations

2.2. Integrated Lane Use and Speed Management

The use of integrated lane use signs (LUS) to allocate available road space with speed limit signs to manage speeds provides a clear and efficient means of managing traffic.

The signs are used to manage an incident or roadworks site in a similar manner to static signs. Figure 2-3 shows a typical layout of lane use signs for an incident and compares the LUMS layout with the components of a typical worksite to demonstrate the principles and similarities.

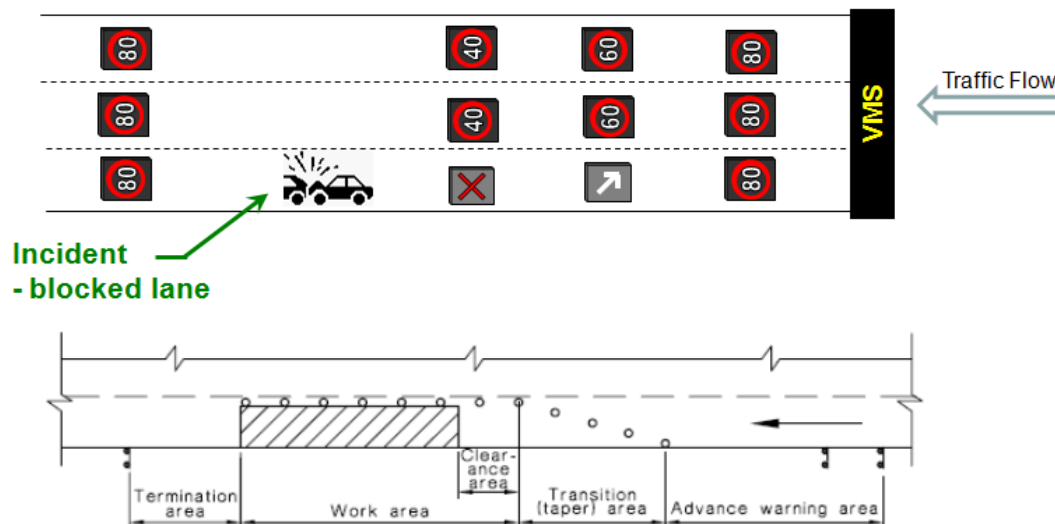


Figure 2-3: Comparison of LUMS with Typical Worksite Traffic Management

During an incident, STREAMS automates traffic management according to traffic management practices and operating principles which are classified as fundamental rules (not to be broken) and policy rules (may be changed by the operator). The principles are generally consistent with traffic engineering and work-site practices and guidelines including AS 1742.3 Traffic Control Devices for Works on Roads, Road Rules-Victoria and the Code of Practice for Worksite Safety – Traffic Management.

2.3. Lane Use Signs

Lane use signs (LUS) are part of the lane use management system to manage speed and lane use during planned and unplanned events. The LUS displays speed limits and symbols using LED pixels arranged in both full matrix and pre-formed shapes. LUSs are traffic control devices and have a regulatory function.

The speed limit sign displays generally comply with the requirements of Rule 21 part 3 and Rule 316, part 5 of Road Rules-Victoria and relevant sections of AS 1742, AS 1743 and AS 1744. It is accepted that due to the 'flaring' of illuminated displays, the widths of the numerals and the annulus may be slightly different than that provided on a static sign.

The lane use sign complies with Rule 329 (traffic control device applying to a marked lane) if it is above the marked lane and Rule 152 (obeying overhead lane control devices applying to marked lanes). In the context of a managed freeway this includes as follows:

- Red diagonal cross: Drivers must not drive in that lane.
- White or green arrow (pointing downwards or indicating one or more directions): Drivers may use the lane. White arrows are used in integrated lane use signs (LUS) while lane control signals (LCS) generally use green arrows.

Note:

Road Rules-Victoria indicates a flashing red diagonal cross indicates that drivers must leave the lane as soon as safe to do so. The use of an angled arrow on a LUS is preferred as it provides improved instruction and guidance relating to the direction in which a driver should change lanes.

The LUS display face consists of the following:

- A display area consisting of a white full matrix LED section to display numbers or special lane use arrows.
- A display consisting of red LEDs to display a red cross or red annulus.



The sign display face and symbols provide flexibility for various applications including the ability to be flashed. Flashing conspicuity lamps in the corners of the signs are used by some road authorities.

2.3.1. Lane Use Sign Display Components

Speed Limits





The lane use sign (LUS) display face consists of white numerals on a full matrix display centrally located within a red annulus on a black background to display Regulatory Sign R4-1.

The speed limit display with steady red annulus indicates the lane is open for use at the normal (default) speed limit. When a reduced speed limit is applicable the inner part of the red annulus flashes. Where multiple LUSs are on the same gantry, all flashing red annuli shall be in phase.

Description	Speed Limit
Speed limit sign (R4-1). Displays numerals up to 100 km/h in increments of 10.	 

White Arrows

The sign displays white 'merge' arrow symbols on the internal white LED matrix. These arrow symbols span the full height and width of the white LED matrix. The arrow symbols should have the ability to be flashed. However, current VicRoads practice is to display arrows in solid state. As a minimum, the sign is able to display the following arrow symbols:

Description	Symbol
Merge left	
Merge right	
Down arrow (may be used in tunnel applications)	
Traffic in the lane to use the exit ramp	

Red Cross

To close a lane the sign is able to display a single red cross. The red cross has the capability of being flashed to indicate a driver should leave the lane as soon as it is safe to do so. However, current VicRoads practice is to use merge left or right arrows for this instruction.

Description	Symbol
Lane closed	

2.3.2. Sign Size






The size of LUS are determined by the size of the speed limit signs applicable to the default speed limit for the freeway section.

- < 90 km/h speed limit: 'B' size signs (600 mm wide).
- ≥ 90km/h speed limit: 'C' size signs (900 mm wide).

2.4. Lane Control Signals in Tunnels with Limited Headroom

2.4.1. Displays

Where vertical clearances restrict the installation of Lane Use Signs, Lane Control Signals with reduced functionality may be used for lane control. The displays should have the ability to be flashed.

Description	Symbol
Merge left	
Merge right	
Down arrow <ul style="list-style-type: none"> • Green: current practice • White: may be considered for future use (consistent with LCS) 	 or 
Lane closed	

2.4.2. Signal Size

The desirable size of lane control signals in tunnels with limited vertical clearance (where VSL signs are side mounted) is 300 mm (200 mm minimum). A black background is desirable to assist with conspicuity of the signals.

2.5. Standards and Design Principles

Lane Use Signs are mounted centrally over each lane on gantries or bridges to manage each lane of the roadway. An example is shown in Figure 2-4.



Figure 2-4: Example of Gantry Mounted Lane Control Signs

The gantry girder should preferably be horizontal above the roadway. If an angled gantry girder is provided, i.e., generally parallel to the crossfall, the sign edges are to be horizontal/vertical.

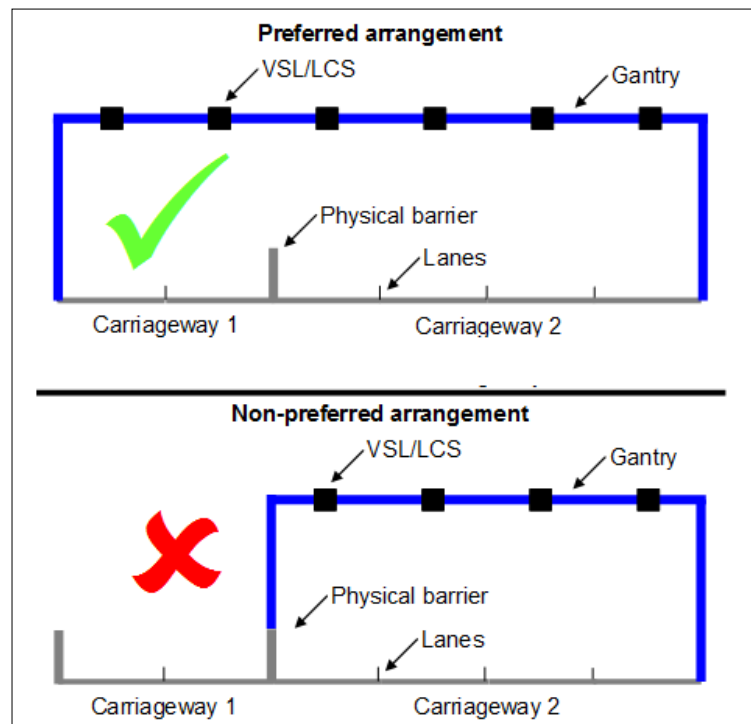
Gantries spanning the whole freeway may be appropriate if a single span is desirable for aesthetic reasons or if a narrow median restricts gantry leg installation.

Gantries spanning each carriageway separately may be appropriate where pavement crossfall (generally on a curve) affects the mounting height of signs with a single span across the freeway. Gantries for the different directions of traffic flow do not need to be positioned at the same location for each carriageway.

The following normal vertical clearances to the structure and signs are provided for the road function and traffic.

- Minimum clearance of 5.4 m for freeways.
- Minimum clearance of 6.0 m for O-D routes.
- Mounting height of signs for visibility through the windscreen and for maintenance access to the sign, preferably a maximum of 8 m.

Where collector-distributor roads are provided adjacent to the main freeway carriageway, consideration needs to be given to the location of the LUS to minimise driver confusion. Where LUSs are in place for one carriageway and are visible from the collector-distributor carriageway, LUS should be installed across both carriageways at the same longitudinal position to avoid potential driver confusion as shown in Figure 2.5.



Source: Green and Pyta (2007)

Figure 2.5: Gantry Arrangement for Adjacent Collector-Distributor Carriageway

The horizontal clearances for gantry legs should be designed for the required clear zone distance or shielded behind safety barriers (refer VicRoads Supplement to the Austroads Guide to Road Design Part 6 - Roadside Design, Safety and Barriers).

Gantry location design also needs to consider the provision of access to the gantry controller cabinet. This includes provision for a maintenance vehicle, e.g., an indent and hard stand area or access behind a barrier as well as the safety of maintenance personnel in relation to freeway traffic.

Note:

VicRoads LUMS gantries are generally non-accessible and require an appropriate maintenance regime of signs with a bucket truck that is undertaken with minimal impact on traffic operation, i.e., generally at night.

Gantry designs which are accessible for maintenance of the signs require larger structures and have a higher whole of life cost. Front or rear access to signs will influence the design of the gantry.

2.5.1. Design Sequence

The design hierarchy for placement of LUMS gantries in relation to other signage are as follows:

- Direction sign locations have the highest priority and should be positioned in the design first.
- LUMS gantries are to be located within the direction sign layout. The typical design sequence for the LUMS gantries is to:
 - position gantries in the vicinity of interchanges; and
 - consider the midblock sections between interchanges.

VMS sign locations would then be determined based on the principles in Section 4.5.3.

2.5.2. Location and Spacing of Gantries near Interchanges

A schematic layout of gantry locations at an interchange in relation to the exit and entry ramps and other signage is shown in Figure 2-6.

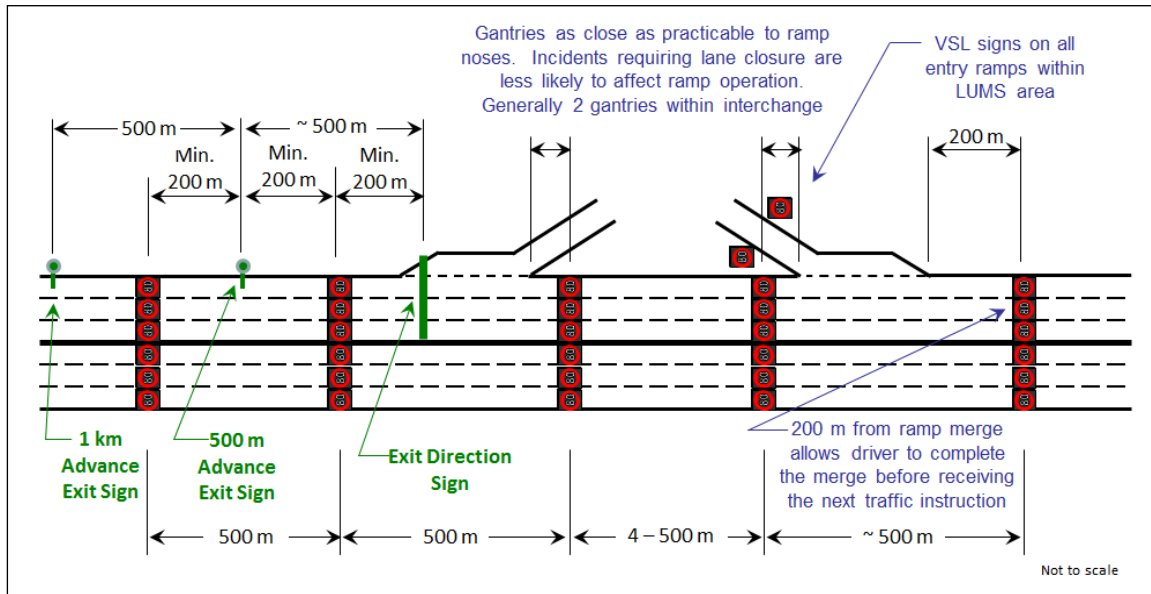


Figure 2-6: Schematic Layout of LUMS Gantries at an Interchange

2.5.3. Longitudinal Gantry Spacing between Interchanges

The spacing between LUMS gantries should typically be 500 m in areas of high activity within a desirable range of between 400 m (minimum) to 600 m (maximum). A summary of the rationale is provided in the Note below.

Where significant practical difficulties restrict the above spacing at a particular location, a spacing up to 800 m may be used for that location. However, this spacing should not be continued to provide a series of widely spaced gantries.

The general minimum spacing relative to other signs, e.g., static direction signs is 200 m. It is desirable to avoid installing direction signs on a LUMS gantry. This should only be considered where geometric constraints exist. Other design considerations relating to gantry locations include:

- interchange spacing;
- proximity relative to other driving decisions, e.g., LUMS is generally undesirable in the vicinity of a taper, lane gain, etc.;
- sight distance to signs clear of visibility restrictions; and
- potential for use of existing bridges.

Mounting LUS signs on other infrastructure to make use of existing overhead structures, e.g., bridges or pedestrian overpasses, rather than the use of an exclusive gantry may be considered. The general principles are as follows:

- Mount signs perpendicular to the direction of travel if the structure is skewed and minimise longitudinal offset between adjacent lanes - Figure 2-7.
- Mount signs centrally over each lane with the sign face perpendicular to the traffic lane and the sign sides horizontal/vertical, i.e., not parallel with the structure.
- Vertical clearances to the structure and sign must match the heights specified in Section 2.5.
- Protected signs from vandalism if necessary.

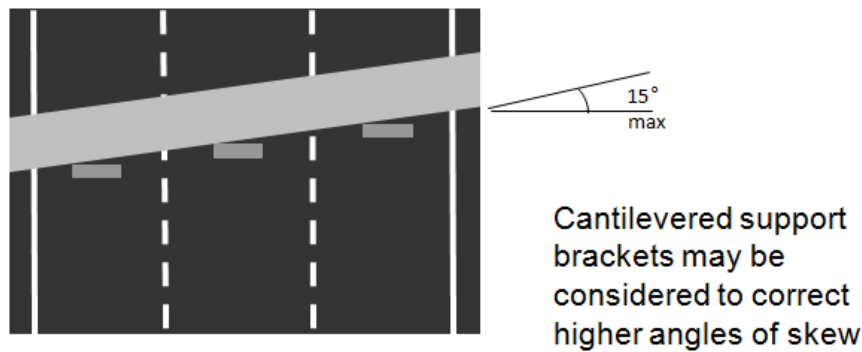


Figure 2-7: Overhead Mounted VSL / LUSs on an Overhead Bridge / Structure

Note:

In determining the requirements for longitudinal spacing of LUMS gantries the following principles have been considered:

- Travel time between gantries. It is desirable for drivers to see a sign at least every 30 seconds to retain lane status information, i.e., travel time within a desirable range of short-term memory retention.
 - At various speed limit values the travel distance in 30 sec. travel time is:
 - at 100 km/h: 833 m (default speed limit);
 - at 80 km/h: 667 m (default speed limit); and
 - at 40 km/h: 333 m (incident speed limit).
- The distance over which transitions occur during incidents:
 - Speed limit reductions from default to 40 km/h requires 2 or 3 steps (more than 2 closed lanes with up to 3 times the gantry spacing distance).
 - Lane closures with sequential lane reductions may take a distance up to 4 gantries for a 5 lane carriageway.
- During degraded operation, e.g., if a sign array is not working, the distance becomes significantly greater for lane or speed reductions.

2.5.4. Longitudinal Position of Lane Control Signals in Tunnels

Tunnels represent a constrained road environment with restrictions due to vertical and horizontal alignment. It may also be necessary to use smaller lane control signals (LCS) with less visibility due to the vertical clearances.

The desirable spacing of LCSs in tunnels enables drivers to always see a signal array. The spacing is also related to the legibility distance for signal size. Typically LCS spacing in tunnels is in the order of 100 to 200 m.

2.6. Operating Principles

The operation of the LUMS is based on a number of operating principles that control the sign operation as well as the setting up of traffic management arrangements for speed and lane management to control and direct traffic in an incident.

2.6.1. Fundamental Rules Preventing Conflicting Symbols

Fundamental rules coded into the control system provide interlocks that will prevent the display of particular combinations of symbols on adjacent LUSs over a single carriageway. These interlocks prevent the display of symbol combinations that are hazardous, logically conflicting or ambiguous. Examples of LUMS fundamental rules to prevent various sign arrangements are shown in Figure 2-8:


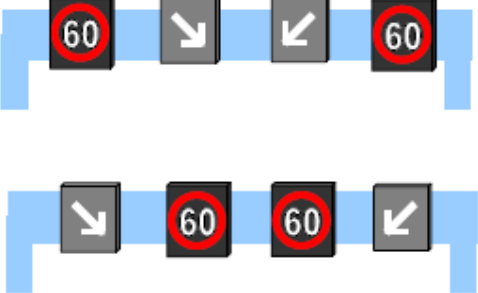




RULE	PREVENTED DISPLAY
No differential speed limit at one site	
Merge arrows cannot point toward each other within one site	
Lane merge signal cannot point towards a closed lane	
Lane merge signal cannot point into side barrier or emergency stopping lane	
One blank sign requires whole site to be blank	
'Exit Only' signal must only be used on furthest trafficable outside lane	

Figure 2-8: LUMS Fundamental Rules preventing Sign Conflicts

2.6.2. Policy Rules for Managing Traffic

Policy rules are used for setting up a traffic management plan when an incident or other event occurs. The policy rules enable an automated response to the event that can be quickly implemented by the operator. Alternatively the operator may modify the traffic management arrangements then implement a revised arrangement. The operational policy rules generally replace requirements for a significant number of pre-determined traffic management plans for various scenarios. The automated system simplifies and speeds up traffic control implementation when an incident occurs. In some complex traffic arrangements some adjustments to traffic plans may be needed.

The policy rules summarising operating principles, rules and layouts of typical operating arrangements for lane control, variable speed limits and closures are in Appendix A.

2.7. LUMS Integration with Other Freeway Devices

2.7.1. Variable Message Signs

Upstream variable message signs become part of an event response to provide advance information to motorists. This may include the nature of the event, advice about a lower speed limit or lane closure or status as well as action in regard to changing lanes etc.

An example of LUMS and VMS operation during an emergency maintenance event is in Figure 2-9. The VMS message needs to match the event description and LUMS arrangement to be part of the integrated response. Further information relating to VMS messages and traveller information for incidents is in Chapter 4.

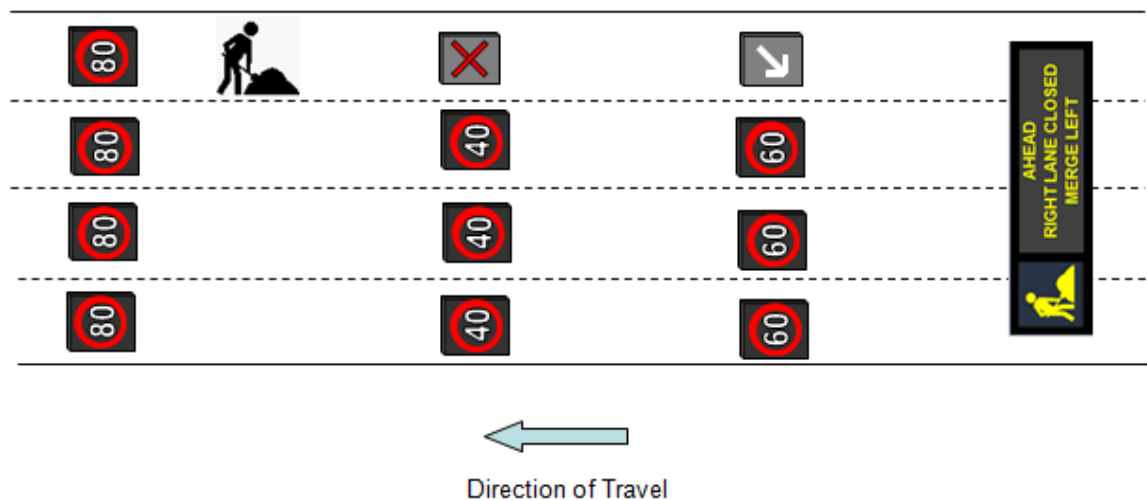


Figure 2-9: LUMS – VMS Event Management Integration

2.7.2. Real Time Information Signs

Traveller information generally associated with the ramp signals such as Real Time Information Signs (RTIS) may also be activated to provide a relevant incident message, e.g., Left Lane Closed as shown in Figure 2-10. The display of the RTIS message is automated to match the LUMS arrangement to be part of the integrated incident response. Other examples of RTIS integration for incident management are in Section 4.8.5.

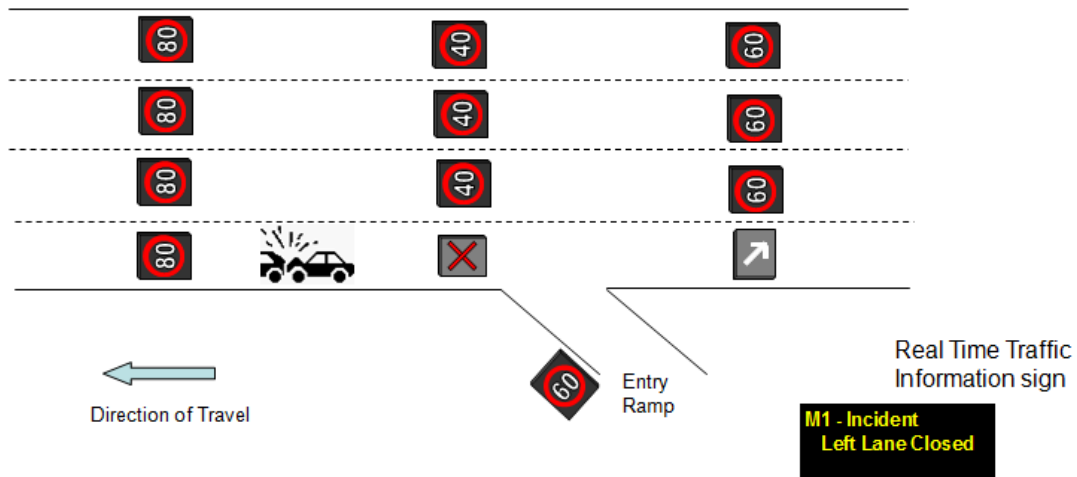


Figure 2-10: Real Time Information Sign supporting LUMS Traffic Management

2.8. Operational Integration with Ramp Signals

Operational integration of ramp signalling equipment with the lane use management system and traffic management during incidents is essential for efficient and effective freeway traffic management. Various applications are summarised in the following sections.

2.8.1. Ramp Signals Response to a Lane Closure

A lane closure activated by the lane use management system restricts the number of lanes for the traffic flow. When an incident results in a lane closure, this induces a significant bottleneck that would generally have a major adverse impact on flow. Lane closures of this nature are random and variable in relation to usual bottlenecks within the set up of the freeway ramp signals.

When a lane closure occurs, the freeway management system provides the number of lanes available at a location relative to the number of lanes normally available. The lane closure situation is addressed within the control algorithm to determine the critical bottleneck from a number of potential downstream bottlenecks. The multiple bottleneck capability within the algorithm will automatically evaluate the critical flow conditions and regulate the ramp access accordingly.

2.8.2. Ramp Signals Response to Changing Speed Limits

Freeway ramp signals switch on and off automatically within thresholds based on freeway flow, travel speed and occupancy. When the freeway speed limit is reduced by a variable speed limit system, the ramp signals could activate unnecessarily under fixed value activating parameters.

In a managed freeway, a variable speed limit lower than the default speed may be activated in concert with LUMS or for other reasons, e.g., high winds on a bridge. The lower travel speed of traffic affects pre-set values for activation and deactivation of the freeway ramp signals. To ensure that ramp metering is not falsely triggered by a speed limit lower than the default limit, the freeway management system provides the current speed limit value for calculations associated with the ramp signals.

2.8.3. Ramp Signals Response to a Freeway Closure

When an event requires a ramp closure, either of the ramp or the downstream section of freeway, the following operation will occur as outlined in the Managed Freeways: Freeway Ramp Signals Handbook:

- The Ramp Control Signs (Sign Ref. No. RC1) will display a FREEWAY CLOSED message alternating with a symbolic No Right Turn / No Left Turn / No Entry sign as appropriate.
- The Real Time Information Signs (Sign Ref. No. RC3) will display the appropriate freeway closed message as outlined in Section 4.8.

- The freeway ramp signals will switch off by initiating the usual close-down sequence. Switching off the signals enables vehicles already on the ramp to clear so that an emergency vehicle can enter, if necessary. Switching the signals off also avoids vehicles being trapped on the ramp. Further entry of vehicles is restricted by the RC1 and RC3 signs.

The ramp closure operation may be activated manually or automatically as part of an incident response. Reopening of the ramp may also be initiated manually or automatically when there is no longer a need for the closure. When the freeway ramp is reopened to traffic the system would return to default ramp operation, i.e., subject to traffic needs at the time, the ramp signals may or may not switch on.

2.8.4. Emergency Vehicle Access when Ramp Signals are Operating

The queues at ramp signals may present problems for emergency vehicle access during an incident where the ramp is not closed as part of the incident response. Where an emergency vehicle requires access at a particular ramp, the emergency service will advise the Traffic Management Centre (TMC) of the route being taken. Where incidents are being managed by a toll-road operator liaison with the TMC could initiate a required action.

To provide uninterrupted access for the emergency vehicle the TMC operator will take the following actions to:

- manually turn off the ramp signals at the applicable ramp to clear the ramp queue; and
- after entry of the emergency vehicle, re-enable the ramp signals so that mainline traffic management continues.

2.9. Incident Management with CCTV Cameras

An actively managed freeway requires full CCTV coverage with pan/tilt/zoom camera capability for traffic monitoring operations as well as assisting in lane use and incident management. CCTV is also essential for monitoring the ramp signals' operations including fine tuning and day to day monitoring of ramp queues, driver behaviour and identification of operational issues. Separate cameras are generally required for mainline monitoring and monitoring of the ramp signalling.

The aim of positioning CCTV cameras is to achieve full overlapping coverage of both freeway carriageways as shown in the schematic diagram in Figure 2-11. The overlapping coverage enables appropriate:

- verification of an incident;
- viewing and observation of incidents from two directions;
- use of separate cameras for simultaneous incident management and observation of general traffic operation upstream of the incident; and
- allowance for redundancy, e.g. malfunctioning.

In complex or incident critical areas where a higher level of monitoring is required, consideration may also need to be given to installing sufficient cameras to provide full time 100% coverage of the road so that when PTZ cameras are in their default position, all parts of the road can be viewed. This will assist with rapid incident detection.

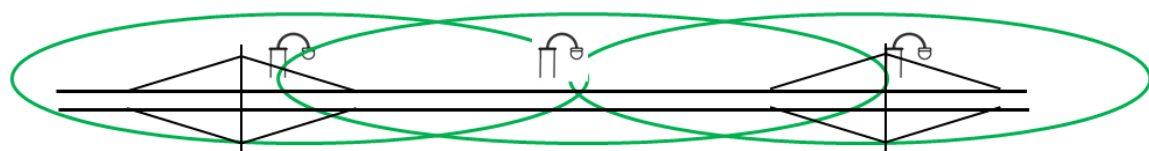


Figure 2-11: Desirable Overlapping CCTV Coverage

Camera locations need to be designed to maximise coverage of the roadway. The design process for positioning of CCTV cameras should be considered as follows:

- Horizontal and vertical alignment, including:
 - positioning on the outside of curves; and
 - positioning on top of crests.
- Avoiding visibility problems with sight lines obscured by bridges, direction signs, LUMS gantries, trees and other obstructions.

Subject to the above constraints, the spacing of CCTV cameras is typically:

- 500 m spacing for complex areas or curved alignments; and
- 1 km spacing for straight alignments.

Cameras may be installed on existing structures or camera poles. Camera poles need to be installed either outside the clear zone or be shielded with a safety barrier.

2.10. Trafficking of Emergency Stopping Lanes

The Road Safety Road Rules (Rule 95) indicates that a driver must not drive in an Emergency Stopping Lane (ESL) unless:

- (a) the driver needs to drive in the emergency stopping lane to avoid a collision, to stop in the lane, or because the driver's vehicle is disabled; or
- (b) information on or with a traffic sign applying to the length of road indicates that a particular class of vehicle may drive in the emergency stopping lane and the driver is driving a vehicle of that class.

The trafficking of Emergency Stopping Lanes (freeway shoulders) may be considered where congestion is causing operational problems and delays for public transport (buses and taxis), or where best use of the infrastructure is required to improve freeway capacity.

Note: Trafficking of ESLs is currently under review by VicRoads

2.10.1. Part-time Treatment

Public Transport

Part-time use of the ESL may be considered to improve the operation of buses and taxis, typically during peak periods. In such circumstances, special signage as shown in Figure 2-12 is used. Applicable times and/or advisory speed information may also be displayed.



Figure 2-12: Example of Signs for Public Transport Part-time ESL Use

The part-time use of the ESL for traffic can be problematic, particularly at exit and entry ramps. When used by public transport, special line marking is used to merge vehicles back into the left general traffic lane prior to an exit. The Traffic Engineering Manual Volume 2: Signs and Markings (Chapter 12) provides further information.

General Traffic

Part time use of the ESL may be considered to achieve an additional general traffic lane on the freeway.

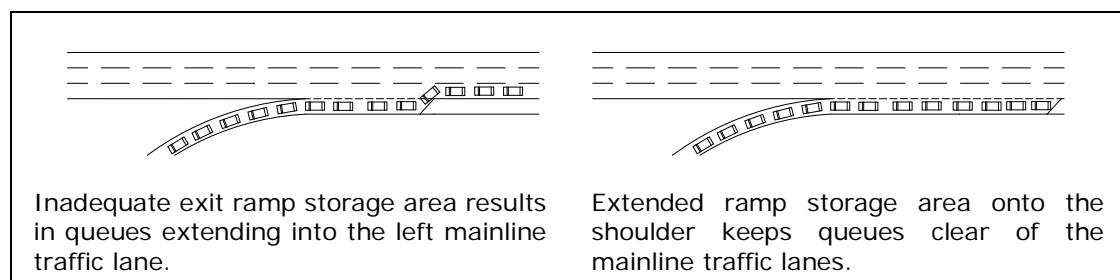
However part-time use of the ESL may create operational issues across ramp exits and entrances unless special linemarking is provided. This part-time operation would also generally require inspections prior to reopening each day to ensure the lane is free of obstacles. For these reasons part-time use of ESLs in Victoria has generally not been adopted in the past to provide additional capacity. When additional capacity has been needed and widening has not been cost-effective, the ESL has been replaced with a full-time traffic lane to make permanent use of the full roadway width.

When an ESL is trafficked for fixed times of the day or used by specific classes of vehicles, this can be indicated by static signs.

Exit Ramp Queuing

The use of the ESL may need to be given consideration where a queue extends from an exit ramp into the through lane. This operational problem may be due to a short ramp or an interchange with inadequate capacity.

To address this problem consideration can be given to permanent or part-time lengthening of the exit lane storage into the shoulder area to allow vehicles to queue clear of the through lanes as shown in Figure 2.13.

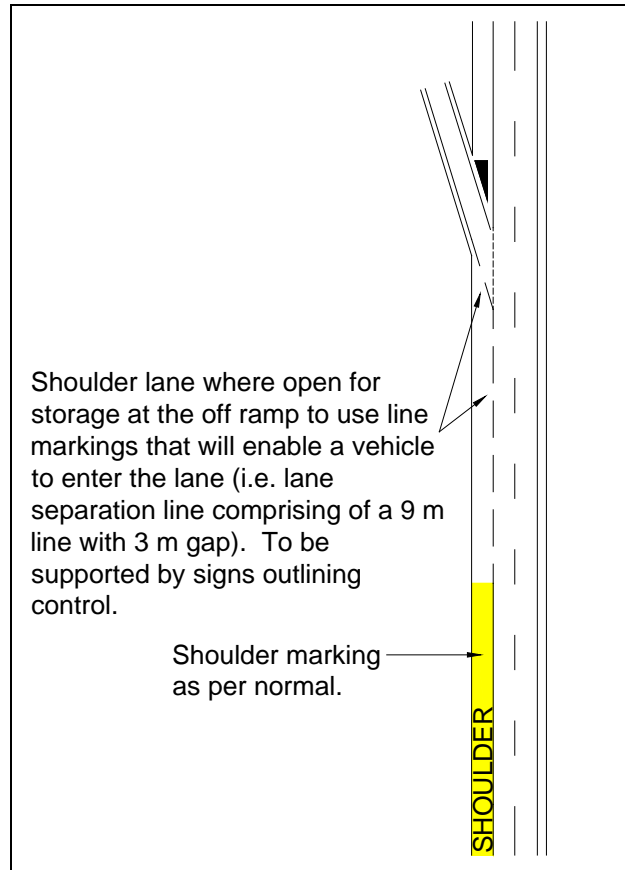


Source: Adapted from Booz Allen Hamilton (2003)

Figure 2.13: Extension of Exit Ramp Storage using the Shoulder

To address this problem with a permanent treatment, subject to the extent of the problem, consideration could be given to an exit taper in the form of a rural 'step out' exit ramp marking (refer Traffic Engineering Manual Volume 2: Signs and Markings - Chapter 12). Additional length may be necessary in some instances.

To address this problem with a part-time treatment, lengthening the exit lane into the ESL area to allow vehicles to queue clear of the through lanes could be considered as shown in Figure 2.14. Depending on the desired operation, the traffic arrangements could either be communicated to motorists via static signage indicating the peak period times of operation (minimum required) or dynamic signage (preferred). Dynamic signage allows for easy future expansion of the operating times as well as automated operation that would activate by the use of queue detection as necessary (preferred). A narrow painted separator between the queuing traffic and the mainline freeway could also be implemented to provide additional clearance and safety as well as to discourage entry during the non-permitted period.



Source: Austroads (2009b)

Figure 2.14: Part-Time use of ESL to Provide Exit Ramp Queue Storage

2.10.2. Permanent Treatment

A permanent use of the ESL area may be appropriate where widening is not feasible or desirable to increase capacity. The provision of an additional though lane may also need to be considered in the context of balancing capacity along the route and adjacent sections of freeway.

The permanent use of the ESL requires the lane to be converted to a permanent vehicle lane with the same surface and lane markings. This may be provided over a significant length of the freeway or between interchanges where the ESL is used as an auxiliary lane between the entry and exit lanes.

2.10.3. Issues to Consider

Under either part-time or full-time use of the ESL for general traffic, the matters that may need to be considered are as follows:

- Pavement depth and strength.
- Clearance from the edge of lane to structures and safety barriers.
- Possible adjustment of lane widths to reallocate road space.
- Provision of a lane use management system to actively manage safety risks and incidents.
- Provision of a lower speed limit or a variable speed limit system. This is generally desirable to actively manage narrower lane widths, safety risks and incidents. However, community acceptance of a low speed limit on what is otherwise a high standard alignment can be problematic.
- Provision of mainline VMS to desirably manage safety risks and incidents actively.
- Removal / modification of special surfacing or pavement markings.
- Sight distance for the operating speed, particularly on curves.

- Provision of emergency stopping bays (refer Section 2.10.4).
- Improved incident management to identify stopped vehicles or debris in the lane as well as faster incident response times, e.g., typical response targets include:
 - Attend 80% within 10 minutes of notification;
 - Clearance target 50% within 10 minutes of notification; and
 - Additional access (cross median or from local road network) is desirable.
- Access along the freeway for emergency vehicles.
- Detectors in trafficked left lane for managing flow and for traffic analysis / counting.
- CCTV coverage.

For part-time use additional matters that may need to be considered are as follows:

- Potential for more operational issues compared with full time use (i.e. no ESL).
- Appropriate signing and pavement marking, including:
 - provision of Lane Use Signs or Lane Control Signals over the ESL;
 - a continuous line should not be used as a lane line that can be crossed – consider a 9/3 pattern or an 11/1 pattern (150 mm wide); and
 - How to manage the lane through interchanges (options for exclusive exit lane or dynamic line marking).
- Integration of lane use with the ramp signalling system regarding the number of lanes available for through traffic.
- Need for physical patrolling or inspection of the ESL with CCTV before opening to traffic to ensure the lane is clear of stopped vehicles or debris.

2.10.4. Emergency Stopping Bays

On freeways where there is no ESL for emergency use, emergency stopping bays (ESB) need to be provided along the route to store vehicles clear of the trafficable lanes in the event of an emergency (tunnels require further consideration due to possible width constraints). ESBs are also highly desirable in case of part-time use of the ESL, especially if there is no trafficable area beyond the edge of the ESL for vehicles to use.

Emergency stopping bays replacing a continuous ESL need to be as extensive as practicable within the width and alignment available. The following general guidelines outline the provision and design of ESBs:

- The desirable spacing is 400 to 500 m (max. 1000 m).
- Locations are preferably separated from entry ramp merge areas and exit ramp diverge areas to avoid confusion in these manoeuvring areas.
- Locations should satisfy minimum sight distance requirements.
- The width of the parallel storage area should be a minimum of 3 m wide (desirable 3.5 to 4 m) from the edge of the traffic lane and preferably wider if adjacent to a safety barrier.
- The desirable minimum length of the storage area is to store a heavy vehicle plus a response or enforcement vehicle clear of the trafficable lane, e.g., a minimum 40 m long parallel storage area (25 m B-double plus an additional 15 m for another vehicle).
- The desirable provision of deceleration distance within the length of the ESB for a vehicle to stop from the freeway operating speed (by using the entry taper and storage area to decelerate).
- The desirable provision of acceleration distance / taper for a vehicle to re-join the traffic stream, although this may not be viable for some locations.

Provisions within emergency stopping bays include:

- an emergency help phone;
- information signing to enable users to identify their location when contacting the TMC or an emergency vehicle operator;
- CCTV coverage so that the TMC can monitor activity and take appropriate action; and
- Vehicle detectors to alert the TMC when a vehicle has entered the emergency area.

Chapter 3

Variable Speed Limits

3. Variable Speed Limits

3.1. General Principles

Variable speed limit (VSL) systems on managed freeways operate to activate lower speed limits appropriate to the travelling conditions with the aim of improving road safety and traffic flow.

Conditions when VSL may be initiated can relate to congestion, an incident or other event, roadworks or environmental conditions such as high wind speeds affecting traffic operation on a bridge.

Improved safety by variable speed limits is achieved by:

- reducing the speed differential between vehicles;
- minimising the speed variations between aggressive and conservative drivers;
- minimising lane changing and braking caused by speed differential; and
- providing more homogeneous flow.

Reduced speed also improves safety by:

- increasing time for drivers to react to changing conditions;
- reducing the likelihood of an impact; and
- reducing the severity of a crash if an impact does occur.

3.2. VicRoads Speed Zoning Guidelines

Guidance relating to speed limits in Victoria, including speed limits on freeways is provided in the Austroads Guide to Traffic Management Parts 5 and 13, Austroads Guide to Road Safety Part 3 and VicRoads supplement to those guides in the Traffic Engineering Manual Volume 1: Traffic Management, Chapter 7, Speed Zoning Guidelines.

This handbook provides additional guidance in relation to the use of variable speed limits on managed freeways.

3.3. Benefits of VSL

The benefits of variable speed limits have been documented in a number of studies relating to road safety, the environment and traffic flow / capacity. While benefits relating to safety and the environment have are significantly clear, the impact on traffic flow and capacity are less conclusive.

The ARRB Research report 'Best Practice for Variable Speed Limits: Literature Review' (2009a) has summarised a number of studies relating to reported safety benefits of variable speed limits. The following sections briefly summarise various studies relating to VSL benefits. Specific emphasis and more detailed comments are provided in relation to the evaluation of studies on the potential for capacity and traffic flow improvements from VSL (Section 3.3.3).

3.3.1. Safety Benefits

Safety benefits are the principle benefits resulting from variable speed limits. The benefits of lower speed limits are particularly applicable during congestion and incidents. A summary of VSL safety benefits studies is provided in Table 3-1.

Studies	Safety Outcomes
1983 Dutch trial	15.6% accident reduction overall, 27% in heavily trafficked sections
Dutch project on A13	50% reduction in accidents
German applications	20 to 30% crash rate reduction
UK project on M4	30% crash rate reduction
UK project on M25	10% reduction in injury accidents
Crafrers Highway, Adelaide	24% crash reduction in first 12 months

Table 3-1: Summary of VSL Safety Benefit Studies

3.3.2. Environmental Benefits

The environmental benefits relating to emissions, fuel consumption and noise have been documented in various studies and a summary is provided in Table 3-2.

Studies	Environmental Outcomes
IH-35 Corridor in Austin Texas case study (Wang & Walton 2006)	10.8% daily reduction in NOx emissions on an Ozone Action Day
M25 study in the UK (Highways Agency 2004 and Harbord et al. ITS World Congress 2006)	Emissions decreased overall by between 2% and 8% Fuel consumption improved Weekday traffic noise adjacent to the roadway reduced by 0.7 decibels (J15-16) and up to 2.3 decibels (J12-14)

Table 3-2: Summary of VSL Environmental Benefit Studies

3.3.3. Capacity and Traffic Flow Benefits

The VSL benefits relating to capacity and traffic flow have been documented in various studies and a summary is provided in Table 3-3.

Studies	Capacity and Traffic Flow Outcomes
A9 Freeway Germany (Brilon 2005)	3% flow increase
Dutch trial 1980s (Klijnhout 1984)	Traffic flow past bottlenecks increased by 4-5% Number and severity of shock waves also decreased
Dutch trial 1992 (Smulders 1994)	Average speed – small decrease. Number and severity of shock waves – decreased. Short headways – decreased. Speed variations between lanes – decreased. Throughput – no increase.
A13 EB Rotterdam to The Hague Holland (Department of Public Works Management 2003)	3% flow increase
M25 in the UK (Harbord et al. ITS World Congress 2006, and Highways Agency 2004)	J15-16 CM section: 5% increase in throughput over 5-hour peak periods. J10-15: reduction in AM peak shock waves from 7 to 5 due to smooth driving behaviour
M42 in the UK (Harbord et al. ITS World Congress 2006)	J3A to 7 section: potential to increase flow capacity inconclusive – some locations slight increase while at other locations no increase
A12 Motorway in the Netherlands	More even lane distribution with higher flow in the outer

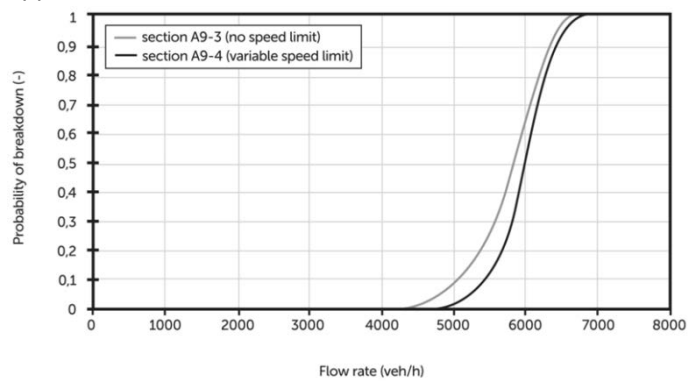
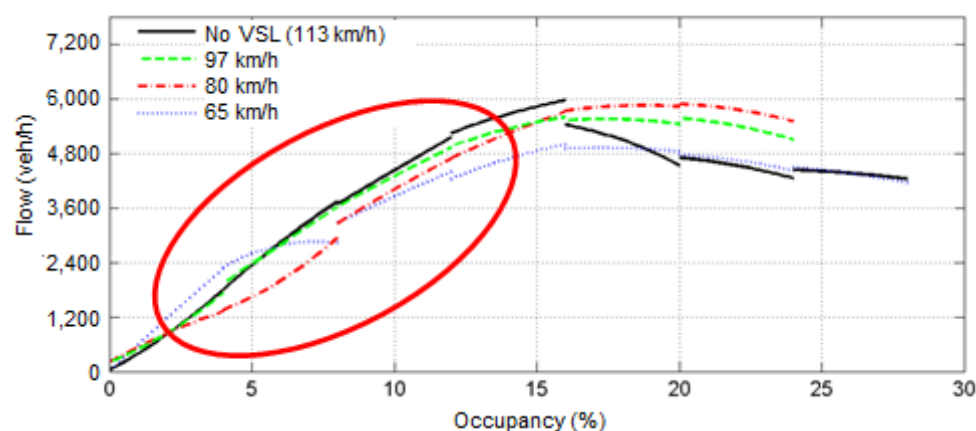
Studies	Capacity and Traffic Flow Outcomes
– 60 km/h VSL (Knoop et al. 2010)	lane. May increase capacity but also increase merge difficulties at ramps, i.e., due to smaller gaps.
A7 Motorway France (Serti 2006)	10% increase in peak period flows and 16% reduction in congestion by reducing speeds from 130 km/h to 110 and 90 km/h
German 3-lane freeways (Brilon 2005)	5 minute counts over several months indicated a reduced probability of flow breakdown with VSL as shown in the graph below, e.g., at 6,000 veh/h the probability of flow breakdown reduces by 10% from approx. 60% to 50% with VSL. 
European motorway which is understood to be the M42 in the UK (Papageorgiou, et al 2008)	Study focussed on aggregate traffic flow behaviour and observed a change in the shape of the flow-occupancy fundamental diagram. Different outcomes were observed relative to under-critical densities and over-critical densities and further discussion on these outcomes is provided in Sections 3.3.3.1 and 3.3.3.2 below.

Table 3-3: Summary of VSL Capacity and Traffic Flow Benefit Studies

3.3.3.1. Flow Impacts at Under-Critical Densities

The traffic flow impacts investigated by Papageorgiou et al (2008) on a European motorway were shown by presentation of data in 'fundamental diagrams' indicating the relationship between flow and occupancy. A typical example of the flow-occupancy diagrams from the study is shown in Figure 3-1.



Source: Papageorgiou M (2008)
(Speeds shown in km/h)

Figure 3-1: Flow-Occupancy Diagram Example for Under-Critical Densities

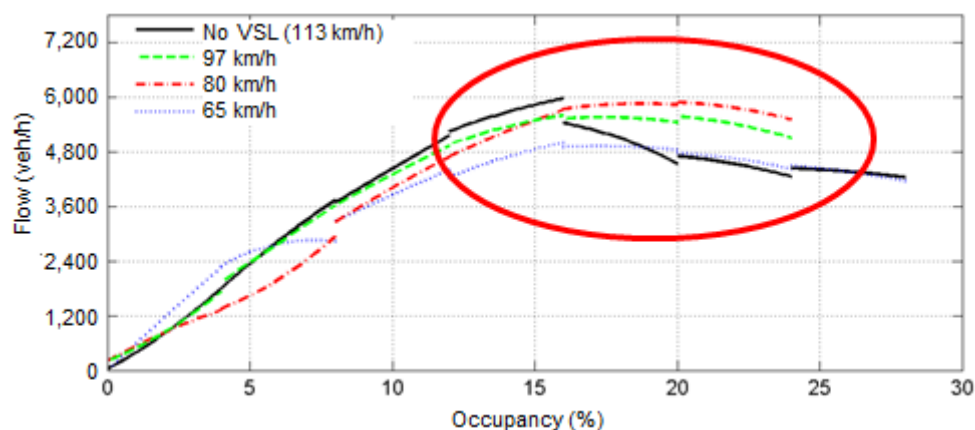
The following conclusions relating to VSL outcomes at under-critical densities can be drawn from the study:

- Lower variable speed limits shift and flatten the slope of the flow-occupancy diagram (i.e., the lower speed limits shifts the occupancy to higher values at the same flows).
- There is an adverse impact on traffic efficiency (i.e. the VSL increases travel time).

Other adverse outcomes may be that some traffic is diverted away from using the freeway due to the restrictive speed limit.

3.3.3.2. Flow Impacts at Critical and Over-Critical Densities

The traffic flow impacts from the study data highlighting the critical and over-critical areas in the flow - occupancy diagram is shown in Figure 3-2.



Source: Papageorgiou M (2008)
(Speeds shown in km/h)

Figure 3-2: Flow-Occupancy Diagram Example for Critical and Over-Critical Densities

The following conclusions relating to VSL outcomes at critical and over-critical densities can be drawn from the study:

- Variable speed limits shift the occupancy, including critical occupancy to higher values, i.e., a VSL may delay the onset of flow breakdown. However, the VSL generally has limited ability to prevent flow breakdown.
- Variable speed limits generally provide similar flows at higher occupancy values.
- At low variable speeds (refer blue line at 64 km/h in the study), variable speed limits may reduce maximum throughput.

The variable speed limit at critical levels of operation provides a reduction of speed differences between vehicles (i.e. the homogenisation of speeds, and this can result in an improvement in the stability of flow).

3.3.4. Conclusions and Summary of VSL Benefits

Available studies have shown that the operation of VSL can result in significant benefits, particularly in relation to road safety. Some studies also raise concerns about the impact of VSL on capacity and traffic flow. In the case of overseas studies, some of the motorways controlled with VSL are very high speed motorways (e.g., 130 km/h) or rural motorways and the applicability of these studies to urban Australian freeways is questionable. However, general conclusions relating to VSL benefits are summarised in Table 3-4.

Operational Criteria	Summary of VSL Outcomes
Safety benefits	Significant benefits of between 10% to 50% reduction in accidents
Environmental benefits	2% to 10% emissions reduction together with fuel and noise reductions
Capacity and traffic flow benefits	<ul style="list-style-type: none"> • VSL can have a stabilising affect on flow. • Increased flow is generally slight (typically up to 5%) and some studies are inconclusive. • VSL can reduce the potential for flow breakdown or delay flow breakdown. • VSL generally shifts the critical occupancy to higher values. • The timing of VSL activation is critical: <ul style="list-style-type: none"> ◦ Activation too early can adversely affect efficiency (travel time); ◦ Desirably activate when critical occupancy is reached.

Table 3-4: Summary of VSL Benefit Studies

The real data studies do not indicate conclusive outcomes relating to the impact of VSL on traffic flow capacity and most recent studies have only considered VSL operating in isolation (i.e. without operation of coordinated ramp signalling to optimise throughput and speed). The integration of ramp signalling with VSL further complicates the VSL relationship to traffic flow benefits. However, a study that simulated benefits of VSL operating with ramp signalling by Abdel-Aty et al (2009) indicated that at conditions approaching congestion, the combination of ramp metering and VSL produced the best benefits. The results illustrate the potential of combining ITS strategies to improve the safety and efficiency of urban freeways.

3.4. Overview of Devices and Standards

Variable speed limit signs are illuminated signs that comply with the format and colours specified for static speed limit signs with the speed limit value capable of being changed electronically.

Variable speed limit signs are similar to static R4-1 speed restriction signs but with illuminated white numerals in an illuminated red annulus on a black background in accordance with Road Rules – Victoria. Requirements for electronic, variable speed limit signs are set out in AS 1742.4.



Reduced speed limits (less than the default speed) use a continuously activated conspicuity function to attract driver attention where part of the annulus flashes to signify a speed limit reduction.

Note:

Some road authorities use alternating flashing yellow lights as conspicuity devices in the corners of the sign. This is not current VicRoads practice. A sign needs to comply substantially with the Road Rules. Conspicuity devices are considered a form of enhancement to the standard.

3.4.1. Sign Size

The size of the VSL signs are determined by the default speed limit applicable to the freeway section.

- < 90 km/h speed limit: 'B' size signs (600 mm wide)
- ≥ 90km/h speed limit: 'C' size signs (900 mm wide)

3.5. Design and Installation Principles

The design principles for VSL schemes are similar to the principles used for static speed limit signs. Signs are required at the start of the zone with repeater VSL signs within the variable zone. VSL signs are either side mounted or installed as part of a lane use management system (LUMS).

Where a section of freeway is controlled by variable speed limit signs the general principles are to provide:

- normal static speed limit signs at the start of the VSL zone. These signs indicate the default speed limit in the event of a sign 'black out' or VSL system failure. Repeater 'black out' static signs within the variable speed zone are generally not required unless a new default speed limit is applicable; and
- normal static speed limit signs at the end of the VSL zone, otherwise the last VSL sign continues to apply in the downstream non-VSL section of the freeway.

3.5.1. Longitudinal Spacing

The general principles for longitudinal design of signs for a VSL system are as follows:

- Where a VSL zone is part of a lane use management system (LUMS) reference should also be made to the principles in Section 2.5.
- VSL signs are located 200 m downstream of the end of the entry ramp merge taper (refer Figure 2-6).
- Urban freeways (VSL or combined VSL/LUS): Provide VSL signs typically at 500 m spacing (maximum 800 m). Some flexibility in location may be required relative to other infrastructure or road features, for example:
 - desirable 200 m separation from direction signs and VMS;
 - signs to have good sight distance, e.g., avoid visibility restrictions such as bridge piers/abutments, poles, vegetation etc.; and
 - Preferably avoid decision-making locations, e.g. near exit tapers, high weave areas etc.
- In tunnels the spacing of VSL is typically 500 m maximum.
- Within a section of freeway with VSL all entry ramps also require VSL signs. VSL signs on entry ramps are generally located 20 m upstream of the ramp nose, i.e., downstream of the ramp signals, as follows:
 - Left side for ramps merging to a single lane at the ramp nose.
 - Both sides of the ramp for ramps with two lanes at the ramp nose.
- On exit ramps appropriate static speed limit signs are provided on the approach to the arterial road intersection.

The general sequence for sign location design is as follows:

- Design locations near interchanges first, e.g., end of ramp merges and downstream of exit ramps.
- Then consider the infill spacing between interchanges.

3.5.2. Lateral Position of Signs

Side Mounted

Side mounted VSL signs are generally installed on 2B traffic signal pedestals as shown in Figure 3-3. As posts are roadside hazards, appropriate shielding with a safety barrier would normally be required. Signs may also be installed on suitably located structures. Side mounted VSL signs are generally installed on both sides of the mainline carriageway. Side mounted VSL signs are generally suitable for:

- carriageways up to 3-lanes wide. On 3-lane carriageways with a high percentage of trucks overhead mounting may be considered to alleviate visibility restrictions. Overhead mounting may also be appropriate if the freeway has a lane use management system, including a 2-lane collector-distributor road adjacent to a mainline carriageway with LUSs;
- entry ramps, downstream of the ramp signals as outlined above; and
- tunnels if vertical clearance is restricted.



Figure 3-3: Side Mounted VSL Signs

Overhead Mounted

Overhead mounted signs suspended above the roadway on gantries are more easily seen by motorists under heavy traffic conditions. Gantry mounted VSL signs are applicable for:

- carriageways with four or more lanes – generally part of a lane use management system as shown in Figure 3-4; and
- three-lane carriageways with:
 - a lane use management system; and
 - a high percentage of heavy vehicles. Using cantilevered supports may also be an option for improving visibility of signs.



Figure 3-4: Overhead Mounted VSL Signs within a Lane Use Management System

For guidance related to standards and design principles for overhead mounted VSL signs which are part of a lane use management system installation, refer to Section 2.5.

3.6. Overview of VSL Operation

The modes of VSL initiation and operation within an integrated system need to vary according to the nature of the circumstances requiring the VSL activation. A hierarchy of control for initiating VSL within the VSL system needs to ensure that a speed limit can operate independently to address specific traffic management needs. For example, during an event (incident, high winds, roadworks or planned event), the VSL needs to be able to activate independently to manage safety. However, under free-flow conditions the VSL would not activate until initiated by the system to improve the ability to manage flow and efficiency.

3.6.1. Speed Limit Operation during Incident Situations

During incidents requiring a lane closure or traffic diversion the speed limit is generally reduced to improve safety for the lane changing manoeuvres as well as safety at the incident site for the benefit of workers, incident victims and the travelling public. The lower operating speeds also assist in managing safety within congested sections of the freeway and in minimising the potential for secondary incidents. A speed limit reduction may also be initiated due to high winds in some locations, or planned roadworks or event.

On the occasion of an incident or other need for speed limit reduction, the VSL needs to be determined to suit the traffic management needs associated with managing the event, e.g., via the lane use management system (LUMS). VSL operation during this period may also need to address the results of congestion.

Under the circumstances where the VSL is activated by an incident, the coordinated ramp signalling will generally operate independently (unless a ramp or freeway closure is required), to manage the congestion and to facilitate flow recovery.

Operational Principles

The operating principles for VSL displays that function as part of the lane use management system are outlined in Section 2.6. The general principles are as follows:

- The first VSL sign group immediately upstream of the incident site is set to the safest speed limit. If the incident management requires a lane closure the first sign group generally requires a speed limit reduction to 40 km/h.
- Upstream of the first sign group a buffer speed limit is generally needed to step-down the speed. If the speed limit reduction is to 40 km/h then:
 - for 80 km/h default speed limit: The speed limit reduction steps are generally no greater than 20 km/h, i.e., 80 > 60 > 40;
 - for 100 km/h default speed limit with a single lane closure: The speed limit reduction steps are generally no greater than 30 km/h, i.e., 100 > 70 > 40; and
 - for 100 km/h default speed limit with two or more lane closures: The speed limit reduction steps are no greater than 20 km/h, i.e., 100 > 80 > 60 > 40.
- VSL sign groups immediately downstream of the incident indicate the normal default speed limit.

Signs at the same location on a carriageway must always display the same speed limit. Entry ramp VSL signs must always be consistent with the mainline VSL and display the same speed limit as VSL signs upstream of the ramp.

3.6.2. Sign Failure

If a single VSL sign in an array (on pole or gantry) is blank all other signs in the array are also blanked (i.e. the whole gantry is inactive). If an entire gantry or set of pole mounted signs is blank, the last speed limit sign passed is still applicable.

3.6.3. Speed Limit Operation during Congestion

The modes of VSL initiation and operation within an integrated system need to vary according to the nature of the circumstances requiring the VSL activation. In a situation involving an incident, high winds, roadworks, planned event or congestion, the VSL needs to be able to activate independently to manage safety. This can alleviate accidents related to merging and lane changing manoeuvres as well as assist in reducing potential for speed differential between vehicles.

The hierarchy of control for initiating VSL needs to be structured to ensure that during congestion, VSL can operate independently to address traffic management needs. When flow breakdown and congestion do occur, VSL operation can assist in suppressing shockwaves and could also operate to improve safety by:

- matching the speed limit to the congested traffic speed; and
- protecting the back of a queue by slowing vehicles approaching the congestion.

These forms of operation require specific investigation in association with evaluating currently available algorithms.

Under the circumstances where the VSL is activated by congestion, the coordinated ramp signalling will generally operate independently to also manage the congestion and to facilitate flow recovery.

3.6.4. Speed Limit Operation during Free-flow Conditions

Variable speed limits manage travel speed and can reduce the potential for flow breakdown. Typically, variable speed limits have limited ability to prevent flow breakdown or manage density and throughput. However, research by Papageorgiou et al (2008) indicates that variable speed limits can result in more stable flow at optimum and post-optimum flow conditions by shifting the critical occupancy to higher values. This may delay flow breakdown but will generally not prevent congestion.

There is limited information available relating to VSL operation integrated with ramp signalling. However, under free-flow conditions, the VSL could activate relative to the ramp signalling in the following manner to improve the management of flow and efficiency:

- The coordinated ramp signalling would activate first to optimise throughput.
- During ramp signalling operation VSL may activate if traffic flow deteriorates to:
 - increase densities with the objective of prolonging optimum throughput;
 - assist in homogenising traffic speed to minimise potential turbulence; and
 - provide a lower VSL upstream of the bottleneck to initiate mainline metering (if the technology is proven to be acceptable and effective).
- In the event that flow breakdown and congestion do occur, VSL operation could be activated to assist in managing the congestion and to improve safety as outlined in Section 3.6.3.

To maximise freeway efficiency it is important to adopt sound control logic for both the coordinated ramp signalling system and a variable speed limit system. These forms of operation require specific investigation in association with evaluating currently available VSL algorithms.

3.7. Speed Management for Environmental Reasons

Environmental monitoring and control systems may be appropriate in certain circumstances due to the significance and likely consequences that could result from severe weather conditions. To improve road safety on some Victorian freeways, ice detection / warning systems and weather stations have been implemented to advise drivers of possible traffic hazards such as fog, ice, high winds and/or flooding. Where automated systems are not available, the TMC operators may respond directly to severe weather events (e.g. storms) by manually activating speed management and traveller information devices.

The West Gate Bridge has an environmental monitoring system which includes monitoring of wind speeds. The following sections outline the integrated response using LUMS variable speed limit signs and traveller information devices such as mainline variable message signs and real time information signs at adjacent interchanges.

3.7.1. West Gate Bridge High Winds Response

The West Gate Bridge has anemometers to monitor wind speed on the bridge. When high winds are detected within configurable thresholds, a weather condition algorithm in STREAMS automatically activates the following lower speed limits across the bridge.

Wind Speed	Speed Limit
> 60 km/h but < 80 km/h	60 km/h
> 80 km/h	40 km/h with 60 km/h transitional speed limit (buffer)

When lower speed limits are activated on the bridge, traveller advice on mainline VMS and real time information signs are also activated to assist in managing vehicle speeds.

The system also provides automated pop-up notification to TMC operators indicating:

- when a lower speed limit and traveller advice is being activated;
- if the wind speed increases to the higher threshold and a further reduction in speed limit has been activated; and
- When the lower speed limit(s) and traveller advice have been modified or deactivated.

3.7.1.1. LUMS Responses to High Wind Events

When a 60 km/h high wind event occurs, the four LUMS gantries over the West Gate Bridge in both directions display the 60 km/h speed limit on the LUSs with flashing annulus.

When an 80 km/h high wind event occurs, the four LUMS gantries over the West Gate Bridge display the 40 km/h speed limit on LUSs with flashing annulus. In addition, the LUSs on the upstream gantry in each direction display a buffer speed limit of 60 km/h with flashing annulus.

High wind event LUMS responses do not override existing active LUMS responses, e.g., a lane closure. However, lower speed limit values to suit the wind conditions may need to be implemented in addition to existing LUMS traffic management.

3.7.1.2. Mainline VMS Responses to High Wind Events

When a 60 km/h high wind event occurs the mainline VMS immediately upstream of the West Gate Bridge on each approach will display the message in Figure 3.5.



Figure 3.5: VMS Message on West Gate Bridge Segment for 60 km/h Wind Event

When an 80 km/h high wind event occurs the following messages will be displayed:

- The mainline VMS immediately upstream of the West Gate Bridge on each approach will display the message in Figure 3.6.
- The mainline VMS within each of the adjacent freeway approaches further upstream will display the message in Figure 3.7.



Figure 3.6: VMS Message on West Gate Bridge Segment for 80 km/h wind event



Figure 3.7: VMS Message for 80 km/h wind event on Adjacent Segments

3.7.1.3. Real Time Information Sign Responses to High Wind Events

When either a 60 km/h or 80 km/h high wind event occurs on West Gate Bridge, the RTISs display the event message as shown in Figure 3.8 which alternates with the default travel time frame at the following ramps:

1. Williamstown Rd (eastbound ramp); and
2. Todd Rd and Prohasky St (westbound ramps).

RTIS Signing			Incident Severity
Frame 1		Frame 2	
RTIS at Williamstown Rd eastbound and Todd Rd / Prohasky St westbound			
M# - Fwy condition		High Winds on	1
Destination 1 ##		West Gate Bridge	
Destination 2 ##		Reduced Speed	

Figure 3.8: Examples of RTIS Messages in a High Winds Event

3.8. VSL Integration with Ramp Signals

A variable speed limit that is lower than the default speed may be activated as part of a LUMS incident response or for other reasons, e.g., high winds on West Gate Bridge. The lower travel speed of traffic may affect the pre-set values for activation and deactivation of the freeway ramp signals.

Freeway ramp signals switch on and off automatically within freeway flow, travel speed and occupancy thresholds. When the freeway speed limit is reduced, the ramp signals could activate unnecessarily. To ensure that ramp metering is not falsely triggered by a lower operating speed, the system provides the current speed limit value for calculations associated with the ramp signals.

Chapter 4

Traveller Information

4. Traveller Information

4.1. General Principles

4.1.1. Overview

Real-time traveller information relating to freeway operation and use is part of the broader application of 'traffic information services' on the road network. Real-time traveller information informs motorists about current or future traffic conditions on the freeway and allows drivers to choose the most efficient route to their destination.

Traveller information systems use traffic data and other traffic management information to provide timely and detailed information about travel time, congestion, traffic incidents, roadworks, special events and the weather (if applicable), to improve safety and travel time predictability. This can make the road network more resilient, enable drivers to make better choices and can also assist in reducing congestion.

The effective operation of automated on-road traveller information contributes to the overall provision of a traveller information system for a managed freeway that may also include media reports and web-based information. As well as fulfilling a need for day-to-day travel information, the system and facilities provide valuable information and assist in traffic control as part of an overall communications and management plan associated with special or periodic events.

The purpose of the traveller information system is to display real-time traffic and travel information and information relating to changing travel conditions.

This chapter provides:

- an outline of traveller information to be used on the urban freeway network;
- functionality, principles of operation and types of information for on-road traveller information;
- principles for determining travel time destinations;
- descriptions of sign types for traveller information; and
- principles for sign locations that can be used for the design of detailed signing schemes.

On-road real-time traveller information includes the use of various types of signs to display a range of sign messages appropriate to the travel conditions. The freeway management system manages traffic devices that operate in default mode for travel information as well as providing special information during incidents or congestion. These systems are integrated for operation and consistency of messaging, as well as providing consistent message libraries, graphics and abbreviations.

4.1.2. Benefits of Providing Traveller Information

The operation of traveller information assists in optimising operation and safety performance across the network and in providing appropriate advice to motorists. This is achieved by providing travel time, congestion and incident information to enable improved travel choices. The benefits include:

- influencing motorists' route choices - particularly during an incident involving roadworks or congestion;
- improving safety in the event of changing road conditions, e.g. a lane closure or an upcoming incident, i.e., reduce the likelihood of crashes particularly rear-end crashes;
- providing drivers with travel time information as well as likely delays; and
- providing drivers with other relevant information, e.g., the reason for a speed reduction.

Note:

Austrroads (2009) has provided the following summary and examples of the benefits of providing traveller information:

- Ramsay and Luk (1997) found that the Melbourne drive time system shortly after its implementation increased the diversion rate off the freeway from 1.1% to 2.3% for every additional minute of travel time. During a significant incident (i.e. road closure) the diversion rate was found to be 33%. The same study also found that the Brisbane drive time system resulted in increased diversions during a significant incident with an increase in the peak diversion from 15% to 35%.
- Travel time was reduced by up to 8% based on a Federal Highways Administration (FHWA) national review of VMS (Austrroads 2007a).
- On the Ile de France (Paris metropolitan region) freeway network, 6% of traffic diverted on the VMS displaying a message that there was congestion on the network. It was reported that if 2% of the drivers altered their route this could result in a reduction in total travel time of 12% (Austrroads 2007a).
- In a study undertaken within the Borough of Kingston in London, the display of the message 'Delays Kingston Centre, through traffic use A3' resulted in 12% of the traffic diverting around the affected link (Austrroads 2007a).
- MacCubbin et al. (2005) reported that VMS resulted in a 2.8% decrease in crashes.

4.1.3. Traveller Information Provided and Overview of Sign Types

Traveller information is provided to motorists on the freeway mainline as well as near interchanges on the arterial or local roads approaching the freeway to provide information before they enter the freeway. The general scope of the on-road traveller information includes:

- estimated travel time to significant downstream destinations;
- freeway operating condition (quality of traffic flow) generally compared with free-flow travel conditions, i.e. level of congestion, including escalating messages related to the extent of congestion;
- displays of freeway operating condition and travel time being shown colour coded green, yellow or red as related to free-flow travel;
- location and information about incidents and events (planned or unplanned) including road closures;
- location and information about roadworks (current or proposed); and
- other information as applicable, e.g., community safety or promotion messages.

Advising the public about travel time, incidents and roadworks in real time can influence motorists into using alternate routes by providing the opportunity for drivers to make informed travel choices. This not only reduces individual inconvenience experienced by waiting in slow moving traffic, but has the potential to reduce the demand on mainline flow and improve safety by giving advance warning.

The signage locations for the traveller information include:

- on-freeway signs to provide information to drivers using the freeway; and
- off-freeway signs to provide information before motorists enter the freeway. These locations include ramp entrances and the arterial road approaches to interchanges.

Traveller information for motorists is typically displayed on mainline variable message signs (VMS) and real-time information signs (RTIS) on roads approaching the freeway interchanges (either at the interchange or on advance signs at a remote location). Travel time and freeway condition information may also be displayed on separate trip information signs.

The principles in this handbook are generally consistent with the Austrroads Guide to Traffic Management Part 10: Traffic Control and Communication Devices.

4.2. Travel Time and Traffic Conditions

4.2.1. Overview

The travel time information is a 'snapshot' of travel time along the freeway based on the mainline speed data from each detector location.

Travel time and freeway traffic condition information is typically displayed on mainline variable message signs, real time information signs, trip information signs, trip condition signs and freeway condition signs.

Travel time and congestion information is considered important even if it is recurrent congestion as this may differ from day to day and throughout different times of the day. Providing this information enables road users to make informed decisions.

4.2.2. Traffic Condition Thresholds and Messages

Note: The values in this section are currently under review by VicRoads.

The detector speed data and spacing distance along the mainline are used to calculate travel times which are then amalgamated to calculate the following values between the sign location and the signed destinations:

- Nominal travel time (NTT) in minutes along the freeway based on a speed of 100 km/h. This speed value is not displayed but provides consistency in calculations across the freeway network irrespective of the default speed limit, e.g., the 'Light' to 'Medium' colour change at 67 km/h is also an appropriate indicator of travel conditions in an 80 km/h speed limited section of freeway.
- Estimated travel time (ETT) in minutes along the freeway to exit destinations based on current traffic conditions. These snapshot values are displayed on the mainline VMSs and the Trip Condition Signs (refer to Sections 4.5.6 and 4.7). If ramp metering is operating, the vehicle queuing delay on the ramp prior to entering the freeway is calculated by the ramp signal algorithm. This delay value is included in the ETT for the Real Time Information Sign displays (refer Section 4.8).
- The freeway condition (Light, Medium, Heavy, Major Delays or Seek Alt Route) based on the ratio of the ETT to the NTT for the first nominated travel time destination downstream of the ramp. The purpose of the 'Major Delays' and 'Seek Alt Route' messages is to divert traffic from the freeway during heavy congestion and are only used on the Real Time Information Sign and Advance Real Time Information Sign displays (refer Sections 4.8 and 4.9).
- The colours (green, yellow or red) of the displayed freeway condition and travel time values reflect the mainline travel conditions for those destinations relative to travel conditions without delays (ETT / NTT ratio).

The messages displayed on traveller information signs indicating how the freeway is performing are based on thresholds as shown in Table 4-1.

Travel Time Colour	Freeway Traffic Condition	ETT / NTT Ratio	Equivalent Speed Range (km/h)
Green	Light	< 1.5	> 67
Yellow	Medium	1.5 to < 2.0	50 to 67
Red	Heavy (Steady red message)	2.0 to < 2.5	40 to 50
Red	Major Delays (Flashing red message)	2.5 to 4.0	25 to 40
Red	Seek Alt Route (Flashing red message)	> 4.0	< 25

Table 4-1: Freeway Traffic Condition Travel Thresholds and Messages

Note:

An Instinct and Reason report prepared for Austroads (2008) relating to research on road user information needs with an emphasis on variable message signs, indicates that 80% of participants would find travel time in minutes useful and that 79% would find the colour coding of traffic flow useful.

A Sinclair Knight Merz report (2005) based on focus group discussions relating to the Drive Time System indicated that "The 'minutes' information was considered most valuable to regular road users whereas the 'colours' based information was thought to be most useful to infrequent users."

4.3. Freeway Segments for Managing Travel Time

4.3.1. Destinations Signed for Travel Time

Destinations signed for travel time are generally locations on the freeway where a significant number of motorists would be leaving the network. They are typically as follows:

- **On-freeway destinations.** These are locations on the freeway on which the motorist is currently travelling or on the freeway being entered from an arterial or local road.
- **Off-freeway destinations.** These are locations that are reached from another downstream freeway, i.e., after leaving the current freeway being used. Generally, these destinations are only signed when close to the freeway exit.

4.3.2. Rationale for Choosing Travel Time Destinations

Travel time information has most benefit when provided to significant arterial roads which are strategic intersecting routes within the road network, including system (freeway to freeway) interchanges. It is not necessary or practicable to provide travel time signing to all freeway exits. The signing of strategic interchanges focuses on:

- significant destinations for high volume movements which benefit a large number of motorists;
- high capacity routes that facilitate route choice for deviation of traffic, e.g., during periods of high congestion or incidents; and
- Routes with good connectivity within the network.

Other less significant interchanges may need to be used on the outer limits of the managed freeway where data stations are available (e.g. Duncans Road for westbound traffic on Princes Freeway West).

The signed travel destinations are generally arterial road interchanges on the route(s) being travelled. In some cases, important off-freeway destinations may be considered if they are destinations for a significant number of travellers, e.g., City (central business district) or airport. Alternatively, off-freeway destinations are signed via the freeway interchanges from which they would be reached.

The signing of off-freeway travel destinations may be difficult due to the unavailability of data (e.g. queuing at the airport drop off area). Specifying the precise location to which the destination signing refers may also be difficult (e.g. to which part of the City is the end point).

A traveller information strategy prepared for each freeway route will document the travel time destinations and hence freeway segments for managing travel time and traffic condition. Example maps of travel time destinations for the M1 and M80 freeways are shown on the maps in Appendix C.

4.3.3. Signing Principles

Generally, all downstream travel time destinations cannot be shown on signs unless the sign or freeway entry is near the end of the route. Therefore, destinations for each location are a subset of the overall list of destinations input into the system for the freeway route.

The following principles generally apply to the use of destination signing:

- Travel time destinations are consistent with names on freeway directional signage to facilitate understanding and navigation by motorists.
- The first displayed destination is typically 4 to 5 minutes travel time (two interchanges or more) downstream from the mainline VMS location or the interchange entry ramp being entered. This provides reasonable accuracy and credibility of travel time within the data generally available.
- The mainline VMS displays one frame with a maximum of three destinations.
- RTISs display the nearest key destination and second nearest key destination, i.e., close destinations are generally shown rather than distant destinations. Further destinations would be shown on the mainline VMS which can display up to three destinations.
- When close to the end of the freeway or a freeway fork (freeway diverts into two routes of similar importance, e.g. M80 approaching the M1 freeway):
 - the upstream mainline VMS will only display travel time to the freeway interchange, i.e., destinations on each continuing route will not be displayed to avoid alternating frames on the VMS (e.g. on M80 the M1 interchange will be signed on the VMS but not travel time destinations West Gate Freeway or Princes Freeway West);
 - upstream Trip Condition Signs (if provided) may display off-freeway destinations on the two downstream routes; and
 - Two Real Time Information Signs are desirable at each signing location on upstream arterial roads so that separate signs and destinations are provided for each route, including downstream of the interchange, if applicable. Installation of two signs avoids the distraction of alternating frames in the default (travel time) situation. Destination names on the same frame must be on the same route.
- When close to other system interchanges (generally a crossing freeway):
 - upstream mainline VMS will only display on-freeway destinations on the continuing route;
 - upstream mainline Trip Condition Signs (if provided) will display off-freeway destinations on the intersecting route(s); and
 - Real Time Information Signs at upstream freeway interchanges may display destinations on the continuing route and an intersecting route (two signs required at each signing location).
- If a key destination name is longer than the available space on the sign (VMS and RTIS may differ), it should be shortened to display an abbreviated name with consistency from site to site. There is to be no scrolling of messages.

4.4. Traveller Information during Incidents

4.4.1. Incident Severity

The severity of a freeway incident determines the details of messages displayed on upstream traveller information signs (mainline VMS and entry ramp RTIS), as well as the length of freeway and the number of interchanges over which the event messages are displayed.

In a high severity incident where there is a significant impact on freeway flow, the information is displayed over a longer distance upstream of the event. This advanced information recognises the importance of managing large traffic volumes to discourage freeway use and to facilitate the exiting of traffic, i.e., the 'unloading' of the freeway, over a large number of interchanges. The information upstream of the incident will provide opportunities for traffic to divert and be distributed to a number of routes rather than creating an impact on one particular route.

Upstream incident advice may also be provided on more than one freeway route. For example, when a freeway closure of the inbound carriageway of the West Gate Bridge occurs, information would be displayed to motorists at entry ramp RTISs and mainline VMS on the Princes Freeway West and Western Ring Road within specified distances of the closure as well as VMS and RTISs for the West Gate Freeway.

The incident severity criteria and the default value freeway distances over which traveller information is provided are shown in Table 4-2. The default freeway distances over which traveller information is provided is configurable within STREAMS and for any particular event, the freeway distances over which traveller information is provided is also adjustable. The severities are the same for freeway sections with and without LUMS and/or mainline VMS.

Incident Severity		Criteria	Mainline VMS	Real Time Information Signs (RC3) at Entry Ramps
1	Minor	Emergency Stopping Lane affected;	A warning message may be provided at the discretion of the TMC operator if the incident is likely to affect safety or traffic flow.	Generally no message.
		or Other hazard that may affect all lanes but without a reduction in lane usage, e.g., high winds, sun glare, surface debris (sand, oil etc.).	In the case of high winds on West Gate Bridge requiring a speed reduction, the appropriate mainline VMS and RTIS signs will indicate a high winds event (refer Section 3.7).	
2	Major	1 traffic lane affected.	Default: Upstream for 5km (configurable)	
3	Severe	2 or more traffic lanes affected.	Default: Upstream for 8km (configurable)	
4	Freeway Closure	All freeway lanes on the carriageway are to be closed; or More than one carriageway on the freeway is to be closed.	Default: Upstream for 15 km (configurable)	

Table 4-2: Incident Severity Criteria and Extent of Upstream Traveller Advice

Note:

The default distances and severity definitions in Table 4-2 have been determined on the basis of the general spacing of interchanges and major routes in Melbourne that would enable motorists to exit the freeway or to choose alternative routes to avoid entering the freeway. It also recognises the impact of incidents on traffic and the importance of managing large traffic volumes to discourage freeway use and to facilitate the exiting of traffic. The distances vary slightly from the Austroads Guide to Traffic Management – Part 10: Traffic Control and Communication Devices.

4.5. Mainline Variable Message Signs

4.5.1. Overview and Functionality

Mainline Variable Message Signs (VMS) are permanent variable message signs for providing real time, changeable advice to road-users. The signs are generally used as part of incident and event management, and where provided, to support the operation of a lane use management system to provide integrated and consistent driver advice. The mainline VMS may also be used for travel time and freeway condition information.

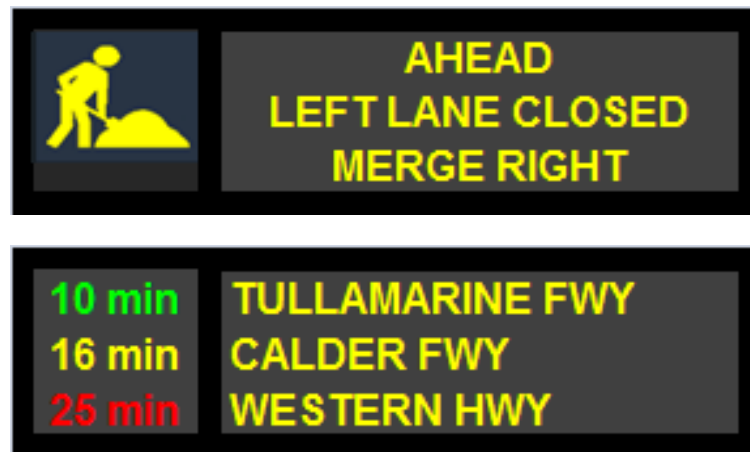


Figure 4-1: Examples of VMS Messages

As a general principle for the deployment of VMS, VicRoads will install multi-purpose VMS rather than single-purpose VMS and limit the number of different VMS types to a minimum. On managed freeways VicRoads will deploy VMS which are able to display incident warnings as well as real time traffic information and travel time information as shown in the examples in Figure 4-1. These will supersede Trip Condition Signs (TCS) and Trip Information Signs (TIS) for new or upgraded managed freeways and replace TCS and TIS in the long-term.

Mainline VMS are generally of the types as follows:

- Current multi-purpose standard. Text and pictogram VMS consisting of two areas side by side to display:
 - a message in an alphanumeric format on a 128 x 40 LED pixel matrix accommodating up to 3 lines of text and up to 18 characters per line. The displays are generally consistent with AS 4852.1-2009. Upper and lower case fonts may be used as appropriate; and
 - a pictogram or symbol on a 64 x 64 pixel LED matrix in four-colours – white, yellow, green and red.
- Previous standards, which involves:
 - text and pictogram layout with single colour pictogram; and
 - text based VMS – typically a 'C' type sign as defined in AS 4852.1-2009.

Characters have a typical height of 400mm in a 100 km/h speed environment (minimum 320 mm for an 80 km/h speed limit) with a 7:5 Height: Width ratio and minimum character, word and row spacings in accordance with AS 4852.1—2009.

4.5.2. Message Hierarchy

4.5.2.1. Purpose of Permanent VMS

The primary purpose of VicRoads network of permanent VMS is to display real-time or changeable transport conditions information relevant to the road user for their current trip at the current time. Accordingly, information that has the largest impact on journeys currently in progress receives the highest priority.

A secondary purpose of the permanent VMS is to display changeable transport conditions relevant to trips on that route in the near future – such as upcoming works.

The VMS represent only one means of communicating with road users and are not the appropriate channel for all messages. It is essential to maintain trust and credibility with road users so that they are more likely to choose to read and act upon messages displayed on the signs. The use of VMS for messages that do not accord with their primary purposes reduces the effectiveness of the VMS.

Messages are to be formatted in accordance with this handbook and other guidelines developed by Policy and Programs.

4.5.2.2. Message Priority / Hierarchy

VMS have the capability of displaying messages of a number of different types. To ensure that each VMS is being used for its highest value and in line with its primary purpose, the following message hierarchy has been established, together with guidelines for their use.

1st Priority: Incident Messages
2nd Priority: Community Safety Messages
3rd Priority: Transport Conditions Messages (includes travel time)
4th Priority: Planned Works and Events Messages
5th Priority: Campaign or Promotion Messages

The VMS 'default' state is the display of transport conditions such as travel time and traffic condition (3rd priority). These messages are highly desirable, particularly during peak periods, and should generally be displayed unless a higher priority message needs to be displayed as outlined in Table 4-3 below.

1. Incident Messages	
Content Definition:	<p>Incident messages provide information to road users about incidents or unplanned events or conditions on the road network. Messages are displayed where that incident or unplanned event will impact upon the travel of a significant proportion of road users reading/passing that sign.</p> <p>Messages relating to changed speed limits or lane availability on managed freeways as part of Integrated Speed and Lane Use Management (LUMS) would be considered as incident messages.</p>
Exclusions:	More general unplanned events such as major storms, fires and floods are considered to fall in the Community Safety messages category.
Approval:	TMC Officers, according to business rules established by the Manager Traffic and Incident Management. It is important for road users to be provided information about these incidents as soon as practicable.
Priority / Hierarchy:	This message type has the highest priority. When there are multiple incident messages relevant to a sign, the message displayed is to be the one reflecting the greatest impact on the greatest number of road users passing / reading that sign.

2. Community Safety Messages	
Content Definition:	Significantly important information to road users about a major region-wide unplanned event such as major storms, fires and floods.
Exclusions:	Messages that do not relate to a current major unplanned event – e.g., campaigns to alter driver behaviour or improve road safety; these would be classified as campaign or promotion messages.
Approval:	<p>TMC Officers, according to business rules established by Manager, Traffic and Incident Management.</p> <p>It is important for road users to be provided information about these events as soon as practicable and that they are removed promptly when no longer applicable.</p>
Priority / Hierarchy:	This message has the second highest priority and will be displaced by any incident messages.

3. Transport Conditions Messages	
Content Definition:	Information about real time transport conditions, including travel time information, comparative real-time travel times with alternate modes and real-time availability of parking at transport interchanges. These messages must be relevant to a significant proportion of road users passing / reading that sign.
Exclusions:	Information that is not real-time or dynamic in nature.
Approval:	Manager - Traffic and Incident Management, or as delegated in business rules established by the same. These messages will be largely automated in nature.
Priority / Hierarchy:	These messages will be displaced by incident and community safety messages. If there is a significant change to travel times compared to normal conditions due to a disruption to the network, this could be considered for display as an incident message.

4. Planned Works and Events Messages	
Content Definition:	<p>Messages about future road or lane closures for roadworks and community events that will have a significant impact on the route to which the sign applies, or to nearby roads that are important to a significant proportion of road users reading/passing that sign.</p> <p>The Traffic Management Plan for the works or event needs to set out how the information will be communicated to road users in the event that the permanent VMS is being used for other purposes. No guarantee can be provided that the permanent VMS will be available to display the works or event messages.</p> <p>VMS signs are not a substitute for roadworks or traffic management signs. If the message is essential for safe travel through or around the works or event (e.g., merge left, lane closed) and is required during peak periods for peak direction traffic, or for longer than 6 hours on one day, or for longer than 4 hours per day on consecutive days, then permanent VMS should not be used as this renders the permanent VMS unavailable for other messages. Temporary roadworks or traffic management signs and portable VMS signs should be used in these cases.</p>
Exclusions:	Messages are only to cover the impact of the event on traffic (e.g. road or lane closure) and not to promote or raise general awareness of the event.
Approval:	Manager - Traffic and Incident Management, or as delegated in business rules established by the same. Proposals for display of messages should indicate the time period for display of the message prior to the event.
Priority / Hierarchy:	<p>The impact of the planned works or event must have a significant impact on road users passing / reading this sign.</p> <p>When there are multiple planned works or event messages relevant to a sign, the message displayed is to be the one reflecting the greatest impact on the greatest number of road users passing / reading that sign.</p> <p>Priority 4 messages will not displace any incident or community safety messages. It may only displace travel time messages (Priority 3) if the traffic conditions are 'Light', e.g., off-peak periods.</p>

5. Campaign or Promotion Messages	
Content Definition:	Messages that promote road safety or relate to congestion and accessibility as part of an approved campaign.
Exclusions:	<p>Messages that have the potential to distract road users from their primary driving tasks.</p> <p>Messages that do not relate to an approved road safety or congestion and accessibility campaign.</p>
Approval:	<p>Executive Director – Metropolitan Operations. Where sufficient public benefit is demonstrated, this approval may allow the message to be displayed instead of Priority 3 (transport conditions) messages on arterial roads at times when traffic conditions are 'Light' and there is little variability in travel times (e.g., outside peak periods).</p> <p>The potential that VMS offers to reach a large audience of road users with these campaign or promotion messages must be balanced against the need for road users to be motivated to read the VMS by believing that the messages will be relevant to their current travel – i.e., that the road user will derive benefit from reading the VMS. Accordingly there is a need to limit the use of the signs for promotional messages and to consider for approval only specially designed messages that have limited durations of display.</p> <p>Proposals for display of messages should indicate the period of time for display of the message.</p>
Priority / Hierarchy:	These messages must not displace travel time information during peak period travel. These messages can only be used when the traffic conditions are 'Light'.

Table 4-3: VMS Message Hierarchy and Purpose

4.5.3. Design Principles

4.5.3.1. Location, Spacing and Position relative to Other Devices

Signs are placed where displayed messages for an incident or event is relevant to a significant proportion of motorists using the freeway.

The longitudinal positioning of VMS generally follows the following levels of importance that are reflected in the sequence of design:

1. Static directional signs.
2. Lane use signs (LUS) as part of a lane use management system (LUMS).
3. VMS.

The spacing of VMS is typically between 3 km and 5 km apart (1 km minimum), subject to the spacing of significant interchanges and the presence of a LUMS environment. Signs need to be located clear of structures or other sight distance restrictions. VMS are undesirable in decision-making locations such as areas of merging, braking, weaving and exiting.

Typical guidelines for longitudinal placement of signs are as follows:

- 900 m to 1,200 m prior to major decision points (minimum 300 m) to provide adequate time for drivers to read and respond. Major decision points include:
 - significant exit ramps, e.g., likely to be used for trip diversion; and
 - freeway to freeway (system) interchanges.

- At least 200 m prior to a LUMS environment to support and advise of lane closures or reduced speed limits.
- Spacing of 200 m relative to static direction signs.
- A minimum of 500 m beyond an entry ramp (nose), i.e., install beyond the merging area.

It is generally undesirable to locate VMS with lane use signs in a LUMS environment as information is critical during periods of incident management when messaging needs to avoid complexity and potential for confusion. However, VMS may need to be installed on the same gantry as lane use signs if location constraints exist.

4.5.3.2. Supporting Structure

VMS may be side mounted on posts or a cantilevered structure or may be installed over the carriageway on a gantry.

Overhead mounting of VMSs on gantries provides good visibility and is the most effective way of conveying important information to motorists on a high-volume, high-speed freeway. Gantry mounting is suggested where the VMS forms part of a lane use management system (LUMS), i.e., where lane use signs are provided over the carriageway, or where the carriageway has four or more lanes. Lightweight gantries (non trafficable for maintenance) generally provide an economical mounting structure.

Sign support posts within the clear zone are roadside hazards and shielding with safety barriers is generally necessary.

4.5.4. Operating Principles and Display of Messages

4.5.4.1. General

Message displays shall generally be in a single frame. This would include a message in a maximum of three lines in the text section of the VMS.

Although single frame messages are preferred, where necessary and to avoid full replacement of messages within the message hierarchy, a maximum of two frames may be used with alternating messages. If two message frames need to be used, e.g., an incident message (Priority 1) and a traffic condition/travel time message (Priority 3), preferably there should be a maximum of two lines per frame. The changes between frames shall be a complete blanking of one display and simultaneous generation of the next display. Multi-frame messages should not be used to include a Priority 5 message.

Abbreviations may be used if necessary. There shall be no scrolling of messages.

4.5.4.2. Incident Displays

The VMS incident messages typically provide the following information, as applicable:

Problem statement:	Defines the situation or type of incident that will affect traffic operations, e.g., incident, roadworks, high winds etc.
Location statement:	Describes the location of the incident, e.g., distance to incident, interchange name, exit name or number or a landmark.
Effect statement:	Describes the state of the road or the effect the problem will have on traffic, e.g., left lane closed, major delays, freeway closed.
Action statement:	Describes what the motorist is required to do, e.g., proceed with caution, prepare to stop, consider alternate route.
Attention statement: (special case)	Identifies specific drivers to whom the message is directed if the message does not apply to all traffic, e.g. trucks.

Table 4-4: Incident Message Statements

A mainline VMS using a pictogram and text message with three lines of text typically enables the display of 4 categories of information as shown in Figure 4-2.



Figure 4-2: Example of a VMS pictogram and text displays

Examples of VMS messages and pictograms in the VicRoads message library incorporated into the STREAMS freeway management system are shown in Appendix B.

Note:

VicRoads has carried out perception testing to determine drivers' understanding of the standalone pictograms alone and in conjunction with a text message. The feedback and results were positive and the pictograms on their own were well comprehended. When combined with a text message, all the pictograms were fully understood.

While tactical messaging for incidents generally follows the outline of Problem, Location, Effect and Action, in some situations there may be strategic reasons for signing the location first, e.g., prior to an exit for an event or closure on another road. In this case, a strategic message would have the format: Location, Problem, Effect, Guidance (or Action). In this instance it may be more appropriate to indicate the location first, due to the non-immediate nature of the problem and its applicability to a smaller number of road users.

4.5.5. Automated VMS Response

An automated VMS response is generated when an incident response plan is initiated. The automated generated response provides information to motorists regarding the incident ahead. The system allows manual override of the message before and after implementation.

The automated VMS response generates one or two different messages for display at different segments of the freeway. Depending on the severity of the incident, an alternating supplementary message may be required for an event.

Main Message (first VMS upstream of the incident)

A main text message together with an appropriate pictogram will be displayed on the VMS upstream of the LUMS traffic arrangement that is managing the incident.



Figure 4.3: Example of a Main Message

The following principles apply in generating the main message:

- Pictogram should depict the 'event type' from the operator input.
- No pictogram is used for Planned Works and Events messages (Priority 4) or Campaign or Promotion messages (Priority 5).
- Top line is to provide status information on the traffic lane(s) affected.
- Middle line is to display 'AHEAD' for incident on the mainline or specify a location where incident occurs, such as:
 - on a connecting freeway, e.g., Western Link;
 - on an exit ramp collector-distributor, e.g., Kings Way;
 - on West Gate Bridge, e.g., West Gate Bridge; and
 - on either of the tunnels, e.g., Domain Tunnel.
- Bottom line is to display 'Merge Left' or 'Merge Right' depending on the lane closure.
- At this stage conspicuity lights in the corners of the display section will not be used.

Supplementary Message (other upstream VMS)

A supplementary message, also complemented by a pictogram, is displayed on all VMS in the upstream segment of the incident within the default length of freeway based on the incident severity (refer Table 4-2). The supplementary message is required for Major, Severe and Freeway Closure incidents if VMS exist on the upstream sections of freeway.

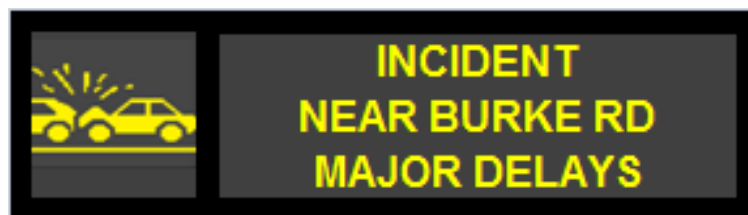


Figure 4.4: Example of a Supplementary Message

The following principles apply in generating the supplementary message:

- Pictogram should depict the 'event type' from the operator input.
- Top line is to provide event type information, e.g., OIL SPILL or INCIDENT.

- Middle line is to display 'NEAR' and 'the nearest entry or exit ramp road name. Middle line may also display 'AHEAD' for incident on the mainline or specify a distance or location of the incident, such as:
 - on a connecting freeway, e.g., Western Link;
 - on an exit ramp collector-distributor, e.g., Kings Way;
 - on West Gate Bridge, e.g., West Gate Bridge; and
 - on either of the tunnels, e.g., Domain Tunnel
- Bottom line is to display a freeway condition message based on 'nominal' travel conditions as defined in Section 4.2. Table 4-5 indicates the applicable VMS messages based on traffic condition.

Freeway Condition Message in RTIS Header	VMS Automated Response	Average Speed Ranges (km/h)
Light	(no message)	> 67
Medium	EXPECT DELAYS	50 to 67
Heavy	EXPECT DELAYS	40 to 50
Major Delays	MAJOR DELAYS	25 to 40
Seek Alt Route	USE ALT ROUTE	< 25

Table 4-5: Automated VMS response based Traffic Condition

An example of an automated integrated VMS response to an incident is shown in Figure 4.5.

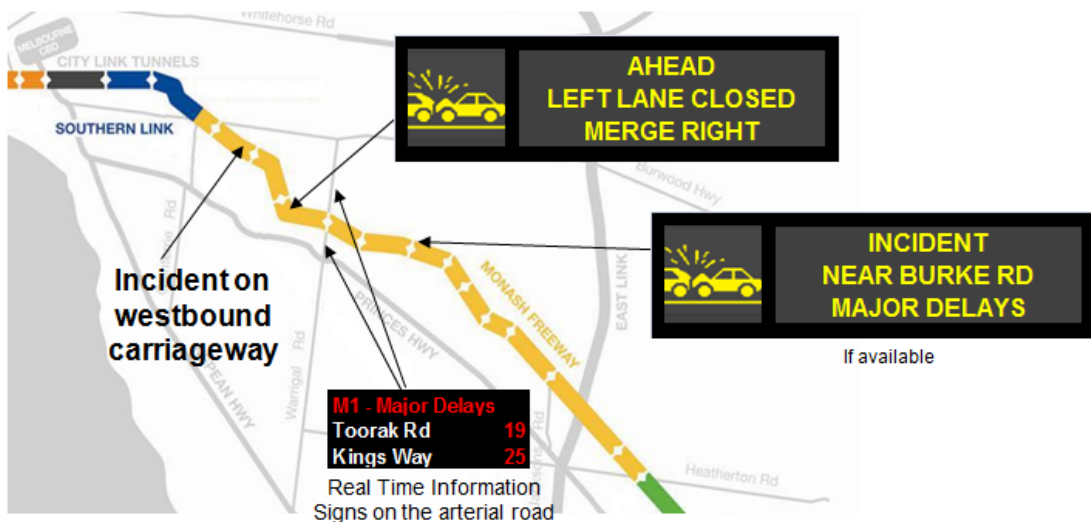


Figure 4.5: Example of an Automated VMS and RTIS Incident Response

Special Message – Freeway Closure

In the event of a full freeway closure the first VMS upstream of the closure and exit ramp shall display the following:

- 'EXIT with arrow' pictogram (exit only) to be shown;
- top line is to display 'FREEWAY CLOSED';
- middle line is to display 'USE NEXT EXIT'; and
- bottom line does not display any message.



Figure 4.6: Example of a Special Message for Full Freeway Closure

Special Message – Start of a LUMS Environment

The VMS prior to the first LUMS gantry managing an incident is integrated as part of the LUMS response if the gantry is displaying a red cross. In this case the usual upstream VMS and LUS are not available to provide the advance warning, merge symbol or speed reductions. The following principles will apply in this situation:

- '40 AHEAD' pictogram to be shown.
- Top line is to provide status information on the traffic lane(s) affected.
- Middle line is to display 'MERGE LEFT' or 'MERGE RIGHT' depending on the lane closure.
- Bottom line does not display any message.



Figure 4.7: Example of a VMS Message as part of LUMS Response

4.5.6. Display of Travel Times

The display layout and format for travel times provide the displayed order of the destinations based on how the sign will be read by motorists, i.e., from the top down. This sequence provides:

- consistency with other messages displayed on the VMS, e.g., incident messages;
- destinations in the order they will be encountered when driving along the route. The closest destination is considered the most important destination for most motorists as it relates to the immediate section of freeway ahead, as well as relevant information in the case where the sign is not fully read; and
- consistency with the order of destinations on real time information signs (RTIS) and reassurance direction signs.

The VMS will provide travel time and freeway conditions to downstream on-freeway destinations at various interchanges consistent with the principles in Section 4.3 relating to freeway segments for managing travel time. An example is shown in Figure 4-8.

The sign display includes:

- estimated travel time to each destination in minutes;
- colour coding of the travel time to indicate the freeway operating condition relative to nominal travel time (refer Section 4.2); and
- a form of display that is consistent with the RTIS format that motorists will see on the arterial roads prior to entering the freeway.

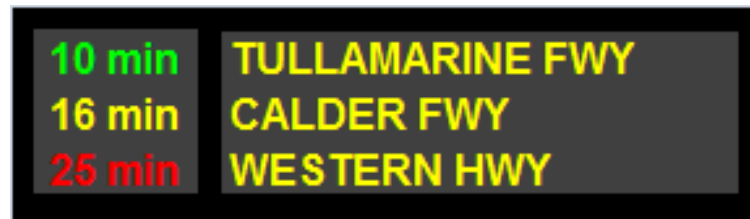


Figure 4-8: Example of a Mainline VMS Travel Time Display

4.6. Mainline Trip Information Signs

4.6.1. Overview of Device, Usage and Functionality

Trip Information Signs (TIS) have been used on some Melbourne freeways to provide travellers with travel time and freeway traffic conditions to destinations along the route being travelled. An example of a Trip Information Sign is shown in Figure 4-9. Historically, TIS were installed to provide travel time signage as part of the Drive Time system.

On new projects or when upgrading freeways to provide travel time information, i.e., where existing TIS are not installed, current practice is to provide mainline travel time information with multi-purpose mainline VMS using a coloured full matrix panel to provide travel time information instead of installing TIS, (refer Section 4.5.6). The VMS provide travel time information to three destinations which are colour coded according to the freeway traffic condition.



Figure 4-9: Example of a Trip Information Sign

Information displayed on TIS is based on freeway speed data that is used to calculate the travel time and traffic flow conditions relative to nominal travel time as outlined in Section 4.2.

A TIS will display travel time (in minutes) to listed destinations as well as a colour coded indicator that displays the freeway traffic condition corresponding to either 'light' (green), 'medium' (yellow) or 'heavy' (red), as appropriate, for the various travel time destination segments. Freeway traffic conditions equivalent to 'Major Delays' and 'Seek Alt Route' are displayed red.

While TISs have been used effectively in the past, future projects to provide mainline travel time information are to use VMS travel time displays (refer Section 4.5.6).

4.6.2. Design Principles

Typically, TIS are installed prior to significant exits, generally where another 'parallel' route can provide an alternative to travelling on the freeway. This enables a motorist to take the arterial route if they consider it preferable to the freeway, given current traffic operating conditions.

TIS are generally located 900 m to 1,200 m upstream of the exit. The sign needs to be clear of sight distance restrictions and it is generally undesirable to locate the signs in decision-making areas, e.g., areas of merging, braking, weaving and exiting.

The detailed longitudinal design and placement of signs relative to other traffic management devices or freeway features is typically:

- no closer than 200 m to static direction signs or lane use signs (LUS);
- a minimum of 300 m prior to an exit ramp; and
- a minimum of 500 m beyond an entry ramp (nose), i.e., install beyond the merging area.

Trip Information Signs are generally installed to minimise their presence as roadside hazards by adopting an appropriate offset to the traffic roadway or by shielding with a safety barrier, where feasible.

Where TIS are being replaced by multi-purpose VMS, the design and location principles should be in accordance with Section 4.5.

4.7. Mainline Trip Condition Signs

4.7.1. Overview of Device, Usage and Functionality

Trip Condition Signs (TCS) have been used on some Melbourne freeways to provide freeway travellers with travel time and freeway traffic conditions to destinations which are reached from an intersecting freeway (i.e., destinations that are not on the route currently being travelled). An example of a Trip Condition Sign is shown in Figure 4-10. In this example the sign is installed on the inbound carriageway of Princes Freeway West but provides freeway traffic condition and travel time information to destinations on the Western Ring Road.

Historically, TCS were installed to provide travel time signage as part of the Drive Time system. On new projects or when upgrading freeways to provide travel time information, i.e., where existing TCS are not installed, current practice is to provide mainline travel time information with multi-purpose mainline VMS using a coloured full matrix panel as shown in Figure 4-11 to provide travel time information instead of installing TCS.

On TCS the travel time (in minutes) and the freeway traffic condition information (colour coded green, yellow and red for 'LIGHT', 'MEDIUM' and 'HEAVY' respectively) are displayed for the intersecting freeway leading to the listed destinations. For travel time and traffic condition to be calculated the intersecting freeway needs to be equipped with traffic data detector stations. Freeway conditions and travel times equal to 'Major Delays' and 'Seek Alt Route' (refer Table 4-1) are displayed as 'HEAVY' (red).

TCS and multipurpose VMS installed for similar purposes provide valuable information for motorists intending to leave the freeway and may also facilitate route choice decisions for drivers, e.g., whether to use the freeway or whether to use another route.

Multi-purpose VMS rather than TCS are able to provide the name of the intersecting freeway together with travel time information to two destinations colour coded according to the freeway traffic condition. Other messages related to the intersecting route, e.g., incidents, may also be displayed.



Figure 4-10: Example of a Trip Condition Sign

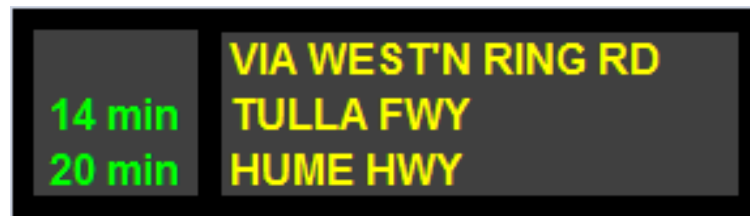


Figure 4-11: VMS Example of Traveller Information for an Intersecting Route

4.7.2. Design Principles

TCS are typically located 900 m to 1,200 m upstream of the exit leading to the off-freeway destinations signed to provide adequate time for drivers to read and react. The sign needs to be clear of sight distance restrictions and it is generally undesirable to locate the signs in decision-making areas, e.g., areas of merging, braking, weaving and exiting.

The detailed longitudinal design and placement of signs relative to other traffic management devices or freeway features is typically:

- no closer than 200 m to static direction signs or lane use signs (LUS);
- a minimum of 300 m prior to an exit ramp; and
- a minimum of 500 m beyond an entry ramp (nose), i.e., install beyond the merging area.

Where VMS are to be used for traveller information on an intersecting route, closer spacing of other upstream VMS needs to be considered so that different VMS can be used for the intersecting route and the continuing route.

Trip Information Signs are generally installed to minimise their presence as roadside hazards by adopting an appropriate offset to the traffic roadway or by shielding with a safety barrier, where feasible.

Where TCS are being replaced by multi-purpose VMS, the design and location principles should be in accordance with Section 4.5.

4.8. Real Time Information Signs on Arterial Roads

4.8.1. Overview of Device and Usage

Real Time Information Signs (RTIS) provide warning and other traveller information to road users before they enter the freeway. RTIS are generally installed on the arterial roads near freeway interchanges prior to the left turn and right turn lanes as shown on the sketch in Figure 4-13.

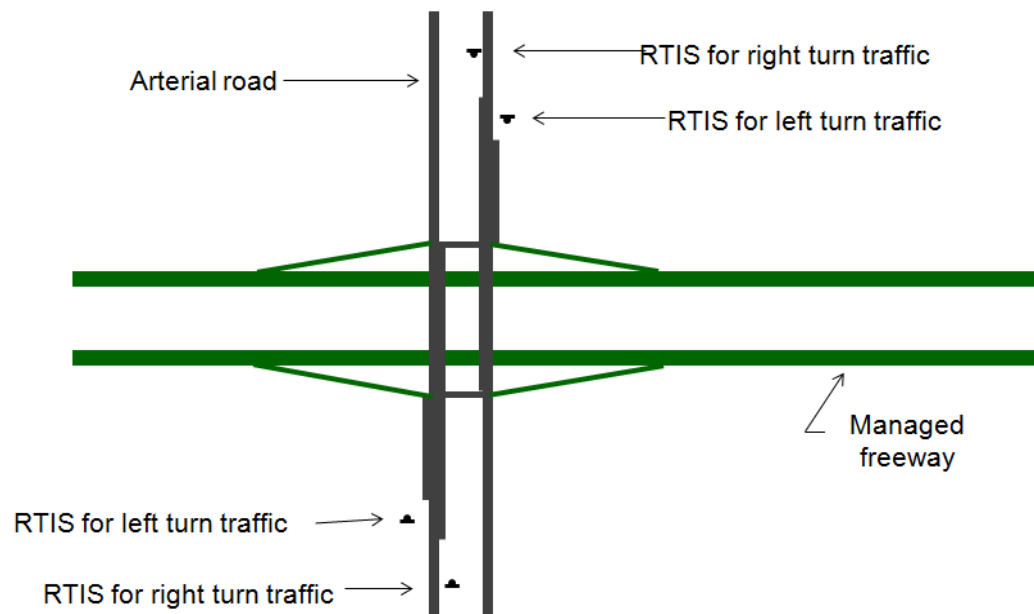


Figure 4-12: Typical Locations of Real Time Information Signs

RTIS (sign reference number RC3) provide travel time information as well as integrated messages associated with traffic conditions, i.e. extent of congestion, incidents or roadworks. Where a LUMS is in place on the freeway the signs are also integrated within the system to provide consistent messaging.

Advising the public in real time of travel time, incidents and roadworks can influence motorists into using alternate routes by providing the opportunity for drivers to make informed travel choices. This not only reduces individual inconvenience experienced by waiting in slow moving traffic, but has the potential to reduce the demand on mainline flow and improve safety associated with advance warning. Diverting traffic can also improve recovery of the freeway after periods of congestion.

The RTIS is a full matrix multicolour light emitting diode (LED) variable message sign with a display size of 128 pixels (1536mm) wide by 40 pixels (480mm) high. The sign incorporates 4 x 3mm LEDs per pixel using green, red, yellow and white LEDs with a pixel spacing of 12mm.

4.8.2. Functionality and Messages

The VMS 'default' state is the display of transport conditions such as travel time and traffic condition (Priority 3 message). These messages are highly desirable, particularly during peak periods, and should generally be displayed unless a higher priority message needs to be displayed as outlined below.

The RTIS displays travel time information as the 'default' message for the freeway route/s downstream from the interchange. The sign messages relating to incidents and roadworks will complement and be compatible with the operation of mainline VMS and LUMS signs. Examples of RTIS displays are shown in Figure 4-13 and include the following types of messages:

- Traveller information relating to:
 - travel time (default);
 - freeway condition, i.e., level of congestion;
 - incidents; and
 - roadworks.
- Freeway closure information.

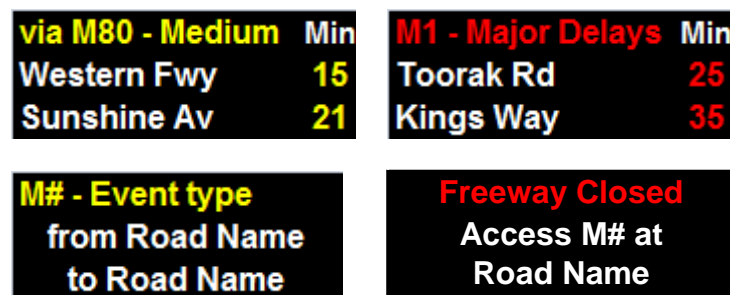


Figure 4-13: Examples of Real Time Information Sign Messages

The travel time information will generally provide estimated travel times to two travel destinations. At interchanges close to a downstream fork or system interchange (freeway to freeway) where motorists may travel in different directions, four key destinations (two destinations per route) can be provided by using two signs at each location.

4.8.3. Design and Location Principles

The general principles for positioning Real Time Information Signs are to:

- provide separate RTISs for all turning movements onto the freeway at interchanges where ramp signals are provided. Signs are generally provided in advance of the indented left and right turn lanes if a divided roadway and if turn lanes are provided. Signs may not be required where a very low traffic movement turns onto the freeway ramp or where the entry point is near the end of the freeway and there is minimal benefit in providing traveller information;
- where practicable, position the signs on the same side of the road as the movement that is being signed, i.e., left side of the road for signing left turn movement and right side in the median for signing the right turn movement;
- the locations chosen for RTISs should provide clear sight distance without visibility restrictions, e.g., trees or other signs etc.; and

- the desirable minimum sign installation distance prior to the action point to enable a road user to react appropriately and the desirable separation distance relative to other signs are shown in the following table:

Installation	Speed Environment (km/h)	
	60 and 70	80
Distance prior to action point	60 to 80 m	80 to 120 m
Spacing to other signs	50 m	60 m
	Minimum $0.6V$ m (where V is the 85 th percentile speed in km/h)	

Based on AS 1742.2-2009 (Appendix D)

When the interchange is close to a downstream freeway fork, i.e. the freeway divides into two downstream routes creating a route choice, two separate RTISs on the same pole are to be provided at each arterial road approach to enable separate displays of travel information for each downstream freeway.

RTISs are generally installed on special poles designed to accommodate wind and sign loadings. The sign poles should be installed to minimise their presence as roadside hazards by adopting an appropriate offset to the traffic roadway or shielding with a safety barrier, where feasible. In some instances shielding may not be an option due to various factors affecting sign location or provision of a barrier. Road safety risks may need to be assessed, however, risks are generally similar to those associated with other poles on arterial roads, e.g., traffic signal poles.

The mounting height to the bottom of the sign is generally a minimum of 2.5 m to provide clearance over footways and to minimise potential for vandalism.

4.8.4. General Operating Principles

4.8.4.1. Sign Messages and Priorities

The display of transport conditions such as travel time and traffic condition are highly desirable, particularly during peak periods, and should be displayed as the 'default' state unless a higher priority message needs to be displayed.

The RTIS displays travel time information for the freeway route/s downstream from the interchange. The travel time information will provide estimated travel times to:

- two destinations at most sites; and
- four destinations (two destinations per route) for locations close to a freeway to freeway interchange where the traffic can travel in different directions.

Various freeway segments are used for advising motorists about travel times, congestion and events. When interchanges are close to a downstream fork, two signs are provided as outlined in Section 4.8.3. This avoids alternating frames² and also enables more information to be provided during incidents or roadworks.

² Note: Initial RTISs installations provided alternating frames displayed on a single RTIS to provide information for downstream directions on different routes. This is no longer current practice. New installations should use two RTISs in these situations.

The priority of RTIS messages operate in a similar manner to displayed messages on mainline VMS signs as outlined in Section 4.5.2, although some message types are not applicable. The hierarchy of control to reflect appropriate RTIS priorities are outlined in Table 4-6. Typically, when a higher priority message is activated, this would also display travel time and traffic condition information or the incident message would alternate with the default traffic condition and travel time display (refer Sections 4.8.5.2 and 4.8.5.3).

Priority	Message type	Purpose / Description
1.	Incidents	Incident messages provide information to motorists about: <ul style="list-style-type: none"> • An incident, e.g., a crash. • An unplanned event, e.g. breakdown or lost load. • Other road or traffic conditions, e.g., oil spill or congestion.
2.	Community Safety	Not applicable.
3.	Traffic Condition and Travel Time (Default)	Default operation: Dynamic information about real-time traffic conditions, including travel time information.
4.	Planned Works / Events	<p>Messages about roadwork or lane closures and community events that will have a significant impact on a future trip.</p> <p>Generally, RTIS are not a substitute for normal roadworks or traffic management signs, particularly long term works. The traffic management plan for the works shall set out how the information will be communicated to motorists in the event that the RTIS is being used for other higher priority messages.</p> <p>Messages may only relate to the impact of the event on traffic and not promote or raise general awareness of an event.</p> <p>These messages may only alternate with travel time information if the traffic conditions are 'Light' and the impact of the planned works or event is to have a significant impact on road users.</p>
5.	Campaigns / Promotions	Not applicable

Table 4-6: RTIS Message Hierarchy and Purpose

4.8.4.2. Display Details

The full matrix display has the capability to display three horizontal lines of text - typically at 120mm high. A combination of upper case and lower case lettering is used to provide the required legibility and to maximise the display length of messages within the sign width. The sign and font sizes recognise the balance required between font size, sign size, installation cost, display impact relative to static signs and legibility for the likely approach speeds which are typically in the order of 60km/h as motorists enter the turning lane.

The close pixel pitch provides an image with well shaped characters (minimal 'staircase' effect) and the impression of solid lines and surfaces when viewed at the required reading distances. A slightly smaller text size (9 pixels) can be used in the main header. The font sets used on the RTIS are shown in Appendix D. To assist with legibility, the RTIS character, word and row spacings as shown in Table 4-7 generally exceed the minimum requirements of AS 4852.1—2009.

Item	Inactive Pixels
Character spacing	3
Word spacing	6
Line spacing	4

Table 4-7: RTIS Character, Word and Line Spacing

4.8.5. Sign Messages

4.8.5.1. Travel Time and Traffic Condition Messages

The default RTIS message displays travel time to two downstream destinations and traffic condition on the freeway.

The information displayed is based on freeway speed data that is used to calculate the travel time and traffic flow conditions relative to nominal travel time as outlined in Section 4.2. The rationale for choice of travel time destinations is in Section 4.3.

The first line (header) are as follows:

- The freeway 'M' number (left aligned) on which the key destinations are located, as well as directional assistance, if applicable. The colour will be green, yellow or red according to the colour of the freeway condition or event information.
- Freeway condition information and colour (green, yellow or red as appropriate).
- The word 'Min' coloured white and right aligned above the travel time numerals. For some displays it may be necessary to abbreviate the route / traffic condition information to provide space for the 'Min' heading. For some displays abbreviating the route information and freeway traffic condition may not be feasible so it may be necessary to omit the 'Min' heading. This latter layout is generally undesirable as it may cause confusion for some motorists.

M1 - Light	Min	M1 - Medium	Min	M1 - Heavy	Min
Forsyth Rd	6	Toorak Rd	11	Toorak Rd	19
Duncans Rd	14	Warrigal Rd	20	Kings Way	25

Figure 4-14: Examples of RTIS Travel Time and Traffic Condition Messages

In general, modifying the header is to provide additional directional assistance if the key destinations are not on the continuing route or in different directions on an intersecting route.

The general principles are as follows:

- When the key destinations are on two different routes, directional assistance is included, e.g., example signs for southbound traffic entering Western Ring Road at interchanges upstream of the M1 interchange are shown in Figure 4-15.

M1 to City-Medium	Min	M1 to Geel. - Light	Min
Williamstown Rd	12	Forsyth Rd	15
Kings Way	19	Duncans Rd	24

Figure 4-15: RTIS Messages with Directional Assistance in the Header

- Where the key destinations being signed are not on the freeway being entered, the 'M' freeway number on which the destinations are located is shown in the header, i.e., not the freeway being entered. In these cases, subject to space limitations, the word 'via' is included in the header to provide directional assistance as shown in the examples in Figure 4-16.

via M80 - Medium	Min
Western Fwy	15
Sunshine Av	21

Sign at Princes Freeway West / Kororoit Ck Rd
for inbound traffic travelling to the Western Ring Road

via M420 - Heavy	Min
Pound Rd	15

Sign for east bound traffic entering Monash Freeway at Stud Rd

Figure 4-16: RTIS Messages with Directional Assistance in the Header

The freeway traffic condition message is either 'Light' (green), 'Medium' (yellow) or 'Heavy' (red) as appropriate.

Colour coded travel time information is shown to the chosen destinations. The travel time value includes freeway travel time to the destinations and the ramp delay but do not include the travel time between the sign location and the freeway ramp.

Congestion management traffic condition messages as shown in the examples in Figure 4-17 are either 'Major Delays' (flashing red) or 'Seek Alt Route' (flashing red) as appropriate.

M1 - Major Delays	Min	M1-Seek Alt Route	Min
Toorak Rd	25	Toorak Rd	30
Kings Way	35	Kings Way	45

Figure 4-17: RTIS Congestion Management Messages

4.8.5.2. Incident and Event Management Messages

The applicable event message will be displayed on the RTIS as a separate frame which will alternate with the freeway condition / travel time message frame.

Examples of the RTIS messages are shown in Figure 4.18. If the event involves a left lane closure immediately downstream of the ramp entrance due to a LUMS response, the automated display provides this additional information. In this situation the event location (btw Road Name and Road Name) is not displayed.

RTIS Signing			Incident Severity
Frame 1		Frame 2	
(a) Event signing at upstream interchanges within distance defined for severity			
M# - Fwy condition		M# - Event type	2 or 3
Destination 1 ##		from Road Name	
Destination 2 ##		to Road Name	
(b) Left lane closed immediately after entry, i.e., first downstream LUMS			
M# - Fwy condition		M# - Event type	2 or 3
Destination 1 ##		Left Lane Closed	
Destination 2 ##			

Figure 4.18: Incident and Event Messages

Note:

At interchanges where a single RTIS is used to display travel times to downstream destinations on two routes (old practice), i.e., there are already two alternating frames, the event information will replace the freeway condition / travel time information. If incidents occur on two downstream routes the travel times on both routes would be replaced by incident messages.

Generally it is preferable that locations with a single sign for two downstream routes (old practice) be upgraded to provide two signs.

4.8.5.3. Freeway Closure Messages

When the freeway is closed immediately downstream of the entry ramp and traffic must not enter, the message will provide a freeway closed message and indicate where access to the freeway is available. The road name where access is available is defined as the first entry ramp downstream of the closure location.

Where the freeway closure is beyond the next downstream interchange, the location of the closure message will be displayed. The freeway closure may be between two adjacent interchanges or over a longer distance. This frame will alternate with a travel time / freeway condition message frame. Where travel time destinations are not reachable, the travel time will be replaced with a red 'X'.

Examples of the closure messages and the alternating frames with travel time information are shown in Figure 4.19.

RTIS Signing			Incident Severity
Frame 1		Frame 2	
(a) Freeway (or ramp) closure at the RTIS entry ramp			
Freeway Closed Access M# at Road Name		Freeway Closed Event type Use Alt Route	4
(b) Freeway closure downstream - before first travel time destination, i.e., no travel time destinations are reachable			
M# - Closed from Road Name to Road Name		M# - Fwy condition Destination 1 X Destination 2 X	4
(c) Freeway closure downstream - between the first and second travel time destination, i.e., one travel time destination is reachable			
M# - Closed from Road Name to Road Name		M# - Fwy condition Destination 1 ## Destination 2 X	4
(d) Freeway closure downstream of second travel time destination, i.e., two travel time destinations are reachable			
M# - Closed from Road Name to Road Name		M# - Fwy condition Destination 1 ## Destination 2 ##	4

Figure 4.19: Freeway Closure Messages

4.9. Advance Real Time Information Signs

4.9.1. Overview of Device and Usage

Advance Real Time Information Signs (ARTIS) used on the arterial road network in the vicinity of the freeway to provide real time information about the freeway traffic conditions. The signs are generally located some distance away from the freeway at major arterial road intersections where route choices are available. Current usage of ARTIS replace the use of Freeway Condition Signs (refer Section 4.10).

ARTIS as shown in the example in Figure 4-20 are variable message RTIS (refer Section 4.8). The sign provides dynamic travel time to two destinations as well as colour coded freeway traffic conditions.

M80 - Light	Min
Hume Fwy	10
Tulla Fwy	18

Figure 4-20: Freeway Condition Using a Real Time Information Sign

4.9.2. Design Principles for Sign Locations

The principle for positioning signs is to provide information of freeway conditions at travel decision points prior to a driver being committed to enter the freeway. This enables a motorist to take an alternative route if they so desire.

As shown in the sketch in Figure 4-21, ARTISs are generally installed where other alternative 'parallel' routes can provide travel to similar significant end-destinations when compared to travelling on the freeway. Typically, FCSs are only provided in locations remote from the freeway where alternative routes are available.

The ARTISs supplement RTISs which are installed as part of the ramp signalling design at most interchanges to provide travel time and freeway traffic conditions. ARTIS signs are not required in locations where there is no alternative route prior to the freeway and there are RTIS signs at the freeway entry ramps.

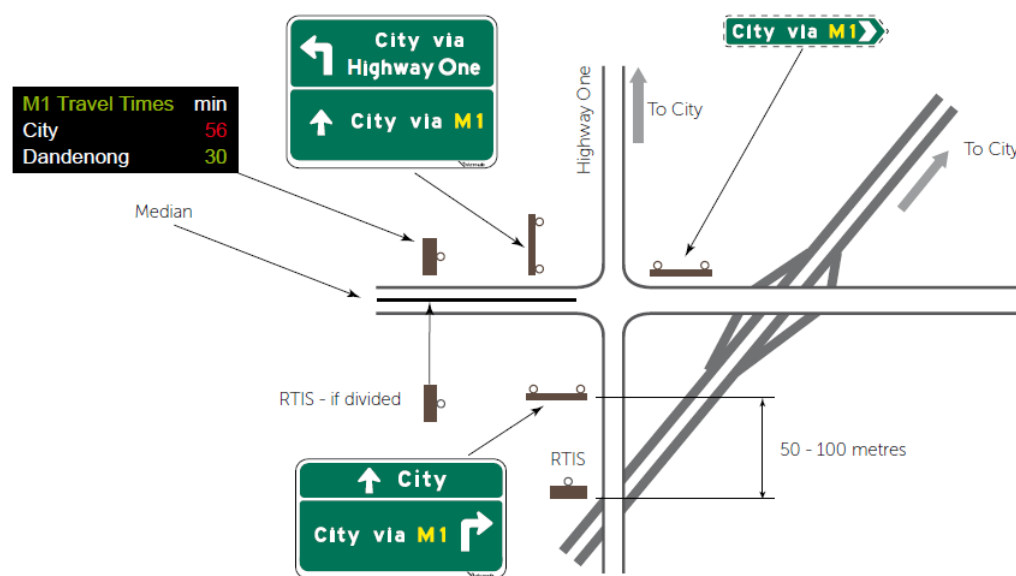


Figure 4-21: Typical Advance Real Time Information Sign Location

ARTIS would generally be installed 50 to 100 metres in advance of associated destination signs, thereby separating the more detailed freeway / arterial condition information from the destination sign information.

On divided arterial roads leading to a full diamond freeway interchange, ARTISs may be appropriate on the median and the left side of the carriageway if traveller information and alternative routes are available in both directions. On undivided roads where the sign can only be installed on the left side of the carriageway, it may only be appropriate for advising motorists of conditions that apply to left turning traffic.

4.9.3. Operating Principles

Information displayed on FCSs is based on freeway speed data that is used to calculate the travel time and traffic flow conditions relative to nominal travel time as outlined in Section 4.2.

Real Time Information Signs used as Freeway Condition Signs display a freeway traffic condition message in the header line as either 'Light' (green), 'Medium' (yellow), 'Heavy' (red), 'Major Delays' (flashing red) or 'Seek Alt Route' (flashing red) as appropriate, according to the principles as outlined in Section 4.2. Colour coded travel time information, in minutes, to the chosen freeway destinations. The travel time value includes freeway travel time and the entry ramp delay but do not include the travel time between the sign location and the freeway ramp.

4.10. Freeway Condition Signs

Freeway Condition Signs (FCS) are used on the arterial road network in the vicinity of the freeway to provide real time information about the freeway traffic conditions. The signs would generally be located on the approach to an interchange or be located some distance away from the freeway at major arterial road intersections where route choices are available. FCS are useful for trips when motorists are considering the use of alternative routes.

FCS consist of an electronic display within a static direction sign as shown in Figure 4-22. The variable display is able to show a dynamic colour coded single line message – LIGHT (green), MEDIUM (yellow), HEAVY (red), CLOSED (red), according to the traffic conditions on the freeway as outlined in Section 4.2. Freeway traffic conditions equivalent to 'Major Delays' and 'Seek Alt Route' are displayed as 'HEAVY'. The static part of the signs provides guidance to alternative routes.



Figure 4-22: Example of a Freeway Condition Sign in an Advance Direction Sign

Historically, FCS were installed to provide travel time signage as part of the Drive Time system. To a large extent, FCS located near interchanges have now been superseded by Real Time Information Signs (refer Section 4.8). On new projects or when upgrading freeways to provide travel time information current practice is to provide Advance Real Time Information Signs (refer Section 4.9) to provide travel time information instead of installing FCS.

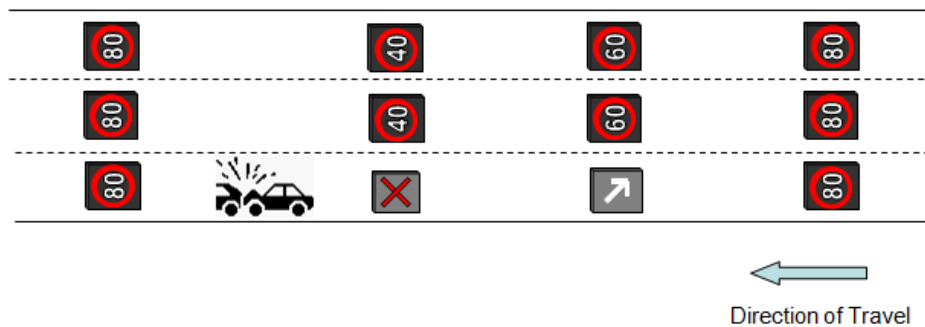
Appendices

APPENDIX A: LUMS Traffic Management Policy Rules

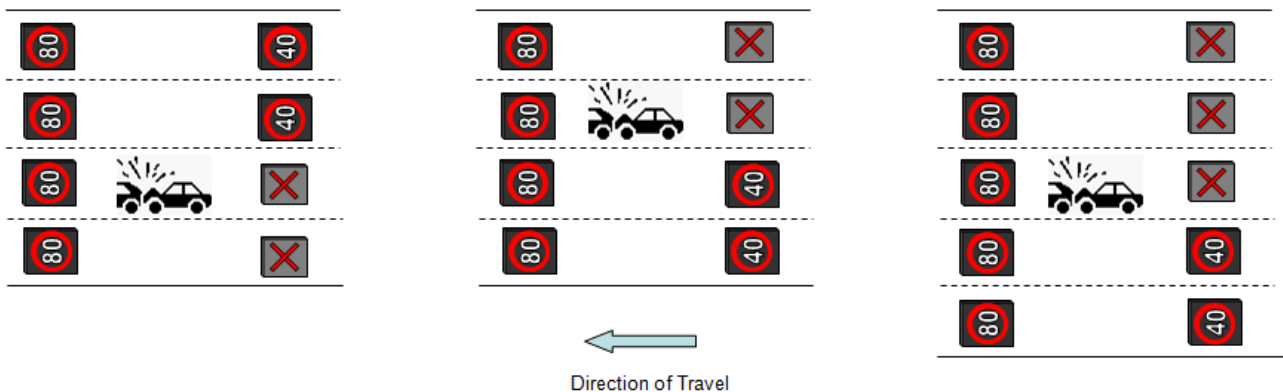
This Appendix outlines principles and typical layouts for lane control, variable speed limits and freeway closure arrangements. Rules are combined to provide the most appropriate response. Automated response plans need to be accepted by the operator before being activated. The operator is also able to modify details of a plan prior to implementation or to change details during an incident based on changing circumstances.

Lane Control

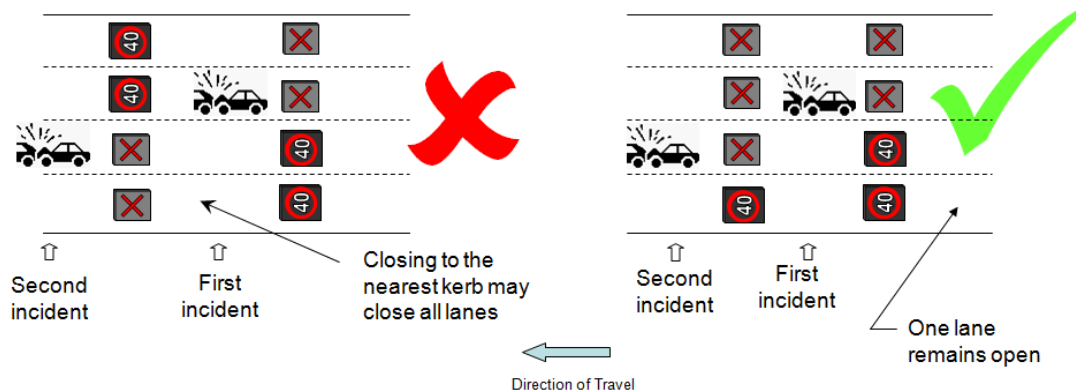
- For an incident, close lane at upstream gantry with a red cross.
- Merge symbol to be displayed at the next upstream sign from a red cross.
- Maintain uniform speed limit across gantry for a single direction. Lowest speed limit to be adopted for the gantry.



- Close adjacent lanes to the nearest kerb at incident gantry.
- Where there are an equal number of adjacent lanes at the incident gantry, close lane to median (right) side.

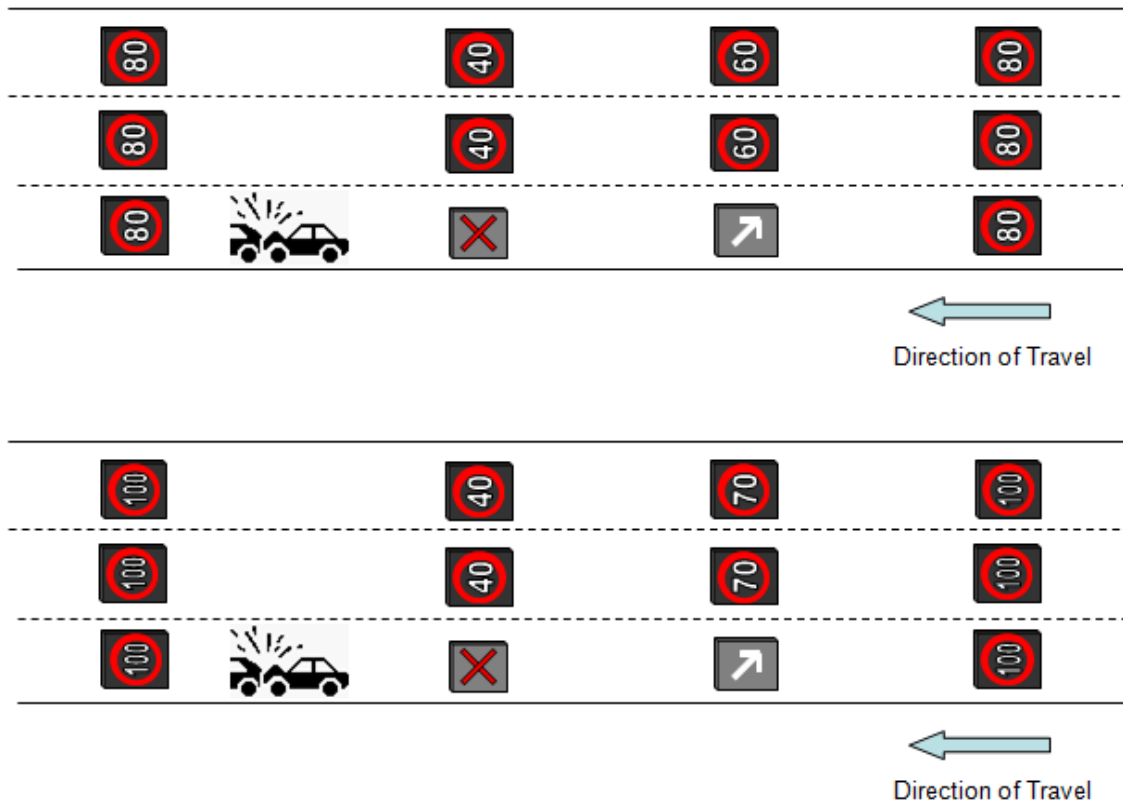


- For secondary incidents, close lanes to the same kerbside as the first incident.

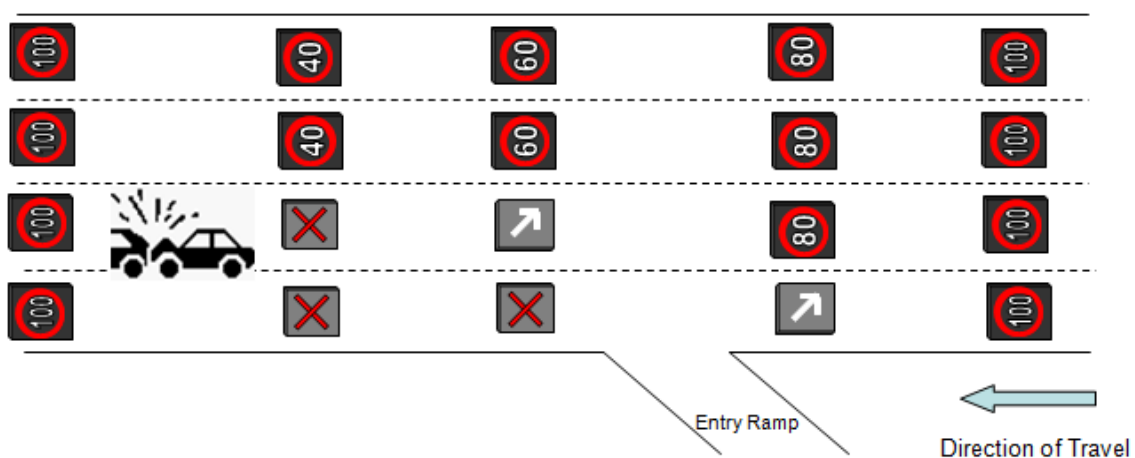


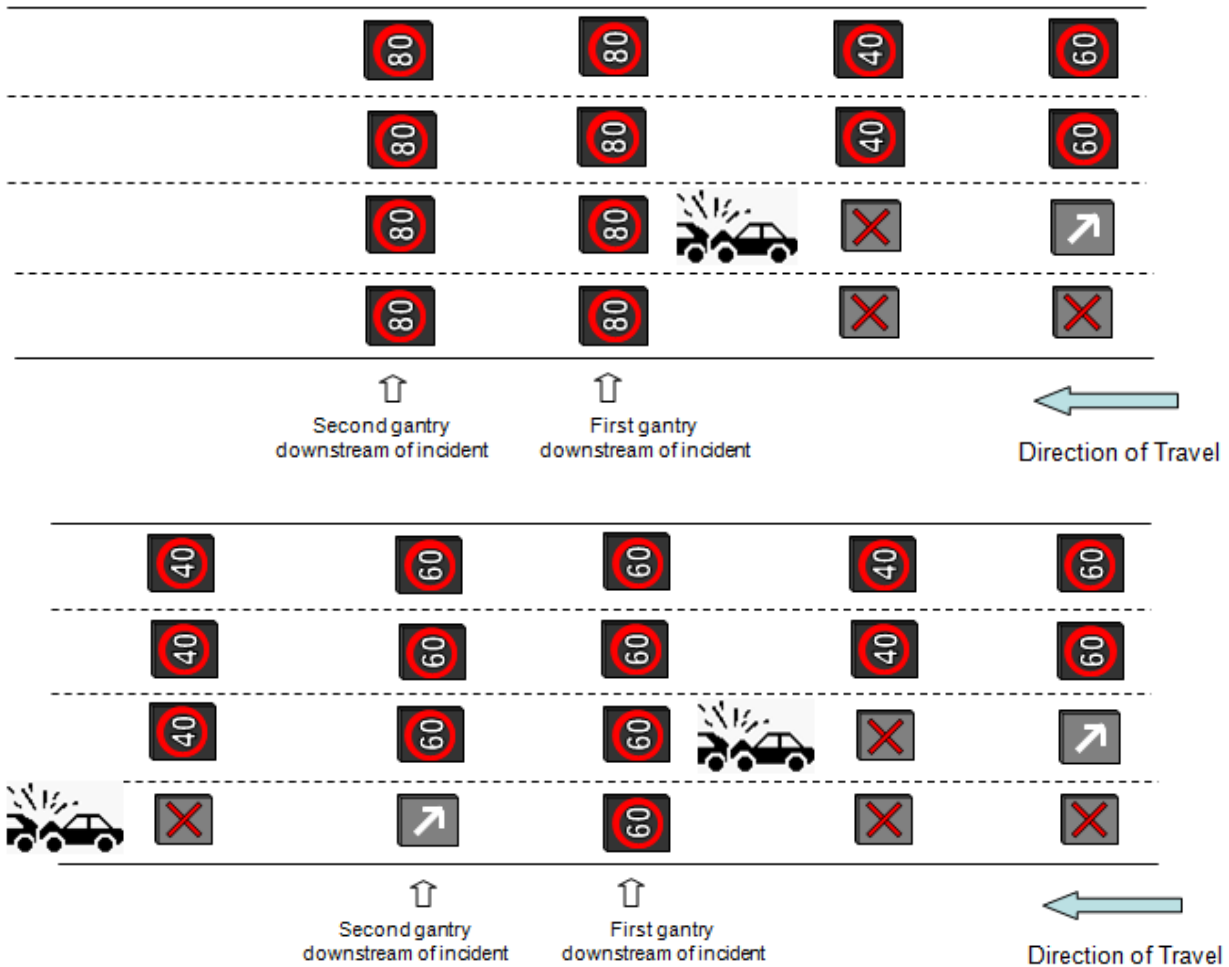
Speed Limit

- The maximum speed limit reduction in relation to an upstream gantry is based on the default speed limit in the section of freeway. In general this involves:
 - 80 km/h: 20km/h maximum reduction; and
 - ≥ 90 km/h: 30km/h maximum reduction.
- The speed limit on the gantry immediately upstream of the incident is 40 km/h.

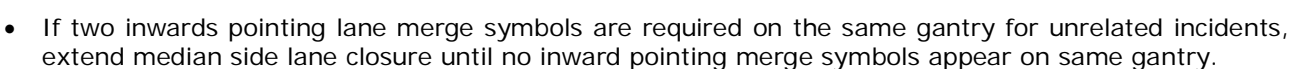


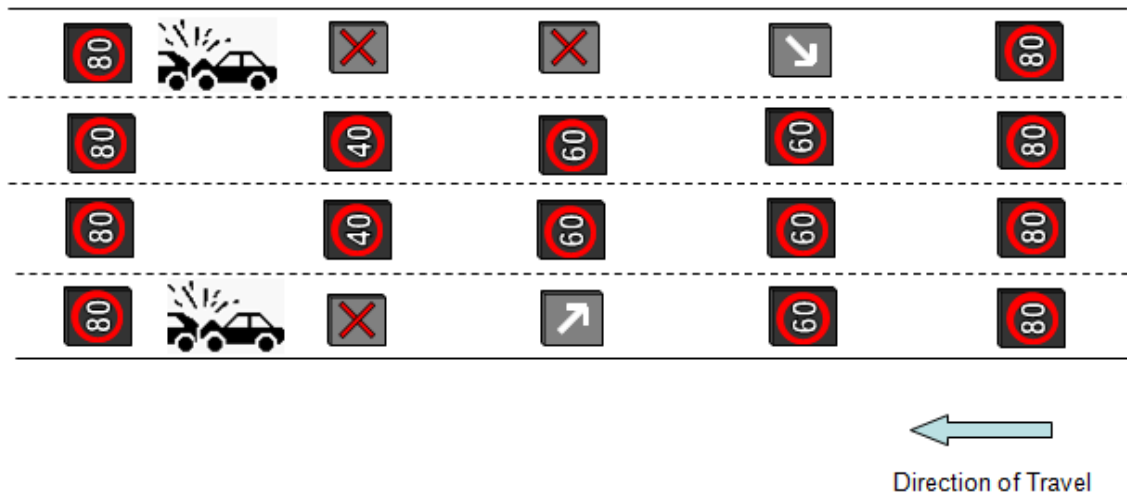
- If gantry has more than one non speed limit, set speed limit to 60km/h unless the gantry is immediately upstream of an incident.
- Subject to the above rules, if a gantry is displaying one non speed limit, the speed limit on that gantry is 'default speed limit minus 20 km/h'.





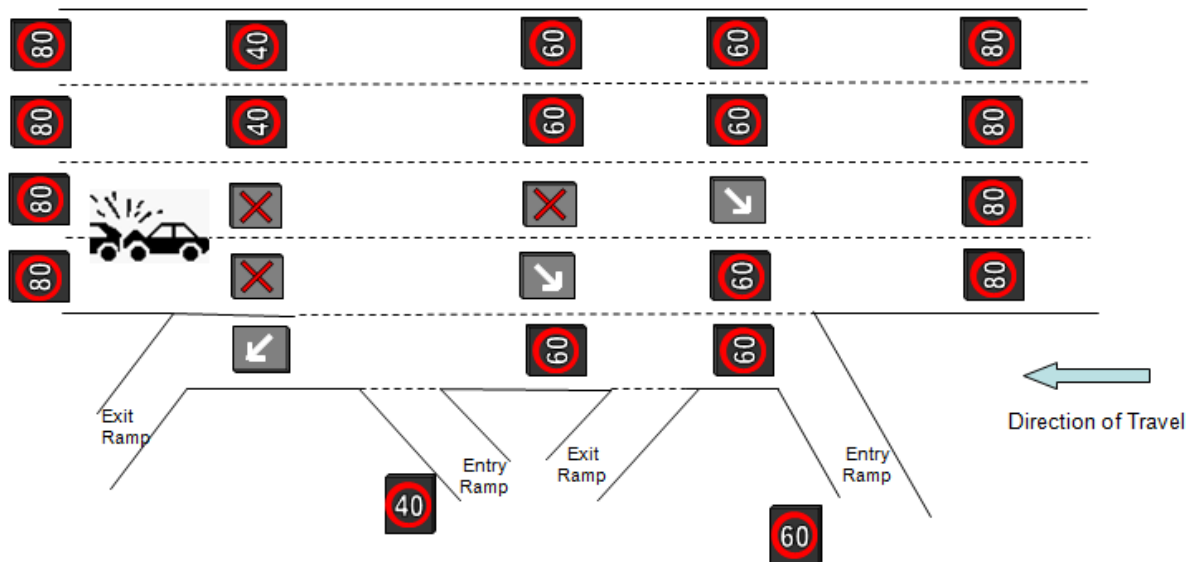
- Multiple lane closures must be propagated (cascaded) to ensure single lane merge movement per gantry.





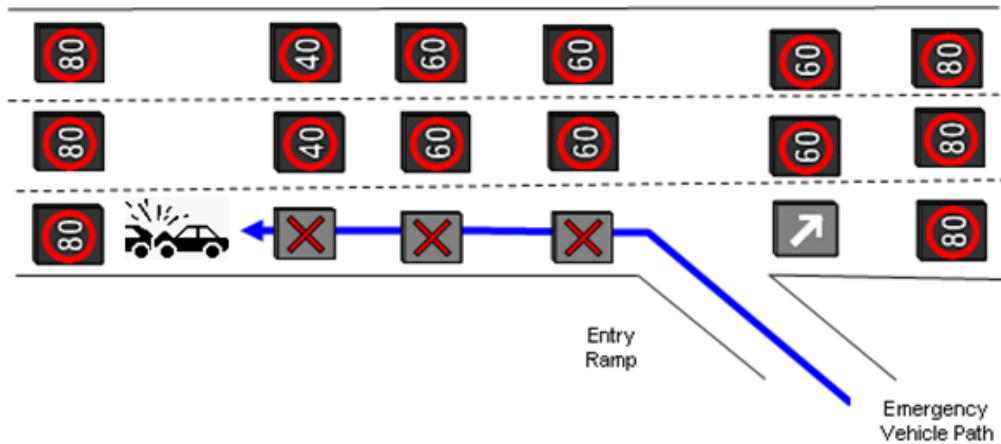
Added Lane

- No split running of lanes unless an add-lane is present
- Add-lane will only be closed if the incident affects the add lane.

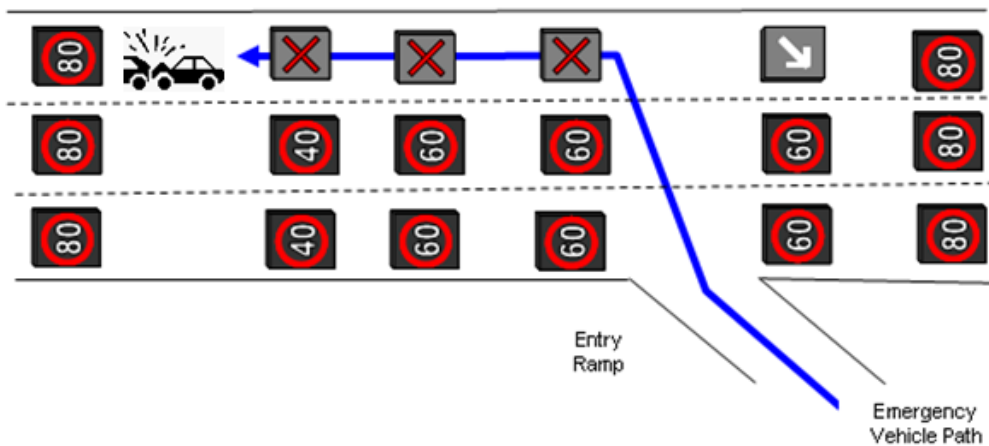


Emergency Access Lane

- Extend kerbside lane closure to the next upstream entry ramp, unless continuous emergency lane is provided between incident and entry ramp.



OR

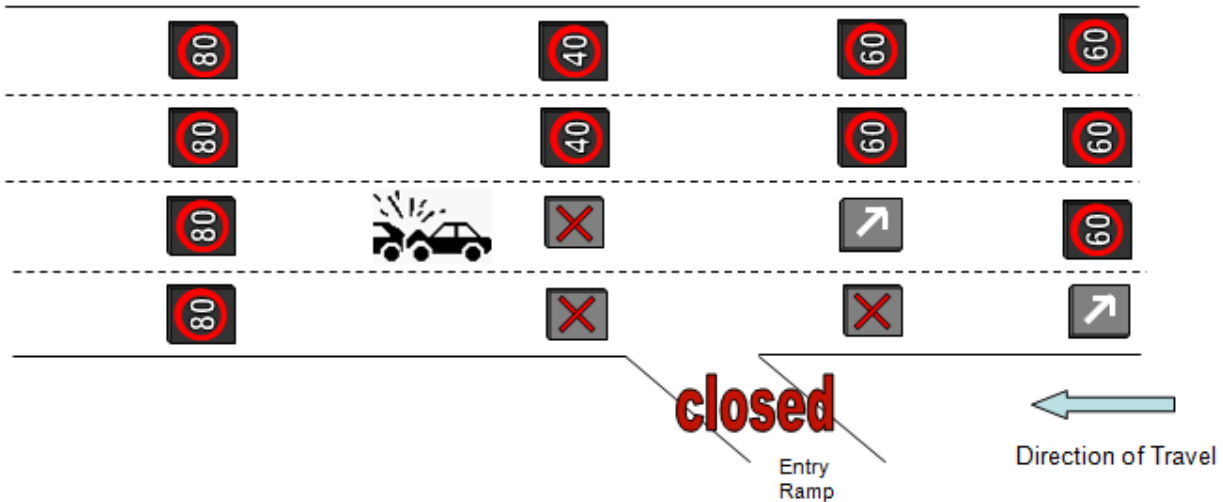


Entry Ramps

- Entry ramp speed limit signs will always display the same speed as the mainline gantry directly upstream from the ramp.
- If next upstream gantry is blank (e.g., failed or disabled), keep moving upstream until a non-blank gantry is found.
- If next upstream gantry is displaying lane control symbols only, entry ramp speed should be 40 km/h.

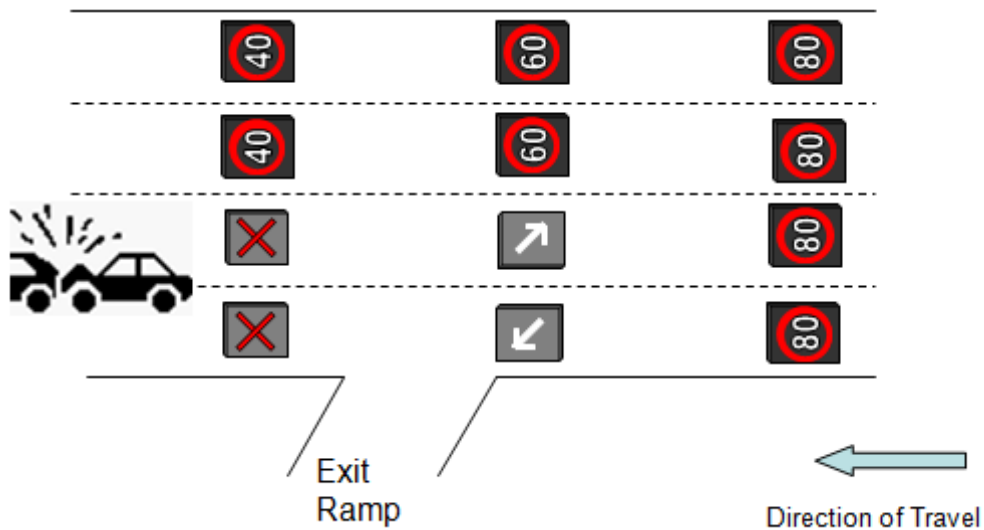


- Close entry ramp if left lane is closed at the upstream gantry.



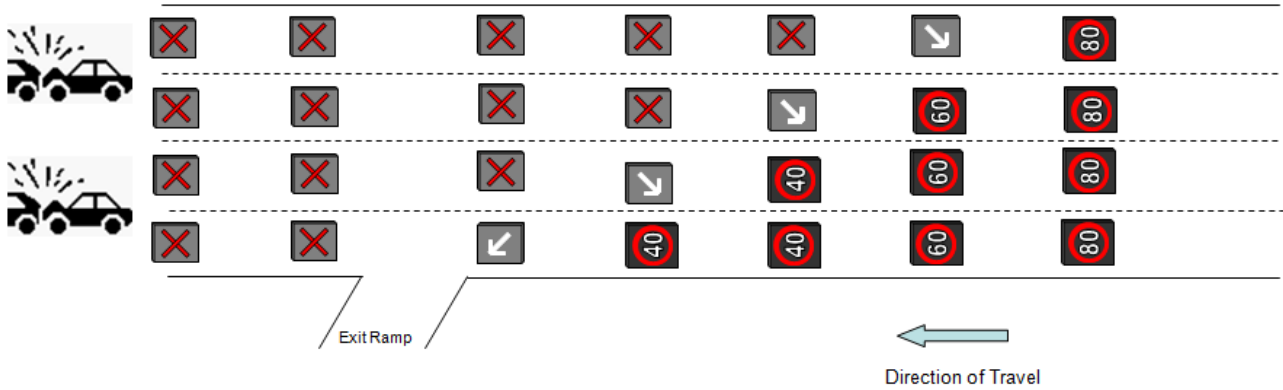
Lane Exit Signal

- A lane exit signal is to be displayed on the upstream gantry of an exit ramp, where two downstream left lanes are closed.
 - Lane Exit signal can only be used on the left kerbside lane.
 - Lane Exit signal generally used when motorists are required to exit freeway.

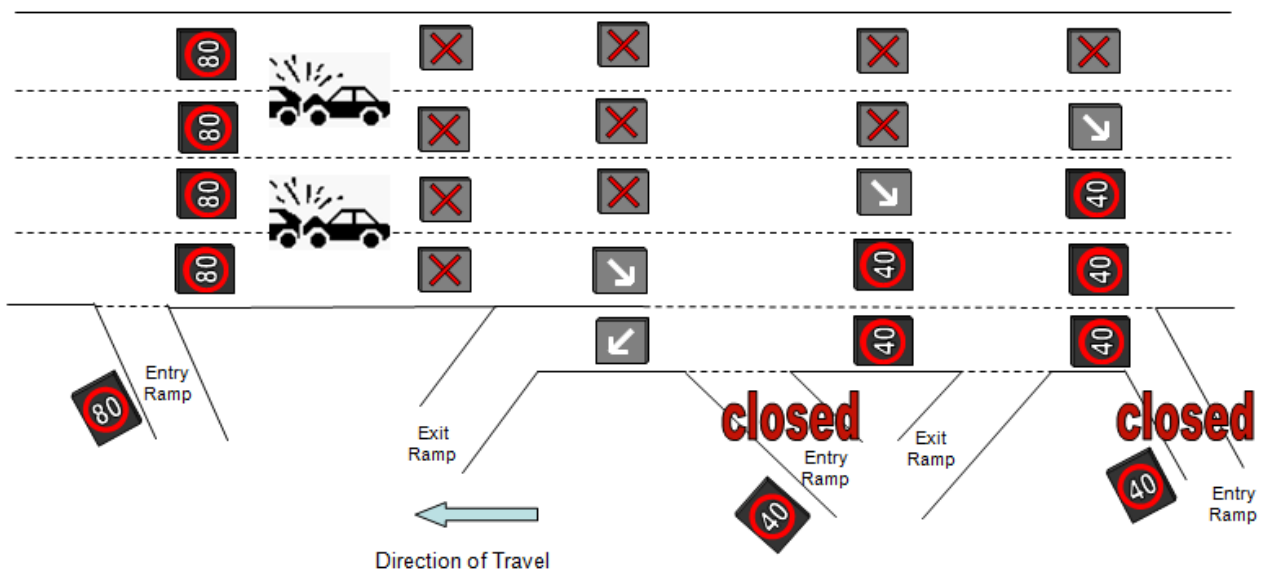


Full Freeway Closure

- All lanes across all gantries will be closed upstream to the next exit ramp where a full freeway closure occurs. Single incident propagation will be applied upstream of the exit ramp.
- 40km/h speed limit on all gantries within the propagated lane closure length where a full freeway closure occurs, except the first gantry.
- First gantry speed limit equals 'default minus 20km/h'.

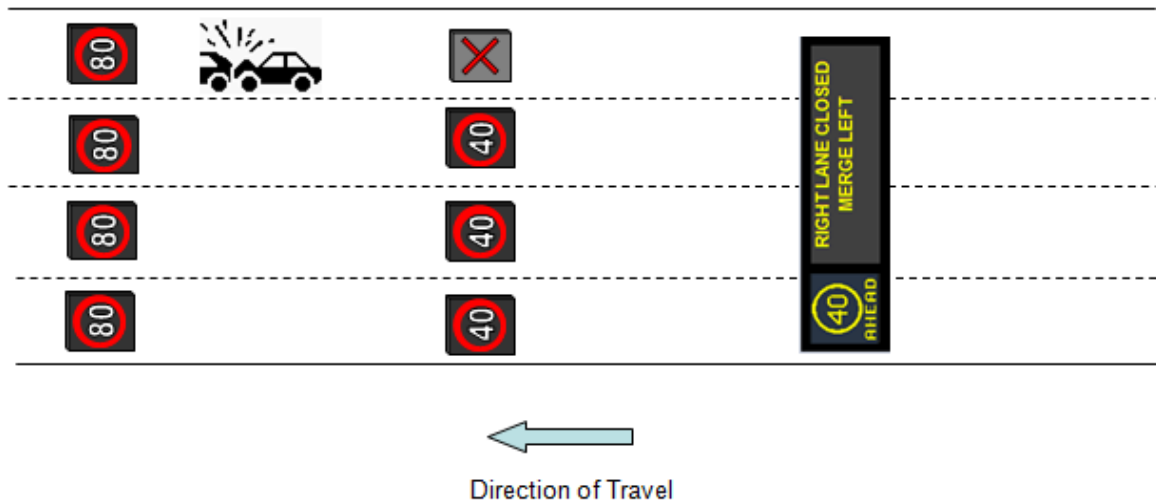


- Close all entry ramps within the closed freeway and lane closure propagation section during full freeway closure.



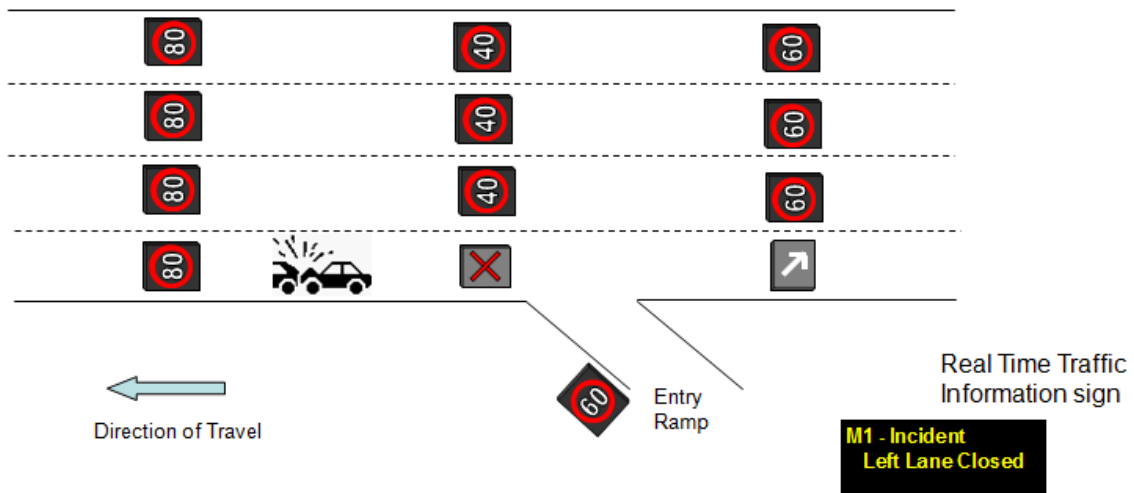
Variable Message Signs

- For a lane closure immediately downstream of first LUMS gantry, upstream VMS must provide reduced speed and lane status information of downstream gantry. The VMS becomes part of the LUMS response.



Ramp Control Signs

- Real Time Information Signs provide lane status information for left lane closure at a downstream gantry. The RTIS becomes part of LUMS response.





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Rule Feature	Description	Parameters		Type	Additional Notes
Speed					
Uniform speed	Uniform speed must be maintained across site, lowest speed limit to be adopted for site.	-	-	Fundamental	
Decreasing speed buffer	Maximum speed reduction that a site may display in relation to the upstream site is determined by the site parameters	* Default ≥ 90 * Default < 90	30 km/h 20 km/h	Policy	
Lane closure speeds	Appropriate speeds must be displayed for lane closures. The maximum speed allowed is based on the number of lane control symbols to be displayed at each site	* Target site * > 1 symbol / site * 1 symbol / site	40 km/h 60 km/h Default - 20 km/h	Policy	Target site refers to location of active event, such as an incident or roadwork site. No speed buffer site required before lane merge site.
Full freeway closure speed	40km/h speed limit on all sites, with at least one lane closed, within the propagated lane closure length where a full freeway closure occurs.	-	-	Policy	First site with merge symbol to act as buffer site. ie. Default - 20km/h
Entry ramp site speed	Ramp sites will always display the same speed as the mainline site directly upstream from the ramp.	-	-	Fundamental	The following conditions are extensions to this rule: * If next upstream site is blank (e.g. failed or disabled), keep moving upstream until a non-blank site is found. * If next upstream site is displaying lane control symbols only, entry ramp speed should be 40km/h
Restoring speed limit	Default speed limit should be restored past the incident site, subject to the speed limit of the first site beyond the incident matching the second site downstream of incident			Policy	This rule aims to prevent three different speed limit changes across three consecutive sites where secondary incident has occurred downstream
Lane Control					
Lane closure	Display red cross for all affected lanes at upstream site	-	-	Fundamental	
Lane merge symbol	Merge symbol to be displayed at the next upstream sign from a red cross. Lane closure propagation will begin at the next upstream site from a lane closure	-	-	Fundamental	* Merge must point to an available lane * Two merge symbols must not point towards each other at the same site * Merge must point to, in the downstream site: - an open lane - a lane merging in the same direction - potential exception in add-lane situation
Multiple lane closures (single incident)	Multiple lane closures must be propagated (cascaded) to ensure single lane merge movement per site	-	-	Policy	
Lane closure side	Close adjacent lanes to the nearest kerb at incident site	-	-	Policy	Where there are equal number of adjacent lanes at the incident site, close lane to median (right) side
Add-lane	If add lane is present, do not include the add lane whilst determining lane closure arrangements. Add lane closure will only occur if the incident occurs in the add lane.	-	-	Policy	Note 'Uniform speed' rule
Access lane	Extend kerbside lane closure to the next upstream entry ramp, unless a continuous emergency shoulder is provided between incident and entry ramp	-	-	Policy	
Secondary closure	Close lanes for a secondary incident to the same side as the original incident	-	-	Policy	
Unrelated incidents	If two inwards pointing lane merge symbols are required on the same site for unrelated incidents, extend median side lane closure until no inward pointing merge symbols appear on same site.	-	-	Policy	
Lane exit symbol	To be displayed on the upstream site of an exit ramp, where two downstream left lanes are closed, or where the left lane is an exclusive exit lane and the adjacent lane is closed.	-	-	Policy	*Lane Exit symbol can only be used on the left kerbside lane *Lane Exit symbol generally used when motorists are required to exit freeway
Full freeway closure	All lanes across all sites will be closed upstream to the next exit ramp. 'Multiple lane closures (single incident)' propagation will be applied upstream of the exit ramp.	-	-	Policy	Note 'Full freeway closure speed' and 'Lane exit signal' rules
Other Devices					
Ramp closure	Close all entry ramps within the closed freeway and lane closure propagation section during full freeway closure	-	-	Policy	
	Close entry ramp if left lane is closed at upstream site			Policy	
RC3 signs	RC3 signs must provide lane status information for left lane closure downstream site (RC3 sign becomes part of LUMS response)	-	-	Policy	
VMS	VMS prior to first LUMS site must provide reduced speed and lane status information of downstream site (VMS becomes part of the LUMS response)	-	-	Policy	

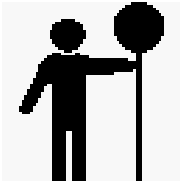


Definitions



Site = LUMS across a separate carriageway
 Target site = First gantry upstream of the incident
 Policy = Operational rules that are not supposed to be broken but can be overwritten
 Fundamental = Rules that can not be broken



APPENDIX B: VMS Pictogram and Sign Library


NO.	SYMBOL	EVENT TYPE	LOCATION	EFFECT	ACTION	Comment
1		HIGH WINDS	- ON _____	- _____ CLOSED - FREEWAY CLOSED	- CAUTION - REDUCE SPEED - DRIVE SAFELY - USE ALT ROUTE - USE EXIT "number" - USE "name" EXIT - USE NEXT EXIT	<i>The pictogram shall be used to represent high winds. This will be used at bridges during winds greater than the prescribed threshold.</i>
2		- CONGESTION - QUEUES	- AHEAD - AT ____ - ____ TO ____ - IN TUNNEL - ON _____ - NEAR ____ - AFTER ____	- EXPECT DELAYS	- PREPARE TO STOP - CAUTION - DRIVE SAFELY - USE ALT ROUTE	<i>This pictogram shall be used for congestion and queuing.</i> <i>The Event Type is to be displayed in the text message section of the sign or beneath the pictogram.</i>
3	No Symbol used for Planned (future) Event	- SPECIAL ROAD EVENT	- ____ TO ____ - IN TUNNEL - ON _____	- EXPECT DELAYS - SEEK ALT ROUTE (NON ACTIVE)	SCHEDULED DAY/DATES - "Day" – "Day" - "No." "Month" - "No." "Month" - "No." "Month" - "No." AM – "No." PM	<i>No pictogram is used for planned events information (i.e. future road works or special road events etc.).</i> <i>The Effects shown red are only used in planned event messages.</i>
		- ROADWORK	- AT ____ - ____ TO ____ - IN TUNNEL - ON _____	- EXPECT DELAYS - NIGHT WORKS - SEEK ALT ROUTE (NON ACTIVE)	SCHEDULED DAY/DATES - "Day" – "Day" - "No." "Month" - "No." "Month" - "No." "Month" - "No." AM – "No." PM	

NO.	SYMBOL	EVENT TYPE	LOCATION	EFFECT	ACTION	Comment
4		BREAKDOWN	<ul style="list-style-type: none"> - AHEAD - AT ____ - IN TUNNEL - ON ____ - NEAR ____ - ____ AHEAD - AFTER ____ 	<ul style="list-style-type: none"> - LEFT LANE(S) CLOSED - RIGHT LANE(S) CLOSED - ON SHOULDER - ____ CLOSED - FREEWAY CLOSED - EXPECT DELAYS 	<ul style="list-style-type: none"> - MERGE RIGHT - MERGE LEFT - REDUCE SPEED - USE ALT ROUTE - USE EXIT "number" - USE "name" EXIT - USE NEXT EXIT - PREPARE TO STOP - CAUTION - REDUCE SPEED - DRIVE SAFELY 	<i>This pictogram shall be used to represent a broken down vehicle</i>
5		ROADWORKS	<ul style="list-style-type: none"> - AHEAD - AT ____ - ____ TO ____ - IN TUNNEL - ON ____ - NEXT ____ - ____ AHEAD - AFTER ____ 	<ul style="list-style-type: none"> - LEFT LANE(S) CLOSED - LEFT LANE(S) CLOSED - LEFT SHOULDER CLOSED - RIGHT SHOULDER CLOSED - ____ CLOSED - FREEWAY CLOSED - MAJOR DELAYS - MINOR DELAYS - EXPECT DELAYS 	<ul style="list-style-type: none"> - MERGE RIGHT - MERGE LEFT - USE ALT ROUTE - USE EXIT "number" - USE "name" EXIT - USE NEXT EXIT - PREPARE TO STOP - CAUTION - REDUCE SPEED - DRIVE SAFELY 	<i>This pictogram shall be used for any active roadwork.</i>

NO.	SYMBOL	EVENT TYPE	LOCATION	EFFECT	ACTION	Comment
6		TRAFFIC CONTROLLER	<ul style="list-style-type: none"> - AHEAD - AT ____ - ____ TO ____ - IN TUNNEL - ON ____ - NEXT ____ - ____ AHEAD - AFTER ____ 	<ul style="list-style-type: none"> - LEFT LANE(S) CLOSED - RIGHT LANE(S) CLOSED - LEFT SHOULDER CLOSED - RIGHT SHOULDER CLOSED - MAJOR DELAYS - MINOR DELAYS - EXPECT DELAYS 	<ul style="list-style-type: none"> - MERGE RIGHT - MERGE LEFT - PREPARE TO STOP - CAUTION - REDUCE SPEED - DRIVE SAFELY 	<i>The Traffic Controller sign shall be used to give advance warning of the presence of a traffic controller. PREPARE TO STOP shall be used in conjunction with this sign if traffic is required to stop at the traffic controller position.</i>
7		- FLOODING	<ul style="list-style-type: none"> - AHEAD - AT ____ - ON ____ - NEXT ____ - ____ AHEAD - AFTER ____ 	<ul style="list-style-type: none"> - ____ CLOSED - FREEWAY CLOSED - MAJOR DELAYS - MINOR DELAYS - EXPECT DELAYS 	<ul style="list-style-type: none"> - USE ALT ROUTE - USE EXIT "number" - USE "name" EXIT - USE NEXT EXIT - PREPARE TO STOP - CAUTION - REDUCE SPEED - DRIVE SAFELY 	<p><i>This pictogram shall be used to represent water over road.</i></p> <p><i>The Event Type is to be displayed in the text message section of the sign or beneath the pictogram.</i></p>
8		EMERGENCY VEHICLE		<ul style="list-style-type: none"> - LEFT LANE CLOSED - RIGHT LANE CLOSED 	<ul style="list-style-type: none"> - MERGE RIGHT - MERGE LEFT - CAUTION 	<i>This pictogram shall be used when a lane closure is implemented solely for use by an emergency vehicle.</i>

NO.	SYMBOL	EVENT TYPE	LOCATION	EFFECT	ACTION	Comment
9		CYCLING EVENT	<ul style="list-style-type: none">- ____ TO ____- IN TUNNEL- ON ____	<ul style="list-style-type: none">- LEFT LANE(S) CLOSED	<ul style="list-style-type: none">- MERGE RIGHT	<i>This pictogram shall be used for an active cycling event.</i>
		<ul style="list-style-type: none">- RIGHT LANE(S) CLOSED		<ul style="list-style-type: none">- MERGE LEFT		
		<ul style="list-style-type: none">- LEFT SHOULDER CLOSED- RIGHT SHOULDER CLOSED			<i>The type of cycling event is to be displayed in the text message section of the sign or beneath the pictogram.</i>	
		<ul style="list-style-type: none">- _____CLOSED- FREEWAY CLOSED		<ul style="list-style-type: none">- USE ALT ROUTE- USE EXIT “number”- USE “name” EXIT- USE NEXT EXIT		<i>This pictogram shall be used for an active running event.</i>
		<ul style="list-style-type: none">- MAJOR DELAYS- MINOR DELAYS- EXPECT DELAYS		<ul style="list-style-type: none">- PREPARE TO STOP- CAUTION- REDUCE SPEED- DRIVE SAFELY		
10		<ul style="list-style-type: none">- OIL SPILL- DEBRIS- CHEMICAL SPILL- FOG- SMOKE- ANIMAL	<ul style="list-style-type: none">- AHEAD- AT ____- IN TUNNEL- ON ____- NEAR ____- AFTER ____	<ul style="list-style-type: none">- LEFT LANE(S) CLOSED	<ul style="list-style-type: none">- MERGE RIGHT	<i>This pictogram shall only be used when there is not a more specific pictogram available. It may be used individually or in conjunction with words indicating the Event Type.</i>
				<ul style="list-style-type: none">- RIGHT LANE(S) CLOSED	<ul style="list-style-type: none">- MERGE LEFT	
				<ul style="list-style-type: none">- _____CLOSED- FREEWAY CLOSED	<ul style="list-style-type: none">- USE ALT ROUTE- USE EXIT “number”- USE “name” EXIT- USE NEXT EXIT	<i>The Event Type is to be displayed in the text message section of the sign or beneath the pictogram.</i>
				<ul style="list-style-type: none">- MAJOR DELAYS- MINOR DELAYS- EXPECT DELAYS	<ul style="list-style-type: none">- PREPARE TO STOP- CAUTION- REDUCE SPEED- STAY IN VEHICLE- DRIVE SAFELY	

NO.	SYMBOL	EVENT TYPE	LOCATION	EFFECT	ACTION	Comment
11		INCIDENT	<ul style="list-style-type: none"> - AHEAD - AT ____ - IN TUNNEL - ON ____ - NEAR ____ - AFTER ____ 	<ul style="list-style-type: none"> - LEFT LANE(S) CLOSED - RIGHT LANE(S) CLOSED - ____ CLOSED - FREEWAY CLOSED - LEFT SHOULDER CLOSED - RIGHT SHOULDER CLOSED - MAJOR DELAYS - MINOR DELAYS - EXPECT DELAYS - RIGHT LANE(S) CLOSED 	<ul style="list-style-type: none"> - MERGE RIGHT - MERGE LEFT - USE ALT ROUTE - USE EXIT "number" - USE "name" EXIT - USE NEXT EXIT - CAUTION - REDUCE SPEED - STAY IN VEHICLE - DRIVE SAFELY - MERGE LEFT 	<i>This pictogram shall be used to for an incident or a crash.</i>
12		(Used as part of a LUMS response only)		<ul style="list-style-type: none"> - LEFT LANE(S) CLOSED - RIGHT LANE(S) CLOSED 	<ul style="list-style-type: none"> - MERGE RIGHT - MERGE LEFT 	<i>This pictogram shall only be used prior to the start of a LUMS environment to display advance warning of a reduced speed limit to 40km/h and lane closure at the 1st LUMS gantry, i.e., when there is no other upstream gantry to indicate a lane change is required.</i>

NO.	SYMBOL	EVENT TYPE	LOCATION	EFFECT	ACTION	Comment
13		EXIT		- FREEWAY CLOSED	<ul style="list-style-type: none"> - USE EXIT "number" - USE "name" EXIT - USE NEXT EXIT 	<i>This pictogram shall be used only on the VMS upstream of a full freeway closure and upstream of an off ramp informing motorists that they must exit at the next exit.</i>

APPENDIX C: M1 and M80 Travel Time Destinations

This Appendix provides examples of travel time destinations as used on the M1 and M80.

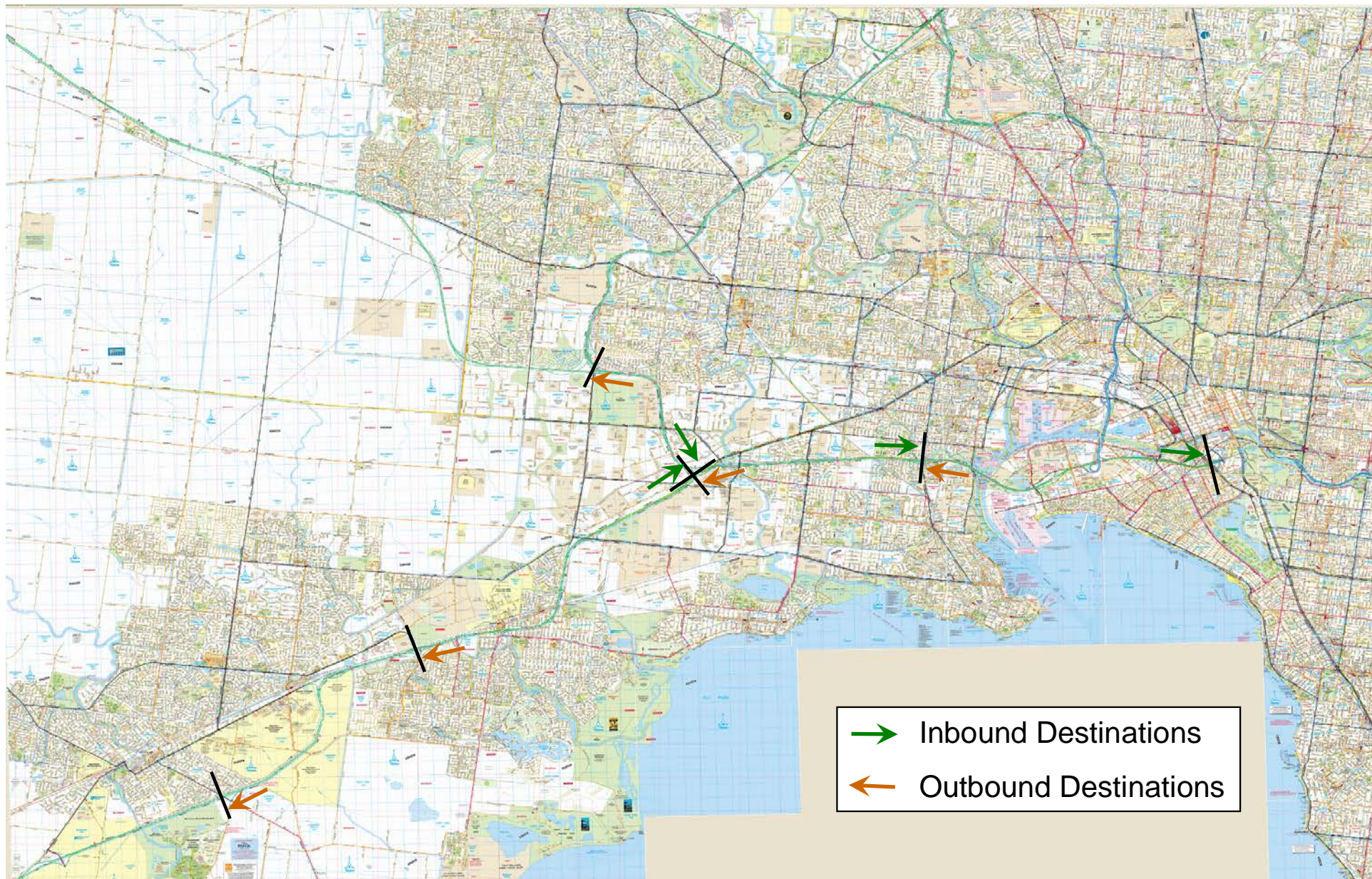


Figure A-1: M1 Travel Time Destinations - West of the City

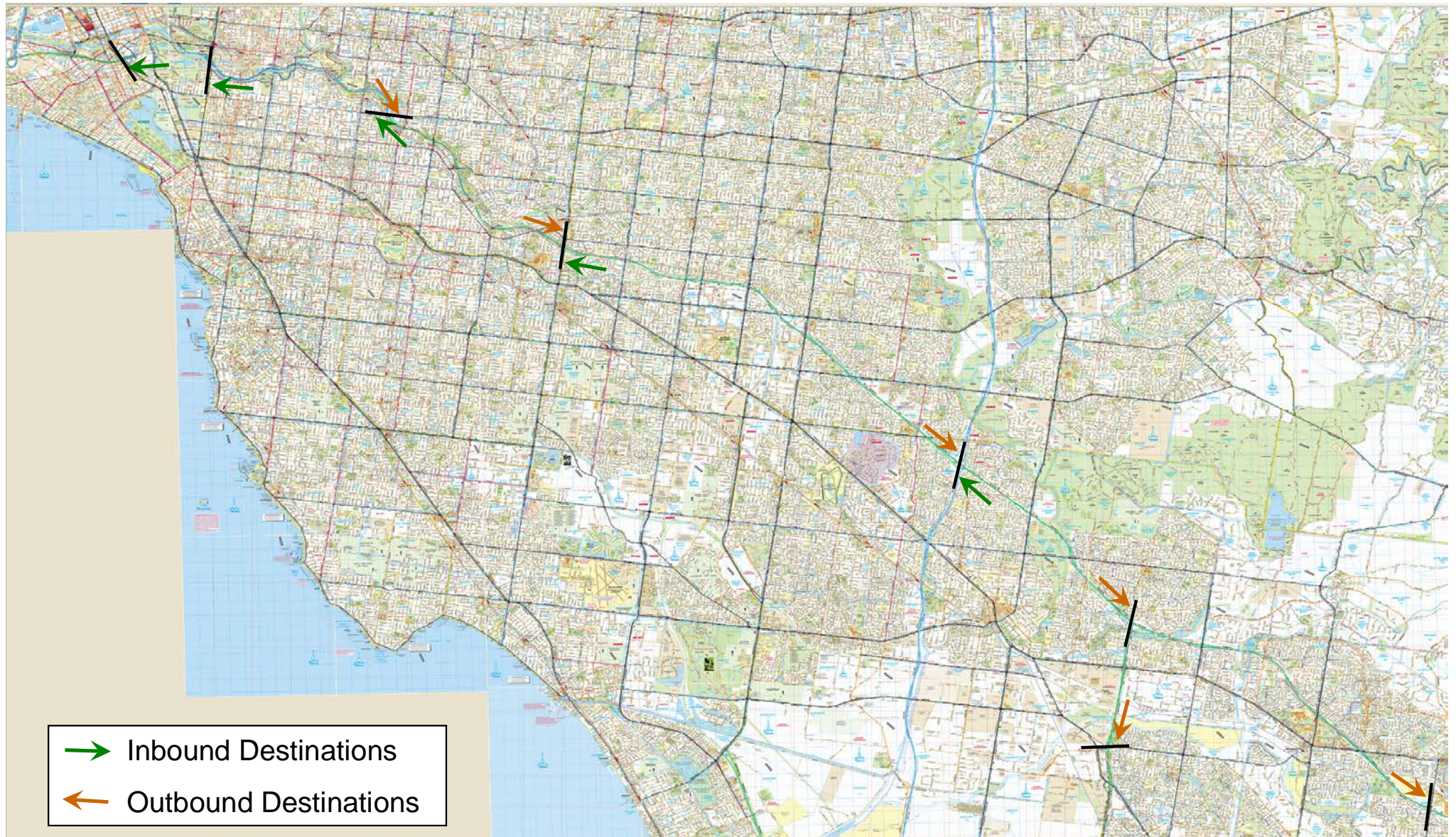


Figure A-2: M1 Travel Time Destinations - East of the City

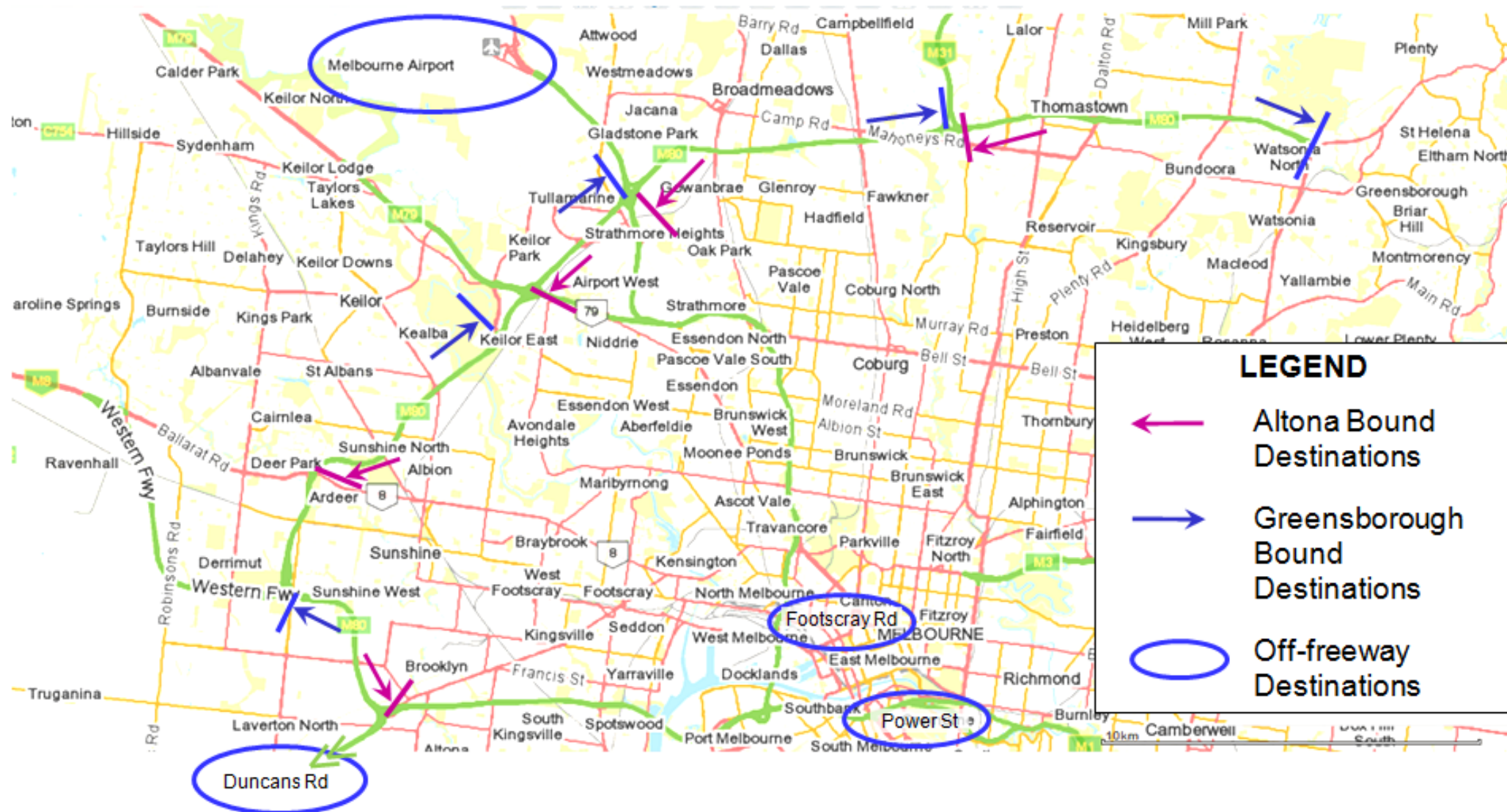


Figure A-3: M80 Travel Time Destinations

APPENDIX D: Real Time Information Sign Fonts

The 12mm matrix size and use of lower and upper case lettering requires a special font set which is coded into STREAMS for its operation.

9 Pixels high

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z
0 1 2 3 4 5 6 7 8 9 < > + - ' , . & / \ ()

10 Pixels high

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z
0 1 2 3 4 5 6 7 8 9 < > + - ' , . & / \ ()

APPENDIX E: References

- Abdel-Aty, Haleem, Cunningham and Gayah 2009, *Application of Variable Speed Limits and Ramp Metering to Improve Safety and Efficiency of Freeways*, 2nd International Symposium on Freeway and Tollway Operations, Hawaii, 2009.
<http://2isfo.eng.hawaii.edu/Presentations/06%20Plenary%20Session%204/PS4%20-%20Abdel-Aty.pdf>
- Austrroads 2009, *Guide to Road Design Part 6: Roadside Design, Safety and Barriers*, Austrroads, Sydney, NSW.
- Austrroads 2008, *Guide to Road Safety Part 3: Speed Limits and Speed Management*, Austrroads, Sydney, NSW.
- Austrroads 2007a, *Tools that Impact Network Performance: Dynamic Traffic Management Tools*, by D Green & C Karl, AP-R312/07, Austrroads, Sydney, NSW.
- Austrroads 2007b, *Traffic Incident Management: Best Practice*, by P Charles, report AP-R304/07, Austrroads, Sydney, NSW.
- Austrroads 2008, *Guide to Traffic Management Part 5: Road Management*, Austrroads, Sydney, NSW.
- Austrroads 2008, *Guide to Traffic Management Part 10: Traffic Control and Communication Devices*, Austrroads, Sydney, NSW.
- Austrroads 2009, *Guide to Traffic Management Part 13: Road Environment Safety*, Austrroads, Sydney, NSW.
- Austrroads 2009a, *Best Practice for Variable Speed Limits: Best Practice Recommendations*, report AP-R344/09, Austrroads, Sydney, NSW.
- Austrroads 2009b, *Freeway Design Parameters for Fully Managed Operations*, Report AP-R341/09, Austrroads, Sydney, NSW.
- Booz Allen Hamilton 2003, *Better Utilisation of Motorway Infrastructure, Final Report*, Ref No. A4118, August 2003, VicRoads, Kew, Vic.
- Green, D & Pyta, V 2007, '*Lane Use Management Investigation*', contract report VC73451-1, ARRB Group, Vermont South, Vic.
- Highways Agency (2002), *Incident Management Study*, Highways Agency, UK.
- Instinct and Reason, 2008, *Traveller Information – Stage 4 Reporting, Quantitative Survey with Drivers*, Austrroads Project NS1149, Austrroads, Sydney, NSW.
- MacCubbin, RP, Staples, BL, Mercer, MR, Kabir, F, Abedon, DR & Bunch, JA 2005, *Intelligent Transportation Systems Benefits, Costs, and Lessons Learned: 2005 update*, report FHWA-JPO-05-002, Department of Transportation, Washington, DC.
- Papageorgiou M., Kosmatopoulos, E., and Papamichail, I., 2008. Effects of *Variable Speed Limits on Motorway Traffic flow*, TRB 2008 Annual Meeting, Washington, DC.
- Ramsay, ED & Luk JYK 1997, *Route Choice under Two Australian Travel Information Systems*, Research report ARR 312, ARRB Transport Research, Vermont South, Vic.
- Road Safety Road Rules 2009, Victorian Legislation and Parliamentary Documents.
<http://www.legislation.vic.gov.au/>
- Road Safety (Traffic Management) Regulations 2009, Victorian Legislation and Parliamentary Documents.

<http://www.legislation.vic.gov.au/>

Standards Australia 2009, *Variable Message Signs Part 1: Fixed Signs*, AS 4852.1—2009 Sydney, NSW.

Sinclair Knight Merz, 2005, *Perceptions of Behavioural Responses to the Victorian Drive Time System*, Armadale, Vic.

VicRoads June 2010, *Monash-CityLink-West Gate Upgrade Project: Traveller Information, Incident Management and Ramp Signals Integration*, (Internal Report), VicRoads, Kew, Vic.

VicRoads 2012, *Managed Freeways: Freeway Ramp Signals Handbook*, VicRoads, Kew, Vic.

VicRoads 2011, *VicRoads Supplement to the Austroads Guide to Road Design Part 6 - Roadside Design, Safety and Barriers*, VicRoads, Kew, Vic.

VicRoads 2011, *Traffic Engineering Manual Volume 2, Signs and Markings*, VicRoads, Kew, Vic.

Victoria Government (2010), *Code of Practice for Worksite Safety – Traffic Management*, Road Management Act 2004, Victoria Government Gazette No. S 351 Tuesday 31 August 2010.

