Chapter 4

Criteria for Provision of Freeway Ramp Signals

4.1. Existing Freeways

4.1.1. Background Analysis

The analysis of freeway flow data will generally involve assessment of flow, speed and occupancy information along the freeway. This assessment is to identify bottlenecks at merges and other locations as well as consideration of the frequency and duration of flow breakdown from day to day or the potential for flow breakdown.

4.1.2. Isolated Locations

These will be locations where isolated ramp metering control may be provided because the breakdown of the mainline freeway flow is localised and clearly associated with platoons of traffic entering at a particular ramp. Generally, the localised flow breakdown will be unrelated to downstream congestion or high upstream flows.

4.1.3. Route Treatment

A route-based treatment will be required:

- Where the congestion and flow breakdown is occurring at a number of bottlenecks over a length of freeway, or
- Where flow breakdown occurring at a particular location cannot be addressed by an isolated ramp meter, i.e., the freeway flow causing the flow breakdown results from a combination of a number of upstream entry ramps, or
- Where the peak period traffic volume for the freeway mainline between interchanges is 1700 pc/h/ln or more, without flow breakdown.

Generally, in a route-based treatment, effective control of the freeway flow at a particular bottleneck can only be achieved by metering upstream entry ramps for a distance of at least six ramps. This also improves access equity via the balancing of ramp queues.

4.1.4. Provision at New Ramps on Existing Freeways

Where new ramps are being added to an existing freeway, ramp metering signals are to be provided in the following circumstances:

- Where other upstream or downstream ramps along the freeway are currently metered, or
- Where a need for metering along the route has been identified and the route is proposed for metering, or
- Where the peak period traffic volume for the freeway mainline between interchanges is 1700 pc/h/ln or more, with or without flow breakdown.

4.2. New Freeways

The consideration of ramp metering on new freeways or on connections or extensions to existing freeways is to be based on detailed investigation and analysis of anticipated peak traffic demand on the freeway within 10 years of opening.

Where the new freeway is extending or connecting to an existing freeway, it is necessary to recognise the potential impact of additional traffic on adjacent downstream, or upstream, sections of the existing freeway. The investigation must account for the expected additional traffic and possible redistribution of traffic. The impact may extend for a number of interchanges.

In undertaking this assessment the analysis should identify all freeway sections which meet the following conditions:

- The peak period traffic volumes are 1700 pc/h/ln or more for the mainline flow along any section of the new freeway,
- The new freeway results in the downstream peak volumes between interchanges on adjacent sections of freeway to increase above a value of 1700 pc/h/ln.

A route-based treatment would generally be necessary to provide effective control of the freeway flow at a particular bottleneck or over a length of freeway and to provide balancing of ramp queues for access equity. This would usually require metering of at least six entry ramps.

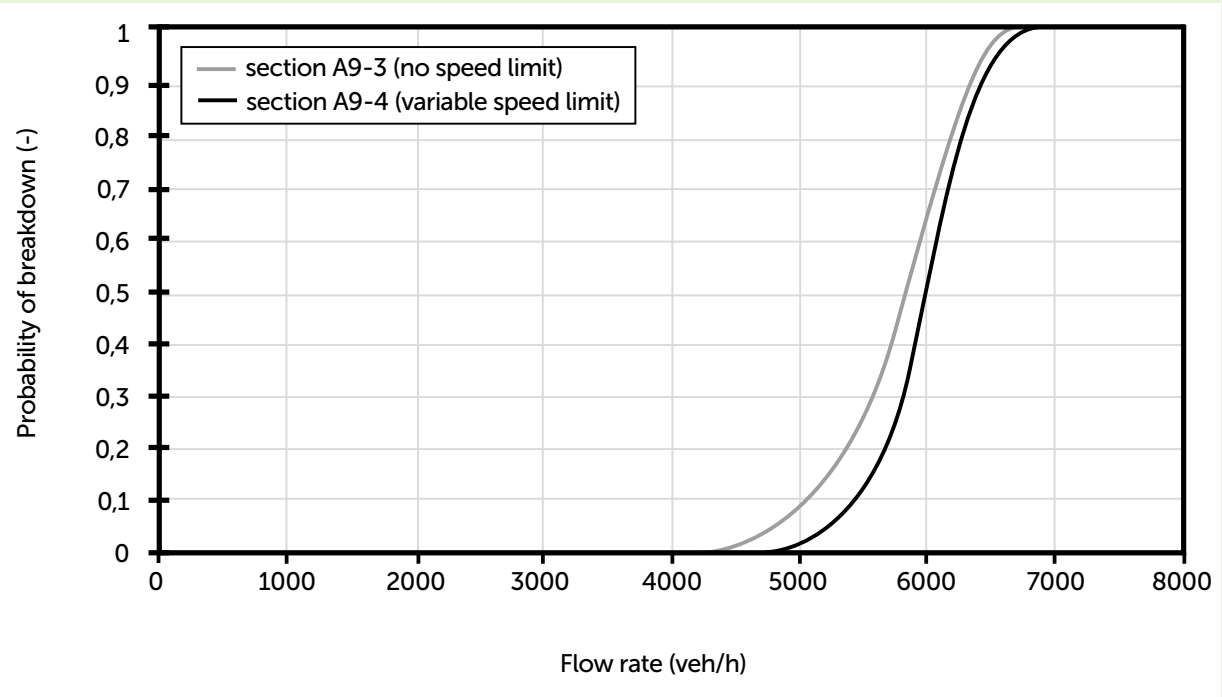
The business case or scope approval report for the project shall provide a summary of the findings of the above analysis, with a recommendation on whether ramp meters are required as part of the new freeway or freeway extension/connection project.

Note:

The criteria of 1700 pc/h/ln for provision of freeway ramp signals is based on a number of factors including:

- The probability of flow breakdown occurring. Research by Brilon et al (2005) indicates that at flows in this range there is approximately 5% to 10% probability of flow breakdown occurring (refer Figure 4.1). At 2000 veh/h/ln the probability is in the order of 50 to 60%.
- The objective of preventing flow breakdown, even at low levels of probability, given the economic impact that this can have on traffic efficiency and safety.
- The breakdown at entry ramp merges is a probabilistic rather than a deterministic event. Research by Elefteriadou et al (1995) indicates that reaching capacity flow is not a prerequisite for flow breakdown and that the clusters of vehicles from the ramp, rather than ramp flow, affect the ramp merge. Further comment relating to entry ramp merges is in Section 2.4.3.
- At mainline flows of this value, generally the entry ramp flows are also becoming significant.
- To provide a margin for future demand increase, and
- Consideration of traffic flows and the stability of flow on Melbourne's freeways.

The use of pc/h/ln is due to the potential flow effects of heavy vehicles in the traffic stream.



Source: Brilon et al (2005)

Figure 4.1: Probability of Flow Breakdown on a 3 lane Freeway

4.3. Operational Standard for New Ramp Signals

All new ramp signals, including isolated ramp signals that are to be under local control, are to be designed and installed to operate dynamically within the VicRoads coordinated freeway ramp signals system utilising the HERO suite of algorithms. When compared to fixed time operation, the dynamic operation of ramp signals that adapt to changing traffic flows on the freeway has been shown to improve freeway flow and minimise flow breakdown (refer Appendix B).

4.4. Freeway to Freeway Ramps

The performance of a managed freeway is determined by its ability to minimise or avoid flow breakdown, to perform well under stress and to recover as soon as possible in the event of congestion occurring. This means designing the infrastructure to minimise the potential for flow breakdown and providing facilities to manage traffic demand and flow within the freeway's capacity. Therefore, the general principle is to control and regulate all traffic entering a managed freeway.

Freeway-to-freeway (system interchange) ramps provide connections between high speed facilities where drivers may not expect to stop, nor expect to encounter a queue of stopped vehicles. Generally, these ramps are high traffic flow environments where it is desirable to provide an uninterrupted freeway journey. Freeway to freeway ramps may also be difficult locations for provision of the widening and storage facilities required to manage metered traffic due to structures or fill. However, as flows entering a managed freeway from another freeway would contribute to the potential for flow breakdown on the managed freeway, ramp signals need to be considered. Where ramp metering is provided it would only operate when needed and uninterrupted free-flow operation would be available at other times. If flow breakdown does occur on the managed freeway this would impact not only the managed freeway but also the traffic from the entering freeway.

Metering the upstream entry ramps from arterial roads, rather than the freeway-to-freeway ramps, may be a workable strategy for managing the freeway-to-freeway merge and downstream section of freeway. But, where the intersecting freeway does not have entry ramp signals or where the upstream ramp metering is unable to provide the necessary management of entering flows and additional control is required to manage downstream flow on the mainline, freeway-to-freeway metering would generally be required. A further advantage of metering freeway-to-freeway ramps is that it would assist in the ability to manage traffic during incidents and improve the recovery from flow breakdown after an incident.

Where the intersecting freeway joins with the managed freeway as shown in Figure 4.2, the traffic from ramps immediately upstream of the interchange makes a significant contribution to the flow entering the managed freeway. The metering of several upstream ramps can then be used to control the traffic at the interchange merge as well as the downstream section of freeway.

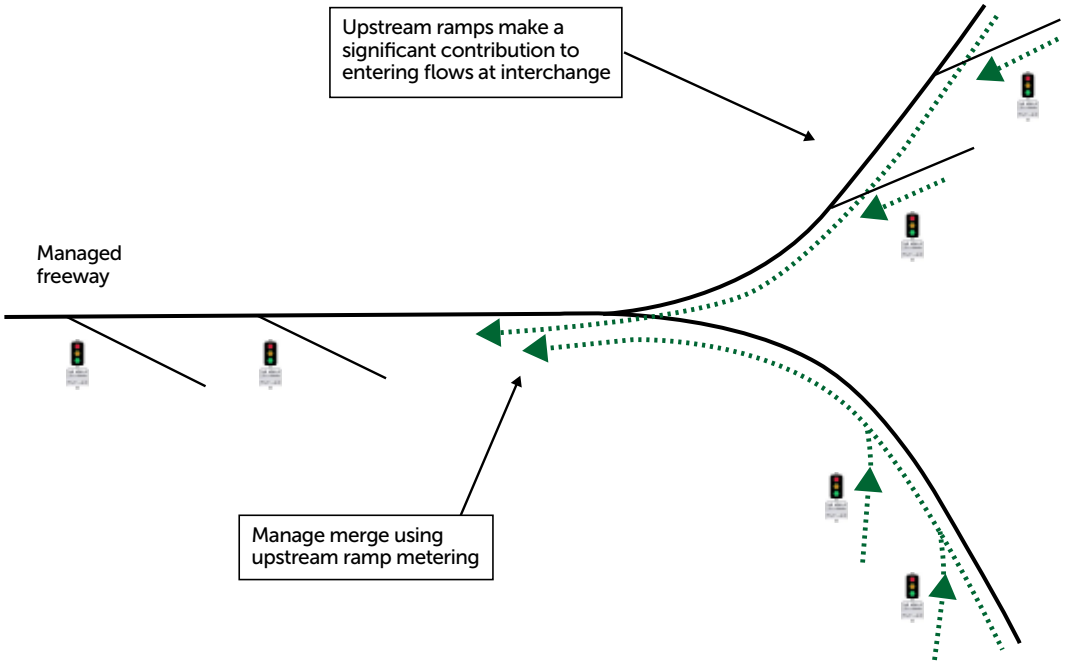


Figure 4.2: Traffic Flows at Freeways that Join

For interchanges where the major traffic flow crosses the managed freeway, as shown in Figure 4.3, the metering of the upstream ramps on the intersecting freeway may not provide the desired level of control for the managed freeway as the ramps immediately upstream of the interchange would generally make a lower traffic contribution to the turning flows at the interchange. The metering of upstream ramps on the intersecting freeway would also disadvantage traffic that is not exiting to the managed freeway. In this situation ramp signals on the freeway-to-freeway ramp would generally be required for effective control of entering flows at the interchange merge as well as control of the downstream section of managed freeway.

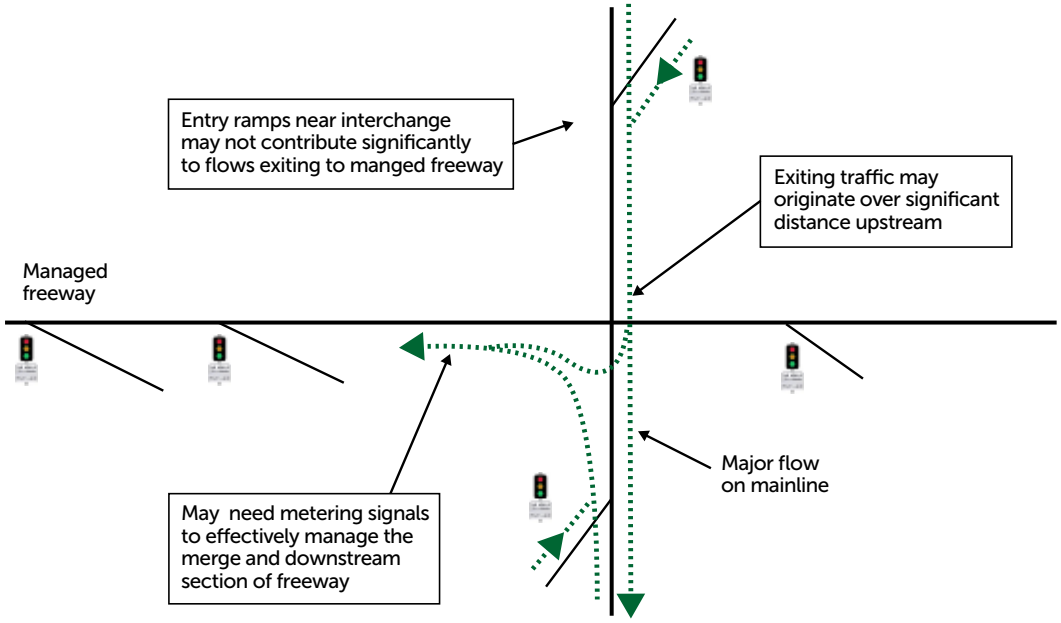


Figure 4.3: Traffic Flows at Freeways that Cross

Managed freeways are generally only effective when traffic is controlled at all points along a route. Effective control of traffic density, particularly critical bottlenecks, means that control needs to be provided close to where problems are likely to occur. A freeway ramp meter should be controlled when analysis indicates the critical freeway bottleneck(s) is at the freeway-to-freeway entry ramp and/or in the downstream sections of freeway (e.g. within 6 or 8 interchanges of the freeway entry ramp).

If the analysis shows that it is not necessary for the freeway entry ramp to be controlled consideration should be given to:

- Using unmanaged freeway capacity values for the capacity analysis on the freeway section downstream from the uncontrolled ramp, i.e., a maximum flow of 1,800 pc/h/lane.
- Ensuring a continuing added lane is provided to increase capacity on the downstream section of freeway.
- Providing geometric controls to limit the freeway-to-freeway ramp flow to the available mainline capacity downstream, e.g., providing a single added lane to limit flows to about 1800 veh/h, rather than providing an added lane plus merge (two lanes at the ramp nose). This would reduce turbulence associated with merging and provide an effective 'cap' on the entering flow.

The provision of metering at upstream arterial road entry ramps compared with metering at an entry ramp from an intersecting freeway requires an understanding of travel patterns or typical trip lengths on the freeway. The traffic implications need to be analysed and this may involve an origin-destination study of the freeway trips associated with traffic entering the managed freeway from the intersecting freeway.

Safety is a prime consideration when considering the metering of a freeway to freeway ramp. Section 6.4.5 provides further guidance relating to typical arrangements for the layout of traffic management devices.

4.5. Designing for Future Retrofitting Ramp Signals

In the design of new freeways or ramps that do not meet the criteria for the provision of ramp signals within the 10 year timeframe, it can be beneficial to incorporate future provision for ramp signals that are likely to be retrofitted. This may be desirable in an urban growth area.

The specific design features that should be considered to facilitate the future retrofitting of ramp signals are:

- The ramp width between the ramp entrance and the future stop line location should provide for the minimum width likely if the ramp was to be metered. This is typically a minimum of two lanes (7.0 m) with interim marking of a single lane and shoulder
- The provision of full depth pavement under shoulders to provide for future traffic when an additional lane is marked
- Entry ramp lengths (minimum 420 m from ramp entrance to physical nose) to provide for future storage (up tp 1,200 veh/h)
- Location of conduits along ramps. In some instances it would be desirable to install power and communications conduits as part of the initial ramp construction, particularly if other conduits are being installed, e.g., for roadway lighting or freeway data stations
- The provision of data stations at interchanges for traffic counting and evaluation of future traffic management needs with detector locations designed to suit ramp signals.
- For higher entry flows consider future ramp widening / lengthening to suit three or four lane layouts.