Transport Modelling Guidelines

Volume 4: Simulation Modelling

Fri, 2 Aug 2019

Connecting
our communities

vicroads

TRANSPORT FOR VICTORIA

Document Information

Document Title	**Transport Modelling Guidelines (Volume 4)**
FileIt Reference	**16275208**
Filename	**TransportModellingGuidelinesVolume4SimulationModelling(small).pdf**
Last Saved	**Friday, 2 August 2019**

Revision History

Version	Date Issued	Prepared by	Reviewed by	Approved by
Draft	20 Sept 2018	Julian Laufer	Cameron Lee	Jeremy Burdan
1.0	30 June 2019	Julian Laufer	Cameron Lee	
1.01	02 August 2019	Julian Laufer	Cameron Lee	

Executive Summary

This document outlines the guidelines for simulation of traffic and transport for delivery of VicRoads modelling pursuits. The document aims to complement the existing volumes of guidelines and build for industry direction on the expectations from VicRoads for a suitable investigation. The guideline outlines details within selected key topics, with an underlying focus on building an evidence based pursuit to develop a narrative for consideration from all stakeholders.

The key areas discussed within this report include the following topics:

- Data collection, data types, cleansing and analysis
- Model development, including calibration and validation
- Model performance and reporting of conditions
- Scenario testing and options explorations

In amongst the elements for consideration within this guideline, is a discussion about the three primary areas of model calibration, which includes the following topics:

- Demand considerations
- Behavioural considerations
- Network considerations

A strong focus is provided on the differences between the terms of demand and throughput as an input to the model development. The core of developing a base model is to ensure that this simulation measures well to reflect the current conditions observed. This is also utilised as a platform to progress forward and consider changes in the network for either immediate effect or for change in a future horizon.

Direction is provided to explore network validation for application of journey times, rather than by traffic volumes. Some discussion is also provided about secondary validation measures which include the demand profiles, the signal plans and additional measures. The guidelines also provide some direction to outline conditions for when validation is required for a notable change in travel times.

Performance metrics are discussed within the guidelines to ensure that the correct evidence is provided to tell the narrative of the proposed conditions. This includes but is not limited to intersection performance, corridor performance and network performance. Discussion about the robustness of a model is also provided as are methods to better present this detail in the narrative.

A number of points about network development and delivery expectations are listed within to ensure that the proposed schemes can be delivered as simulated. Topics in this space include consideration of demand and time profiles, signal plans, public transport and more. One of the primary topics of discussion is the difference between the future year demand estimates and the design requirements. A number of key inputs are listed to ensure that the scenarios developed are comparable against the base model or equivalent Business As Usual condition.

Overall the guidelines intend to ensure that the modelling reports provided to VicRoads and stakeholders can be read and comprehended without the need for further interpretation by third parties. This involves producing a narrative that outlines the evidence as well developing discussion of the current or expected problem/s within the network explored. Where required, some amelioration to the problem may need to be discussed and addressed.

Transport Modelling Guidelines

Table of Contents

Figures

Tables

1. Introduction

This document provides an outline of the requirements for the development of simulation models conducted for VicRoads including projects with VicRoads as a stakeholder. The topic of simulation models explore matters of traffic and transport analysis typically in the areas of micro-simulation, meso-simulation, hybrid simulation and pedestrian simulation.

The document is the fourth volume in the VicRoads Transport Modelling Guidelines with the other volumes as follows;

Volume 1: General Guidelines

Volume 2: Strategic Modelling

Volume 3: Mesoscopic Modelling (to be renamed)

Volume 4: Simulation Modelling Guidelines

It is intended that the document will be periodically reviewed and updated by VicRoads as required so that it is current, useful and relevant for VicRoads delivery teams, stakeholders and modelling practitioners.

The document aims to outline the collection, analysis and reporting expectations for simulation modelling conducted for pursuits within Victoria. In this way VicRoads anticipates a faster process of model reviews and accompanying discussions about proposed changes to network and operational considerations. This guideline is intended for modelling pursuits whereby the key component to the network is a matter of operational investigations using algorithms for vehicles with a range of heterogeneous attributes. In this way algorithms are applied and calculations are updated for numerous times with each second analysed. These algorithms use the variation in the modelling process which is a different prospect than a deterministic (average) modelling solution.

The guidelines outlined within this document help to better define VicRoads expectations and ensure that these specialist reports can be reviewed and comprehended by all stakeholders involved. It is not uncommon that such documents received by VicRoads require further interpretation for the delivery teams before a message of the findings become clear. This document also aims to showcase the matters pertaining to developing an evidence based decision making process to identify and evaluate proposed network changes for delivery within Melbourne and Victoria.

It is intended that future versions of this document shall incorporate the latest thinking and advancements in data collection and analysis for simulation modelling. As such, this document should be applied for all simulation modelling pursuits that have begun before January 2021, unless updated by a new release. In declaring this expiry date, it is the responsibility of VicRoads to update and/or re-release these guidelines for public issue by December 2020.

1.1. Correspondence

All enquiries or correspondence into these guidelines or any transport modelling guidelines developed and released by VicRoads should be directed through the one common access point of networkdesignservices@roads.vic.gov.au

This is the one address that is equipped and prepared to manage queries of such technical documents. However, a repository of technical documents developed by VicRoads is available online for consideration and can be found at the following location:

https://www.vicroads.vic.gov.au/business-and-industry/technical-publications

1.2. The role of VicRoads

VicRoads and its predecessors have a long history as the roads agency within Victoria, with more than 100 years of experience. VicRoads is now part of the Department of Transport, and continues to play a significant role in the operation and maintenance of the road network. This is with a focus on the delivery of journeys across the network for all road users as VicRoads becomes the operator of the arterial roads network.

While major transport infrastructure projects may be delivered by different government agencies, it is necessary for VicRoads to be involved in the planning, design and construction of these projects as VicRoads becomes the owner of each of these projects over time. This involvement remains to ensure the quality of delivery so that VicRoads can adequately operate and maintain this infrastructure in the majority of circumstances.

For major road projects, VicRoads expectations and requirements need to be upheld for the transfer of ownership over time. For some projects, this may be over a longer-term horizon, but for other projects this transfer may be achieved in a shorter timeframe. Therefore, it is important that VicRoads statements for each project (typically operations and scope of area for evaluation) are included within the design and analysis of such projects.

In this way the delivery of projects are not simply limited to the construct, build and revenues of distinct projects. For all network modifications the analysis of such projects needs to sit within the context of the user experiences and operational matters of the roads agency for each journey achieved. This may include exploration of connections between services as well as operational signal deliveries that may be within proximity or may even be further afield from the site of delivery.

Note as well that as VicRoads defends the needs for deliveries for the general public. This matter may produce different opinions into a modelling scope whereby the model development has been developed for the interest of a private sector client but not explore conditions in line with VicRoads expectations. Under such conditions where an oversight has been achieved, VicRoads will require teams to revise their initial direction to manage in the interests for all parties involved.

All or any documents or piece of work may need to be provided to media or public enquiries through the legislation of the Freedom of Information Act (1982). For this reason VicRoads will require projects to be developed and documented so that they can be read and interpreted from any party with or without a technical background. Documents and reports should hold enough evidence based support to identify the strengths and trade offs associated with a proposed scheme or development. An absence of supporting documentation with a clear narrative and analysis may hinder the timeframes originally envisaged for a project closure.

1.3. Quality Assurance

Quality Assurance is an important component for the delivery of a project in the perspective of the parties involved in a development or delivery. This entails that suitable measures have been put in place to ensure that the aspects of the investigation have been conducted through a suitable lens. Within this context this means that deliveries provided to VicRoads should have a number of assurances in place prior to this time; including the following considerations:

- Review of scope and potential impact;
- Review of data collected and analysed;
- Review of the model calibration and validation; and
- Review of the technical elements that are used to form the narrative.

It is expected that teams that declare achievements in a formal quality assurance process have conducted these pursuits prior to delivery or (where failed) be potentially subject to an independent review of their systems.

1.4. Purpose of these Guidelines

These guidelines have been developed by VicRoads to ensure that quality in delivery of the professional services conducted by various parties meets an expected quality. This is primarily directed towards the following topics of:

- Modelling scope;
- Model Development;
- Data collection and analysis; and
- Development of the narrative.

> The guidelines outline the scale and investigation that is expected for documentation and analysis in providing a professional service to deliver a change to the landscape.

The guidelines have not been developed as a means to explain concepts for this development and analysis and have not been written as an introduction to transport modelling or traffic engineering pursuits. Such documents already existing through multiple reports and textbooks and are not required for repetition within the VicRoads modelling guidelines.

The content held here is not simply to direct industry leadership on local requirements, but also to provide further direction for those whom wish to step into this space. Some discussion on the variation from selected parameters has been explored to showcase to interested parties as to why these measures are so critical to achieve within a professional delivery. This has been complemented by a checklist at the end of each chapter – to outline and reconsider what has or could be considered at this time in the project development.

The document directs to ascertain expectations on a number of requirements and limitations within particular modelling techniques or components, for which previously industry may have sought direction on these topics. A number of technical parameters are applied throughout this document. To complement this, a number of empirical datasets (typically held within VicRoads solutions) are also documented throughout the guidelines.

The modelling guidelines aim to outline expectations in quality of the professional services in order to ensure that project delivery is appropriate and can be hastened through the required approvals. Without achieving this structure and direction projects may strongly need to be reviewed or redeveloped in order to be of value to the narrative and the community.

1.5. Guideline Stakeholder Focus

The fourth volume of VicRoads' transport Modelling Guidelines have been written to provide advice and direction for two distinct groups within the modelling framework:

1. Those with a technical comprehension that seek advice as to deliver to VicRoads expectations. This subset is typically transport modellers.
2. Those without a technical awareness but wish to better examine why some technical elements are deemed to be important in the modelling framework. This subset is those whom are new to delivering within this space.

These guidelines are not developed as a training course, nor as an introduction into project management of a modelling investigation.

2. Overview

These guidelines intend to provide a comprehensive overview into the expectations for delivery of a simulation model conducted for VicRoads or as per collaborative efforts where VicRoads is a stakeholder. This structure aims to explore on matters of

- identify the problem or issue;
- developing the evidence;
- conducting a sound analysis;
- developing solutions to mitigate the current or expected matter; and
- articulate a narrative to explain the work effort and the formation of the findings.

The simulation modelling received by VicRoads can have core elements required that have not been considered by the party responsible for the model development. These items may pertain to matters about data collection, and the importance of collecting and analysing quality data for a robust modelling pursuit. The implications of utilising low quality data can have a continued impact throughout the model development and process (e.g. misdirected travel times may deliver variations in route choices with additional volumes) and may potentially impact on the delivery and recommendations. Therefore, this document aims to ascertain VicRoads delivery expectations within such models including analysis, evaluation and reporting.

The guidelines outline an expectation (rather than suggestion) of delivery that builds a narrative within a simulation modelling report. This approach is to not only to assist VicRoads teams with internal matters but also showcase the evidence based decisions that have been developed on any project where stakeholders and community interact. It is imperative that the reporting outlines the above elements in clear English with reduced jargon. This not only identifies the modelling processes undertaken but also the findings from explored options to all stakeholders without the need for a technical translation. These guidelines continue to be valid for application and delivery even when modelling scopes or contract requirements have stipulated other documents for micro-simulation or meso-simulation modelling.

VicRoads will use the guidelines set out in this document to ensure that deliverables are achieved before the model is accepted by VicRoads or for VicRoads pursuits.

Key matters within the model development and analysis stage involve;

- collecting the appropriate datasets efficiently for analysis (the evidence);
- building the narrative of the existing and future suggested operational considerations;
- analytical pursuits that are well documented and embed the context so that the end-user can comprehend the investigation and complexity of the matter at hand; and
- Explain the risk and considerations for projects and organisations with the intent to deliver a proposed solution that was explored within the modelling platform(s).

2.1. Why Conduct Transport Modelling

Transport modelling allows teams to ask questions about traffic and transport considerations across the landscape to consider matters of planning and operations over the short, medium and longer term horizons. These explorations provided for a number of investigations into structure of the transport network and can cover broad matters of strategy formation, infrastructure requirements, journey planning and network operations over time. Different scales of modelling have particular strengths in exploring some of these topics (See Section 2.3).

However, in all cases the pursuit of modelling tasks are to explore a current (or future) issue of concern and explore measures for resolution to an improved position. The methodology of this pursuit will vary by modelling horizon to explore the question at hand (a question of policy formation, infrastructure funding or detailed design for a controller). The core of this modelling work remains to develop solutions to assist in design and operational matters and ensure that journeys can continue moving through the transport network. Some of these explorations are locally driven, while others involve complexity across one or more local government areas. At the broader extents are planning and investment needs across the metropolitan and state levels (as well as beyond).

In all situations, irrespective of the scale of the exploration are the underlying principles that

- investigations are required to be evidence based. This allows stakeholders to comprehend the matters of complexity that relate to the landscape today, before exploring the matters of tomorrow; and
- scenarios allow for the exploration of complexities to be explored and a number of metrics to be quantified and showcase the value of the investment. The scenarios allow for strengths and weaknesses of each suggested solution to be outlined (including movement of journeys, benefit cost appraisal, complementing network requirements and more).

In all cases modelling should develop a strong narrative of the change impacts (and resolution) that can be supported by the evidence and data.

The evidence based platform allows for the complexities of multiple and cumulative network considerations to be evaluated in a comparative process. It allows teams to ask questions and begin to explore answers about proposed changes, including consideration for elements of complexity and choices undertaken from a user perspective. The transport modelling tasks undertaken for VicRoads provides for a more educated and robust stance to the organisation for the movement of journeys, the value of investment and additional considerations for the drivers' experiences. Ongoing delivery in quality modelling and associated reporting provides for a better comprehension in the value for such a pursuit, which in turn justifies the purchase of further modelling services.

2.2. Terminology

A glossary of transport, simulation and modelling terms is provided within Section 13 of this guideline. This is not a comprehensive set of terms but should provide guidance as appropriate. To complement this section of the guidelines, some terminology is provided at the outset of the report.

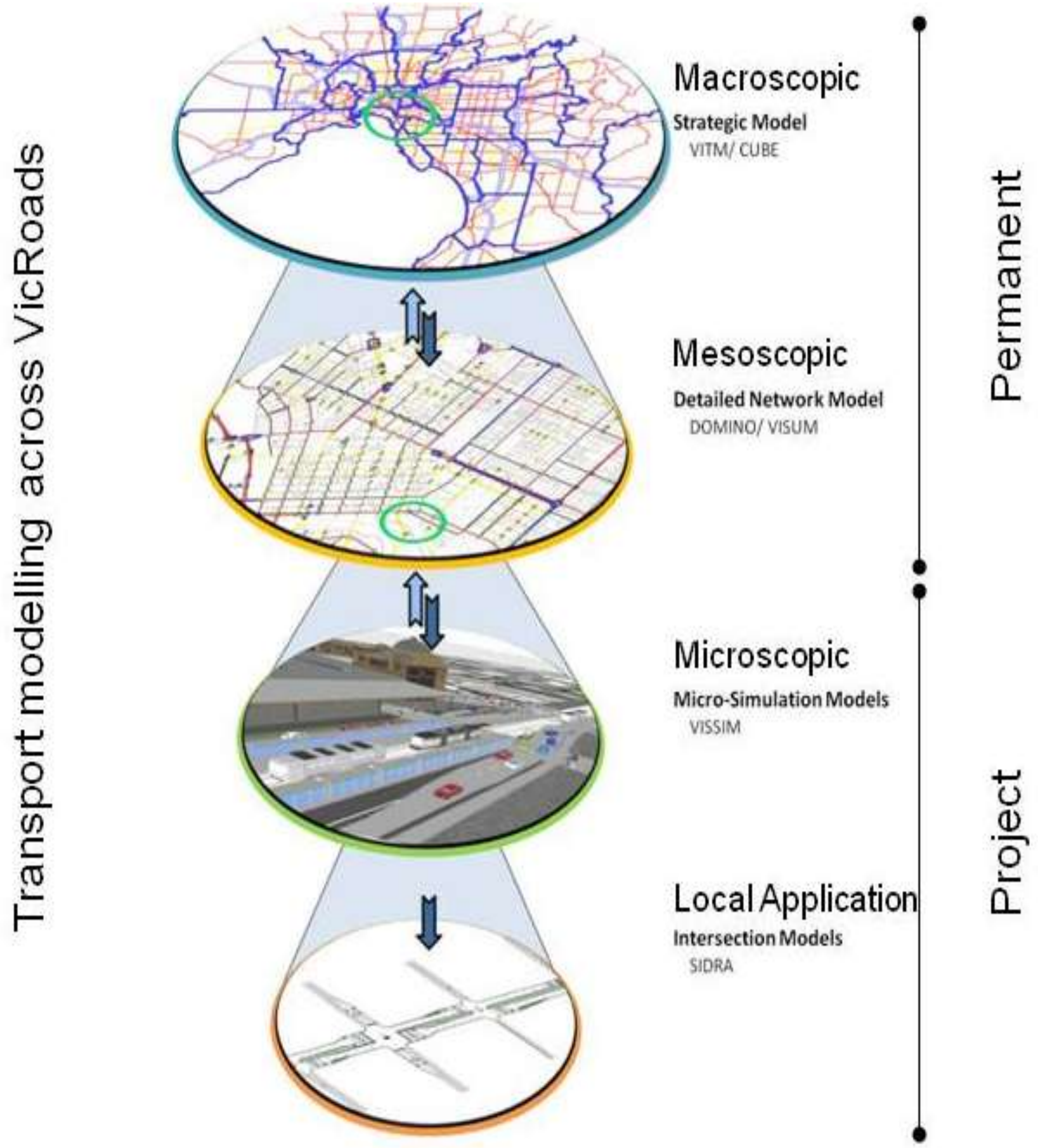
Within these guidelines, the term of the arterial road and the urban road may be used interchangeably. This context then allows for traffic analysis within urban centres (town centres and suburbs) outside the metropolitan area to be applied and explored in the same manner. Application of the term “urban” therefore can be applied for regional cities and towns rather than suggestion of an exclusion from the analysis.

The term motorway applies to both freeways and tollways, irrespective of the payment to utilise the road network. There is a common sense of behaviour (and behavioural algorithm set) on this style of road which is distinctly different from that of the driving condition experience on the urban road network. However, some attributes may be perceived to have similarities applied generally across the landscape, with further variation applied at the site specific location.

2.3. Model Types

Transport modelling operates at various levels of detail and scale. It is important for all delivery managers and modellers to note that many projects involve more than one level of modelling and analysis, due to the varied challenges involved within an investigation (e.g. planning, design, operations, construction etc). An outline of the transport modelling hierarchy is outlined in Figure 8. Note that this is not a comprehensive structure. Within each layer of modelling in this hierarchy is the trade-off between factors used to comprehend the delivery of journeys through a network.

Figure 8: Transport Modelling Hierarchy used at VicRoads



At each stage of the modelling pursuit the data requirements used to feed the development are different. A simple rule of thumb is that the effort of developing a model is in the increasing order of macroscopic, mesoscopic and microscopic. Austroads, Guidelines for Selecting Techniques for the Modelling of Network Operations (January 2010) and Austroads, Guide to Traffic Management Part 3: Traffic Studies and Analysis (November 2017) Section 4 provide further commentary on model types. However, note that such structures may not be comprehensive and could be limited to the scope and mandate for these guidelines.

The determination of a modelling methodology may be determined by a number of key factors including (but not limited to) matters of:

- Stage of the project development (strategy formation, business case development, options exploration, concept design, detailed design, operational matters);
- Complexity and significance of the pursuit;
- Geographic scope required for consideration;
- Timeframes for delivery; and
- Accuracy of the result required.

In most conditions the focus of the project deliverable is directed by the project objectives that are typically run to explore topics of design, patronage, journeys, network resilience, driver safety, network enhancement or other multipronged pursuits. Objectives will vary by projects. However the modelling requirements to develop a simulation model and ensure quality delivery to stakeholders does not change by the intent at hand. Under all circumstances VicRoads (as the State's Roads Agency) will inherit the developed solution for the life of the road and needs to ensure that appropriate considerations have been implemented throughout the course of such pursuits.

For this context note that the Austroads definition of model types has not been brought forward for the "Local Applications" classification. Such measures were initially defined as "micro-analytical" but are only reduced in geography rather than in timeframes between recalculations. Furthermore many "micro-analytical" intersection models are deterministic solutions with a singular (not a repeated) calculation of journey effort. As such, the application of the Austroads naming convention can be misleading.

2.4. Modelling Software

Software used for transport modelling investigations for VicRoads should consider the following three key elements before network development.

1. The software algorithms about the simulation and interaction of objects in the model are published and accessible through literature such as research and conference papers. While the end user may not specifically comprehend how the algorithms operate, it is important that an independent party can review and comprehend how these algorithms achieve this simulation.

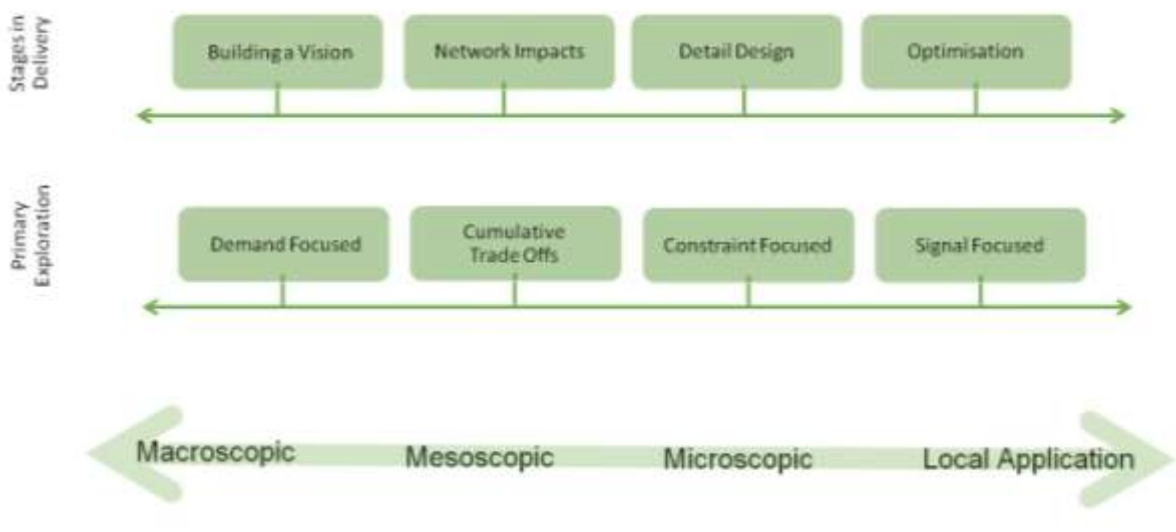
2. The solutions applied require an independent team dedicated to customer support that is not simply a duplication of role of the developer.

3. The software should be commercially available so that pursuits can undergo an independent in-model review with or without the modelling team that developed the project model. This review may be conducted in the shorter term or provide opportunities for third parties to build on this model at a later stage.

2.5. Criteria for Selecting Modelling Methodology

A modelling methodology is often dictated by project objectives followed with the technical intricacies of the modelling investigation. The following basic criteria outlined in Figure 9 can assist in directing the modelling methodology required to meet the objectives of the investigation. However note that often multiple level of modelling may be required to build an appropriate narrative on various perspectives into the problems of the landscape.

Figure 9: Modelling Scales with focus for Delivery and Explorations



Further insights into the direction of the modelling pursuit are identified within Table 1.

There are a number of models that are perpetual and maintained by government organisations within the State of Victoria. These include the following;

- Macroscopic Model: Victorian Integrated Transport Model (VITM) by the Victorian Department of Transport
- Mesoscopic Model: Detailed Operational Model for Intersection and Network Optimisation (DOMINO) by VicRoads

Simulation models are typically not maintained over the longer term as these are often developed for a specific investigation. However, such solutions can be developed from perpetual models and updated through network and land use changes over time.

Table 1: Example Criteria for Selecting Modelling Methodology

Model Criteria	Options	Modelling Type			
		Macroscopic Simulation	Mesoscopic Simulation	Microscopic Simulation	Local Application
Study Characteristics					
Scope Size	Regional	Yes	Permitting	Rarely	No
	Corridor	Yes	Yes	Permitting	Permitting
	Subarea	No	Yes	Yes	Permitting
	Isolated	No	No	Yes	Yes
Network Size[1]	Large (>1,000 Zones)	Yes	Permitting	Rarely	No
	Medium (>100 Zones, <1,000 Zones)	Yes	Yes	Permitting	No
	Small (<100 Zones)	Yes	Yes	Yes	Yes
Time Periods	Peak Period	Yes	Yes	Yes	No
	Structured Peak Hour	Permitting	Yes	Yes	Yes
Input Data Characteristics					
Granularity	< 15 minutes	Rarely	Yes	Yes	Yes
	15 minutes - 1 Hour	Permitting	Yes	Permitting	Permitting
Reliability	Data Source	Medium	Medium	High	High
Accuracy	15 minutes	No	Yes	Yes	Yes
	> 1 Hour	Yes	Yes	Yes	No
Desired Functionalities					
Strategic Direction		Yes	No	No	No
Demand Forecasting		Yes	No	No	No
Route Choice Determination		Yes	Yes	Yes	No
Intersection Analysis		No	Yes	Yes	Yes
SCATS Data		No	Yes	Yes	Yes
Site Specific Capacity		No	Yes	Yes	Yes
Visualisation Animation		No	Yes	Yes	No
Weaving / Merge-Diverge		No	No	Yes	No
Queuing		No	Yes	Yes	Yes
Flow (by link)		Yes	Yes	Yes	Yes
Flow (by lane)		No	Yes	Yes	Yes
Signals Inclusion		No	Yes	Yes	Yes
Signals (Public Transport Priority)		No	No	Yes	Yes

[1] Zone size and structure change by varied modelling pursuits

3. Types of Simulation Modelling

The term of simulation modelling covers an extensive range of model applications, for a varied range of traffic and transport investigations. Micro-simulation is the modelling of individual vehicles with heterogeneous behaviour. Heterogeneous refers to the varied attributes of individual vehicles within the network, e.g. influenced journey speed, vehicle lengths, safety distances to the vehicle in front when travelling etc. As a result of modelling individual objects, micro-simulation enables consideration of adaptive complexities (e.g. signal operation) to understand traffic flow impacts.

Other simulation modelling investigations such as meso-simulation, hybrid simulation and pedestrian simulation adopt similar approaches but either have a more simplified modelling structure to cover a broad simulation area (i.e. meso or hybrid simulation) or are specific to an operation within the simulation area (i.e. pedestrian simulation). The nature of complexity that is involved in undertaking varied traffic modelling levels requires greater depth of investigation at every stage of the modelling hierarchy. The document intends to provide the guidance to ensure that the appropriate analysis and reporting narrative is adopted for every stage of the simulation modelling process.

Simulation modelling explores options on a more detailed level and is covered by the following broad areas;

- Micro-simulation;
- Meso-simulation;
- Hybrid simulation; and
- Pedestrian simulation.

These methodologies are briefly explained below.

Teams should expect to provide all components of the modelling work, both hard copy and soft copy including surveys, internal working notes, modelling development, reports, presentations and simulation videos should be supplied to the team that originated the contract. All or any section of the reporting may be reviewed for quality assurance purposes and confirmation of advisory services at any time, or provided to third parties for an equivalent pursuit.

All working remains the property of the Victorian public sector. Private sector teams that have been working towards a development for a transport agency cannot make claims on intellectual property for advisory services rendered.

3.1. Micro-simulation

Individual vehicles with heterogeneous behavioural attributes are simulated to investigate the cumulative elements of hindrance (signals, lane changing, on-street parking, speed zones etc) and the impacts on traffic flow. This provides for a strong visual and analytical representation of the landscape investigated.

> Key from the VicRoads perspective is that this form of modelling can (and is expected to) simulate the microscopic complexities of diver’s experiences (ie the micro-complexities are simulated).

As micro-simulation models are built to explore the matters of complexity on the transport networks, the criteria for model validation are different and tighter (reduced variance) than those applied for other modelling pursuits. i.e. the point of this professional task is to simulate the conditions experienced by users of the road network in order to advise on design plans or congestion resolution.

One aspect of value for VicRoads within this modelling technique is the insights into signal planning (signal designs, coordination, public transport activation etc) for delivering journeys across the transport network. Micro-simulation models are also conducted with a focus on exploring the detail within intersection design considerations for infrastructure delivery and upgrades.

3.2. Meso-simulation

Mesoscopic simulation is a middle ground between macroscopic and microscopic modelling. One of the key differences in mesoscopic modelling that differentiates this approach from microscopic modelling operates is that the model handles traffic flow in a simplified state. The absence of detail allows exploration of larger networks than microscopic modelling. Individual vehicles are not visualised in animation so the graphics are limited to bars and colour schemes. Solutions also provide this style of modelling within macroscopic style models.

One aspect of value for VicRoads within this modelling technique is the insights into the network impacts and extents of a proposed change (e.g. road enhancements or closure, diversion strategy etc) in a transport system, as well as concept design for new infrastructure solutions.

It is important to note that meso-simulation modelling is not a simple replacement of traffic assignment and still requires calibration tasks to develop a network and validation to confirm the effort achieved.

Refer to Section 8 for further details.

3.3. Hybrid simulation

Mesoscopic and microscopic simulations can be combined together in a single network to operate through different equations at different geographies. This is referred to as a hybrid simulation model. This measure can be particularly useful when detailed network operations are required for selected locations in the network, but a large network is required to model the journey. Some aspects of the network can be explored in the specifics of a micro-simulation model while much of the remainder can be explored in a simplified state.

Refer to Section 8.2 for further details.

3.4. Pedestrian simulation

Individual pedestrians with heterogeneous behaviour are simulated to understand the movement of people. This can include the interaction with individual vehicles (trams, buses, taxis etc) to explore the cumulative effects of managing public transport connections within the traffic environment.

Pedestrian simulation matters may relate to the cumulative impacts of demand estimates to explore how the boarding and alighting at complex public transport locations may impact on the delays for general traffic (network management and signal operation) within close proximity.

Refer to Section 9 for further details.

3.5. Examples

The following tables explore examples of investigations where different styles of simulation modelling would be appropriate pursuits:

Table 2: Microscopic (Micro-simulation) modelling with pedestrians for signal activation (example)

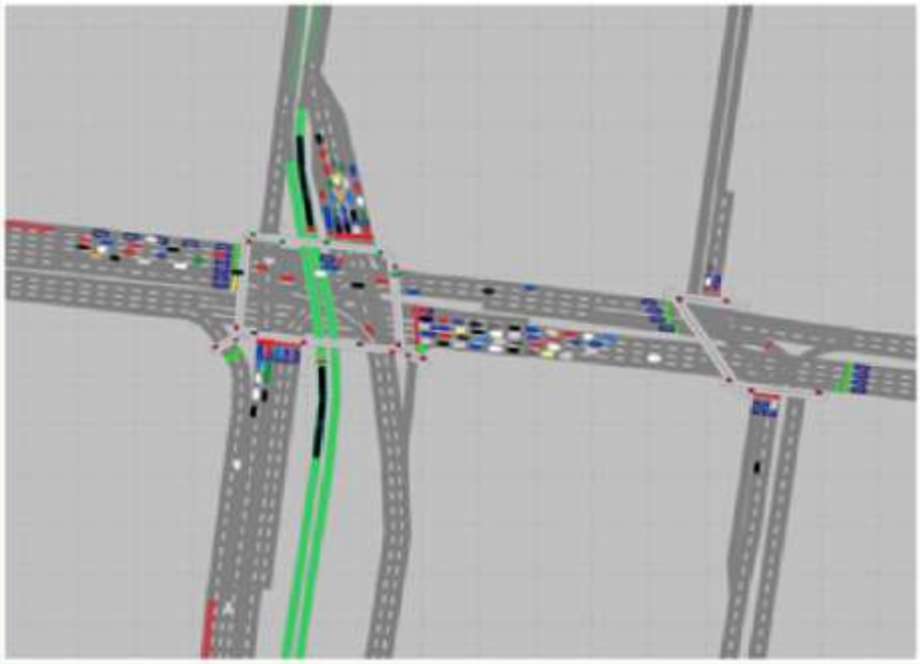
Type of Simulation Modelling	Microscopic modelling with pedestrians for signal activation
Study Scope	Micro simulation modelling of a motorway layout which includes interchange upgrades
Typical visual	
Study Objective(s)	Identify motorway operation constraints for various layout options considering merging and weaving section and the impact from ramp metering
Time Periods Modelled	AM and PM peak period
Scenarios Modelled	Various layout designs for each horizon year
Number of Scenarios	15+
Horizon Years	Current year, 2021 and 2031
Network Size	Five interchanges over a 5-kilometre length of motorway
Model features	• Adaptive Signals with public transport priority • Ramp metering • Turn Prohibitions • Link volumes, turning movements volumes, speeds for vehicles, travel times, delays, queue Lengths, speed distribution • Complex driver behaviour for motorway operation
Outputs	• Heat plots of link flows and average speeds • Travel time plots for predefined routes • Flow bundle plots showing route diversions • Signal performance outputs including ramp metering for motorways and pedestrian walk activation for signalised intersections • Queuing behaviour plots • Merging and weaving behaviour plots • Network evaluation outputs • Speed flow and density plots for motorway
Limitations	• Additional time and resources in modelling greater areas which effects data collection, calibration and validation processes.

Table 3: Hybrid Modelling – Mesoscopic/Microscopic simulation modelling (example)

Type of Simulation Modelling	Hybrid Modelling – Mesoscopic/Microscopic simulation modelling
Study Scope	Simulation modelling that incorporates meso and micro simulation components to model proposed Activity Centre Structure Plan options.
Typical visual	
Study Objective(s)	• Analyse link and intersections improvements that are required to accommodate the proposed zoning changes while maintaining standard operational Level of Service (LoS) • Analyse the impact of additional traffic associated with the proposed zoning changes on existing arterials and local roads
Time Periods Modelled	AM and PM peak period
Scenarios Modelled	Various layout designs for each horizon year
Number of Scenarios	15+
Horizon Years	Current year, 2021 and 2031
Network Size	10 intersections covering an area of 10 square kilometres
Model features	• Public transport with extra complexity of operation at intersections • Adaptive Signals in same locations • Signal Progression • Turn Prohibitions • Travel times, link counts, flow bundles, average speed extractions in meso sections • Link volumes, turning movements volumes, speeds, stops, travel times, delays, queue Lengths, speed distribution extractions in micro sections • Combination of simple and complex driver behaviour in certain sections • Parking simulation in micro sections.
Outputs	• Heat plots of link flows and average speeds • Travel time plots for predefined routes • Flow bundle plots showing route diversions • Signal performance outputs • Queuing behaviour plots • Network evaluation outputs
Limitations	• Signal co-ordination of detailed/complex signalised intersection • Limited driver behaviour parameters in meso simulation sections on the approach to intersections that have been converted into a micro-simulation section • Limited visual presentation for private and public transport systems in areas of meso simulation. • Simplified behaviour models limit the ability to model weaving or merging behaviour in the meso section

Table 4: Mesoscopic simulation modelling (example)

Type of Simulation Modelling	Mesoscopic simulation modelling
Study Scope	Simplified car following assignment modelling for a subarea covering council's jurisdiction to test major construction activities
Typical visual	
Study Objective(s)	Identify route diversions and potential bottlenecks and queues as a result of the major construction activities
Time Periods Modelled	AM and PM peak periods
Scenarios Modelled	Traffic management and capacity improvements
Number of Scenarios	5 scenarios that cover each construction stage
Horizon Years	Current year
Network Size	50 intersections covering an area of 55 square kilometres
Model features	• Public transport • Pre-Timed Signals • Signal Progression • Turn Prohibitions • Time-of-Day Differences • Synthesized from planning-level trip tables • Volumes estimated from traffic counts, seasonality factors • Travel times, link counts, flow bundles, average speed extractions
Outputs	• Heat plots of link flows and average speeds • Travel time plots for predefined routes • Flow bundle plots showing route diversions • Network evaluation outputs
Limitations	• No detailed/complex signalised intersection modelling using adaptive controls • No detailed/complex driver behaviour modelling • Limited detail in simplified solution

4. Project Investigation and Scope Formation

4.1. Introduction

The best way to begin reporting of an investigation is to start at the beginning. This should allow for a good explanation into the context of the investigation and the need for the associated transport modelling. The introduction should briefly outline the problem identification with subsequent tasks to provide context for secondary considerations within the pursuits. With regard to modelling tasks, this means that teams should be able to provide an introduction into the modelling space which outlines the strategic background, context and intended deliveries of the pursuit. This approach should showcase to readers how and why there is need to develop a modelling task for the landscape.

It is an important task to outline where the modelling and reporting sits within the context of the investigation, despite appearing obvious to the model develop team at outset. However, modelling projects and reports can often re-appear at a later time, or may be associated with another stage of the infrastructure development. For this reason, appropriate discussion of the context needs to be provided at this stage of the report formation.

VicRoads require an introduction to the project that sets the strategic context for the investigation. This forms the building blocks in identifying the project definition and the simulation modelling development considerations. Delivery of this text needs to be more than a simple statement for delivery of business case, but needs to provide the strategic context to confirm the need for transport modelling services. The introduction should be held from the perspective of the local community interests and outline the prospective opportunities that may arise from this delivery.

The introduction in the modelling report should outline the following (as a minimum);

1. Project scene which focuses on establishing the setting through description and imagery. Should include the following;
    - Location of the study area;
    - Control systems in the network i.e. existing roundabouts, traffic signals;
    - Land use i.e. industrial, school, shopping centre;
    - Key operations i.e. freight route, cycling corridor, growth area;
    - Key stakeholders i.e. PTV, VicRoads, VPA, MTM etc;
    - Safety problems; and
    - Congestion locations through available data i.e. schematic of observed speeds.
2. Project problem definitions and explain with available statistics and imagery
3. Project key performance indicators i.e. project and/or government commitments
4. Strategic context (setting for planning and growth in the area) and suggested responses that are being considered. Also consider the following;
    - Project scene if there is no change (a “Do-Nothing” or “Do Minimum[2]” approach) by exploring what the VITM strategic model suggests may be forthcoming in the area.
    - Department of Transport and Victorian Planning Authority (VPA) outlook in the area i.e. expected increase in traffic, journey time, land use shift
5. Preliminary analysis undertaken prior to choosing simulation modelling

[2] “Do Minimum” approach refers to the transport planning approach that considers anticipated (planned but may be not committed) infrastructure upgrades, land use developments and associated future year demands, but excludes any modifications associated with the project being evaluated.

4.2. Project Definition

The development considerations of the modelling that align to the project definition need to be determined before the data collection, calibration, validation and performance reporting are undertaken. The model that is developed for the investigation is often referred to as the "base model".

The project definition in the modelling report needs to explore and explain the following (as a minimum);

- Outline the primary (and any secondary) objectives of the model development;
- Respond to the strategic considerations in the project; and
- Outline the requirements of the modelling pursuit i.e. in response to suggested demand estimates and then investigating operational issues of a transport corridor.

4.3. Project Considerations

There are a number of considerations that a project needs to explore and provide direction on within the development of a modelling report. This will assist readers of the report to identify with the comprehensiveness of the existing landscape for the investigation and the purpose of such pursuits.

Project considerations that should be explained within the written format of the report (to provide the appropriate reader perspective) include the following items:

- Define the scale or study area (map required). This needs to align to the project objectives and show a meaningful approach to the investigation.
- Define the roads by name that need to be included and any excluded. This will need to be evaluated on the number of journeys and that the journey times and response to journey time is adequately represented i.e. consider a volume threshold of 50 vehicles per hour but consider the impact of minor roads on project objectives (map required).
- Identify future applications as part of the modelling pursuit including
  - Consider current and future transport assumptions for the area
    - Changes in land uses i.e. large scale developments produced within the study area;
    - Changes in demand i.e. interpeak demand formation;
    - Changes in public transport services, schedules, stop locations;
    - Changes in operational controller systems including the upgrade of roundabouts to signalised intersections;
    - Changes in route operations due to changes in road hierarchy; and
    - Changes in project commitments.
  - Identify the impact these future assumptions would have on the model pursuit and whether the model extents should be further explained based on these considerations.
  - Design life of the project needs to be considered and its impact on the surrounding area e.g. strategic model suggests that a nearby road will be upgraded in the next 15 years.
  - Consider future options testing and how this may impact on data collection requirements and scale of analysis for the investigation.
- Time horizons (future years) need to be specified and is usually mapped to the strategic modelling responses. This is usually investigation specific and needs to consider the overall impact on the network. When investigating multiple time horizons, it is a requirement to ensure that the upper time horizons are considered in the investigation pursuit.

4.4. Project Geography

The project scope should ensure that the study area is suitability defined to account for proposed changes to properly consider factors such as route choice and traffic operation. For example, applying a change in a study area that is too small may draw an excess of traffic into the site. The study area should be large enough for all key stakeholders to be content that the core area of the modelling explores their area of concern. Key signals need to be considered within the study area even if they are not adjacent to the area of the proposed change. e.g. key constraints immediately adjacent to the study area may not achieve a notable change, but agencies need to comprehend how to manage these bottlenecks and the upstream issues within the context of the investigation.

The scale of the study area would normally be determined through measures of a network difference plot (with/out proposed project) where any of the following four items apply within the network:

- Volume (veh/hr) changes by more than 10% from base model;
- Speeds (km/hr) changes by more than 10km/hr from base model;
- Road Utilisation (volume capacity ratio) at intersections change by more than 10% from the base model; and
- Delay (seconds or hours) changes by more than 10% from the base model.

It is suggested that application of the VicRoads Domino model be used to ascertain the prospective project geography through a brief application of a network revision (e.g. road closure or enhancement).

In addition, simulation models developed for the investigation need to be contiguous upon delivery and evaluation. It is not suitable to develop a simulation model as a series of geographies that are unrelated except for model purpose.

A core and peripheral area of analysis is favoured by VicRoads as a method to simulate the conditions of the existing and the proposed landscape. Teams should undertake the following to identify the core areas and the periphery areas of the model development.

- The core area is usually the geography of the model where the problem definition is determined and in many cases, would form the entire model i.e. corridor model. It is also the area that is considered to have a more defined impact on performance metrics such as journey time. As a result, the core area undergoes a more rigorous level of calibration and validation requirements.
- The periphery area is that part of the model that is not in the area of direct change and may have a simplified modelling approach to consider elements of demand flow, signal coordination and traffic bunching. As a result, the periphery area undergoes a less rigorous level of calibration and validation compared to the core area.
- When using large area models, it is still a requirement that some areas are incorporated as core areas so that sufficient detail is simulated for responding to project objectives
- The study area should be large enough to determine the how traffic conditions are varied within this area of change. The study area should not be determined as a function of cost minimisation as typically the operational costs exceed those of the exploring an expanded simulation network
- Complex modelling process such as motorways, level crossings or grids when considering route choice (an iterative assignment approach as discussed in section 7.3) would form part of the core area.
- As a volume guide, links with a volume 1,000 vehicles per hour or greater will need to be considered as part of the core area.
- Map identifying the core areas needs to be provided within the report; else it is considered that the entire model is treated without a periphery area.
- Options to be explored within this pursuit, and the accompanying operations of the simulation landscape should be considered when developing the scope of the core area of the investigation.

An example of core and periphery areas is provided in Figure 10.

Figure 10: Example of Potential modelling Focus and Network Extent to be explored (Core and Periphery)

4.5. Modelling Framework

A framework for the development of the investigation is outlined within Figure 11. This graphic directs that the narrative to explain the challenges of the landscape is as important as the modelling pursuits. In this way modelling teams need to develop both the narrative of the project as well as the modelling of the project. The reporting should then outline the project narrative in the context of definition and objectives before exploring matters of the model inputs and refinements. To complement these tasks, a thorough explanation into data collection, model calibration and validation tasks, should also be outlined within the development report.

4.5.1. Development of the Base Model Process

The development of the base model process is essential in determining the appropriateness of the simulation platform for the intended use. A base model needs to be established for all investigations to ensure that benchmarking of the outcomes from the proposed change can be attributed to the delivery rather than to the model formation. This involves two key components:

- Development of a model for the current horizon to establish benchmarks
- Calibration and validation of the model to ensure that the benefits of the change model are not outweighed by the noise of the base model. That is, the intent is to remove errors from coding matters that might falsely allocate costs or benefits to the investigation.

As outlined within the chapter on model calibration, the tasks at hand are not simply to benchmark the selected criteria. Rather the development task is to ensure that enough evidence is formed to better comprehend the movements and traffic and the general operating conditions when future year and/or project conditions are implemented. This not only pertains to demand and behavioural matters, but also about constraints and limitations within the network.

For this reason a base year model for the required periods of analysis will need to be developed for each and every pursuit undertaken. It is expected that a base model will be developed for at least an AM peak hour and a PM peak hour (or period as appropriate) evaluation.

However additional periods of heightened operational and design matters may require further timeframes to be considered. The requirement of the completion of the two peak hours/ periods aligns to VicRoads responsibilities to ensure that appropriate measures are explored and addressed prior to development. In this way delivery for only one interval may omit matters for resolution (e.g. a new weaving element that is addressed in the other peak) and will need to be simulated prior to consideration for approval.

Should projects wish to seek an exemption from the development of a base model, this needs to be explored and provided in written format from the traffic modelling specialists within VicRoads. Exemptions are not likely to be provided when the project exists within an established area, even if the infrastructure being explored is yet to be developed as the remainder of the network needs to be benchmarked for quality of delivery. Such exemptions may be provided if the development is of notable distance from an existing road or facility e.g. the formation of a major new regional airport may not require a base year calibration. However, those seeking an exemption should also show the evidence collected from similar sites to showcase awareness of the forthcoming challenge (a part of the narrative).

The development report, should outline the formation of the base model, as well as topics of the calibration and validation of the model. It is imperative that the reporting of outputs from the base model should also sit within the development report and not withheld until exploration of options. This may be in part to ensure that metrics are correctly calculated and that the correct reporting is provided within the baseline modelling.

A base model should be reviewed by VicRoads or an independent party using the guidance in this document before the base model proceeds to option modelling. Exemptions for development of a base model cannot be provided once the options explorations have already begun.

4.5.2. Option Modelling Process

The option modelling process should only proceed when the base model is considered appropriate for the intended use. This process is diverse due to the project specific requirements as outlined in Figure 12. The typical approach considers adjustments based on seasonality, future year growth and detailed design considerations. These are then adopted as required for respected future year and the associated scenarios which usually include a ‘Do Minimum’, ‘Do Something’ option plus potentially ‘Mitigations’ to the scenario. The detailed design adjustment would not need to apply for all models but only those that operate successfully in the future year estimate that are considered to be implemented.

The potential future year options should also be considered and explored with the relevant stakeholders prior to the data collection process. This may designate a small increment in data collection requirements in order to better value the proposed change to the transport system.

The project investigation, definition and objectives are the guiding information required for this process. Future Year Modelling and options testing are discussed in section 10 and should be considered when planning this process.

4.6. Identify the appropriate evaluation time period.

The evaluation period is defined as those times within the simulation for which the modeller needs to extract performance results. This is different to the simulation period which may include a period that the simulation forms congestion as well as a period to explore for the expected demand to move through the study area.

The definition of the evaluation period should involve the following considerations:

- Identify the period of time that the model is expected to simulate so that the project objectives can be analysed;
- Confirm the warm up period, the period prior to the start of the evaluation period which aims to ensure appropriate conditions in traffic demand at the commencement of the evaluation period. This period is usually double the length of the longest journey time in the evaluation period;
- Determine the length of time applied for the cool down period. This is used in the simulation following completion of the evaluation period. This element aims to identifying any delay performance impacts pertaining to demand estimates released in the evaluation period, including additional time required for the demand estimates to complete their journeys. Cool down periods should also continue to have demand generated into the network as this time; and
- Identify the type of simulation modelling to be undertaken by using the guide in section 3.

The appropriate evaluation time period should be determined from a well established project definition. This is an important element to confirm before consideration of data collection requirements and techniques.

4.7. Legacy Models

There may be times when a team is required to adopt a previously developed (legacy) model for an investigation. This may regularly occur during a process when models are developed for a base setting, prior to a tender process for explorations of options.

It is the opinion of VicRoads that the professional service conducted to manage and develop the options also ensures the adoption of the quality of the base model. In this context if the base model is dated or not validated (for reasons unknown) or poorly developed, then it is the responsibility of the modelling team to ensure that the baseline is adequate.

This might involve a contingency element within the modelling proposal (to review and refine the base model) but needs to be at a suitable quality in order to be a baseline and evaluate the scale of change. In appropriate delivery of the benefits of the change model should not simply be a function of the baselines coding. This refinement may not be limited by further calibration, but may also involve matters of the demand matrices and the scale of the network. Nonetheless a key part of the adoption process needs to be the ownership of the base model by the new handler.

Legacy models should not be benchmarked against the previous performance, but against the empirical metrics available (traffic volumes, journey speeds, delays etc).

Figure 11: Development of the Base Model Process

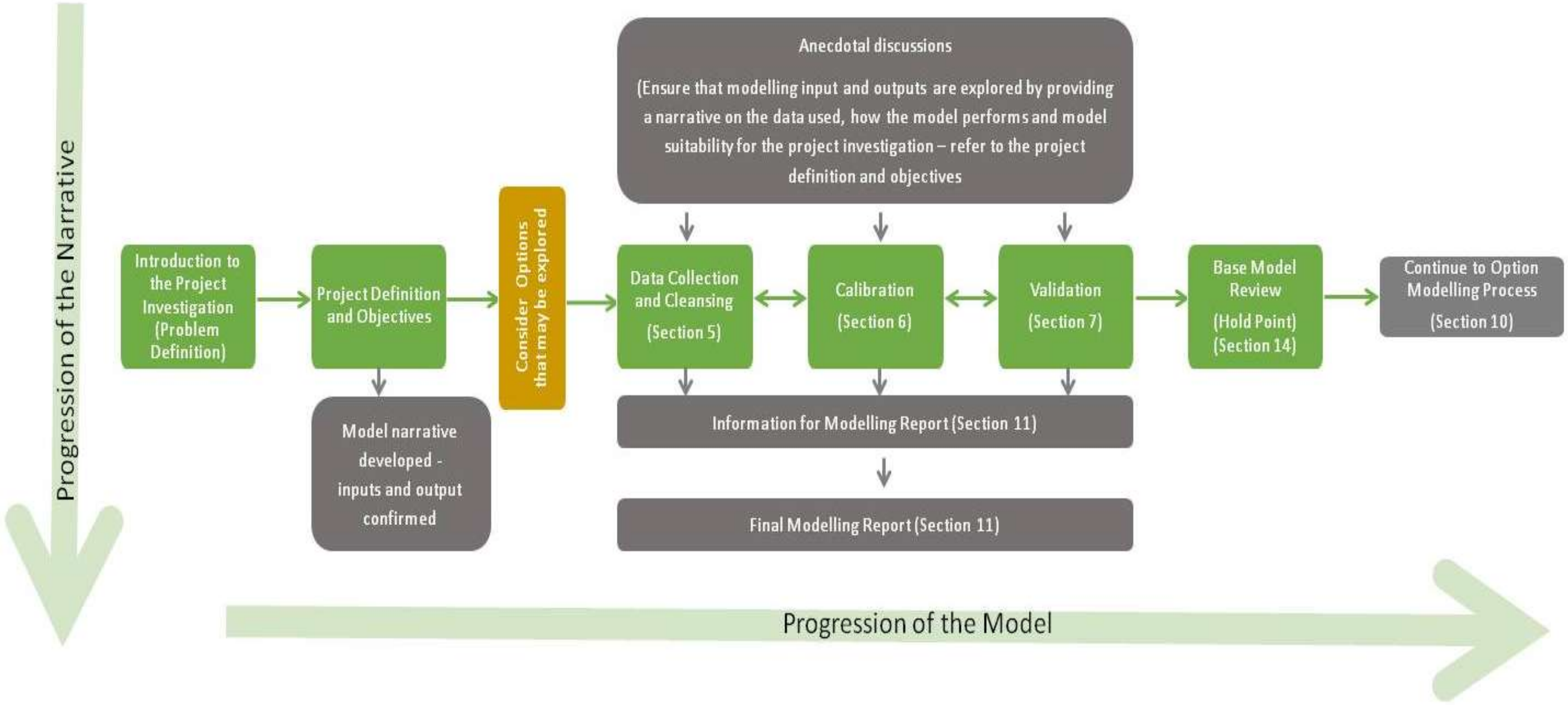


Figure 12: Development of the Option Modelling Process

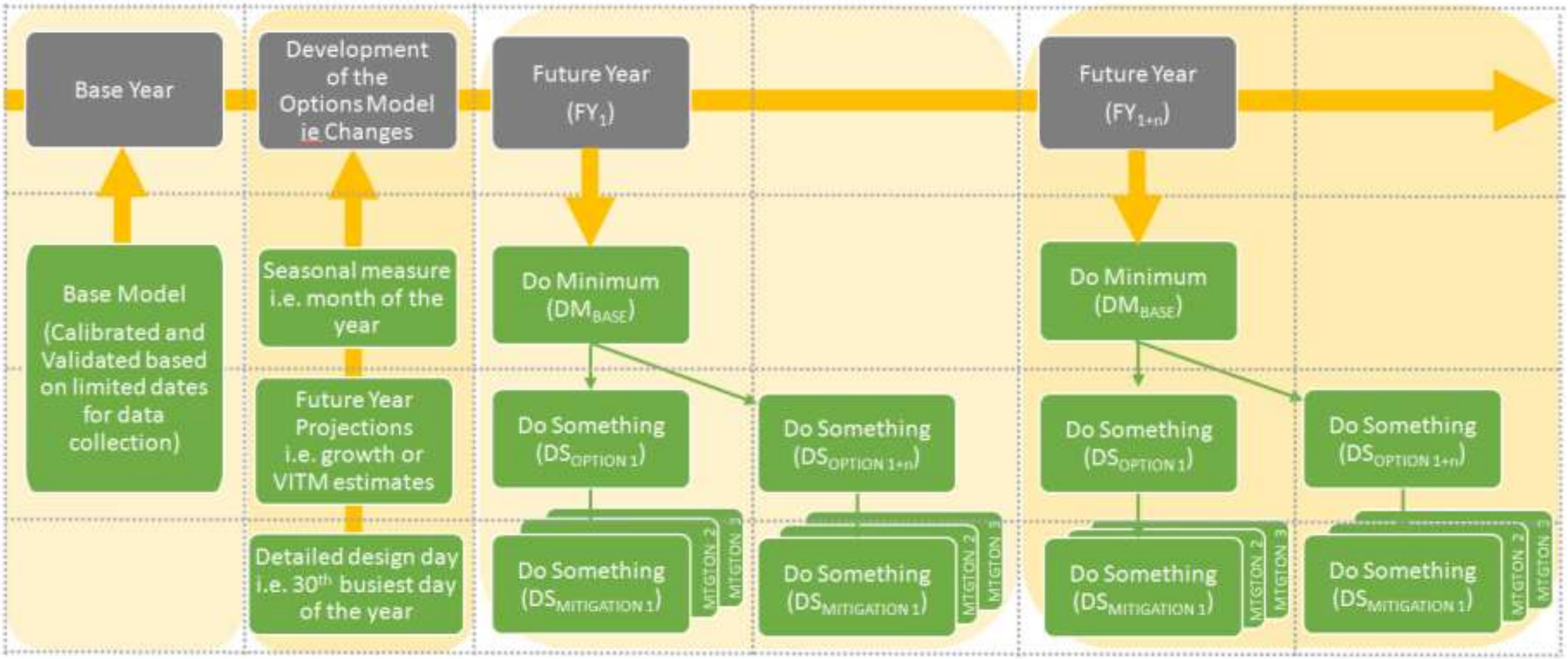


Table 5: Chapter Checklist for Project Formulation

Topics for Discussion and Reporting	Yes	No	N/A
Has the project team outlined the reason for developing a simulation model? What are the overarching objectives for this pursuit?	☐	☐	☐
What are the secondary objectives to complement the primary purpose?	☐	☐	☐
Does the modeller/consultant comprehend the strategic context of the project?	☐	☐	☐
Have the potential options to explore been provided so that appropriate data collection can be obtained?	☐	☐	☐
Has a site visit been conducted to review the current operational conditions to explore constraints and behavioural matters?	☐	☐	☐
What is the medium to long term landscape expected to be within this location? Are there strategic deliveries that may subvert the work effort of this project?	☐	☐	☐
How has the study area been defined? Is this the right area for analysis and which stakeholders will object? Has the project team worked through this matter before going to forwards?	☐	☐	☐
How is the local landscape expected to change over time? (e.g. more traffic or more congestion or different residential density or new traffic control systems) Does this project then require a rethink in the context of this expected network change (different acceptable density, varied developer contributions)	☐	☐	☐
How far ahead does the team need to consider for impacts and network changes in the context of stakeholder needs for this project?	☐	☐	☐
Does the core of the modelled area identify with the challenge being explored?	☐	☐	☐
Are the correct time intervals being explored for network operations and investment in the development of the network?	☐	☐	☐
Is there a strong narrative about the value of investment for this delivery?	☐	☐	☐
Are all stakeholders aligned for the objectives and deliveries required from this simulation model?	☐	☐	☐

5. Data collection

The development of simulation models and their accuracy to represent the observed conditions is highly dependent on the quality and consistency of input data. To ensure that the quality and consistency is maintained, the source of the data should be understood and not assumed to be error-free or correct simply because they are provided by a credited or approved source. All data sources have limitations (in both collection and interpretation) but can be used to help establish the analysis. This is a case of developing the evidence to then consider how changes may impact on the area of landscape.

It is vital for transport modellers to determine beforehand what datasets are required for the chosen modelling approach including what data is available against that which needs to be acquired, and how the data will be processed for the modelling pursuit. Models developed for VicRoads need to deliver for all modes of on-road transport and hence appropriate datasets (evidence) are required. Some datasets can be obtained retrospectively (e.g. signal operations, SCATS volumes, some travel time data) but other matters including observations directly relate to the survey timeframes.

A data collection and processing strategy needs to be developed that focuses on the following principles:

- Collection period considerations which should cover the typical periods to be modelled. The typical period may not necessarily be a normal day but may require consideration of other factors (as discussed in Table 6);
- Special observation on the day of data collection (as discussed in Table 7);
- Type of data and modelling purpose, whether it is for model calibration (i.e. direct input of datasets into the model – refer to section 6), or for model validation (i.e. independent datasets for model output comparison – refer to section 7). This is discussed in Table 8,
- Quality of data collection as discussed in section 5.2; and
- The potential future year options should also be considered and explored with the relevant stakeholders prior to the data collection process. This may designate a small increment in data collection requirements in order to better value the proposed change to the transport system.

All data collected and used for investigations for VicRoads' (and other government agencies) needs to be provided to the relevant VicRoads data manager for inclusion to VicRoads data systems.

This should be provided physically on an appropriate drive or disk for longer term storage by VicRoads. This should be undertaken without the need for explicit request prior to issue of the final invoice to VicRoads or associated agency. Note that due to longevity matters, provision by cloud (download) access does not meet such acceptable criteria. For any clarifications on whom is the correct person to receive the data collected, please direct a query to traffic_requests@roads.vic.gov.au

For field survey data collection, typically a Transport/Traffic Survey Specification is developed that outlines the requirement of the collection process. Austroads, Guide to Traffic Management Part 3: Traffic Studies and Analysis (November 2017) section 2 further explores traffic studies and survey considerations.

The more detailed discussion on types of data and its quality is further explored in section 5.2.

Table 6: Collection period considerations

Criteria	Considerations	Impact & Outcome
Day of week	Consider representative days (avoid weekday/weekend, late night shopping, etc).	Data is generally collected from Tuesday to Thursday as it considered to be representative of the network demand and is subject reduced impact from weekend related events.
	Consider weeks based on seasonality i.e. avoid weeks in the summer months (December, January and February).	Data is generally collected outside the December, January and February months due to variability in network demand from high volume of holiday activity due to school holidays and public events. VicRoads preference is to collect data during the months of May and November.
	Consider avoiding school holidays, public holidays, major sporting and special events including adjacent weeks to these sessions.	Data is generally collected on weeks that do not fall on a school holiday, public holiday or special event. Adjacent weeks are generally excluded but will depend on the extent of impact on network demand. Avoid special events that influence the network by more than 10% of additional delay. The AFL Grand Final, Melbourne Cup or a major music concert at the MCG are such examples.
Time of day	Peak periods, inter-peak, off-peak, warm-up, cool down.	Data is generally collected for the peak period but it may be different across the network as the period may extend into inter-peak or off-peak periods. The warm up and cool down periods need to ensure that the operation is fully captured. Typically, volumes/demands are collected over three days in the weeks not affected by public holidays or school holidays. The times commonly chosen are 6-10AM and 3-7PM.
	Consider impact from shopping centres opening times and school drop off and pick up periods.	Peak fluctuations can occur due to shopping centre and school activity as the chosen time of day should ensure that these impacts are captured otherwise calibration of the network complexity may be difficult to achieve for a specific time interval.
Time increments	Consider the interval at which the various data collection should be provided. Depending on the project investigation, the granularity of the time interval may vary.	Data is generally collected in 5-15 minute intervals to assist with identifying time profiles and any spikes in demand. However, for more congested and highly time sensitivity transport operations such as motorways the data is generally collected at 1-5 minute intervals.
Adverse or abnormal weather	Consider the impact of adverse or abnormal weather conditions such as heavy storms, lightening, icing surfaces, strong winds, bushfires etc.	Data is generally collected on clear days as adverse or abnormal weather does not provide a typical representation of network demand, is a cause of heightened vehicle incidence, increase caution on the roads and on-road mitigating scheme such as reduced speeds due to extreme winds.
Change in traffic control	Consider the traffic impact that is proposed before or after the data collection.	Data quality may be compromised if a traffic control device is installed on the network that impacts the data collected i.e. ramp metering for motorways, accident management, and construction projects.

Table 7: Special observations on the day of any data collection

Criteria	Considerations	Impact & Outcome
Issues or incidents	During field data collection, any issues or incidents need to be captured. The modeller should ideally visit the site to observe and understand traffic conditions during field data collection periods.	Data quality may be affected depending on the issues or incidents identified during the field data collection. The modeller's presence on site will assist in the calibration process to simulate as observed rather than just match datasets e.g. illegal movements, emergency services interaction, unfamiliar taxi movements etc.
Anecdotal observations	During field data collection, any site specific characteristics need to be photographed and documented. The modeller should have visited the site prior to development to observe and understand traffic conditions during field data collection periods.	Data quality maybe effected due to site specific characteristics not being documented. Modeller's presence on site will assist in identifying specific transport behaviour. Typical considerations include: • Queuing that is effecting the demand upstream • Specific under-utilisation of lanes at the approach to intersections • Illegal movements • Treatment deficiencies or driver confusion due to signage or linemarking.

Table 8: Type of data collection and modelling purpose

Type of data	Example of Field Survey Data Availability	Example of Historic Data Availability	Data for Model Calibration[1]	Data for Model Validation[2]
Traffic Counts	• Manual counts i.e. onsite resources, video recording • Automatic count systems i.e. tube counts, infra-red-light beams	• SCATS inductive loop counts • Motorway data stations • Permanent manual count sites	Yes[3]	No
Classified Counts	• Manual counts i.e. onsite resources, video recording • Automatic count systems i.e. tube counts, infra-red-light beams	• Motorway data stations • Permanent manual count sites	Yes[3]	No
Journey Times	• Floating car • GPS tracking of public transport • Bluetooth • Wi-Fi	• Bluetooth (VicRoads & AddInsight Traffic Intelligence System) • GPS Probes	No	Yes[3]
Journey Speeds	• Floating car • GPS tracking of public transport • Bluetooth • Wi-Fi	• Bluetooth (VicRoads & AddInsight Traffic Intelligence System) • GPS Probes	Yes[3]	No[4]
Strategic model data	• Not applicable as the data is outputs from another model. • Consider the data collection that was used in developing the strategic model	• Not applicable as the data is outputs from another model. • Consider the data collection that was used in developing the strategic model	Yes[3]	No
Queues	• Manual counts i.e. onsite resources, video recording • Drone footage	• GPS Probes (speed profiles) • Anecdotal evidence	Yes[3]	No[4]
Signal Times	• Generally, not applicable as data is collected by the SCATS regional computer	• SCATS operation files i.e. SCATS Strategic Monitor Inputs, SCATS Access, LX File Inputs • SCATS output files i.e. History File, IDM	Yes[3], based on SCATS operation files	Yes[3], based on SCATS output files
Origin-Destination Data	• Household survey • Intersection roadside interview • ANPR • Bluetooth • Wi-Fi	• Household survey • Intersection roadside interview • Mobile Phone • GPS Probes	Yes[3]	No[4]
Pedestrian data	• Manual counts i.e. onsite resources, video recording • Bluetooth • Wi-Fi	• Permanent manual count sites • Mobile phone	Yes[3]	No

Type of data	Example of Field Survey Data Availability	Example of Historic Data Availability	Data for Model Calibration[1]	Data for Model Validation[2]
Cyclist Counts	• Manual counts i.e. onsite resources, video recording • Automatic count systems i.e. tube counts, infra-red-light beams	• Permanent manual count sites	Yes[3]	No
Public Transport i.e. schedules, stops, dwell time, speed and length	• Manual counts i.e. onsite resources, video recording • Automatic count systems i.e. tube counts, infra-red-light beams • Speed through riding the service	• Online publications • GPS Probes (dependent on public transport type) • Ticketing system tracking	Yes[3]	No
Motorway data i.e. speed flow curves	• Manual counts i.e. onsite resources, video recording • Automatic count systems i.e. tube counts, infra-red-light beams	• Motorway data stations accessible via STREAMS	Yes[3]	No
Level crossings	• Train operating speed (may be different to line speed) • Flashing time (activation/deactivation) • Train departure time (inc. passing train, directions) • Dwell time • Type of train service (vline, metro) • Boom gate operation time (horizontal & rise-time)	• SCATS data if the level crossing is linked with a signalised intersection • Victrack and PTV available data such as arrival times and departure times	Yes[3]	No[4]
Car sharing	• Manual counts i.e. onsite resources, video recording (if facilities clearly demarcated) • Application data	• Data access based on car sharing provider's policy	Yes[3]	No
Taxis	• Manual counts i.e. onsite resources, video recording • Application data	Data access based on relevant provider's policy	Yes[3]	No
Parking	• Manual counts i.e. onsite resources, video recording • Automatic count systems i.e. tube counts, infra-red-light beams • Application data	• SCATS inductive loop counts (if parking • Permanent manual count sites • Private parking datasets i.e. boom gate operation	Yes[3]	No
Saturation flow	• Manual counts i.e. onsite resources, video recording • Loop detector data in saturated conditions	• STREAM saturation flow outputs • SCATS max flow output	Yes	No

[1]Direct input of datasets into the model (refer to section 6)
[2]Independent datasets for model output comparison (refer to section 7)
[3]Consider the quality of dataset when using it for calibration and validation process
[4]Can be considered for validation process if the dataset is of high quality

5.1. Data Collection Summary

Data collection should be visually presented with details of the collection type, period and source provided in a table format. This approach provides the data collection narrative to the project definition developed for the project investigation.

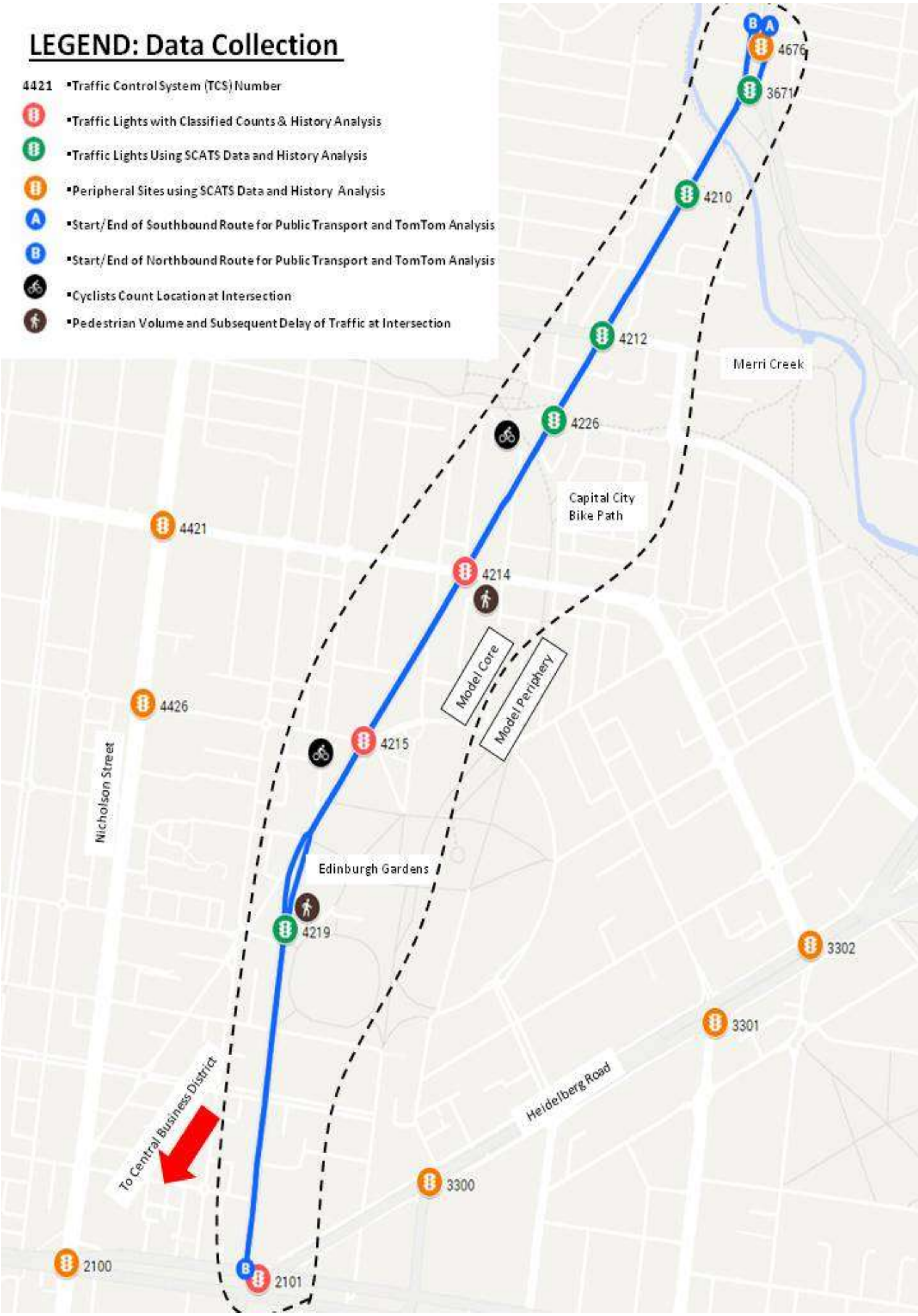
The preferred method to present the data collection is to provide an image map showing the location of each data source and the data type. To reduce potential conflicts in presenting the locations and to illustrate specific data types such as bus routes, several image maps may need to be produced to provide the whole data collection outcomes.

A locality plan to show how the data collection area fits within the broader network needs to be provided as well. Many readily available mapping tools and online applications are available to meet this requirement.

The data collection methodology listed in Figure 13 is an example of such a process to map the collected data. This image has been mapped using the Google Maps solution which provides for a cost free mapping and display structure (free account is required). The map has been developed to identify where classified traffic surveys were undertaken to complement the SCATS loop detector counts obtained. The image identifies a number of sites with a focus on pedestrian and cyclist's data collection, as well as the routes used to determine journey times for both public and private transport systems. A number of key locations within this study area are also marked to help provide for perspective for various readers.

If the survey data was conducted on different dates, it would be advised to also colour code or develop symbols to showcase the survey date for each site.

Figure 13: Data Collection map (AM Peak Period) for the Investigation



5.2. Types of Data

5.2.1. Traffic Counts

Traffic counts often represent one of the core datasets applied within simulation models to explore matters within the transport network and can represent a snapshot of the number of journeys travelling in the study area. Traffic counts are the numeration of vehicles passing a designated point or section on the road. This are generally collected at intersections and at midblock locations (between intersections).

Traffic counts are the most commonly applied data type in simulation modelling and are generally used in all areas of the model development i.e. verification and calibration. Traffic counts should be segregated into appropriate intervals based on the type of model i.e. motorway 1-5min intervals, sensitive time profiles 5min intervals, other 15min intervals. Data collected should not simply be aggregated to an hourly interval for simulation modelling.

It is important that the element of traffic counts collection obtains the demand for the movement and not simply the throughput achieved. These distinct differences are explained in Section 6.1.4. In order to identify the appropriate component to acquire, teams may need to conduct a site visit prior to arranging data collection. This also means that data sets provided (e.g. SCATS Volumes) may still need to be complemented by the collection of midblock counts. Otherwise the analysis is likely to be understated.

Investigations are always encouraged to explore traffic count locations on the network that are prominent on many motorways through various traffic loggers via STREAMS. SCATS (detector) datasets provide extensive metrics around traffic volumes but should not be the sole representation of data collection due to a number of key factors:

- Detector failures (irregular but potential);
- Detector undercounting (common but accountable);
- Detector overcounting (chatter); and
- Detector placement (see as an example).

Temporary traffic count sites are common through the use of Automatic Traffic Counts (ATC) such as pneumatic tubes or infra-red-light beams or manual counts through video recognition. VicRoads strongly encourages that a number of key locations are surveyed for each investigation, even if SCATS detector data is available for the location. This will in itself better confirm or debate the validity of the SCATS data as well as providing for a number of further benefits into traffic composition, site observations etc.

Traffic surveys may also need to be conducted for explorations of turning counts where SCATS detectors identify for multiple movements at the approach, eg a shared through and right turn lane at a signalised intersection.

Availability of information:

1) VicRoads have a repository of manual count data from detector and survey locations. For further information and project specific request visit the following link: https://www.vicroads.vic.gov.au/traffic-and-road-use/road-network-and-performance/road-use-and-performance
2) SCATS data is available through the Victorian Government Open Data Portal and can be found at: https://www.data.vic.gov.au/ . An increased volume of SCATS outputs and performance metrics are now provided on a daily basis.

5.2.1.1. Traffic Assignment from Strategic Modelling

The use of traffic count data from strategic modelling for simulation modelling assignments is considered acceptable (as a starting point) but should not be used without appropriate review and analysis. In particular, the following should be considered;

- Understand the limitations identified in the strategic modelling i.e. where is the model weak and strong. Review the calibration and validation of the technical report rather than an immediate acceptance of the delivery. This may not require refining the strategic model, but editing prior to application within a simulation model;
- Undertake a capacity constrained assessment to understand the speed flow relations and its effect on capacity. This may involve the refinement of the demand estimation (due to the generous capacity definitions often applied with strategic demand estimations) and the refinement of the varied route choice considerations in the traffic assignment. VicRoads encourage this to be undertaken through mesoscopic modelling to further understand the transport performance impacts. The VicRoads detailed network model, DOMINO can be used in this situation;
- Undertake analysis of any intra-zonal trips that are not assigned in the strategic modelling network. The intra-zonal trips are the trips that begin and end same travel within the zone and deals on a more detailed level than in strategic context. Currently, intra-zonal trips account for about 10% of the network demand. As these trips are not assigned to a strategic model, this omission understates the intersection performance. Breakdown of zone structures need to be considered before moving towards simulation modelling. The VicRoads detailed network model, DOMINO can be used in this situation; and
- Application of the patterns of trips within the strategic travel demand model may help to identify the underlying distribution of journeys within a simulation model. This is intended to provide a starting point for the simulation model and should be subject to change due to the differences in the network modelling. However, the overarching distribution of journeys should maintain a similar appearance in the network, given the above discussion points.

The data held in Table 9 provides an example of the difficulties of applying a strategic modelling pursuit within a simulation model. The intents of the strategic modelling are for a very different purpose (demand estimation and route assignment) rather than exploring the specifics of the points of complexity for each route. The simplest metric of analysis is the screenline, which showcases (as it does here) that the model provides for a good overall representation of trip making patterns within the study area. However, each individual site has a major discrepancy between the modelled and the observed numbers – which is hidden in the bottom row (screenline aggregate) by the magnitude of the values at Site F. With this may be considered as a suitable delivery for the foundation of a strategic model, the application of this data for any one location at sites A-E is not appropriate. Extraction of this data for simulation modelling would need to achieve further refinement (see points above) before being developed for exploring of constraints and deliveries within a simulation setting.

Table 9: Extract from Strategic Model Screenline results (AM Period, Location withheld)

	Observed Count	Modelled Flow	Abs Difference	PC Difference
Site A	6,480	5,450	1,030	16%
Site B	760	1,610	850	112%
Site C	750	1,310	560	75%
Site D	4,560	3,600	960	21%
Site E	1,400	1,670	270	19%
Site F	12,060	11,730	330	3%
Total Screenline	26,010	25,370	640	2%

5.2.1.2. Pivot Point Modelling

Some teams have a preference for developing a revision to demand matrices through a process referred to as a pivot-point matrix. This is a process of revising the demand matrix in the context of some surrounding measures at the trip end (row and column totals of a matrix). The process was initially developed to explore changes conditions of the land use and derive transitions to either be increased through an additive process or through a multiplicative process (i.e. new volumes formed by an increment or a factor of growth for each cell). The structure of cell value revisions was originally developed to explore changes in trips as a function of the formation of new (or revitalised) land uses as a percentage growth from an empty plot (or a suburb yet to be developed) where the factor of increment would produce a future year result to match the current setting (zero journeys).

When developing demand matrices from strategic transport models and applying a pivot point process, teams are required to report on the procedures used to transition the cell values. This should involve provision of a matrix structure to identify the following elements:

- Initial demand estimate of the cell (prior value);
- Transition process within each cell (value between 1 and 8 to outline the change derived);
- Transition value of each cell; and
- Final demand matrix with transition matrix applied.

There needs to be a suitable narrative to explain the values applied and rates of growth indicated. Note as well that the direct application of the pivot point calculations as applied within this context may misrepresent the choices made by residents on journeys. That is within the strategic modelling context the current and future mode choice decisions are derived from journey time functions. Application of the strategic modelling results as well pivot point modelling may misconstrue the future conditions that are to be simulated.

5.2.2. Classification Counts

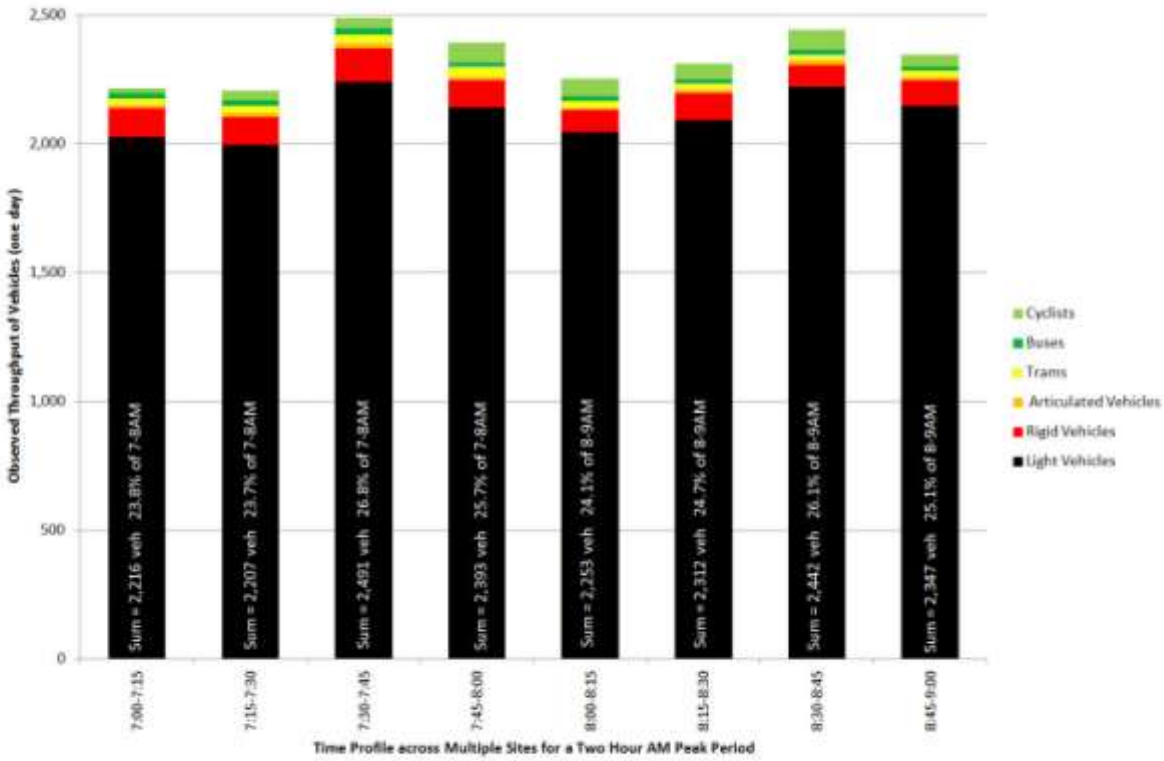
Classification counts are the recording of vehicle types at a designated point or section on the road. These counts are important due to the differing performance characteristics and road space occupied by the various vehicle types (i.e. semi-articulated and rigid vehicles). As a minimum, the classifications should include light and heavy vehicles, but improved model accuracy if required (i.e. motorways) can be achieved with a greater range of vehicle classifications. In such cases, the classification for heavy vehicles would be split into rigid and articulated vehicles. Refer to Austroads Technical Report: Automatic Vehicle Classification by Vehicle Length (August 2006) which details the established vehicle classification system by axle configuration and vehicle length for Australia and New Zealand.

VicRoads are required to confirm classification categories for simulation modelling pursuits as deemed fit for the modelling investigation. The term “classified count” may not distinctly consider other modes such as taxis, hire cars, light commercial vehicles, motorcycles or other variants. As such urban centres typically receive a high proportion of the observed fleet defined within one category of vehicle.

Any location (turn or link or model particular lane) that has a distinct vehicular volume comprising at least 10% of the aggregate volume should ensure that these measures are distinctly addressed as a classification within the simulation model. This requirement will represent conditions of taxi lanes, HGV movements, bicycle lanes and additional vehicular measures within the metropolitan network. The same designation can also be applied to T2 and T3 lanes where applicable. Of course there are times when such high occupancy lanes allow singular occupancy vehicles into the space, as determined within the existing legislation (Australian Road Rules).

Considerations for a full classification count usually occur in areas of high truck presence and turning movements (i.e. where truck volumes are ≥10% of total volumes), motorways, steep grades and undulating terrain. This may be less significant near suburbia but more significant around industrial land uses and port locations. Many of the devices used for traffic counts have capability to undertake classification counts. Classification and the length of each vehicle type plays an important role when evaluating car parks and keep clear conditions. As an example, Figure 14 below depicts the diversity of classification counts at seven selected locations in inner Melbourne (measured as throughput) from traffic surveys undertaken for VicRoads.

Figure 14: Diversity of classification counts observed in North Melbourne (Example)[3]



[3] Throughput volumes only from traffic surveys conducted for VicRoads
Sum of several key sites in Melbourne (inner) which are weighed by the time profile by all movements within the intersection. There may be a natural double counting of journeys within the network due to the passing through multiple key sites considered.

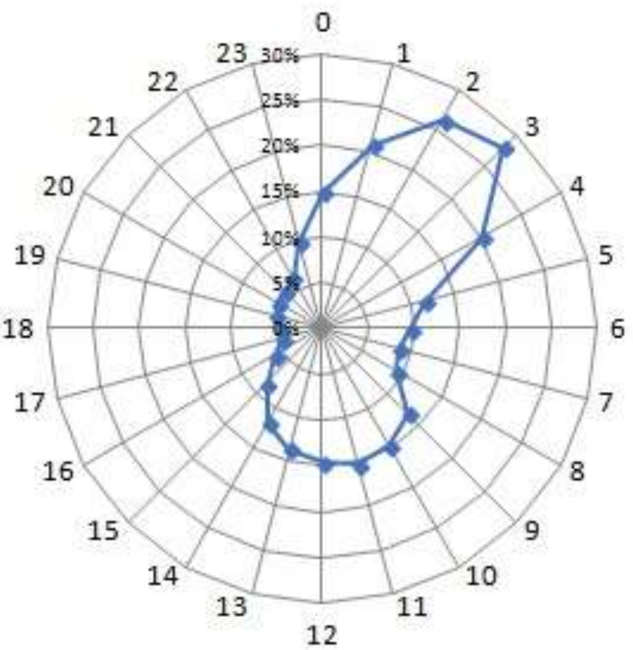
5.2.2.1. Heavy Goods Vehicles

The application of Heavy Goods Vehicles within simulation modelling is a common practice for delivery of the traffic and transport operations, even when simulating conditions of the inner metropolitan area. Commonly such measures are presented as either Rigid or Articulated vehicles, or disaggregated into the assortment of Austroads classifications. The mix of fleet within the areas of investigation may commonly change amongst different locations simulated as well as throughout the day. This is not merely a function of the nearby land uses but of the road hierarchy and the routes used by such vehicles to reach their destinations.

Empirical data collection from June 2018 identifies that the split of HGVs in the general traffic flow can be as low as 5% of the demand in the PM peak periods but as high as 28% in the one hour interval of 3-4AM (when general traffic volumes are typically lower). The aggregate analysis is outlined within Figure 15 as a measure of the analysis of twenty-five sites throughout the metropolitan area. These sites are typically arterial road and motorway locations.

Of those sites with AM peak hour demands (8-9AM) in excess of 3,000 vehicles per hour, the proportion of Heavy Goods Vehicles is quite diverse. Some locations such as Hoddle St Bridge (South of Harcourt Pde) were observed to have less than 1.8% of the flow as HGVs. By comparison the empirical data on the West Gate Freeway East of Millers Rd identified that this measure was nearly 65% of the fleet movement for the morning peak hour.

Figure 15: Empirical split of HGVs in Melbourne throughout the day



Overall the analysis identifies that a classified count needs to be undertaken for each study area in order to comprehend the varied mix within the fleet. There are no "rules of thumb" to determine HGVs proportions within the peak periods, nor by volume measures or by time of day considerations. Heavy Goods Vehicles continue to remain as a function of the land uses and road hierarchy. Therefore classified surveys should be conducted within each investigation in order to ascertain the localised conditions of traffic flow within that landscape. These conditions may be further enhanced by HGV functions associated with the investigation such as delivery of roads to a new port access or within proximity of a distribution centre.

5.2.3. Journey Times

Journey time collection is often the survey of travel time of vehicles along a defined route and represents the results of journeys within the landscape as a function of the varied constraints (competing traffic, signal plans, signposted speeds, on street parking, public transport etc). From all that drivers endure to achieve their journey, the time spent travelling (and corresponding journeys speeds) is perhaps one of the more relatable performance metrics.

As journey times are a function of the cumulative system of hindrances within the landscape the resulting indicators are quite variable. This helps to explore many impact factors with simulation modelling and provides a very robust solution to validate a well developed (calibrated) model.

These routes to explore journey times should be continuous and cover the extents of the model. However the routes should not overlap as this effectively misrepresents the sampling conducted and may skew the results of the analysis.

For journey time collection, a minimum number of runs or a sample size (depending on technology used) is required to have a greater degree of confidence in the route travel time.

Practitioners shall adhere to either of the journey time sample requirements provided below:

- Minimum number of runs if using floating car survey: 20 runs per hour per direction for each route
- Minimum sample size from journey time datasets (mobile/probe solutions): 10% of the equivalent daily traffic volume. This value can be decreased to 6% for regional areas (outside the urban growth boundary) where traffic penetration is lower. This sample can be derived from numerous days to meet minimum dataset requirements

Solutions such as GPS probe data solutions that can be used to investigate journey times. Consideration on the appropriateness of using such technology should be based on the project objectives. These datasets are available privately through various sources. While penetration of the market is not an issue, data reproduction maybe be a matter for consideration.

Data collection of journey times should not be limited to the peak periods (or hours) of the investigation. Teams should also utilise data collection methods to explore journey experiences in the off peak periods (e.g. midnight to 6AM) as the most likely measure to collect information about the intended journey speeds; that is the journey conditions that drivers would be willing to travel at were other drivers not on the road network.

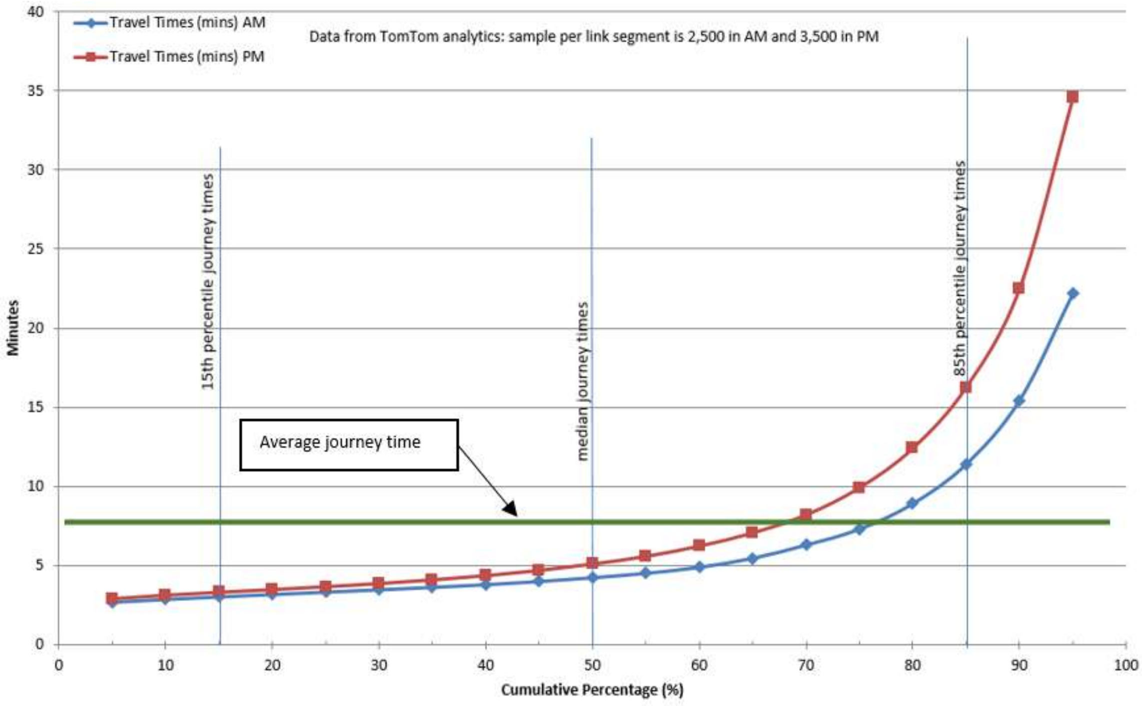
5.2.3.1. Median Journey Time

The primary metric within a wide sampling of journey times is the median journey time. The outputs used should focus on the median (50^{th} percentile) and not on the average travel time, as the sample of data can potentially infer a less regular travel time due to variability in the dataset.

This dataset should be managed in the same way that traffic count data is managed. That is, irregular days are removed from dataset used for analysis. The process to identify days to be omitted from the analysis (for the experience of a day of typical conditions) may be to identify dates with a polarised speeds and confirm an event (school holiday, public holiday, localised crash, road works etc). However, not all polarised experiences should be removed from the analysis simply for their variation from the median condition, as this might define the sensitivity of the site from irregular pressures.

As shown in Figure 16, the average journey time is higher than the median journey time due to the variability seen developing at 85^{th} percentile as depicted by the curve projection. In this instance the average journey time in this figure is closer to the 70^{th} percentile value rather than the 50^{th} percentile value and would be expected to misconstrue the results of the simulation modelling.

Figure 16: Median Journey Time vs Average Journey Time



5.2.3.2. Journey Time Consistency

Journey time validation is considered as a primary method for model suitability and as such requires appropriate exploration and analysis such as journey time reliability. In the analysis of collected data, it may become apparent that some locations within the network are subject to more significant variation in journey times. This variation can occur through the course of a peak hour or peak period or across a timeframe such as over a year.

Whilst many deterministic models provide for assumptions of a common journey experience and will not consider matters of journey time consistency, the reality on the road networks can often be far more fluid. This is not simply a function of seasonality, time of day comparisons or (modelled) seed values applied, but can directly be a consideration of the factors that inhibit flow of traffic. This is the reason that simulation models are often used to explore networks of intricacy and complexity.

For this reason, it is not appropriate to report on a median journey time when the operating conditions are subject to notable fluctuations. These locations or corridors are often subject to considerations of:

- Tram operations;
- Level crossing conditions;
- Motorway conditions;
- Motorway ramps;
- Extensive weaving; and
- Filtered right turns.

These considerations may involve the irregularity of arrivals (both public and private services) that produce a less consistent performance of operations in the landscape. For example, the proximity of the arrival of rail services in one or more direction can significantly impact on boom gate operations, which in turn effects on road capacity. In a similar matter changes in traffic weaving on motorways can lead to variations in flow brake down and variance of journey times in a morning peak hour.

For these reasons, networks that showcase a notable fluctuation in observed journey speeds should not be validated as a single interval, but as multiple time intervals (e.g. 15-20 minute intervals as determined appropriate from review of collected data). Such an approach should provide for a better representation that the network complexities to achieve the appropriate impacts of scale in the simulated network.

Clarification as to whether a network experiences considerable fluctuation requires the following approach (presented in Figure 17) to explore the collected journey data:

- Analysis identifies that median journey times between smaller time intervals (e.g. five to fifteen minutes) vary results by more than 20% from the median over the hour. E.g. an eight minute median journey time from 7:00-7:15AM but a median journey time of twelve minutes between 7:45-8:00AM; or
- Analysis identifies that the 85^{th} percentile journey time of the dataset over the season is at least three times longer than the median journey time. E.g. median journey time is seven minutes but the 85^{th} percentile time is 21 minutes.

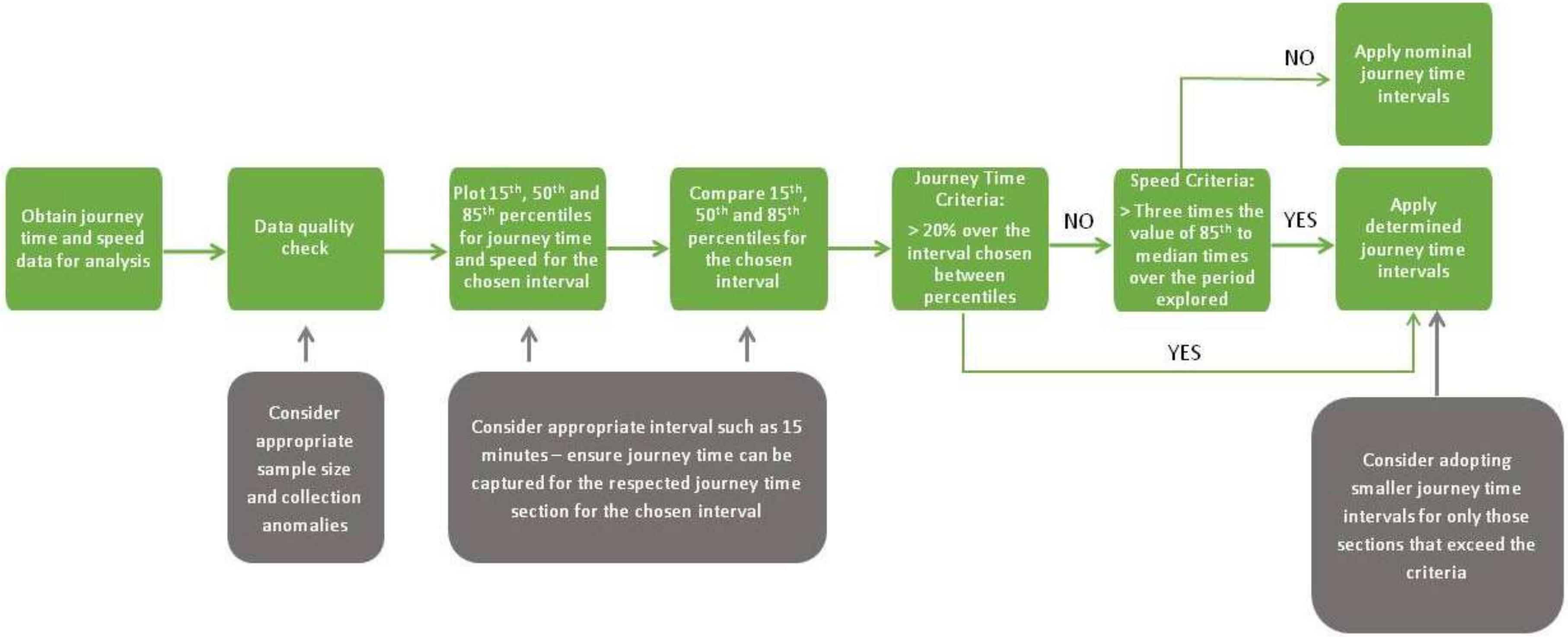
Under such conditions where the recorded median journey times are significantly different between smaller time intervals, the simulation models should be developed to benchmark the changed landscape experienced. In such situations the journeys would be subject to notable changes within an hour or time period so that a minor difference in departure times might produce a notable variation in arrival times to the destination travel zone.

This approach may involve either or both of the following considerations (dependent on the conditions on site):

- A dynamic assignment modelling approach whereby conditions in the simulation change as the time intervals progress; and
- A modelling solution with better delivery of the adaptive signal plans. This may involve conversion of fixed time signal plans into an adaptive solution or a revision of adaptive signal plans to a closer delivery of the variations that occur through the simulation intervals.

Note that refinement of this empirical dataset might involve cleansing the dataset prior to application. That is, in cases where the raw data is provided, teams might wish to remove dates pertaining to Mondays, Fridays, weekends, weeks with school holidays, weeks with or adjacent to weeks with public holidays or potentially dates there were subject to very irregular traffic operations (e.g. closed motorway for rehabilitation has pushed traffic elsewhere).

Figure 17: Journey time consistency check



\

5.2.4. Queue Lengths

Queues provide a metric of congestion that is more comprehensible to stakeholders. This is an item that individual parties remember and benchmark changes through the hour with the inclusion of anecdotal “back of queue” placements (e.g. queuing back to the post box, the minor road, the next intersection etc). However, counting or calculating queue lengths is a subjective exercise which is often difficult to define in a fixed manner over the course of the time interval.

Queue length data is the collection of stationary or slow-moving vehicles at an approach to a traffic constraint. Queue length calculation may be difficult since queued vehicles will often still be moving slowly (a rolling queue) and it will not always be clear what criteria should be used to constitute a queue. Also, since data is likely to be collected (quantified) by a number of surveyors it is unlikely that consistent and accurate reporting will be possible across the study area. Additionally, software packages may each calculate queue lengths using different criteria and methodologies which add a further level of complexity.

Nevertheless, reporting on queue lengths is important to understand the network impacts. Queue lengths assist in identifying the traffic demand and operational issues i.e. closely linked intersections.

When undertaking survey of queue length, the outputs should be produced in 5 minute intervals to show the fluctuation of the queue and for the purposes of comparing with the model outputs at the 95^{th} percentile. The survey should aim to capture photographic evidence of the queuing conditions used for benchmarks and time obtained from the surveys.

Data collection might consider the back of queue at the commencement of green lanterns (phase commencement) so that data collection occurs once a cycle. This metric might be the distance from the stop line (i.e. marking on a map or GPS positioning) or else use the number of vehicles in the defined queue. Data collection may also occur for determine the operational conditions at the commencement of the evaluation period.

5.2.5. Signal Controllers

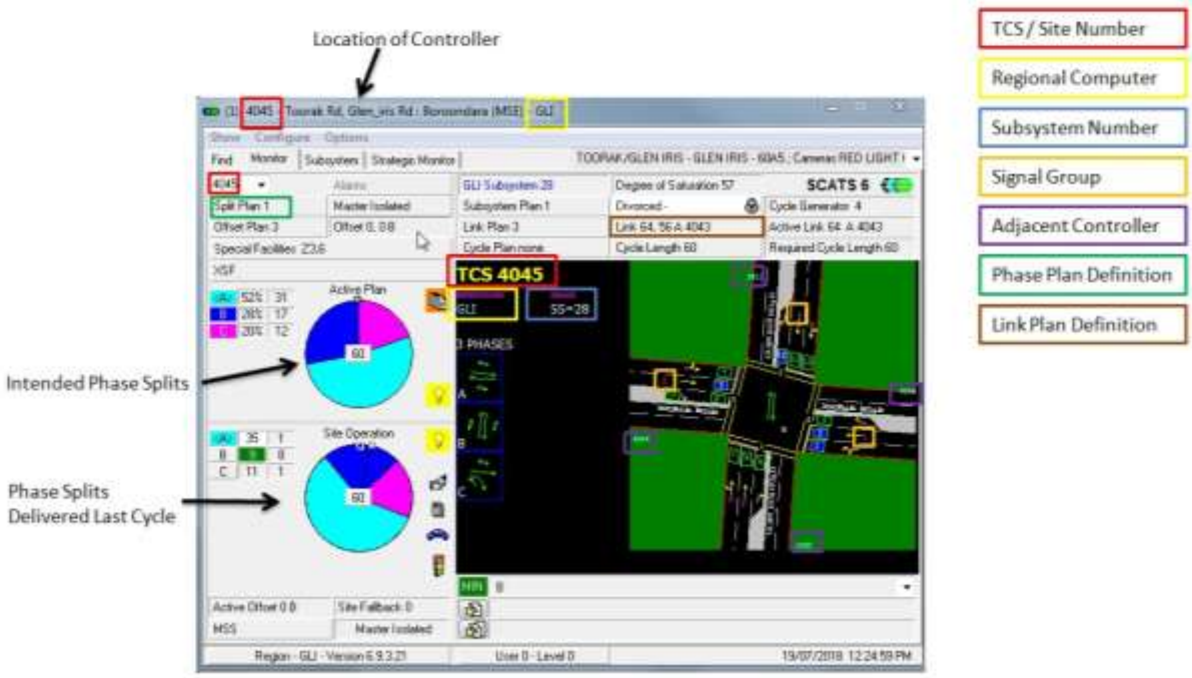
Signalised intersections have a significant impact upon the capacity of modelled traffic networks as they manage a volume of conflicting traffic movements that are only allocated a portion of available green time. The adjustment of signal timings, and associated parameters that affect stop line saturation flows, directly control the throughput of each approach in the model and often dictate matters such as capacity and hence journey times and route choices.

VicRoads operates the traffic signal controllers in most of Victoria through the SCATS controller system. This provides for a series of magnetic loops in the road (typically at stop lines) to explore the current needs for demands to instigate a response in phase plans. In this way signals can be adaptive and can change for each cycle that they operate. A brief outline of the SCATS display and some selected attributes are listed in Figure 18.

Some intersections operate in isolation, but many signal controllers work together through the integration of sub-systems. In this way SCATS will aim to operate a small number of controllers to work together to increase the throughput and reduce the localised delays. However these locations are typically limited to no more than four of five controllers operating together as a sub-system. The subsystem operates a master controller (often the most complex or constrained location) with adjacent sites providing a supporting role. Subsystems are often limited to this geographic extent due to operational considerations including varied pedestrian requirements, number of movements and the consistency of platooning (the Link Plan) which dissipates over a larger network size.

The SCATS controllers are linked through a regional connection which allows adjacent subsystems to irregularly work together in a more harmonious manner. Some controllers are occasionally directed to operate with a set cycle time (such as those within the Hoddle grid), while the road operator has the ability to overwrite the intended delivery through a centralised Traffic Management Centre. The motorways including many of the ramps in Melbourne are applied with the STREAMS platform that also provides for an ITS framework of adaptive messaging and speeds, amongst other attributes.

Figure 18: SCATS Access Controller showing selected attributes



The information required to accurately calibrate signalised intersections include the following:

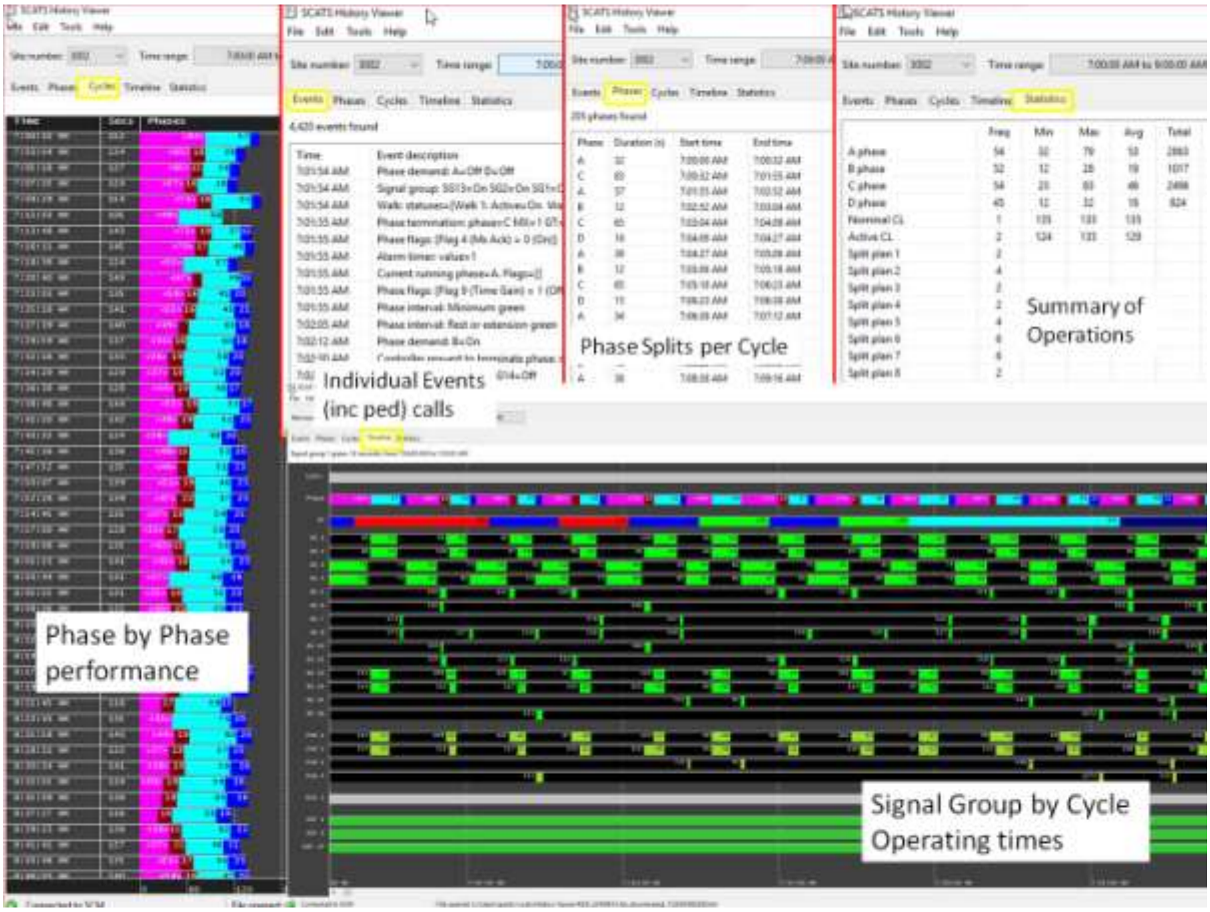
- Operation sheets that shows the layout plan and the intended signal deliveries.
- LX File from SCATS contains data necessary for communications, planned signal timings and sequence, inter-green intervals, pedestrian walk and clearance timings. This information is reflective for the surveyed days and builds on the information provided in the operation sheet. Note that the files for co-ordination of signals can also be found within the SCATS Access graphics. In this example provided within Figure 18 the graphic indicates that the cycle begins between 56-64 seconds after the end of the A phase in TCS 4043 (see brown box in Figure 18, which is subject to an offset plan).

The information required to accurately validate signalised intersections include the following:

- SCATS History File is a timeline output of all the phase and pedestrian operations (Figure 19). The SCATS History Viewer is the typical program that is used to output the signal data. Note that SCATS History Files can be obtained retrospectively, whereas IDM structure needs to be established prior to data collection. Note as well that the material provided from the Split Plan outlines what is intended to occur (proportional splits) whereas the history file identifies what did occur in the cycle by cycle variation.
- Intersection Diagnostic Monitor (IDM) output from SCATS which shows the phase frequency, minimum phase time, maximum phase time and average phase time for a specified period. The outputs should be provided as a minimum in 15 minute intervals. The output also provided pedestrian crossing activations. Although this data format is still available, the value of this approach is somewhat dated and not encouraged as a first means to examine signal operations.

The strength of the SCATS History file can be viewed within the collage of Figure 19. The dataset showcases the variation of the phase lengths for each cycle, as well as the occurrence of the phase calls in each cycle. This allows for a better review of the specific operations in effect with the simulation of conditions that are to be simulated and benchmarked. The datasets also identify the individual calls of pedestrian crossings at the intersections as well as primary flag calls to enact a change in the signal operations.

Figure 19: Collage of SCATS history file outputs



The data collected for traffic signals should match the days and time period chosen for the collection of other data types. It is good practice to have a minimum of three days of signal information to mitigate against any SCATS server disruptions/alarms that may prevent the recording of data.

Signal plans under SCATS operation will differ between days and time periods due to their adaptive nature, potentially every cycle is typically different from the proceeding cycle. The plans often hold a defined phase structure and split plan as an initial configuration before adapting to the immediate delivery requirements. The information collected needs to be evaluated as to which signal plans are typical for the days and time periods chosen for the data collection.

Signal time applications within simulation models are typically held in one of four formats:

- Fixed time solutions;
- Schedule Fixed Time profiles (signals);
- Adaptive plans; and
- SCATSIM.

Sometimes signal plans are fixed during peak periods or fluctuate due to real time peaks in traffic demands. Signal plans can also include other functions such as forcing a phase to run every cycle, moving time between phases and skipping phases when there is no vehicle demand detected (known as a false green). The signal operation should always be considered before choosing the appropriate signal plans for the specific simulation modelling project.

It is important to note that signal controllers may be programmed to be responsive to a signalised intersection beyond the study area – under such arrangements the study area should be extended to encapsulate those matters that directly relate to the study area – which is to simulate the matters of traffic and transport complexities and operations within the landscape. Without correct development of the base year model, the complexities that may actually arise with future horizons may not be identified.

Some teams occasionally aim to operate a fixed cycle delivery with variation for each interval explored. That is, the parameters for gap acceptance, phase splits, cycle time and maximum times might be varied for each 15 minute interval. However within each interval the controller operates as a fixed time solution. This rolling average of conditions through a peak period is known as a Schedule Fixed Time solution, and operates typically within an actuated setting, albeit without the complexities of the actuated delivery. This arrangement can be useful under conditions where the phase structure is relatively consistent and the cycle variation is nominal. However, the signals will not be able to deliver an adaptive solution o explore the complexities of optimisation strategies.

To assist in understanding the signal operations, the following needs to be obtained;

- An explanation of how the signals operate by referring to the phase times, cycle time and special phase operations. Phase diagrams should be presented;
- Diagrams also need to identify which phase is declared as the pivot phase within the cycle;
- Declaration of the subsystems – and hence a map of controllers that aim to work together within the study area. It may be required to develop this prior to designation of the study area, so that sites within the study area are not functional based on sites excluded from the study area;
- Comparison between the days surveyed should be presented to show variability in the signal plans by showing the frequencies, averages, minimum and maximum phase times from the History files in 15 minute intervals and the associated volumes for the respected phase operation;
- Signal plans utilised in the model need to be clearly explained and presented, especially if different time periods and/or days have been utilised; and
- Summary of pedestrian phase activations which are typically pedestrian push button calls. A comparison between pedestrian numbers versus pedestrian phase activations would be necessary to understand the pedestrian flow profile on phase activations.

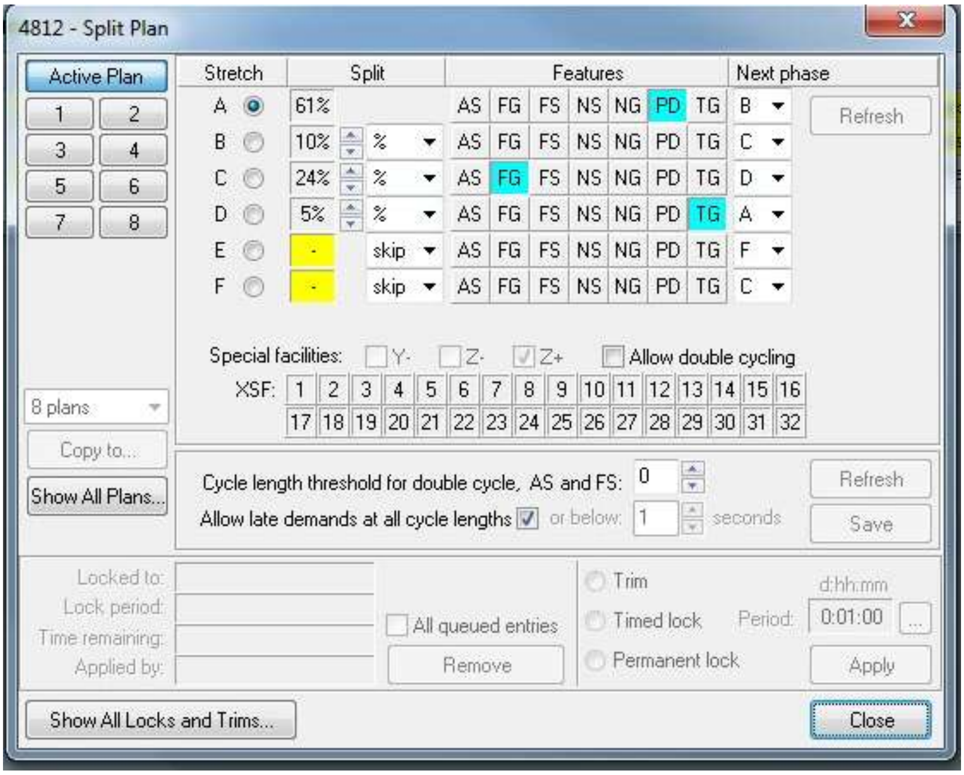
These materials provided may be outlined against that held within Figure 20 to discuss the operational plan including those phases expected to run as well as the proportional (or absolute) length of time per phase. The split plan confirms the intended phase order and may define which phases might be skipped when demand is absent as well as those with a mandatory call.

Signal timings on site (empirical) typically take one of four experiences as outlined within Figure 21. However each site is subject to unique qualifiers and conditions that result in the need to explore the traffic controllers in each modelling pursuit.

The four examples of controller operations during peak period conditions can be explained as follows:

1. Fixed time operations: These sites have cycle lengths and phase times locked by the operator, that results in a regular and fixed set of deliveries. Typically these locations are inner city and/or have a very high and regular set of pedestrian volumes that produce the more significant flow of journeys at said location.
2. Saturated and demanding operations: These sites involve a consistent pattern of journeys into the intersection, but are subject to subtle variations associated with the heterogeneous conditions of traffic (e.g. turning movements, vehicle lengths, driver attributes). Each cycle represents a similar but subtle difference in operating conditions making the site adaptive to give the pivot phase a slight advantage. Typically these sites are subject to high volumes and are busy intersections.
3. Completely adaptive and variable solutions: These locations are recognised by all drivers as sites that are subject to notable changes in phase splits and cycle length on a cycle by cycle basis. Often these locations are near to a venue such as a railway crossing. The change in operations is not consistent in length or repetitiveness.
4. Isolated intersections: These locations are sites that have regular changes in demands and hence phase splits and cycle times, but are less variable in experiences that the previous demarcation. Cycles and phase times have a degree of consistency but are evaluated by the SCATS system in each phase to determine phase skipping (false green) activities. Signals regularly explore the chance to transition between phases and experience variation in cycle lengths.

Figure 20: SCATS Split Plan Example

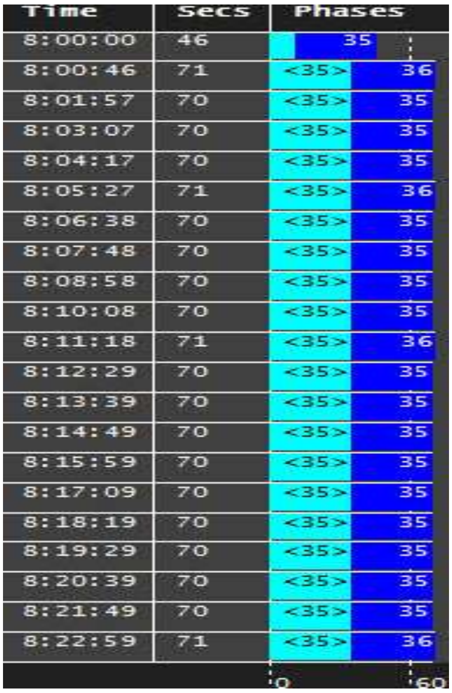


Fixed time signal operational solutions can be achieved in simulation models if the collected data closely supports this form of operation. This should be agreed with by the transport modelling specialist at VicRoads prior to the development of the base model, but once the prospective options have been explored. Note that there is potential for fixed time solutions to need to be developed into an adaptive solution when the scheme may involve an enhancement to the public transport priority movements within the area of investigation.

Figure 21: Example of Different Signal Applications

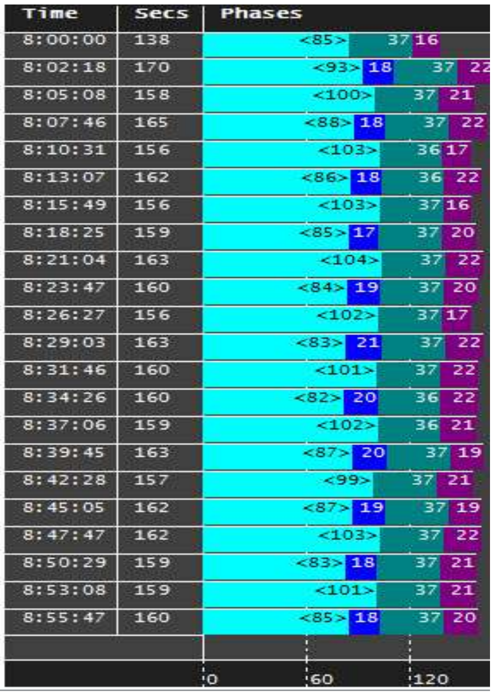
Site 4597: Elizabeth St and Bourke St, Melbourne

Experience: High Pedestrian Priority with fixed time delivery



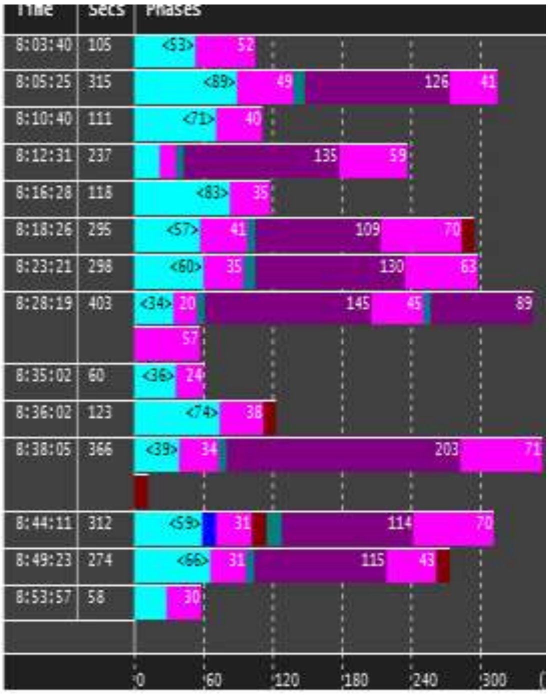
Site 3383: Hoddle St and Gibbs St, Collingwood

Experience: Saturated with consistent demand for subtle adjustments in Signal Times



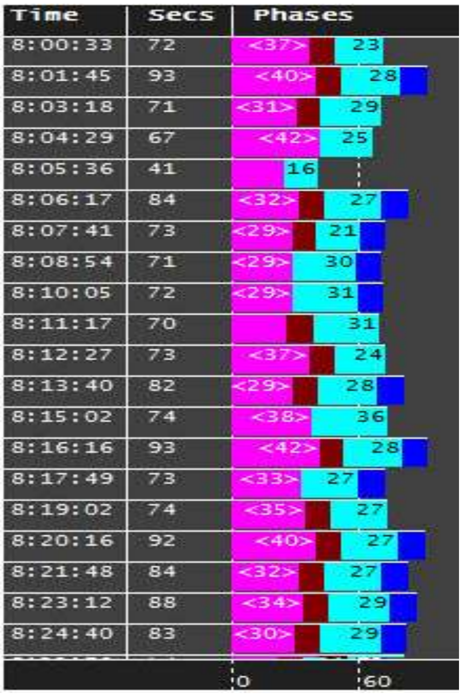
Site 4812: Swan St and Madden Grove, Richmond

Experience: Adaptive solutions with considerable variation due to rail services



Site 585: Springfield and Surrey Sts, Blackburn

Experience: Isolated controller with demand responsive (adaptive) signal times



5.2.6. Origin-Destination Data

Origin and destination (O-D) data provides insight into how people choose to travel by understanding the start of their trip (i.e. origin) and the end of their trip (i.e. destination). Origin and destination data can be collected from strategic models but the limitations in the data need to be explored as discussed in section 5.2.1.1. Surveys of origin and destination can come via various sources. Austroads, Guide to Traffic Management Part 3: Traffic Studies and Analysis (November 2017) Table 2.3 which is replicated in Table 10 compares the various technologies available.

Table 10: Journey Pattern Data collection options

	Household Survey	Intersection Roadside Interview	ANPR[1]	Bluetooth Wi-Fi	Mobile Phone	GPS Probes
Sample size	1-3%	10-25% local	100% local	10-30% local	20-50%	5-15%
Data collected	Trips, tours, vehicle ownership, journey purpose, mode, OD, VISTA etc.	OD purpose, (vehicle ownership)	Local OD, travel times	Local OD, travel times	OD, travel times, journey purpose, mode	Travel times, OD
Time coverage	1-3 average days	1 average day	1 or more days	1 or more weeks	Any time period, any day	Any time period, any day
Geographic coverage	General as sampled	General as sampled	Local	Local	General	General
OD matrices	Yes	Yes	Entry/exit	Entry/exit	Yes	Yes
Journey purpose	Yes	Yes	No	No	Yes, with data fusion	Yes, with data fusion
Modes used	Yes	Yes observed	Vehicles only	Possible but difficult	Possible but difficult	Rare
Travel times	No	No	Local	Local	Yes	Yes
Set-up task	Yes	Yes	Yes	Yes	Minimal	Yes
Intrusive	Yes	Yes	No	No	No	No
Delay for analysis	Months	Weeks	Days	0 to 1 week	1 to 4 weeks	0 to 1 week
Collection and processing cost	Very high	High	Medium	Medium	Medium	Low
Vehicle classification	Yes	Yes	Yes	Difficult	Difficult	Yes
Limitations	Access, underreporting, simplification	Coverage, disruption, refusal, simplification	Masking, local OD, vehicles only	Correct sampling, mode, local OD	Access, correct sampling, mode	Correct sampling, mostly vehicles
Bias	Can be corrected	Can be corrected	Not significant	Mostly unknown	Correctable	Mostly unknown
Data fusion with	Census, GIS, counts	Census, GIS, counts	Counts, GIS	Counts, GIS	Census, GIS, counts	Census
Privacy concerns	Some	Low	Some	Medium	Medium	Low

[1]Automatic number plate recognition

Household survey data is readily available from Transport for Victoria (TFV) via the following link through VISTA survey data: https://transport.vic.gov.au/data-and-research/vista/vista-data-and-publications/. The data sample size should be considered in the context of the project pursuit and if considered low should be supplement by other data sources. It should be noted that the VISTA data collection achieves circa 12,000 households per year across a state of a population of 6.2 million (Census ERP 2016).

With regard to ANPR and Bluetooth/Wi-Fi collection methods, the locations of detection sites need to be placed strategically to understand the origin and destination patterns. VicRoads continue to enhance their Bluetooth collection methods for applications of journey management across the metropolitan area.

5.2.7. Pedestrians

Pedestrian data is highly dependent on the project definition and whether specific pedestrian areas are required to be modelled. The following data is typically required for pedestrian modelling;

- Volumes passing through the network;
- The saturation flow of various pinch points in network such as escalators, gates and narrow paths;
- Impact on traffic flow (delay in seconds);
- Queue lengths;
- Travel times between key origins and destinations;
- Percentage of mobility impaired pedestrians;
- Number of people choosing to use stairs/escalators or lifts;
- Current timetabled public transport services; and
- If traffic signals are in the network, traffic signal data would be required (Refer to section 5.2.5).

A site visit is recommended to better understand the local conditions and behaviour of the pedestrian network and to gain an understanding of what factors are influencing the capacity of the network.

If pedestrian spaces are not required to be modelled, there would still be a consideration in undertaking pedestrian and movements surveys to identify the impacts that pedestrians have on traffic flow. This would allow teams to simulate the operation of signalised intersections, pedestrian operated signals (POS) and other priority crossings such as zebra crossings. This may not require a survey of pedestrian volume metrics, but a survey of vehicle delays in response to the pedestrian crossing volumes.

When developing plans and designs for signalised intersections, the activation of a pedestrian crossing can sometimes determine specific signal phase operation or determine if a phase green time should be extended for the pedestrian walk and clearance times beyond standard settings. When exploring pedestrian operated signals (POS), the puffin operation may influence the length of clearance time allocated for the crossing. This is critical in areas with a high activity of senior citizens.

Other considerations could include the impact on vehicles turning left from vehicles waiting for a crowd of people to complete a crossing during “no walk” operation (refer to Figure 22) and pedestrian bunching at varies spaces.

For pedestrian simulation modelling (pedestrian areas) guidance on calibration and validation refer to section 9.

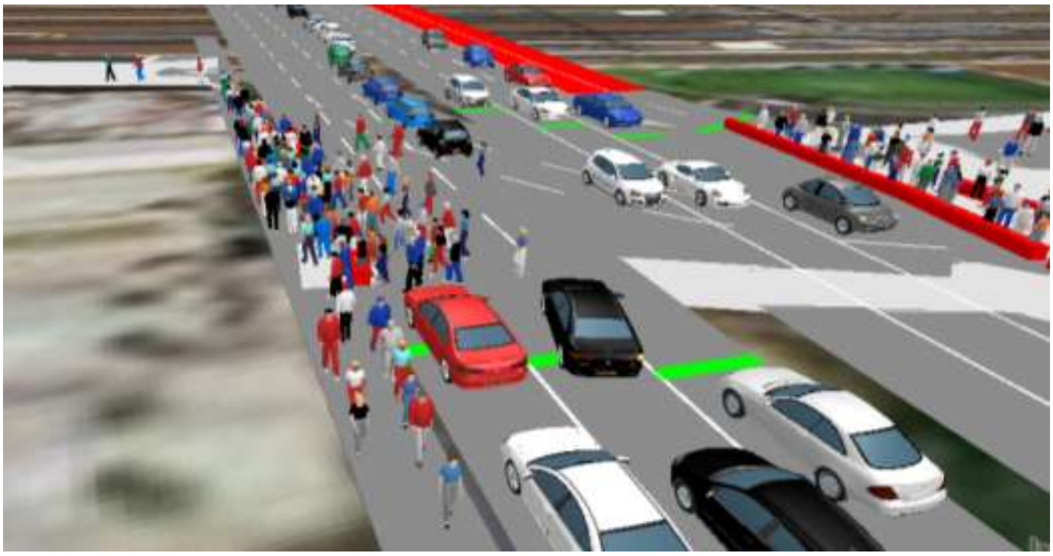
5.2.8. Cyclists

The count collection may vary depending on the type of facility provided (on or off road) with loop counts more common for off-road count data. The survey should consider the interaction of cyclists with other modes of travel especially vehicles and pedestrians as this can impact on travel times and capacities especially for left turning lanes.

VicRoads operates a number of count stations with volume and speed data available for 42 off-road sites and four on-road sites. These data are available via the following link:

https://www.data.vic.gov.au/data/dataset/bicycle-volumes-vicroads

Figure 22: Clearance time operation implications due to a crowd of people



5.2.9. Motorway Data

Speed Volume Occupancy

Speed Volume Occupancy data are traffic flow data primary used for uninterrupted flow (i.e. motorways) operations to understand outputs of flow breakdown, productivity and route optimisation. VicRoads and Austroads publications explore these relationships in detail in the following documentations:

- Motorway Design Volume Guide: Design volumes for increased safety, reliability and productivity on motorways (VicRoads, December 2017)
- Managed Motorway Framework: Network Optimisation & Operations Rationale and Technical Requirements (VicRoads, March 2017)
- Guide to Smart Motorways (Austroads, December 2016)

The data can be obtained from similar devices that is used for urban traffic counts e.g. magnets amongst other collection methods. Generally, this motorway data and can output this information in one minute intervals and are often placed at intervals of approximately 500m distances along a motorway. The datasets are held through the STREAMS system that forms the platform for VicRoads motorway management system. Refer to Figure 23 for SVO examples sourced from VicRoads.

Ramp Signals

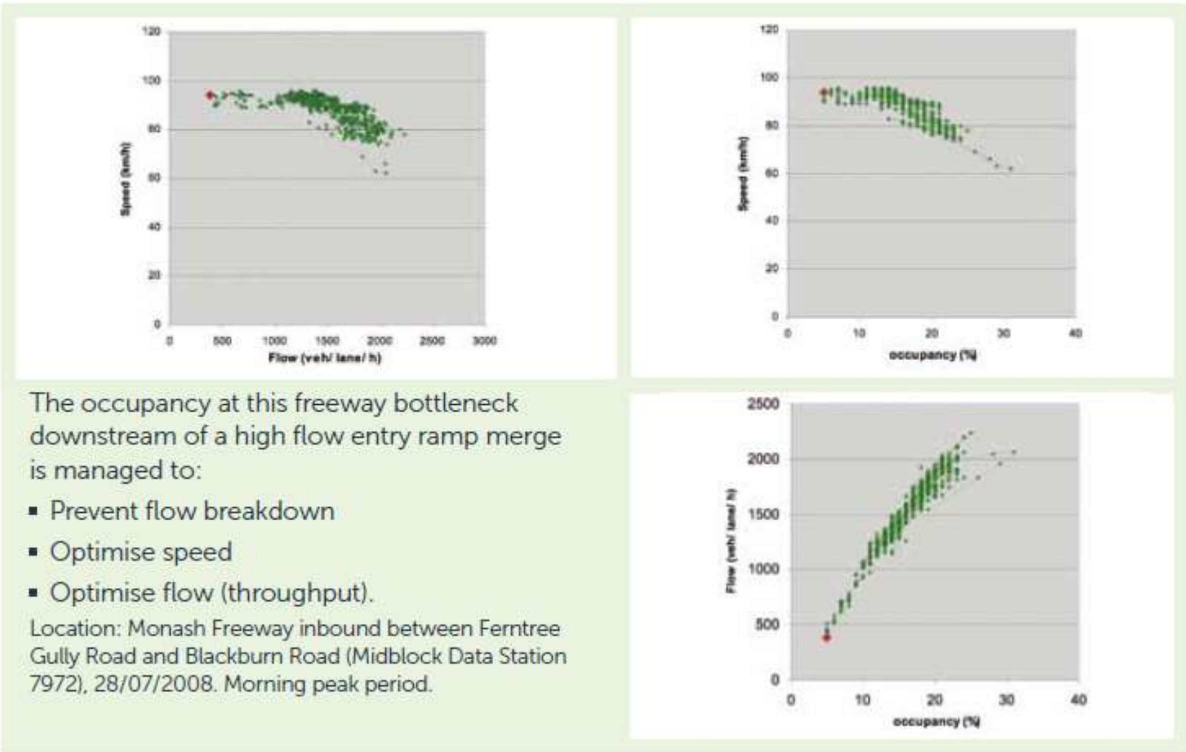
Ramp signal operation can be obtained through STREAMS system that forms the platform for VicRoads motorway management system. Ramp metering is applied to better manage the flow and operation of the motorway main carriageway by limiting conditions for entering this space at the expense of the arterial road system. In particular the ramp signals are part of a coordinated motorway system that uses a dynamic algorithm to make a combined decision based on SVO data combined from a number of entry ramps and mainline settings both upstream and downstream. This operation is able to regulate the entry of traffic from a number of ramps to address the overall motorway objectives and to balance flows between ramps. The data provides information on how the signals operated during the surveyed period i.e. cycle time. The modeller needs to ensure that they comprehend the dynamic nature of the ramp signal operation. In this context the operations of the motorway ramps may not be a function of the localised conditions but in consequence of the downstream considerations that are a declared priority.

VicRoads explores some of these relationships in detail in the following documentation:

- Managed Freeways: Freeway Ramp Signals Handbook (VicRoads, July 2013)

However note that typically the algorithms to operate the controller systems may not be published within this document, due to matters of Intellectual Property. For this reason it is encouraged to chat with the appropriate VicRoads personnel about ramp operations prior to conducting an investigation.

Figure 23: Example of SVO relationships (Fundamental Diagrams) at a Bottleneck Managed with Ramp Metering



5.2.10. Public Transport

The impact of public transport is critical in simulation modelling. This should explore how the public transport occupies road space, effect signal operation and interact with off-road infrastructure and other modes of transportation.

Routes and Schedules

Public transport service routes and schedules are available on Public Transport Victoria (PTV) website - https://www.ptv.vic.gov.au/. An example of this is provided in Figure 24 that outlines mapped routes departure times at stops and schematic display of the service. In addition, PTV provide a consolidated Melbourne local area maps that shows all public transport in the area. The operation of the public transport service may vary to the routes and schedules developed by PTV due to site specific matters of congestion and signal operations. As such schedules should come from observations not just from planned intents. GPS probe data maybe suitable for such as pursuit. Other services such as school buses or other non-service related vehicles need to be considered.

Stops

The key public transport stops to be considered are bus, tram and train stops. All stops have different characteristics and stops can also vary significantly within each subgroup i.e. bus stop at kerb side operates different to a bus terminal at a train station. Site observations and existing scaled plans should confirm the layout of the stops especially an understanding on the length of stop to understand how many services can be accommodated any given time i.e. bus storage capacity, tram platform capacity. Some stops can be timer stops (layovers) to regulate headways between each service, rest stops or driver changeovers. Such stops should be specified during data collection and considered when determining dwell times.

Dwell Times

Dwell time are an important measure for journey times and public transport priority at signals. Survey on dwell times for different stops and activity may be required for broader networks, whilst specific public transport modelling may require detailed dwell times for each service and stop. Dwell times can also be calculated by the software package but it will require distinct parameters about the vehicle type including the occupancy and the commuter boarding and alighting at each stop location. Public transport bunching may affect the dwell time operation of a service route.

Data collection may also need to focus on the demand at each stop that cannot board the first available service, and accompanying dwell times as a result.

When a simplified method is applied in simulation modelling that does not explore specific service utilisation, VicRoads preference is to understand the range of dwell times and present this as a distribution of time spent at the stop, rather than as a mean figure.

Some further adaptive solutions (different to dwell times) may be required to present operational matters as the vehicle dwell conditions change through a peak period e.g. loading for school services.

Figure 24: PTV Routes and Schedule Example

(Source: PTV - https://www.ptv.vic.gov.au/)

Rolling Stock

Vehicle size characteristic such as length and capacity are required to comprehend how the public transport service functions at various stops and moves around the network. i.e. articulated buses will occupy more lanes for turning movements, the longer E-class trams will mean that vehicles are required to stop further away from the stop location for passengers and have to increase effort in overtaking whilst the dwell time for the service maybe higher to cater for passenger movements.

5.2.11. Level Crossings

Level crossings have a distinct and systematic operation that may be required to be modelled. As such, an extensive amount of data collection is required as the impact on the road network can sometimes be significant i.e. traffic queues impacting motorway exit ramps and motorway operation. The extent of data collection rests on the objectives for all stakeholders. If train operations are to be modified with the level crossing remaining (i.e. new schedule) as part of option testing then the modelling approach needs to consider all the parameters that effect the train arrival, train departure and hence boom gate operation. In all cases development of train operations are required to be explored to better comprehend how the extended signal plans currently feed off the crossing point.

5.2.12. Car Sharing

Car sharing services are becoming more frequent and though they may display similar characteristics to taxis or to public transport, the route choice and movements maybe more distinct and varied to general commuters. Such information needs to be explored further and its implication on the study area, especially if it is a network wide model.

Car sharing may involve chains of vehicle trips to be developed within a network. There may also be specific road spaces dedicated to such facilities (both kerbside and on road).

5.2.13. Taxis

Data collection for taxis is dependent on the study area and the objective of the project. Taxis may have different access provisions, kerbside activity and behaviour, as well as responses to opportunities near designated roads i.e. motorway toll roads. This may impact on route choice decisions that are different to general traffic considerations.

Collection can be undertaken through manual video counts which will also capture illegal turns. Data from applications may become a more significant resource. Additionally a sample of journeys may be provided over time through the open data portal, albeit this is yet to be developed. The City of Melbourne holds material on taxi ranks available within the council bounds.

5.2.14. Parking

Parking can have a significant impact on the study area. Parking can be either on-road or off-road and the various operation of parking can reduce lane capacities. When undertaking data collection for parking consider the following;

- Volume counts using manual or automatic methods;
- Parking bay utilisation, dwell times and turnover including occupancy at the commencement of the simulation;
- Queue measurement to understand any queue flow on affect to upstream traffic especially on the adjacent road;
- Driver behaviour around parking bays and facilities;
- Parking signs and the impact on dwell times and operation; and
- Consider the implication of off road parking being full on driver behaviour.

Some simulation modelling requires a form of kerbside operations to be undertaken to address the dwell times as passengers board and alight for periods of time. This may be conditions simulated at an airport, at a transit station, taxi rank or even outside a school. In all cases VicRoads expect that the material collected to explore such kerbside behaviour be formed into a cumulative distribution curve rather than just exploration of the average and standard deviation (as a normally distributed curve). This is not simply to do with a misconstrued belief in the shape of the behaviour, but a means to simulate the impacts when these outliers are applied within the network model.

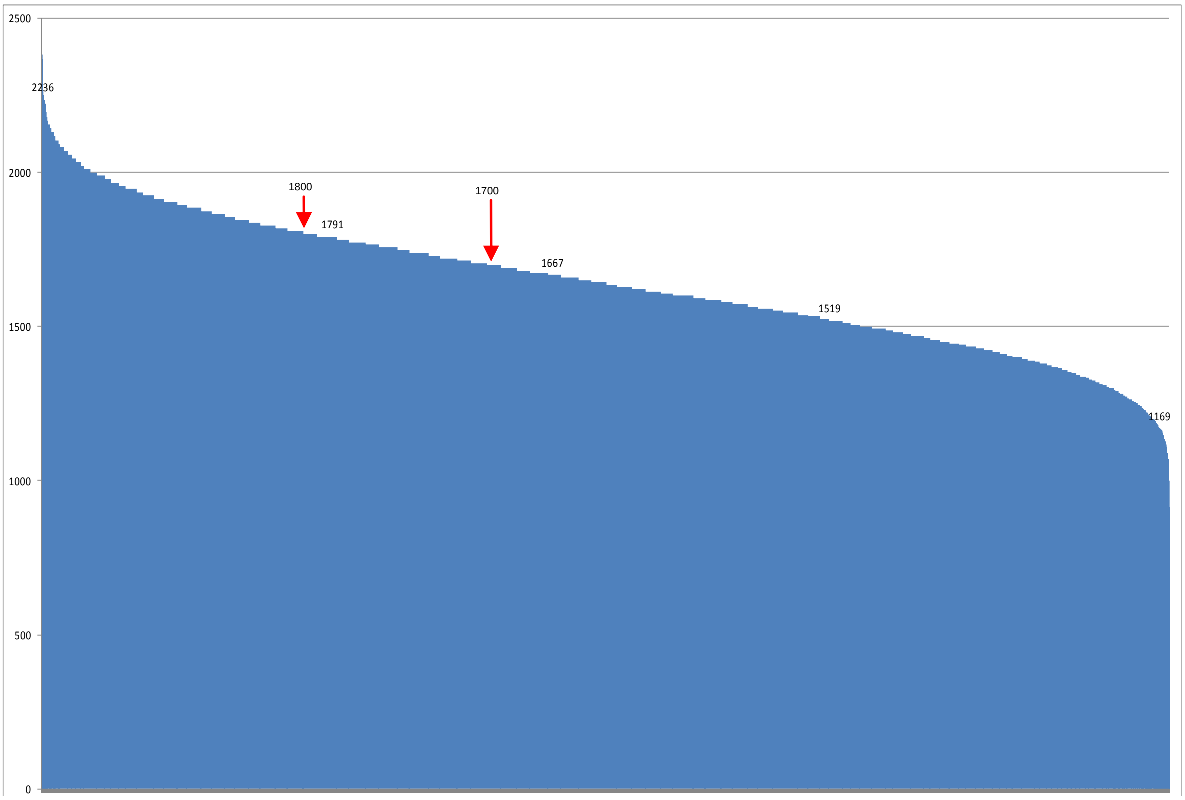
5.2.15. Saturation Flow

The saturation flow rate may be defined as the maximum rate of flow that can pass through a given traffic movement (or intersection approach) under the prevailing roadway and traffic conditions, usually expressed in vehicles per hour (vehicles per hour), after taking into consideration the traffic composition and geometric constraints of turning movements. It is typically one of the more understated elements of simulation modelling that can have a more significant impact on traffic flow and design considerations. Saturation flow is variable and may be different for each lane due to lane utilisation and gap acceptance parameters. While this is commonly applied at signalised intersections, a turn and lane specific saturation flow will become more obvious and critical on locations such as roundabouts.

The Maximum Flow parameter that sits within SCATS can provide insight into the higher-level saturation flow values. This measure provides uses the detector occupancy and empirical green time splits during each cycle to determine the equivalent hourly throughput of traffic potentially achieved. This figure is calculated for each cycle and can be associated with the smallest headway of two vehicles over the course of the day observed. That is, a maximum flow figure of 1,800 gives direction that at the best of times a headway of 2.0 seconds was recorded. It is important to note that saturation flow is constantly changing as detector occupancy is recalculated by the SCATS system. However, the significance of the maximum flow figure represents the highest achieved throughput of the day and defines a metric that should not be exceeded by traffic modellers or a saturation flow designation.

Figure 25 represents conditions of a single day, albeit a maximum determined for each lane recorded across metropolitan Melbourne. The figure identifies the hourly equivalent throughput based on the closest headway of two vehicles for each location (approximately 2,500 signalised intersections). These values are obtained from May 2015 and indicates a spread of SCATS maximum flow calculations (higher end values) of between 1,169 and 2,236 vehicles per hour with an average circa 1,600-1,700 vehicles per hour.

Figure 25: Empirical Maximum Flow metrics across metropolitan Melbourne (May 2015)



The maximum flow figure is limited in information relating to when the calculation was actually recorded with anecdotal evidence suggesting that SCATS figures (covering the 24 hours of the previous day) are recorded during off-peak or interpeak periods. That is the high end figures are typically lower in the peak periods. VicRoads suggest that in the absence of provided metrics, a starting point for SCATS max flow is 1,700 vehicles per.

The SCATS Maximum Flow (MF) figure can be found within the LX files recorded for each region on each day. All MF figures for the day are listed within the one SCATS regional file for each lane designated to observe. Note that this data is now available for access and download through the Victorian open Data portal and are provided by lane for each day. As the figures recorded represent the high end value, which typically would be found outside the peak periods, an estimated reduction from this flow between 5-10% is suggested to present for peak period conditions. The scale of reduction may be a function of road hierarchy or proximity from a major centre or National Employment and Innovation Cluster. In this way sites near to locations with a regular disruption (level crossings) may need to apply a larger discount from the maximum flow figure.

The data in Table 11 identifies empirical measures from maximum flow figures obtained through the SCATS system. These values have been rounded for simplicity and identify a declining measure of saturation flow as the road hierarchy changes. Motorways have not been included due to the absence of intersections along the carriageway. The data enables benchmarking of likely operating conditions across Melbourne for a higher end saturation flow.

Further empirical figures exploring the 85^{th} and 15^{th} percentile measures of maximum flow (high end saturation flow) by location and road hierarchy can be found within Appendix B

.

Table 11: Empirical Maximum Flow Figures (Median, Scaled Down[4], Rounded) from Detectors

	Highway	Primary	Secondary	Collector	Local
Banyule	1700	1600	1575	1400	1350
Bayside	1775	1575	1525	1425	1275
Boroondara	----	1500	1525	1475	1375
Brimbank	1675	1575	1575	1500	1450
Cardinia	1675	1625	1525	1475	1425
Casey	1575	1550	1575	1400	1325
Darebin	1650	1525	1550	1500	1425
Frankston	1400	1550	1425	1400	1275
Glen Eira	1700	1475	1450	1375	1125
Greater Dandenong	1625	1600	1525	1375	1350
Hobsons Bay	1500	1500	1475	1350	1350
Hume	1675	1650	1575	1500	1425
Kingston	1725	1625	1625	1425	1350
Knox	1700	1675	1550	1575	1425
Manningham	1625	1650	1600	1500	1325
Maribyrnong	1625	1525	1450	1475	1375
Maroondah	1800	1700	1575	1625	1425
Melbourne	1550	1500	1425	1325	1250
Melton	1625	1525	1575	1525	1325
Monash	1750	1650	1575	1450	1350
Moonee Valley	1950	1550	1575	1450	1300
Moreland	1675	1525	1450	1400	1350
Mornington Peninsula	1625	1350	1400	1375	1225
Nillumbik	----	1575	1675	1425	1325
Port Phillip	1650	1550	1475	1325	1575
Stonnington	1700	1475	1425	1425	1350
Whitehorse	1725	1700	1600	1525	1375
Whittlesea	----	1650	1550	1500	1425
Wyndham	1775	1600	1575	1500	1400
Yarra	1575	1450	1475	1325	1275
Yarra Ranges	1625	1575	1600	1350	1425

[4]Proportion of 5% was removed from the Maximum Flow figure prior to rounding and publication

5.3. Seasonality

5.3.1. Overview

Seasonality or season variation is a common consideration when evaluating traffic flow and patterns. The matter of seasonality is important as the effort for investment can often be based on a limited dataset that may not appropriately reflect conditions needed to annualise benefits. This may be data collection for a day or week as the basis of showcasing the return on investment. As such the quality of the data collected will always need to show context of the scale of regularity in the network.

The problem applied by modellers exists where a baseline for simulation performance uses a single day or week of surveys before progressing this to a future year operation. This matter fails to put the limited data collection into the appropriate context before extracting an economic evaluation of benefits with the implementation of the project. Significant investment values are supported by little to no data which is often not appropriately held within the conditions experienced through the year. To account for this, the following considerations need to be utilised:

- Collect data on a seasonally appropriate time of year (historically difficult)
- Develop analysis within the scope to identify the significance of the survey data within the experiences of the previous twelve months or annual year (e.g. entire year of 2018)

The preferred collection period for undertaking data collection are in the months of May or November as these cases best represent the times of year with greater chance of aligning to a day of regular operational conditions. However in all cases the traffic conditions and survey data obtained for the study area needs to be set into the appropriate context of conditions throughout the year. This will involve a review of data to determine matters of seasonality.

Seasonality occurs because trip making patterns change throughout the year due to factors including but not limited to the effects of school holidays, public holidays as well as factors of professional annual leave. Note that in addition to this, mere factors of cumulative congestion across the network can impacts the arrivals of journeys into a study area. These factors not only effect geographic locations (access to beaches in summer, access to ski fields in winter, access to educational sites) but have other cumulative impacts on trip making patterns (and hence volumes) throughout the year.

5.3.2. Accounting for Seasonality

An adjustment for seasonality is a means of understanding design requirements in the context of the varying demand effect in the study area for a more regular delivery of operations. The data provided in Table 12 showcases examples of the seasonal variation that occurs throughout the year. This data is sourced from locations shown in Figure 26 and represents a handful of locations to indicate seasonality across Melbourne.

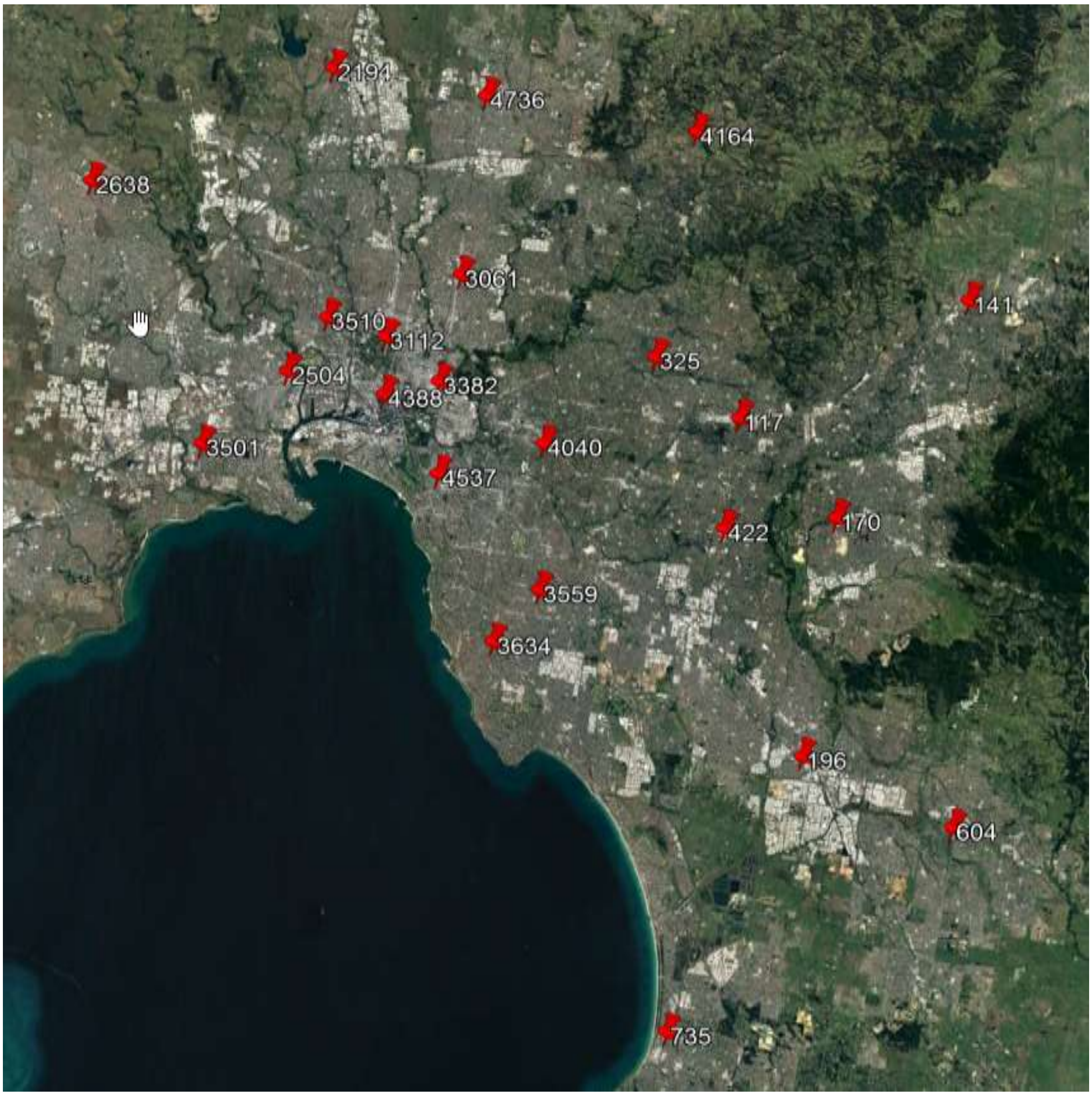
Seasonality remains an important aspect for consideration in design and operational planning, the primary purpose of simulation modelling investigations. While demand models tend to apply a static set of volumes for design matters, in reality this is not consistent in volume or operations on a daily basis. The demand figures fluctuate due to a number of matters including road operations, events, weather, personal matters, illness and annual leave. In this way there is a difference in considerations between the regular operations provided from the state's strategic demand model and the design standards and requirements.

There are times when seasonally adjusted volume is less suitable e.g. when exploring for retail centres whereby a metric greater than the 30th busiest hour of the year is appropriate for design matters. These dates may be early to mid-December dates prior to the Christmas retail period.

The example within Table 12 shows the seasonal variation (how counts change over a 12-month period) for sites depicted in Figure 26 above. However, in line with this land use specific pursuit, VicRoads generally discourages data collection in the summer months. December is a period of time that is identified to two polarised experiences as follows:

- First two weeks involve little annual leave taken by residents with higher volumes on the roads and greater congestion around shopping centres; followed by:
- Two Weeks of significant leave and school holidays, irregular special events, reduced volumes on roads during typical peak hours and highest annual volumes on the regional roads throughout the state.

Figure 26: Site Location for Seasonality Adjustment (Site numbers shown)



The summer months (December, January and February) are periods with which data is not encouraged for collection. These months are also identified with traditionally lower volumes than the remainder of the year. The removal of the summer months from this analysis as shown in

Table 13 provides more direction on regularity during the remaining nine months. While Table 12 explores a form of adjustment factor, VicRoads encourages adjustments using a structure based on

Table 13 so that data collected is benchmarked closer to regular operations and removes outliners from the comparisons.

Other seasonal variation tables for different day and time of day are available in Appendix A.

Note that VicRoads does not require traffic models to refine the count mechanisms based on the data held within

Table 13. While this data is accurate from collected materials, the measures provided cover expectations rather than prescription solutions. That is, teams are welcome to explore alternate datasets to explore seasonality within their investigation. However this chapter provides direction on tasks to conduct and potential matters to consider when collecting information.

Note as well that a comparison of survey volumes against an Annual Average Daily Traffic (AADT) volume will include the summer months within the analysis. This may be appropriate for exploring the economic evaluation of the campaign but will not assist to deliver measures for regular operations within the network investigated (A standard to VITM and future year VITM estimates). As such there may be surveys conducted that exceed the AADT volumes but still require an adjustment upwards to account for operational deliveries.

Should the survey dates be shown to undercount for the conditions of the 100th busiest hour (a metric for more regular operations as presented within a strategic travel demand model), it is expected that the model would be calibrated and validated to specific requirements in line with the evidence at hand (See Chapter 6). This model should then adjusted to account for the shortcomings to become a seasonally adjusted model suitable for design purposes than can then be brought forward to explore the experiences of a different time horizon.

A complementing evaluation for an investigation is a volume rank plot that covers the calendar year. The volume plotted can be derived on SCATS counts from a nearby controller and can be sourced from VicRoads through the Open Data Portal. If required SCATS counts for major approaches can be evaluated to explore the significance of the survey day to the seasonal range. The plot should showcase the data in a ranking from lowest volume to highest volume over the year (as per Figure 27) and highlight the 30th busiest day and the survey day volume to identify the gap at hand. It may be appropriate to only consider the movements on the major approaches to ensure some consistency in this analysis.

Figure 27: Total volume ranking by day of the year to benchmark 30th busiest & surveyed day

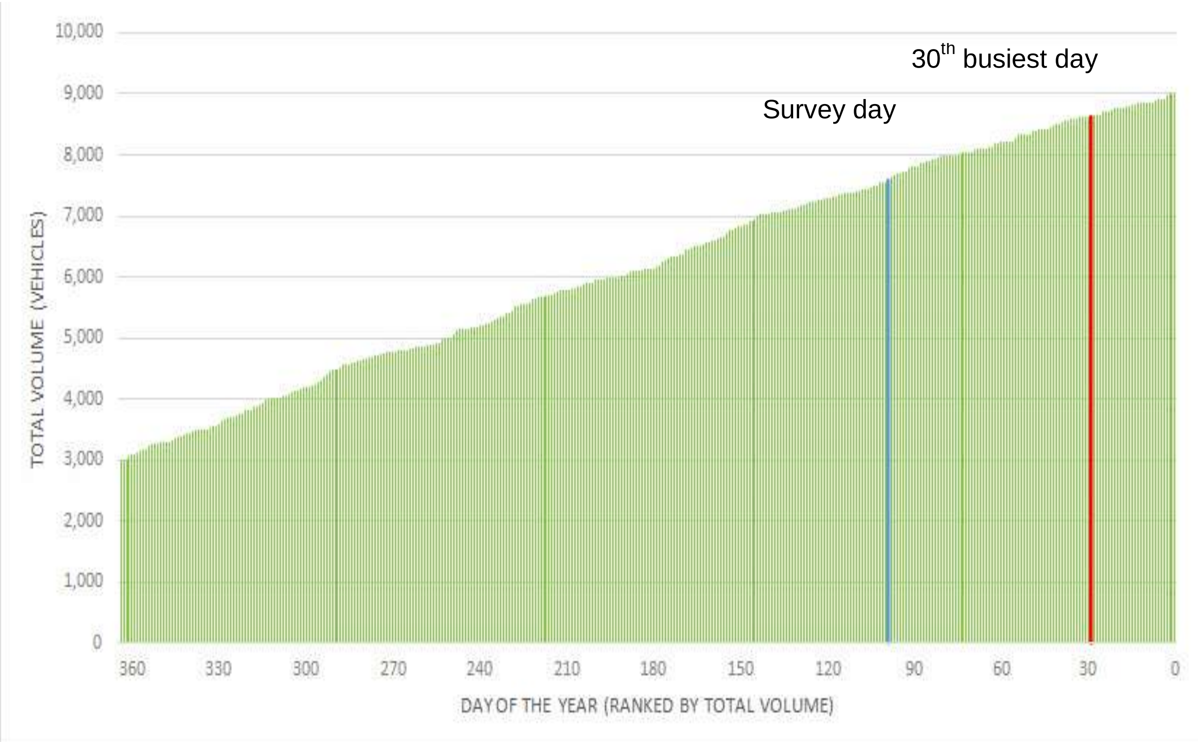


Table 12: Seasonal Variation of Throughput over the Year (AADT)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	0.74	0.80	1.06	1.05	1.09	1.06	1.04	1.06	0.97	1.02	1.07	1.03
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	0.76	0.83	1.04	1.04	1.09	1.04	1.04	1.01	1.01	1.05	1.06	1.04
170	Burwood Hwy	Stud Rd	Knox	063, J11	0.70	0.87	1.08	1.07	1.06	1.04	1.07	1.10	0.82	1.07	1.08	1.04
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.73	0.86	1.08	1.04	1.07	1.00	1.01	1.08	1.04	1.07	1.06	0.96
325	Doncaster Rd	Tram Rd	Manningham	047, D01	0.62	0.88	1.07	1.03	1.07	1.03	1.04	1.06	1.01	1.06	1.07	1.05
422	Springvale Rd	High Street Rd	Monash	071, D01	0.86	1.04	1.02	1.06	1.01	1.06	1.12	1.01	1.10	1.12	0.97	1.00
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.84	1.03	1.02	1.08	1.02	1.05	1.10	1.02	1.06	1.08	1.01	1.00
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.73	0.86	1.02	1.04	1.04	1.04	0.99	1.09	1.06	1.06	1.05	1.03
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	0.71	0.83	1.04	1.03	1.07	1.00	1.01	1.08	1.03	1.09	1.08	1.02
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.73	0.83	1.02	1.03	1.05	1.01	1.02	1.09	1.06	1.09	1.07	0.99
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.73	0.84	1.02	1.04	1.07	0.98	0.99	1.07	1.03	1.09	1.09	1.04
3061	Bell St	Plenty Rd	Darebin	030, G01	0.74	0.85	1.05	1.04	1.04	1.01	1.05	1.06	1.03	1.06	1.06	1.00
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	0.68	0.86	1.07	1.05	1.08	1.01	1.03	1.08	1.05	1.07	1.05	0.94
3382	Hoddle St	Johnston St	Yarra	044, D04	0.75	0.83	1.04	1.07	1.06	1.00	1.02	1.06	1.03	1.08	1.11	0.95
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.75	0.84	1.03	1.02	1.04	0.98	1.05	1.09	1.02	1.05	1.09	1.04
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	0.38	0.89	1.13	1.11	1.12	1.10	1.15	1.12	1.03	1.01	0.99	0.98
3559	North Rd	Koornang Rd	Glen Eira	068, H09	0.60	0.85	1.07	1.00	1.07	1.02	1.06	1.09	1.04	1.03	1.12	1.06
3634	South Rd	Bluff Rd	Bayside	077, B04	0.75	0.81	1.07	1.05	1.09	1.00	1.02	1.10	1.01	1.03	1.04	1.01
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.68	0.82	1.00	0.96	1.03	0.97	1.10	1.19	1.05	1.12	1.06	1.01
4164	Main St	Collins St	Nillumbik	011, K05	0.70	0.87	1.06	1.02	1.07	0.98	1.07	1.11	1.02	1.04	1.06	1.00
4388	Elizabeth St	Victoria St	Melbourne	043, G06	0.75	0.85	1.06	1.07	1.06	1.01	1.09	1.11	1.02	1.01	1.03	0.94
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.75	0.86	0.97	1.01	1.04	1.01	1.06	1.11	1.06	1.08	1.08	0.98
4736	High St	Epping Plaza	Whittlesea	182, A12	0.74	0.85	1.06	1.01	0.98	1.00	1.08	1.11	1.05	1.04	1.02	1.05

Table 13: Seasonal Variation of Throughput over the Non-Summer Months (ADT)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)								
					Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	1.01	1.00	1.04	1.02	1.00	1.02	0.93	0.97	1.02
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	1.00	0.99	1.04	1.00	1.00	0.97	0.97	1.00	1.02
170	Burwood Hwy	Stud Rd	Knox	063, J11	1.03	1.02	1.02	1.00	1.03	1.05	0.78	1.03	1.03
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	1.03	0.99	1.02	0.95	0.96	1.03	0.99	1.02	1.01
325	Doncaster Rd	Tram Rd	Manningham	047, D01	1.02	0.98	1.02	0.98	0.99	1.01	0.96	1.01	1.02
422	Springvale Rd	High Street Rd	Monash	071, D01	0.98	0.96	1.00	0.95	1.00	1.06	0.96	1.04	1.05
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.98	0.97	1.03	0.97	1.00	1.04	0.97	1.01	1.03
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.98	1.00	1.00	0.99	0.95	1.04	1.02	1.01	1.01
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	1.00	0.99	1.02	0.96	0.97	1.03	0.98	1.04	1.03
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.98	0.98	1.00	0.96	0.98	1.04	1.01	1.04	1.02
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.98	1.00	1.03	0.94	0.95	1.03	0.99	1.04	1.05
3061	Bell St	Plenty Rd	Darebin	030, G01	1.01	1.00	0.99	0.97	1.00	1.02	0.99	1.01	1.02
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	1.02	0.99	1.02	0.96	0.98	1.03	1.00	1.02	0.99
3382	Hoddle St	Johnston St	Yarra	044, D04	0.99	1.02	1.01	0.95	0.97	1.00	0.98	1.02	1.05
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.99	0.98	1.00	0.94	1.01	1.05	0.98	1.01	1.05
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	1.04	1.03	1.03	1.01	1.06	1.03	0.95	0.93	0.91
3559	North Rd	Koornang Rd	Glen Eira	068, H09	1.02	0.95	1.01	0.97	1.00	1.03	0.98	0.98	1.06
3634	South Rd	Bluff Rd	Bayside	077, B04	1.03	1.00	1.05	0.95	0.98	1.05	0.97	0.98	1.00
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.95	0.92	0.98	0.92	1.05	1.13	1.00	1.06	1.00
4164	Main St	Collins St	Nillumbik	011, K05	1.01	0.98	1.02	0.94	1.02	1.06	0.97	0.99	1.02
4388	Elizabeth St	Victoria St	Melbourne	043, G06	1.01	1.01	1.01	0.96	1.04	1.06	0.97	0.96	0.98
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.93	0.96	1.00	0.96	1.01	1.06	1.01	1.03	1.03
4736	High St	Epping Plaza	Whittlesea	182, A12	1.02	0.97	0.94	0.96	1.04	1.06	1.01	1.00	0.98

The plot can utilise SCATS counts for the day of collection and identify the gap (percentage difference) between the sample and the seasonally adjusted day. Also worth exploring is the design standard which is the 30th busiest hour of the year. This is an important element when developing options for future year considerations as the 30th busiest hour of the year is a benchmark applied for delivery requirements. The significance and purpose of the investigation needs to be considered, but generally the 30th busiest day of the year is considered to provide a balance between the investment in the deliverables to the associated costs.

The 30th busiest hour of the year measure is also specific to design matters whilst the seasonally adjusted measure is a more viable tool for planning matters. The volumes of this benchmark reflect the 90th percentile busiest day in the year. Note that this metric might utilised as the busiest hour or busiest peak period in the 30th busiest day or simply defined as the 30th busiest hour of the year. There is no requirement that the 30th busiest hour for the AM conditions are from the same day for the 30th busiest hour in the PM conditions. Care should be made to evaluate such metrics within the correct context. There are arguments that the appropriate benchmarks should be higher (network resilience) and lower (economic value) but currently directions are expectations are set to design for the 30th busiest hour of the year.

An example of this expansion can be viewed within Table 14 to outline the appropriate expansion factors to be applied. A recent project conducted by VicRoads involved a survey of traffic counts without immediate consideration of seasonality. When analysis was conducted for this adjustment factor three distinctly different figures were available. Data identified a much higher daily volume than that of the survey timeframe, but a very similar AM peak hour volume to that of the survey. The difference lay in the expansion of the AM peak period, which matched the three hour evaluation period within the modelling. An expansion factor for the single hour would not have been appropriate, as neither would the daily figure (despite being larger). The growth for the period of analysis (peak period) was the correct measure to consider for the pursuit at hand. This may imply that modelling teams should explore a range of time intervals to consider the expansion period which would account for seasonality and deliver for an appropriate design solution.

Table 14: Exploratory Expansion Factors

Expansion Interval	Gap from Survey
30th busiest daily total to Survey daily total	15%
30th busiest AM peak period to Survey AM peak period	9%
30th busiest AM peak hour to Survey AM peak hour	1%

In addition, Figure 28 explorers the difference between regular operations such as strategic modelling versus design requirements such as the 30th busiest day. The graph demonstrates how these days compare to the busiest day for 25 selected sites across Melbourne. The comparison is based on SCATS throughput volume over a year excluding right turns and minor arms. For example, the 30th busiest day has throughput that is approximately 90-95% of the busiest day for the considered sites which is a benchmark commonly used for design purposes. This may then be applied to a future year horizon, as outlined within Figure 29.

It is important to note that the VITM model aims to deliver on traffic volumes for a regular day which may be interpreted as a seasonally adjusted volume or approximately the 100th busiest day of the year. In this manner the design volumes for future years for a new (or existing) infrastructure program is not an immediate quotation of the VITM forecast but is actually an expansion on top of this value. Again where not defined, the fallback position is to increase the demand estimate by 5% to account for the design volumes.

Figure 28: SCATS throughput volumes: Comparison over a year against busiest day (25 sites)

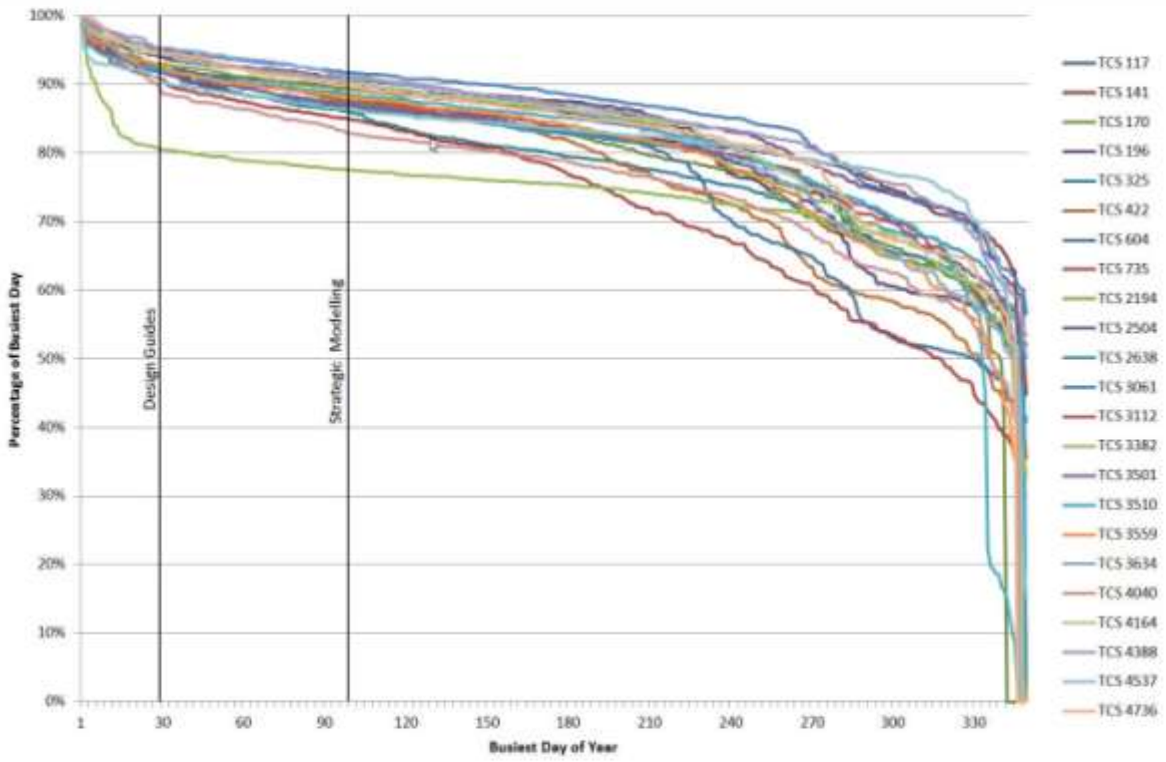
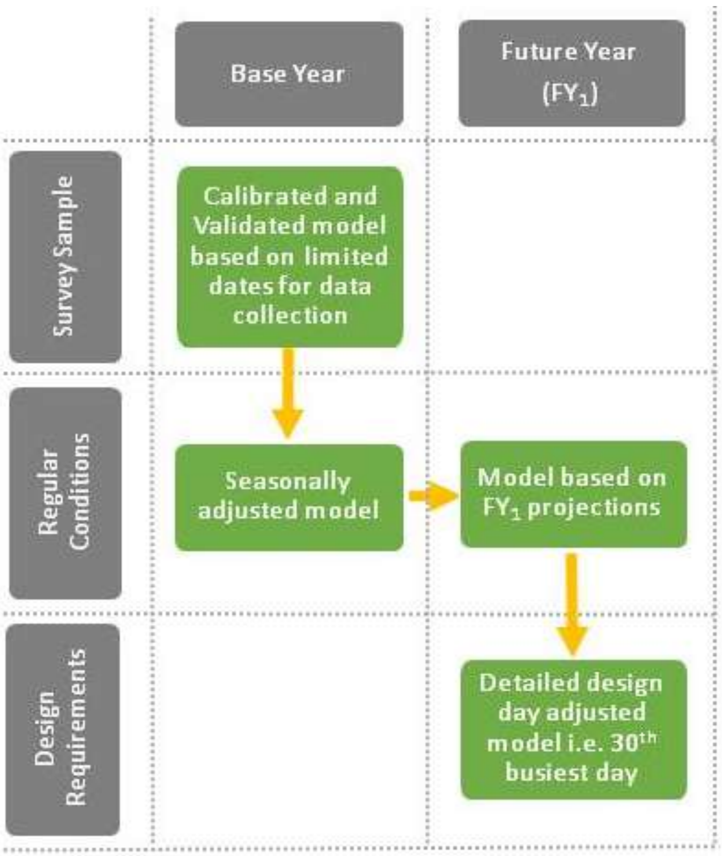


Figure 29: Progression from Survey to Design through Seasonality



5.4. Growth Factors

Growth factors may be considered from historic trends and strategic modelling results. For historic trends past and current volume and classified counts can assist in determining the increase (or decrease) in various transport modes such as various vehicle types, pedestrians and cyclists. However, this needs to be held within context of the spare capacity and not developed out of context.

If strategic modelling outputs are utilised to determine growth factors then the validation should have been conducted over multiple links within the simulation study area to a suitable scale of accuracy. The development of the strategic model needs to sit within the context of the investigation purpose and have transparency on the assumptions adopted. Strategic modelling can provide growth factors for both light vehicles and heavy vehicles. In most growth factor considerations, the land uses changes in and around the area need to be considered as the growth may not be linear but rather a step growth and not consistent between zones. The land use impacts should consider schools, universities, hospitals, airports, new residential, industrial developments etc that may all change at a different rate.

VicRoads preference within this space is to develop suitable capacity constrained models that consider route choice and demand considerations from the base model. Such measures would then be updated for future year land use estimates and infrastructure planning. This approach would allow for consideration of the constraints and route choice factors across a broader area.

5.5. Other Contributing Factors

The data collection process needs to be held into the appropriate context for which the data is being applied. As many surveys are collected ad hoc for distinct investigations, it is important that the values of survey volumes are not misrepresented for application.

In this way it may be that a major construction project could be underway in a nearby location (upstream, downstream, parallel routes etc) which themselves may have impacted on the survey volumes. This is a common observation for more significant projects in the inner city areas, where multiple routes can receive variations in traffic volumes. Under such conditions the empirical data may need to be adjusted or “normalised” to better represent the steady state condition. This can be achieved through a review of historical measures such as SCATS counts. While debate may rage about the detection accuracy, the historical trends may identify how some temporary works have generated a new set of regular circumstances for drivers within the road network.

The advantage of this approach is to better determine the achievable benefits from growth once the “temporary” disruption is settled and the traffic conditions return to a similar measure as prior observed.

5.6. Developing data collection methods

5.6.1. Drones

Drones in the context of data collection are unmanned aircrafts, often referred to as flying robots which can be remotely controlled or can fly on autopilot mode through a software controlled flight plan. More formal names include unmanned aerial vehicles (UAVs) or unmanned aircraft systems. These devices can be equipped with high-resolution cameras, high-capacity data links and automated navigation systems with flight times of several hours.

Drones have been used in previous data collection assignments for providing aerial video of the surveyed period. The videos have been successfully used to explore queue lengths, traffic counts and identify illegal or unorthodox movements that would generally be hard to spot on ground mounted videos. The videos also provide more depth in understanding driver behaviour conditions by evaluating how drivers merge, change lanes, keep within lanes and utilise lanes at the approach. This resource can also be used to assist in exploring synchronous matters including signal coordination and queuing.

Collectively this information can be used to explore multiple facets of the landscape simultaneously to capture queues, speeds, congestion, turn experiences and pedestrian impacts as well as more.

5.6.2. GPS Probes

GPS probes have been discussed as a potential source for data collection in areas of journey time, origin-destination, and queues and used to either calibrate or validate the model. The dataset provides useful insight but needs to be used based on a quality which considers sample size and data collection techniques.

The footage available for collection from drones includes metrics of journey speeds and turning volumes, that can be acquired quickly and effectively. This includes empirical metrics by turn as evident in the footage available in Figure 30 which explores the range of speeds for individual approaches and turns at an intersection, as well as queue lengths.

Figure 30: Drone Surveillance Analysis

Whilst penetration into the market is not an issue for most commercial suppliers, the ability to reproduce this data is an important element. That is, a penetration of 10% may miss obtaining experiences of 90% of the fleet, but will showcase the ease of movement and points of congestion across the area of investigation from a more than suitable scale of traffic hits.

5.7. Study area types and degree of data collection

As a project develops as per the project definition, the study area may dictate the level of data collection that would be required. These study areas are briefly discussed below.

To appreciate the level of data collection required for each broad study area type refer to Table 15 that follows the introduction to the studies.

5.7.1. Intersection studies

Intersection studies are typically limited to one location within a study. Such an approach may work for isolated intersections. These studies are more focused on the operation of the specific intersection due to the level of complexity with operation and /or driver behaviour. When more than one interaction is included, pursuits should explore coordination of the controller with the same subsystem.

It is important to note that due to the elements involved in the development, application of a simulation model for an isolated intersection is not encouraged. In most cases the model will need to consider both the upstream and downstream considerations which directly impact on the performance of the location in question. Some exception here may be locations such as isolated level crossings within regions, whereby there may be no other factors for consideration within 1km from the site of investigation.

5.7.2. Corridor studies

Corridor studies include a length of road that is usually an important strategic movement corridor (e.g. access to National Employment and Innovation Centres or to Major Activity Centres, has a defined route number) and provides access to other key routes along the network i.e. key tourist destinations, motorways etc. These studies are usually given propriety movement and as such are highly likely to have well developed signal coordination and key public transport routes.

It is important to note that corridor investigations will require consideration of the upstream and downstream locations in the perpendicular movements. This will be an important element to correctly explore the delay and intersection performances on the corridor being reviewed. The simulation models should deliver on the elements required to appropriately deliver the correct performance matters within the network, which typically implies inclusion of all controller factors (upstream signals, pedestrian crossings) within 500m from the venue.

5.7.3. Town centre studies

Town centre studies can vary in size depending on whether it has a rural or urban perspective. These studies may include route choice due to the availability of various movement corridors and other complexity such as both on street and off street parking. Off street parking may explore multiple access points to the one destination.

5.7.4. Local Government Area (LGA) studies

Local Government Area studies can vary in size. These studies may include route choice due to the availability of various movement corridors and may potentially have major through movements.

5.7.5. Motorway studies

Motorway studies consider the high speed unimpeded movement corridors that have unique operation considerations (i.e. ramp metering) and measures (i.e. SVO data). In all cases, motorway studies would include multiple interchanges and consider matters around merging and weaving.

5.8. Quality Limitations

The quality of data collection is an important consideration as it reduces uncertainty in the data collected and provides a means of developing a more robust transport performance analysis. Data quality has been explored for key data types in section 5.2. With any data collection process undertaken, the quality of the data should always be tested and documented in the data collection summary.

If the data quality is considered to be poor, it should always be documented so that a more informed decision-making process is undertaken. This may involve collection of a new sample of data to replace poor datasets obtained previously. This can assist in building the narrative and the approach as part of the calibration and validation process.

Examples that may impact on the quality of survey data include:

- Traffic operation i.e. accident/incident
- Weather
- Sporting event (planned/ unplanned)
- SCATS server down

Table 15: Study area types and degree of data collection comparison

R – Required L – Likely NR – Not required

	Study Type				
Items	Intersection(s)	Corridor	Town Centre	Local Government Area (LGA)	Motorway
Traffic Counts	R	R	R	R	R
Classified Counts	L	L	L	L	R
Journey Times	R	R	R	R	R
Journey Time Criteria	20 runs / 10% sample size of total volume	20 runs / 10% sample size of total volume	20 runs / 10% sample size of total volume	20 runs / 10% sample size of total volume	20 runs / 10% sample size of total volume.
Queues	L	L	L	L	R – for interchanges and motorway ramps
Signals Data	R	R	R	R	L – ramp signal and signalised interchanges
Origin-Destination Data	L	L	R	R	R
Origin-Destination Criteria	Project specific	Project specific	Project specific	Project specific	Project specific
Pedestrian Counts	L	L	R	L	L – for interchanges
Cyclist Counts	L	L	L	L	NR
Public Transport i.e. schedules, stops, dwell time, speed and length	L	L	R	R	L
Motorway Data i.e. speed flow curves	NR	L	L	L	R
Level Crossings	L	L	R	R	L – if ramp interaction near level crossings
Car Sharing	NR	NR	L	L	NR
Taxis	NR – unless specific purpose	L	L	L	L – especially for transit lanes
Parking	L	L	L	L	NR
Saturation flow	L	L	L	L	L
Seasonality	L	L	L	L	L
Growth Factors	L	L	L	L	L

Items	Intersection(s)	Corridor	Town Centre	Local Government Area (LGA)	Motorway
Validation considerations	• Journey time routes for through movements and major turn movements • Queue length • Saturation flow	• Journey time routes that follow the entire length of the corridor and also routes that cross the corridor • Queue length • Saturation flow • Independent O-D route	• Journey time routes that comprehensively cover the study area	• Journey time routes that comprehensively cover the study area	• Journey time routes that follow the entire length of the motorway and also routes that cross the motorway along interchanges • Independent speed flow occupancy plots
Additional build elements	• May need to consider SCATSIM to explore more detailed signal operation • May need to explore more than just the intersection in isolation • Consider arrival pattern and signal coordination	• Consider coverage for just more than key corridor. • Signals on adjacent corridors. • Consider arrival pattern and signal coordination	• Consider dynamic assignment modelling	• Consider dynamic assignment modelling • Consider through traffic on corridors as static paths	• Consider that each part of the motorway behaves differently • May need to apply unique behaviour settings
Coefficient of Variation (COV)	Below 3%	Below 3%	Below 5%	Below 5%	Below 5%
Analysis Period	• Influenced by the peak period spread, typically 2 hours is required	• Influenced by the peak period spread, typically 3-4 hours is required	• Influenced by the peak period spread, typically 2 hours is required	• Influenced by the peak period spread, typically 2 hours is required	• Influenced by the peak period spread, typically 3-4 hours is required

Table 16: Chapter Checklist for Data Collection and Analysis

Topics for Discussion and Reporting	Yes	No	N/A
Has a map of the data collection measures been prepared for presentation?	☐	☐	☐
Have a number of datasets been utilised to present the story of this landscape being investigated?	☐	☐	☐
What forms of datasets have been used to explore this story? How much of this process utilised existing datasets or required the collection of new material?	☐	☐	☐
Has the data been reviewed and cleaned for quality of the network analysis? Can we be sure that the data collection timeframes did not experience unusual congestion or an excess of unplanned incidents that may impact on the surveyed conditions?	☐	☐	☐
Have we determined the consistency of journey times along the study area and should we be exploring these variations with more detail in the model?	☐	☐	☐
What mix of methodologies have been applied to simulate the traffic signal operations within the network model? How well do the traffic signals have a representation to the manner that VicRoads delivers these solutions?	☐	☐	☐
Is the data collected of a fine enough granularity to explore the traffic operations experienced?	☐	☐	☐
Does the data collected tell the story of the traffic movements within the study area? Is it representative of the challenges that drew attention by the transport agencies?	☐	☐	☐
Does the data collection consider enough material to comprehend the movements for alternative modes of travel as well as those for pedestrians?	☐	☐	☐
Has material been collected to explore the public transport operations including details on actual operational arrivals, stop locations and delays at the stop, dwell times, and rolling stock?	☐	☐	☐
Where is on street (and off street) parking provided within this network?	☐	☐	☐
Has saturation flow been considered for the varied locations within the study area?	☐	☐	☐
Has seasonality been accounted for? Have measures been undertaken to adjust from a limited survey or a strategic model to deliver requirements for a detailed design?	☐	☐	☐
Where are the gaps in the data collection process for application of the simulation modelling in this pursuit?	☐	☐	☐

6. Calibration

The purpose of model calibration is to define the parameter values used to present the operational complexities that were observed (and supported by collected data) for the study investigation. While software provides algorithms based on a number of collected experiences, calibration is a process to refine these measures for the operating conditions experienced in the landscape. This allows models to showcase a range of quantified measures that feed into the modelling development.

This process is not just a task to develop an appropriate demand matrix but also about establishing and defining the matters that pertain to journeys and the complexities within the network. Ultimately this involves simulating conditions to reflect the experiences and choices made by drivers as a function of the journey impedances undertaken. This is in part the paths options chosen by drivers, but also of the friction from other drivers including routes, journey speeds, delays and demand estimates experienced that entices drivers to make these movements. Again an emphasis is placed on the requirement that micro-simulation modelling projects explore the micro-complexities that individual drivers face on the road network

The calibration process of simulation models is broken down into three broad areas of:

- Demand calibration;
- Behaviour calibration; and
- Network calibration.

The process is iterative in nature and the effort on this process will vary based on factors such as the complexity of the simulation models and the parameters that require consideration. The quality of this data collection (as discussed section 5) needs to be resolved to ensure that the iterative nature of a calibration process is minimised. It is important to make sure that the simulation model simulates the network conditions in a similar manner (or as close as possible) to the data collected for the investigation.

This calibration section identifies the simulation modelling parameters that need to be further considered and discussed to provide VicRoads with a more robust simulation model. The results of this calibration process should be thoroughly documented within the development section of the report.

6.1. Demand Considerations

6.1.1. Demand Matrices

Demand refers to the person journeys undertaken from any given origin to any given destination within the modelled study area. These trips are generally stored in origin to destination table structures (trip tables) for simulation models. However, this is not limited to a single format.

The source of the demand data can vary; some might be sourced from another model; some from origin-destination survey information. The adjustment to the demand data can be done through various approaches, commonly through a matrix refinement process and manual revisions. However, this can also be conducted with a single or double constrained refinement process (whereby the refinement holds firm the trip end values for both origin and destination totals).

Matrix estimation is usually provided by the simulation modelling software package. Matrix estimation or matrix refinement typically works through a number of points to ensure the quality of delivery with the end solution. These points are not specific but provide guidance to explore for development of a suitable matrix for simulation modelling. Key points within matrix formation include the following:

- It is important to check the validity of the output by reviewing model outputs against observed or anticipated data in terms of trip productions/attractions and trip length distribution. Some distortion of travel patterns can result if matrix estimation techniques are used without suitable monitoring and control of the process;
- Typically this change in matrix values might lead to an increase in shorter trips to enhance a match in traffic volumes on turns and on links. As such when developing the demand matrix, the process should be documented with assumptions, key findings and issues identified;
- Where appropriate, the key land uses should be identified on a graph. A logic check of the demand matrix should be undertaken for each model;
- These checks may then ensure (for example) that a volume of demand coming from or going to destinations such as national parks will not exceed beyond reasonable expectation; and
- A flowchart showing the process of this estimation should also be included.

Separate demand matrices are usually developed for separate vehicle classes to allow different network access arrangement, demand loading, vehicle parameters, route cost characteristics and output statistics. A common segmentation is light (e.g. cars, light goods vehicles) and heavy vehicles (i.e. rigid and articulated trucks) plus cyclists and motorcyclists where declared. Taxis may be loaded separately if sufficient information is available as they can have different network access (e.g. taxi ranks, use of bus lanes are to be modelled).

Public transport is not generally loaded using demand matrices but are loaded on fixed routes with defined frequencies. However, in appropriate circumstances a singular vehicle matrix can apply with a mode split managed internally to the system. The project definition and objectives will determine the appropriate approach for such circumstances.

Demand extraction from travel demand models

Demand matrices are commonly developed from an extraction of travel demand models that are developed across the metropolitan network for evaluation of strategy formation (vision building). This can involve consideration of land use and also of infrastructure planning and requirements over a period of time, typically through short medium and longer term horizons.

Development of a matrix from a starting point of a strategic travel demand model does have a number of advantages including a general distribution matrix for application and refinement within a simulation model. However, there are a number of elements that modellers need to consider for both base year and future horizon considerations when extracting datasets from travel demand models. This includes the following matters that are notable differences between the two modelling techniques:

- Capacity is often loosely (generically) defined and not calibrated to the challenge of the simulation modelling task. This can imply that more demand is forecast than can actually be carried within the model (both for base and future horizon);
- Validation of the throughput in travel demand models is often analysed through different styles of benchmarking compared to that of a simulation model. This may deliver a different demand estimate for both base year and future year horizon, including error from surveys. While potentially not a critical matter this may begin to account for differences in demand estimates that may require some refinement prior to simulation modelling;
- Impedance may not specifically be reflected appropriately within the travel demand model due to often generic application of volume delay functions within a network. Potentially this may not impact on locations with notable flow volumes (e.g. midblock on a freeway) but understate demand requirements elsewhere such as adjacent to a railway station;
- Connections between land use estimates and network definition may have an impact on where traffic is released. In this way demand estimates could be overstated or even understated simply due to the connections for these journeys to achieve access and egress to the zone; and

- Intra-zonal demand is generated but not assigned within travel demand models. In areas with coverage of a larger geography this may impact on the scale of demand on the road network. In regional locations this may potentially provide a greater bias towards through traffic and a reduced focus on local needs.

In all cases where demand is extracted from a strategic travel demand model it is expected that a comprehensive review of the metrics are undertaken. This should be observed and documented within the model development report, to outline considerations before exploring future year horizons.

6.1.2. Total Demand

The total volume of demand should be reported in a table format. This output should illustrate an aggregate overview of the relative demand for the chosen evaluation period to outline how much demand is within the network for each time horizon and for each scenario explored. This table should be listed as the aggregate of demand as well as a percentage of heavy vehicles. Refer to Table 17 below for an example.

Table 17: Total volume of demand for AM and PM evaluation periods (example)

	Total Volume of Demand	
	AM	**PM**
All Vehicles	4,503	6,010
Heavy Vehicles (HV) (%)	5%	6%
Other (%)	0%	0%
AM Peak evaluation period: 07:00 to 09:00 **PM Peak evaluation period: 16:00 to 18:00**		

6.1.3. Travel Zones

As part of the model development, travel zones determine the location of the origin and destination of the journey within the simulation model. As such a map of the zones (Figure 31) used in the development of the demand matrices should be produced and included in the main body of the simulation modelling report.

Travel zones should be numbered so that they can be referenced against demand matrices provided within appendices of the report. A suitable approach is to provide a locality plan (adjustable size as warranted) with appropriate imagery to capture the project area and a more prescriptive scale to cover a suitable level of detail for the zones.

Within a simulation model travel zones are typically developed to represent one of the following experiences:

- A midblock location for generation or attraction of journeys;
- An internal location for land use considerations within the network; and
- A form of parking measures (either on street or off street solution).

Travel zones are typically disaggregated from the coarser structure applied for the strategic network modelling pursuits. This difference is applied due to the different geographic compositions of the simulation models, as well as the varied impact on local land uses within the network developed. This also has considerations on the matter of inter-zonal trips which are succinctly addressed in a travel demand model but need to be further elaborated within a simulation model.

The zones presented should be clearly visible with no ambiguity. (refer to Table 49 in section 11.3.2 for further details) Travel zones can have multiple access or egress locations but should be clarified within a model development report. Longer streets that may have zones named and also appear multiple times on a network map should be appropriately defined with clarity for all stakeholders.

Figure 31: Simulation model showing the location of travel zones (Example)

Sometimes travel zones are used by modelling teams in a pursuit to account for the gap between surveyed metrics. Under such conditions a "balancing" zone may help to explain for conflicting survey volumes that may have been collected on different dates. Sometimes teams utilise old survey metrics to benchmark flow volumes, without reviewing the appropriateness of this measure and apply a balancing zone to account for the gap. Balancing zones may have a place in simulation modelling to account for the matter of data "sinks and sources" within a network. However the value of these measure should be provided to explore the gap in a comprehension of the land uses rather than a failure to measure against the correct metrics. Therefore balancing zones should (in aggregate) hold no more than 5% of the demand across the entire network. Balancing zones should also hold no more than 5% of the aggregate volume on the adjacent road network.

In addition to the zone map, a trip in and out matrix (trip ends) should be provided for the evaluation period in the appendix with a table summarising the total trips in the main body of the simulation modelling report. An example of such a table is shown below.

Table 18: Summary of total trips for AM evaluation period (7:00am to 9:00am) (Example)

Zone No	Description	Trips In Totals		Trips Out Totals	
		Observed	Modelled	Observed	Modelled
1	Keilor Road – West	690	702	521	529
2	Newman Street	122	120	143	144
6	Calder Freeway Exit Ramps at Keilor Road	360	354	0	0

A trip frequency distribution curve may need to be provided amongst selected models to explain how the table of journeys (demand matrix) relates to empirical or other modelled trip patterns. This might be used to demonstrate the proportion of trips covering full length of a route or help to explain proposed changes to the design of interchanges (i.e. a collector distributor arrangement). Finally note the considerations also for developing local (short trips) to better refine the demand matrices to match the observed count volumes.

Typical trip frequency distribution curves should consider trip length classifications of no greater than 2.5km increments. However, as and when appropriate a shorter distance increment should be applied based on the length of the shortest 90% of journeys in the area of investigation.

6.1.4. Saturation Flow

Saturation flows need to be considered and therefore be calibrated using available information such as traffic survey, STREAMS saturation flow outputs (for motorways) and SCATS maximum flow outputs (for non-motorway roads). The accuracy of the calibration is generally limited due to available data. However, the model is required to demonstrate that modelled saturation flow volumes are reasonable and are with 10% of observed saturated flow volumes.

Simulation models will require some level of driver behaviour modifications to calibrate to known saturation flows noting that many factors such as geometry, gradient, visibility, gap acceptance, lane width and the urban density (number of ingress/egress and on street parking) may influence the flows. This refinement should not be an estimated revision from user experiences, but consist of evidence based refinements through solutions such as the SCATS Max Flow figures or equivalent STREAMS analytical measurements.

For general guidance on observed saturation flows and limitations empirically identified within the metropolitan Melbourne motorway network, please explore the VicRoads Motorway Deign Volume Guide (2017) that can be obtained from the VicRoads website.

It is important to note that when intersections are oversaturated, the demand estimates may provide insights into the capacity of the intersection for the period analysed.

Saturation flow for key intersection approaches and/or motorway sections should be presented in a diagrammatic format against modelled saturation flows, and the list of modifications adopted to driver behaviour to produce these results. Key changes that would need to be considered include headway and the standstill distance between vehicles. Reference to relevant lane capacities (vehicles/hour/lane) needs to be considered.

New infrastructure delivery projects whereby traffic volumes (and as such saturation flows) do not exist need to use existing and similar network conditions to apply into the simulation model. That is the behavioural elements used to calibrate the network for operational deliveries need to be evidence based from similar sites. As an example, a new motorway that has no current volumes or behavioural conditions (as the motorway does not exist) should be calibrated against the wealth of motorway data that VicRoads holds on experiences from other motorway in Melbourne. Note that as per many other conditions, operational matters vary between motorways as well as within each motorway.

For this reason a review of the appropriate operational matters should be reviewed and explored before being applied to calibrate traffic operations being simulated within a new infrastructure delivery. Where appropriate mature equivalent experiences cannot be found within Melbourne or Victoria as a comparable measure for a new delivery matter, experiences from interstate or overseas can be considered for application to develop the operational measures.

Throughput vs demand:

In section 5.2.1, it was discussed that traffic counts generally measure the passing of a vehicle across a point or section. Typically this can be a stop line at the approach to a set of signals. The quantified metric is normally referred to as throughput but is often misrepresented as demand. That is, the figure obtained identifies what did get through the intersection rather than that what actually intended to do so. Although the difference may appear to be nominal, the implications on available (spare) capacity may present a different story. This is a notable difference between strategic models and simulation models.

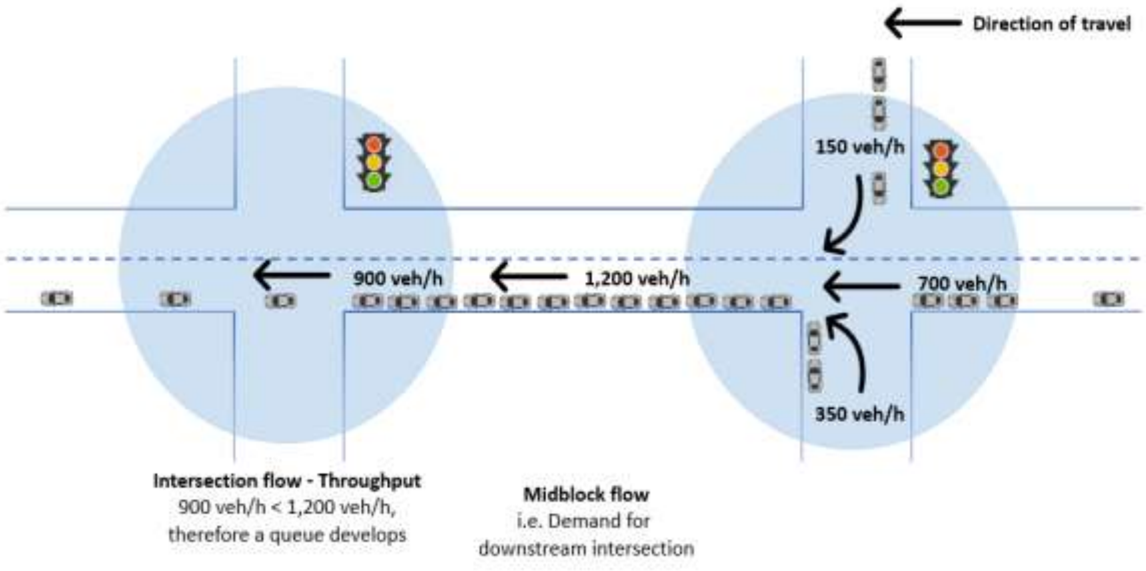
Collection of throughput volumes can only assist in understanding the potential traffic throughput in a congested environment and other techniques and measures are required to further understand the traffic demand of intended movements. One technique is to collect traffic counts outside the queued extents and beyond the area with congestion. It is important that the queued extent should be captured (representing the unmet demand on the network) adjacent to the study area during periods of congestion. This may be achieved by comparing the upstream turn volumes into the link against those turning out at the intersection in focus. With this approach a diagram showing discharge volume and demand should be presented, with photographic evidence to provide context of the situation. Note that this may extent the limits of the study area, but should then fall in line with the identified problem for the involved stakeholders.

Where such discrepancies occur between demand and throughput, it is important to benchmark the delivery of both measures within the network simulation. This should be achieved by a showcase of link turning volumes (into and out from the link) to emphasise the disparity at play here. These sites should also be included as a part of the corridors used for model validation to emphasises the delays and congestion already experienced and observed in this space.

Figure 25 demonstrates the difference between throughput and demand. The upstream signalised intersection flows show a midblock flow that exceeds the number of vehicles that are able to go towards the downstream signalised intersection. The 900 vehicles per hour is the throughput and the 1,200 vehicles per hour is the demand for this signalised intersection approach.

Figure 33 demonstrates the demand and throughput outcomes that result in queuing at a dominant approach to a roundabout, based on site observations.

Figure 32: Illustration showing the difference between throughput and demand (Example)



6.1.5. Demand Time Profiles

Demand time profiles serve to operate on two key aspects of simulation modelling.

- The first is to better manage for the release of traffic into the area of investigation, which reduces the variation explored amongst the complexities of the simulation modelling. A more refined series of time intervals provides for better control in the flow of demand throughout the model run to be a closer match to the observed conditions.
- The second key measure here is to explore some conditions about a model warm up period – outside the period of evaluation to ensure that the model reflects appropriate scales of congestion at the commencement of the evaluation period. The evaluation period chosen aims to reflect the study area and the objectives of the simulation modelling assignment.

Figure 33: Observed conditions to demonstrate the difference between throughput and demand

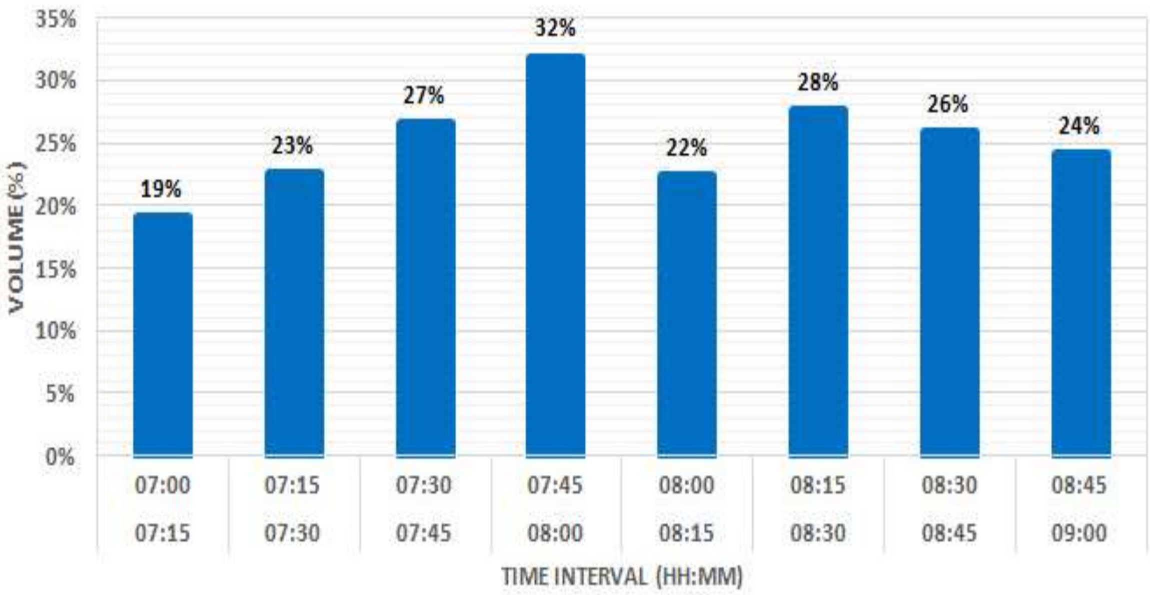
In general, the peak periods are commonly chosen and the practice is to model a supporting period that complements the peak periods. Simulation models require congestion to develop within the network as the key driver on performance (congestion) is the limitation developed from the vehicle in front of each other vehicle. This element of congestion takes time to form within models so that the full extent of the demand associated with the peak periods is captured. It is important that the appropriate scale of congestion is reflected at the commencement of the evaluation period, in line with the conditions observed from site visits. An evaluation period needs to be modelled with appropriate warm up and cool down periods.

As simulation modelling assignments evaluate the opportunities for vehicles and network performance evaluation every time step, it is imperative that better controls are defined to manage the uncertainty. This can in part be achieved by developing time profiles for the network.

Time profiles should be considered (where required) for travel zones as they can have a significant impact on how congestion and queue lengths develop throughout the network. Key considerations are areas of high inter peak activities such as near schools and shopping centres (land use specific venues) which may experience a different profile to the arterial networks. The time profile outputs from the model need to be calibrated to the time profile inputs using data that is disaggregated into no more than 15 minute intervals (albeit five minute intervals are preferred, depending on the study area).

An example of a time profile for a zone release is provided within Figure 34 for which each interval is determined as a function of the hour, rather than the aggregate time period.

Figure 34: Time profile release for light vehicles



The current discussion around time profiles has historically focused on the departure or release demand and generally occurs at the boundary of the model. However, the release demand profile for the network model needs to be a function of a number of intersections in the core of the model so that the demand profile developed can better reflect the traffic operations at the centre (core) of the study as per Figure 35. These measures should be validated against the model outputs as a simple column chart to benchmark how the model matches the observed volumes for each 15 minute period in the investigation. An understated exploration in simulation models is to explore that the congestion is appropriate at the commencement of the evaluation period.

In addition to this measure there may also be site (zone) specific releases or arrival profiles that operate differently than the remainder of the area of investigation. These locations should be further refined to reflect the observed conditions of site specific behaviours (e.g. car unloading at a ferry port).

The profile of throughputs from empirical data in the interior of the network model, for which it takes time for journeys to reach from the cordoned area, is referred to as arrival profile. This measure considers the movements that occur within the model and as such is a better representation of the demand profile than the use of a departure profile from sites on the edge of the network.

Models that have a journey time in the network of more than ten minutes should consider developing an arrival profile in the base year development.

Note that the time profiles developed for the network model do not always need to be brought forward to future modelling pursuits as a direct match. The demand profile should be reviewed when considering growth in the study area as it may be that a flatter time profile may develop over time (site specific). Under such conditions it is advisable to develop arrival profiles for the established and significant sites.

Figure 35: Time Profile development from within core of investigation area

6.1.6. Warm Up / Cool Down Periods

Warm up and cool down periods are an integral part of any simulation model. Simulation models require this warm up period (unlike strategic or deterministic models) as adequate congestion needs to be formed for the commencement of the evaluation period, as observed from site. The calibration of the warm up period at the start of the evaluation period should be long enough prior to the required model evaluation period to demonstrate sufficient traffic densities, queues and vehicle volumes in the network at the start of the evaluation period.

As a base setting the modelled warm up period should be double the length of the longest journey time experienced in the evaluation period. This value should then be rounded up to the next appropriate 10-15 minute period to fall in line with the measures of the evaluation period. If the warm up period is not sufficiently produced there will be an under representation of congestion both on the network for both based year and scenarios explored. Potentially teams may need to collect data about conditions in the network (queues, congestion) for the interval prior to the evaluation period as a means to simulate the time interval being explored.

The volume release and time profile of a warm up period should be reflected in the surveyed information gathered. If this is not available then this warm up period considered for application should provide for a direct match to the demands of the first interval of the evaluation period.

To demonstrate that the warm up period is able to reflect the start of the evaluation period, an image of the model is required within the report showing the traffic condition at the commencement of the evaluation period. The image should be at a prescriptive scale to cover a suitable level of detail. The image snapshot should be clear enough so that the scale of congestion (presence or absence) is clearly visible with no ambiguity (refer to Table 49 in section 11.3.2 for further details).

A cool down period should ideally include the period when excess demand (from earlier in the peak period) completes their traversal of the network or traffic densities/ vehicle volumes reduce to uncongested conditions. The cool down period is generally of similar length to the warm up period and is an important period in evaluation of scheme options in heavily congested conditions.

The volume release and time profile of a cool down period should be reflected in the surveyed information gathered. If this is not available then it should be a replica of the last interval of the evaluation period. It is inappropriate for this time interval to be void of demand. A cool down period should not be void of new demand entering the network.

6.1.7. Screenlines

Screenlines represent imaginary lines drawn across the landscape to explore the general movements of traffic and transport vehicles within a network. These solutions are regularly applied at within large-scale (deterministic) network models and seldom utilised within simulation models. However, it is not uncommon to use these measures in exploring simulation models within a network setting as a more aggregate measure of individual link or turn flows. Such measures may represent a broader part of the narrative for movements across a river or a rail line or adjacent to an arterial road.

The application of screenlines should be introduced into simulation models when a notable transformation of the land use is taking shape, that provides little to no room for model validation of the current network e.g. developing a greenfield site or a golf course where no development currently exists. It is expected that the screenlines will be developed to run alongside the arterial road system as well as placement in other selected key positions.

In some circumstances, the detail of a design may wish to be explored to ascertain traffic operations and movements including intersection performances, queue lengths and network viability. This may include matters pertaining to developer contribution funds or even a revisit into the planning and design of the land uses investigated. In such circumstances where screenlines are applied, the development of a simulation model will be used to benchmark throughput against estimates determined from another circumstance – i.e. not from observed settings, but from another synthetic development. This might be from the formation of a strategic travel demand model exploring future year requirements, or might be extrapolated from a planning session of the development site. The screenline measure would be used to benchmark details in operations that the planning component may not be able to determine with such accuracy, such as turn volumes, route choices or network accessibility.

Note that this approach is only to be used is there is not a strong foundation for developing a base model from observed datasets and existing validation processes. For this reason, it is not directed towards the development of conditions typically experienced within the established area, but from select parcels of land or expansion areas on the fringes of the metropolitan network.

6.2. Behavioural Considerations

Driver behaviour is a key component of simulation models to reflect the heterogeneous elements of driver's experiences within the landscape. This element will require some level of adjustment as part of the calibration process. The intent of the calibration of behavioural considerations is to explore the experiences of drivers and journeys and make adjustments in the simulation to better reflect such occurrences. Typically this change should be applied predominantly at the local level (site specific) rather than across the global compass of the simulation model

A map detailing locations where the behaviour representation has changed from the default conditions with an explanation is required (i.e. reflect how the model details the operational complexities. One approach is to colour code the road segments that have specific adjusted driver behaviour parameters on a plan at a prescriptive scale to cover a suitable level of detail. The location of changes presented should be clearly visible with no ambiguity (refer to Table 49 in section 11.3.2 for further details).

In particular, the following specific driver behaviour parameters are to be discussed for the development report:

6.2.1. Behavioural Algorithms

Simulation models use sets of behavioural algorithms to impact vehicle movements and manoeuvre these objects across the network. Such measures typically involve several well researched (and published) algorithms including the following considerations:

- Route choice algorithms;
- Car following algorithms; and
- Lane change algorithms.

Together these sets of algorithms allow for conditions to be explored that are site specific (calibrated) rather than generic from the initial research of the developer. It is critical that investigations aim to explore the complexities of the network and achieve a calibrated (and validated) simulation model through the application of these behavioural elements in effect. While matters of the demand are important, the calibration act is a function to showcase that the experiences of the estimated demand is represented by the simulation model. The behavioural algorithms (route choice, car following and lane change) should be managed at both the global and local level.

Teams undertaking investigations for VicRoads should utilise solutions that allow for adjustment of the above algorithms. It is also important that these sets of equations are not limited to application in a holistic manner (the entire network) but can be reproduced and adjusted for site specific measures as required for the pursuits at hand. The parameters of the behavioural models should be adjusted to better represent the conditions of journeys within the landscape explored – which means calibration of parameter sets for multiple locations, rather than a single application across the network. In this way teams can then simulate different scales of complexity on seemingly similar types of the roads (e.g. arterial roads with different saturation flows or headways).

For each part of the investigation, teams developing simulation models should begin to explore the parameters used within these algorithms to comprehend what they do and how sensitive such values may be. This may involve developing small (but simple) example models to comprehend the broader nature of the task. These example models may be limited to a small representation of a single intersection or a small corridor of 200m of intersections to benchmark operational performances (speeds, throughputs, delays etc)

Both anecdotal and empirical (not provided here) perspectives identified by research held conducted within VicRoads identify that the behavioural conditions of motorways are less consistent than those for arterial roads. This is not to suggest frequent changes in the operating conditions of motorways at any one location, but to identify that a singular behavioural algorithm is more applicable to arterial roads than to motorways. A well calibrated motorway operation would expect to have multiple applications of site specific behaviour to achieve various performance metrics (throughput and journey speeds, amongst other measures).

Teams should be aware that the algorithms operate together to explore the utilisation by drivers across the network for a multitude of movements at any one location. Note that it is the parameters of the collective set of algorithms that determine the behavioural condition rather than a direct setting or condition on the road. That is to determine a base line calibration and be prepared to analyse changes from a proposed scheme a defined input metric, such as a lane use proportion, should not be in effect. These measures should be subject to the input frameworks to develop the driving condition rather than to hard code the definition of the behaviour.

6.2.2. Omitted Vehicles

Some software solutions provide measures to alleviate traffic congestion from forming in the network simply as a function of poor coding. These solutions are intended to provide a format for exploring the coding problems within the simulation as the network model is being matured. In this way the elements that differentiate between the operational matters of the road network to those of the simulation network can be minimised (and later resolved) rather than network failure due to a singular blockage.

Individual behavioural sets may be able to provide different restraints before removing vehicles from the network. To ensure that the model is developed to an adequate scale of delivery, the various reporting elements outlining the number of vehicles removed should be provided or reported upon. When reported, a table of locations (link numbers or road names) and the frequency of vehicles removed from the network in the evaluation period should be listed.

The model should ensure that the following three points hold true for the completed network model:

- no more than ten vehicles per hour are removed from any one location and
- no more than thirty vehicles are removed from all locations across the network;
- the volume of vehicles removed is less than one percent of the demand to be generated within the network.

However, the intent is that the developer of the simulation model will work through the coding matters to ensure that no further vehicles are removed from the landscape.

6.2.3. Speed

The speed profiles utilised and the locations of such speed areas can have a noticeable impact on the driver behaviour and network operations during peak periods. This can affect simulation models outputs such as journey time and journey time reliability as well as subsequent matters such as route choices and performance metrics. The two speed types are discussed below.

Posted speed

Posted speed limits reflect a primary element to model behavioural aspects of drivers in a landscape and should be reviewed for the full extents of the study area. In particular the speed profile should be calibrated to available speed data collected through means such as automatic tube counts, GPS data sets or point to point detection tools. Speed data values obtained in the off peak periods (e.g. midnight to 6AM) should be used to replace the default software values that represent the intended journey speeds. This is the time of day that typically achieves nominal delay for journeys and produces datasets of the intended journey speeds (without congestion). This approach provides for a useful calibration tool to localise the driver behaviour within the modelled environment.

A reminder that the observed speeds from the peak periods are those metrics to be used for model validation, not for calibration as this considers the delay in response to traffic movements and congestion within the network.

The tables and graphs below provide examples of intended journey speeds for a motorway and arterial for roads. Motorway data was obtained from various locations along the Melbourne motorway network and arterial data was obtained from a site in each of the municipalities. These datasets represent the uninhibited journey speeds of vehicles and is considered to have minimum impact from the considerations of a car following algorithm.

It is important to note that the speeds identified for the peak periods should be used for model validation rather than model calibration. It is also not appropriate to adjust speed distributions in the model to match observed values to recreate congestion since these observed values are a consequence of the congestion and associated vehicle and lane changing algorithms. In cases where speed data is not available, other factors may still warrant adjustment such as pedestrian friction, visibility issues, on street parking and speed enforcement.

Simulation models need to reflect the intended operational matters of drivers. For this reason it is not simply appropriate to settle on default distributions associated with regulatory measures. Note as well that this consequently has an impact on the delay calculations which is the gap between modelled and intended speeds. For this reason it may not be appropriate to simply operate a signposted speed as a default measure but to explore operational characteristics of drivers within several sections of the project area.

Speed observations should be tabulated in the report with 15^{th}, 50^{th}, 85^{th} percentile speeds and an image of all changed speed profiles locations with modified speed curves provided. The image should at a prescriptive scale to cover a suitable level of detail. The location of changes presented should be clearly visible with no ambiguity (refer to Table 49 in section 11.3.2 for further details).

Again please note that the data held within Table 19 and Table 20 have not been provided for the purpose of mandating such a distribution of speeds. Rather, this material is provided to showcase what can be achieved and how the simulation models are expected to be calibrated by speeds. A simple application of default settings or even by signposted speeds may not be appropriate for the representation of behavioural considerations within the area of investigation. Collection of off-peak journey speeds through mechanism such as pneumatic tube counts, automated count systems or historical datasets through telematics providers provide a good first step into better determining the distribution of speeds that are intended for movement.

Posted speeds should be managed at both a global and a local level of consideration.

Table 19: Speed profiles for motorways (See Note) (Example)

	Speed (km/hr)															
Motorway Site Description	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125
Monash Fwy - IB West of Huntingdale Rd	0%	0%	0%	0%	1%	1%	2%	3%	6%	18%	59%	93%	98%	99%	100%	100%
Monash Fwy - OB West of Huntingdale Rd	0%	0%	0%	0%	1%	1%	2%	3%	6%	18%	59%	93%	98%	99%	100%	100%
Monash Fwy WB at Warrigal Rd	0%	0%	0%	1%	1%	2%	3%	6%	14%	45%	91%	99%	100%	100%	100%	100%
Monash Fwy EB at Warrigal Rd	0%	0%	0%	0%	0%	1%	1%	2%	5%	26%	84%	99%	100%	100%	100%	100%
Monash Fwy - IB Midblock between Stud Rd and Heatherton Rd	7%	11%	15%	19%	23%	28%	41%	72%	95%	98%	99%	100%	100%	100%	100%	100%
Monash Fwy - OB Midblock between Stud Rd and Heatherton Rd	1%	3%	5%	10%	17%	26%	40%	71%	94%	98%	99%	100%	100%	100%	100%	100%
Monash Fwy IB Stud Rd	3%	6%	12%	29%	56%	78%	91%	95%	98%	99%	99%	100%	100%	100%	100%	100%
Eastern Fwy at Kenneth St footbridge	0%	0%	0%	1%	1%	1%	1%	2%	6%	23%	77%	97%	99%	100%	100%	100%
Eastern Fwy at Kenneth St footbridge	0%	0%	0%	0%	1%	1%	1%	4%	13%	48%	92%	98%	99%	100%	100%	100%
Eastern Fwy Kilby/Willsmere Rd Inbound	2%	3%	4%	5%	6%	6%	7%	7%	9%	18%	81%	99%	100%	100%	100%	100%
Eastern Fwy Kilby/Willsmere Rd	4%	5%	5%	6%	7%	8%	10%	11%	17%	39%	86%	97%	98%	99%	100%	100%
West Gate Bridge (EB) Gantry 3 (800m east of Williamstown Rd)	8%	12%	18%	23%	29%	52%	88%	99%	99%	100%	100%	100%	100%	100%	100%	100%
West Gate Bridge (EB) Gantry 4 (1250m east of Williamstown Rd)	15%	18%	23%	27%	39%	72%	97%	99%	100%	100%	100%	100%	100%	100%	100%	100%
West Gate Bridge (EB) Gantry 5 (950m west of Todd)	8%	12%	15%	19%	26%	48%	90%	99%	100%	100%	100%	100%	100%	100%	100%	100%
West Gate Bridge (OB) Gantry 6 (300m west of Todd) Position 1	11%	14%	17%	23%	29%	57%	95%	99%	100%	100%	100%	100%	100%	100%	100%	100%

PFW IB near Campbell St	1%	1%	1%	1%	3%	5%	9%	12%	21%	48%	89%	98%	99%	99%	100%	100%
PFW OB near Campbell St	0%	0%	0%	0%	0%	1%	1%	2%	3%	15%	77%	97%	99%	99%	100%	100%
Calder Fwy West of Keilor Rd overpass	4%	4%	5%	5%	5%	7%	10%	16%	34%	67%	92%	98%	99%	99%	99%	100%
Calder Fwy West Melton Hwy overpass	14%	15%	15%	15%	15%	17%	21%	30%	50%	79%	96%	99%	99%	100%	100%	100%
400 East of Jacana tunnel	0%	0%	0%	0%	0%	1%	1%	3%	13%	47%	91%	98%	99%	100%	100%	100%
20 East of Widford St bridge	0%	0%	1%	4%	7%	8%	9%	11%	18%	56%	95%	99%	100%	100%	100%	100%
WRR/440m East of Tilburn Rd	0%	1%	1%	1%	2%	2%	4%	6%	16%	49%	93%	99%	100%	100%	100%	100%
WRR/440m East of Tilburn Rd	0%	0%	0%	0%	1%	1%	2%	3%	9%	34%	80%	97%	99%	100%	100%	100%

Note: Low value speeds may need to be further investigated and potentially allocated a 5% contribution. This would be based on any further validation considerations. Data between midnight and 6AM for midweek February 2017 – sample size of approximately 2,000 vehicles.

Figure 36: Empirical Speed Curves for Motorway (Example)

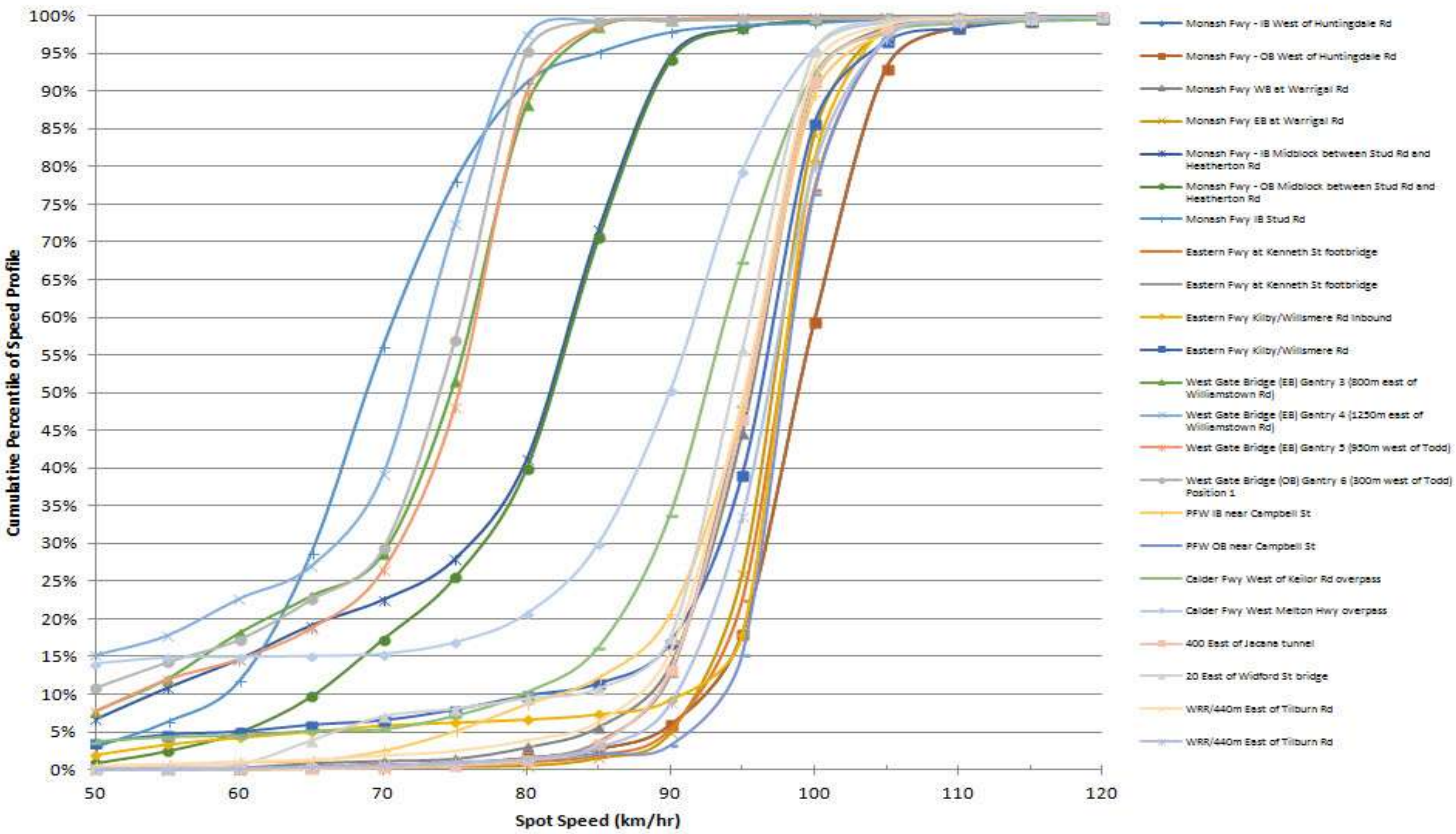
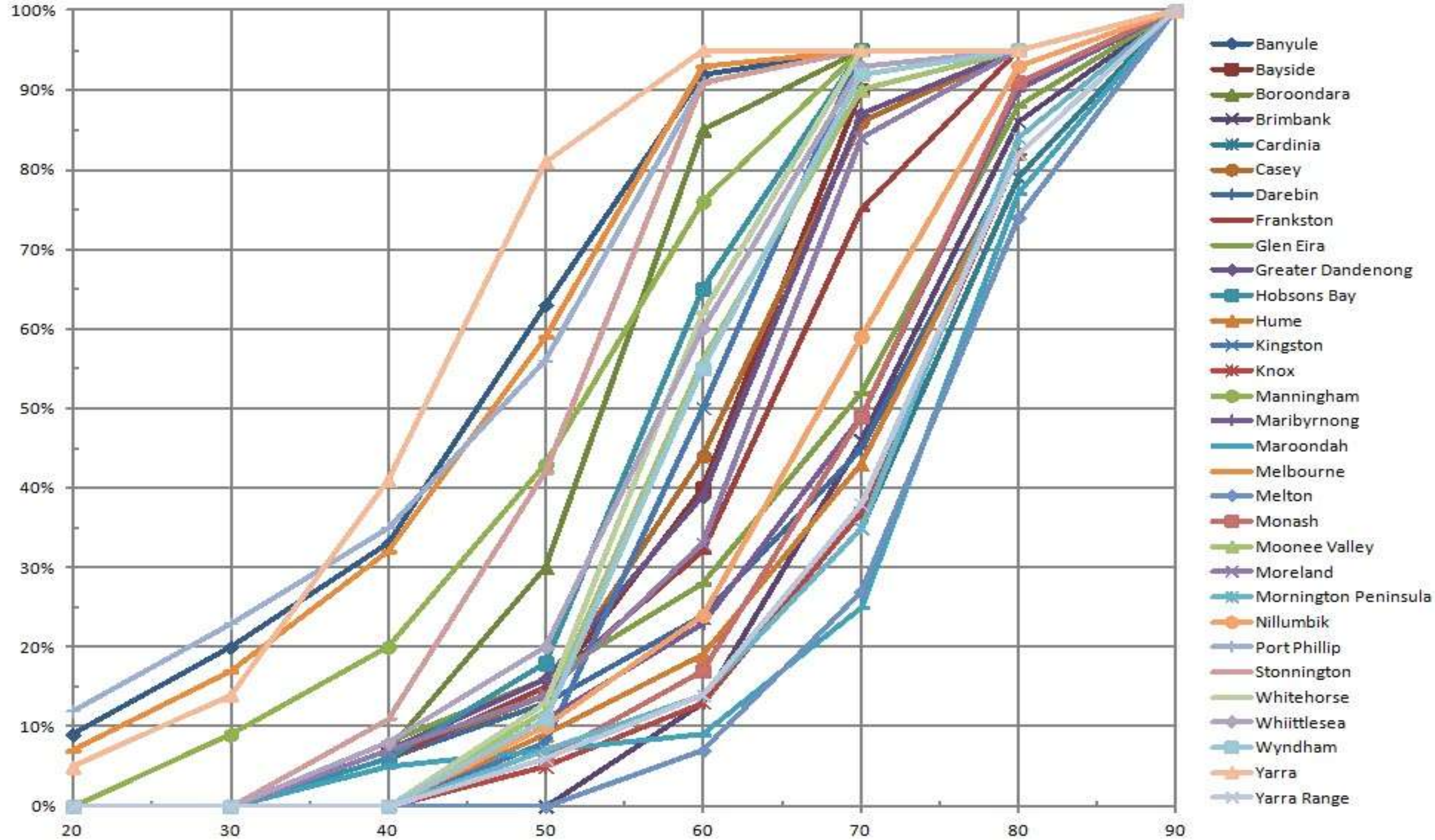


Table 20: Speed profiles for arterials (See Note) (Example)

							Percentile Speeds																		
Municipality Area	Road	Direction	From	To	Est. Distance (km)	Sign Posted Speed	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
Banyule	Bell St	WB	Cope St	Daley St	0.4	70	15	20	25	30	34	38	41	43	45	46	48	49	50	52	53	55	56	58	61
Bayside	South Rd	EB	Hampton St	Ivy St	1.0	70	35	46	51	54	56	57	58	60	61	62	63	64	65	66	67	68	69	70	72
Boroondara	Barkers St	WB	Glenferrie Rd	Denmark St	0.7	60	38	43	45	47	49	50	51	52	53	54	55	55	56	57	58	59	60	61	63
Brimbank	Green Gulley Rd	NB	Driscolls Rd	Tanjil Ct	1.1	70	52	58	61	63	65	67	68	69	70	71	71	72	73	74	76	77	79	82	86
Cardinia	Princes Hwy	WB	Racecourse Rd	James Rd	1.1	80	48	55	61	64	67	68	70	71	73	74	75	76	77	78	79	80	81	83	86
Casey	Pound Rd	WB	Shrives Rd	Tarella St	0.6	70	38	46	50	53	55	56	58	59	60	61	62	63	64	66	67	68	69	71	74
Darebin	Lower Plenty Rd	SB	Bannockburn Rd	Graham Rd	2.0	80	38	46	52	56	60	63	66	68	70	71	73	74	76	77	78	79	81	82	86
Frankston	Moorooduc Hwy	NB	Golf Links Rd	Winifred St	1.9	70	37	44	49	54	57	59	61	62	64	65	66	67	68	69	70	71	73	75	78
Glen Eira	North Rd	EB	Ormond Rd	Murrong Rd	1.2	80	34	42	49	54	58	61	63	66	67	69	71	72	74	75	76	77	79	80	83
Greater Dandenong	Dandenong Bypass	WB	Frankston-Dandenong Rd	Eastlink Trail	1.4	70	37	43	49	52	55	57	59	60	61	62	63	64	65	66	67	68	69	71	74
Hobsons Bay	Millers Rd	NB	Ross Rd	Mason St	0.8	60	38	45	48	51	53	54	55	56	57	58	58	59	60	61	62	63	64	66	69
Hume	Cooper St	EB	Hume Hwy	Greystone Ct	2.8	80	43	51	57	60	63	65	67	69	70	72	73	74	76	77	78	79	81	83	87
Kingston	Nepean Hwy	NB	Edithvale Rd	Hearle Ave	3.0	60	46	51	54	56	57	58	58	59	59	60	61	61	62	62	63	64	65	67	70
Knox	Burwood Hwy	WB	Scoresby Rd	Applewood Dr	0.7	80	49	57	61	64	66	68	69	71	72	73	74	75	76	77	78	79	81	82	85
Manningham	Doncaster Rd	EB	Whetherby Rd	Churchill St	1.5	70	22	30	36	40	43	46	47	49	51	52	54	55	57	58	59	61	63	65	68
Maribyrnong	Geelong Rd	SB	Somerville Rd	Francis St	1.6	80	40	48	54	58	61	64	65	67	69	70	71	73	74	75	76	77	78	80	82
Maroondah	Maroondah Hwy	NB	Murray Rd	Kent Ave	1.0	80	38	60	65	68	70	71	73	74	75	76	76	77	78	79	80	81	82	84	87
Melbourne	Victoria Pde	WB	Simpson St	Salvation Ln	1.3	60	16	23	28	32	36	39	41	44	46	47	49	50	52	53	54	56	57	59	61
Melton	Melton Hwy	WB	Goulray Rd	Storybrook Blvd	1.0	80	57	63	66	68	69	71	72	73	74	75	76	77	78	79	80	82	83	86	90
Monash	Springvale Rd	NB	Winmalee Dr	Botanic Dr	1.3	90	49	55	59	61	63	65	66	68	69	70	71	72	73	74	75	77	78	79	82
Moonee Valley	Buckley St WB		Clydebank Rd	Rachelle Rd	1.4	60	43	49	51	53	54	55	56	57	58	59	60	61	61	62	64	65	67	69	74
Moreland	Sydney Rd	SB	Murray St	Argyle St	1.3	70	35	46	51	54	57	59	61	62	63	64	65	66	67	67	68	69	70	72	75
Mornington Peninsula	Nepean Hwy	NB	Craigie Rd	Strachans Rd	2.0	80	46	54	60	64	67	68	70	71	72	73	74	75	76	77	78	79	80	82	84
Nillumbik	Diamond Creek Rd	SB	Yan Yean Rd	Civic Dr	1.5	80	40	50	55	58	60	62	64	65	67	68	69	70	71	72	74	75	76	78	81
Port Phillip	Kingsway	NB	Park St	Dorcas St	0.3	60	12	17	22	27	31	36	40	43	45	47	49	51	52	54	55	56	58	59	62
Stonnington	Williams Rd	SB	Toorak Rd	Malvern Rd	0.7	60	33	39	42	44	46	47	48	49	50	51	52	53	54	55	56	57	58	59	62
Whitehorse	Middleborough Rd	SB	Ashley St	Attunga St	0.7	60	41	48	51	53	54	55	56	57	58	58	59	60	60	61	62	63	64	67	70
Whittlesea	Epping Rd	NB	Findon Rd	De Rossi Blvd	2.8	60	36	43	47	50	52	54	55	56	57	58	59	60	61	62	63	64	66	68	71
Wyndham	Sayers Rd	EB	Morris Rd	Skeleton Ck	0.6	70	43	49	52	53	55	56	56	57	58	59	60	61	62	63	64	65	66	68	72
Yarra	Johnston st	EB	Young St	Smith St	0.4	60	18	26	31	34	36	37	39	40	41	42	43	44	45	46	48	49	51	53	56
Yarra Range	Canterbury Rd	WB	Mt Dandenong Rd	Liverpool Rd	1.8	80	48	57	61	64	66	68	69	70	72	73	74	75	76	77	78	79	81	83	86

Note: All data from TomTom database, covering weekdays (Tuesday-Thursday) between late March 2017 and late November 2017, excluding weeks with or adjacent to those containing public holidays or those with school days. All data covers the interval of midnight to 6AM.

Figure 37: Empirical Speed Curves for Arterials (Sample) across Melbourne for the Period of midnight to 6AM (March-November 2017)



Pre-emptive speed changes

The speeds conditions generally adopted for segments of the model due to circumstances such as geometry may require a variant in speed conditions. These solutions often require pre-emptive changes in journey speeds for network considerations to reflect small sections of the road network due to matters of traffic engineering (design, grade, turn radius etc). In particular areas of revised speeds should be adopted for turning movements, tight horizontal curves or speed humps. Pre-emptive speed changes should be developed and revised only for a local level of application.

In some cases, these locations are adopted in replicating the observed speed at the periphery of the model. As such, a detailed explanation in the use and effectiveness of the objectives of the current and future modelling need to be explored within the text of the reporting.

Typically, a distribution with a high-end value of 15-20km/hr for left turn and 30km/hr for right turn at intersections (typical 90 degree turns) should be applied to the network model.

The Austroads Guide to Road Design (AGRD) Part 4 publication provides extra guidance on this topic. In amongst this discussion are notes that a left turn treatments design speed limited to an upper speed of 30km/hr with unsignalised pedestrian crossings. AGRD Part 4A Figure 5.2 can help guide turning speeds for other sections of road with radius less than 240m. Also consider Austroads Design Vehicles and Turning Path Templates Guide for HGV – design is usually a 15m radius with speeds of 5-15km/hr (minimum requirement/ maximum turning speeds).

An image of the reduced speed area locations should be provided in the report. The image should be at a prescriptive scale to cover a suitable level of detail. The locations presented should be clearly visible with no ambiguity (refer to Table 49 in section 11.3.2 for further details).

Simulation packages that utilise a decay equation in speeds (as a function of the radius) will need to revisit such reductions for each turn. The simulation software needs to ensure that the turn speeds (and approach measures) are accurate to represent the challenges faced by drivers on the road. An application of default conditions from within the simulation software may not be appropriate to represent these operations in the network model.

6.2.4. Intersection Blocking

The location of intersections with downstream blocking pushing back to the site should be documented in a tabular or graphical display. The method and condition with which these sites have been simulated should be described i.e. keep clear zones.

It is important to consider that a uniform behaviour does not need to be applied across such sites in the simulation. Of more importance is the consideration that the model reflects as per the observed conditions on site. In this context congested locations may experience irregular blocking in the intersections at different times through the simulation and the model runs. Refinement of these parameters from delivery of a consistent and uninterrupted solution to a degradation in potential delivery may be a requirement to achieve a more appropriate scale of model calibration.

Intersection blocking attributes should be developed for application only at a local level of calibration. However it is not uncommon that many intersections share a scale of consistency to other sites within the same simulation model.

6.2.5. Gap Acceptance

Although the notion of saturation flow was previously discussed in the context of demand considerations, these measures are metric of behavioural settings. Sign controlled intersections (unsignalised) and some turns at conflict points within signalised intersections may require a refinement in parameters to better reflect the flow conditions as observed. This may not just be a function of the minimum or average headway, but may also consider both demand and throughput as the separate quantified measures from observed settings in the landscape. Gap acceptance needs to sit within the context of the number of conflicts for that movement and as such should also be calibrated to the site specific challenges (local level).

Gap acceptance criteria are well discussed amongst traffic engineers to explore the movement of journeys through an intersection, with numerous Austroads guides discussing the topic of critical gaps and follow up parameters. Also discussed are the implications on these values on prospective throughput or a saturation flow. Note that these publications may serve as a starting point for an application for which each site should be explored to determine the current empirical gaps taken by traffic to enter the intersection from the approaches or turn movements.

Calibration of sign controlled locations can be a critical measure in benchmarking design matters at selected locations as this can impact on both current and future design matters as well as warrants for revisions to the controller mechanism (e.g. upgrade to a different style of intersection).

The calibration of gap acceptance measures is a discussion and documentation as to where values have been revised from a default application, including the evidence observed to achieve this approach. Evidence may involve site observations (that are documented) to explore differences between demand and throughput. Metrics may identify how the model matches simulated conditions in line with anecdotal observations, or site specific (localised) speeds obtained at the conflict point. Presentation of the revisions in gap acceptance should be tabulated by location, with an outline of the supporting evidence. Note this entails providing more than the statement of "site observations" but discuss how revision to this parameter outlined observations of other metrics. The sites that are revised should also be mapped to ensure that stakeholders can comprehend the limitations within the network.

The value of calibration of gap acceptance within sign controlled intersections and at points of conflict then pertains to defining limitations (and prospective achievements) within a future year condition or a design to resolve the constraint. The revision of these parameters in a base model cements a condition to stakeholders where there are differences between both demand and throughput measures rather than defining a volume and expanding on this in future years.

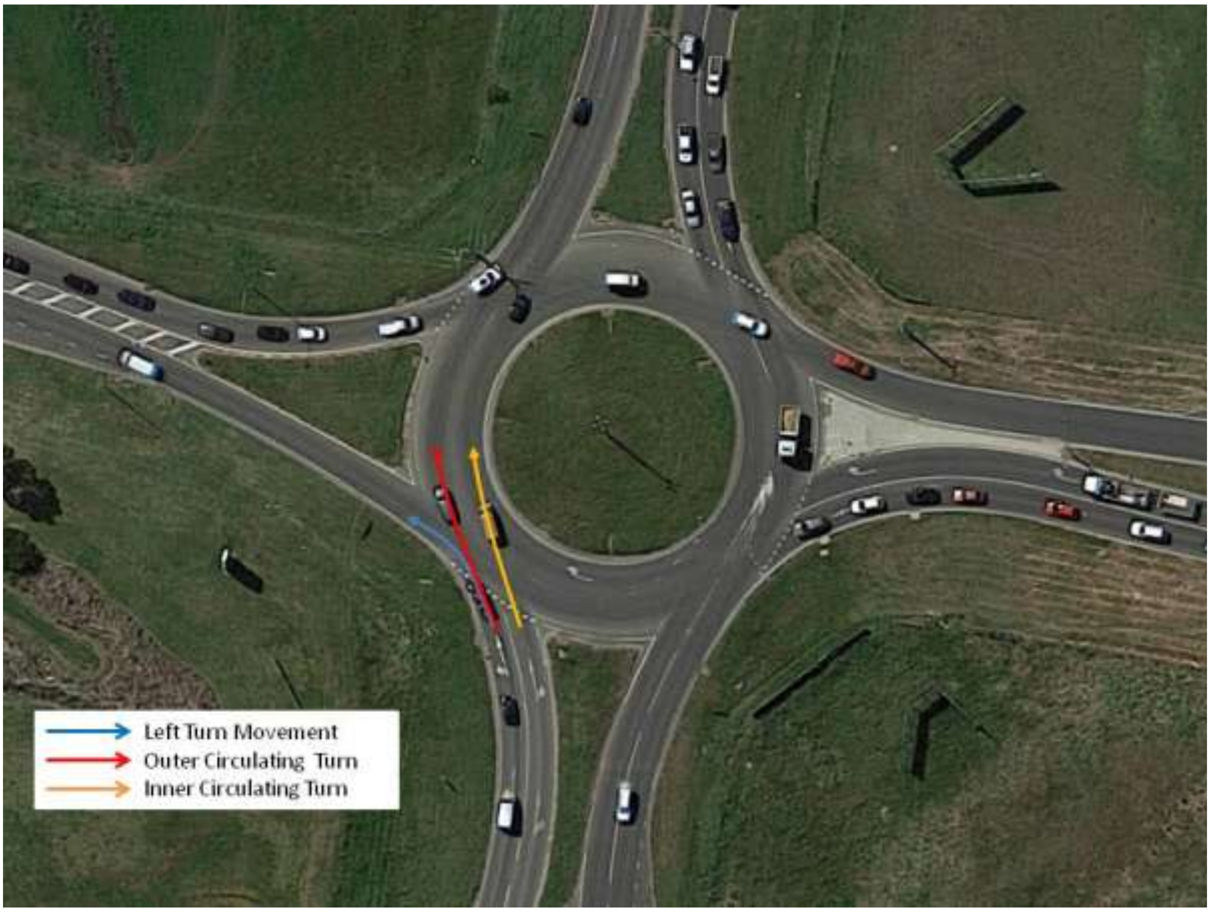
The three movements identified within Figure 38 would each be expected to have different gaps (and as such saturation flows) for the movements at the intersection. In this example the left turn (blue movement) might be subject to a very different headway to that of the through movement due to the experiences of the circulating traffic. By comparison the movement of the red arrow in the outer circulating turn needs to ensure enough of a gap is declared for a single lane of movements, while the orange arrow represents a journey across potentially two circulating lanes of traffic, for which the saturation flow could be considerably lower.

Micro-simulation models need to be in a position to be able to simulate the separate lane conditions as a function of the constraints and associated variables (demand, movements, gaps etc) within the landscape explored. Application of a consistent gap acceptance measure without empirical support suggests a limited calibration exercise may have been conducted.

Note that the gaps on individual turns and lanes described within this section are expected to be explored and defined for multiple classes of vehicles rather than as a single metric for all traffic flow. This may be defined potentially into cars and also heavy goods vehicles, or taken at a more disaggregate level than initially suggested. It is this refinement of conditions to reflect the observed conditions that is deemed by VicRoads as an important task in calibration of micro-simulation models.

The value of calibration of gap acceptance within sign controlled intersections and at points of conflict then pertains to defining limitations (and prospective achievements) within a future year condition or a design to explain and mitigate the constraint. The revision of these parameters in a base model defines a condition to stakeholders where there are differences between both demand and throughput measures rather than defining a volume and expanding on this in future years.

Figure 38: Varied Gap Acceptance on lanes to a roundabout approach (Western Port Highway at Hall Rd)



6.2.6. Weaving, Merging and Diverging

The matters of weaving and merging and diverging traffic flows will play a significant element in defining and exploring traffic operations and design requirements within an established area or an area subject to changes or development. Each topic plays an important element in managing design requirements. These elements are important in exploring matters in simulation models for the arterial network, but play an even more significant component when exploring the motorway network.

Research and analysis of motorway operations conducted by VicRoads identifies that the aspect of lane changing remains one of the most significant components of flow disruption. Section 2.3.2 of the VicRoads Motorway Design Volume Guide identifies a decay of traffic volumes with additional motorway lanes. This decay function identifies that additional lanes do not achieve a linear growth on traffic volumes, as the number of lane changes increases with more lanes. In this way the research identifies that varied lane configurations as parallel routes (collector-distributor solutions) should achieve a greater throughput than holding the same number of lanes on a single carriageway. This decay is identified from the increased lane changes that are more frequent in the kerbside location than the centreline position and reflects the ongoing friction of movements within these spaces.

Intuitively the matters of merging and diverging and weaving are all linked together as they often involve a different component of a single manoeuvre. These three elements have a very strong overlap in approach and resolution. Calibration for weaving and merging and diverging should be explored at the local level but may involve numerous elements at the global level associated with behavioural algorithms.

As per all network operations, the results of the simulation are not just a function of the design and the infrastructure provision, but also as per the accumulation of site specific elements that require calibration in line with observed settings. When exploring how to develop and design these elements, teams should observed from site inspections and have an idea of the lane specific throughput volumes as well as saturation rates.

The primary factors to consider in this space are:

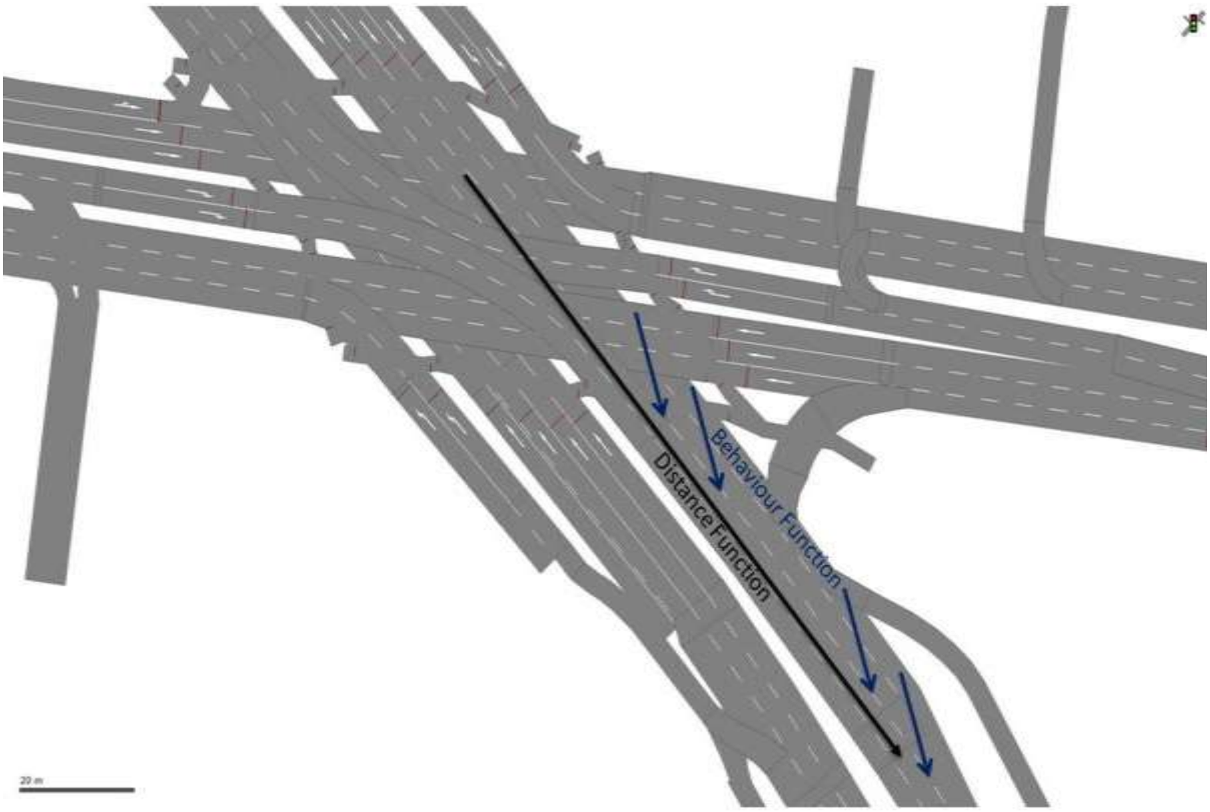
- Distance factors from the next diverge (the counter flow on the merge);
- Behavioural factors to explore the move across a lane (the acceleration required to becoming a leading vehicle and for adjacent lanes to become trailing vehicles); and
- The saturation flow of drivers on these lanes.

The act of lane merging within a simulation model needs to explored and developed suitably for both urban and motorway networks. This is predominantly as a function of the behavioural algorithms within the simulation software. However, the calibration required to match observed behaviour may be more localised than as a simple application of the type of road.

Note that examples used for model calibration of merges and diverges should be obtained from existing locations within Victoria. For urban network considerations, applications should be derived from a Melbourne context.

Merging on an urban or arterial road may require formation of lane change parameters to better reflect the approach to a lane drop. This may typically occur downstream from the signalised intersection, and is a function of a managing the throughput at the controller. The landscape at these locations may require more of a structured process of drivers progressively moving from the lane drop once beyond the intersection and may need exploration of both distance and behavioural parameters. An example of such a condition for the urban network using both behavioural and distance functions can be found in Figure 39. Under such conditions a site specific driving behaviour may need to be applied rather than application of a default measure.

Figure 39: Application of an Urban Merge using Distance and Behavioural Functionality



A diverge process within the urban network may involve similar factors to a merge process and consider both distance and behavioural factors to impact on the operations. Note that the saturation flow should be reported to provide insights into the calibration process. An overzealous saturation flow may suggest understatement of a design problem when constructed which may cause a breakdown of traffic flow. In areas without adequate supporting evidence of achievable saturation flow, VicRoads may require a sensitivity pursuit with a different saturation flow to be applied. This may provide for further insights into the potential limitations in the network design.

By comparison a merge process on a motorway can typically involve provision of an acceleration lane and multiple merging actions along this location. The design and operation of the merge process can become a critical element in exploring design matters of the motorway and can be considered critical for exploring demand and throughput estimations. Behavioural algorithms should be applied to better reflect observed conditions of lane behaviour, albeit noting that more friction is typically applied to the kerbside lanes that are midblock between motorway on ramps and off ramps (the weave).

Note that weaving analysis on motorway sections should explore those lanes whereby the lane changing occurs (those lanes oriented towards the kerbside) rather than all lanes involved in a motorway midblock segment. That is the section of a freeway between on-ramp and the off-ramp should report on both the weaving and non-weaving interactions between the two kerbside lanes. Delivery should not focus on metrics for an average of all lanes, as there is typically reduced weaving elements within this space for the mainline lanes. Note that the weaving conditions simulated can be used as a feed into a safe system design for potential for incidents developing.

It is important to note that many motorways in Victoria use a dual lane on ramp solution that involves two merge considerations. In this way the merge behaviour may not simply be limited to one transition but actually a function of multiple factors. Potentially this may have a further impact on the operation of throughput and lane performance on the main carriageway.

Some simulation solutions develop behavioural considerations for drivers to avoid matters of the weave areas by moving out of the lanes with higher friction. Through traffic may aim to explore journeys in the faster lanes while merging traffic makes use of the motorway ramps. Weave areas also should be calibrated to match observed conditions – albeit this is a difficult task to represent in a fluid network consideration. Volumes and speeds can begin to tell a story but these metrics should be matched by lane based density indicators and respective Level of Service calculations.

Also note that the application of a simulation model should not intend to apply a merging behaviour in order to meet demand estimates from a strategic model. It may be that the demand estimates from strategic models cannot be achieved within a simulation framework. This is predominantly a function of the granularity within the network model at both a demand and a network supply side – that neither components are calibrated to address matters of the natural bottlenecks within a transport system.

Strategic models are developed primarily to advise on the suitability of policy formation – and while they may be used for business case planning there is no consideration or adjustment in functions to account for operational matters of a congested network. Typically the link capacity in a strategic travel demand model is an estimate of a higher end function, rather than an expected performance of delivery. It may well be that the capacity is in line with the motorway maximum flow value, but unrelated to the maximum sustainable flow volume.

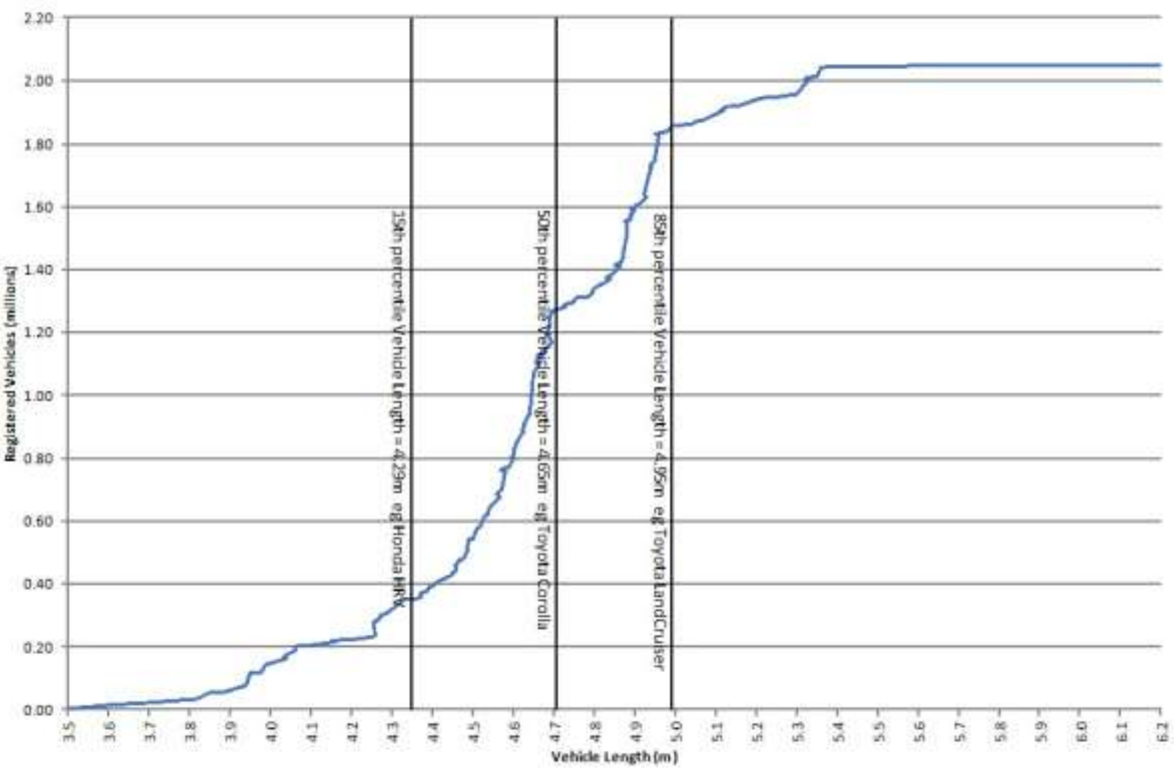
6.2.7. Vehicle Lengths

A review of data into the registrations of vehicles in Melbourne (not Victoria) has provided a brief overview of the characteristics of this fleet for application into Simulation modelling. A breakdown of vehicle by make and model for the month of May 2018 was tabulated to explore the mix of vehicles within the metropolitan network.

The data identified that filtering of this solution to the most common 200 types of vehicles (by make and model) still accounted for circa 87% of the fleet. This process removed more than 300 additional makes and models from the dataset but reduced the aggregate count from 2.6 million registered vehicles to still be above 2 million. From this filtered list a number of heavy goods vehicles were also omitted, and cleansing on selected typos in the dataset itself was conducted e.g. "Holden Commdore" instead of Holden Commodore. The dataset was then compared against the manufacturers vehicle specifications online by exploring the product documents. Note that this immediately implies that the vehicles referenced below take the form of the modern build, which may not be correct. In this arrangement this analysis may have a fleet size that is mildly larger than on the network, albeit this also depends on the age of the existing rolling stock.

The analysis of this solution identified that the remaining mix of the fleet covers a range of vehicle lengths of between 3.5 metres long (Suzuki Alto) to the maximum length of 6.2 metres (Renault Master Van) as viewed in Figure 40. The median vehicle length from this large sample was identified at circa 4.65m (Toyota Corolla). The 85th percentile length of the fleet was determined to be 4.95m (Toyota Land Cruiser) while the 15th percentile length was categorised as a Honda HRV at only 4.29m. This data also showcases some differences in lengths between passenger solutions and light commercial (goods) vehicles that sit at the higher end of this spectrum.

Figure 40: Lengths of Registered Passenger Cars (Melbourne)



Further analysis of vehicle lengths are provided in Table 21, which explores the proportional splits of the fleet rounded to one decimal place. This might further assist in development of a vehicle fleet to be Melbourne-centric for passenger car movements.

Again note that this analysis has simply filtered out most commercial vehicles from the analysis due to the limited volumes of each make and model experienced within the network. Further to this there are (of course) other vehicles on the Melbourne and Victorian road network that are registered in other states. This is a more significant aspect for heavy goods vehicles than compared to the passenger vehicles.

This data does not consider movement within the metropolitan area, but simply outlines a large sample of vehicles registered to be located in the location. This task has not been undertaken to establish a Melbourne specific vehicle fleet but to give insights into how this might appear. As noted the data has multiple assumptions and simplifications and is there to provide insights rather than define a prescriptive fleet structure. Each and every investigation will find a different fleet length from observations due to the specifics of the pursuit, the age of the vehicles, the sampling of data collected and many more elements used to establish a distribution of heterogeneous behaviour.

Table 21: Vehicle Lengths of Passenger Cars (Metropolitan Melbourne)

Length (Rounded)	Percentage of Fleet	Cumulative Percentage	Example
3.5m	0.1%	0.1%	Suzuki Alto
3.6m	0.6%	0.7%	Ford Fiesta
3.7m	0.4%	1.1%	Nissan Micra
3.8m	0.0%	1.1%	Hyundai Getz
3.9m	1.6%	2.7%	Nissan Pulsar
4.0m	4.4%	7.1%	Hyundai i20
4.1m	2.7%	9.8%	Hyundai Excel
4.2m	1.0%	10.8%	Suzuki Vitara
4.3m	4.7%	15.5%	Mitsubishi ASX
4.4m	3.8%	19.3%	Audi Q3
4.5m	7.4%	26.7%	Kia Sportage
4.6m	13.8%	40.5%	Holden Cruze
4.7m	21.4%	61.9%	Mazda 6
4.8m	3.3%	65.2%	Ford Mustang
4.9m	13.0%	78.3%	Ford Fairmont
5.0m	12.4%	90.6%	Holden Rodeo
5.1m	1.3%	91.9%	Mazda CX9
5.2m	2.1%	94.0%	Mitsubishi Triton
5.3m	1.5%	95.5%	Holden Colorado
5.4m	4.2%	99.6%	Ford Ranger
5.5m	0.0%	99.6%	Not Disclosed
5.6m	0.3%	99.9%	Not Disclosed
5.7m	0.0%	99.9%	Not Disclosed
5.8m	0.0%	99.9%	Not Disclosed
5.9m	0.0%	99.9%	Not Disclosed
6.0m	0.0%	99.9%	Not Disclosed
6.1m	0.0%	99.9%	Not Disclosed
6.2m	0.1%	100.0%	Not Disclosed

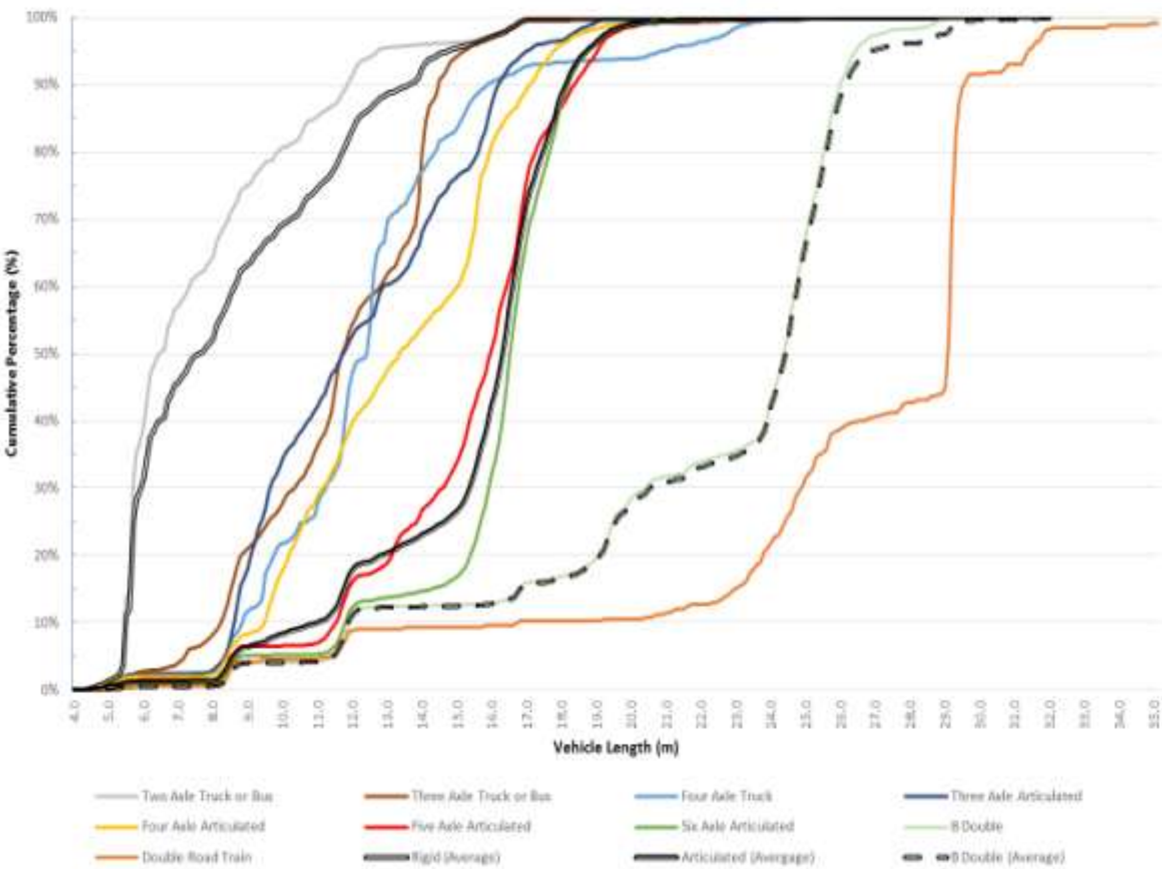
A review of HGV vehicle lengths were identified from data acquired for August 2018. This metric explored eight selected motorway sites dispersed across the Melbourne metropolitan motorways including the following locations of:

- Monash Freeway;
- West Gate Freeway;
- Princes Freeway East; and
- Western Ring Road.

Detection provided through the technology identified a sample for this one day of more than 88,000 HGV movements and acquired information on each individual vehicle passing the detection point to determine time, length number of axles and more. The HGVs comprised approximately 14% of the throughput within this sample date. A summary of the distribution of these HGV vehicles can be shown within Figure 41 for each axel distinction of HGV as well as aggregations of Rigid, Articulated and B-Double solutions.

The data held within Figure 41 identifies the weighted values held in Table 22 through the black lines of the graphic. This is a weighted value by volume of the fleet rather than a simple numerical average of the multiple curves of the graphic. Both the graphic and the table identify the median vehicle length for Rigid trucks as that which is much smaller than Articulated solutions and B-Double services. Overall the vehicle length of the median rigid vehicle is less than half of the median articulated solution. However, this gap is not consistent at either 15th or 85th percentile levels. Further research from VicRoads identifies anecdotally that the HGV fleet using the Hume Freeway in the off-peak period is notably different to the fleet on other parts of the metropolitan Melbourne motorway network.

Figure 41: HGV length distributions across Melbourne Motorways



Overall it is encouraged by model developers to explore the vehicle fleet within the study area being applied (to calibrate the composition of the fleet and give context to the site). If no further information is acquired in this area from surveys, teams are encouraged to utilise the resources of this section for a form of local distribution within the simulation model.

Table 22: HGV Distributions by Classification

Percentage	Rigid	Articulated	B Double
10%	5.4	11.0	11.8
15%	5.6	11.7	16.8
20%	5.6	12.8	19.1
30%	5.9	15.3	20.5
40%	6.4	15.8	23.8
50%	7.6	16.3	24.4
60%	8.6	16.5	24.7
70%	10.2	16.9	25.1
80%	11.7	17.4	25.5
85%	12.1	17.7	25.8
90%	13.6	18.1	26.1
Sample Size	54,989	24,935	8,672

6.2.8. Network Colours

Although this is a nominal topic, it is worth briefly addressing within the simulation guidelines. The topic is only considered nominal from an analytical perspective but is still critical when presenting the findings of a simulation model.

The movement of vehicles across screens to showcase design and operations and planning provides great value to stakeholders, who can immediately comprehend the value or the complexities and challenge associated with the investigation. What was only a concept on paper is brought to life with the ability of the simulation suite.

This works well when stakeholders have the luxury to follow individual vehicles across a part (or more) of a network. However, the value is lost when stakeholders need to be reminded as to which red (or blue or green) vehicle they were actually following through the network. This may lead to a reduced degree of comfort in the work undertaken then if stakeholders can follow the operations of the selected vehicle.

To achieve this, VicRoads advises an approach to develop at least three shades of colours for each predefined colour. That is, instead of exploring blue cars, there may be a light blue, a navy blue and mid blue set of colours. This variation tends to provide better acknowledgment from stakeholders with fewer homogenous blue cars in the simulation. When mixed with the other colours and other sets of colours (more shades of red, more shades of green etc) the results provide for a better distribution of the vehicle fleet for stakeholder engagement.

VicRoads encourages that the yellow vehicles are distinctly held for taxis, which may (or may not be) simulated within the model. A similar shade (e.g. mustard) could then be applied for similar journey purposes (i.e. the derived demand of moving people) undertaken by shared services such as Uber and Lyft solutions.

When developing images for delivery into a presentation or a report, VicRoads advises that a solid white background be applied under conditions where an aerial image (or alternative) is not utilised. Some software solutions allow for adjustments to the quality of background maps or aerial imagery, for which a toning down of colour is welcomed if this helps to deliver the narrative of the investigation.

6.3. Network Considerations

6.3.1. Network Design

There are many manuals provided throughout the world of road building (and journey planning and network development) that are written to discuss matters pertaining to road design. This is not a new topic and should not require an extensive introduction for traffic engineering specialists working within this industry to develop simulation models. However, key within this action in this notion to ensure that the designs used to deliver simulation models are in line with engineering standards as applied within direction from VicRoads. This may also require a review of documents from Austroads, the US Highway Capacity Manual and a number of other documents pertaining to design matters.

Within this context are network specific design measures that need to be delivered. Key in this space in the direction that the building blocks used to construct the simulation model should not dictate the decisions made by the objects (agents/ vehicles) to determine choices. Rather as a simulation model this behavioural element needs to be as a function of the algorithms that influence drivers to react to the downstream and localised tactical conditions. The simulation models developed should not physically determine matters (such as how and where drivers change lanes) using prescriptive metrics but operate as a function of the algorithms and choices built into the system. Calibration of these movements needs to be a function of the parameters provided within the software.

To make this clear VicRoads requirements are for the directional flow of the carriageway to be developed to reflect each physical cross section in the network. The inclusion of lane drops and lane gains (including dedicated turn lanes or slip lanes) should be reflected as a single building block as per the design of the intersection. In this way the inclusion of a turn pocket should not accompany alongside to the main carriageway but be a core part of this network object. Behavioural components within the software will then determine how traffic manoeuvres into the appropriate lane rather than having a predefined position. By comparison the design of a collector/ distributor arrangement would require separate parallel objects where appropriate but a singular object to reflect the merge and diverge complexities.

The simulation model should be cultivated so that the complexities of the landscape (for which investigations are undertaken) are not compromised by the quality of the model development. This may also involve application of site specific settings to calibrate the behavioural models as discussed in Section 6.2.1.

Behaviour is not simply limited to the calibration of parameters within the car following algorithms built into the software, but also needs to be calibrated against observed behavioural matters (such as gap acceptance at unsignalised intersections). The calibration of behaviour is not a global application but may be a localised measure which has global implications. An example of this situation identifies where the model may misrepresent saturation flow and hence delays are incorrectly stated. This process may not draw traffic in where limited route choices impact so investment is provided into alternate sites across the network to receive a new design.

6.3.2. Time Steps

Time steps represent the number of calculations undertaken for each second that is simulated in the model run. That is: each vehicle explores questions about individual acceleration, braking and lane changing and more with regular changes considered in the simulation.

The simulation model should be run with no less than five time steps per simulation second.

While the study area needs to be put into context, enhancing this figure will produce a smoother flow of movements, but will generally extend the computational times of the network model. The value applied provides for a balancing of model run times and calculated opportunities for traffic within the network, which acts as a trade off between metrics. At no point should fewer time steps be applied to a simulation model than as stated above.

In the case of motorway modelling, the greater number of time steps per second (e.g. ten) indicates that drivers can looks at the tactical setting (headways) more frequently. As such, highly congested motorway models or urban networks may consider more time steps per simulation second as a measure to model calibration. Urban networks may use the greater number of times steps to better manage access from the side roads (a suitable gap) and move into the more significant road. As many models hold for both motorway and arterial roads, investigations need to weight the focus towards on the more centralised component of the simulation model. This may commonly but not comprehensively be directed at the motorway journeys.

The number of time steps per simulation second needs to be consistent for all model runs throughout the project which includes the base model and any option or future year models. Outputs will be effected by the value applied for this parameter and should be consistent through all models developed for an individual investigation (base developed and options explored for network changes and/ or future year evaluations).

6.3.3. Queue Length

The model parameters for recording queues should be as defined using measures held within Table 23 unless there is a justifiable reason why it should be adjusted. Teams conducting investigations need to be aware that queues may be defined with a maximum distance, and ensure that this maximum distance does not misrepresent the reporting.

If the reporting of a queue length equates to the maximum queue length, then the model needs to be re-run with a revised maximum length for the parameter. That is, the extended queue lengths should be recalibrated to better reflect the story of the current and proposed issues within the network.

Table 23: Queue definition parameters

Queue Definition	
Begin when less than:	10 km/hr
End when greater than:	12 km/hr
Max headway:	20m (consider keep clear provisions when determining max headway)
Adjacent lanes:	Include the queues formed on adjacent lanes merging into the traffic
Max back of queue:	2 kilometres

6.3.4. Signalised Intersections

Most simulation modelling assignments are of urban areas and as a result will involve a large number of signalised intersections. As such, accurate calibration of signal parameters is required and in most cases critical to developing a meaningful model. In general, models typically adopt one of the following four formats:

- Fixed time signals;
- Scheduled fixed time profiled signals;
- Adaptive signals; and
- SCATSIM modelling.

The use of the most appropriate techniques is dependent on the objectives of the study area as well as direction from the supporting data gained through SCATS History files. Simulation models do not inherently need to have adaptive signal plans (if evidence supports this) but are typically expected to have this capability to explore variations in network planning. It is an important component that the model reflects the conditions of the signals as observed in order to provide sound advice of the localised network conditions in a future year model.

Vehicle Actuated signal coding provide for more complex signal operations than fixed time. These signals operate under a dynamic plan that can respond to calls from detectors or other controller logic to provide variable green times and phase structures to address matters such as public transport priority phases or "false green" readings. Such measures might be applied when delivering operational matters with public transport priority or sites that achieve regular variation in phase calls or in cycle lengths.

The Scheduled Fixed Time Profiling of signal plans might be adopted for signals with variable signal timing (i.e. any SCATS site) but for a fixed phase sequence. In general, this should be provided in no more than 15 minute intervals. Under such conditions the signal plans would be expected to be consistent and should therefore not be applied to sites that have public transport solutions or irregular phases called in the time periods used in the investigation. Cycle times should not vary by more than 10 seconds throughout the simulation interval applied.

SCATSIM should only be used when developing or testing the SCATS EPROM when the adaptive operation of the intersection is more complex then applying a SCATSIM solution. SCATSIM also requires knowledge of the signal plans for adjacent sites, which also requires exploration of controller operations in the subsystem as well as SCATS operational pursuits such as the desire for subsystems to marry or divorce and change the focus of immediate delivery. SCATSIM solutions require exploration of more than just an isolated intersection in the network.

When calibrating signalised intersections, the following parameters should be considered as part of the process:

- Phase frequency;
- Phase green time average, minimum and maximum;
- Pedestrian crossing activation frequency (and impact on traffic flow);
- Special purpose phases such as priority public transport phases are dependent on the arrival of the public transport mode and may be effected by parameters such as alighting and boarding. The phase frequency between surveyed and modelled needs to be explored further; and
- Coordination with adjacent signalised controllers.

It is expected for all investigations that the current VicRoads intersection operating sheets are downloaded from the Victorian OpenData website. These operations sheets should be explored to identify the phase sequence, the gap times, operational signal flags as well as development notes that accompany the controller. It is noted that simulation modelling requires more in the development of the signalised intersections than just the definition of a phase sequence and a cycle length.

Typically, but not in all cases, the right turns are leading rather than trailing for a signal plan. This may require the last phase of a cycle to be a right hand turn movement that progresses into a through movement and the commencement of the following cycle.

Signal operations need to aim to reflect the complexity of the delivery on site, which may be subject to different applications as and where required. For example, sites with public transport considerations (including jump starts and phase extensions) often require more adaptive solutions than heavily saturated locations that only cater for private transport considerations. Isolated sites may require a more adaptive solution as the cycle lengths as well as phase splits can be quite variable.

One of the key designations to consider in network development is the scale of coordination between adjacent controllers within the same subsystem. This does not directly imply for operations of the same cycle lengths, but a determination of which phases are more reactive in response to changes in the adjacent sites. This does identify that modelling sites within a signal optimisation framework series may not be appropriate as a detailed design (in simulation models) for delivery of a coordinated or priority corridor within a network.

As a very basic measure of direction for the format of signal controller deliveries in simulation modelling in outlined within Table 24. This table outlines for a review of the cycle times that occur within each hour of the simulation model. The movement from a delivery of fixed time into scheduled fixed time is dependent on a consistency of signal phasing, for which is not consistent will require a more actuated solution of delivery.

This approach is intended for delivery in the core areas of the model as application in the periphery of the network may be delivered as fixed time solutions, unless critical to the conditions of the core area. The focus of this table is suggestive to VicRoads expectations rather than as a critical delivery metric. That is, some minor overlap can be adhered to, if there is confidence it will not directly impact on the modelling and performance metrics.

The more critical directive for determination of signal control deliveries remains the content in Table 25 that utilises the nature of the intersections as the driving force. The structure of Table 24 provides awareness of the minimum expectation provided by VicRoads in development of simulation models, subject to the more precise sense of direction that is outlined within Table 25.

Table 24: Suggested Approach towards Signal Delivery (Core Area)

Cycle Time Variation (per hour)	Freeway	Highway	Arterial	Secondary	Collector	Local
Less than 10 seconds	S	S	F	F	F	F
10-20 seconds	S	S	S	S	F	F
More than 20 seconds	A	A	A	A	S	S

Where the following abbreviations apply:
F = Fixed Time
S= Scheduled Fixed Time
A = Actuated Solutions or SCATSIM

In all cases the higher complexity applies for application to a simulation model. As an example, VicRoads direction for network coding at an intersection of a collector coming into an arterial road with 10-20 seconds cycle time variation would require a form of scheduled fixed time operations. Control sites that operate only using local or collector roads at the signalised intersection may still be developed as a scheduled fixed time solution. However, inclusion at any approach of a sub-arterial or arterial road (secondary or primary) directs that the structure lusted within Table 24.

Expectations for actuation within a mesoscopic or hybrid model are discussed within Section 8.2.

> In all cases, modelling investigations need to ensure that the delivery of the change model can successfully be evaluated for operational deliveries. This may be a more critical determinant to identify the most appropriate measure for coding of signalised intersections.

By comparison the data in Table 25 outlines the minimum requirements expected for delivery of signal operations within a simulation model by controller purpose. This table outlines a number of requirements in order the adequately calibrate the operational considerations of the network model and the area being investigated. This includes considerations of the following designation:

- Minimum signal method for delivery;
- Conditions of the cycle time;
- Conditions of the phase time;
- Reviews for the phase order; and
- A review of the phase frequency.

As illustrated within Figure 21 traffic control systems, even those that appear to be saturated are often developed to operate in an adaptive environment. Only a small number of sites (predominantly determined by a high pedestrian volume) actually operate as a fixed time delivery. Teams should identify that phases may not run consistently or in a simple pattern. For these reasons and the movement towards testing signal operations, a preference for variable traffic operations is encouraged, and under selected conditions outlined within Table 25 is specifically required.

However, all measures can be scaled down if operational evidence is provided to the VicRoads traffic modelling specialists prior to the formation of the base year traffic model. This should only be conducted once the options testing has been conceptualised for delivery, as it may be that traffic signals should be reconfigured to a greater variable condition in the option.

The role of pedestrian interactions with traffic movements needs to be explored and considered for all investigations. Pedestrian considerations may be simulated within models at signalised crossings, various forms of pedestrian crossings and potentially with public transport solutions. The considerations may not be limited to matters of volumes, but may also relate to the impact (or delay) that pedestrians have on traffic flow such as the left hand turn movements that may limit the throughput of the kerbside traffic.

Reports into the development of simulation models should include a tabulated summary of sites with signalised intersections as well as cycle lengths and phase splits. Documentation should outline the style of phase plan as well as accompanying empirical measures from observations (i.e. SCATS history signal data, phase split plans etc).

Table 25: Minimum Expected Signal Configuration

Application	Context	Minimum Signal Method Delivered	Cycle Time	Phase Splits	Phase Order	Notes
Signalised Pedestrian Crossings (Midblock)	Intended for midblock crossing locations	Scheduled Fixed Time	Variable	Variable	N/A	Demand Responsive
Signalised Intersections (Fixed Time)	Only for sites that Actually operate as Fixed Time Solutions	Fixed Time	Fixed	Fixed	As Operations	-
Signalised Intersections (Scheduled Fixed Time)	For Sites with limited variation in the simulation period, fixed time deliveries that change through simulation intervals	Scheduled Fixed Time	Changes per Interval	Changes per Interval	As Operations	-
Signalised Intersections (Isolated)	Strongly Encouraged to explore Actuated Solution as there is often notable variation	Scheduled Fixed Time	Changes per Interval	Changes per Interval	As Operations	Demand Responsive. Intersections at only local or collector roads can follow advice in Table 24
Signalised Intersections (Saturated)	Strongly Encouraged to explore Actuated Solution	Scheduled Fixed Time	Changes per Interval	Changes per Interval	As Operations	Typically Scheduled Fixed Time in Cycle Times and Phase Splits
Signalised Intersections (Coordinated)	Strongly Encouraged to explore Actuated Solution, as sites can be responsive to those of the subsystem	Scheduled Fixed Time	Changes per Interval	Changes per Interval	As Operations	Notably works better with actuated operations
Sites with Public Transport Priority	Review Operations Sheets to identify how to apply Public Transport Priority	Actuated	Variable	Changes per Interval	-	May overwrite approach to coordinated sites, also consider phases to clear traffic.
Metered Roundabouts	Application through selected intervals to improved operational flow.	Actuated	Variable	Changes per Interval	As Operations	Demand Responsive
Railway Crossings	Sites are known to have significant variation in signal times	Actuated	Variable	Changes per Interval	As Operations	Consider phases to clear traffic from services and venue
Ramps (onto Motorways)	Complex algorithms determined by downstream conditions beyond site	Actuated	Variable	Variable	N/A	Achieves regular changes in operations
Emergency Services	Irregular calls but a priority system as required	Actuated	Variable	Variable	-	Consider phases to clear traffic from services venue
Test Prom Coding	Exploration for delivery of new controller	SCATSIM	Variable	Variable	Needs to be reviewed	Requires accuracy in calibration of all other components.

6.3.5. Ramp Signals

Ramp signals are dynamic in nature as they respond to the mainline conditions. Ramp signals need to be coded to reflect the changing nature of the motorway and thus the operation of extended headways when required. This task may not just be about using an average cycle time or a time profiled solution as the functionality of the ramps may pertain to mainline operations that are downstream from the from location. This distance may be quite significant and may be outside of the area simulated for the investigation.

The calibration procedure is the same as for signalised intersections and needs to be presented within the model development report.

Note as well that VicRoads operates freeway to freeway ramp metering at selected locations across Melbourne. This solution operates with a similar approach to ramp signals; that the activation of these adaptive solutions may be triggered by operational conditions that are a significant distance from the actual site being simulated.

6.3.6. Model Stability

Simulation models use random number sequences to produce a small level of variability (changeability) within each simulation to reflect a scenario whereby each vehicle has a subtle change in the range of behaviours as exhibited in the real world. This relates to the heterogeneity of the driver experiences within the network. Over the course of the simulation modelled period (or time interval), such measures will in aggregate match the distribution of inputs. However, this allocation at any point in time may present a different set of results (such as intended journey speeds) to the landscape at that moment.

This matter of the model variation can explained through the narrative of defining the requirements for the length of a turn pocket. This portrayal can be viewed by envisaging the following circumstance:

1. Image that a right hand turn pocket is expected to move a demand volume of 240 vehicles within a morning peak hour.
2. As the sight runs a cycle time of 120 seconds this would allow for 30 cycles to be run within the one hour evaluation period. This would produce an average of eight vehicles for each cycle to turn right.
3. At an average of 7m per vehicle, these calculations would suggest a turn pocket lengths is require at 7m x 8vehs = 56m (or 60m after rounding).

However, this approach assumes a consistent arrival pattern for the turn, when such arrivals achieve a less structured consistency. Turn movements can often receive a higher demand rate in one cycle and a reduced response at another time. Further to the above, this calculation assumes an absence of constraints upstream and downstream that may inhibit the traffic flow. Finally the above calculations also fail to consider measures for both seasonality and growth for future year horizons.

The range in behaviours capture the variability in release patterns of vehicles (for each destination), the individual intended journey speed to a particular vehicle as well as other attributes such as length. It is therefore important to ensure that the model is run at least five times to sufficiently capture the broad or limited extent of this variability. The running of a simulation model allows for an evaluation to be made of the stability of the network being simulated.

Every micro-simulation software package allows the modeller to provide an initial “seed" value for each model run. The seed value affects the generation of the random numbers that influence the variability of attributes applied to the vehicles. Therefore, each time the model is run with a different seed value, a slightly different set of outputs should be generated. It would generally be expected that these outputs would be very similar, but not identical, and it is an analysis of the variability between these results over the accumulation of the evaluation period that indicates the stability of the model.

Unstable models should be discussed in the report and should not be hidden from the account. The narrative around the identification and resolution of this matter of instability needs to be outlined prior to further development of the investigation. This ensures that the stakeholders of the information are aware of the sensitivity of the aspects within the simulation model.

6.3.7. Seed Analysis

Seed values within simulation models reflect the starting point for the randomness that is generated from within the computer's operating system. This randomness should be repeatable to generate the same delivery of results within the network pursuits.

The seed values chosen for this task is at the discretion of the modeller as each and every seed value is just as arbitrary as any other value applied.

The seed values applied to the base model developed needs to be used consistently throughout the project for each scenario and for each time period. A minimum of five seed values are required as part of the initial model stability check. However, more seed runs are encouraged. Typically, the model is developed and validated from one seed run before exploring the stability of results.

The associated outputs should be as follows;

- A table of descriptive statistics for Vehicle Hours Travelled (VHT) and Vehicle Kilometres Travelled (VKT) in a table format to show various network outputs including the median seed run as well as the standard deviation and range of values from these outputs;
- Coefficient of variation (COV) comparing both VHT and VKT needs to be produced. The level of variation should be within 3%.for intersection and corridor studies and within 5% for all other studies such as networks. This is an important measure for model delivery for base and potentially for future horizon/ change models; and
- The COV formula is $COV = \frac{SD}{\mu} \times 100$ where SD = standard deviation and μ = mean.

To achieve this metric, it is expected that scatter plots of the individual Vehicle Hours Travelled (VHT) and Vehicle Kilometres Travelled (VKT) for each seed run will sit within 5% of the median value (i.e. a range of ten percent around the median). The display in Figure 42 illustrates such a comparison between seed runs and outlines the 5% variation from the median in the red outline. The median seed should also be graphically marked in another colour within this scatterplot as well as documented within the report.

Models of different time intervals (AM and PM) do not need to use the same median seed values.

Where the criteria of five seeds within a set threshold have not been achieved, then the resulting conditions should be reviewed and documented. Teams should be able to explain the reasons for the variations between seed runs including the degree for the variation in the modelling results. Seed values that fall outside the range thresholds should be identified by both number and relative scale of the difference. Any unstable seed numbers need to be documented and the occurrences for the instability discussed to outline the scale and location of the flow brake down.

Where five seeds have not been suitably achieved, then further modelling needs to be conducted so that five out of seven seed values as defined in Table 26 are delivered. The seed numbers listed were conducted through application of 400 seed runs in a single model, and extracting selected values to compare in another model run. The collective values were deemed to be suitably consistent in both modelled applications.

At the conclusion of model stability investigation, a chosen seed value should be specified as part of the calibration and validation process. However, note that different time periods (AM, PM) can use different seed values as each model needs to independently be calibrated. Models are not required to use a single value for all tasks within the project. However the same seed values need to be brought forward to ensure consistency of the time periods explored (e.g. AM and PM peak period models can use different seed values).

Figure 42: Scatter plot comparing VHT and VKT for each seed run (Example)

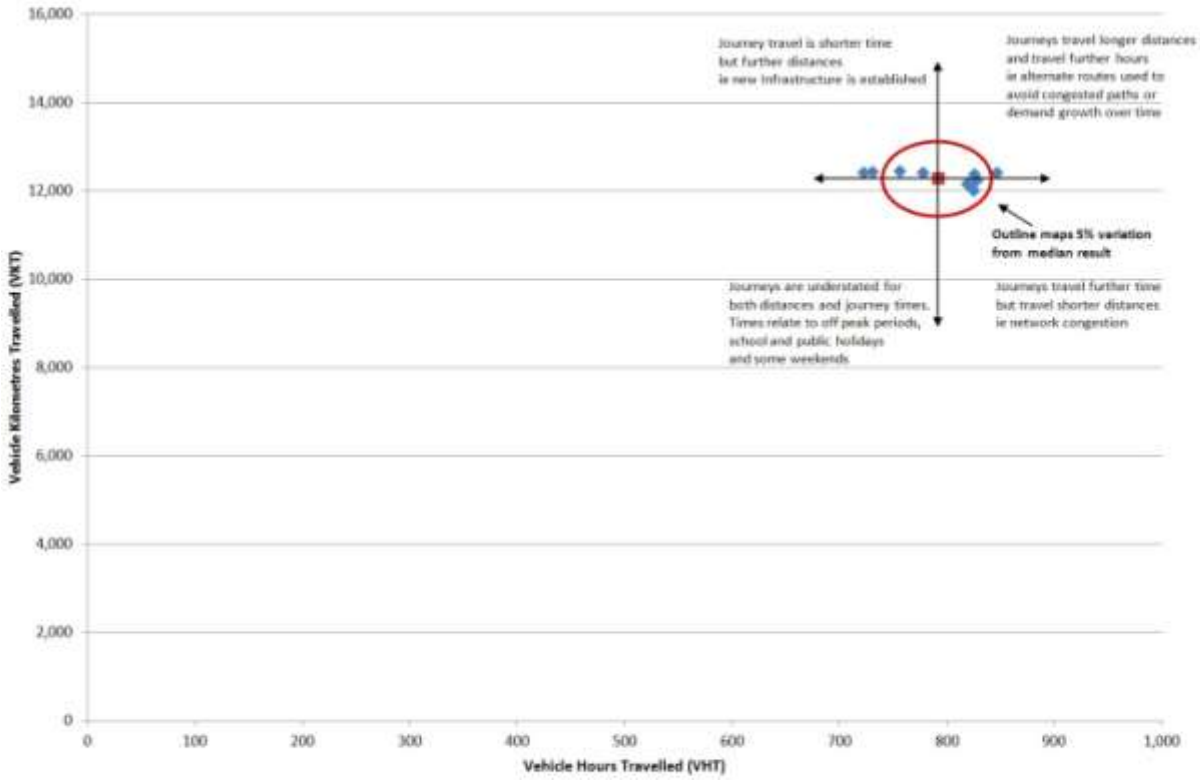


Table 26: VicRoads Seed Values

Seed Run No.	Seed Value
1	340
2	480
3	680
4	840
5	860
6	1380
7	1880

Note that VicRoads does not require use of a median seed value to be reported, not an average of all valid seed runs. A single seed run of acceptable consistency can be benchmarked for the model calibration, if the reporting can outline the common performances achieved through the other seed runs. This may require more work or documentation for individual projects (eg to prove project designs are resilient) but emphasises that the base model developed and properly calibrated can potentially be used as suitable guidance on consistency. The reported seed run will need to be within the appropriate thresholds of the median seed and not sit as an outlier to the remaining runs. All seed runs require delivery of stability plots including those outlined within Figure 43 and Figure 44.

The selected seed value that has been run for the base model should be used consistently throughout the modelling investigation as it continues into option explorations. Additional seed values can be undertaken to explore matters relating to sensitivity and reliability. VicRoads does not require results to be provided as an average of all seed runs produced, albeit teams are welcome to deliver this.

Teams should ensure that the report produced clearly outlines the seed numbers used for one or more time periods simulated.

Change models do not require the application of seed values, but may be undertaken when exploring the propensity for flow breakdown within a complex network or with innovative design matters.

6.3.8. Stability Plots

In addition to the VHT and VKT model stability check for the evaluation period, a model consistency plot should be produced for 'number of vehicles in the network' and 'average speed'. These plots are to be produced at one minute intervals for the model run. The individual seed runs are compared against the median values and ideally should be within a desirable tolerance of 10% but cannot exceed a tolerance of 15%. Otherwise further exploration is required to understand the variation. This may involve refinement of model itself to resolve matters of reduced stability from the solution.

The image in Figure 43 identifies the variation of the model runs for the seven seed values listed within Table 26. These seven values are observed to have a good degree of consistency for each second simulated within the network model. However, note that one seed holds marginally more variation in the final 900 seconds of the run – which may prompt the need to review the matters in the model and resolve this issue. Note that this graphic does not include the warm up or cool down periods within this analysis.

To complement this image is a graph in Figure 44 to benchmark network wide journey speeds in the model for each second of the simulated period. The graphs aims the visually support the matters of network consistency between the varied seed values applied within the simulation modelling. This in turn will suggest that the model is well calibrated to address the matters experienced by drivers within the network, from the data collected and the work undertaken by the modeller.

Teams should be able to deliver the "number of vehicles" plot to showcase the stability of the model run within the report for any investigation. Discussion around this measure should include the variance that occurs from the median seed at any one time (i.e. no more than 8%) and identification. Modelling teams are welcome to discuss changes made in the networks developed (those objects revisited) to showcase efforts undertaken to achieve this scale of consistency between seed runs.

It is important to note that the design requirements of selected briefs to meet the delivery of 95th percentile traffic estimations does not refer to the confidence levels of the model stability. Rather, this needs to be read in the reference of delivering for matters of seasonality in future year conditions, as outlined within Figure 29. That is to ensure that the design requirements are met for at least 95% of the daily traffic conditions while accounting for the seasonal changes that occur. However, for major and significant infrastructure deliveries the requirements for design and network resilience may be that the planned infrastructure can deliver on irregularly high traffic flows outside of the standard expectations.

Figure 43: Number of Vehicles in the Network for Each Seed Run (Cumulative Through Simulation)

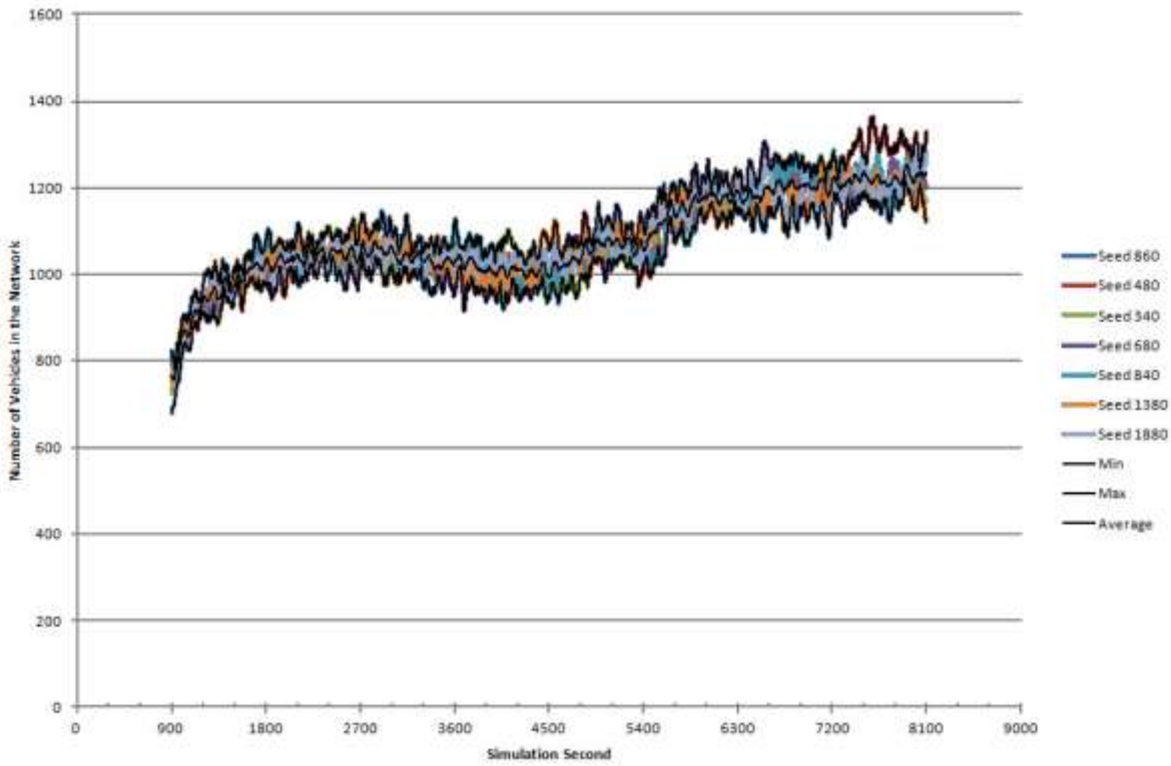
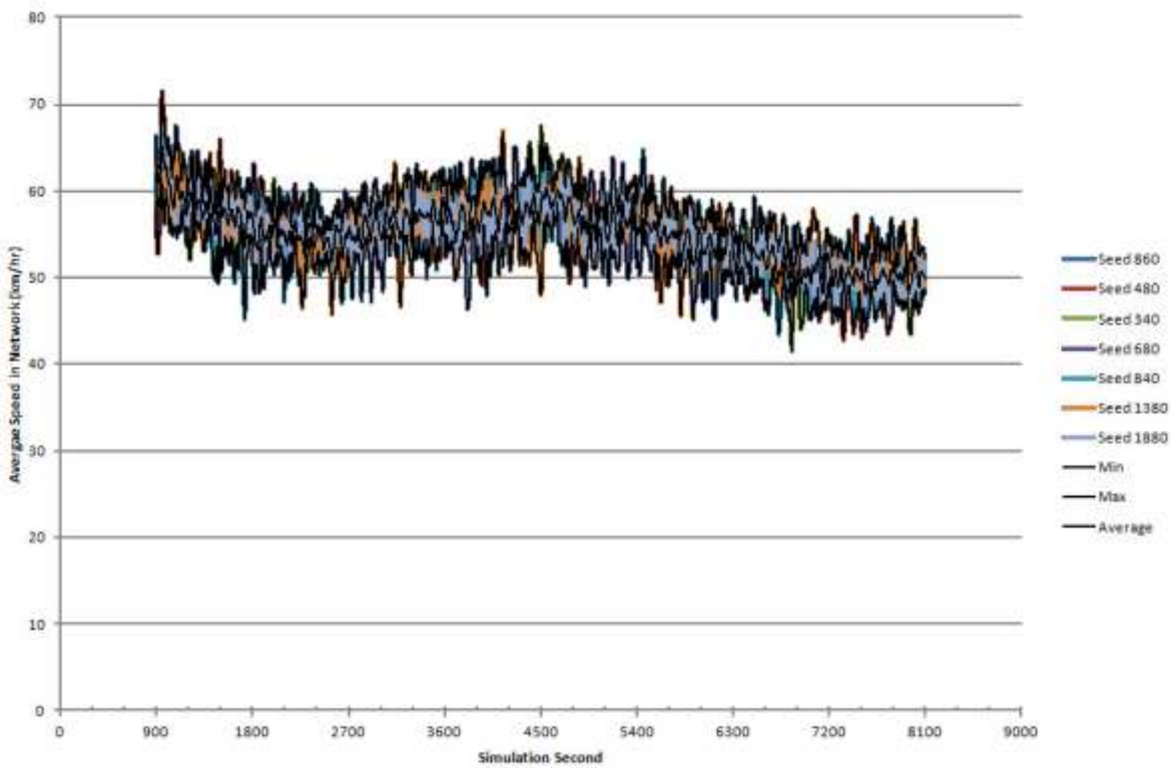


Figure 44: Average Speed in Network for Each Seed Run (Cumulative Through Simulation)



6.3.9. Latent Demand (Unrealised Journeys)

Through the development of the base model and into scenario testing, there is a critical element that needs to be considered specifically for simulation modelling. This element relates to the unreleased trips (also called latent demand) and is common in congested conditions especially for future year testing where the network may become oversaturated.

This situation describes those vehicles which are unable to enter the modelled network, typically due to localised congestion near the point of release. As these vehicles sit outside of the modelled network for some of (and occasionally all of) the simulation period, the unrealised potential travel distance and travel time relating to their desired trips are not fully reflected in the various metrics produced such as network wide outputs (i.e. vehicle hours travelled (VHT), vehicle kilometres travelled (VKT) and number of stops).

In addition to these metrics journey time and intersection performances may be misrepresented from the inadequacies of the demand calculations used in the investigation.

As a result, incorrect conclusions can be drawn from the results of modelling runs especially into future year modelling where different levels of latent demand exist. In order to permit modelling results to be used credibly and effectively for project selection, justification, optimisation and prioritisation, it is imperative that latent demand be addressed so as to ensure 'like with like' comparability across different scenarios. The stability check is one method that attempt to address the presence of latent demand with the simplest method is to extend the network boundary.

Network models that are understated or models that use strategic demand estimates that have not been refined through a capacity constrained method are more likely to experience these conditions.

Base year network models (excluding scenarios) should ensure that the volume of unreleased demand is minimised in the evaluation period where achievable. This can be accomplished by either:

- revising the demand estimates, or
- exploring the constraints within the simulation model, or
- by enhancing the extents of the network model.

Note that the option to extend the model to address this matter will also involve additional calibration tasks that complement this refinement (i.e. route choices, driver behavioural elements etc).

The following two thresholds are applied for the evaluation period with all models:

- Each zone with a demand estimate above 1,000 vehicles per hour should have an unreleased proportion of no more than one percent of the demand estimate; and
- Zones that release less than 1,000 vehicles per hour can acceptably constrain less than two percent of the demand figure.

In all cases the modelling team behind the investigation should aim to explore measures to set this unreleased demand to a zero figure in the baseline models. Note that these matters need to be documented within the report including both location and zone volume per hour in the evaluation period.

Simulation models should ensure that the volume of unreleased demand is tabulated to showcase the demand estimates from the matrices as well as the locations where this latent demand is generated from. Table 27 provides an example from a small simulation model of only eight travel zones whereby one travel zone has a small but overstated volume of unreleased vehicles. As a part of the narrative into the model development, teams should include snapshots from the screen at the end of the peak hour or period to demonstrate the simulated experiences in the network.

Table 27: Unreleased (Latent) Demand Report (example)

Zone Number	Location	Approach	Demand (Matrices)	Unreleased Demand (veh)	Percentage Unreleased	Compliance
1	Centre Rd	Eastern	447	6	1.3%	Yes
2	East Boundary Rd	Southern	122	2	1.6%	Yes
3	Tucker Rd	Southern	282	3	1.1%	Yes
4	Jasper Rd	Southern	379	2	0.5%	Yes
5	Centre Rd	Western	322	4	1.2%	Yes
6	Jasper Rd	Northern	317	3	0.9%	Yes
7	Tucker Rd	Northern	303	6	2.0%	No
8	East Boundary Rd	Northern	326	3	0.9%	Yes
Total			2,498	29	1.2%	

An alternate approach is to review the demand volumes that have entered the network at the cordon of the model extent through consideration of the volumes that did enter the modelled landscape.

6.3.10. Public Transport

Public transport solutions are commonly included in urban modelling investigations with varied modes available in Melbourne, including trains, trams and buses. These public transport systems are usually connected to one another to improve passenger connectivity and service operation. In many cases public transport will have some form of priority in the network. This may vary from phase priority at signalised intersections though to dedicated lanes on key corridors. To effectively model public transport, the modeller needs to explore a number of considerations that may include service dwell time, arrival patterns, stop utilisation and journey speeds.

In addition to these topics listed, simulation models may also need to consider those service runs in the public transport networks that do not carry passengers. Typically these “dead head” services operate a movement of rolling stock to change the geography of the commencement of the service.

6.3.10.1. Stop Allocations

Stop positions are a very important element in operating public transport services as they administer the locations for passenger to both board and alight the rolling stock. It is important to identify the actual site position of the stop and observe the behaviour of service stopping patterns. Service operations routinely are achieved when the service sits within the stop location. However teams should explore and consider the arrangements for stopping patterns if a second (or additional) service pulls behind the initial route. It may be that the second service provides for un/loading of passengers with only the front of the rolling stock within the stop declaration, or alternatively the service may wait until at the front of the allocation before commencing this task. Teams should explore the local operations for any investigation to match the operating conditions observed. Such measures should also note the specifics of the rolling stock which may impact on the stopping arrangements.

When developing a new site or set of stopping locations, the modelling team should investigate similar locations (bus station, tram stopping area etc) to identify nearby experiences that might be reproduced on site.

6.3.10.2. Dwell Times

Dwell times are the period of time that a public transport system requires to stop at a designated public transport stop. Dwell times may be a function of demand or a function of alighting and boarding but may vary by rolling stock capabilities used on the service. Other factors to consider are timed stops due to driver changeover or schedule compliance.

Survey information provides good insight into how each public transport stop operates as well as automatic counts that are fitted on new public transport fleets. Dwell times for on-road public transport can be a critical influence on traffic flow due to lane blockage whilst dwell times for off-road public transport can be a critical influence on traffic flow due to public transport priority at signalised intersections and level crossings.

The collection of public transport dwell times can come from passenger journeys and mobile phone apps that position the person on the service. A review of this data can then identify the precise times (to the second) that the service accelerates or decelerates to/from the stop, as well as time spent at the stop.

VicRoads would typically expect that the public transport dwell times applied are derived from empirical solutions. A tabular comparison of observed dwell times with the modelled dwell times is required to explain the formation of the dwell time applications. It is expected that a review of empirical dwell times will be used to formulate at least three variations of dwell time solutions for each investigation (a nominal dwell time, a long dwell time and a midrange dwell time). It is not correct to lump these results together into one set of dwell times for application to all service stops.

There may be times when public transport service dwell times may be extended beyond typical conditions due to full utilisation of the service. That is, some or all of the passenger demand is restricted from boarding the service due to the absence of available space. Under such conditions the further delays and frequency of such a situation needs to be recorded within the data collection process. The simulation modelling may need to recreate this measure that passengers are not able to board the first service on the route.

6.3.10.3. Arrival Patterns

The arrival pattern of public transport can be surveyed or extracted from timetable schedules. The detail of schedule provide for a good measure to determine when the public transport services should enter the simulation network model. However, VicRoads preference is that observations from the service performances are recorded and used for the simulation modelling rather than a planned expectation.

Timetable schedules should always be checked against site operations and performance metrics from public transport operators. Arrival patterns for public transport can be a critical influence on traffic flow due to public transport priority at signalised intersections and level crossings.

In all cases the observed conditions should be applied rather than the scheduled settings. However if the observed settings are not suitable for input to the simulation model, perhaps due to external factors (e.g. downstream road crash impacts capacity and hence arrival times and service headways) then the data should be considered invalid for application. Service patterns from another service date (subsequent day) should be applied within the network operations.

A comparison of observed or scheduled arrival times with modelled arrival times is required for the development report to help to develop the narrative of the existing landscape.

Simulation modelling also provides a means to consider variance on the planned introduction of the service into the network. This should be applied where appropriate subtle changes using the mechanics provided within the tools at hand.

6.3.10.4. Skipped Stops

Some solutions allow for public transport stops to be skipped in the simulation if the individual service is full and there passengers do not intend to alight at that location. Skipped stops can be determined from the surveyed undertaken for arrival patterns or should consider the function by which dwell time is calculated. Some stops may be utilised at different periods of the day as evident for buses and trams on the network.

A comparison of observed skipped stops with modelled skipped stops is required based on project definition.

By comparison, investigations should also explore conditions (including frequency and service numbers) whereby passengers cannot board the first service that arrives. This may be due to the occupancy of the service and/ or volume of passengers that wish to board the service. Where observations are conducted teams should also provide some reference to the rolling stock used for such services.

6.3.10.5. Journey Speeds

The journey speeds of public transport can be measured on site using GPS loggers and trackers or extracted from new public transport fleets. Journey speeds between stops can vary significantly due to the proximity of stops to one another and the awareness of public transport operator on whether a stop is occupied (more applicable to bus operation). Journey speeds may vary by rolling stock and terrain as well as passenger occupancies along the corridor.

A comparison of observed journey speeds with modelled journey speeds is required based on project definition.

6.3.11. Other modes of transport

6.3.11.1. Bicycles

Bicycles may be an important consideration in the model, as per the directions of the project definition. Vehicle behaviour should reflect the interaction with bicycles especially at junctions, noting legislation changes such as one metre lateral clearance. Bicycles have varying behaviour traits compared to vehicles and pedestrians and can respond to conditions in a more lateral perspective.

Site specific behaviour should also be considered including the movement on on-road and off-road facilities, interaction with other modes and compliance to road rules. In addition, bicycle movements at signalised intersections are critical due to some signal controllers having priority for this active transport system. Evidence based calibration of bicycle movements and the environment around is required.

In all cases where an on-road bicycle lane comprises a part of the area of investigation, the mode specific infrastructure must be coded into the network. Formation of bicycle demand can be developed through either trip tables or from a form of designated route. However the evaluation of suitability for cyclist throughput should be conducted as a separate measure from that of general traffic flow. Demand figures (both observed and modelled cyclist volumes) need to be tabulated and presented in a report, ideally accompanied with a GEH calculation.

6.3.11.2. Pedestrians

Pedestrians are another active transport system that can be an important consideration in the model based on the project definition. In many simulation models, pedestrian movements will affect traffic flow through the operation of signalised intersections or midblock locations based on the number of phase calls and allocated crossing time. The reverse is also true where an increase in traffic activity has an impact on pedestrian movements.

Pedestrians crossings may also include puffin operations thus improving the ability to manage crossing time intervals. The objective of Puffin operations is to ensure that sufficient crossing time is available for pedestrians by monitoring and extending the presence of pedestrian times along the crossing.

In addition, pedestrians may also impact on traffic flow operation in areas of public transport boarding and alighting as well as other non-controlled crossings such as zebra crossings. The impact from pedestrians will always vary depending on the location and size of groups experienced on site. The driver behaviour should reflect the interaction with pedestrians at such uncontrolled locations or situations.

It may be the case when simulating pedestrians that the key focus is not about the volume of persons at the crossing, but actually on the quantified impact on traffic movements/ or signal operations on site I.e. how much delay on traffic comes from the pedestrian crossing at the signalised intersection. This information may need to be collected through video surveys.

Pedestrian simulation modelling should be considered to answer specific questions around space, movement and public transport interaction. For further considerations and calibration and validation criteria refer to section 9.

6.3.12. Journey Impedance

Journey impedance is an important consideration when understanding route choice and assignment considerations in simulation models. This measure may be used to better advise on the routes considered by drivers in the networks investigated, given the myriad of data sets collected. Traffic assignment models are fundamentally determined through measures of journey impedance and provide a measure of consideration before the introduction of a change to this metric – typically either through more journeys (an increase in demand pushing through) or the delivery of an additional constraint (change to the network supply).

Journey impedance can be measured in several ways with some simple and common ways is to use either actual travel distance or travel time between origin and destination zones (travel zones) or applying a ‘generalised cost’. A ‘generalised cost’ is a weighted combination of route choice matters (distance, time, tolls etc) and is used to determine route attractiveness or the effort of the journey. Although difficult to accurately calculate through observations, a series of proxy measures (volumes, journey times) are used to reflect the decisions experienced by motorists within simulation models.

Some costs that may need to be considered may include value of time, vehicle operating cost rate to travel time and travel distance and toll fees. Industry has access to various data on observed journey experiences through measures such as such as Bluetooth, Wi-Fi, mobile network and GPS probe. This data should be considered when investigating journey impedance and calibrating route choice against these known datasets is required based on project definition.

Detailed simulation modelling of traffic and transport operations may also need to explore non-linear factors that contribution to the journey impedance. Such factors that can inhibit traffic flow in local areas may include the movements of freight and goods vehicles including those of deliveries. Service based journeys may contribute to the local landscape as a chain of trips or a less optimal movement than through traffic may intend to pursue.

6.4. Volume Confirmation

Many guides and manuals may refer to observed volumes as counts, which in the context of the simulation modelling guideline can be an interchangeable term. Traffic volumes tend to provide a core metric in comprehending operational and design considerations from models. Traffic volumes help to build a narrative about user perspectives. However from an engineering perspective this provides a readily accessible and quantifiable indicator. While traffic volumes are a measure of notable consideration, this is not the only metric to be considered in the project narrative.

6.4.1. Benchmark Metrics

The most readily available and accepted method of undertaking calibration of traffic volume is through the GEH calculation.

The GEH is an empirical calculation used in traffic modelling to compare two sets of traffic volumes. This calculation is loosely based on chi-square measures that are used to derive correlation figures. The strength of the GEH computation is that this equation considers both absolute and proportional differences in flows. The GEH calculation is formulated as follows:

$$GEH = \sqrt{\frac{(observed - modelled)^2}{0.5\ \times\ (observed + modelled)}}$$

Note that the GEH index is not a statistic (not based on probability) and does not have a unit of measurement. It is just a calculation.

In general, the GEH index is less sensitive to the above statistical biases since a modeller would probably feel that an error of 20 in 100 (i.e. 20% error) would be roughly as bad as an error of 90 in 2,000 (4.5% error). The comparison of both estimates would develop a GEH calculation near to the value of 2.0.

Values that are close to zero infer a closure match between the observed and modelled values. The following key metrics take hold in evaluating such calculations of assigned volumes with observed flows:

- Estimates that produce a GEH index of 5.0 or less are categorised as an acceptable fit;
- A calculation that produces a metric of 2.0 of less is desirable (aspirational) to better reflect the constraints of complexities of the simulation model. This typically provides a better step into the model validation against journey times;
- Any GEH calculation greater than 5.0 would require further attention and scrutiny including a revisit as to why there are such differences between the modelled and observed values. This should include discussion in the documentation on how these conditions have occurred; and
- A value above 10 (core area) and 12 (periphery) identify an unacceptable result in the model to reflect the observed network observations.

The metric of a GEH index less than 2.0 is listed here as an aspirational target as the model purpose is to comprehend the cumulative constraints within a landscape of the investigation. This is an appropriate direction for delivery of simulation models whereby the focus of model development is to encapsulate those factors that inhibit traffic flow.

Critical locations of the network modelled need to be discussed within the narrative of the documentation, irrespective of their observed or modelled throughput figures.

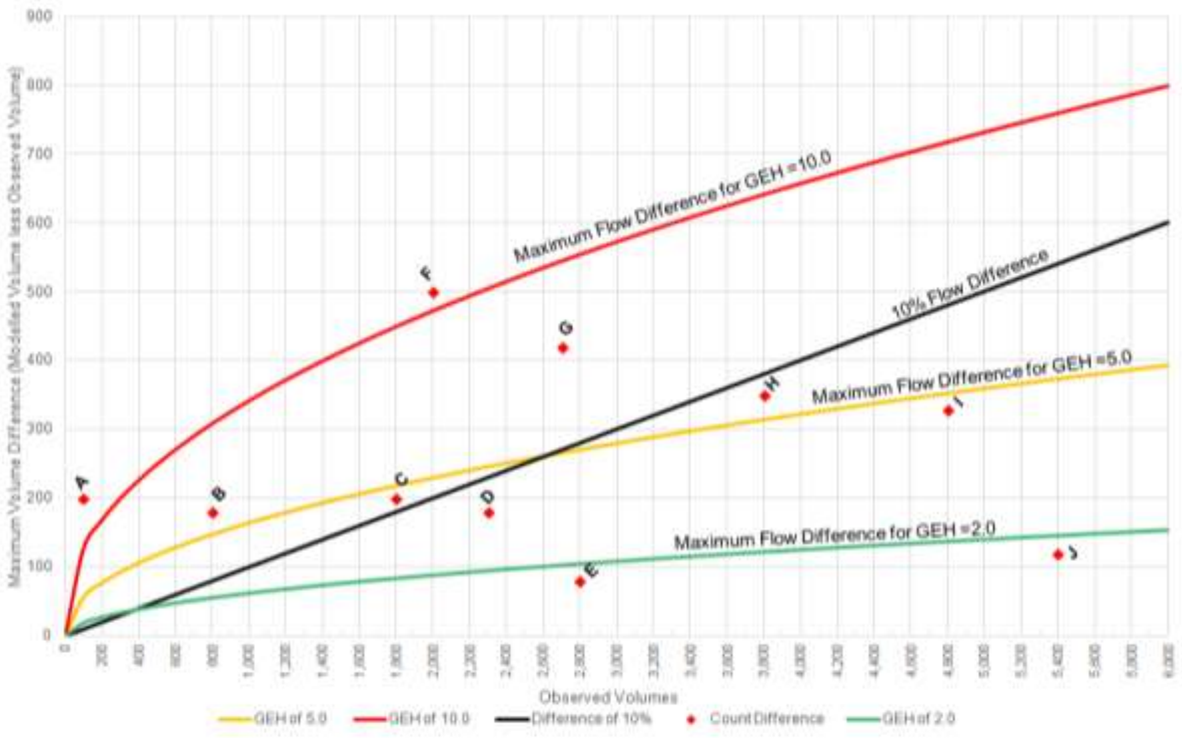
The measures for the GEH calculation hold a built in sway towards low count volumes, given that the absolute differences between such numbers are (by default) close to each other. For this reason any GEH calculations conducted for use of a time period smaller than a one hour interval should apply factored volumes to present as an hourly equivalent. That is a ten minute count of twenty vehicles should then be analysed as if it were a volume of 120 vehicles per hour (six intervals times the count volume).

6.4.2. Methods of Evaluation

The value of this approach to use the GEH calculation can be seen in Figure 45. This image showcases the difference between the absolute difference and GEH when observed flow is compared against the residual in the modelled result. The data in Figure 45 and the associated Table 29 interpret the various scenarios between adopting a percentile flow difference and GEH calculation.

To better showcase the significance of Figure 45, a total of ten points have been selected to assist in showcasing the suitability of data requirements when benchmarking results. These ten locations on the graphic have been labelled as points A through to J and comprise both a modelled and observed volume, as well as absolute and percentage differences and the GEH calculation. For each of the ten points, the three GEH bands of values set at 10.0, 5.0 and 2.0 as well as a measure of the 10% flow variation are held in context. The ten percent variation figure is not applied to simulation modelling pursuits and only used here to showcase the significant of the remaining benchmarks.

Figure 45: Suitability of Modelled Differences (by GEH)



Point A identifies that the volume at this location is not similar to the observed count, as the data points sits beyond the red band of the GEH 10.0 threshold. This count location will not achieve an acceptable measure for analysis and needs to be further revised in the model prior to acceptance. Point B is below this red band, but above the gold band of the GEH 5.0 threshold. Note that this measure is greater than the 10% flow difference (black line) but is still categorised as worth a review before agreement in the network.

Point C is below the GEH 5.0 threshold but above the 10% flow difference line indicating that this GEH figure needs to be held in the appropriate context. A percentage difference may have little impact on the GEH figure, despite the suggestion of variation from the observed traffic count. By comparison Point D is nearby and sits below both the gold GEH 5.0 line and the black line of the 10% flow difference figure. While both points C and D are acceptable, point E reflects the desirable (aspirational) condition in order to achieve a better match with journey time metrics. The above points of A-D relate to the scale of volume that would be a difficult match when exploring other measurables.

Another set of data points for comparison of the datasets also sit within Figure 45. In this case it can be seen that although the volumes are much greater, there are clear comparisons between Point F and Point A. Both items sit outside the GEH 10 threshold and are not considered to be an acceptable check of the modelled volume to that of the observed (empirical) dataset. Point G is similar to Point B as both values sit above the GEH 5.0 index but below the GEH 10.0 estimate. It is interesting to note that both figures fall well outside the 10% flow variation but still land within the scale of a need for a review before determining the appropriateness (suitability) of the modelled results.

Point H lies within the 10% flow difference threshold but still lies outside the GEH 5.0 line which identifies that the condition should be reviewed before categorised as acceptable. In this graphic Point I is located nearby to Point H but below both the black Flow Difference line and the gold GEH 5.0 threshold. Under such existing guidance within this manual Point I would be categorised as an acceptable flow.

By comparison, Point J remains a more desirable solution to better match the traffic flows and be positioned below the green GEH 2.0 threshold. A traffic modelled throughput volume that is typically better located solution to match against the observed conditions of the corridor or network journey times experienced from the data collection process, which in turn provides for a reduced risk consideration when examining prospective future year demand considerations.

A further example is provided within Table 28 which explores the absolute scale of error from a rounded hourly volume. In this table it can be viewed that an absolute error of 27 vehicles from an observed volume of 200 vehicles would generate a GEH calculation of 2.0 (13.5% error). By comparison an error against this observation by 65 vehicles would produce a relative error of 32.5% and a GEH calculation of 5.0.

Table 28: Examples using a GEH calculation

	where GEH = 2.0			where GEH = 5.0			where GEH = 10.0		
Observed (veh/hr)	Modelled (veh/hr)	Absolute Error	Relative Error	Modelled (veh/hr)	Absolute Error	Relative Error	Modelled (veh/hr)	Absolute Error	Relative Error
100	81	19	19.0%	56	44	44.0%	22	78	78.0%
200	173	27	13.5%	135	65	32.5%	81	119	59.5%
500	456	44	8.8%	394	106	21.2%	300	200	40.0%
1000	938	62	6.2%	848	152	15.2%	708	292	29.2%
2000	1912	88	4.4%	1783	217	10.9%	1577	423	21.2%
3000	2891	109	3.6%	2732	268	8.9%	2477	523	17.4%

Similar measures are identified within an observed flow volume of 2,000 vehicles an hour whereby an error of 217 vehicles would produce a GEH calculation of 5.0 at more than 10.9% variation from the empirical metric. By comparison the error of 423 vehicles would achieve a 21.2% relative error and be classed as a GEH index of 10.0

Table 29: Details of Selected Points from Figure 45

Scenario	Observed	Modelled	Absolute Difference	Relative Difference	GEH	GEH less than 10.0?	GEH less than 5.0?	GEH less than 2.0?	Count within 10%[5]	Interpretation
A	100	300	200	200%	14.1	No	No	No	No	Reject comparison
B	500	680	180	36%	7.4	Yes	No	No	No	Needs review but not acceptable as yet
C	1,800	1,600	200	11%	4.9	Yes	Yes	No	No	Acceptable comparison
D	2,300	2,480	180	8%	3.7	Yes	Yes	No	Yes	Acceptable comparison
E	2,800	2,880	80	3%	1.5	Yes	Yes	Yes	Yes	Desirable comparison
F	2,000	2,500	500	25%	10.5	No	No	No	No	Reject comparison
G	2,700	2,280	420	16%	8.4	Yes	No	No	No	Needs review but not acceptable as yet
H	3,800	4,150	350	9%	5.6	Yes	No	No	Yes	Needs review but not acceptable as yet
I	4,800	4,470	330	7%	4.8	Yes	Yes	No	Yes	Acceptable comparison
J	5,400	5,280	120	2%	1.6	Yes	Yes	Yes	Yes	Desirable comparison

[5] Only a measure for comparison of data, but not a measure used for analysis of the model suitability

6.4.3. Reporting the Differences between Volume Sets

The information provided about the GEH calculations should be in both tabular and graphical form, illustrating how the volumes fit with the GEH criteria. Analysis within this space should predominantly be directed to turn volumes rather than link volumes within the network models. This remains one of the more important reporting mechanisms so that VicRoads can identify the risks within the network model prior to exploring the change model. The principles are defined for a review of traffic volumes within the simulation models as follows:

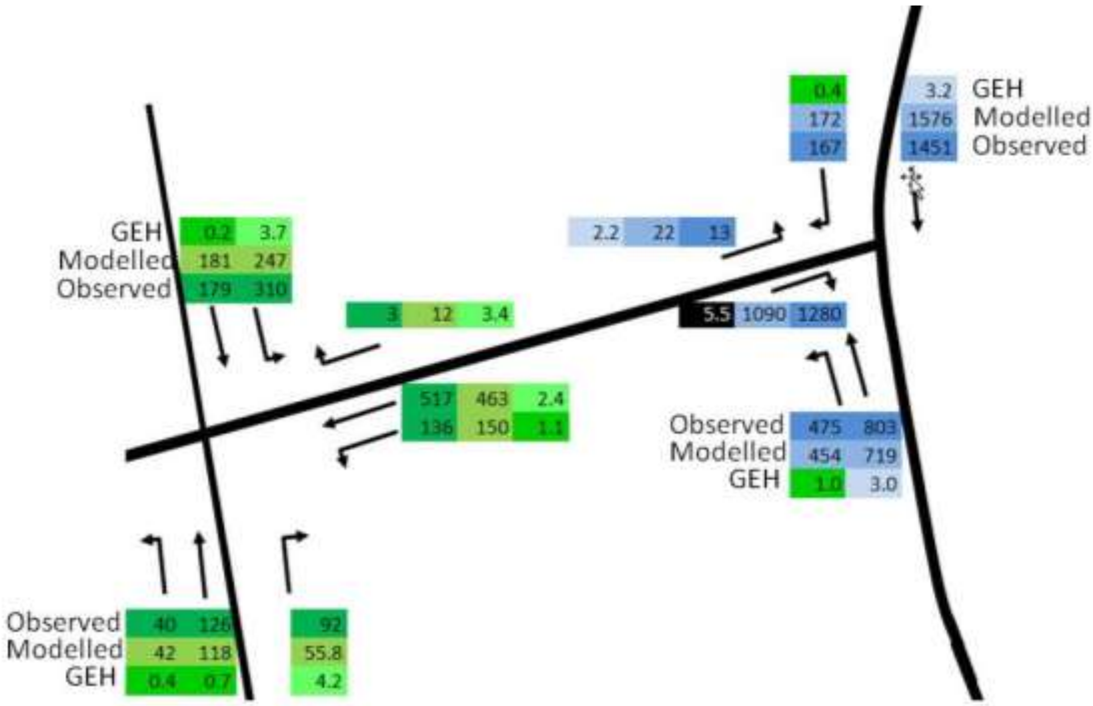
- GEH figures do not require more than one decimal point;
- Volume difference in both percentage and absolute for each turn (and link where provided);
- One table should be provided for each time interval with observed and modelled volumes for each turn (and for each link where provided). Turns (and links) should be appropriately labelled so that the reference point is clearly identified. This may involve street names, compass reference of the approach and/or the corresponding perpendicular street names. Approach directions are preferred (e.g. Western Approach) rather than the movement of journeys (e.g. westbound flow) as this can be ambiguous;
- Volume comparisons within the core of the model should sit at the top of the table, with the sites explored in the periphery listed at the bottom of the table;
- GEH calculations should be provided alongside the volumes, with GEH value highlighted based on the GEH value: Green less than 5.0, Amber between 5.0 and the 10.0/12.0 threshold with values greater than this limit in red or black;
- Core area on the top of the table and periphery area at the bottom of the table;
- Turns and links that carry observed volumes of more than 50 vehicles per hour need to be included in the GEH benchmark table. Any turns and links with a volume of above 50 vehicles per hour that are not included within this analysis need to be justified within the narrative; and
- Critical locations of the network modelled need to be discussed within the narrative of the documentation, irrespective of their observed or modelled throughput figures.

A schematic display of turn comparisons, with GEH calculations (as per Figure 46) is required to outline how the network performs within locations across the network. This regularly assists stakeholders to comprehend the suitability of the network developed for the investigation. This mapping process also assists the stakeholders to comprehend if the risks being obtained from the model development are likely to be applied to highway or arterial or to local roads. Such measures are often lost (hidden) within a tabular delivery context, which involves an extensive process to identify numbers and operational matters.

In this example the diagram holds three values of the observed count, the modelled volume and the GEH calculation. This example holds turns values in blue and green cells as different intersections or approaches to alleviate queries for stakeholders (colours have no meaning). However, the GEH calculations are conditionally coloured to showcase the scale of suitability between the two datasets. Typically green indicates suitable measures while red suggests greater alarm for further exploration.

Reports are expected to provide a map to showcase empirical and modelled turn volumes of the validated model as well as corresponding GEH metrics. These mapped evaluations can be directly sourced from the model or provided as a schematic, but need to be clear for stakeholder interpretation of the results.

Figure 46: Schematic Display of Turn Comparison and GEH Calculation within Network



A summary table needs to accompany the GEH comparison to outline the total percentage of links (and turns where provided) that have met each category of criteria.

The minimum benchmarks achieved are outlined in Table 30 as follows:

Table 30: Benchmark Thresholds for Volume Suitability

	Core	Periphery
Proportion of counts with a GEH of less than 5.0	90%	80%
Maximum Acceptable GEH Calculation for 100% of count sites	10.0	12.0

The delivery focus of simulation models are directed to the definitive movements within the core of the model, that provide the reason for conducting the investigation in the initial context. These elements need to be delivered suitably to understand the matter at hand. Note that this task of professionalism is not simply to deliver a graph or a table of matching volume numbers, but to provide appropriate scale of delivery that the modelling matters to date have explored and understand the operational challenges on site. This provides a baseline for progressing the modelling forward to understand how the advisory services applied will deliver a difference to the transport systems.

The modelling guidelines provide for less specification within the peripheral areas of the simulation modelling conducted. Benchmarks around definitions within the study areas need to be applied, including considerations for high volume locations as well as existing bottlenecks that may be responding to the proposed revision in the transport network.

To assist with the analysis of the traffic model to match the throughout measures obtained through data collection, the following (modified) metric initially developed from the UK Design Manual for Roads and Bridges (DMRB) has also been found to provide value in analysis. Investigations should be able to benchmark comparisons between datasets as outlined within Table 31.

Table 31: Categorised Count Comparison measures for benchmarking modelled results.

	Observed Count (vehicles per hour)	Acceptable Range
Category 1	<100	Within 30 vehicles per hour of observed
Category 2	100-700	Within 50 vehicles per hour of observed
Category 3	700-2700	Within 15% of observed of observed
Category 4	2700+	Within 400 vehicles per hour of observed

These metrics should be achieved for at least 90% of the turn locations for all parts of the core of the network modelled and at least 80% of the periphery of the network in order to progress the modelling investigation.

Models that have a well defined demand matrix and favourable GEH metrics should not have difficulty in achieving these benchmarks. Models that cannot achieve this scale of performance should be revisited for matters of data collection, or model calibration or the value in developing as a model with heterogeneous characteristics of the drivers. A model that cannot achieve these benchmarks should not proceed to explore project options for the current or future years.

A table of turn volumes should be provided either within the content of the work or as provided in an Appendix to explore the accuracy of individual turns. This measure will provide a comparison of modelled and observed volumes as well as providing for GEH calculation and absolute and relative differences. The GEH calculation should be colour coded to highlight the scales of accuracy in the network model.

Statements should be provided to discuss for both the Volume category and the GEH calculation suitability to benchmark the model formation against the observed traffic volumes. An example of this is provided within Table 32. However, note that the location or approach locations should be suitably defined by text.

Within these tables there is a sometimes a preference by transport modellers to list the movements within the intersection with a directional element. References of the approach are strongly encouraged (e.g. Eastern Approach), while departure references (e.g. Westbound) are discouraged. This is merely a function of the multiple movements within selected intersections that are making the distinct movement towards that departure reference. I.e. there are westbound movements from all approaches not just from a single approach.

Table 32: Turn Flow Analysis for a one hour interval (example)

				Time Interval 7-8AM						
Location in the Model	Intersection	Approach	Turn	Observed Counts	Modelled Counts	GEH	Volume Difference (Abs)	Volume Difference (%)	Volume Category	Criteria Check
Core	Intersection 1	East Approach	Left Turn	181	203	1.6	22	12%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
			Through	1,158	1,160	0.1	2	0%	Category 3: 700 veh/hr to 2,700 veh/hr	Category 3 Met
			Right Turn	141	144	0.3	3	2%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
		West Approach	Left Turn	366	393	1.4	27	7%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
			Through	2,742	2,536	4.0	206	8%	Category 4: >2,700 veh/hr	Category 4 Met
			Right Turn	67	66	0.1	1	1%	Category 1: <100 veh/hr	Category 1 Met
		South Approach	Left Turn	56	79	2.8	23	41%	Category 1: <100 veh/hr	Category 1 Met
			Through	98	123	2.4	25	26%	Category 1: <100 veh/hr	Category 1 Met
			Right Turn	140	150	0.8	10	7%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
		North Approach	Left Turn	313	324	0.6	11	4%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
			Through	122	124	0.2	2	2%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
			Right Turn	54	55	0.1	1	2%	Category 1: <100 veh/hr	Category 1 Met
	Intersection 2	East Approach	Left Turn	224	223	0.1	1	0%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
			Through	1,225	1,495	7.3	270	22%	Category 3: 700 veh/hr to 2,700 veh/hr	Category 3 Not Met
			Right Turn	222	224	0.1	2	1%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
		West Approach	Left Turn	140	150	0.8	10	7%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
			Through	3,113	3,324	3.7	211	7%	Category 4: >2,700 veh/hr	Category 4 Met
			Right Turn	73	72	0.1	1	1%	Category 1: <100 veh/hr	Category 1 Met
		North Approach	Left Turn	327	375	2.6	48	15%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
			Through	221	172	3.5	49	22%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
			Left Turn	195	233	2.6	38	19%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
Periphery	Intersection	East Approach	Left Turn	54	67	1.7	13	24%	Category 1: <100 veh/hr	Category 1 Met
			Through	1,623	1,699	1.9	76	5%	Category 3: 700 veh/hr to 2,700 veh/hr	Category 3 Met
			Right Turn	105	112	0.7	7	7%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
		West Approach	Left Turn	285	325	2.3	40	14%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
			Through	312	435	6.4	123	39%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Not Met
			Right Turn	345	301	2.4	44	13%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
		North Approach	Left Turn	175	190	1.1	15	9%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met
			Right Turn	397	423	1.3	26	7%	Category 2: 100 veh/hr to 700 veh/hr	Category 2 Met

To complement the data in Table 32, two summary tables should be provided as a complement. This should sit within the main body of the report to highlight the benchmarking of the modelled volumes. The two tables are outlined below in Table 33 and in Table 34. Both solutions are derived from the data held within Table 32.

The data held within Table 33 is simply a summary of the volume categories as defined within Table 31. This table identifies the size each category (count) as well as both aggregate observed and modelled volumes. A GEH calculation is derived based on the differences between these two figures. Absolute and relative differences are also provided here.

The data held within Table 34 identifies the breakdown of accuracy measures by location and by suitability of the result. In this instance the summary table outlines that 95% of counts within the Core area and have achieved a GEH figure below 5.0. By comparison the peripheral area is at 88% suitability of the analytical evaluation. In both the core and the periphery segments there are no count locations that achieve a GEH calculation beyond the acceptable limit (10 for the core and 12 for the periphery).

The data in Table 34 also identifies that there is a single count location in the core are with a difference in the modelled flows of 22% from the observed. In this instance it is advised that the matters behind this discrepancy be reviewed before submission to VicRoads.

Table 33: Summary Table of Volume Categories (derived from Table 32)

Classification	Min Count	Max Count	Range	Count	Observed Counts	Modelled Volumes	GEH	Volume Difference (Abs)	Volume Difference (%)
Category 1	0	100	30v	6	402	462	2.9	60	15%
Category 2	100	700	50v	18	4,211	4,501	4.4	290	7%
Category 3	700	2700	15%	3	4,006	4,354	5.4	348	9%
Category 4	2700	∞	400v	2	5,855	5,860	0.1	5	0%

Table 34: Summary Table of Geographic Location and Calculations (derived from Table 32)

	Location	Count	Sum of Observed Counts	Sum of Modelled Volumes	Volume Difference (Abs)	Volume Difference (%)	Network Sample Within Acceptable Tolerance
GEH Less than 5.0	Core	20	9,953	10,130	177	2%	95%
	Periphery	7	2,984	3,117	133	4%	88%
GEH from 5.0 to Limit	Core	1	1,225	1,495	270	22%	5%
	Periphery	1	3,296	3,552	256	8%	13%
GEH above Limit	Core	0	0	0	0	0%	0%
	Periphery	0	0	0	0	0%	0%

6.4.4. Screenlines

Where screenlines are applied for the benchmarking of the modelled volumes, it is expected that analysis of screenline totals will be used. This may be applied to mesoscopic simulation models and larger micro-simulation models. For such an approach, it is expected that each individual screenlines will benchmark planned volumes against modelled volumes and produce a GEH figure below a set value of 4.0. Given the aggregate nature of screenlines, it would not be acceptable for any screenline to achieve a value above 8.0

Note that this comparison is to explore the sum of the planned traffic volumes crossing the imaginary line against what the model suggests may occur for the same designation. A volume of 5,000 vehicular journeys per hour across a screenline would need to produce a throughput in the simulation of between 4,720 and 5,300 vehicles to be within the baseline of 4.0. While the GEH index is a primary measure of analysis, each aggregate screenline volume should be within 10% off the observed count.

In addition to the aggregate analysis, individual crossing points within the screenlines should also be conducted through a GEH calculation to ensure that each crossing location has a scale of accuracy resulting with a figure below a 10.0 metric.

6.4.5. Further analysis

One technique to assist in exploring the suitability of the simulated volumes against those observed is to develop a scatterplot and present the findings in a linear diagrammatic format. This scatterplot can then showcase the suitability of the two traffic counts in the context of the GEH calculations. The scatterplot should list the observed volume on the base (x) axis with the modelled volume on the growth (y) axis.

Equivalent metrics should be able to showcase the suitability of the graph to the data requirements to model the observed conditions, based on quantified throughput (traffic counts). This material is useful to show the suitability to represent the empirical data, and sits well within analytical discussions, but remains a secondary measure to the schematic display which outlines suitability at each location.

The following key measures are required to as part of the development of a GEH scatterplot graph:

- Observed and modelled volumes are plotted as a scatter plot with GEH line and area for both GEH of 5.0, 10.0 and 12.0 tolerances displayed in green, orange and red colours respectively;
- Observed sites that that produce a GEH index greater than 5.0 should be labelled in the graphic;
- A slope equation and an R squared value to be included with plots with a slope of the curve between 0.9 and 1.1 and with an R-square value above 0.9;
- The line of best line (linear graphic) needs to intersect with the x-axis at zero as this analysis is a comparison of values, rather than development of a causal relationship;
- All sites from the survey with more than 1,000 vehicles per hour need to be benchmarked against the modelled results in the analysis; and
- A single graph is required for each volume category for each interval validated against i.e. a three hour model run should produce this equivalent graphic for each hour in the simulation period. , If the evaluation period is three hours than three separate intervals are compared.

The data held within Figure 47 identifies these sites fall in line with the above description, and this helps to build a narrative of the professional work conducted. However, this analysis is still limited within the scale and context that scatterplots can deliver. Indeed there are a range of traffic counts benchmarked against simulated volumes for which many of the sites are clustered together. By comparison, it is difficult to comprehend the volume of sites investigated as many of the dots overlap on each other.

Figure 47: GEH & Scatterplot Graph – All Counts (Example)

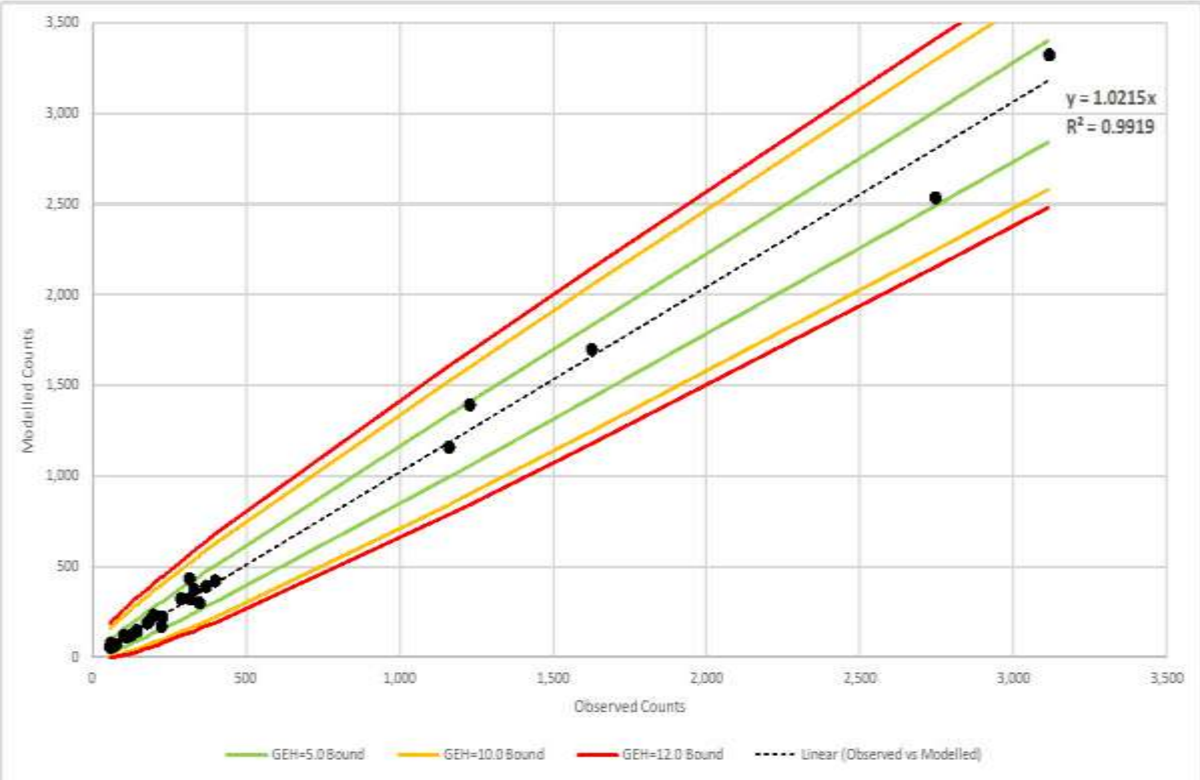
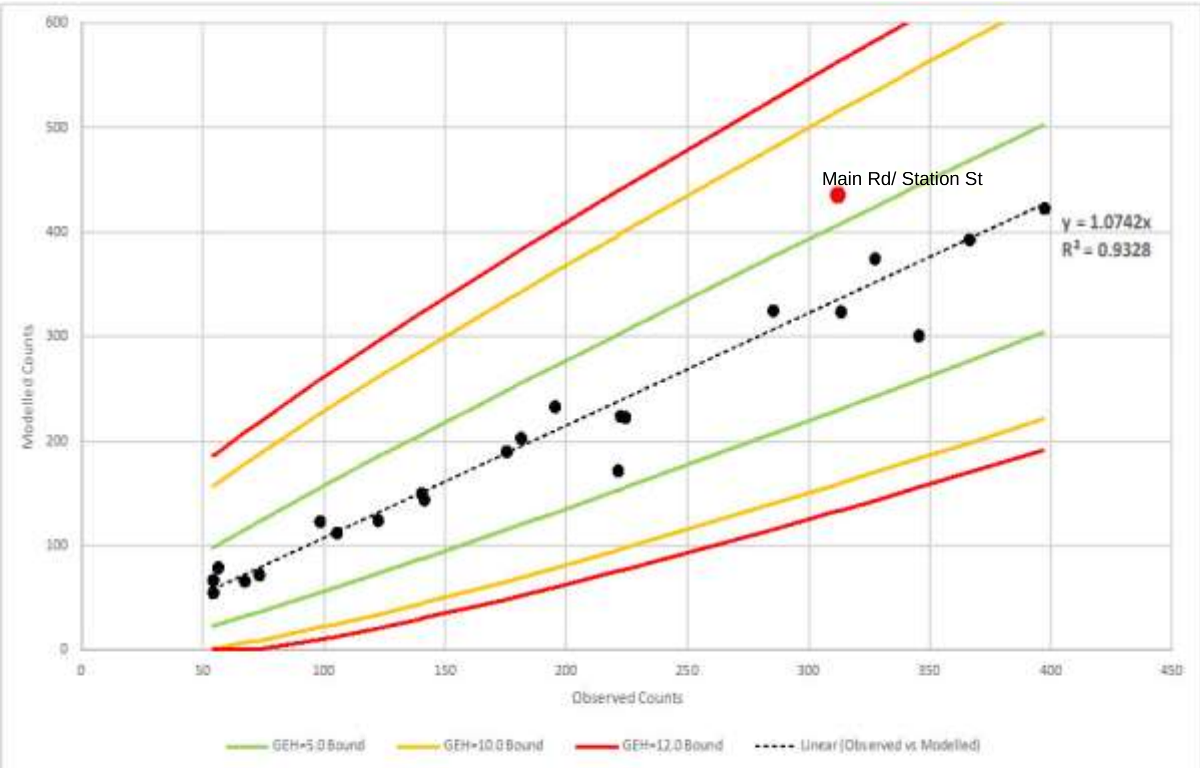


Figure 48: GEH & Scatterplot Graph – Category 1 Volumes Only (Example)



While these numbers align well to the expected deliveries of an investigation, the metrics sometimes do not align as well for individual pursuits. This analysis might identify a consistent performance or a suitable line of best fit. However, both metrics need to be provided to suitable scales in order to benchmark the quality of this solution for defining the current landscape.

Teams may wish to deliver this form of graphic for individual categories of counts (defined through Table 31) as a means to ensure that the cluster of observed counts in bottom left hand corner of the graphic have merit and are interpreted correctly. Again this may involve the development of several graphics to deliver the narrative and ensure that the model suitably reflects some conditions of the landscape being investigated.

Note that this approach may reduce the correlation value for higher volume locations, as the accuracy of these sites are typically anchored within a scatterplot by a smaller volume sites. The data held within Table 33 is presented as individual points in Figure 48 and identifies this metric for link volumes between 100 and 700 (Category 2). The figure provides for a similar scale of accuracy as displayed with the comprehensive dataset.

By comparison to the performance in Figure 47, the graph developed in Figure 49 explores the appearance of conditions of a good line of fit but does not deliver an acceptable solution. Simple cross checks between the observed count of 400 vehicles per hour shows that only 300 vehicles per hour were simulated. Although this rate of return is consistent, the slope of the curve understates the value of the modelling in this task. Figure 50 identifies a different pattern with a very good best line of fit, but achieves too much disparity across the benchmark with a poor correlation metric.

The red line presented within both Figure 49 and Figure 50 represents the perfect match of observed and simulation throughput. This line is only provided as a reference to benchmark the errors or slope and correlation within the diagrams.

The timing interval used for observed volume validation should consider the following principles:

- Volumes should be compared for hourly time periods in the model within the evaluation period. So, if the evaluation period is three hours than three separate intervals are compared using GEH;
- If there is a significant operational change within the hourly time period than a more granular time interval would need to be considered to show the volume impacts. An example could be a pedestrian crossing operating in full control in the first half hour to partial control (flashing yellow) in the second half hour. As a guide, 15 minute interval will be appropriate for level crossing investigations; and
- Warm up and cool down period may need to be investigated as part of the calibration process in a similar way to the evaluation period. This need to be determined during the project definition especially if the warm up and cool down periods impact the results of the evaluation periods (e.g. apply too much or too little demand in the warm up period to reflect the appropriate congestion at the start of the evaluation period).

Investigations should consider the volume of graphs (and graphics) provided on a single page so that the modelling efforts undertaken are not lost by the delivery of the narrative or presentation.

Figure 49: Scatterplot Relationship for Review #1

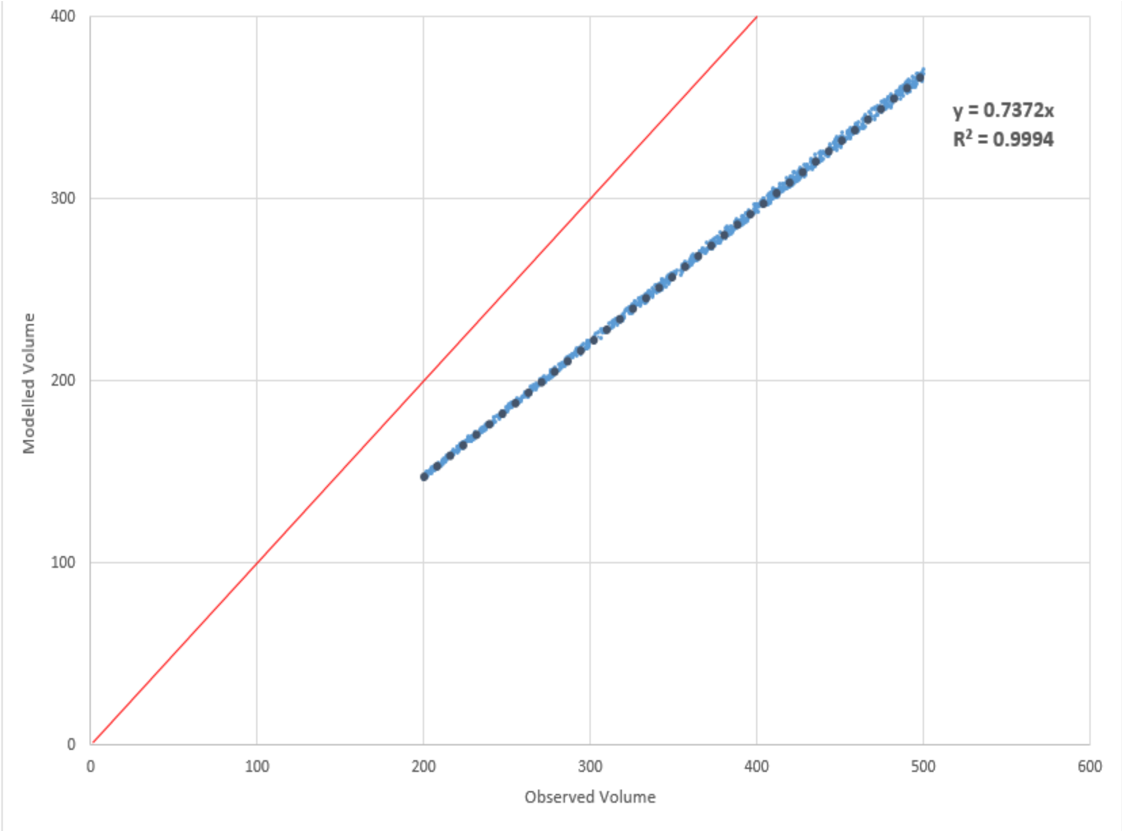


Figure 50: Scatterplot relationship for Review #2

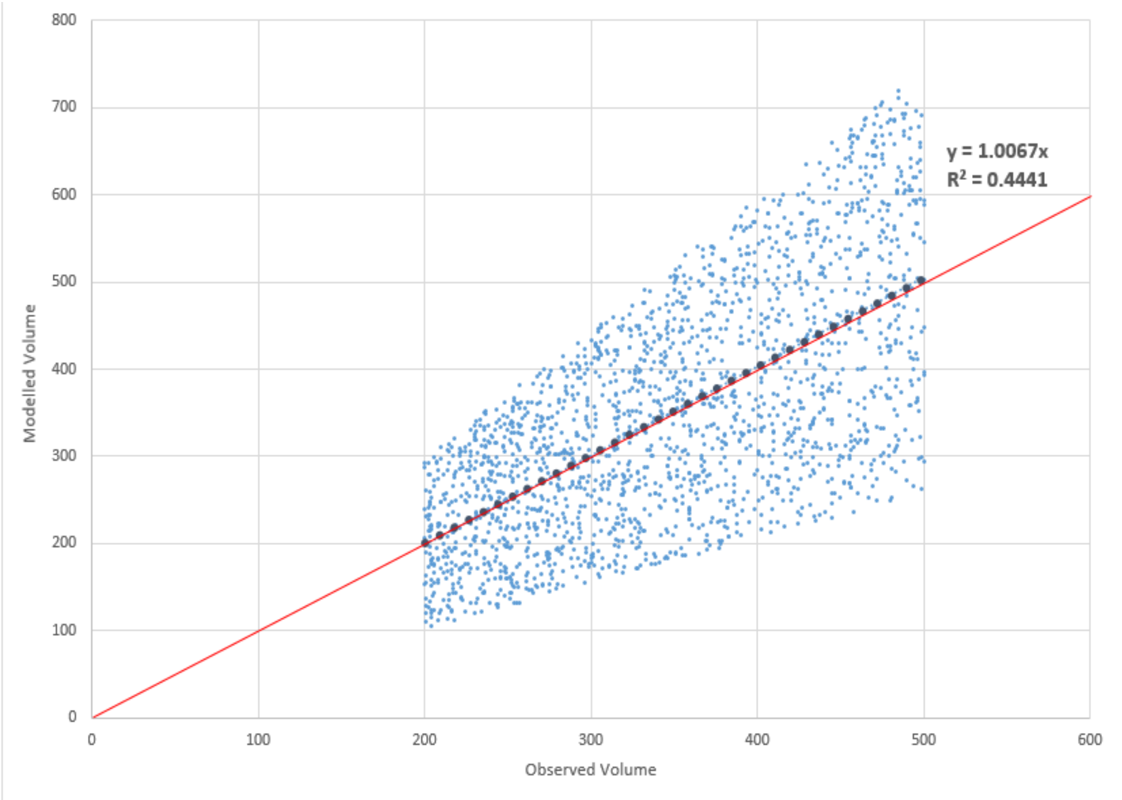


Table 35: Chapter Checklist for Model Calibration

Topics for Discussion and Reporting	Yes	No	N/A
Does the report explain the matrix development process and the key movements within the network?	☐	☐	☐
Does the report outline the total demand in the model, as well as the traffic composition for each time interval?	☐	☐	☐
Is there a map that clearly outlines the location of the travel zones provided within the report?	☐	☐	☐
How have internal zonal journeys been accounted for within the simulation modelling?	☐	☐	☐
The reporting and analysis should consider the demand and not just the throughput of vehicles at the locations within the network.	☐	☐	☐
The reporting should explain how the time period was developed, including those sites used to formulate general profiles, as well as specific departure or arrival profiles. Time profiles should be documented within the reporting.	☐	☐	☐
Does the model explain how the warm up and cool down periods have been developed? The derivation of the warm up period and successive time interval weights should be presented in the report. How have these measures for the warm up period been confirmed at the commencement of the evaluation period?	☐	☐	☐
How have traffic routes been determined within the modelling? What has impacted these decisions and what features have been applied to impact on the significance of these considerations?	☐	☐	☐
How much traffic is removed from the simulation due to coding matters? Where are the locations and how can this be reduced to a nominal volume?	☐	☐	☐
How have the intended journey speeds been determined within the simulation model? And how do these measures change at different locations of the network?	☐	☐	☐
What gap acceptance parameters have been applied throughout the network model to change the saturation flow at individual locations?	☐	☐	☐
Have the algorithms of the simulation modelling been applied to determine weaving and merging matters within the network or as the model been artificially adjusted to deliver a solution?	☐	☐	☐
How well do the designation of signal operations reflect the delivery from VicRoads? Reports should address signal plans and applied cycle lengths and phase splits.	☐	☐	☐
Are the known bottlenecks within the network reflected to the same scale within the simulation of this landscape?	☐	☐	☐
Is there enough direction to suggest there is stability in the model? How many seed values were run? What were they and what was the median seed number applied to generate results? What variation is there across a network plot of the number of vehicles or the average	☐	☐	☐

network journey speed between seed runs?			
How much traffic could not be released into the network during the evaluation interval due to matters of congestion?	☐	☐	☐
How well does the public transport network reflect the operational conditions of the landscape investigated?	☐	☐	☐
How well do the assigned volumes match the observed counts, through means of a performance measure such as GEH calculation? Has a table of results and a schematic display of the accuracy been provided within the report? Have the count measures also been checked against a revised DMRB configuration? Have appropriate summary tables also been provided in the report?	☐	☐	☐
Has a map of observed and modelled volumes been prepared for each evaluation period within the report?	☐	☐	☐
Do all GEH measures within the model sit below the defined upper limit for core or periphery conditions?	☐	☐	☐

7. Validation

The purpose of model validation is to confirm that the calibrated modelled elements within the simulation can produce performance metrics that closely represents the observed operational conditions. A model cannot be considered to be validated without appropriate reflection of these elements, despite what the benchmarked outputs may suggest. Observed counts are generally not utilised for model validation as they are an integral input into the model development process. Simulation models should be validated against another variable (quantum) rather than just another dataset or a split dataset.

Traditional discussion around model validation outlines suggestion of an independent data source. However, a more appropriate response is to use this metric to determine the risks of the model performance to suggest responses within a change model. Guidance around performance measures for model validation will indicate a success or failure of the model to represent the observed conditions, before projecting to a change or future year horizon.

In addition, partial validation or validation of forecasting outputs are not considered an acceptable approach as it does not consider the entire operation of the model. This then can lead to uncertainty around operation matters in areas where validation has not been conducted and impede the decision-making process.

A validated simulation model will primarily be based on a match of the journey travel times within the modelled network. Secondary validation elements target only parts of the modelled network and provide a greater confidence in the model development process.

The secondary validation elements will vary depending on the study area and quality of data collected and may include the validation of the following:

- Time profiles;
- Level crossings;
- Signal operations;
- Visual checks;
- Origin-Destination journeys; and
- Queue lengths.

Validation process is also highly dependent on the quality of data collection as discussed in section 5. The validation process should also be undertaken for the median seed run as determined in the model stability section 6.3.6. In addition, the core and periphery parts of the model would have varying scrutiny and importance as part of the validation process.

7.1. Journey Time Validation

The movement of people is an important measure in analysing travel patterns and travel time. In most cases a journey time is declared for a specific set of routes in the model, that are collected on site or extracted from historical databases to form the backbone for validation.

The validation of journey time should be a process to compare the median journey time in the observed data as the average observed journey time can be sensitive to the impacts of outliers (see Figure 9). The median observed journey time is actually a more useful and stable value to benchmark conditions of regular operations. However, there are situations when reliability of travel time is affected through the course of the evaluation period. This investigation will need to be undertaken to determine whether multiple time intervals are required to show the variation of journey time. This may involve a filtering of the data set to omit any journeys times from irregular circumstances such as unplanned disruptions. Journey times vary by time of day as well as throughout a time interval and can showcase matters of reliability, congestion and accessibility. Refer to section 5.2.3 for more details on this topic.

In addition, the journey time validation process needs to ensure that the collection technique on site is consistent with that adopted in the model. The collection process should ensure that the journey time route can be explored in sections by declaring waypoints. These sections are defined as being the distance between intersection stop lines in an urban area, ensuring that the journey time is recorded when the vehicle leaves the stop line to ensure that the delay for that section is captured. In rural areas or urban areas with fewer such defined settings, then median openings or key location points will need to be considered.

The validation criteria should be as follows:

- Modelled journey time to be within 10% of median observed journey time for the full length of the route. Each route should be graphed by section;
- The use of absolute time differences such as the application to be within one minute will **not** be considered acceptable. This approach is a dated measure and only encourages a split of routes in the short sections to excuse delivering on model validation;
- Modelled journey time to be within 20% of the median observed journey time for each individual sections. Albeit this variation should be limited to no more than 10% at the core and critical sites of the investigation;
- These metrics for both modelled and observed need to become tabulated, to ensure a quantified measure can be undertaken for the journeys times along each selected corridor; and
- Journey time validation should meet benchmarks for all routes examined, not just for a subset of routes near to the problem site. This is because the modelling tasks are directed towards exploring the series of factors that inhibit traffic flow in the network. However, when a model explores more than 15 distinct routes then allowance is provided for 90% of the routes to be within 10% of the median observed settings.

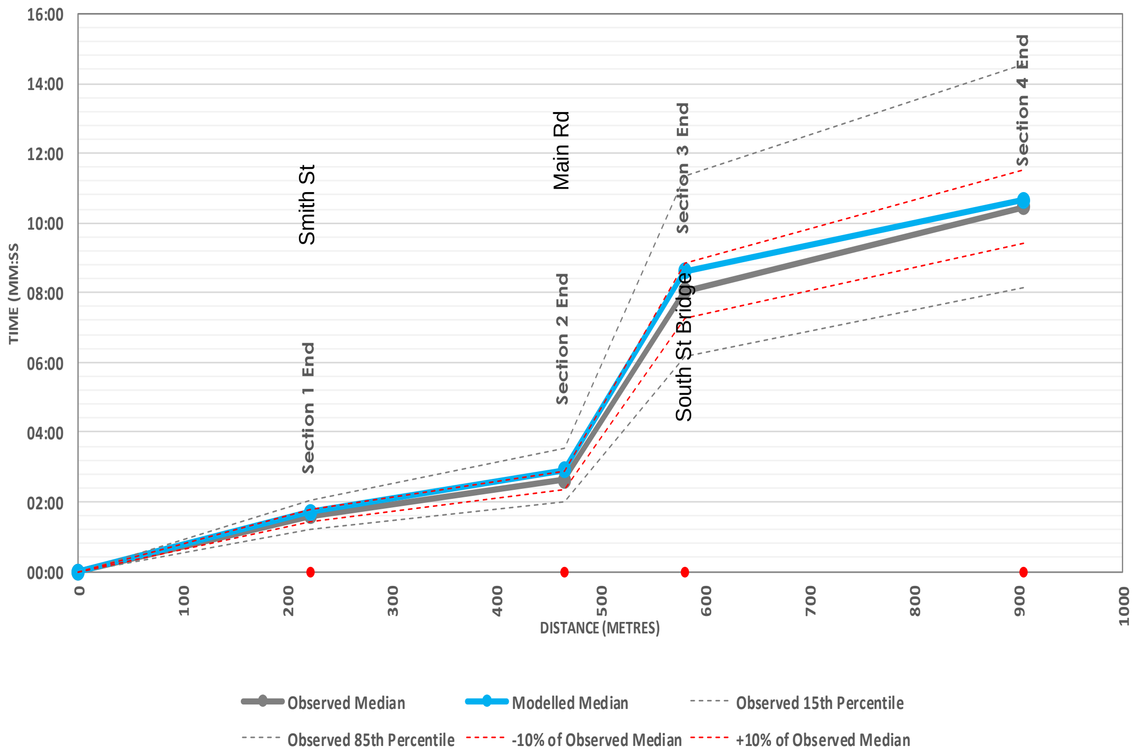
It is an important element that the model validation process limit the risk of errors with the change model. A threshold of error is defined to ensure that the model suitably accounts for the micro-simulated conditions experienced by the drivers. This limit on the error ensures that the benefits from the prospective changes would typically outweigh the benefits from a change model or future horizon. In this way the validation is used (with an example) to ensure that a 12% journey time benefit is not offset by a 15% margin of error. The smaller gap between observed and modelled results within a simulated setting should better mitigate the project risks and provide for greater potential to deliver the identified benefits.

The cumulative line graphs that are presented for journey time validation should also include the 15th percentile and 85th percentile for both observed and modelled journey times rather than maximum and minimum. A maximum and minimum journey time should not be plotted as it provides little meaning unless exploring “outlier” conditions. This task itself provides direction to increase the sample of journey time data collected. A typical graph is presented in Figure 51 to outline the journey time segments as well as cross roads or landmarks used to determine such measures.

Journey time plots should use axis of time (minutes) and chainage (distance) along the route. It is expected that at least three markers will be provided within the graphic to identify key cross roads or landmarks (e.g. bridges, major buildings etc). Note that journey time plots with crossroads as the x-axis is not appropriate as this misconstrues the journey speeds between intersections over varying distances. For this reason the x-axis requires a consistent metric such as distance.

Tabulated journey times should also be accompanied by the equivalent average journey speeds, listed in unites of kilometers per hour (km/hr).

Figure 51: Journey time comparison along a corridor



The routes determined for journey time validation need to meet the following criteria:

- The routes should cover the full extents of the model area. For corridor models, the full length of the corridor needs to be the primary route;
- The routes should not overlap. This will ensure that the validation is not duplicated over large sections of the model area and misconstrue the error or accuracy of the validation task; and
- The routes should have at least three points for journey time recording.

The timing interval used for journey time validation needs to have the following principals adopted:

- Generally, journey time is compared for hourly time periods in the model within the evaluation period. So, if the evaluation period is three hours than three separate cumulative line graphs are prepared for each hour per route; and
- If there is significant operational changes within the hourly time period than a more granular time interval would need to be considered to show the travel time benchmarks. An example could be a pedestrian crossing operating in full control in the first half hour to partial control (flashing yellow) in the second half hour.

There are investigations whereby the validation of journey times on corridors for general traffic flows will need to be conducted separately for public transport services. That is the operation of tram and bus services should be reported and benchmarked as separate line items to the performance measures of general traffic flow.

When analysing the journey time data that will be used for validation, it is imperative that the data is checked against “outliers” for examination or exclusion. Outliers as irregular occurrences in the data sample that may have an adverse effect in reproducing regular operations in the simulation model. One way to check for outliers is to refer to the GPS tracking file of each floating car run to ensure that the route taken was consistent. However, if data is subject to significant changes on a daily basis, then quality controls need to take place on the day of the survey.

7.2. Secondary Validation Requirements

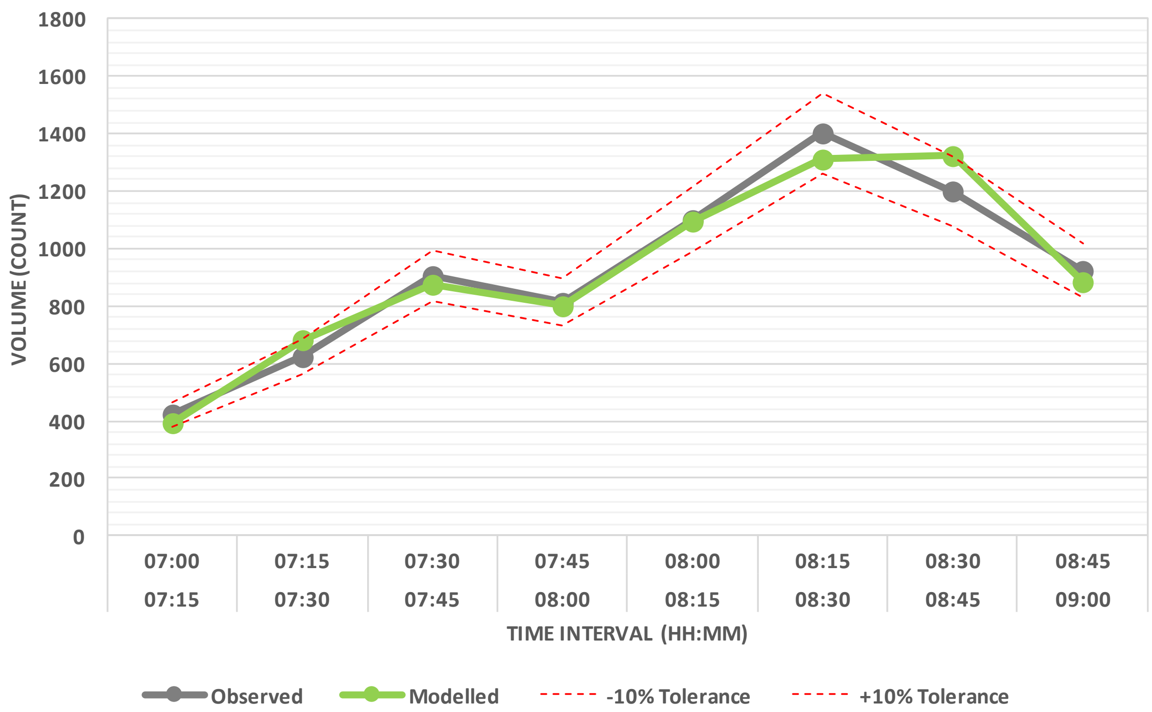
These elements help to explain the suitability of the simulation model developed, but cannot claim to have achieved a validated model without the delivery of the primary element – that of journey time validation.

7.2.1. Time Profile

The release time profiles adopted during the calibration process need to be checked during the validation process. The modelling should ensure that the release profiles lead to appropriate arrival patterns at key intersection approaches. This ensures that the inputs are consistent with the results from the model and that the network extents have been chosen adequately.

This process is to confirm the time profiles for observed and modelled volumes for key locations within the core of the model. This cannot be the first intersection at the extent of the model but a closer match to the centre of the investigation as per Figure 35. The comparison should be as per the input time interval using a column graph as shown in Figure 52. The modelled time profiles should be within 15% of observed time profiles. That is, if 300 vehicles are observed in the first 15 minutes of an hour profile, then the modelled number of vehicles for this first 15 minutes needs to be within 255 and 345 vehicles.

Figure 52: Arrival profile graph (example) Exploring match between Observed and Modelled throughput.



7.2.2. Level Crossings

Level crossing operations are required to be validated using the boom gate downtime collected from survey dates, as well as additional traffic metrics such as journey times. This is achieved by comparing the flashing red light operation by taking the observed time from when the flashing red lights start to when they finish with the modelled equivalent start and finish times.

The comparison should be represented using a linear graph with graph spikes indicating the start and end of the flashing light operation for each service. The modelled start and end times should be with

15% of the observed figures with the frequency of modelled boom gate closure to match the observed boom gate closures on site. It is important to note that service arrival may not impact on boom gate operations consistently. This is most obvious when a station (platform) is immediately adjacent (upstream) from the level crossing location. In such instances the boom gate operations will be active while passengers board and alight at the station. An illustration to match the service arrivals (triggers for signal changes), the observed down times and the simulated signal plans, such as that shown in Figure 53 should be provided.

This is an important element to calibrate correctly, not simply to show the impacts on the traffic movements but to ensure that the reactions to train arrivals are appropriately simulated. Train services can often have a significant impact when exploring measures for high service frequencies along the rail network.

An example of the boom gate down time analysis is provided within Figure 53. This measure explores the timeframes between services in two directions at one level crossing site. This graphic should be complemented by a table indicating the start and end times of each modelled boom gate closure. Details also need to be provided to confirm that the simulated period is within 15% of the observed boom gate closure times.

7.2.3. Signal Operation

When dynamic signal operations are present in the model, the various signal parameters need to be validated. The criteria include the following (Refer to table and graph outputs below):

- Observed and modelled phase green time average to be within 10%, as displayed within and an accumulation of proportional splits over the evaluation period as shown in Figure 54. This means that if an observed phase average time is 30 seconds, then the modelled phase average time is required to be within 27 and 33 seconds. Maximum and minimum phase time should also be compared and any significant differences explored;
- Observed and modelled phase frequency (Figure 55) to not differ by more than two occurrences if called ten or more times in an hourly interval, or within a rate of one occurrence if called less than ten times in a one hour period (or equivalent);
- Observed and modelled average cycle time to be within 10%. This means that if an observed average cycle time is 30 seconds, then the modelled average time is required to be within 27 and 33 seconds;
- Observed and modelled pedestrian crossing activation frequency to not differ by more than two occurrences; and.
- Special purpose solutions such as priority public transport phases are dependent on the arrival of the public transport service and as such the adaptive nature of such operation. This may reduce the effectiveness of the phase frequency to be met. The phase frequency between surveyed and modelled needs to be explored further in the context of the service patterns.

This various signal parameters are usually validated against SCATS history files which is the historic outputs from SCATS sites. It is important that this data is not used in the calibration process, rather the input parameters such split plans, special phase operations, minimum run times and gap out provisions. Other measures for consideration include the application of “false green” phases and the time allocated to pivot phases

Figure 53: Level crossing boom gate closure graph (example)

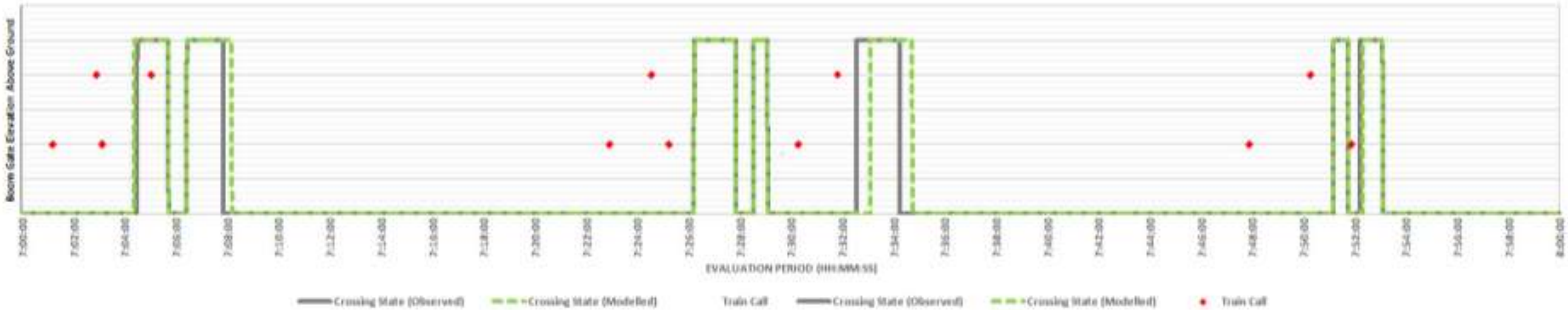


Figure 54: SCATS Site Signal Comparison – Includes accumulative phase duration (Example)

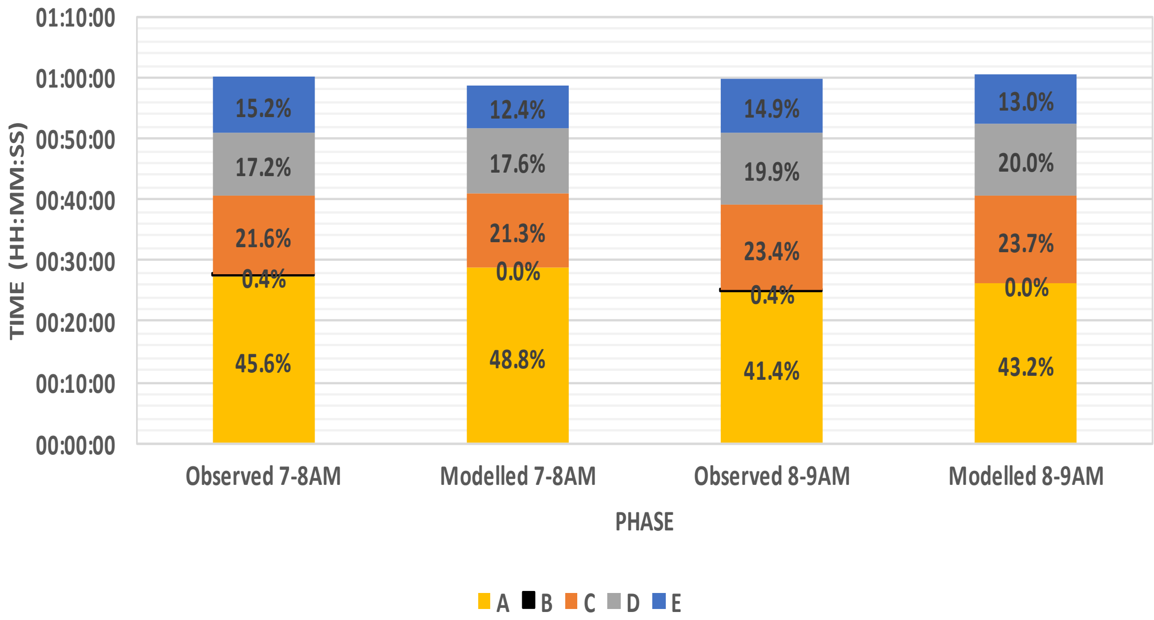
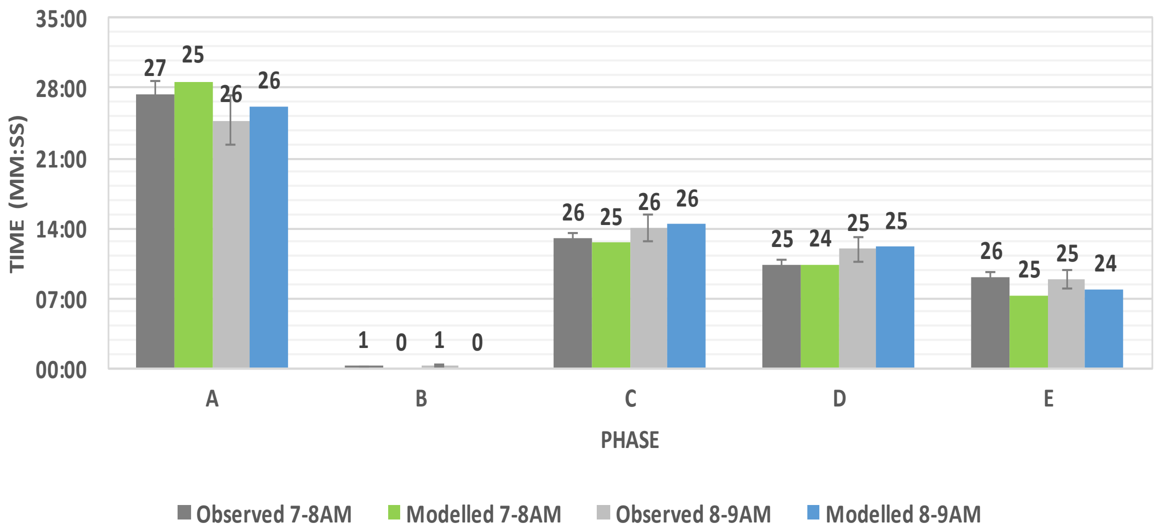


Figure 55: SCATS Site Signal Comparison – Includes phase lengths, tolerances and frequencies



7.2.4. Visual Checks

Most simulation software provides a strong visualisation of the simulated vehicles in the network and can be used as a last step in the validation process. Simulation models can provide a strong visual setting and ensure the reliability of vehicle movements in the route choices developed.

Performing visual checks is a recommended approach when simulation modelling is conducted. It is expected that image snapshots of the simulation model will be reported at the commencement and completion of the evaluation period and as required from other time periods in the model runs.

7.2.5. Presentation of Results

A sample of origin- destination data, queue length and speed data can be used to show model validation of certain areas of the network model. This provides a more robust model solution to complement the journey time validation. Consideration on how the data was collected and how it is reported by the model needs to be explored as sometimes accuracy in the collection process (i.e. sample rate, technology or subjective opinions) makes it difficult to show matching outcomes.

VicRoads encourages that this form of display does not use a dot point plot mechanism to give suggestion of area based density measures such as the origin-destination function. These forms of graphics are often misconstrued as being more literal than sampled and can often undermine the message presented in the narrative of the investigation.

7.3. Iterative Assignment Modelling

Simulation models can provide traffic assignment measures (definition of routes) through a multitude of deliveries including both a fixed (declared) route and calculated route choice. Some simulation packages provide one format or both formats for deliveries. Where appropriate, some solutions can utilised both methods in a single simulation model.

The process of forming routes through a network with multiple options between a journey commencement and completion builds choices through a series of mathematical equations so that traffic takes the path with the least effort or cost required by the motorist. This route choice formation provides a feed back of journey times into the model both during and between the model runs (iterations) of the simulation runs. As each iteration progresses, the effort of the journey (and hence traffic volumes) in simulation models slowly move towards a balance for each origin-destination pair over time.

The route choice is based on a generalised cost metric which is defined for turns and links in the model, the progressively change during the model runs. The iterative assignment, for validation purposes needs to go through a process called convergence that aims to reduce the variation in routes and traffic volumes from the updated cost estimates between iterations. Convergence is a process that determines the stability and confidence of the simulation model in representing route choice. This is not just a measure of consistent volumes from within the model.

Convergence will be deemed to have been satisfactorily achieved when the following criterion has been met over each hourly period:

- Travel times on 90% of all paths (origin to destination) change by less than 10% for at least four consecutive iterations. This needs to be presented in a tabular or graphical form as per that of Figure 56;
- It is not uncommon for low volume paths to fail in achieving convergence. However, any incident that involves an origin-destination pattern of more than five journeys should be highlighted and discussed; and
- Assignment convergence needs to be applied for all time intervals within the evaluation period.

Note that all models that are built using origin-destination matrices are required to showcase that convergence has been achieved even if the model developer perceives that there is no route choice. By default, this implies that all models of this nature require a second iteration with the simulation. It is not uncommon that a model developed without route choice does deliver for some alternate movements that the modeller has not immediately considered.

Modellers should ensure that journeys are appropriately defined on roundabouts by removing a full loop through the intersection from route choice analysis. Observations during the convergence process need to be discussed to ensure the narrative of the model performance is transparent.

As a general concept, running additional assignment iterations should achieve more stable set of results, closer to the equilibrium solution. Some networks will converge better than others, and some iterative methods converge better than others. The modeller should choose the appropriate method and convergence procedures to achieve the convergence criterion defined within these guidelines.

The convergence diagram in Figure 56 identifies that the criterion of 90% the paths formed changed by less than 10% for each time interval in the sixth iteration of the simulation run. In this image each line presents for the proportion of paths that had nominal changes in journey times for each ten minute period. The period of the four sequential iterations with less than 90% of paths achieving a journey time change above the express figure can be viewed between iterations six through to nine.

Figure 56: Model Convergence Diagram

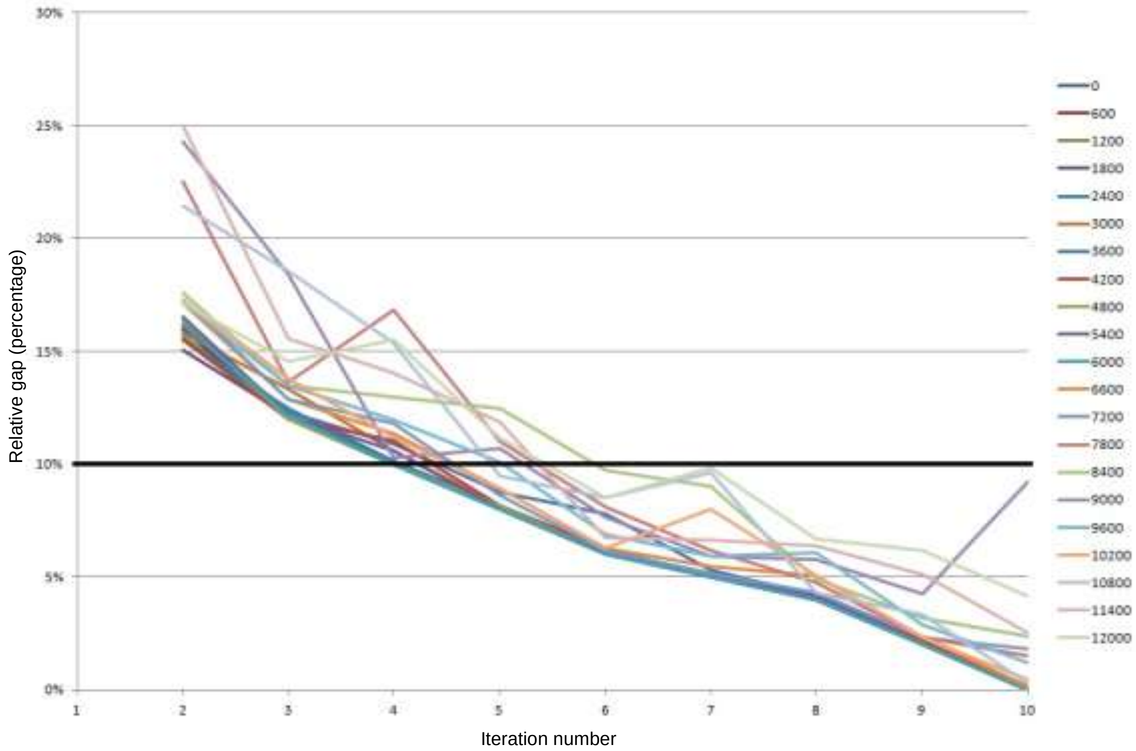


Table 36: Chapter Checklist for Model Validation

Topics for Discussion and Reporting	Yes	No	N/A
Does the model reflect the observed journey times for corridors determined within the landscape? Has this been tabulated and graphed to show the scale of suitability?	☐	☐	☐
Have the time profiles developed been confirmed by the simulation model or should these measures be further refined to match the conditions identified?	☐	☐	☐
Are the delays and irregularity experienced from site specific interactions such as Level Crossing locations appropriately been defined and benchmarked by the variation in journey times?	☐	☐	☐
Are the signal operations of the simulation model in line with the delivery of that pursued by VicRoads or should the signals be refined further?	☐	☐	☐
Have visual checks for the beginning and the end of the simulation run (as well as during the interval) been provided to display the experiences of road users at the selected time of day?	☐	☐	☐
Has the model converged for each time interval within the simulation, and to a suitable scale of (limited) variation?	☐	☐	☐

8. Mesoscopic Modelling

The notions of mesoscopic modelling are not a well-defined methodology as it is constantly changing or developing. As such, it is appropriate to categorise and represent this form of modelling as a middle ground between macroscopic and microscopic modelling. One of the key differences in mesoscopic modelling that differentiates it from microscopic is how it handles traffic flow. It combines the properties of both macroscopic and microscopic modelling approaches.

Macroscopic models have the advantage in evaluating very large areas but fall short in their ability to model congested network details i.e. intersection delay. Microscopic simulation models can capture a high level of traffic detail, but fall short to model route choice for large networks and are also limited in the extent of model size due to factors around delivery timeframe and resources.

Some forms of mesoscopic modelling provide for a simplified car following and lane changing algorithm to move vehicles, while other formats separate the delay metrics of nodes and links. Different development teams often explore different approaches under the guise that is mesoscopic modelling. Mesoscopic modelling may include (but are not comprehensively limited to) attributes such as heterogeneous behaviour, dynamic assignment, separate intersection and approach delay functions or abstract capacity definition. However, for the context of VicRoads, pursuits may often be to explore a landscape that holds more detail than the strategic VITM model.

Mesoscopic modelling is best applicable to:

- Evaluate the impacts of traffic congestion in a transport network;
- Explore constraints at intersections and merge points in a network;
- Evaluate alternative, operational, and policy changes in area; and
- Evaluate emergency evacuation plans and strategies and so forth.

Modelling teams should consider the downstream design of longer lengths of links to ensure a more appropriate utilisation of available lanes. This may require splitting some lanes to ensure that lane based algorithms have a departure point from the end of the link. Typically this might be applied near to the commencement of the lane merge or lane drop process so that a large component of the link is unchanged from the original formation.

Model calibration of these forms of modelling aligns closely to the conditions of the micro-simulation, albeit with an additional layer to report the dynamic conditions of the network. This can involve more time and effort to refine the network modelling by both volumes, time profiles (release or arrival) as well as journey time variability. While the modelling requirements appear to be simplified, this can have the limiting response in the ability to calibrate a model to localised conditions. In this way modellers should note that delivery of a solution derived from a simplified car following algorithm may not lead to a better model representation of the landscape. The approach taken and complexities held within the products involve decisions and complications that the modellers need to analyse and determine prior to formation of the model.

Despite applying a simplified car following algorithm into the simulated landscape, VicRoads holds the validation criteria for meso-simulation modelling and hybrid modelling as a consistent delivery requirement to the micro-simulation modelling. The delivery of allows for a broader exploration of the landscape, which in turn should not be associated with a reduction in model performance.

Validation of the journeys in the model by means of a journey time evaluation remains an important measure for all simulation models with heterogeneous behaviour.

8.1. Assignment Type

In mesoscopic modelling, there are commonly two types of traffic assignment, Static Traffic Assignment (STA) and Dynamic Traffic Assignment (DTA).

- In a Static Traffic Assignment model, each link is described by a volume speed decay function or link time performance function. These equations are used to present an average (or steady-state) journey time on a link as a function of the volume of traffic on the link which itself is determined by the pattern of trips via routes identified; and
- In Dynamic traffic assignment (DTA), each link is modelled as a density delay function. In such situations traffic flow dynamics ensures direct linkage between travel time and congestion. If link outflow is lower than link inflow, link density will increase leading to congestion, and speed will decrease (fundamental speed–density relationship), increasing the journey time.

There are two commonly used forms of DTA, namely:

- the Dynamic User Equilibrium (DUE) and
- Non-Iterative or One-Shot DTA.

8.1.1. Dynamic User Equilibrium (DUE)

Dynamic traffic assignment models are often assigned and set to converge based on the criteria for each origin-destination pair, the actual travel times are nearly equal or differences are minimal. As vehicles are loaded into the network, they select paths based on their "cost or utility" which is usually interpreted as the shortest travel time. This procedure is iterative, terminating once some upper limit on iterations has been reached, or when the DUE has reached a significant level of convergence.

The convergence is based on statistical criterion called the Relative Gap. As the Relative Gap approaches zero it is inferred that travel time between any origin-destination pair is fixed and was able to find a shortest possible route.

Simulation/ agent based models use multiple iterations to build journey costs and inform each successive iteration. Varying journey costs, in turn, are used to build paths to reach destinations and inform the 'agents' in the model about the routing for the next iteration. For this reason, it becomes essential that the model study area includes network which encompasses all possible variations in the paths.

Model study areas for micro-simulation or hybrid approach based investigations are usually carved out of larger strategic models which use static assignment algorithms. It is common for such models to artificially 'overload' parts of the network in case of congested conditions or high demand. If a subnetwork from such model is cut out for the purpose of a micro-simulation/hybrid study 'too close' to the project area, there is a risk that the model will have incongruous demand. Instead of making efforts to calibrate such models and get them to converge, it is better that a larger area is selected which includes all alternative paths.

In some modelling software packages, this can be referred to as simulation based assignment, where demand time slice can be an attribute.

8.1.2. One-Shot Dynamic Traffic Assignment

One-Shot DTA is generally used to model the effects of scenarios such as short-term work zones, incidents in critical sections, and to investigate impact of elements such as tourist attractions or commuter unfamiliar with the network. One-shot DTA is assisted by the provision of past predefined routes or routes produced as the result of a DUE assignment.

Under such conditions the following can be considered:

- Some percentage of the vehicles force the predefined routes either static (historical) or time dependent (DUE);

- some are assigned to new routes based on current conditions and follow them to the end; and
- in some cases a third group is allowed to re-route during their trip based upon given updated information regarding traffic conditions.

One-Shot assignment is very useful while investigating complex networks, where DUE simulations can take very long times and therefore not efficient, while One-Shot are faster and can produce informative results. However, the absence of a comprehensive feedback loop to the assignment process creates a downfall to this solution and is therefore generally not an encouraged methodology.

8.2. Hybrid Approach

The Hybrid modelling approach includes application of multiple assignment algorithms in a contiguous network. The key advantage of this methodology is that the simulation of journeys do not require severance of the connection between areas and approaches. Therefore, a hybrid approach is suitable if an area is to be modelled in detail using microscopic simulation but needs to be analysed within a larger peripheral area with less detail. This can potentially eliminate the housekeeping efforts required to manage the interface between two separate models as well as budgetary matters of the detail required to produce the network at a micro-simulation scale of detail.

The key to defining a suitable Hybrid model is to keep the microscopic areas as targeted as possible. That is:

- The micro-simulation area should focus around an interchange or linear series of interchanges / segments of road; and
- Not extend to model a region with significant route choice (a detailed network model should provide context for such queries)

An example of a hybrid network is provided in Figure 57 whereby two orange sections (around major intersections) within the network utilise an extensive driving algorithm, but a simplified lane based solution across the remainder of the network.

The main risk and associated common mistake is where the microscopic area continues to extend to a scale where it augments the ability for the route choice models (algorithms) to an extent where origin-destination pairs have multiple route choices to consider at different assignment scales (e.g. one route may be entirely mesoscopic, microscopic or hybrid).

It is important that the varied computational methods of impedance do not skew the results of the assignment. It may be that a change made within a micro-simulation section of a model has greater impact than intended on route choices across the broader network. While model convergence may be easily reached there is potential that the model may misconstrue the impact of the proposed change. Alternatively it may be that the limited effort in calibration of the meso-simulation sections might simply identify the micro-simulation areas to be too intensive in journey effort. Again, a balance and calibration of such conditions needs to be conducted in order to achieve a validated and converged model.

This potential dilemma can make it difficult to achieve convergence as there is no 'true' relative gap that can be calculated between path choices simulated at different scales. Results from such models cannot be relied upon due to the non-uniformity of the approaches.

An alternative approach is use traversal (sub-networking) rather that hybrid models. A dynamic traversal maintains the time profile for each of the external zones to represent the simulated traffic flows from a mesoscopic assignment. These profiled matrices can then be run in a designated micro-simulation within the traversal subnetwork.

Using a hybrid approach to build models of varying complexity does not absolve the modeller from the responsibility of model validation outside of the core area where microscopic approach is used. A well validated core area surrounded by poorly validated peripheral area can potentially hide shortcomings such as demand suppression or artificial congestion. This, in turn, can impact the quality of forecast when such models are used to assign future year demand matrices. As such, validation of corridors needs to be the full corridor and not limited to a section of the network investigated.

Figure 57: Example of a Hybrid Model

The application of Hybrid modelling will require a calibration of network conditions, in the same approach that all models require efforts to deliver a match to localised conditions. Hybrid models need to ensure that the simplified car following algorithms do not produce an exaggerated performance within 100m on approach to a landscape of the precise. That is, upon conversion from an abstract network setting (meso-scopic) into the finite of individual vehicles and choices (micro-simulation) this buffer area should not achieve a utilisation rate of more than 100% of the achievable capacity. Efforts will need to be conducted to ensure that this transition allows for accurate calculation of conditions within the microscopic state. Misrepresentation of these conditions in this way simply undermines the performance measures extracted from the modelling investigation.

Although hybrid solutions have the ability to model with adaptive solutions, VicRoads strongly encourages that those elements (including signalised intersections) that are modelled as variable deliveries should be contained within the micro-scopic applications. That is, when searching for representation of the adaptive nature within the network complexities, a definition of the individual vehicle to instigate the change is required. This should be applied for both reporting and visual confirmation of the prescribed adaptive solution.

Table 37: Chapter Checklist for Mesoscopic Simulation Modelling

Topics for Discussion and Reporting	Yes	No	N/A
Is the modelled landscape suitably covered to explore the network changes?	☐	☐	☐
How extensively are localities of micro-scopic conditions provided for within the network of investigation?	☐	☐	☐
Does the reader of the report have the opportunity to determine the value of the dynamic solutions within this modelling approach?	☐	☐	☐
How has the driver behaviour algorithm been calibrated within this network and where are there noted changes in delivery of this solution?	☐	☐	☐
Has a buffer been determined on approach to the areas of micro-simulation so that the traffic is not overloaded on the network once presented as an individual object?	☐	☐	☐
Have images been provided within the report to outline those locations where a detailed or a simplified algorithm has been applied within the network?	☐	☐	☐
Have adaptive signals been applied using areas of micro-simulation rather than a varied form of simulation algorithm?	☐	☐	☐
Does the model provide acceptable delivery of validation to the base data or should further work be conducted before a review process is conducted?	☐	☐	☐
Have comparative travel times between adjacent corridors been developed to ensure validity of the hybrid model?	☐	☐	☐

9. Pedestrian Simulation

Pedestrian simulation modelling is a form of microscopic modelling (agent based solutions) to investigate design delivery matters for more than just traffic movements. The project definition will determine the simulation complexity and level of integration with other simulation modelling components such as traffic and public transport operations. In all pursuits with substantial pedestrian and vehicle interaction, the models need to be contiguous.

The current pedestrian landscape and behaviour needs to be understood through detailed data collection and sites visits that are built into the narrative. In this structure many of the same queries about model development and calibration need to be applied as per traffic studies. That is the following needs to be considered and explored:

- Project objectives;
- Data Collection, cleansing and analysis;
- Calibrate model for demand, for behaviour and for network design;
- Find means to validate the modelling;
- Report on model benchmarks;
- Explore change options; and
- Develop an evidence based narrative to advise on the potential impact of the change/ project.

Pedestrian simulation can be a useful tool to evaluate how pedestrians will move through a network. It can lead to decisions on footpath requirements, vertical transport connections and infrastructure needs to manage open spaces. Simulation models can explore integrated modes to investigate the design and journey requirements for passenger or crowd volumes that may impact on vehicles journeys at a number of locations including for:

- pedestrian crossings;
- the design of bus and tram stations;
- rolling stock requirements; and
- boarding and alighting operations and the cumulative impact on the wider network.

The modelling guidelines have ideally been written to direct teams about requirements and considerations when simulating pedestrians with connections to the transport network (in some manner). The guidelines are not developed to explain principles of open planning requirements or design principles for pedestrian landscapes in the same manner as land use planning is not explained when exploring traffic simulation modelling within these guidelines. The text within this chapter distinctly relates to conditions of pedestrian modelling that are developed to simulate person movements within the vicinity of transport projects developed where VicRoads is a stakeholder or shall become the owner or operator of the infrastructure.

The calibration and validation of the pedestrian simulation models is used to understand how well the model can replicate a network and show that the model developed represents existing conditions (often referred to as the "base model"). Many of the matters pertaining to data collection for traffic investigations (quality and seasonality) can also be applied to pursuits for pedestrian simulation modelling. The data collection is critical for the calibration and validation process and is further discussed in section 5.

9.1. Data Collection Considerations

Data collection for the formation of a base model may be undertaken through means of a video or CCTV camera. This often can provide the means to determine initial requirements such as volumes, distribution of movements and a number of behavioural features. Some teams may be able to obtain validation measures through use of footage to determine journey times between two key points.

However it is of note that the intended distributions of journey speeds should be obtained from the user experiences outside the most congested times for use of the infrastructure.

Many simulation software use the same project processes to develop a pedestrian model as per traffic and transport simulation, albeit with a different driving algorithm of the objects.

Development of a calibrated and validated base model can allow the investigation to understand:

- how pedestrians behave in the network;
- how they determine paths; and
- how they may be affected by different physical constraints.

Pedestrians will behave to distinct benchmarks in different locations and are expected to have a heterogeneous behaviour across the network. This can be influenced by the land use, such as shops or schools, influence from the proximity to roads and influenced by the trip purpose (a commuting trip, a recreational trip or shopping trip). These factors can then be taken into the future models in order to test various scenarios. However other key determinants for behavioural considerations for simulating pedestrians relate to:

- crowd volumes that they must endure;
- crowd volume that they can move with;
- objects to negotiate through a crowded space (structural poles, street furniture); and
- angle with which to turn on their journey.

9.2. Software Expectations

Professionals working within this area of interest need to consider the three points directed within Section 2.4 of these guidelines. That is that the software applications used in investigations need to provide on the following matters:

- published material on the algorithms to drive the objects;
- dedicated software development and support teams that are not an overlap of roles; and
- commercially available software that can then allow for independent reviews of the investigation without direct involvement from the model development team.

In addition to this, teams should ensure that the pedestrian software applications correctly define the term for integrated modelling so that traffic and transport and pedestrian movements are all directly tied together. Integration of pedestrian movements should not simply be limited to the appearance of multiple objects within the same landscape, but the connection between these objects. In this way models can then deliver the transport network as a single integrated simulation rather than as different parts of the jigsaw. It is expected that a pedestrian simulation model could explore the connections from rail to street to tram or from event to street to rail as a single delivery.

9.3. Calibration

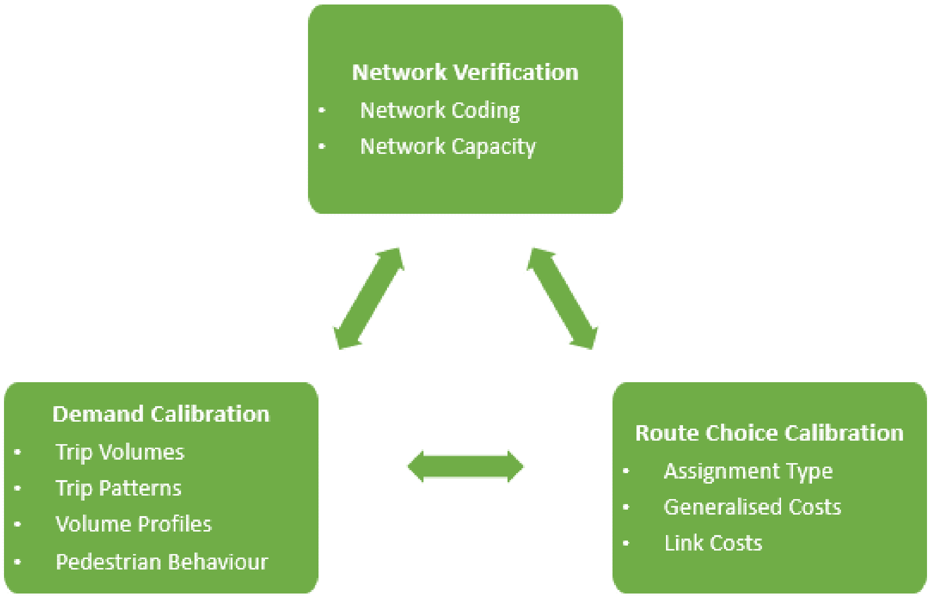
Model calibration is an iterative process that involves making evidence based changes to networks, to behaviour, to path formation and to demand considerations until pedestrian movements are representative of the observed existing conditions. The diagram in Figure 58 provides a visual outline of the calibration process.

Localised behaviour should be observed for a site visit and supported with video footage (where available). The site visit should aim to identify considerations within the current network as well as factors of causality, and any localised behaviour that needs to be reflected in the model. Details of the observed behaviour and route choice conditions should be documented and reported.

Parameters used to achieve the correct flows and conditions in the simulation model should be described in the modelling report. It should be stated how pedestrians choose their overall route (i.e.

the pattern and those factors to influence these measures), as well as considerations that influence smaller pedestrian decisions along the route (e.g. choices between stairs and escalators and lifts or route choices when travelling through a scramble crossing).

Figure 58: Pedestrian Simulation Calibration Process



Pinch points in the network such as stairs, escalators, narrow corridors and areas likely to increase journey times should have sites investigated and simulation models calibrated to the observed. If sites do not exist then a comparable situation should be observed. The surrogate site should have features that closely match those investigated in the landscape (e.g. high demand flows set number of escalators and lifts, demographics of passengers, widths of the gaps between ticket gates).

Project investigations should be able to explore notions of saturation flow from existing on site observations that can be reproduced and quantified within a simulation model. These questions may consider the volume of passengers in busy periods moving through a network point (ticket gate, escalators, passed a station pylon etc) within a small timeframe such as 1-2 minutes. From a station or a tram perspective, this may occur as the service arrives to the stop location.

As simulation models are delivered around design considerations in line with the behavioural settings, it may be that some very similar components require different adjustments. For example the proportion walking (rather than standing) on a moving walkway may be different to those of an escalator. Similarly the direction of the escalator may also impact on the factors applied and on the performance metrics. Teams may need to explore different values at an appropriate existing site prior to design and planning for new similar facilities. This may impact (for example) on vehicular operations as passenger alight services. The requirements for validating tickets upon alighting public transport services will have different impacts the release of persons alighting and hence the dwell times for each service.

At the same time, teams should explore metrics of data capture rather than simply limit the analysis to the more fundamental requirements. For example teams might wish to consider exploring pedestrian volumes per step on an escalator (as a distribution), rather than simply the number of passengers using the escalator to understand potential throughput for a proposed design.

Simulation models should also explore the capacity limitations of proposed rolling stock deliveries when simulating patronage of the public transport system and the road network. It may be the case that the boarding and alighting of passengers from the service may dictate the dwell time of the service and the corresponding impact on the adjacent traffic movements. Simulation models should consider rolling stock and consult with Public Transport Victoria or the Department of Transport on prospective changes in the rolling stock that may be introduced for the change model, especially when exploring future horizons. Key attributes will include:

- Carrying capacity
- Number and position of doors
- Occupancy on the service (when entered the network and at each stop)

It may be the case that the dwell times associated with the rolling stock relate more to the unmet demand for the service (over capacity) rather than the a simpler equation of alighting and then boarding functions.

9.3.1. Design Considerations

One important requirement for planning and simulating pedestrians is to hold these movements in the context of the design guidelines. It is worth noting that some benchmarks for pedestrian planning explore as a volume per hour. However, there are times when this volume should (and is expected) to be read as a rate per minute – in particular for occurrences when the throughput over the hour is expected to be released in a small time allocation. This could be to the release of school volume which typically has a peak movement over 15 minutes rather than over an hour.

Planning and design for major events may also need to be considered in addition to the context of the more regular event. This may involve specialty design requirements for pedestrian crossings, station or service access as well as path design measures. Ideally those locations associated with cultural events will be considered for within design and planning for pedestrian movements: ie cultural festivals, memorial services, sporting events. Delivery should be based on an expectation of a full house in attendance, with potential sensitivities to then explore options of a reduced volume.

9.3.2. Walking speed distribution

In many software packages, the capacity of these pinch points can be calibrated by adjusting factors such as the walking speeds. People walk at a variety of speeds so an application of a deterministic solution may not be appropriate for design and delivery where pedestrians and passengers are involved. The speed with which individuals walk as well as the distribution of speed will both affect the throughput of the network constraints. People whom move faster and more consistently will generally pass through an obstacle faster, while slower pedestrians may build a constraint for the people behind them. The range of speeds will vary based on a number of factors including terrain, grade, journey purpose, size of the group and their desire to reach the destination faster.

Walking speed distribution and behavioural factors that have been changed from the default should be detailed in the modelling report. This includes mapping locations where variants from the default have been introduced.

Data collection is strongly encouraged and is expected with all simulation pursuits. As a simple exploration: VicRoads recorded and analysed a five minute segment of person movements within a retail centre in central Melbourne. The multiple floors provided a good opportunity to record these measures without being observed by participants. The data identified 385 persons moving between two selected points within this time interval, covering approximately a 30m distance. While the distance appears to be short, this measure provides for a greater sample between the two points, subject to the conditions experienced on the day.

Observations from this analysis identify a wide range of walking speeds, between 2km/hr and 12km/hr with a distribution of journey speeds as identified in Figure 59. The data graphed in 0.25 km/hr bands provides a suggested average journey speed from this sample of 4.25-4.50 km/hr. The 15th percentile journey speed is estimated in the band at 3.25-3.50km/hr and holds an 85th percentile speed of 5.25-

5.50 km/hr. A cumulative distribution curve of this small sample is provided within Figure 60. The higher end speeds should not be categorised as “walking” speeds.

Again it should be noted that this dataset provides an example of data collection and analysis for model calibration. The data held within Figure 59 and Figure 60 should not be applied in a prescriptive manner but provide insights for teams to pursue similar for their own pursuits. Localised speeds for areas such as stairs or pedestrian crossings may need to be further considered to improve calibration as well as allowing different speeds for different demographic and/or mobility groups such as the mobility impaired.

A review of walking speeds in the academic literature by Bosnia and Weidmann (2017) in “Physica A” provided a worthwhile summary table to explore how significant variable impact on journey speeds. This included the following considerations on the average walking speeds:

- Gender – men travel at faster speeds;
- Land uses - CBD areas achieved faster walking speeds;
- Inclination – gradient affects speed uphill but not downhill;
- Facility type – Notable differences on Stairs;
- Group Size – more people in a group reduce walking speed;
- Roof Coverage – outdoor areas produce faster walking speeds ;
- Journey Purpose – Education and Retail based trips achieve slower speeds; and
- Day of Week - Sundays are as fast as weekdays, but Mondays are as slow as walking speeds on Saturdays (albeit there may be cultural elements here that impact on trip patterns and purpose rather than assuming the same actions experienced in Victoria.

A number of factors there were not determined to be significant in walking speeds including the following attributes:

- Age (demographics);
- Body weight or height;
- Presence of luggage;
- Race;
- Size of the urban establishment;
- Temperature;
- Month of Year;
- Time of Day;
- Data collection methods; and
- Country – except from the 54 countries recorded, walking speeds in Australia were deemed (on average) to be the fastest

9.3.3. Additional Factors for Model Calibration

A number of additional factors should be explored when developing pedestrian models to connect to the transport system. The local (site specific) calibration should explore the following components:

- Proximity to others – The proximity to stand or move near to other people can assist to calibrate simulation models at selected locations. Pedestrians choosing to stand closer together may increase the density when boarding an escalator or a transit service. This factor needs to be calibrated in order to better reflect the operational considerations observed from existing facilities;
- Willingness to overtake– The desire of pedestrians to react to other pedestrians will determine how quickly they can move passed another pedestrian and the space required to overtake; and
- Reaction to Others - Pedestrians will make their decisions in response to other pedestrians around them. Pedestrians in a limited space will take the opportunity to move forward based on those equally small spaces created by other pedestrians in front conducting the same tasks themselves. A higher reaction might be observed in locations with higher densities (around ticket gates and the base of escalators).

Teams conducting pedestrian movements may also need to explore simple behavioural conditions relating to the operational matters within the area of investigation. For example, with regard to an escalator a number of attributes for consideration may include:

- Utilisation of each step (how many steps have zero, one or two persons on the step?);
- Are the steps with two or more persons bunched together or a random arrangement?;
- What proportion of people observed stand to ride the escalator?;
- What proportion of passengers walk on the escalators? Are these numbers consistent or different going up or down escalators?; and
  Do passengers on the up escalators frequently leave a step between themselves and the person in front?

In the same manner as traffic simulation models, the calibration of a pedestrian model involves refinements to the network, the demand and the behavioural elements. When calibrating the demand movements, the observed and modelled volumes need to be compared. The GEH evaluation should be used to check the critical areas including footpaths, gated areas and pedestrian crossings and to check the validity of the route choice within model. The GEH evaluation criteria is to ensure that the modelled pedestrian volumes are calibrated to a GEH of less than 5.0 throughout the model.

Figure 59: Speed Distribution for Pedestrians (Example)

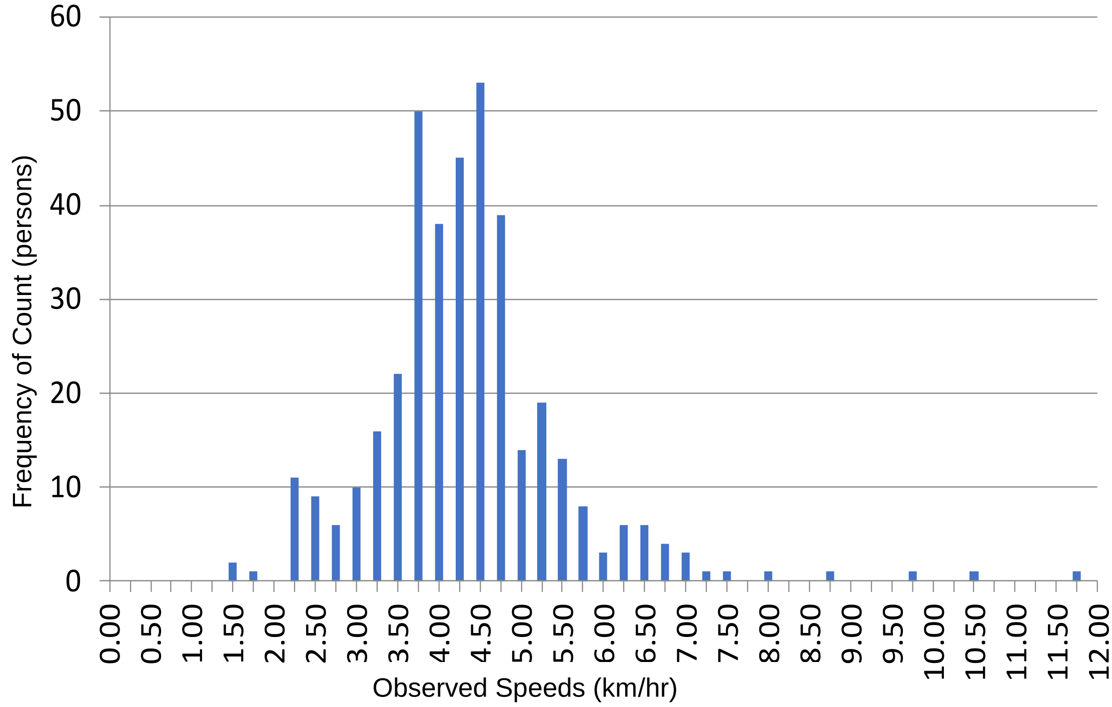
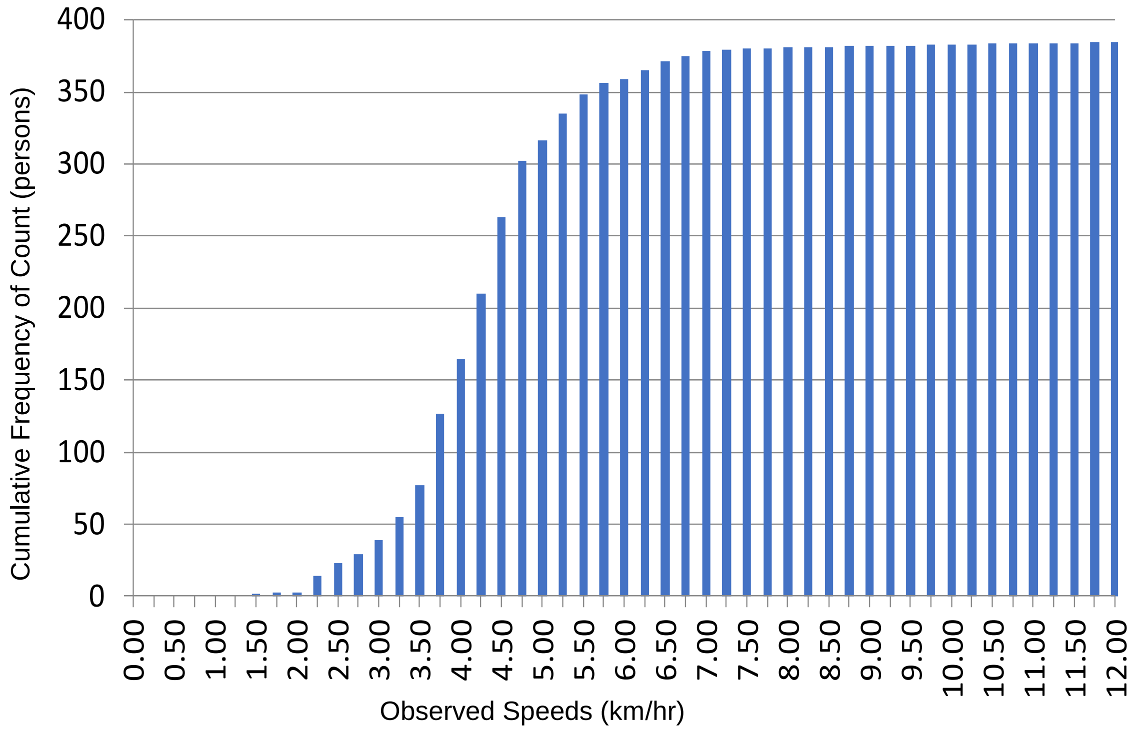


Figure 60: Cumulative Distribution of Journey Speeds



9.4. Validation

Model validation is a verification process, where results from the calibrated model are compared to an independent data set, different from those used to calibrate and code the model. Models should be validated using a comparison of observed and modelled journey times. Observed journey times can be obtained through tracking pedestrians throughout the network with video footage or using Bluetooth/Wi-Fi to track mobile phones as appropriate for the investigation.

There is a potential for observed data to be less reliable than modelled if participants are aware of being observed they can change their route or behaviour, sometimes actively avoiding cameras or site survey personnel.

The collected journey time data is then able to be used in determining the observed 15th, 50th and 85th percentiles and providing insight into:

- delays at various obstacles such as signalised intersections and stairs;
- free flow speeds; and
- delays due to crowding.

Journey time validation is considered to be a primary validation method that compares the observed and modelled journey times using cumulative line graphs showing the journey times through each section along a predetermined route. However as journey time collection is a more difficult task for pedestrian movements than for traffic volumes, the sample size might be reduced in comparison.

Validation through the means of benchmarking pedestrian volumes is not encouraged to determine suitability of the model to meet current conditions. This is predominantly associated with the matter that the demand matrices has been developed from the observed volumes rather than as a secondary measure (e.g. VITM derives volumes from trip rates at land uses, rather than from observations of the traffic volumes produced). Validation by throughput volumes would suggest a means to confirm the model through means developed as the same input to the simulation.

Journey times of a base model might be collected through video or CCTV footage. Alternatively this material can be collected by means of a floating person survey. This involves going out on site and achieving multiple journeys with the crowd, as per the practice of a floating car data collection process. For sites that are yet to be developed, this will be a difficult challenge. However for sites that are to be extended or upgraded the collection of journey time data for model validation should be collected from other pedestrian movements that already existing within the development area. This may imply extending the simulated area for such purposes of model validation that can then be transferred across as a suitable representation for an upgrade or enhanced site.

The cumulative line graphs that are presented in Figure 61 for journey time validation should also include the median, 15th percentile and 85th percentile for both observed and modelled journey times rather than maximum and minimum. A maximum and minimum journey time should not be plotted as it provides little meaning unless exploring ‘outlier” conditions.

Journey time plots should use axis of time (minutes) and distance along the route. It is expected that markers will be provided within the graphic to identify key decision points i.e. signals, stairs, ticket gates.

The validation criteria for journey time should be as follows:

- Median modelled journey time to be within 10% of median observed journey time for the full length of the route. Each route should be graphed by section. The summary of these routes (modelled and observed) should also be tabulated for numerical awareness;

- Modelled journey time to be within 20% of the median observed journey time for each individual sections. Albeit this variation should be limited to no more than 10% at the core and critical sites of the investigation;
- The use of absolute time differences such as the application to be within one minute will **not** be considered acceptable;
- Journey time validation should meet benchmarks for all full routes examined, not a subset of them as the modelling of detailed network operational issues is often the purpose of the investigation undertaken;
- The cumulative line graphs that are presented for journey time validation should also include the 15th percentile and 85th percentile for both observed and modelled journey times (where available) rather than maximum and minimum. A maximum and minimum journey time should not be plotted as it provides little meaning unless exploring ‘outlier” conditions.

Another secondary technique to support model validation is to compare the modelled and observed queues. The modelling report should demonstrate how queues in the model matched those identified on site. The shape of the queue (whether people were standing in a linear queue or a disorderly queued) should also be discussed as a part of the validation process. Queuing is a difficult measure to observe but may identify shape, composure, length as a sense of maximum or scale of regularity.

Figure 61: Comparison of a modelled and observed journey time for pedestrians

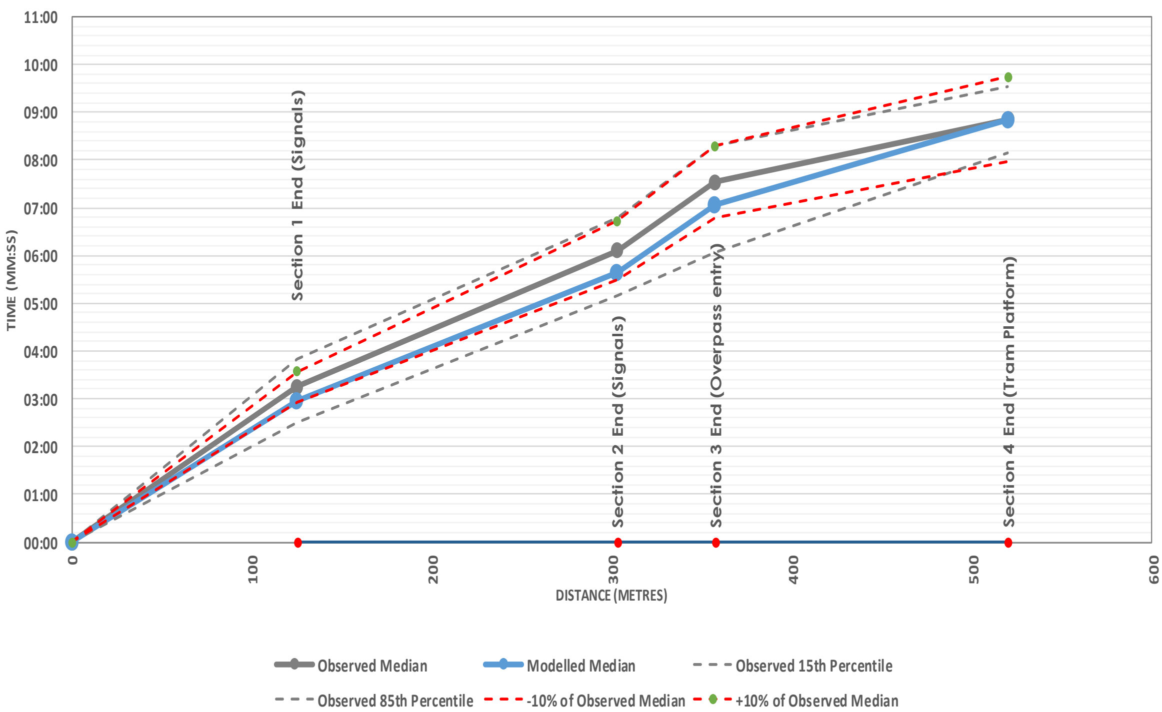


Table 38: Chapter Checklist for Pedestrian Simulation Modelling

Topics for Discussion and Reporting	Yes	No	N/A
Has enough data been collected to explore the varied conditions experienced within the area of investigation?	☐	☐	☐
Does the report outline a profile of walking speeds obtained through uncongested landscapes? Does this data cover more than one location and time interval of the day?	☐	☐	☐
Have observations from the site or from similar sites been used to explore personal behaviour that could/would be applied to this location?	☐	☐	☐
Has a calibration task been undertaken to explore responses to particular infrastructure usage (e.g. escalators, lifts, crosswalks etc) from existing or equivalent delivered sites?	☐	☐	☐
Has data been collected to explore the variation in journey times across the network?	☐	☐	☐
Does the model provide acceptable delivery of validation to the base data or should further work be conducted before a review process is conducted?	☐	☐	☐

10. Exploration of Options (Change models)

Many investigations undertaken aim to explore a proposed change of conditions, typically to explore design requirements for future year considerations or to address a more immediate operational matter. These solutions need to use the base model to benchmark the changed conditions, as a function of demand or design or operational deliveries. The base model provides for direction on a set of existing performance metrics, which are supported in a proxy format by suggestion of a validated model.

Options testing may provide for a current or a future year. For future year modelling to be robust, stakeholders need to confirm direction on the specifications (assumptions) into the expected changes to the network.

10.1. Conformity

The investigation conducted needs to hold conformity with a number of parameters or future or options models in scenarios that are in place in the base model. These measures need to be held consistently for the following key parameters:

- Time steps – the number of calculations for each second simulated in the network needed to be the same value as applied when developing the base model;
- Seed values – the seed values, used to determine the starting position of the randomness of distributions applied within the model need to be consistently applied as the base model. If the scenario explores conditions using only one seed value, this needs to be the result used for reporting within in the base model for the respective time period;
- Gap acceptance – this relationship for site specific behaviour needs to be held consistent in line with the efforts used to explore the model calibration. Unprecedented changes to gap acceptance parameters and the estimated limits of traffic flow may need to be justified through empirical support of similar conditions and volumes (both throughput and conflicting);
- Saturation flow- the standard behaviour parameters need be applied in a consistent manner unless additional scenarios to explore set modifications are introduced into the future year setting;
- Generalised costs parameters – the parameters and the weighting of factors to influence the assignment considerations need to be held to match the conditions of the base network; and
- Intended speed conditions – the unconstrained or intended traffic flow speeds in the scenarios applied need to be held consistently with the same pattern as benchmarked for the base model developed.

10.2. Future network development

The condition of the future year or modified network application needs to consider the changes expected to be introduced over the short medium and longer term timeframes for consideration. It is not appropriate for external teams to determine which timeframes need to be considered in developing future year applications.

Future year models and base year models with scenarios applied will need to identify how both the adjacent land uses and the traffic volumes are expected to change over the horizons. Teams should not simply make assumptions that there will not be a change in the network operational conditions over time. Teams should make use of the future year horizons in either VITM or in DOMINO to consider how traffic flows and operational speeds may remove any remaining capacity in the network over time, separate to the investigation being undertaken.

Simulation models developed for a future year consideration need to be delivered to ensure that the standards in intersection design achieve a suitable performance measure for the 30th busiest day. This may be a distinctly different demand estimate from strategic planning solutions such as the VITM demand estimate, which itself aims to deliver traffic estimates for a regular day of operations. In this way a design based on VITM estimates is understating the requirements for suitable delivery within each investigation.

Analysis of the comparison between the 30th busiest day and the 100th busiest day using empirical data held in identifies a gap in volumes of between 5-10% of the regular day figures. For this reason the future year design considerations need to increase the strategic modelling demand estimates by a minimum of 5% for suitable design and performance analysis for any time horizon consideration. This increase may appear to be a nominal value when using strategic demand estimates, but will provide for a revision in design of intersections including geometry, turn lanes and phase operations within the area of investigation.

Investigations should be able to showcase the land use and infrastructure changes within the network to better provide context of the operational challenges and conditions experienced within the landscape. This explanation should not simply be limited to tables and graphics (maps) but present the changes with a narrative to the expected operational setting that is anticipated. That is, teams need to outline to readers how and where there are major drivers for change, in the context or both demand changes as well as supply side changes. Teams should be able to showcase how and where this infrastructure delivery sits within the puzzle to expand the network.

10.3. Network Size

The consideration and application of a future year network needs to be large enough to present the route choice modifications applied due to the investigation. Modelling too small an area may misrepresent the route choices currently or planned to be undertaken. This may inadvertedly draw in too much traffic than likely delivers as the relative appeal of the new or improve route considerations (a favourable generalised cost) which itself may impact on the economic business case (benefit cost appraisal) as well as the intersection design and signal operations.

Sometimes modellers perceive that suitable delivery involves minimising the challenges involved in the delivery. However this may not always be the appropriate methodology. Teams should ensure that the model is developed to an appropriate size – which can typically investigated within a VITM or DOMINO style model. These approaches can be used to determine the area of analysis by implementing the proposed change (project) and exploring the network effects prior to developing a simulation model.

This area of impact for the project change should be applied whereby any one of the following can be noted from the base model benchmarks:

- Journey speeds change by more than 10km/hr; or
- Volumes change by more than 10%
- Volume/capacity ratios change by more than 10% of the capacity
- Aggregate or average delays change by more than 10%

This approach should also include key bottlenecks on the edge of the project investigation, so that VicRoads can determine how to deliver these sites in a changed landscape.

10.4. Signal Details

Signal details are a complex topic and in many cases remain adaptive where the SCATS system in applied. The revision and development of new signal plans need some further considerations when developing for new signal controllers within Victoria.

New signal controllers will need to consider the formation of a cycle length, a phase plan and signal coordination between adjacent controllers. Teams should also consider how a new controller operates within a subsystem of several signal controllers operating to work together. In this matter signal plans should not be developed in isolation from adjacent sites less than 500m from the area of investigation.

The designation of attributes for a planned signal controller should not be taken from evaluation of isolated operations. This may include a review of cycle length expected ranges, as well as development of phase plans.

Where a new signalised controller is developed as crossroads for four legs to the centre of the intersection, a specific signal plan should be reviewed so that the more optimal throughput of traffic can be achieved, rather than just for a specific land use. For this reason signal controllers with four legs to the intersection should not be developed using a "split" phase plan. These signal controllers should be developed to explore for a diamond arrangement, which may also include a trailing phase when required. Split phase plans provide for a less suitable (inefficient) delivery of green times within an adaptive framework at an intersection.

Signal times should be developed within the context of the adjacent locations that are both expected and those planned. With an established area the controller attributes (including cycle length, phase split and subsystem) should be developed in line with the operations of the adjacent controller. Where sites are developed in growth areas, the controller should be designed within the planning structure of the broader area, which may imply modelling a broader area than just the localised applications of the investigation. Development of new controllers in growth areas also need to consider the revision to further sites which may have previously been developed from an out of date or misdirected concept.

For development or refinement of signalised controllers within both growth and established areas an optimisation solution for the design and operation of the controller may not be an appropriate or acceptable solution. Rather the development of the new controller should be managed within the context of the existing and expected operational considerations to develop a strategy for the operation of the subsystem. Within this context, it is also not appropriate to formulate a strategy of a linear corridor if the current operations operate over multiple subsystems. The application on site will not deliver a solution for the controllers with a singular cycle time, as there are often multiple complex and changing factors that need to be considered by VicRoads operations. In part this may also consider the application of pedestrian crossing times at selected intersections which underpins the optimisation functions for maximum throughput on the adjacent sites.

In all cases, where public transport priority is to be applied on site, the signals need to be developed as an adaptive phase solution. This might be a comprehensive actuation solution or development of a SCATSIM EPROM solution. However, fixed time or time profile signal plans will not be suitable for delivery of the modelled scenarios to explore the adaptive operations.

In all cases when developing a new signal controller, teams should be in contact with the regional signals manager at VicRoads. It is expected that correspondence and advice can be tracked between the relevant parties.

While not directly related to signal details in developing operational requirements, it is important to remember that appropriate deceleration and acceleration requirements need to be incorporated into the design. Turn pocket lengths need to ensure that traffic can safely move into short lanes and achieve zero velocity at the stop line at times other than those typically modelled (the peak periods). Designs need to be are appropriate to accommodate the higher traffic speeds that are associated with the movements in the off-peak periods (less demand, less congestion).

10.5. Time Profiles

The formation of a time profile for the development of a base year model needs to be built from empirical data and ensure that validation of this time profile is delivered. Time profiles reflect the variants in demand through the course of the evaluation period, typically as fifteen minute intervals for a succession of one hour periods.

Deterministic demand estimates from strategic travel demand models have no insights into time intervals within an evaluation period. However, this is a core element of simulation models. It is recognised that demand patterns and as such the operational conditions across a landscape do not need to be held consistent over time. For this reason VicRoads recognises that established (and validated) time profiles may begin to subtly vary with future year demand estimates.

The rate with which this demand profile is adjusted should be a function of a number of changes in the network including the following considerations:

- Inequity in the existing demand profile between time intervals;
- Length of the future year time horizon being explored; and
- Land use and infrastructure changes planned (expected) in the broader region.

10.6. Public Transport Planning

Models that explore future year considerations or revisions to an operational plan should aim to explore changes to the public transport components of the network for the horizon investigated. VicRoads can accept in simulation models that the existing arrangements for public transport may not align to the development efforts for service delivery in a future year horizon. Organisations such as Transport For Victoria or Public Transport Victoria or other private operators may not be in a position to confirm matters for longer term delivery horizons, but may be able to suggest if such changes proposed for the simulation are likely for delivery.

This may a focus on the details of a potentially revised timetable – which may be either changes to the headways of services or the particulars of timetable (e.g. changes to start times which may offset arrival at a downstream rail station and better integrate for passenger connectivity between modes).

Modellers who are exploring the prospective changes to public transport considerations within a simulation setting may also need to explore the following attributes as follows:

- Rolling stock of services - will this aspect change over time so that services (bus, tram, rail, ferry) carry more passengers for each journey;
- Routes – are there new routes planned or express route considered for access between boarding and alighting stops, which may even involve the clearance of existing services for a new or different destination (this may be more prevalent in growth areas across Metropolitan Melbourne);
- New stops or types of stops (e.g. creation of more super stops within and near to NEICS and MACs);
- New access considerations which may impact on the route, stop locations and private transport considerations within the network investigated;
- Revisions in signal plans for public transport priority; and
- New ticketing systems that may impact on boarding and alighting and as such then on dwell times for the services.

10.7. New Modes of Transport

Simulation models currently explore general traffic and transport movements across an area of investigation to provide insights into operations and design considerations, amongst other pursuits. These models typically explore a slender mix of transport systems limited to forms of cars, heavy goods vehicles, buses, trams, rail and pedestrian movements.

Many models omit further items of complexity that can include taxis, emergency vehicles, motorcycles, scooters and high performance freight vehicles as well as less common (but present) modes such as the segway. While a broader spectrum of transport modes is not required when developing future year horizons, teams might need to consider some further variants to the existing fleet of transport modes.

This could include an increased proportion across the fleet over time of autonomous vehicles, as well as variants in on-demand vehicles. It should be noted that some solutions may require mode specific infrastructure elements or changes to the behavioural parameters that push the simulation algorithms. Other solutions such as the on demand services may require differences in the route structure as these may not be a single purpose journey but contain a chain of journeys amongst a shared system.

10.8. Demand Growth

The derivation of demand for future year horizons on any road or route is paramount to exploring operational matters and delivering on design and performance criteria.

Existing solutions within the public sector provide for direction on demand estimation, notably the Victorian Integrated Transport Model as developed through Transport for Victoria. This is a demand estimate derived from land use considerations (population, employment and educational enrolments) amongst other factors. The traffic assignment is then a function on the scale of costs for travelling along various routes to reduce the effort of travel and complete the journey. That is, the demand estimates over time are a function of the network performances rather than a series of independent numbers.

VicRoads directs that any estimation on growth in the medium to longer term horizons should be a derived from and (when revised) benchmarked against the strategic travel demand model.

The process of demand estimation for design and delivery matters should not be a function of a "bump up" of vehicle numbers (or patronage) which often involves a percentage estimate increase on existing volumes. Not that this approach is not suitable given the presence of the statewide VITM model and the metropolitan DOMINO solution. VicRoads reserves the right to decline investigations where a percentage growth rate is the key designator to determine design and operational matters for delivery (in both intersection and traffic signal solutions). However, note that this is not the same determinant as interpolating matters between VITM future year horizons where a reference case has not been established.

As previously discussed within this guideline, teams must be wary of the traffic volumes extracted from the VITM model and not simply apply these measures at face value. Further discussion around these points includes the following considerations:

- Demand estimates are typically based on standardised trip rates that may or may not be appropriate for the location being investigated. Teams should consider the value of residuals in these trip rates when exploring future year horizons;
- Traffic volume considerations need to be considered within the context of Travel Zone Access and Egress. Notably the positioning of centroid connectors can have an important factor on the release of traffic onto the network, which may determine link specific volumes, and hence design and operational matters;

- Demand estimates from the VITM travel demand model are strategic in nature which means that they are validated suitably to determine guidance for policy formation, rather than specifically for design and operational deliveries. All demand estimates should be reviewed within the context of the network specifications;
- Intra-zonal trips need to be considered - These journeys both commence and are completed within the same travel zone, for which deterministic models such as VITM will not assign these traffic volumes. Hence the demand figures may be understated for intersection design and operational deliveries; and
- Future year models should be delivered in line with the requirements to meet design guidelines. Note that these volumes are different (categorically, but feel similar with an initial review) from those values from the strategic travel demand model that utilises the expectation of a regular day of traffic movements (as per the calibrated base model but with different land use values and infrastructure scenarios). Where direction is required, it is expected that the gap between volumes in the regular set of conditions to the design requirements is in the order of an additional measure of 5% traffic movements.

Some teams favour the application of a demand refinement process such as the PivotPoint model to determine a new demand, based on a change (or pivot) on the observed volumes. It should be noted that these demand estimates require enough details of the existing and proposed land uses to calibrate this process and delivery for the volumes generated. This process uses empirical data to then determine how land use changes will impact on trip rates and then road volumes modelled in the network. The functionality is dependent on generation of a synthetic demand matrix, which is compared against the existing demand, as per the VITM demand matrix. However, note that the VITM demand matrices are already a synthetic solution based on a number of limited observations (small sample of household travel surveys, limited traffic volume collection). For this reason the forecast estimates when using this process need to be substantially reviewed prior to delivery of a design and operational consideration.

Investigations should also account for the paradox of traffic assignment with parallel routes. Within this context the demand estimations from a strategic model may provide requirements for design and operational considerations. Overdesign of a signalised controller should deliver an improved intersection performance (Level of Service). However when out of context from the adjacent or competing locations, an intersection that performs favourable or well can be subject to drawing in additional traffic volumes. In this manner the demand estimate may over or understate the demand subject to the design and delivery of the proposed intersection performance. Nonetheless simulation models should aim to minimise the delays for the estimated demand figures provided.

10.9. Exploring Performance Differences

The value of an investment is based on the demonstration that the change to the network can enhance the movement of journeys across a network in a more effective and efficient manner. This process of developing a business case to illustrate the benefit cost appraisal is a key component in delivering for an improved network performance for drivers across a network. To achieve this demonstration, the investigation needs to tabulate (or show) a number of performance measures and indicators from the simulation model, which itself will show the scale of improvement to motorists and users of the road network.

Simulation modelling often involves delivery of new infrastructure and new signalised intersections. These changes to the network can have the impact to misconstrue the effects in delivery, subject to the suggested changes. As an example, a new road connecting a land use to the arterial system will dissect the road lengths previously used to calculate the delay times. For example a section of road that had two intersections that were one kilometre apart may now have three intersections at set 500m intervals. This process may reduce the overall delay calculations for the two outer intersections (as this time is now allocated to the central location) improving the overall performance of the original two sites. This element appears counter intuitive and required documentation to explain the matter as well as specifications within the reporting tables.

Modellers need to ensure that the network changes do not misrepresent the performance metrics of the scenario explored. For each investigation there should also be a comparable series of metrics that explore intersection performance as consistently as possible between demand and design options.

To better present for such matters, all simulation models need to report on a number of performance metrics about conditions experienced by road users across the entire network model. All links and nodes need to be considered for evaluation of the simulation conditions. This should provide for a series of network attributes to be tabulated and compared for changes experienced with the introduction of the network solution. This process itself then implies that conditions of a Business as Usual model (or Do Minimum setting, depending on conditions) should be modelled so that road user experiences can then be benchmarked by expected future network performance.

10.10. Sensitivity Modelling

In a future year horizon with additional demand and new infrastructure designs (potentially) there may be value in an exploration of the sensitivity of the network model. This approach can be matched by the discussion outlined within Section 6.3.6 and 6.3.7 of this guideline.

The process of applying multiple seeds to distribute the randomness of attributes within a fleet typically shows the strength or stability of a network model. This is commonly applied in a base model to explore matters of network risks, as well as provide confirmation of the stability in the network performance. Although not commonly applied, a similar pursuit with an already established stable model and subsequent series of seed values can be used to explore the performance under a varied set of demand and infrastructure deliveries. Such conditions might include an arrangement whereby a demand variation of ±5% might identify network operational considerations including the variation in:

- perceived journey times;
- route or corridor volumes;
- intersection performance;
- weaving flow breakdown; and
- number of stops.

The existing set of stability metrics and reporting should accompany this component of the investigation to provide direction on the design and operational considerations of the network pursuit.

10.11. Pedestrian Planning

A regular crossing time for pedestrians ensures that this fragile group of road users can achieve the intended aspect without endangering themselves by moving at the incorrect times. While most design and planning for signalised controllers will ensure that pedestrian crossing opportunities occur on a very regular basis, this application is sometimes overlooked.

Developments to the road network (temporary or permanent), for either short or medium or longer term solutions need to ensure that at no time the wait for pedestrians to cross any part of the road will exceed 180 seconds. As most signalised intersections operate cycle lengths that are smaller than this timeframe, this is not an issue for regular conditions, but only for irregular occurrences.

Existing standards for pedestrian planning may quote figures for an hourly arrival rate. Design measures should ensure that this rate per minute can be achieved. As an example a pedestrian crossing needs to be developed suitably to account for the 300 persons using this within a busy hour. A review of conditions identifies that as this location is adjacent to a school then 90% of demand within that hour uses the crossing within one 15 minute interval. Design requirements need to ensure safe passage for this movement rather than for a hourly benchmark.

10.12. Reporting and Presentation

The reporting of modelled results from scenarios and options needs to be developed so that the options explored can be analysed as a structured comparison. This approach may require a limited number of tables with multiple attributes to identify the expected conditions in the future year horizon. The tables are encouraged to be formed with attributes as rows and scenarios as columns. Scenarios should be appropriately labelled with a reference and a time horizon (future year).

It is expected that tables and graphics would be developed to explore the results from the simulation model with regard to metrics for:

- The network;
- Intersection performance;
- Corridor Performance (e.g. journey times); and
- Approach Performance (queuing).

Reporting tables should be formatted to be legible by all stakeholders. This may involve some colour coded based on results (e.g. Intersection Level of Service) as well as formatting of numbers to produce an easier read of results.

The tables developed from the simulation modelling may also need to complement the tables with a number of graphics in order to better build the narrative to various stakeholders. This is a more common process to ensure that stakeholders with a background in network and infrastructure planning, as well as those without such skills can comprehend the prospective impacts of the future time horizons.

It is expected that some simple line graphs may need to be provided to explore how network attributes change over future horizons or amongst scenarios. Specifically line graphs should be developed to explore network changes across the following metrics:

- Average Journey speeds (km/hr);
- Total delay calculated across the network; and
- Total number of vehicle stops across the network.

The reporting of key indicators and performance metrics needs to be provided with the submission of the base model. These outputs should not simply be limited to the options report.

Table 39: Chapter Checklist for Future Year Considerations

Topics for Discussion and Reporting	Yes	No	N/A
Do the fundamental inputs that the simulation model was validated against still hold true for the project delivery option, including time steps applied, seed values used, saturation flow and parameters for generalised costs?	☐	☐	☐
Does the project modelling account for the anticipated rather than just committed delivery changes within the area that may impact on the scheme explored? Has an adjustment been made for design considerations in addition to the future year demand estimate?	☐	☐	☐
Is the network developed of a suitable size to explore the right scale of response from road users?	☐	☐	☐
Have the signal details been developed within the simulation model to deliver in line with how VicRoads may actually apply a new or revised signalised intersection?	☐	☐	☐
Has the time profile for movement of journeys within the simulation period remained consistent to the base? Has this measure been revised for the project delivery?	☐	☐	☐
Is the public transport suitability accounted for in the project condition, which may include changes to the rolling stock applied, or the routes or stop locations or designs (amongst other elements)?	☐	☐	☐
Has the traffic composition changed within the project model, including new modes or more details disaggregation of the vehicle fleet on the road?	☐	☐	☐
How has demand been accounted for between the base and project model (potentially across multiple time horizons)? What assumptions sit within this delivery including matters of route choices, demand loading from connectors and intrazonal trips amongst other matters? Have the details of a Pivot approach been appropriately documented?	☐	☐	☐
What sensitivity to the demand estimation has been applied within this investigation to identify for the scale of delivery in the network?	☐	☐	☐

11. Analysis and Reporting

A modelling report brings together all the processes discussed in this manual into one area. One modelling report should be developed for the entire modelling investigation which includes:

- Development – data collection and 'base model' calibration and validation process(es) and performance benchmarks; and
- Analysis - option testing.

If the tasks have been split between different parties or inherited from a previous project, then the earlier modelling report(s) need to be part of the current modelling report appendix list. In such cases the following additional requirements need to be adhered to:

- Introduction, project definition and objectives need to be discussed for the current modelling report and modelling investigation; and
- If the modelling report is at the stage of option testing, then a summary of the development and 'base model' calibration and validation need to be provided in the body of the report. The summary should state any limitations likely to impact option testing stage.

Nonetheless, a reminder is that the preference from VicRoads is to deliver a singular modelling report. This may be a modelling report that transforms in content and in title through the progression of the investigation. I.e. initially named a development report and later defined as a modelling report, for which model development comprises a chapter.

The modelling report should suitably provide a narrative to tell the three key matters of:

- story of the problem (context);
- the reporting metrics of that issue (benchmarks) and
- the means to address the query (resolution).

A modelling report should not be required to further be re-interpreted for a delivery manager or for public consideration.

A modelling report template has been provided in Appendix C.

11.1. Model Analysis

11.1.1. Colour Schemes

For reporting consistency, the colour schemes proposed below should be used to display the relevant inputs and outputs in the model. Note that this is not prescriptive for selected attributes but should be applied based on the number of classes in effect. In such a case a metric such as the intersection "Level of Service" might be mapped in a network using a six class system.

Table 40: Colour scheme for performance outputs

Description	4 Classes	5 Classes	6 Classes	7 Classes	Colour (RGB) 7 Classes
Poor					0/ 0/ 0
Performance					131/ 60/ 11
↑					255/ 0/ 0
					255/ 192/ 0
↓					255/ 255/ 0
Best					0/ 176/ 80
Performance					146/ 208/ 80

Under such a system the sites that achieve a Level of Service "F" might be showcased with a black icon or symbol, and perhaps complemented with white text. By comparison a Level of Service "E" which achieves at a slightly better performance might then be displayed as red with black text. Where black is not applied as the main colour for a performance metric, the symbology should be complemented with black text.

Similar measures can be determined for other performance metrics within the models including density calculations, volume displays, dwell times, journey speeds and more.

One commonly displayed metric where a different approach may be required are the images that showcase the number of lanes. Under such conditions the most common frequency of lanes on the modelled links should be provided with a simpler colour (e.g. white or black or grey). The more infrequent or very irregular link definitions (e.g. six lanes or more) might then be displayed with a more outlandish colouring system such as purple.

Table 41: Colour scheme for number of lanes

Number of Lanes	Colour (RGB)	Colour (Appearance)	Description
1	255/255/255 or 0/0/0 or 128/128/128		White/Black/Grey (as appropriate)
2	255/0/0		Red
3	255/215/0		Gold/ Orange 255/215/0
4	60/179/113		Dark Green 60/179/113
5	125/158/192		Blue 125/158/192
6	128/0/128		Purple 128/0/128
>6	255/255/255 or 0/0/0 or 128/128/128	Appropriate colour such as white, black or grey. Should not be in conflict with the colour for 1 lane.	Undefined

When developing difference plots between options or scenarios, colour scheme should be produced so that worsening conditions are in red, while improved conditions are in green. That is a comparison with an introduced change against the option of status quo should showcase higher volume links with red colours on link or bars. This is despite the fact that the road network is now carrying more users within the transport system. While the metrics are increasing (more volumes) actually the user experiences are declining (more congestion and longer journey times). Locations with a reduced volume of traffic should be presented with green bars or links.

Similar measures can be applied to compare average (or median) journey speeds between the project base and scenario. This diagrammatic display might then present slower speeds in a red band (worsening conditions) and a faster speed (enhancement) in a green band. Again the colour schemes are not to deliver directional changes in metrics but in the revision to the operational experienced of the road users.

11.1.2. Intersection performance

Intersection Performance is one of the more common modelling results to emerge from simulation models. These measures aim to determine the impact on the road user and the relative scale of performance at the intersection. There are multiple descriptions to explain the performance metrics, but the six classed structure taken from the US Highway Capacity Manual is used to qualify the performance metrics from the model.

In a simple statement, a performance of an Intersection at a Level of Service A or B suggests that the intersection over provides for the existing demand (too much infrastructure) while the Level of Service F implies that demand has exceeded the available capacity of the site. A Level of Service E condition identifies that there is little growth opportunity and that the intersection is already a congested location. Typically design standards identify performance on day one (opening) of an intersection to be a Level of Service C to D, progressing over the next ten years towards ad D to E level. However this may occur sooner in established areas as signalised solution may be a reaction to an existing (and congested) location elsewhere.

Vehicle delays should be calculated as the average person delay rather than average vehicle delay. Unless otherwise determined public transport services for buses and trams should use an average occupancy of 30 people per service (or maximum capacity is smaller). Private car vehicles should use an average occupancy of 1.2 persons per vehicle for AM peak period models and 1.3 for PM peak period models.

Simulation models outside the peak periods should assume an average occupancy of 1.5 persons per vehicle. (business peaks, off peaks, weekend models). Rail services and the associated occupancy should not be represented within these performance measures.

Table 42: Intersection Performance measures based on per person delay

Level of Service			Signalised Intersection			Sign Controlled Locations		
Grade	Display	RGB values	Average Person Delay (s)		Utilisation	Average Person Delay (s)		Utilisation
A		146/ 208 /80	< 10	AND	<100%	<10	AND	<100%
B		0 / 176 / 80	< 20	AND	<100%	<15	AND	<100%
C		255 / 255 / 0	< 35	AND	<100%	<25	AND	<100%
D		255 / 192 / 0	< 55	AND	<100%	<35	AND	<100%
E		255 / 0 / 0	< 80	AND	<100%	<50	AND	<100%
F		0 / 0 / 0	80+	OR	100%+	50+	OR	100%+

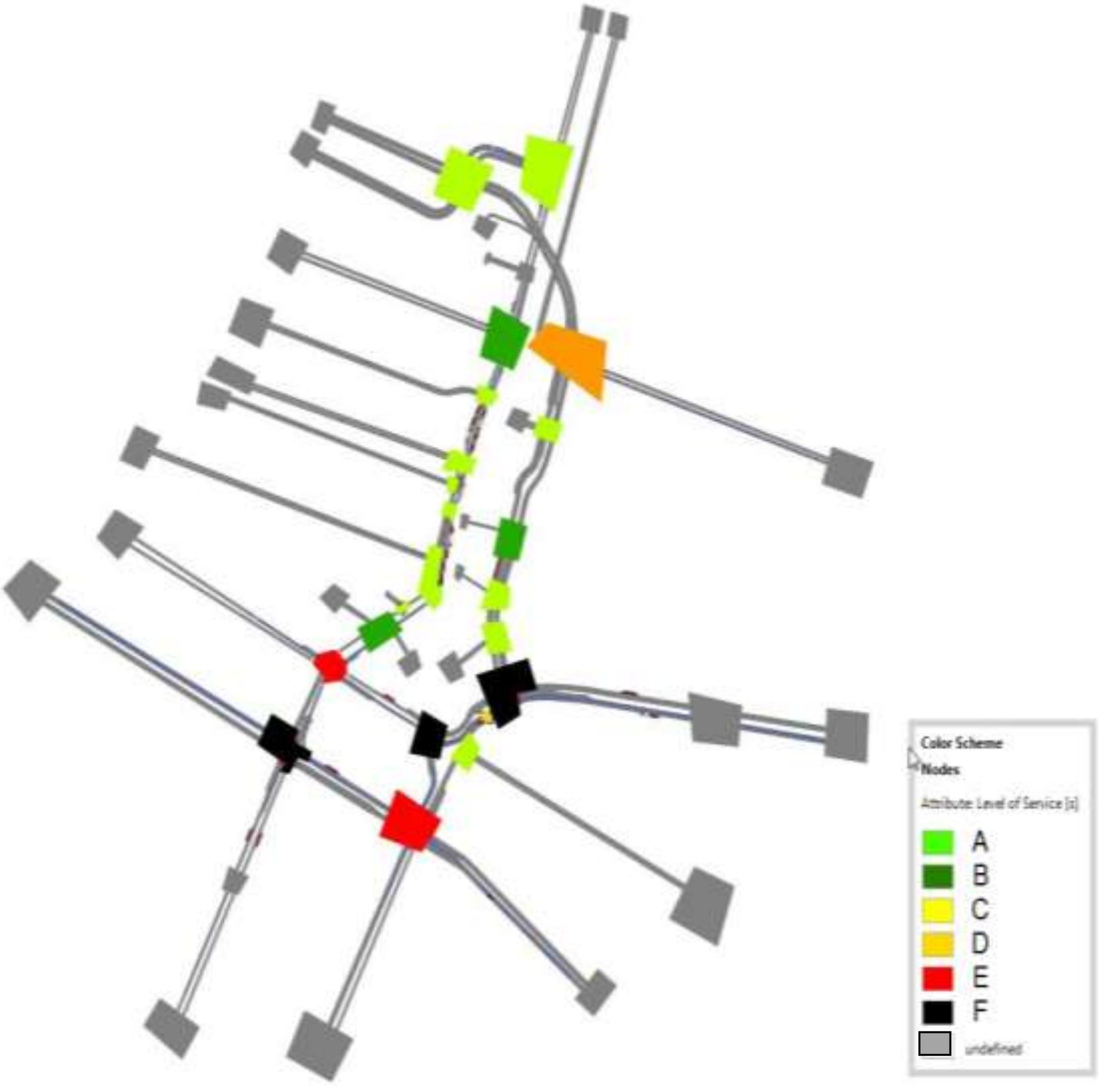
The performance of the intersections should be presented in the network as a plot to showcase the performances and metrics of the simulation. A colour scheme for the performance metrics is outlined in Table 42 and displayed in Figure 62 as an expected delivery.

Intersection performance metrics (Level of Service) should be provided as an hourly solution even if additional time intervals (say 15 minute measures) are also required. An hourly time interval provides for a more reliable evaluation measure when extrapolating conditions to consider a future year demand estimates within the simulation model.

Please note that there may be times when the evaluation of the intersection should compare the volume of the demand rather than the volume of the throughput. These measures are easily obtained from simulation modelling.

Analysis needs to ensure that the calculation of intersection performance (as a function of average person delay) needs to weight the approach delays by the demand. Previously some efforts have taken an arithmetic average by approach, rather than as a reflection of the user experience.

Figure 62: Intersection Level of Service Display



11.1.3. Motorway Performance

The performance of motorway conditions is often determined as a function of density, as a calculation of vehicles per hour per kilometre per lane. This can be re-written as a direct relation of flow and speed for each lane as a function of time.

VicRoads has an extensive collection of research to explore motorway performance and operations across the metropolitan Melbourne landscape. This measure allows for a better handling of complex traffic management and operational delivery matters, including the security of the user experience to undertake a journey across the city. Melbourne operates the world's largest network of managed motorways which identifies that multiple elements are connected together within the planning and operational tasks of the road system. For this reason further investigation from the existing library of technical documents should be explored. Additional analysis on top of the metrics outlined within this guideline may also be required to benchmark and suggest changes to the operational complexities.

A higher flow typically leaders to a greater density value for each time interval evaluated, implying that more traffic is travelling within the space investigated. While the strategic travel demand models can explore highway performance, the simulation models have strength in the delivery of density metrics and the analysis produced.

Motorway density should only be conducted for traffic flow conditions with a free flow speed between 90-120 km/hr.

The data in Table 43 outlines the density metrics for motorway performance of basic segments. These locations should be for motorway operations without significant weaving, merging, diverging or lane changing across the motorway network. Again a lower density of vehicles per lane kilometre per hour will suggest overprovision of infrastructure (or room for growth) while a value at the bottom of the table identifies the need for further planning and delivery of motorway developments. An example of the density analysis can be viewed from a simulation model exploring lane based performance metrics in Figure 63. The image identifies greater density in the northbound movement (the black and red locations) when compared to the southbound movements.

Table 43: Basic Segment Performance Analysis on Motorways

Level of Service			Density Measure
Grade	Display	RGB Values	(vehicles/ lane/km/hr)
A		146 / 208 / 80	0-7
B		0 / 176 / 80	>7-11
C		255 / 255 / 0	>11-16
D		255 / 192 / 0	>16-22
E		255 / 0 / 0	>22-28
F		0 / 0 / 0	>28

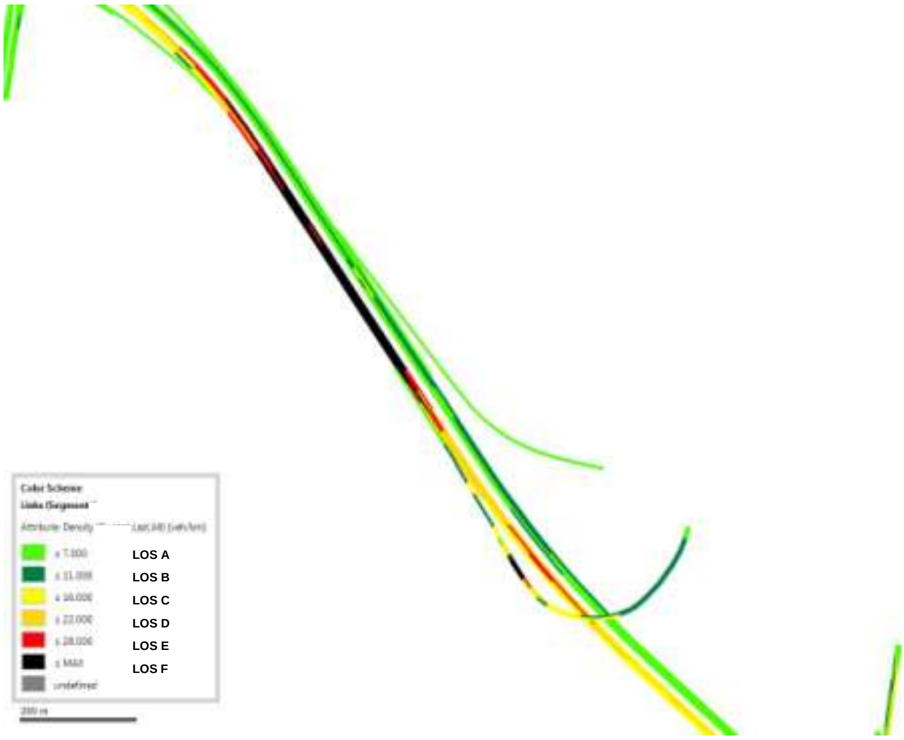
It is advised that density calculations and displays of these metrics may need to be presented as a function of the per lane measure rather than as a per link display.

The US Highway Capacity Manual explores Two Way Two Lane Highways as a classification of three designations, all of which are applicable for Victorian Roads.

- Class I are intercity routes and primary connectors where drivers expect to be travelling at relatively high speeds.

- Class II are slower speed routes that typically involve a non-commute purpose or coastal or rugged terrain movements. E.g. Great Ocean Road or Great Alpine Road
- Class III are those roads with connections into moderately developed areas and hold a mix of both intercity and local access movements.

Figure 63: Density plot on Motorway simulation model



The methods to explore traffic performance for both Class I and Class II roads are defined through the application of the percentage of time spent following another vehicle. However, classification thresholds are different between the two sets of roads. This metric is obtainable from simulation models whereby individual vehicles can be explored for several times in each second simulated. Class III roads require an exploration of the percentage of Free Flow speed achieved in the evaluation period for each link. Thresholds for the three classes of Two Way Two Lane highway for regional settings are provided within Table 44. Further details of these classifications can be found within the US Highway Capacity Manual.

Table 44: Regional Two Way Two Lane Highway Performance (HCM 2015)

Level of Service			Class I	Class II	Class III
Grade	Display	RGB Values	Percentage of Time Spent Following	Percentage of Time Spent Following	Percentage of Free Flow Speed
A		146 / 208 / 80	<35%	<40%	>91.7%
B		0 / 176 / 80	35-50%	40-55%	83.3-91.7%
C		255 / 255 / 0	50-65%	55-70%	75.0-83.3%
D		255 / 192 / 0	65-80%	70-85%	66.7-75.0%
E		255 / 0 / 0	>80%	>85%	<66.7%
F		0 / 0 / 0	Demand Exceeds Supply		

11.1.4. Arterial Road Performance

The performance of arterial roads as a midblock condition between intersections can be explored as a function of journey speed. This might be a discounted measure of conditions against the free flow speed (which is not simply defined as the signposted speed).

Analysis of journey speeds simulated along the arterial corridors may be explored by considering the average journey speed achieved over the course of the evaluation. In this context the roads should be explored as modelled segments, typically as 20 metres sections of road. However, at the discretion of the model development team, this may be up to 50m segments, subject to the designation on the links in the model itself.

A display of the link segments should be presented using a six class colour scheme, which may be outlined using the average journey speed is as follows in Table 45: The data in this table applies a standard colour classification to selected speed designations. In this instance both a general application and an alternate application is presented.

The alternate application represents ten kilometre/ hour increments for conditions of slower speeds, albeit with a baseline in the category of 0-20km/hr. Such measures may be appropriate when exploring town centres or for locations where the regular experiences do not exceed speeds of 60km/hr, despite signposted regulations suggesting otherwise. In all cases an average journey speed of less than 20km/hr should not be further disaggregated as this already represents a very concerning landscape. An application of 10km/hr or even 5km/hr bands may further explain the details and the professional work but do not hide the result of this averaged condition.

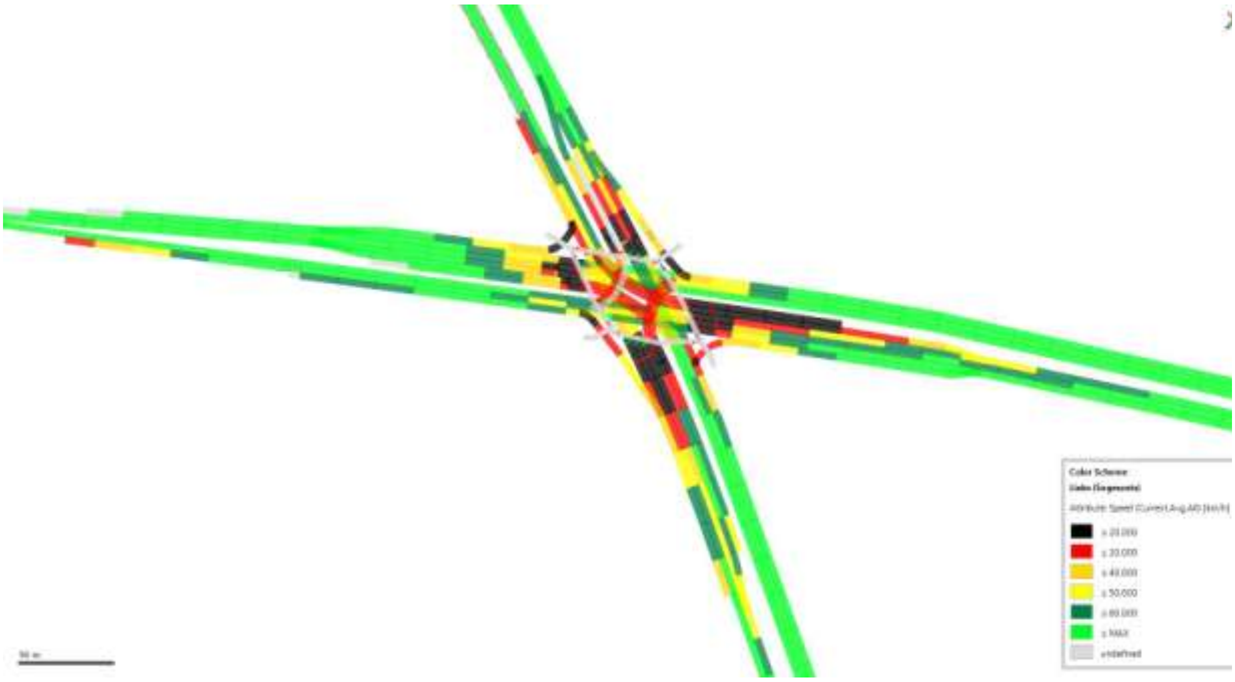
Table 45: Journey Speed Display Settings

Level of Service			Average Speed (km/hr)	
	Display	RGB Values	General Application	Alternate Application
A		146 / 208 / 80	100+	60+
B		0 / 176 / 80	80-100	50-60
C		255 / 255 / 0	60-80	40-50
D		255 / 192 / 0	40-60	30-40
E		255 / 0 / 0	20-40	20-30
F		0 / 0 / 0	<20	<20

It is strongly advised that the classification of the journey speeds is not reduced to a measure of less than 10km/hr designations. That is, the classifications should be 10km/hr increments, or that of 20km/hr increments. The completed result may not need to differentiate higher end speeds which itself may combine potential classes together: that is; a few limited links with average speeds between 100-130km/hr might be designated into a category band of 100km/hr+

The display in Figure 64 identifies the measures of average vehicle speeds on arterial roads at the selected intersection. This data identifies that speeds are typically lower at the intersections top line and higher at the midblock condition. Slower speeds are observed on the southern and on the eastern approaches when compared to the northern and western approaches.

Figure 64: Average Vehicle Speeds on Arterial Roads (20m segments)



Standard speed plots should adopt a similar measure of presentation using the display structure and general application of categories for the area of investigation.

11.1.5. Network Productivity

This term is a recent technique of network evaluation as applied within VicRoads. This process is used to better determine design and operational matters to complement a series of more standard network performance measures of aggregate distance and time travelled (VKT/VHT). The Network productivity aims to identify the benefits of design and operational planning with an increase in throughput and speeds as and where evaluated. This approach should be applied to each link and then evaluated in aggregate.

The process is useful for benchmarking network conditions, as well as to determine the value of distinct routes or roads within a simulation model to determine the value of the investment. This process should not replace traditional performance metrics, but aim to complement these solutions with this approach.

The methodology of this approach to determine the network productivity is relatively simple. This is a function on each link of the number of vehicles multiplied by the average speed.

A throughput of 100 vehicles travelling at 80km/hr would produce a metric of 800 vehicle hours (100 x 80). By comparison a throughput of double this volume (200 vehicles) at a reduced speed of 50km/hr would produce a network productivity on the link of 200 x 50 = 1,000 vehicle hours. This would suggest that the second throughout option would have a greater productivity than the original calculation.

The value in this approach can be viewed within Figure 65 which shows the area of the Calder Freeway and Melton Highway in the Broadmeadows area. The modelling initially identifies that the productivity of the inbound movement on the Calder Freeway (red link bars) for this time interval is two to four times greater than the movement on the Melton Highway. Precise figures for all times intervals can be obtained and tabulated to compare results and the significance for moving people with proposed road designs. Individual link results should be aggregated to a network solution in order to compare scenarios as part of the network evaluation process.

The process allows options in design and throughput to be explored, but may be not explicitly compared. This is due to the shortcoming in the analytical process that more links over the same distance will generate more numbers (and hence higher productivity and a more favourable solution). Nonetheless this approach assists to determine the relative value and strengths of operational solutions within a simple comparative approach.

11.1.6. Network Performance Metrics

Many of the reporting techniques assist in delivering a narrative on the performance of conditions within a selected area of the investigation. Typically the report extracts node performance indicators to advise on the quality of the intersection, while journey time metrics may showcase matters of the arterial corridors. These indicators help to explain prospective conditions within a localised position, but fail to explain matters across all positions within the network. This cumulative measure can help to identify the economic value of the proposed pursuit.

The network statistics can identify the impacts within the simulated network that the other metrics may not be able to explore by definition. For example when designing a new intersection, teams might wish to contemplate the delivery between a new signalised intersection against the metrics of a pair of staggered t-junctions. Exploration of individual intersection performances will generate a localised response, but not hold for comparative delivery (two intersections rather than one). A combined measure can be achieved by exploring the cumulative effects of changes across the network, or as a waterfall diagram to explore the isolated impact of the varied transformations. A network evaluation metric will be able to deliver this indicator.

Figure 65: Network Productivity Display

The most important network metrics to provide as a line graph in the reporting includes the following considerations:

- Total Distances Travelled (kilometres) (VKT);
- Total Hours Travelled (VHT);
- Average Vehicle Speeds (km/hr);
- Aggregate Network Delay (hours);
- Aggregate Number of Vehicle Stops and
- Average Number of Stops per vehicle.

Note that while the tables provide a sound measure of quantified performances from the development of a validated simulation model, these measures should be accompanied by a number of graphics to outline the scale of potential changes for stakeholder engagement. This will involve the development of line graphs for future time horizons on key criteria listed in the network performance criteria to emphasise the prospective scale of change. The two primary mechanisms to explore here include the following considerations:

- Average vehicle Journey Speed (km/hr) as outlined in Figure 66;
- Aggregate number of Vehicle Stops as outlined in Figure 67

It may also be of interest to develop a congestion index to explore the scale of the additional delays experienced within the network, amongst varied change models or over the course of selected horizons. Under such conditions as outlined in Table 46 the following terms are applied:

- Unconstrained Journey time is the gap between the Vehicle Hours Travelled and the Delay calculated. Note that this should consider latent delay calculations;
- Congestion Index is calculated as: 1+ (Delay/Unconstrained Journey time); and
- Congestion Clock identifies the decimals of the Index as a time format.

Table 46: Network Congestion Index Table

Horizon	Interval	Vehicles	Vehicle Hours Travelled	Delay (hours)	Unconstrained Journey Time	Congestion Index (1.00-2.00)	Congestion Clock (00:00-23:59)
Base	AM	4,963	425	60	365	1.17	03:57
	PM	5,679	552	68	484	1.14	03:21
+5 years	AM	5,712	519	96	423	1.23	05:25
	PM	6,881	673	116	557	1.21	05:00
+10 years	AM	6,022	532	115	417	1.28	06:38
	PM	7,345	761	206	555	1.37	08:55
+15 years	AM	6,644	618	162	456	1.35	08:29
	PM	8,274	932	330	602	1.55	13:07

Some teams aim to include numbers in graphics, but this can be difficult to read and detracts from the narrative. Reports should also consider the need to include options or include time intervals or peak periods within the selected graphs.

Figure 66: Average Vehicle Journey Speed in Network over Multiple Time Intervals (Business as Usual)

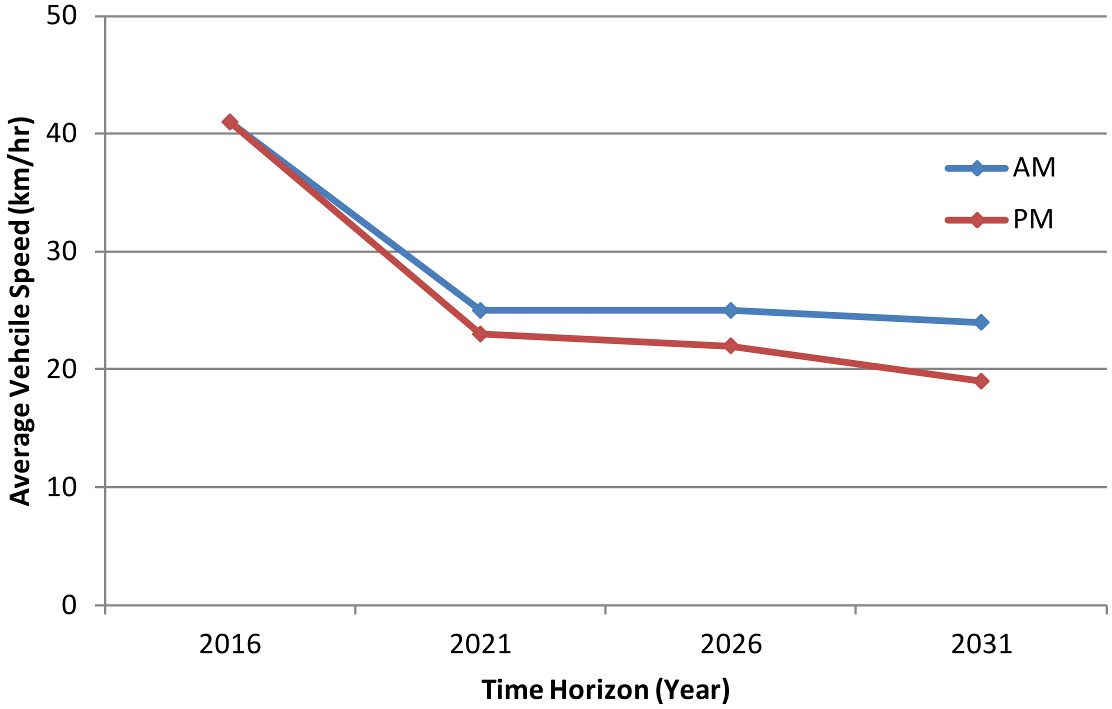
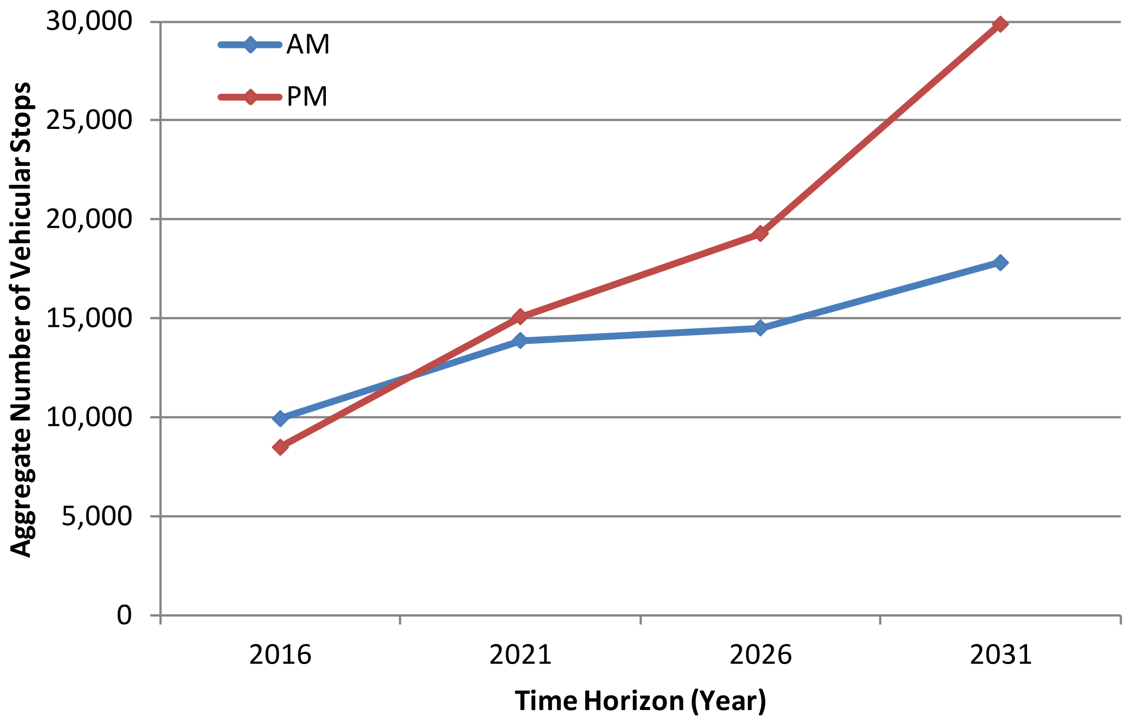


Figure 67: Aggregate Number of Vehicular Stops over Multiple Time Intervals (Business as Usual)



11.1.7. Pedestrian Simulation Modelling Results

11.1.7.1. Density Plots

The performance of the pedestrian modelling network should be reported based on Level of Service (LoS). However, other metrics including throughput and journey times can also be explored to provide more into the narrative of the proposed solution.

There are a number of approaches in exploring a pedestrian Level of Service, for which the most commonly quoted techniques are those derived from Fruin and the Highway Capacity Manual (HCM). Either approach is typically deemed as a suitable criterion to be adopted for determining a pedestrian Level of Service. The Fruin criteria has been around for nearly fifty years (since 1971) while HCM criteria is a more recent adoption for such pursuits. The project investigation will need to ensure that the most suitable criterion is being adopted as each has its advantageous and disadvantageous. The images developed for this guideline utilise the Fruin criteria that are benchmarked in .

Most simulation software packages are able to produce heat maps of an area demonstrating the density throughout the network. VicRoads colour scheme 1 should be adopted for the level of service criteria using the appropriate number of classes/bands. A Level of Service should be determined from a six class structure, with a classification also defined for locations without pedestrian movements.

Separate heat maps for the network may need to be produced in order to show both walking (Figure 68) and queuing (Figure 69) level of service. Heat plots can be provided for an average of operating conditions (excluding unutilised times) as well as a worst performance measure and may need to be presented for both metrics. Heat maps should be able to differentiate between a low density and an unused space. Therefore structures may need to be established within the reporting of the simulation software.

Some teams aim to present the variation of pedestrian movements through a pi chart to allocate the proportional experiences associated with the ebb and flow of the passenger movements. This may illustrate performance metrics of pedestrian operations through the evaluation period into six classifications. However teams are welcomed to utilise a four classification structure if this does not affect the narrative or policies formulated from the results. Under such conditions the results of the pi chart may be presented so that conditions of Levels of Service A and B are combined together, while C and D are also combined together. These two new categories should then be labelled as “A|B” and “C|D” where applied.

When exploring an average performance metric, the analysis should omit the simulation seconds within the evaluation interval when there are no pedestrians within the space. Such items should not be included within the analysis. This approach should also apply when developing an area for density analysis rather than a heat plot. Such locations may include (for example) a train station platform, or a concourse at a transport interchange. Teams may need to provide a multitude of these areas for the analysis of the simulation to develop a narrative of the design (e.g. areas for service quality metrics around station doors, as well as base of escalators amongst other locations).

Simulation modelling of pedestrian conditions within an investigation should ensure that the minimum standards of performance are not exceeded with a design solution covering the following criteria:

1. Level of Service F is not achieved for more than 10% of the evaluation period. Over the period of an hour this would suggest an unacceptable performance for up to six minutes;
2. Level of Service E (or worse) is not exceeded for more than 50% of the evaluation period. Over the course of an evaluation period, this would suggest a performance on the precipice of failure but an achievable and suitable design for up thirty minutes; and
3. Level of Service D (or better) is achieved for at least 50% of the evaluation period.

No location modelled within the simulation model should fail these criteria. Note that the first location to fail is typically the more critical design matters within the landscape.

Again note that for any location or area evaluated, the time steps within the simulation model that does not include pedestrians within that space should be excluded from the analysis and the evaluation. This may further constrain the length of time for

The graphics held in and show the various outputs required for walking and queuing level of service heat maps. The heat maps should show the average density while occupied (rather than throughout the evaluation period), while the maximum should identify the highest 15 second density throughout the network during the chosen peak interval. In particular, and show how the walking and queuing level of service differ in operation for the same area and time interval.

Figure 68: Walk Level of Service (Heatmap)

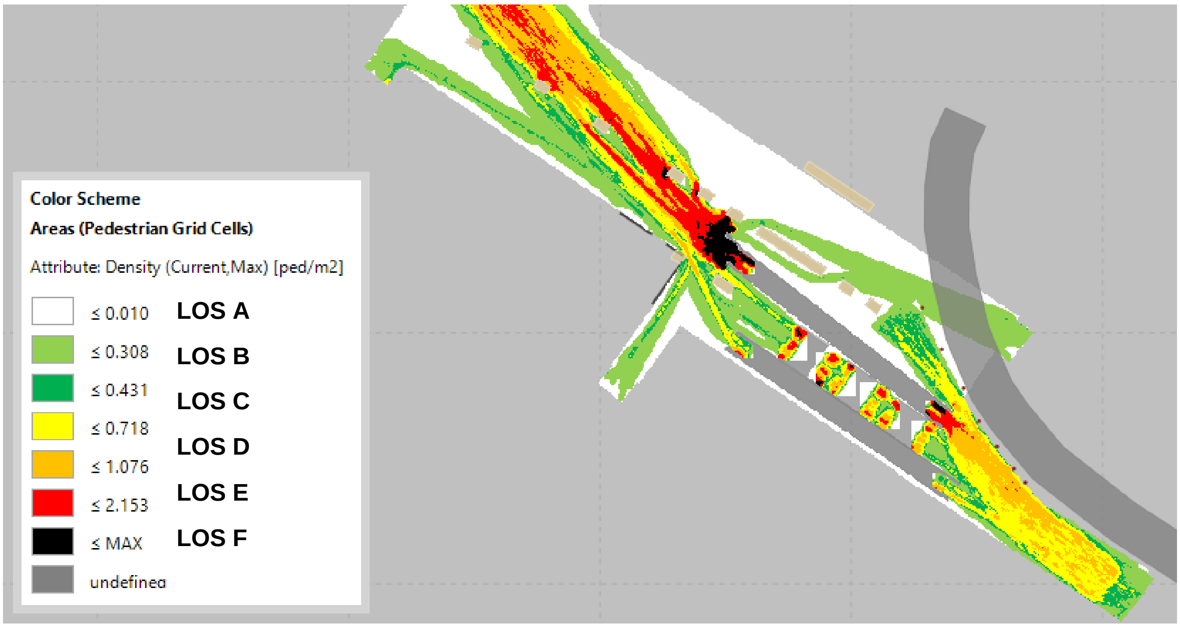
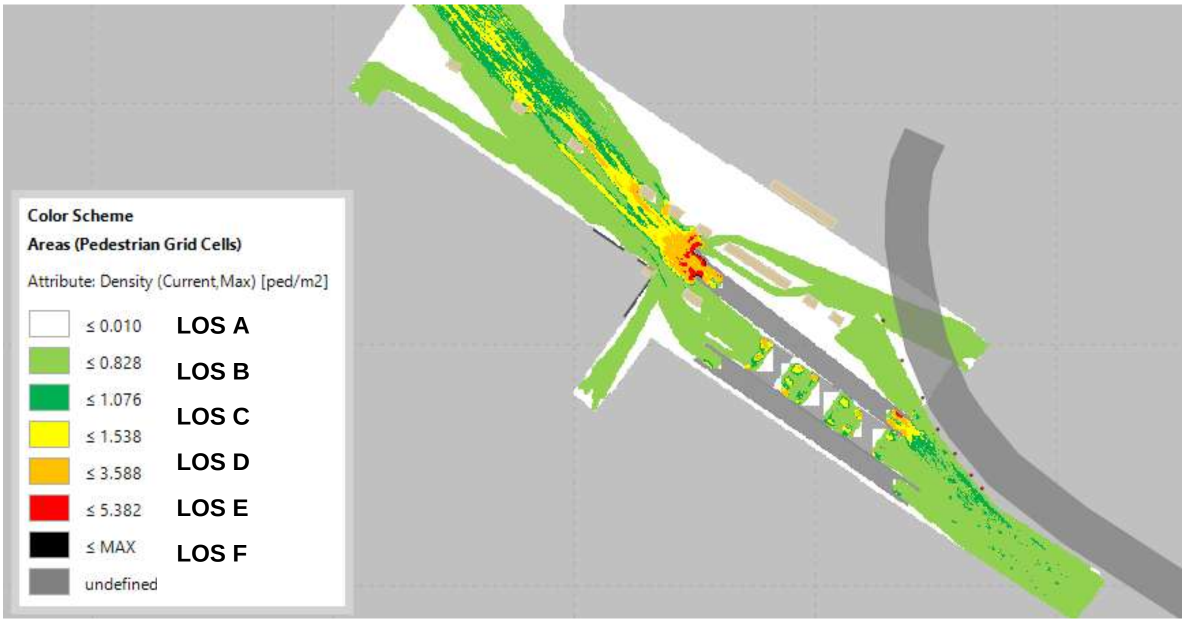
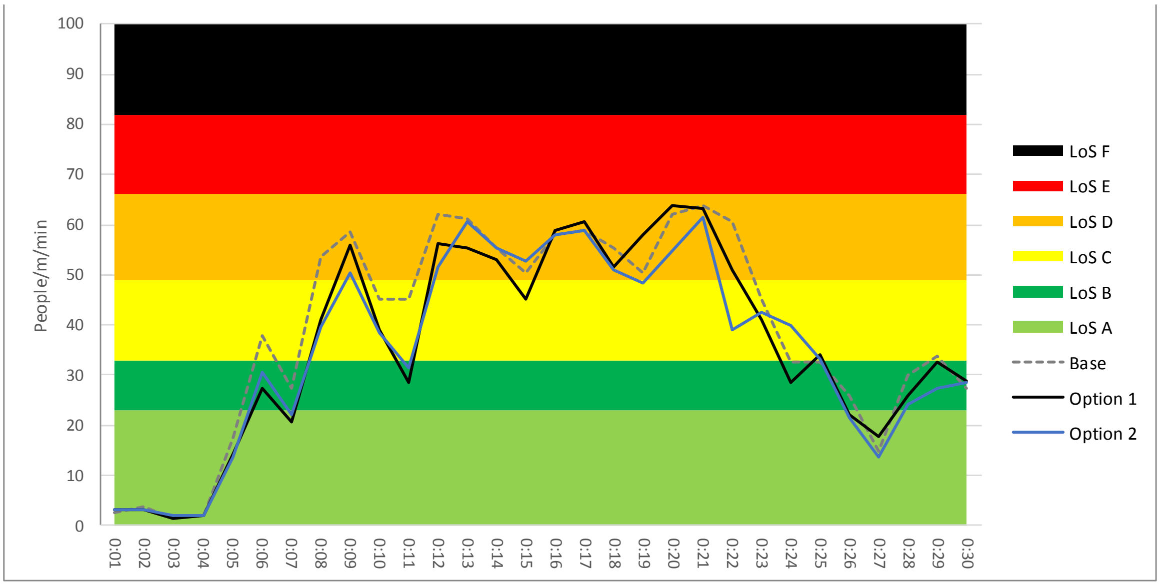


Figure 69: Queue Level of Service (Heatmap)



The areas for walking, queuing and stairs level of service investigations should be agreed with VicRoads and are predominantly defined by site observations and the narrative from the data collected. Some areas such as traffic islands will be more appropriate for queuing level of service investigations whilst other areas are more site specific. By comparison a review of density plots for a defined area (such as around ticket gates or public transport doors) should be displayed as per the structure of whereby the pedestrian density is explored against a scale of time. The level of service metric defined is those used need to be in line with those agree for heat maps.

Figure 70: Graphing showing changing densities throughout the hour



11.1.7.2. Criteria for Outputs

The following tables define the criteria from both Fruin and HCM:

Fruin Level of Service

The Fruin Level of Service is described in the Table 47 and assists in defining the classification of the density plots for walking, queuing and stairs. The tables have been combined for a direct comparison for application of walking spaces, queues and staircases. The description applies to the walking spaces.

Highway Capacity Manual (HCM 2015) Levels of Service

The HCM Level of Service is described in the following tables and assists in defining the areas of the density plots for walking, queuing and staircases. Speed is closely linked to that of density, but provides a more comprehensible narrative to stakeholders. The data held within identifies the classification from Exhibit 24-1thresholds for walkways and can be used for commencement of analysis as an alternate methodology to the Fruin thresholds.

The speeds should represent the average condition experienced while occupied for the time interval. It is not expected that moments in which the locations do not have pedestrians using these spaces should be included within the analysis.

Table 47: Fruin Walking Level of Service (modified to include 'Undefined' category)

Level of Service	LOS for Walking (m^2/person)	Average activity	Visual Example	Description	LOS for Queues (m^2/person)	LOS For Stairs (m^2/person)
Undefined	100 or more	Not applicable	Not applicable	This level has been added to describe areas with affectively no people using them	100 or more	100 or more
A	3.3 -100	< 23		Threshold of free flow. Convenient passing, conflicts avoidable.	1.2 -99	1.86 -99
B	2.3-3.3	23-33		Minor conflicts, passing and speed restrictions	0.9-1.2	1.86 - 1.39
C	1.4-2.3	33-48		Crowded but fluid movement, passing restricted, cross and reverse flows difficult.	0.7-0.9	1.39 - 0.93
FD	0.9-1.4	48-66		Significant conflicts, passing and speed restrictions, intermittent shuffling.	0.3-0.7	0.93 - 0.65
E	0.5-0.9	66-82		Shuffling walk: reverse, passing and cross flows very difficult; intermittent stopping.	0.2-0.3	0.65 - 0.37
F	0.5 or less	> 82		Critical density, flow sporadic, frequent stops, contacts with others	0.2 or less	0.37 or less

Table 48: HCM Levels of Service Criteria for Walkways

LOS		Average Space (m^2/P)	Related Measures: Flow Rate (p/min/m)[a]	Average Speed (km/hr)	V/C Ratio[b]	Comments
A		> 5.57	≤ 1.52	> 4.7	≤ 0.21	Ability to move in desired path, no need to alter movements
B		> 3.72 - 5.57	> 1.52- 2.13	> 4.6-4.7	>0.21-0.31	Occasional need to adjust path to avoid conflicts
C		> 2.23 - 3.72	> 2.13 - 3.05	> 4.4-4.6	>0.31-0.44	Frequent need to adjust path to avoid conflicts
D		>1.39 - 2.23	> 3.05 - 4.57	>4.1-4.6	>0.44-0.65	Speed and ability to pass slower pedestrians restricted
E		> 2.23 - 1.39[c]	> 4.57 - 7.01	> 2.7-4.6	>0.65-1.00	Speed restricted, very limited ability to pass slower pedestrians
F		≤ 0.74[c]	Variable	≤ 4.1	Variable	Speeds severely restricted, frequent contact with other users

a Saturation flow expressed as people per minute per metre.
b v/c ratio n= flow rate/23, based on random flow. LOS is based on average space per pedestrians
c In cross-flow situations, the LOS E-F threshold is 1.21 m2/p

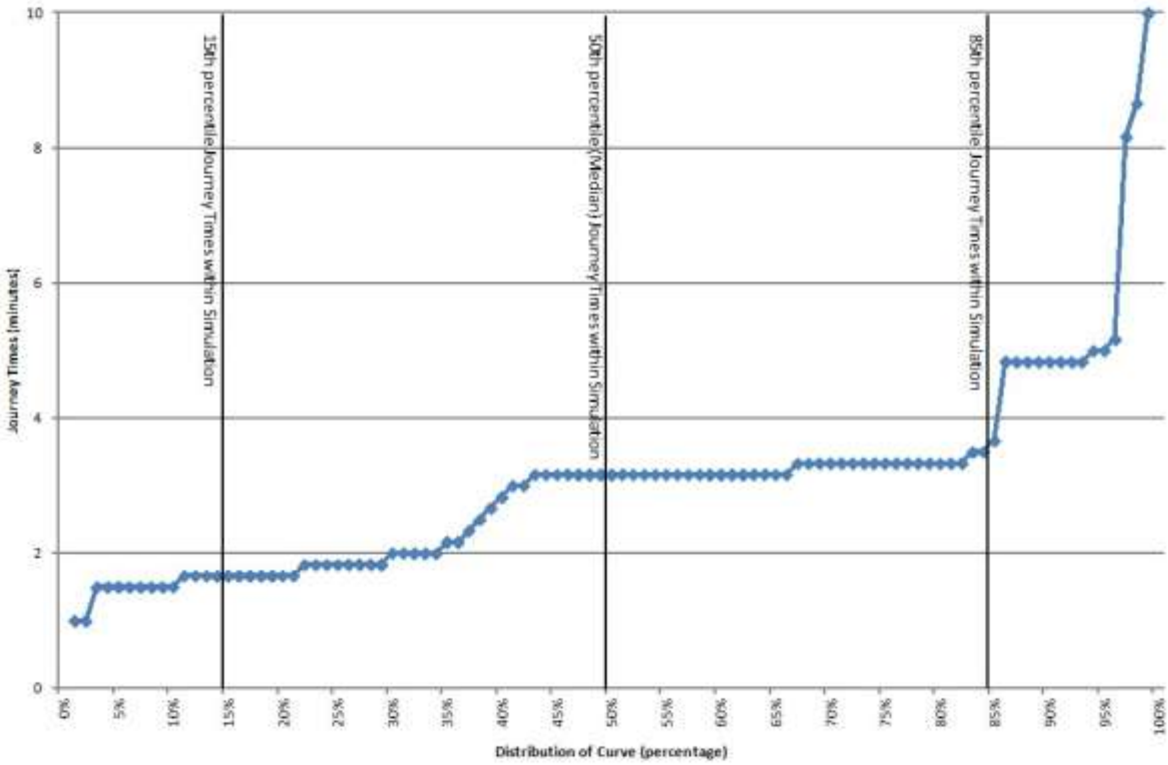
11.1.7.3. Journey Times

Journey times for pedestrian movements should be identified as the time taken between two locations. Journey times might be reflected as the movement of pedestrians between two transport locations, which may be subject to a scale of variation due to service arrivals and signal operations.

This measure should be presented as a distribution curve to showcase the range of speeds obtained from the simulation model, but also complemented by a summary table. The graph should identify journey times for the median (50th percentile) as well as 15th percentile (faster) and 85th percentile (slower) journey times, as outlined within Figure 71. The analysis within this exploration should be able to showcase why (and where) there is variation within the movement of pedestrians between these two locations. This might involve a plot of journey times movements against an axis of chainage (distance) to complement and explain the results produced.

Journey time analysis can be quite varied for a simple connection in a landscape. The variation is due to those matters that change frequently within the simulation network (signal times, service arrivals etc) as per the results shown in . When using these results for model validation the median simulated results should be within 15% of the median observed journey times.

Figure 71: Cumulative Pedestrian Distribution of Journey Times between two locations



Tabulated journey times should also be accompanied by the equivalent average journey speeds, listed in unites of kilometers per hour (km/hr).

11.2. Model Presentation

Simulation models are synonymous with a strong visual component to translate the data analysis and operational complexities into an experience that can be perceived through a less technical lens. This provides for personnel not directly involved into the simulation development to comprehend the challenges and the deliveries of the designated scheme or scenario explored.

Simulation models, including both micro-scopic and meso-scopic simulation models provide the opportunity to develop a high quality simulation video for delivery as a simulation of a three dimensional format. Technically this would actually represent a four dimensional array for the operational network conditions including both time and spatial dimensions.

Simulation videos that are developed for the purpose of presentation are welcomed to limit their video length to less than five minutes per run in order to deliver a narrative. Between base and change models and numerous time intervals, an extended simulation model display can become onerous and lose the value of the effort conducted. However, there may be times when an extended period is acceptable due to the infrequent nature of some locations.

This may mean developing suitable techniques including speed control, editing and control of the video production. All of these video development tasks should be considered prior to development of the end presentation. Those involved in the development of simulation videos should consider a dry run and reviewing the end production prior to presentation. A means to reduce the waste elements of the video production such as transitioning through the interior of a building, should also be reduced and removed, where possible through the use of the means developed within the simulation software.

It is expected that a short video would be produced for each modelled option or scenario as well as the baseline models established. Simulation videos should aim to focus on the more elaborate period of the simulation interval being evaluated, which may typical present a period of middle to late in the model formation. One common method to save on modelling energies is to present the bids eye view (from above) as if the delivery was absent of height.

Simulation videos should be able to contain the following information visually within the model to all stakeholders of the project:

- Time of the recording
- Explanation of the scenario/time interval /horizon presented.
- Selected street names on declared roads and significant points of interest (bridges, buildings as required).

The simulation videos as well as the models developed should be provided to VicRoads so that the videos can be played back to additional stakeholders at any time. Note that many public sector agencies have limited IT access, which restricts the ability to include infrequently used coding devices. For this reason a means to attend to this is to use Microsoft enabled video “codecs” as a means to deliver a compressed file size to VicRoads. A total of two sets of simulation models and videos should be delivered as hard copy to the following structures:

- One copy to the VicRoads modelling team for storage of the network development and analysis.
- One copy to the agency involved in issuing the contract for the project.

This element needs to be an accepted delivery action within each simulation modelling investigation. Time allocated for simulation video development outlined within this section should be included as an optional part of each submission (unless explicitly defined) and can then be excluded by the project as required. It is expected that a comprehensive set of files will be provided so that at any point in the future the model can simulated.

11.3. Report Requirements

11.3.1. Structure

The structure of the report should align with the narrative of this document which includes the following main headings:

- Executive Summary;
- Project Investigation;
- Project Definition (Modelling investigation);
- Data Collection;
- Calibration which includes the various model adjustments and checks;
- Validation;
- Option Testing;
- Results;
- Discussion; and
- Conclusions.

When it comes to option testing, the report structure may differ depending on the project deliverables.

The preference of VicRoads is to receive the various model development and options analysis as a single report. While it is recognised that the provision of multiple deliverables can enhance the value of work, there is greater risk in project deliverables when VicRoads' modellers only receive a part of the reporting. Without the remainder of this report, there is little context to set the narrative which may develop into potential delays to the review process. This can be addressed by further developing a larger modelling report with multiple chapters to explore the points listed within Section 11.3.1. Preference is for a single report rather than the chase for a missing report.

11.3.2. Suitability of Scale

For reporting consistency, the scale of images should be at a prescriptive scale to cover a suitable level of detail. The network element(s) and/or performance output(s) presented should be clearly visible with no ambiguity. For reference when presenting on A4 and A3 size pages, the following model coverage area is possible and respected detail of in the network element such as width of lanes.

Modelling teams should consider the scale of the images provided to showcase both the detail of the work undertaken within the simulation model, without losing the value of the narrative being provided.

Table 49: Scales for reporting

Page Size	Scale	Approximate equivalent length in metres	Example: Size of a 3.5 metre lane
A4 Landscape	1:500	140m	7mm
A4 Landscape	1:1000	280m	3.5mm
A4 Landscape	1:2000	560m	1.75mm
A3 Landscape	1:500	200m	7mm
A3 Landscape	1:1000	400m	3.5mm
A3 Landscape	1:2000	800m	1.75mm

11.3.3. Image and Table Requirements

The following images and/or tables are required to be in the report (some will depend on the type of investigation and modelling approach undertaken) and follow the above colour schemes where applicable:

11.3.3.1. Data Collection

- Image or map depicting the data collection locations and data types (presented in the network with varied symbols and colours). To reduce potential conflicts in presenting the locations and to illustrate specific data types such as bus routes, several image maps may need to be produced to provide the whole data collection outcomes. A locality plan to show how the data collection area fits within the broader network needs to be provided as well;
- Table depicting the days and times of each data collection survey and any specific observations from each survey;
- Table depicting the site observations with photographic evidence (where applicable);
- Analysis in table and graph form provided for the traffic counts collected to ascertain how different collection days perform from one another. Explain how this traffic count data provided evidence on the chosen simulation and evaluation periods;
- Analysis in table and graph form provided for the classification counts to ascertain how matters of seasonality;
- Analysis in table and graph form provided for journey time data including the established median journey time for each predetermined route. Journey time reliability analysis should be tabulated as well to identify 15th and 85th percentile journey times; and
- Seasonality plots and tables.

11.3.3.2. Calibration (Network Development)

- Table illustrating total demand in the model, as well as the percentage of heavy vehicles;
- Images showing all zones in the network including access and egress matters between zone and road network;
- Table illustrating total trips in and out of each zone (determined and simulated);
- Discuss demand matrix development – technique;
- Discuss modelling assignment run method adopted – technique;
- Model network structure plots;
  - Image showing how the model matches the relevant imagery chosen i.e. introduced aerial (date to be provided), CADD drawing (date to be provided) etc;
  - Show all relevant parameters that assist in coding the network, especially if the parameters have been modified specifically for the modelling investigation. The parameters include but not limited to the following:
    - Turns, links and node locations (with road names);
    - Number of lanes (Colour scheme in Table 41);
    - Speed adjustments due to regulatory or geometry matters;
    - Locations with refined driver behaviour algorithms;
    - Signal intersections and accompanying detectors; and
    - Evaluation markers such as journey time, data collection and queue counters markers.
- Volume plots and tables.
  - Diagrammatic plots should include turn volumes (and selected link or approach volumes) for the network (observed and modelled). The may be provided in a schematic form. The associated GEH should be included to map the strengths and shortcomings of the base model;
  - Comparison table - A table summarising the observed and modelled counts with the calculated GEH, absolute difference and percentage difference for turns at all intersections. Road names should be marked;

    - A summary table of GEH performances;
    - Volume summary table to compare flow volumes based on revised DMRB benchmarks; and
    - GEH/Scatterplot graph – Optional graph that shows the correlation between observed and modelled counts and the fit by displaying the slope of the regression line with an intercept of zero and R square value. The volume categories based on DMRB benchmarks need to be considered for each scatterplot.
- Speed plots
    - Assigned speeds (Colour scheme in Table 40) using appropriate bands from the 6 classes.
- Movement plots for assignment considerations.
    - Static routes with magnitude of volume;
    - Edge (between two intersections) restrictions;
    - Path restrictions; and
- Intersection plots and tables.
    - Map of the intersections outlining Level of Service performance metrics; and
    - Level of service table for each intersection using HCM 2015 criteria, including delay
- Motorway plots and tables.
    - Level of service (density) using HCM 2015 density criteria or as directed by VicRoads Managed Motorway Framework;
    - SVO (speed, volume and occupancy); and
    - Weaving diagrams.

11.3.3.3. Calibration (Model Stability)

- Table summarising seed analysis and the selection of the median seed run;
- Scatterplot comparison of VKT and VHT with VKT on the y-axis and VHT on the x-axis; and
- Stability plots outlining changes in mean speed and changes in the number of vehicles in the network for each second simulated).

11.3.3.4. Validation

- Cumulative journey time plots and tables. The plot should show the route chainage on the x-axis and the minutes of travel on the y-axis. The chainage should be appropriately scaled to show the relative distance between waypoints which usually include intersections or landmarks such as bridges. At least three landmarks or road names should be labelled.
- Time profile plots and tables for observed and modelled traffic counts.
- Level crossing activation plots and tables. The plot should show the time profile of the boom gate start and end times for both observed and modelled operations.
- Signals
    - Phase and signal group plots for both observed and modelled operations; and
    - Signal timing plots and tables for both observed and modelled operations.
- Model simulation plots
    - Image snapshots of start, end and peak of the evaluation period for each simulation run at a scale that lane numbers and vehicle placement is clearly defined. The will ensure that warm-up and cool down periods are appropriately represented; and
    - Image snapshots showing findings in the model during calibration and validation process

11.3.3.5. Modelling Outputs

- All reporting metrics for the base year model need to be provided with the development report. It should not require a delivery of future year options or scenarios to understand the performance metrics of the existing year network; and
- Journey time analysis

    - Tabulation of corridor journey times, to complement the model validation. Results should be presented for each option explored as minutes of travel time.
    - Select link analysis (minimum of four per evaluation interval)
        - Identify the point and direction chosen for each select link analysis (use a 'star' marker to identify the link and side of the road); and
        - Multiple select link analysis on one plot can be used if different colours are utilised and the readability is not distorted due to colour overlaps. This is more suitable in showing select link analysis for different directions at the one link.
- Regional Highway Assignment
    - Percent time following results for Two Way Two Lane Highways or Percentage of Free Flow Speeds as determined by classification; and
    - US Highway Capacity Manual comparison of outputs using HCM 2015 criteria.
- Network wide outputs to be tabulated:
    - Aggregate Vehicle Hours Travelled (VHT);
    - Aggregate Vehicle Kilometres Travelled (VKT);
    - Mean speed (km/hr) across the entire network;
    - Mean delay (average additional journey time per vehicle on journey);
    - Mean number of stops (per vehicle across the journey);
    - Mean delay stop (average time spent stopped as a function of the delay);
    - Total delay (aggregate additional journey time experienced by drivers for conducting journeys within the landscape);
    - Aggregate number of stops for journeys across the network;
    - Total delay from stops;
    - Number of vehicles left the network (incomplete journeys within the model during the simulation evaluation interval);
    - Number of vehicles delayed in entering the network (latent demand);
    - Delay related to the number of vehicles delayed in entering the network; and
    - Number of vehicles not released into the network (unreleased demand) – plots showing locations and magnitude.
- Network wide outputs to be graphed:
    - Average Vehicle Speeds (km/hr) (changes between time horizons);
    - Delay (average vehicle) as shown in Figure 62, as well as changes between time horizons; and
    - Number of stops (changes between time horizons);
- Intersection specific outputs:
    - Throughput volumes;
    - Saturation flows;
    - Average per person delay (Results should be presented in minutes based on HCM classifications);
    - Queue length plots and tables;
    - Signal plots and tables; and
    - Level of service Values using HCM 2015 criteria
- Queue length plots and tables. Descriptive statistics should be provided for each queue approach to understand the 95% queue length etc. for observed and modelled conditions, even if not validated.

Additional modelling outputs may be required for delivery at the request of VicRoads or the corresponding agency.

11.3.3.6. Conclusion

- Reports need to outline a conclusion to the wrap up the narrative and explain matters in the network and the analysis;
- For a model development report, this should include matters pertaining to (but not limited to) data collection resources and seasonality, issues in the data collection, analysis of the journeys (volume, distribution), matters of signal operations, shortcomings identified in the analysis or modelling to date, and a finding about the base model for both reflection of the existing conditions and the narrative; and
- In expanding a development report into an investigation report, the conclusion should provide a summary of the model findings, with consideration for the performance metrics, differences between the scenarios and findings in expected volume changes and revisions to journey times. Matters of congested should also be represented.

11.3.3.7. Appendices

- Demand matrices for each time interval and vehicle type; and
- Trip Ends (in and out) should be provided for each time interval and vehicle type

11.4. Report Conclusion

Both the model development report and the options; report need to close the narrative with a conclusion. This is a forgotten element of the reporting tasks and is often mistaken with an executive summary for delivery on the key points to the investigation.

A conclusion for a development report will need to outline matters of the existing or expected problem. This discussion should outline matter of the data collection and analysis of this acquisition. The report conclusion should also outline matters of the model calibration and element of difficulty to simulate the conditions as desired. An overview of the validation is required, as well as an outline of the shortcomings within the results. This report should also be able to briefly discuss a number of the performance indicators from the base model results. Some overview of the time periods explored and the considerations applied to outline a contented effort of the model development should be outlined.

A conclusion for a final or options report will need to briefly outline the base model development (calibration and validation). The option for future year horizons and scenarios will need to be outlined within the conclusion. More importantly, the reporting and discussion of the options tested may not have comprehensively been discussed until this chapter. It may well have been that the previous chapters only compare the metrics and identified the strengths and limitations of the proposed changes. The report conclusion may hold the place to ensure that a discussion of the relative values (model differences) has been undertaken so that stakeholders can better comprehend the considerations in finding a direction forward.

Table 50: Chapter Checklist for Analysis and Reporting

Topics for Discussion and Reporting	Yes	No	N/A
Does the reporting of the investigation provide enough analysis to determine the suitability of the scheme to varied stakeholders?	☐	☐	☐
Does the report outline the intersection performance as a Level of Service in both tabular and mapped display formats?	☐	☐	☐
Are motorway performances appropriately analysed and presented as a Level of Service within the delivery of the report?	☐	☐	☐
Are two way two lane highways analysed and presented through a Level of Service within this report, where appropriate?	☐	☐	☐
Has a plot of modelled journey speeds in the network been provided within the network? Is this to an appropriate scale and structure so that the variations in journey speeds can be easily determined? Have multiple plots been provided to tell the story of conditions that experience enough significant changes throughout the evaluation interval,	☐	☐	☐
Have network performance metrics for the simulation area been provided within a table for easy reading and interpretation of the changing conditions simulated within the modelling? Have a number of these metrics also been graphed to emphasise the expected changes to the landscape?	☐	☐	☐
Has the colouring system for performance been maintained for delivery within this report?	☐	☐	☐
Does the pedestrian simulation modelling suitability represent the scale of density and regularity within the simulated network? Or is a more extreme or exaggerated condition represented?	☐	☐	☐
What performance measure for density has been applied for pedestrian simulation modelling? What are the thresholds applied if another process has been used and how does this build a different narrative or delivery requirement?	☐	☐	☐
How well are the journey times of pedestrians reflected to the observed conditions within the network simulation model?	☐	☐	☐
Does the report of each investigation provide enough of a sound conclusion to identify the options explored, compare results and direct on strengths and weaknesses of conditions explored?	☐	☐	☐

12. Model Review Processes

12.1. Introduction

Reviews of simulation modelling investigations need to be comprehensive. This involves reviewing the modelling report but (more importantly) also reviewing the model that underpins the report. A review of a model is not actioned until the reviewer has explored the actual model that has been developed, irrespective as to how much of the report has been consumed.

Reviewers need to ensure that the effort undertaken achieves this analysis of the modeller's work from the perspective as if VicRoads were themselves conducting tis task.

The review needs to ensure that input data is consistent and that the model can reproduce the outputs that are documented in the modelling report with valid network coding techniques and parameter definition. This needs to fall in line with the guidance outlined within this document.

In most cases one of the models to be reviewed is the "base model" which goes through the calibration and validation process before scenario testing is undertaken. After such time, the scenario model(s) may also be reviewed.

12.2. Structure

The reviews should be undertaken in a reporting format that covers the following sections:

- Introduction – the purpose of the review needs to be discussed. In general, this is to;
  - Ensure the appropriateness of the base model coding to reflect current traffic conditions. Such an approach will form as an accurate and suitable basis for scenario testings. Input data, calibration and validation results associated with the base model developments will need to be investigated as part of this process;
  - Investigate the suitability of the modelling methodology throughout the base case development and scenario testing stages;
- Scope Limitations and Assumptions – identify the information provided and the guidelines used to undertake the review. For all VicRoads simulation modelling investigations, this guideline should be the main guideline;
- Generally, comprehensive amount of information is required to undertake a review. The following information is typically provided for the review but can vary depending on the scope of modelling investigation.
  - Project background information;
  - Model files - AM and PM peak period files;
  - Signal logic and output files including any external signal files or reporting of signal outputs.
  - Model performance files and outputs – including measurements on data points, delay, travel time, queue length etc...) – all seed runs;
  - Files generated from the simulation runs, including measures about vehicles removed from the system. Also demand files;
  - Observed signal data – operation sheets, IDM summaries, LX files, split plans, link plans, history files;
  - Design (CAD) plans used to build scenarios model(s) and aerial images for base model;
  - Analysis spreadsheets used in the calibration and validation process;
  - Raw survey data (all modes), spreadsheets, video footage, travel times GPS plots (vehicle coordinates by second);
  - Public transport timetables;
  - Simulation Modelling calibration and validation reports; and
  - Simulation Modelling scenario testing report(s);

- Use the following categories that the findings are going to be rated against;
  - Critical – Items are fundamentally incorrect within the model that has a clearly factual problem that needs revision e.g. driving on the wrong side of the road;
  - Significant – Items identified would have significant impact to the performance and understanding of the model and highly recommended for correction;
  - Moderate – Should be corrected to enhance the accuracy and understanding of the model; however the impact to the traffic operations is not as concerning as the critical matter;
  - Nominal - Revisions should be explored but are of a minor nature compared to the more critical matters of traffic operations. Often these points are items that could be explored but may not be addressed with such an investigation e.g. emissions and noise analysis; and
  - Comment– Items that do not need to be corrected but worth being aware of.
- Use the structure defined in Table 51 as a basis for identifying areas to review. The report is required to have a table that lists each finding, its recommendation and its rating.

12.3. Topics to be addressed

As a minimum, the review should cover the following areas (however not all areas may be applicable to the model investigation):

Table 51: Review requirements

Review Area	Details
Modelling software package and version	Detail the modelling software package used for the development of the model and the applicable version. Review should be conducted using the same modelling software package and version
Random seed chosen and used	Confirm consistency
Background images/design	Source and accuracy (scale) reviewed
SI Units	Correct units are used
Data collection	Review and cross check the appropriateness of the data collection and whether the model inputs represent the data collected.
Operation conditions	Review and cross check the appropriateness of the modelled operations and the observed traffic conditions (e.g. travel time video footage & queue length survey data, pictures and footage). Specific attention to: • Congestion level (congestion / queue at downstream intersections, queue length, duration of congestion, travel time along a length of road etc); • Interaction between modes (interaction between pedestrians, cyclists and vehicles, changes in phase timing based on pedestrian demand, early start of pedestrian / cyclists' signal, etc.) • Signal operation if demand driven (variation in signal cycle and phase timing over the modelling period based on vehicle and pedestrian demand, demand based phase actuation and timing, public transport priority, linking between two or more signalised intersections) • Variation in the traffic volume and traffic arrival pattern;

	• On road public transport (bus / tram lanes, public transport priority at traffic signals, public transport stops, rail crossings, boom gate operation, etc.)
Model extents	Reviews of the model extents are sufficient to store any congestion within the model to ensure consistent comparison of demand.
Network data	• Link structure against background image/design • Placement and alignment of connectors • Lane change parameters • Lane widths • Flare lengths • Priority rules appropriateness and location • Conflict area appropriateness and location • Desired speed decisions appropriateness and location • Reduced speed appropriateness and location
Driving behaviour	Identify all driving behaviour parameters that have changed and comment on suitability for the investigation i.e. in most cases the driver behaviour does not need to change and if it does the evidence for the change need to be comprehensive
Vehicle Data	• Vehicle types • Vehicle characteristics and model distributions • Vehicle classifications • Vehicle inputs seeds
Traffic data	• Traffic composition • Traffic inputs • Location of routing decisions • Routing decision proportions
Public transport data	• Routes • Location and length of stops • Vehicle type / characteristics • Service frequencies and start times • Method of deriving and applying dwell times
Signal data	• Check the assumed method of signal control is appropriate • Placement of signal heads • Signal heads correspond with appropriate signal groups and signal groups correspond with available signal operation sheets • Cycle times match corresponding signal operation sheets • Intergreens match corresponding signal operation sheets • Green end / red end timings are correct against corresponding signal operation sheet • Walk /clearance timings are correct against corresponding signal operation sheet • Signal stop-line saturation flow rates
Evaluation data	Check the placement of markets and other collection points including grouping of points and associated definition of network performance data.
Assignment and convergence	• Node configuration • Edge closures • Route closures • Parking lots / zones • Evaluation internal • Trip matrix definition

	• Route choice parameters
Check of errors	• Check error log file and provide comments on error impacts to the modelling results
Reporting	• Check appropriateness of model reporting and confidence in model's ability to replicate existing conditions • Comment on the validity of the assumptions, parameters and constraints adopted • Comment on the model's ability to meet the project definition and objectives
Scenario Testing	• Review of the model extents are sufficient to store any congestion within the model to ensure consistent comparison of demand • Ensure global parameters are consistent between base and scenario models (including demographic data) • Comment on the validity of the assumptions, parameters and constraints adopted • Review future year demand on the appropriateness of growth assumptions (due to general growth and development) including any impact due to modal shift • Review of future year distribution assumptions and its relationship with current patterns • Comment on the model's ability to meet the project definition and objectives

Any review that is undertaken for VicRoads' pursuits needs to have both VicRoads' and the state's interest in mind.

13. Glossary

EPROM	See *erasable programmable read only memory*
Erasable Programmable Read Only Memory	A type of memory chip that retains its data when its power supply is switched off. It houses the unique program that configures the traffic signal controller to a specific operational design of the intersection its controlling. This includes specifications of which signal groups run in each phase, the sequence of phases, detector functions, detector alarm conditions, conflict points and default time settings.
GEH	The GEH statistic is a self-scaling empirical statistic with similarities to a chi-squared test. The desired target for model calibration is to achieve a GEH value less than 5.0 at more than 90% of sites in the core area and at least 80% of those in the peripheral element of the network.
IDM	See *intersection diagnostic monitor*
Intersection Diagnostic Monitor	A software feature of SCATS that records (on demand) all of the key operating characteristics of a signalised site for a given time period. Data recorded includes individual and average cycle times, individual and average phase times, number of times a phase runs.
LX File	The data file that feeds into the region computer for each signalised intersection. It contains the data necessary for communications, signal timings, intergreen intervals, pedestrian walk and clearance timings, coordination values, flexilink data and variation routines.
R^2	R-squared is a statistical measure of how close the data are to the fitted regression line. It is the percentage of the response variable variation that is explained by a linear model.
SCATS	See *Sydney coordinated adaptive traffic system*
Sydney Coordinated Adaptive Traffic System	An intelligent transportation system developed in Sydney, Australia by former constituents of the Roads and Maritime Services in the 1970. SCATS primarily manages the dynamic (on-line, real-time) timing of signal phases at traffic signals, meaning that it tries to find the best phasing (i.e. cycle times, phase splits and offsets) for the current traffic situation (for individual intersections as well as for the whole network). This is based on the automatic plan selection from a library in response to the data derived from loop detectors or other road traffic sensors.
Puffin Crossing	A type of pedestrian crossing facility that allows a variable length crossing period according to the walking speed of users traversing the carriageway.
Evaluation Period	The period that is used to extract output data for various applications such as performance review.
Simulation Period	The period that includes the entire model run and consists of the warm-up, evaluation and cool-down periods.
Time steps	The calculation interval used by simulation modelling algorithms to incrementally determine the state and/or position of objects in the model.
Generalised Cost	A cost applied to a route choice model and is used to determine route effort and as such the relative attractiveness.
Time Interval	A period within the simulation whereby a series of measures or rules applied before another distinct period with different rules comes into effect
Time Horizon	A distinct future year
Optimisation	A mathematical calculation to deliver the minimum or maximum outcome from a singular performance metric that cannot be exceeded by any other pursuit.
Deterministic	A calculation process using algebraic algorithms to explore selected conditions once per time interval. Deterministic calculations can be static through the evaluation period (e.g. two hours) or can be dynamic in which the calculated conditions are updated for each smaller evaluation period (e.g. fifteen minutes)

14. Abbreviations

Short Form	Longer Form
AADT	Annual Average Daily Traffic
ADT	Average Daily Traffic ie not from a sample of a year
ANPR	Automatic Number Plate Recognition
ATC	Automatic Traffic Count
BAU	Business as Usual
CT	Cycle time
DOMINO	Detailed Operational Model for Intersection and Network Optimisation
E	East
ECO	Early Cut Off
FY	Future Year
HGV	Heavy Goods Vehicle
HV	Heavy Vehicle
IDM	Intersection Diagnostic Monitor
kph	kilometres per hour
km	kilometres
LV	Light Vehicle
m	metre
N	North
No.	Number
NW	North-West
OD	Origin-Destination
PHE	Princes Highway (East)
POS	Pedestrian Operated Signal
RMS	NSW Roads and Maritime Services
S	South
SCATS	Sydney Coordinated Adaptive Traffic System
sec	Seconds
SE	South-East
SM	Strategic Monitor
TIA	Traffic Impact Assessment
TG	Time Gain
TMC	Turning Movement Count
veh	Vehicles
VKT	Vehicle Kilometres Travelled
VHT	Vehicle Hours Travelled
VITM	Victorian Integrated Transport Model
W	West
WD	Weekday
WE	Weekend

Appendix A – Seasonality Tables

Table 52: Seasonal Variation of Throughput over the Year (Annual Average Weekday Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	0.69	0.81	1.09	1.02	1.08	1.08	0.98	1.10	0.98	1.01	1.08	1.06
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	0.71	0.82	1.09	1.02	1.07	1.06	0.98	1.04	1.02	1.03	1.07	1.09
170	Burwood Hwy	Stud Rd	Knox	063, J11	0.65	0.87	1.11	1.03	1.03	1.06	1.01	1.12	0.83	1.04	1.14	1.11
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.67	0.86	1.11	1.02	1.08	1.02	0.96	1.11	1.06	1.03	1.08	1.00
325	Doncaster Rd	Tram Rd	Manningham	047, D01	0.58	0.87	1.10	1.00	1.06	1.05	0.99	1.09	1.03	1.02	1.09	1.13
422	Springvale Rd	High Street Rd	Monash	071, D01	0.85	1.07	1.00	1.03	1.02	1.01	1.15	1.04	1.07	1.14	1.02	1.00
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.84	1.06	1.00	1.08	1.03	1.01	1.13	1.04	1.03	1.09	1.06	1.00
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.68	0.86	1.04	1.01	1.03	1.06	0.93	1.12	1.07	1.04	1.09	1.07
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	0.67	0.83	1.08	1.01	1.06	1.03	0.95	1.11	1.05	1.04	1.10	1.07
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.69	0.82	1.06	1.00	1.05	1.03	0.96	1.12	1.08	1.05	1.09	1.05
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.69	0.84	1.09	1.02	1.06	0.99	0.91	1.11	1.05	1.05	1.11	1.10
3061	Bell St	Plenty Rd	Darebin	030, G01	0.69	0.84	1.09	1.01	1.05	1.03	1.00	1.09	1.05	1.02	1.08	1.05
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	0.64	0.85	1.11	1.03	1.06	1.04	0.97	1.11	1.07	1.04	1.07	1.00
3382	Hoddle St	Johnston St	Yarra	044, D04	0.71	0.82	1.08	1.04	1.06	1.02	0.99	1.09	1.06	1.02	1.13	1.01
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.70	0.82	1.06	1.00	1.04	1.01	1.00	1.12	1.04	1.02	1.10	1.09
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	0.32	0.88	1.17	1.09	1.10	1.13	1.10	1.15	1.05	0.98	0.98	1.05
3559	North Rd	Koornang Rd	Glen Eira	068, H09	0.58	0.83	1.11	0.98	1.04	1.05	1.01	1.12	1.06	1.01	1.14	1.08
3634	South Rd	Bluff Rd	Bayside	077, B04	0.70	0.78	1.11	1.03	1.08	1.02	0.97	1.13	1.03	1.01	1.08	1.06
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.64	0.82	1.04	0.94	1.03	0.98	1.03	1.22	1.07	1.11	1.07	1.06
4164	Main St	Collins St	Nillumbik	011, K05	0.65	0.86	1.10	0.98	1.04	0.99	1.01	1.13	1.04	1.05	1.07	1.05
4388	Elizabeth St	Victoria St	Melbourne	043, G06	0.71	0.85	1.10	1.03	1.03	1.03	1.04	1.15	1.03	0.98	1.03	1.00
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.70	0.85	1.05	0.98	1.02	1.01	0.98	1.14	1.07	1.06	1.10	1.05
4736	High St	Epping Plaza	Whittlesea	182, A12	0.70	0.85	1.10	0.98	0.94	1.01	1.03	1.14	1.07	1.02	1.06	1.11

Table 53: Seasonal Variation of Throughput over the Non-Summer Months (Average Weekday Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)								
					Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	1.04	0.98	1.04	1.03	0.94	1.05	0.93	0.96	1.04
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	1.04	0.98	1.03	1.02	0.94	1.00	0.98	0.99	1.02
170	Burwood Hwy	Stud Rd	Knox	063, J11	1.06	0.99	0.99	1.02	0.97	1.08	0.80	1.00	1.09
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	1.05	0.97	1.02	0.97	0.91	1.06	1.00	0.98	1.03
325	Doncaster Rd	Tram Rd	Manningham	047, D01	1.06	0.95	1.01	1.00	0.95	1.04	0.98	0.97	1.04
422	Springvale Rd	High Street Rd	Monash	071, D01	1.01	0.94	0.97	0.97	0.95	1.08	0.98	1.01	1.07
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	1.01	0.95	1.03	0.98	0.96	1.07	0.99	0.98	1.04
735	Seaford Rd	Railway Pde	Frankston	099, E05	1.00	0.97	0.98	1.01	0.89	1.08	1.03	0.99	1.05
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	1.03	0.97	1.02	0.98	0.91	1.06	1.00	1.00	1.05
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	1.01	0.96	1.00	0.98	0.92	1.07	1.03	1.00	1.04
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	1.05	0.98	1.02	0.95	0.87	1.06	1.01	1.01	1.06
3061	Bell St	Plenty Rd	Darebin	030, G01	1.04	0.97	1.00	0.99	0.96	1.04	1.00	0.97	1.03
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	1.05	0.97	1.01	0.98	0.92	1.05	1.02	0.99	1.01
3382	Hoddle St	Johnston St	Yarra	044, D04	1.02	0.99	1.00	0.97	0.94	1.03	1.01	0.97	1.07
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	1.02	0.96	0.99	0.96	0.96	1.07	0.99	0.98	1.05
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	1.08	1.00	1.01	1.04	1.02	1.07	0.97	0.91	0.91
3559	North Rd	Koornang Rd	Glen Eira	068, H09	1.05	0.93	0.99	0.99	0.95	1.06	1.00	0.95	1.08
3634	South Rd	Bluff Rd	Bayside	077, B04	1.06	0.98	1.03	0.97	0.92	1.07	0.98	0.96	1.02
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.99	0.89	0.98	0.93	0.98	1.16	1.01	1.05	1.01
4164	Main St	Collins St	Nillumbik	011, K05	1.05	0.94	0.99	0.95	0.97	1.08	0.99	1.01	1.02
4388	Elizabeth St	Victoria St	Melbourne	043, G06	1.05	0.99	0.99	0.98	0.99	1.10	0.98	0.94	0.98
4537	Commercial Rd	Izett St	Stonnington	057, K01	1.01	0.93	0.98	0.97	0.94	1.09	1.02	1.01	1.06
4736	High St	Epping Plaza	Whittlesea	182, A12	1.06	0.94	0.90	0.98	0.99	1.10	1.03	0.98	1.02

Table 54: Seasonal Variation of Throughput over the Year (Annual Average Weekend Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	0.91	0.77	0.97	1.13	1.11	1.00	1.23	0.96	0.96	1.04	1.01	0.92
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	0.88	0.84	0.92	1.09	1.12	0.98	1.22	0.93	0.96	1.09	1.05	0.90
170	Burwood Hwy	Stud Rd	Knox	063, J11	0.85	0.89	0.99	1.17	1.15	1.00	1.26	1.02	0.76	1.18	0.89	0.84
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.92	0.87	0.97	1.13	1.04	0.94	1.19	0.97	0.96	1.20	1.00	0.80
325	Doncaster Rd	Tram Rd	Manningham	047, D01	0.75	0.90	0.98	1.11	1.12	0.98	1.18	0.99	0.96	1.18	1.02	0.83
422	Springvale Rd	High Street Rd	Monash	071, D01	0.89	0.94	1.08	1.14	0.95	1.21	1.04	0.93	1.19	1.05	0.80	1.00
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.83	0.93	1.11	1.10	0.96	1.21	0.99	0.96	1.16	1.03	0.86	1.00
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.90	0.85	0.94	1.14	1.08	0.97	1.20	0.98	1.02	1.13	0.91	0.87
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	0.85	0.82	0.94	1.11	1.08	0.94	1.20	0.98	0.98	1.22	1.03	0.86
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.86	0.84	0.93	1.10	1.08	0.94	1.20	0.99	1.00	1.21	1.01	0.83
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.86	0.84	0.84	1.12	1.11	0.95	1.21	0.98	0.97	1.20	1.04	0.88
3061	Bell St	Plenty Rd	Darebin	030, G01	0.87	0.88	0.96	1.13	1.00	0.95	1.18	0.98	0.98	1.18	1.03	0.85
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	0.80	0.89	0.98	1.11	1.12	0.94	1.22	1.00	0.99	1.17	1.00	0.78
3382	Hoddle St	Johnston St	Yarra	044, D04	0.86	0.86	0.95	1.16	1.09	0.95	1.13	0.97	0.97	1.23	1.06	0.77
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.89	0.88	0.93	1.07	1.06	0.89	1.20	1.02	0.97	1.13	1.06	0.89
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	0.53	0.93	1.01	1.18	1.18	1.02	1.29	1.02	0.95	1.07	1.00	0.81
3559	North Rd	Koornang Rd	Glen Eira	068, H09	0.66	0.89	0.97	1.05	1.13	0.95	1.21	0.99	0.97	1.11	1.06	1.02
3634	South Rd	Bluff Rd	Bayside	077, B04	0.90	0.93	0.95	1.12	1.13	0.91	1.20	1.01	0.96	1.09	0.94	0.88
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.80	0.84	0.88	1.05	1.05	0.92	1.32	1.10	0.99	1.16	1.02	0.88
4164	Main St	Collins St	Nillumbik	011, K05	0.84	0.89	0.93	1.14	1.14	0.94	1.24	1.04	0.96	0.99	1.05	0.85
4388	Elizabeth St	Victoria St	Melbourne	043, G06	0.87	0.87	0.95	1.16	1.13	0.97	1.23	1.00	0.98	1.08	1.00	0.76
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.88	0.89	0.77	1.09	1.10	0.99	1.25	1.02	1.02	1.15	1.01	0.81
4736	High St	Epping Plaza	Whittlesea	182, A12	0.88	0.85	0.95	1.12	1.11	0.96	1.23	1.01	1.00	1.12	0.91	0.87

Table 55: Seasonal Variation of Throughput over the Non-Summer Months (Average Weekend Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)								
					Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	0.93	1.08	1.06	0.96	1.18	0.92	0.92	0.99	0.96
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	0.89	1.04	1.08	0.94	1.17	0.89	0.92	1.05	1.01
170	Burwood Hwy	Stud Rd	Knox	063, J11	0.94	1.12	1.10	0.95	1.20	0.97	0.73	1.13	0.85
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.93	1.08	1.00	0.90	1.14	0.93	0.92	1.15	0.96
325	Doncaster Rd	Tram Rd	Manningham	047, D01	0.92	1.05	1.06	0.92	1.12	0.94	0.91	1.12	0.96
422	Springvale Rd	High Street Rd	Monash	071, D01	0.88	1.02	1.08	0.90	1.14	0.98	0.88	1.12	0.99
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.88	1.05	1.05	0.91	1.16	0.95	0.92	1.11	0.98
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.90	1.09	1.04	0.93	1.16	0.94	0.98	1.09	0.87
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	0.89	1.05	1.03	0.89	1.14	0.93	0.93	1.16	0.98
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.88	1.04	1.03	0.89	1.14	0.94	0.95	1.15	0.96
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.80	1.07	1.06	0.91	1.16	0.94	0.93	1.14	1.00
3061	Bell St	Plenty Rd	Darebin	030, G01	0.92	1.08	0.95	0.91	1.13	0.93	0.94	1.13	0.98
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	0.92	1.05	1.06	0.88	1.15	0.95	0.94	1.11	0.94
3382	Hoddle St	Johnston St	Yarra	044, D04	0.90	1.10	1.03	0.90	1.07	0.92	0.92	1.16	1.01
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.89	1.03	1.02	0.86	1.16	0.98	0.94	1.09	1.02
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	0.94	1.09	1.09	0.94	1.19	0.94	0.88	0.99	0.93
3559	North Rd	Koornang Rd	Glen Eira	068, H09	0.92	1.00	1.08	0.90	1.16	0.95	0.93	1.06	1.01
3634	South Rd	Bluff Rd	Bayside	077, B04	0.92	1.08	1.09	0.88	1.16	0.98	0.93	1.05	0.91
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.84	1.00	1.00	0.87	1.25	1.04	0.94	1.10	0.97
4164	Main St	Collins St	Nillumbik	011, K05	0.89	1.09	1.09	0.89	1.19	1.00	0.91	0.94	1.00
4388	Elizabeth St	Victoria St	Melbourne	043, G06	0.90	1.10	1.07	0.92	1.17	0.95	0.93	1.02	0.95
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.74	1.04	1.05	0.95	1.19	0.98	0.98	1.10	0.97
4736	High St	Epping Plaza	Whittlesea	182, A12	0.91	1.07	1.06	0.92	1.18	0.97	0.96	1.07	0.87

Table 56: Seasonal Variation of Throughput over the Year (Annual Average AM Peak Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	0.63	0.89	1.04	1.04	1.11	1.04	1.03	1.15	1.01	1.07	1.09	0.90
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	0.64	0.88	1.01	1.06	1.15	1.05	1.02	1.06	1.03	1.08	1.06	0.94
170	Burwood Hwy	Stud Rd	Knox	063, J11	0.57	0.94	1.06	1.04	1.14	1.04	1.04	1.19	0.82	1.10	1.13	0.94
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.59	0.88	1.05	1.05	1.12	1.02	1.01	1.15	1.05	1.10	1.10	0.89
325	Doncaster Rd	Tram Rd	Manningham	047, D01	0.47	0.92	1.05	1.02	1.15	1.03	1.03	1.19	0.97	1.10	1.14	0.93
422	Springvale Rd	High Street Rd	Monash	071, D01	0.87	1.01	0.99	1.13	1.02	1.07	1.26	1.02	1.14	1.14	0.87	1.00
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.89	1.03	1.02	1.14	1.02	1.02	1.19	1.04	1.10	1.12	0.92	1.00
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.61	0.87	0.99	1.04	1.12	1.06	1.04	1.15	1.11	1.03	1.01	0.97
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	0.57	0.86	1.04	1.06	1.15	1.03	1.00	1.16	1.03	1.09	1.09	0.92
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.66	0.87	1.02	1.03	1.10	1.02	1.00	1.15	1.06	1.10	1.07	0.92
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.59	0.90	1.03	1.05	1.16	1.00	1.01	1.20	1.03	1.08	1.08	0.89
3061	Bell St	Plenty Rd	Darebin	030, G01	0.66	0.86	1.02	1.05	1.08	1.03	1.05	1.12	1.05	1.07	1.08	0.93
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	0.62	0.87	1.04	1.04	1.13	1.04	1.04	1.16	1.04	1.08	1.07	0.89
3382	Hoddle St	Johnston St	Yarra	044, D04	0.71	0.82	1.01	1.08	1.09	1.02	1.02	1.11	1.04	1.07	1.08	0.94
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.62	0.86	1.01	1.04	1.13	1.02	1.02	1.14	1.03	1.07	1.10	0.96
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	0.30	0.87	1.09	1.11	1.19	1.14	1.15	1.16	1.01	1.07	1.01	0.91
3559	North Rd	Koornang Rd	Glen Eira	068, H09	0.50	0.85	1.02	0.99	1.15	1.03	1.04	1.15	1.05	1.11	1.14	0.97
3634	South Rd	Bluff Rd	Bayside	077, B04	0.61	0.83	1.06	1.04	1.18	1.01	1.02	1.19	0.98	1.11	1.10	0.87
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.59	0.84	0.98	0.99	1.07	1.05	1.06	1.22	1.04	1.14	1.09	0.92
4164	Main St	Collins St	Nillumbik	011, K05	0.56	0.90	1.04	1.04	1.17	1.01	1.04	1.17	0.98	1.10	1.10	0.90
4388	Elizabeth St	Victoria St	Melbourne	043, G06	0.66	0.87	1.05	1.07	1.09	1.04	1.07	1.15	1.04	1.05	1.03	0.88
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.62	0.88	0.98	1.01	1.12	1.03	1.07	1.16	1.02	1.10	1.10	0.90
4736	High St	Epping Plaza	Whittlesea	182, A12	0.58	0.86	1.02	1.03	1.14	1.03	1.04	1.16	1.02	1.10	1.07	0.93

Table 57: Seasonal Variation of Throughput over the Non-Summer Months (Average AM Peak Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)								
					Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	0.98	0.98	1.05	0.98	0.97	1.08	0.95	1.00	1.02
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	0.95	1.00	1.09	1.00	0.96	1.00	0.98	1.02	1.00
170	Burwood Hwy	Stud Rd	Knox	063, J11	1.00	0.98	1.07	0.98	0.98	1.12	0.78	1.04	1.06
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.98	0.98	1.05	0.95	0.94	1.07	0.98	1.02	1.03
325	Doncaster Rd	Tram Rd	Manningham	047, D01	0.98	0.95	1.07	0.95	0.96	1.11	0.90	1.02	1.06
422	Springvale Rd	High Street Rd	Monash	071, D01	0.93	0.91	1.04	0.94	0.98	1.16	0.94	1.05	1.05
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.95	0.95	1.06	0.95	0.95	1.11	0.97	1.03	1.04
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.93	0.98	1.06	1.00	0.98	1.09	1.04	0.97	0.95
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	0.97	0.99	1.07	0.96	0.93	1.08	0.96	1.01	1.02
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.96	0.97	1.04	0.96	0.94	1.08	1.00	1.04	1.01
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.96	0.98	1.08	0.93	0.95	1.12	0.96	1.01	1.01
3061	Bell St	Plenty Rd	Darebin	030, G01	0.96	0.99	1.02	0.97	0.99	1.05	0.99	1.01	1.01
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	0.98	0.97	1.05	0.97	0.97	1.09	0.97	1.00	1.00
3382	Hoddle St	Johnston St	Yarra	044, D04	0.96	1.02	1.03	0.97	0.97	1.04	0.98	1.01	1.02
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.95	0.98	1.06	0.96	0.96	1.08	0.97	1.01	1.03
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	0.99	1.00	1.08	1.03	1.04	1.05	0.91	0.97	0.92
3559	North Rd	Koornang Rd	Glen Eira	068, H09	0.95	0.92	1.07	0.95	0.97	1.07	0.98	1.03	1.06
3634	South Rd	Bluff Rd	Bayside	077, B04	0.98	0.97	1.09	0.93	0.95	1.11	0.91	1.03	1.02
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.92	0.93	1.00	0.98	0.99	1.14	0.97	1.06	1.02
4164	Main St	Collins St	Nillumbik	011, K05	0.97	0.97	1.09	0.94	0.97	1.09	0.91	1.03	1.03
4388	Elizabeth St	Victoria St	Melbourne	043, G06	0.99	1.00	1.03	0.98	1.00	1.08	0.97	0.99	0.97
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.92	0.95	1.05	0.97	1.01	1.08	0.96	1.03	1.03
4736	High St	Epping Plaza	Whittlesea	182, A12	0.95	0.97	1.06	0.97	0.97	1.09	0.95	1.03	1.00

Table 58: Seasonal Variation of Throughput over the Year (Annual Average Weekday AM Peak Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	0.61	0.89	1.06	1.02	1.12	1.06	1.01	1.17	1.02	1.05	1.09	0.90
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	0.62	0.88	1.04	1.04	1.16	1.07	0.99	1.09	1.05	1.05	1.06	0.94
170	Burwood Hwy	Stud Rd	Knox	063, J11	0.53	0.95	1.07	1.01	1.13	1.05	1.01	1.21	0.84	1.09	1.16	0.95
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.55	0.88	1.06	1.02	1.14	1.03	0.99	1.17	1.05	1.07	1.11	0.91
325	Doncaster Rd	Tram Rd	Manningham	047, D01	0.44	0.92	1.07	1.00	1.16	1.04	1.01	1.22	0.97	1.09	1.16	0.93
422	Springvale Rd	High Street Rd	Monash	071, D01	0.87	1.03	0.97	1.13	1.03	1.06	1.27	1.03	1.13	1.16	0.88	1.00
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.89	1.04	1.00	1.14	1.04	1.01	1.21	1.04	1.09	1.12	0.92	1.00
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.57	0.88	1.00	1.00	1.13	1.08	1.02	1.19	1.11	1.01	1.03	0.97
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	0.54	0.87	1.06	1.03	1.16	1.05	0.97	1.19	1.03	1.06	1.09	0.93
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.63	0.87	1.03	1.01	1.10	1.03	0.97	1.17	1.08	1.07	1.07	0.95
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.56	0.92	1.06	1.02	1.17	1.01	0.98	1.22	1.03	1.05	1.08	0.90
3061	Bell St	Plenty Rd	Darebin	030, G01	0.63	0.86	1.04	1.01	1.10	1.05	1.03	1.14	1.07	1.04	1.08	0.96
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	0.59	0.87	1.05	1.02	1.13	1.06	1.01	1.19	1.06	1.05	1.08	0.91
3382	Hoddle St	Johnston St	Yarra	044, D04	0.70	0.81	1.03	1.03	1.09	1.05	0.99	1.13	1.06	1.03	1.09	0.98
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.59	0.86	1.03	1.02	1.13	1.03	1.00	1.17	1.04	1.05	1.11	0.97
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	0.26	0.87	1.12	1.09	1.19	1.16	1.12	1.19	1.02	1.03	1.01	0.94
3559	North Rd	Koornang Rd	Glen Eira	068, H09	0.50	0.84	1.04	0.97	1.14	1.04	1.01	1.18	1.07	1.08	1.15	0.97
3634	South Rd	Bluff Rd	Bayside	077, B04	0.58	0.81	1.08	1.02	1.18	1.02	1.00	1.22	0.99	1.09	1.12	0.87
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.58	0.85	1.02	0.99	1.09	1.03	1.02	1.24	1.06	1.11	1.11	0.91
4164	Main St	Collins St	Nillumbik	011, K05	0.52	0.90	1.07	1.01	1.17	1.03	1.00	1.20	0.99	1.08	1.11	0.91
4388	Elizabeth St	Victoria St	Melbourne	043, G06	0.64	0.86	1.06	1.05	1.09	1.07	1.06	1.18	1.06	1.01	1.03	0.90
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.59	0.87	1.03	0.99	1.12	1.04	1.05	1.19	1.03	1.06	1.11	0.92
4736	High St	Epping Plaza	Whittlesea	182, A12	0.54	0.87	1.04	1.00	1.14	1.05	1.02	1.20	1.02	1.08	1.10	0.94

Table 59: Seasonal Variation of Throughput over the Non-Summer Months (Average Weekday AM Peak Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)								
					Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	0.99	0.96	1.05	0.99	0.95	1.09	0.95	0.99	1.02
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	0.98	0.98	1.09	1.01	0.93	1.03	0.98	0.99	1.00
170	Burwood Hwy	Stud Rd	Knox	063, J11	1.01	0.95	1.06	0.99	0.95	1.14	0.79	1.02	1.09
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.99	0.96	1.06	0.96	0.92	1.09	0.98	1.00	1.04
325	Doncaster Rd	Tram Rd	Manningham	047, D01	0.99	0.93	1.07	0.96	0.94	1.13	0.90	1.01	1.07
422	Springvale Rd	High Street Rd	Monash	071, D01	0.94	0.89	1.04	0.95	0.97	1.16	0.94	1.04	1.06
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.97	0.93	1.06	0.96	0.94	1.13	0.97	1.01	1.04
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.94	0.94	1.07	1.01	0.96	1.12	1.04	0.95	0.96
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	0.99	0.96	1.08	0.98	0.91	1.11	0.96	0.99	1.02
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.97	0.96	1.04	0.98	0.92	1.11	1.01	1.01	1.01
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.99	0.95	1.09	0.95	0.92	1.14	0.96	0.98	1.01
3061	Bell St	Plenty Rd	Darebin	030, G01	0.98	0.95	1.03	0.99	0.97	1.08	1.00	0.98	1.01
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	0.98	0.95	1.05	0.99	0.95	1.12	0.99	0.98	1.00
3382	Hoddle St	Johnston St	Yarra	044, D04	0.98	0.98	1.03	0.99	0.94	1.07	1.00	0.98	1.03
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.97	0.95	1.06	0.97	0.94	1.10	0.98	0.99	1.05
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	1.01	0.98	1.08	1.05	1.02	1.08	0.92	0.93	0.91
3559	North Rd	Koornang Rd	Glen Eira	068, H09	0.97	0.90	1.06	0.97	0.94	1.10	0.99	1.01	1.07
3634	South Rd	Bluff Rd	Bayside	077, B04	1.00	0.94	1.09	0.94	0.93	1.13	0.92	1.01	1.04
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.95	0.92	1.02	0.96	0.95	1.15	0.98	1.03	1.03
4164	Main St	Collins St	Nillumbik	011, K05	1.00	0.94	1.09	0.96	0.94	1.11	0.92	1.01	1.03
4388	Elizabeth St	Victoria St	Melbourne	043, G06	0.99	0.98	1.02	1.00	0.99	1.10	0.99	0.95	0.96
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.96	0.93	1.05	0.97	0.98	1.11	0.96	0.99	1.04
4736	High St	Epping Plaza	Whittlesea	182, A12	0.97	0.93	1.06	0.98	0.95	1.12	0.95	1.01	1.02

Table 60: Seasonal Variation of Throughput over the Year (Annual Average Weekend AM Peak Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	0.75	0.92	0.92	1.15	1.10	0.93	1.15	0.98	0.94	1.20	1.04	0.91
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	0.79	0.88	0.86	1.17	1.09	0.94	1.18	0.89	0.97	1.22	1.05	0.96
170	Burwood Hwy	Stud Rd	Knox	063, J11	0.78	0.87	0.98	1.20	1.23	0.96	1.22	1.06	0.73	1.20	0.92	0.86
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.85	0.86	0.93	1.19	1.01	0.92	1.17	0.98	1.02	1.26	1.04	0.77
325	Doncaster Rd	Tram Rd	Manningham	047, D01	0.69	0.92	0.94	1.16	1.10	0.94	1.15	1.00	0.94	1.20	1.02	0.95
422	Springvale Rd	High Street Rd	Monash	071, D01	0.90	0.87	1.10	1.12	0.93	1.15	1.21	0.94	1.20	1.06	0.79	1.00
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.84	0.89	1.16	1.13	0.90	1.14	0.97	0.98	1.21	1.08	0.92	1.00
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.79	0.83	0.89	1.26	1.05	0.98	1.14	0.97	1.09	1.09	0.93	0.98
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	0.74	0.80	0.92	1.24	1.11	0.92	1.17	0.99	1.00	1.24	1.05	0.84
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.79	0.83	0.95	1.12	1.11	0.92	1.15	1.02	0.99	1.26	1.03	0.81
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.74	0.82	0.84	1.20	1.11	0.91	1.18	1.05	1.00	1.25	1.07	0.83
3061	Bell St	Plenty Rd	Darebin	030, G01	0.78	0.87	0.93	1.20	1.02	0.94	1.16	0.98	1.00	1.22	1.07	0.82
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	0.74	0.88	1.03	1.17	1.13	0.92	1.16	0.99	0.95	1.21	1.04	0.77
3382	Hoddle St	Johnston St	Yarra	044, D04	0.75	0.87	0.92	1.25	1.11	0.93	1.17	1.00	0.97	1.22	1.05	0.75
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.77	0.86	0.91	1.18	1.13	0.93	1.16	1.02	0.95	1.19	1.02	0.87
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	0.48	0.89	0.98	1.21	1.18	1.04	1.25	1.01	0.94	1.23	1.02	0.78
3559	North Rd	Koornang Rd	Glen Eira	068, H09	0.54	0.89	0.90	1.14	1.18	0.93	1.20	0.99	0.95	1.24	1.08	0.98
3634	South Rd	Bluff Rd	Bayside	077, B04	0.78	0.94	0.92	1.18	1.17	0.91	1.14	1.03	0.93	1.20	0.97	0.83
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.68	0.79	0.78	1.03	0.95	1.17	1.30	1.13	0.92	1.30	1.00	0.95
4164	Main St	Collins St	Nillumbik	011, K05	0.74	0.89	0.87	1.18	1.17	0.89	1.20	1.03	0.94	1.21	1.06	0.82
4388	Elizabeth St	Victoria St	Melbourne	043, G06	0.78	0.91	1.01	1.16	1.10	0.91	1.14	1.00	0.94	1.24	1.04	0.77
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.75	0.93	0.76	1.09	1.12	0.99	1.20	0.99	1.02	1.28	1.04	0.84
4736	High St	Epping Plaza	Whittlesea	182, A12	0.78	0.82	0.91	1.21	1.13	0.93	1.16	0.99	1.02	1.23	0.94	0.89

Table 61: Seasonal Variation of Throughput over the Non-Summer Months (Average Weekend AM Peak Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)								
					Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	0.88	1.10	1.05	0.88	1.10	0.94	0.90	1.15	1.00
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	0.83	1.12	1.05	0.90	1.13	0.86	0.93	1.18	1.01
170	Burwood Hwy	Stud Rd	Knox	063, J11	0.93	1.14	1.17	0.91	1.15	1.00	0.69	1.14	0.87
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.88	1.13	0.96	0.87	1.10	0.93	0.96	1.19	0.98
325	Doncaster Rd	Tram Rd	Manningham	047, D01	0.90	1.10	1.05	0.90	1.10	0.95	0.90	1.14	0.97
422	Springvale Rd	High Street Rd	Monash	071, D01	0.82	1.03	1.05	0.87	1.08	1.13	0.89	1.13	1.00
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.84	1.10	1.08	0.85	1.09	0.92	0.93	1.15	1.03
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.85	1.21	1.00	0.94	1.09	0.92	1.05	1.05	0.89
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	0.86	1.16	1.04	0.86	1.09	0.93	0.93	1.16	0.98
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.89	1.06	1.04	0.86	1.08	0.96	0.93	1.19	0.97
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.78	1.13	1.04	0.85	1.11	0.98	0.94	1.17	1.00
3061	Bell St	Plenty Rd	Darebin	030, G01	0.88	1.14	0.96	0.89	1.10	0.93	0.95	1.15	1.01
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	0.97	1.10	1.05	0.87	1.09	0.93	0.89	1.14	0.97
3382	Hoddle St	Johnston St	Yarra	044, D04	0.86	1.17	1.04	0.87	1.09	0.93	0.91	1.14	0.98
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.87	1.11	1.07	0.88	1.10	0.97	0.90	1.13	0.97
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	0.90	1.10	1.08	0.95	1.14	0.93	0.86	1.12	0.93
3559	North Rd	Koornang Rd	Glen Eira	068, H09	0.84	1.07	1.11	0.87	1.12	0.93	0.89	1.16	1.02
3634	South Rd	Bluff Rd	Bayside	077, B04	0.87	1.13	1.12	0.86	1.09	0.98	0.88	1.14	0.92
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.74	0.96	0.90	1.10	1.22	1.06	0.87	1.22	0.94
4164	Main St	Collins St	Nillumbik	011, K05	0.82	1.11	1.10	0.84	1.13	0.97	0.89	1.14	1.00
4388	Elizabeth St	Victoria St	Melbourne	043, G06	0.95	1.09	1.04	0.86	1.08	0.95	0.89	1.17	0.98
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.72	1.03	1.06	0.94	1.13	0.94	0.96	1.22	0.99
4736	High St	Epping Plaza	Whittlesea	182, A12	0.86	1.15	1.07	0.88	1.10	0.93	0.96	1.16	0.89

Table 62: Seasonal Variation of Throughput over the Year (Annual Average PM Peak Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	0.77	0.77	1.04	1.05	1.09	1.07	1.05	1.08	1.02	1.02	1.05	0.99
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	0.76	0.84	1.05	1.04	1.07	1.02	1.06	1.09	1.00	1.05	1.06	0.97
170	Burwood Hwy	Stud Rd	Knox	063, J11	0.70	0.87	1.07	1.08	1.08	1.06	1.09	1.11	0.80	1.04	1.08	1.01
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.69	0.80	1.03	1.04	1.12	1.07	1.07	1.09	1.07	1.06	1.03	0.93
325	Doncaster Rd	Tram Rd	Manningham	047, D01	0.62	0.86	1.07	1.02	1.09	1.06	1.07	1.08	1.02	1.05	1.06	1.01
422	Springvale Rd	High Street Rd	Monash	071, D01	0.84	1.03	1.01	1.13	1.03	1.07	1.13	1.01	1.09	1.11	0.93	1.00
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.85	1.03	1.04	1.12	1.04	1.09	1.11	1.02	1.03	1.06	0.93	1.00
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.69	0.87	1.03	1.08	1.09	1.05	0.98	1.11	1.09	1.03	0.99	1.00
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	0.71	0.83	1.05	1.03	1.06	1.04	1.05	1.09	1.05	1.06	1.04	0.97
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.73	0.83	1.01	1.03	1.05	1.04	1.06	1.11	1.07	1.08	1.05	0.91
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.75	0.84	1.01	1.02	1.08	1.02	1.05	1.11	1.02	1.04	1.08	0.98
3061	Bell St	Plenty Rd	Darebin	030, G01	0.76	0.85	1.01	1.04	1.05	1.03	1.07	1.07	1.04	1.05	1.05	0.97
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	0.65	0.85	1.06	1.06	1.10	1.04	1.05	1.12	1.07	1.07	1.04	0.89
3382	Hoddle St	Johnston St	Yarra	044, D04	0.76	0.83	1.04	1.06	1.09	1.03	1.04	1.10	1.04	1.05	1.04	0.92
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.76	0.84	1.02	1.01	1.05	1.00	1.07	1.10	1.03	1.02	1.09	1.00
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	0.37	0.87	1.11	1.11	1.16	1.10	1.16	1.15	1.03	1.04	0.99	0.90
3559	North Rd	Koornang Rd	Glen Eira	068, H09	0.60	0.84	1.05	0.93	1.12	1.02	1.06	1.11	1.04	1.09	1.12	1.03
3634	South Rd	Bluff Rd	Bayside	077, B04	0.73	0.82	1.06	1.05	1.10	1.01	1.04	1.13	1.01	1.07	1.06	0.94
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.69	0.83	1.01	1.03	1.09	1.00	1.10	1.14	1.05	1.08	1.08	0.90
4164	Main St	Collins St	Nillumbik	011, K05	0.67	0.82	1.04	1.05	1.12	1.03	1.09	1.12	1.01	1.06	1.07	0.93
4388	Elizabeth St	Victoria St	Melbourne	043, G06	0.74	0.86	1.04	1.06	1.08	1.05	1.09	1.14	1.04	1.03	1.02	0.86
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.74	0.85	0.95	0.98	1.03	1.05	1.10	1.14	1.06	1.11	1.05	0.95
4736	High St	Epping Plaza	Whittlesea	182, A12	0.71	0.83	1.04	1.03	1.09	1.05	1.08	1.09	1.03	1.07	1.01	0.98

Table 63: Seasonal Variation of Throughput over the Non-Summer Months (Average PM Peak Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)								
					Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	0.99	1.00	1.04	1.02	1.00	1.02	0.97	0.97	1.00
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	1.01	0.99	1.02	0.98	1.01	1.04	0.95	1.00	1.01
170	Burwood Hwy	Stud Rd	Knox	063, J11	1.02	1.03	1.03	1.01	1.05	1.06	0.77	1.00	1.03
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.96	0.98	1.05	1.00	1.01	1.03	1.00	1.00	0.97
325	Doncaster Rd	Tram Rd	Manningham	047, D01	1.01	0.96	1.03	1.00	1.01	1.02	0.97	0.99	1.00
422	Springvale Rd	High Street Rd	Monash	071, D01	0.96	0.95	1.06	0.96	1.00	1.06	0.95	1.02	1.04
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.97	0.98	1.05	0.98	1.03	1.05	0.96	0.98	1.00
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.98	1.03	1.04	1.00	0.93	1.06	1.04	0.98	0.94
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	1.00	0.98	1.01	0.99	0.99	1.04	0.99	1.01	0.99
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.96	0.97	0.99	0.99	1.00	1.05	1.02	1.02	1.00
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.96	0.98	1.03	0.97	1.00	1.06	0.98	1.00	1.03
3061	Bell St	Plenty Rd	Darebin	030, G01	0.97	1.00	1.01	0.99	1.02	1.02	0.99	1.00	1.00
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	0.99	0.99	1.03	0.97	0.99	1.05	1.00	1.00	0.98
3382	Hoddle St	Johnston St	Yarra	044, D04	0.99	1.01	1.03	0.98	0.99	1.04	0.99	1.00	0.98
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.98	0.97	1.01	0.96	1.02	1.05	0.98	0.98	1.04
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	1.01	1.01	1.06	1.01	1.06	1.05	0.94	0.95	0.90
3559	North Rd	Koornang Rd	Glen Eira	068, H09	0.99	0.88	1.05	0.96	1.00	1.04	0.98	1.03	1.05
3634	South Rd	Bluff Rd	Bayside	077, B04	1.00	0.99	1.04	0.96	0.98	1.07	0.95	1.01	1.00
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.95	0.97	1.02	0.94	1.03	1.07	0.99	1.02	1.01
4164	Main St	Collins St	Nillumbik	011, K05	0.97	0.98	1.05	0.97	1.02	1.06	0.95	0.99	1.00
4388	Elizabeth St	Victoria St	Melbourne	043, G06	0.98	1.00	1.02	0.99	1.03	1.07	0.98	0.97	0.96
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.90	0.93	0.98	1.00	1.04	1.08	1.01	1.05	1.00
4736	High St	Epping Plaza	Whittlesea	182, A12	0.99	0.98	1.03	0.99	1.03	1.04	0.98	1.01	0.96

Table 64: Seasonal Variation of Throughput over the Year (Annual Average Weekday PM Peak Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	0.72	0.79	1.06	1.03	1.08	1.07	0.99	1.11	1.04	1.01	1.07	1.03
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	0.71	0.83	1.08	1.01	1.06	1.05	0.98	1.12	1.01	1.03	1.08	1.04
170	Burwood Hwy	Stud Rd	Knox	063, J11	0.65	0.88	1.10	1.04	1.05	1.07	1.03	1.14	0.82	1.01	1.15	1.08
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.64	0.81	1.05	1.02	1.12	1.08	1.02	1.13	1.08	1.03	1.05	0.98
325	Doncaster Rd	Tram Rd	Manningham	047, D01	0.57	0.84	1.09	1.00	1.08	1.08	1.02	1.11	1.03	1.02	1.08	1.09
422	Springvale Rd	High Street Rd	Monash	071, D01	0.84	1.05	0.99	1.11	1.03	1.02	1.16	1.03	1.07	1.13	0.97	1.00
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.85	1.05	1.02	1.11	1.06	1.05	1.14	1.02	1.02	1.08	0.97	1.00
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.65	0.89	1.06	1.02	1.12	1.07	0.91	1.14	1.07	1.03	1.04	1.01
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	0.68	0.85	1.09	1.01	1.05	1.05	0.98	1.12	1.06	1.02	1.06	1.02
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.70	0.83	1.05	1.00	1.03	1.06	0.99	1.14	1.09	1.05	1.08	0.96
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.66	0.83	1.08	1.02	1.08	1.00	0.97	1.12	1.05	1.05	1.11	1.04
3061	Bell St	Plenty Rd	Darebin	030, G01	0.72	0.85	1.04	1.01	1.07	1.05	1.02	1.10	1.06	1.02	1.06	1.02
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	0.62	0.84	1.09	1.03	1.09	1.06	0.99	1.15	1.08	1.05	1.07	0.93
3382	Hoddle St	Johnston St	Yarra	044, D04	0.72	0.82	1.08	1.04	1.08	1.05	0.98	1.13	1.06	1.01	1.05	0.96
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.71	0.82	1.05	1.00	1.05	1.03	1.01	1.12	1.05	1.02	1.10	1.05
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	0.33	0.86	1.14	1.09	1.15	1.13	1.10	1.19	1.05	1.01	0.99	0.95
3559	North Rd	Koornang Rd	Glen Eira	068, H09	0.58	0.83	1.08	0.92	1.11	1.03	1.01	1.14	1.07	1.06	1.14	1.04
3634	South Rd	Bluff Rd	Bayside	077, B04	0.68	0.79	1.09	1.03	1.10	1.04	0.98	1.16	1.03	1.05	1.10	0.97
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.65	0.83	1.04	1.01	1.08	1.03	1.04	1.17	1.07	1.06	1.09	0.94
4164	Main St	Collins St	Nillumbik	011, K05	0.62	0.81	1.07	1.03	1.10	1.06	1.03	1.15	1.03	1.04	1.09	0.97
4388	Elizabeth St	Victoria St	Melbourne	043, G06	0.71	0.87	1.07	1.03	1.06	1.06	1.04	1.16	1.06	0.99	1.03	0.92
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.69	0.83	1.00	0.95	1.02	1.06	1.06	1.17	1.07	1.07	1.07	1.00
4736	High St	Epping Plaza	Whittlesea	182, A12	0.66	0.83	1.07	1.01	1.08	1.06	1.03	1.12	1.04	1.03	1.05	1.03

Table 65: Seasonal Variation of Throughput over the Non-Summer Months (Average Weekday PM Peak Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)								
					Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	1.01	0.98	1.03	1.02	0.94	1.06	0.99	0.96	1.02
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	1.03	0.97	1.01	1.00	0.94	1.07	0.96	0.99	1.03
170	Burwood Hwy	Stud Rd	Knox	063, J11	1.05	1.00	1.00	1.02	0.99	1.09	0.78	0.97	1.10
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.98	0.96	1.05	1.01	0.96	1.06	1.01	0.97	0.99
325	Doncaster Rd	Tram Rd	Manningham	047, D01	1.03	0.95	1.02	1.02	0.96	1.05	0.98	0.97	1.02
422	Springvale Rd	High Street Rd	Monash	071, D01	0.99	0.93	1.04	0.97	0.96	1.09	0.96	1.01	1.06
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.99	0.96	1.05	1.00	0.99	1.08	0.96	0.96	1.02
735	Seaford Rd	Railway Pde	Frankston	099, E05	1.01	0.97	1.07	1.02	0.87	1.08	1.02	0.98	0.99
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	1.04	0.96	1.00	1.00	0.94	1.06	1.01	0.97	1.01
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.99	0.95	0.98	1.01	0.94	1.08	1.03	1.00	1.02
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	1.02	0.97	1.02	0.95	0.92	1.07	1.00	1.00	1.05
3061	Bell St	Plenty Rd	Darebin	030, G01	0.99	0.97	1.02	1.00	0.97	1.05	1.01	0.97	1.01
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	1.02	0.96	1.02	1.00	0.92	1.08	1.01	0.98	1.00
3382	Hoddle St	Johnston St	Yarra	044, D04	1.02	0.99	1.02	1.00	0.93	1.07	1.01	0.96	1.00
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	1.00	0.96	1.01	0.98	0.96	1.07	1.00	0.98	1.05
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	1.04	1.00	1.05	1.03	1.01	1.08	0.96	0.92	0.91
3559	North Rd	Koornang Rd	Glen Eira	068, H09	1.02	0.87	1.04	0.97	0.95	1.07	1.00	1.00	1.07
3634	South Rd	Bluff Rd	Bayside	077, B04	1.02	0.97	1.03	0.98	0.92	1.09	0.97	0.99	1.03
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.98	0.95	1.01	0.96	0.98	1.09	1.01	0.99	1.03
4164	Main St	Collins St	Nillumbik	011, K05	1.00	0.96	1.04	0.99	0.97	1.07	0.96	0.98	1.02
4388	Elizabeth St	Victoria St	Melbourne	043, G06	1.01	0.98	1.00	1.00	0.99	1.10	1.01	0.94	0.98
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.95	0.91	0.97	1.01	1.01	1.11	1.02	1.02	1.01
4736	High St	Epping Plaza	Whittlesea	182, A12	1.02	0.96	1.03	1.00	0.98	1.06	0.99	0.98	1.00

Table 66: Seasonal Variation of Throughput over the Year (Annual Average Weekend PM Peak Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)											
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	0.94	0.73	0.97	1.10	1.12	1.05	1.25	0.96	0.95	1.08	0.98	0.87
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	0.91	0.89	0.97	1.11	1.09	0.94	1.27	1.00	0.96	1.09	1.00	0.77
170	Burwood Hwy	Stud Rd	Knox	063, J11	0.86	0.86	0.97	1.19	1.19	1.02	1.30	1.02	0.76	1.15	0.87	0.81
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.85	0.76	0.96	1.10	1.13	1.04	1.27	0.97	1.02	1.17	0.97	0.75
325	Doncaster Rd	Tram Rd	Manningham	047, D01	0.77	0.89	1.02	1.07	1.14	1.00	1.23	1.00	0.98	1.14	0.99	0.77
422	Springvale Rd	High Street Rd	Monash	071, D01	0.85	0.92	1.09	1.18	0.99	1.26	1.03	0.94	1.15	1.03	0.76	1.00
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.81	0.94	1.12	1.15	0.98	1.24	0.97	1.03	1.11	1.01	0.80	1.00
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.84	0.80	0.89	1.30	0.96	0.97	1.24	1.02	1.16	1.03	0.81	0.98
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	0.82	0.78	0.92	1.11	1.11	1.01	1.26	1.01	0.99	1.18	0.98	0.82
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.84	0.83	0.91	1.10	1.11	0.98	1.27	1.01	1.03	1.17	0.98	0.76
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.86	0.81	0.82	1.12	1.14	0.98	1.26	1.00	0.98	1.14	1.03	0.85
3061	Bell St	Plenty Rd	Darebin	030, G01	0.86	0.87	0.95	1.14	1.02	0.98	1.22	1.00	0.99	1.15	1.01	0.83
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	0.74	0.87	0.96	1.14	1.16	0.95	1.26	1.02	1.02	1.14	0.98	0.76
3382	Hoddle St	Johnston St	Yarra	044, D04	0.87	0.85	0.94	1.12	1.10	0.98	1.22	1.00	0.97	1.17	0.99	0.79
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.91	0.90	0.94	1.05	1.05	0.92	1.26	1.04	0.97	1.03	1.05	0.88
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	0.52	0.89	1.00	1.17	1.17	1.02	1.33	1.03	0.98	1.13	0.98	0.76
3559	North Rd	Koornang Rd	Glen Eira	068, H09	0.66	0.88	0.95	0.96	1.15	0.96	1.24	1.00	0.97	1.20	1.04	0.99
3634	South Rd	Bluff Rd	Bayside	077, B04	0.90	0.91	0.95	1.11	1.13	0.93	1.23	1.02	0.94	1.13	0.91	0.82
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.82	0.85	0.91	1.09	1.12	0.90	1.29	1.06	0.98	1.18	1.02	0.78
4164	Main St	Collins St	Nillumbik	011, K05	0.81	0.85	0.92	1.10	1.17	0.95	1.29	1.05	0.96	1.11	1.00	0.79
4388	Elizabeth St	Victoria St	Melbourne	043, G06	0.85	0.85	0.93	1.15	1.18	0.99	1.27	1.06	0.95	1.13	0.96	0.68
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.92	0.89	0.76	1.08	1.08	1.00	1.22	1.04	1.00	1.23	1.00	0.78
4736	High St	Epping Plaza	Whittlesea	182, A12	0.86	0.82	0.94	1.12	1.12	1.01	1.26	1.01	0.99	1.19	0.86	0.82

Table 67: Seasonal Variation of Throughput over the Non-Summer Months (Average Weekend PM Peak Traffic)

(Source: VicRoads SCATS Counts 2016, main roads only (where appropriate) with left and through counts adopted at the more significant approaches)

Site	Road One	Road Two	Council	Melway Ref	Seasonal Variation of Throughput over the Year (Entire Day, All Days)								
					Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
117	Maroondah Hwy	Springvale Rd	Whitehorse	048, F08	0.92	1.05	1.07	1.00	1.18	0.92	0.90	1.03	0.94
141	Maroondah Hwy	Manchester Rd	Yarra Ranges	037, G05	0.93	1.05	1.04	0.89	1.21	0.95	0.92	1.04	0.96
170	Burwood Hwy	Stud Rd	Knox	063, J11	0.92	1.13	1.13	0.97	1.24	0.97	0.72	1.09	0.82
196	Princes Highway East	Foster St	Greater Dandenong	090, D08	0.89	1.03	1.06	0.97	1.19	0.91	0.95	1.09	0.91
325	Doncaster Rd	Tram Rd	Manningham	047, D01	0.96	1.00	1.07	0.94	1.16	0.94	0.93	1.07	0.93
422	Springvale Rd	High Street Rd	Monash	071, D01	0.86	1.03	1.11	0.93	1.18	0.97	0.88	1.08	0.97
604	Princes Highway East	Narre Warren-Cranbourne Rd	Casey	110, E06	0.88	1.06	1.08	0.92	1.17	0.91	0.97	1.04	0.95
735	Seaford Rd	Railway Pde	Frankston	099, E05	0.85	1.25	0.92	0.93	1.19	0.98	1.11	0.99	0.77
2194	Pascoe Vale Rd	Somerton Rd	Hume	179, K09	0.87	1.05	1.04	0.95	1.19	0.95	0.93	1.11	0.92
2504	Princes Highway West	Western Hwy	Maribyrnong	042, D03	0.85	1.04	1.05	0.92	1.20	0.95	0.97	1.10	0.92
2638	Melton Hwy	Kings Rd	Brimbank	003, G12	0.78	1.06	1.08	0.93	1.20	0.95	0.93	1.09	0.98
3061	Bell St	Plenty Rd	Darebin	030, G01	0.91	1.08	0.97	0.93	1.16	0.95	0.94	1.09	0.96
3112	Sydney Rd	Brunswick Rd	Moreland	029, G10	0.90	1.07	1.08	0.89	1.18	0.95	0.95	1.06	0.91
3382	Hoddle St	Johnston St	Yarra	044, D04	0.89	1.06	1.05	0.93	1.16	0.95	0.92	1.11	0.94
3501	Millers Rd	Blackshaws Rd	Hobsons Bay	055, B01	0.91	1.02	1.02	0.89	1.22	1.00	0.94	0.99	1.02
3510	Mt Alexander Rd	Puckle St	Moonee Valley	028, J07	0.92	1.07	1.08	0.94	1.22	0.94	0.90	1.04	0.90
3559	North Rd	Koornang Rd	Glen Eira	068, H09	0.90	0.91	1.09	0.91	1.18	0.95	0.92	1.14	0.99
3634	South Rd	Bluff Rd	Bayside	077, B04	0.92	1.07	1.09	0.90	1.18	0.98	0.91	1.09	0.88
4040	Burke Rd	Camberwell Rd	Boroondara	059, J01	0.86	1.02	1.06	0.85	1.22	1.00	0.92	1.11	0.96
4164	Main St	Collins St	Nillumbik	011, K05	0.87	1.04	1.10	0.90	1.22	0.99	0.90	1.04	0.94
4388	Elizabeth St	Victoria St	Melbourne	043, G06	0.87	1.08	1.10	0.93	1.18	0.99	0.88	1.06	0.90
4537	Commercial Rd	Izett St	Stonnington	057, K01	0.73	1.03	1.03	0.96	1.17	1.00	0.96	1.17	0.95
4736	High St	Epping Plaza	Whittlesea	182, A12	0.89	1.06	1.06	0.96	1.19	0.96	0.94	1.12	0.82

Appendix B – Maximum Flow Figures

Table 68: Empirical Maximum Flow Figures (85th Percentile, Scaled Down[6], Rounded) from Detector

	Highway	Primary	Secondary	Collector	Local
Banyule	1875	1800	1750	1650	1500
Bayside	1950	1775	1650	1575	1700
Boroondara	----	1675	1700	1650	1725
Brimbank	1850	1800	1700	1725	1675
Cardinia	1800	1700	1700	1525	1675
Casey	1825	1750	1775	1575	1600
Darebin	1750	1750	1700	1650	1575
Frankston	1625	1750	1675	1625	1350
Glen Eira	1900	1750	1650	1550	1350
Greater Dandenong	1800	1800	1700	1600	1500
Hobsons Bay	1800	1725	1700	1700	1400
Hume	1825	1800	1775	1675	1600
Kingston	1925	1825	1800	1650	1600
Knox	1900	1825	1725	1775	1575
Manningham	1825	1825	1725	1625	1400
Maribyrnong	1825	1700	1625	1675	1600
Maroondah	1975	1850	1725	1825	1600
Melbourne	1750	1675	1625	1500	1500
Melton	1875	1725	1775	1625	1550
Monash	1975	1850	1750	1650	1600
Moonee Valley	1975	1700	1725	1650	1525
Moreland	1900	1725	1700	1625	1550
Mornington Peninsula	1750	1525	1650	1475	1575
Nillumbik	----	1825	1750	1525	1525
Port Phillip	1825	1750	1650	1525	1625
Stonnington	1825	1700	1600	1575	1525
Whitehorse	1875	1875	1725	1725	1475
Whittlesea	----	1825	1725	1725	1750
Wyndham	1775	1725	1725	1725	1550
Yarra	1750	1650	1675	1625	1500
Yarra Ranges	1850	1750	1800	1700	1700

[6] Proportion of 5% was removed from the Maximum Flow figure prior to rounding and publication

Table 69: Empirical Maximum Flow Figures (15th percentile, Scaled Down[7], Rounded) from Detectors

	Highway	Primary	Secondary	Collector	Local
Banyule	1475	1400	1400	1300	1250
Bayside	1525	1400	1350	1300	1175
Boroondara	----	1400	1400	1325	1350
Brimbank	1475	1425	1375	1325	1325
Cardinia	1400	1425	1450	1425	1325
Casey	1400	1375	1350	1275	1225
Darebin	1550	1350	1375	1300	1275
Frankston	1300	1350	1250	1250	1175
Glen Eira	1475	1300	1300	1300	1125
Greater Dandenong	1450	1400	1375	1200	1275
Hobsons Bay	1375	1325	1250	1250	1100
Hume	1450	1450	1400	1325	1275
Kingston	1500	1425	1425	1225	1250
Knox	1475	1475	1400	1425	1300
Manningham	1375	1450	1400	1350	1275
Maribyrnong	1450	1350	1300	1175	1225
Maroondah	1550	1525	1400	1375	1225
Melbourne	1375	1300	1225	1150	1100
Melton	1475	1350	1425	1425	1200
Monash	1525	1475	1400	1200	1225
Moonee Valley	1575	1375	1325	1250	1200
Moreland	1450	1350	1300	1200	1175
Mornington Peninsula	1500	1300	1250	1325	1175
Nillumbik	----	1475	1750	1300	1175
Port Phillip	1475	1350	1325	1225	1325
Stonnington	1525	1350	1275	1275	1225
Whitehorse	1525	1475	1450	1275	1300
Whittlesea	----	1525	1400	1450	1375
Wyndham	1725	1350	1400	1350	1200
Yarra	1400	1275	1325	1125	1125
Yarra Ranges	1500	1350	1400	1200	1150

[7] Proportion of 5% was removed from the Maximum Flow figure prior to rounding and publication

Appendix C – Report Example

Example report may be linked with the guidelines.

Detailed Design – Intersection of Keilor Road/Newman Street and Keilor Road/Grange Road, Niddrie

Transport Modelling Report

Draft - Version 2.0
Fri, 13 Jul 2018

Connecting
our communities

vicroads

TRANSPORT FOR VICTORIA

Detailed Design – Intersection of Keilor Road/Newman Street and Keilor Road/Grange Road, Niddrie

Table of Contents

Figures

All figures have been provided in Appendix C at a higher resolution and clarity

Tables

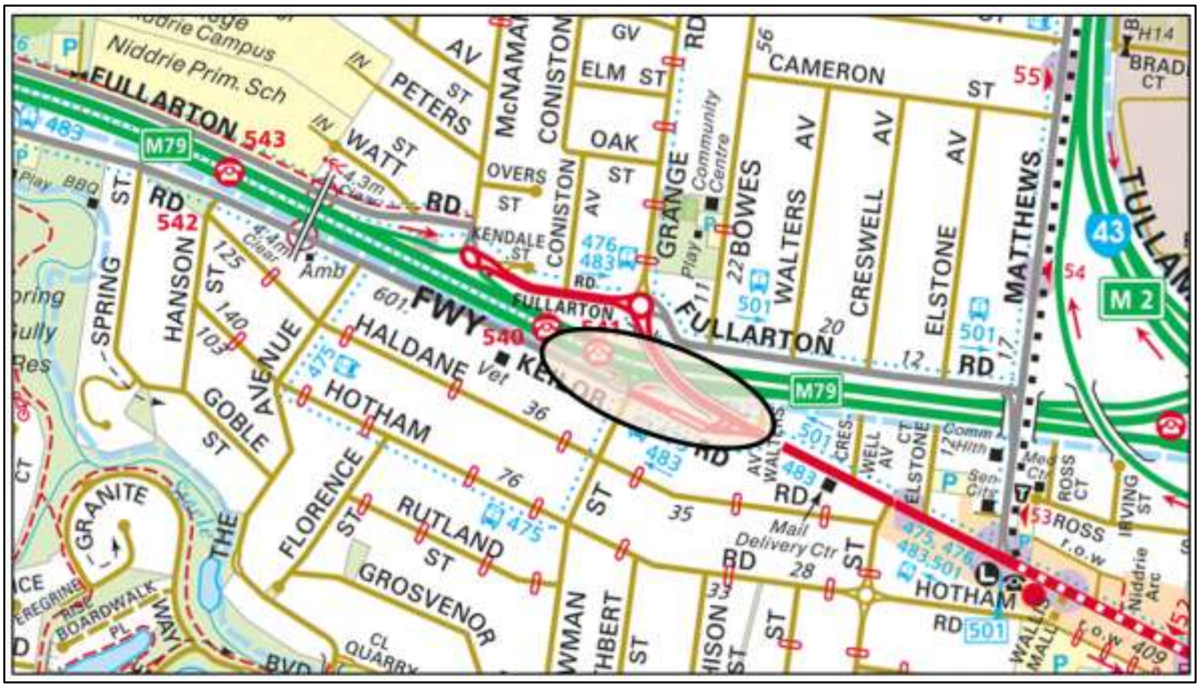
1. Project Investigation

Introduction

VicRoads Metropolitan North West (VR MNW) Region are currently investigating the feasibility of upgrading the unsignalised intersections of Keilor Road/Newman Street and Keilor Road/Grange Road.

The location is to the west of Essendon Airport and is one of the main gateway locations in the Keilor Road Activity Centre Structure Plan by the City of Moonee Valley as shown in Figure 1. This is due to the access to and from the Calder Freeway at both Keilor Road and McNamara Avenue. The immediate area is predominantly industrial and is served by bulky goods retailing/business services. The areas surrounding this immediate area include residential and retail with an extensive shopping precinct to the west that is services by bus services and a tram route.

Figure 1: Investigation location (Source: Melways)



VicRoads Traffic Profiles for Keilor Road shows a consistent volume profile over the weekdays of Tuesday, Wednesday and Thursday as illustrated in Figure 2 and Figure 3 below. The hourly volumes peak at close to 800 vehicles/hour, with daily average 2-way volumes at approximately 7,000 (AADT).

Figure 2: Keilor Road Westbound Hourly Volume Profile (Source: VicRoads Traffic Profile)

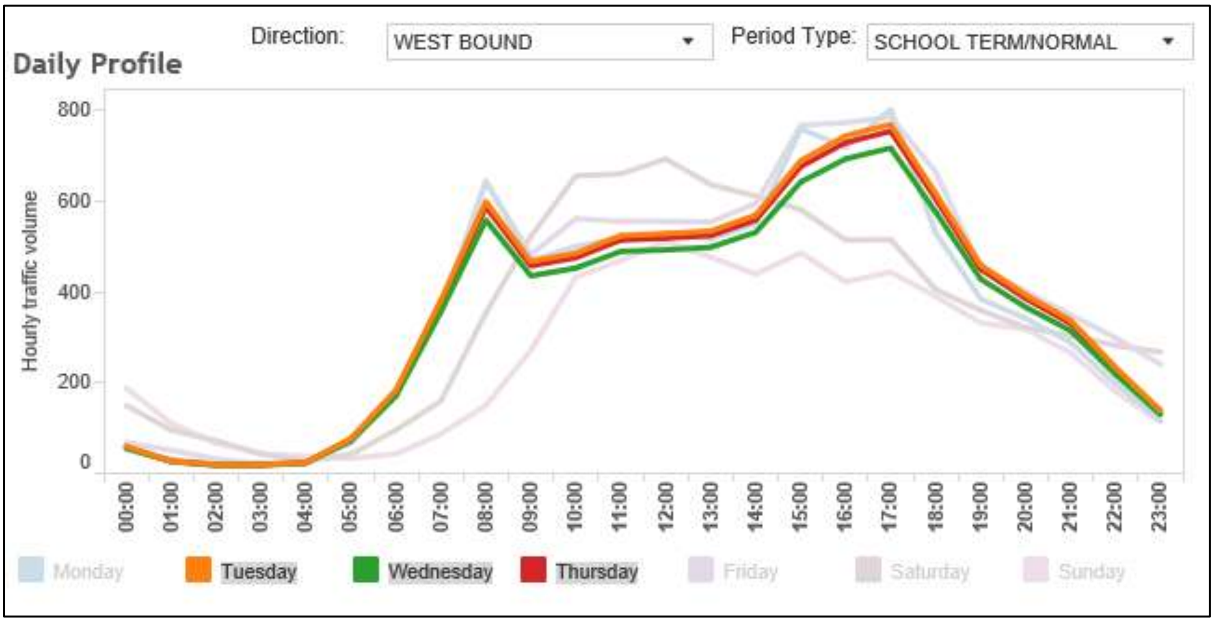
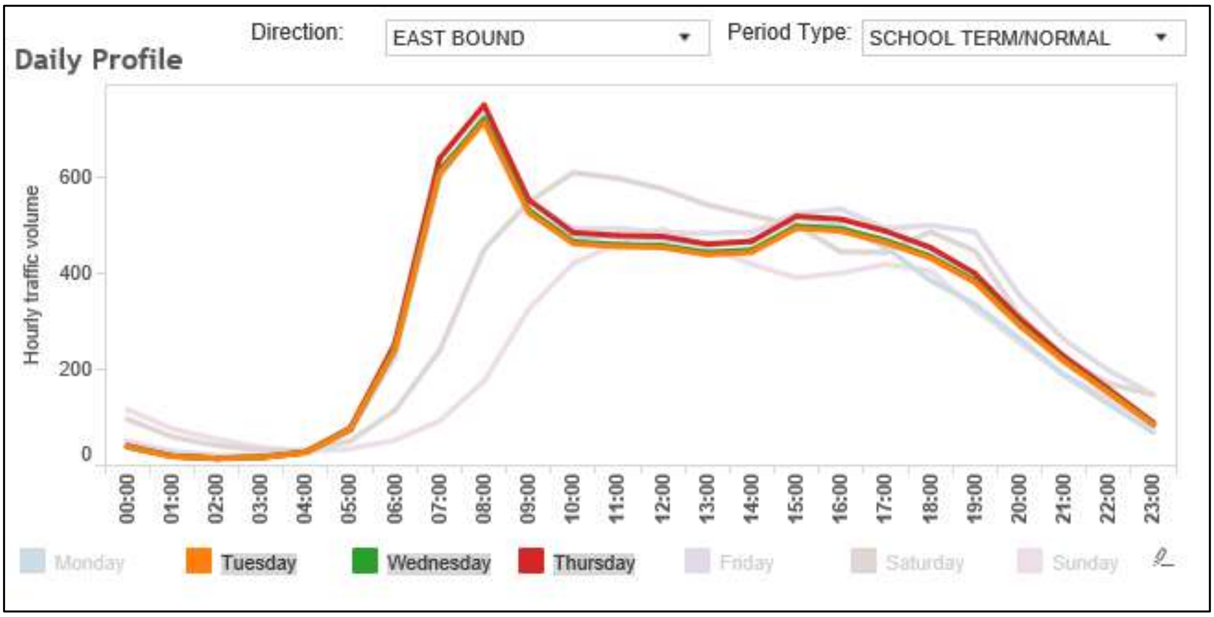


Figure 3: Keilor Road Eastbound Hourly Volume Profile (Source: VicRoads Traffic Profile)



The key reasons for the investigation include:

- Both Keilor Road/Newman Street and Keilor Road/Grange Road intersections are unsignalised. These control systems are significantly constrained by lack of road reserve and tight geometry which affect the sight lines and moveability creating safety concerns.
- Both intersections have increased crash history over the past 5 years (Figure 4) for the area for reasons such as increased demand for both the right turns and through movements. This

provides less opportunities for right turners to choose desirable gaps in the traffic. The two intersections are also key crash locations when considering the broader area (Figure 5).

- Increase delay, confusion and increase risk taking for right turners especially at Keilor Road/Grange Road which is a partial (painted) “Seagull” configuration.

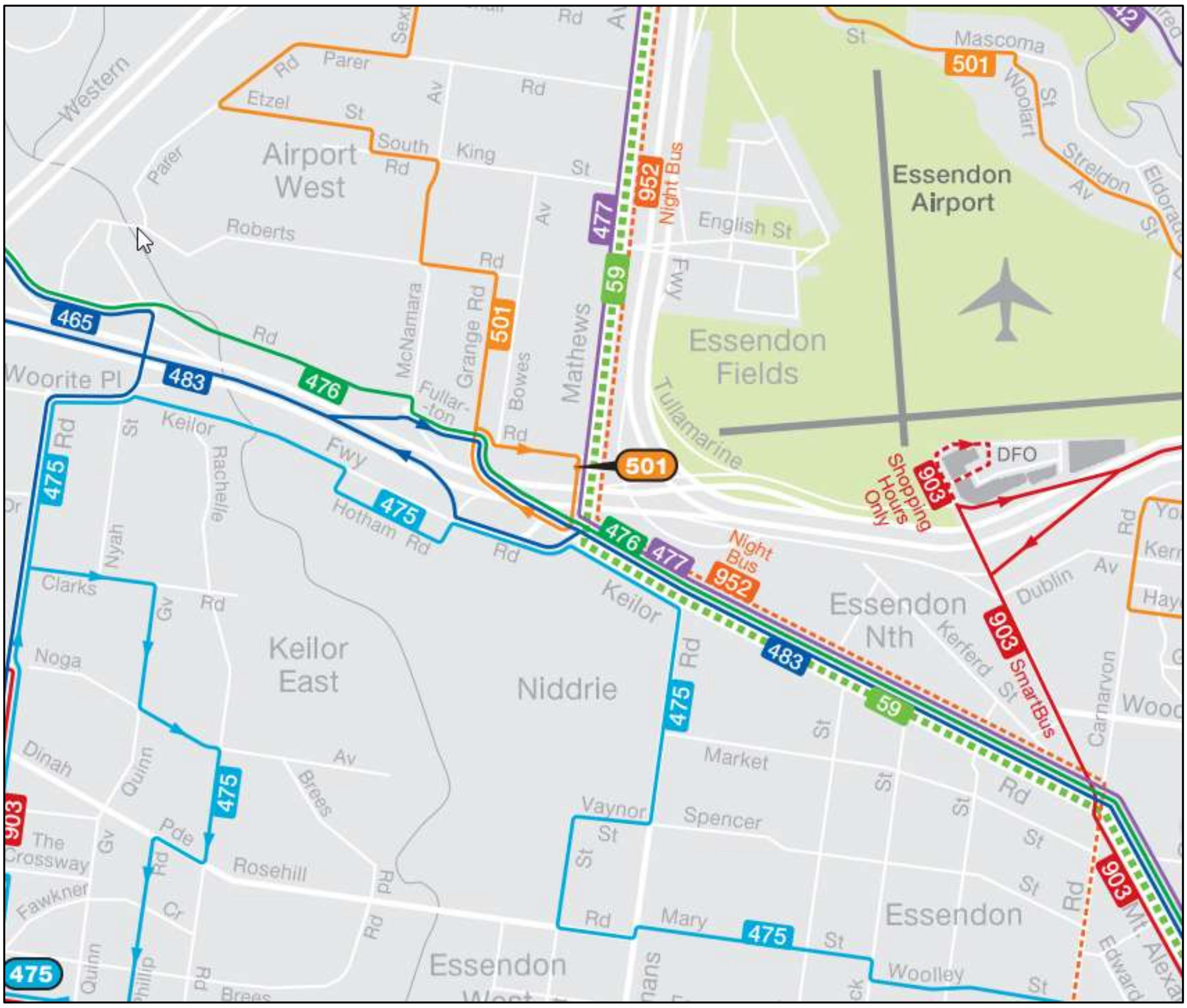
Figure 4: Crashes over the past 5 years – Investigation Area (Source: Victorian Crash Statistics)

Figure 5: Crashes over the past 5 years – Broader Keilor Rd Area (Source: Victorian Crash Statistics)

The key stakeholders include:

- VicRoads as Keilor Road is a declared state road
- City of Moonee Valley as the location is within the municipality area and effects the residents and businesses especially along Keilor Road
- Public Transport Victoria (PTV) due to four bus routes running through the investigation area and other nearby public transport services (Figure 6)

Figure 6: Public transport routes (Source: PTV)



Modelling Considerations

VR MNW has requested that a micro-simulation model be developed for the road network surrounding the Keilor Road/Newman Street and Keilor Road/Grange Road intersections. Preliminary SIDRA analysis was undertaken for both intersections that explored various upgrade configuration and phasing arrangements. However, due to the complex nature of the intersection arrangement (i.e. partial seagull treatment at Keilor Road/Grange Road) and the closely spaced intersections it was considered appropriate to undertake a more detailed modelling using microsimulation. This modelling approach is intended to provide a means to assess the current and future traffic performance of the road network in the vicinity due to the proposed upgrades.

A microsimulation model using Vissim software (PTV Vision) version 9.00-08 was developed for this investigation. The base model developed was calibrated and validated for the investigation area in accordance with VicRoads Simulation Modelling Guidelines, July 2018. The time periods agreed to model with VicRoads were as follows:

- AM peak period – 7:00am to 9:00am
- PM peak period – 4:00pm to 6:00pm

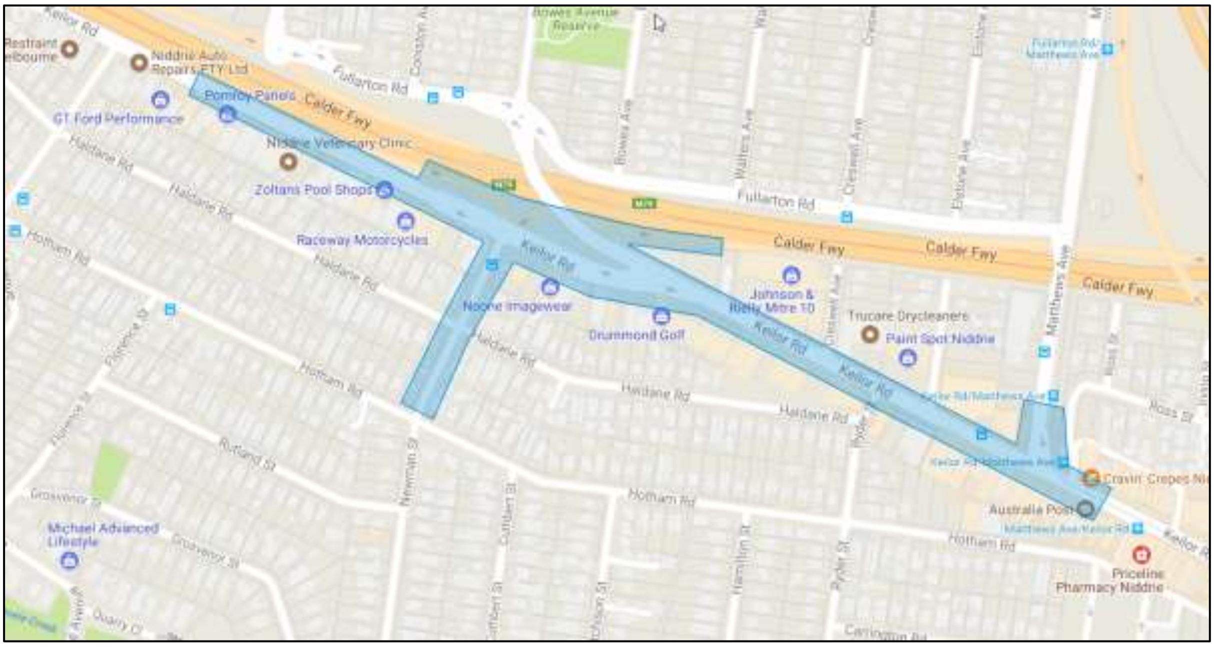
These time periods have been selected to cover the peak volumes recorded in the study area as well as to account for the level of congestion. A minimum 15-minute warm up and cool down period was chosen considering the relatively small model footprint.

The base model will then be used to investigate the various upgrade options provided by VicRoads. These upgrade options include:

1. Traffic Signals at Keilor Road/Newman Street and Keilor Road/Grange Road;
2. Traffic Signals at Keilor Road/Newman Street and Standard Roundabout at Keilor Road/Grange Road;
3. Traffic Signals at Keilor Road/Newman Street and Cut-through Roundabout at Keilor Road/Grange Road;
4. Standard Roundabout at Keilor Road/Newman Street and Standard Roundabout at Keilor Road/Grange Road; and
5. Standard Roundabout at Keilor Road/Newman Street and Cut-through Roundabout at Keilor Road/Grange Road.

The model extents (Figure 7) are considered appropriate for the upgrade options investigation in determining performance measures such as delay. This is due to minimum impact on route choice as the key destinations and access opportunities are considered limited. That is, vehicles opting to use the Calder Freeway access would most likely be residents, businesses and visitors to the shopping precinct and alternative access points are considered to be less favourable due to distance and access provisions.

Figure 7: Micro-simulation Model Extents



The traffic performance measures will be based on comparing the overall network performances, intersections related outputs such as level of service (based on delay per vehicle) and travel time. The objective is to provide a ranking of how various upgrade options perform against the base model and each other to assist in the decision making of upgrading the study area.

Report Structure

This modelling report sets out an overview of the model development, calibration and validation process, upgrade assessment and includes the following:

I. Data Collection and Analysis Process (Section 2)

II. Model Development Process (Section 3)

III. Calibration and Validation Process and Criteria (Section 4)

IV. Calibration and Validation Results (Section 5)

V. Performance Outputs (Section 6)

VI. Calibration and Validation Conclusion (Section 7)

VII. Upgrade Options Investigation (Section 8)

2. Data Collection

Overview

Comprehensive traffic survey was undertaken to understand the movement of various modes and the current performance of the study area. The data was then used to assist in the development and calibration and validation of the base model before it was used to investigate various upgrade options.

The following sections provide further detail on the scope and methodology of the data collected.

Table 1: Transport Data Summary

Turning Movement Counts	Data Audit Systems	Tuesday 22/08/2017	7:00am to 9:00am 4:00pm to 6:00pm	Calibration
Travel Time Surveys	Data Audit Systems	Tuesday 22/08/2017	7:00am to 9:00am 4:00pm to 6:00pm	Validation
Queue Lengths Surveys	Data Audit Systems	Tuesday 22/08/2017	7:00am to 9:00am 4:00pm to 6:00pm	Calibration
Automatic Tube Counts	Data Audit Systems	Thursday 31/08/2017 to Thursday 06/09/2017	24 Hours	Calibration
SCATS Signal Data	VicRoads	Tuesday 05/09/2017	7:00am to 9:00am 4:00pm to 6:00pm	Calibration
Public Transport Data - Schedules	PTV	Tuesday 22/08/2017	7:00am to 9:00am 4:00pm to 6:00pm	Calibration

Turning Movement Counts

Classified intersection turning movement counts were undertaken on Tuesday 22 August 2017 between 7:00am to 9:00am and 4:00pm to 6:00pm at the following three intersections. The classifications were split between light vehicles (LV) and heavy vehicles (HV). These counts were used to assist with the development of existing traffic demands for input into the Vissim micro-simulation model:

- Keilor Road/Newman Street Intersection
- Keilor Road/Grange Road Intersection
- Keilor Road/Ryder Street Intersection

The locations of the above intersections are shown in Figure 8 below.

Figure 8: Location of Surveyed Intersections

Queue Length Surveys

Queue lengths surveys were undertaken on the approaches of the intersections as shown in Figure 8 above. The queue surveys provided good references during the model calibration process.

The distance of the back of the queue from the intersection was noted for every signal cycle when the traffic signal turned to green. Where the traffic signals were not visible from the back of the queue, surveyor noted the maximum queue length at one-minute interval. To match the definition of traffic queue in VISSIM software, a vehicle moving at walking speed (less than 10kph) at the back of the queue was considered as a queued vehicle.

Automatic Tube Count

At the following three intersections, the entry and exit volumes to and from the study area were collected using automatic tube counters:

- Grange Road / Fullarton Road Roundabout
- Keilor Road / Matthews Avenue Intersection
- Keilor Road / The Avenue Intersection

Figure 8 show the location of the tube counts.

Travel Time Surveys

Travel time surveys were undertaken on the same days as the intersection turning movement counts across two bi-directional routes during the following peak times:

- AM peak (7:00am to 9:00am)
- PM peak (4:00pm to 6:00pm)

The travel time survey routes are described below and shown graphically in Figure 9.

- Route 1: Keilor Road/Grange Road between Keilor Road/Matthews Avenue Intersection and Grange Road/Fullarton Road Roundabout
- Route 2: Keilor Road between Keilor Road/Matthews Avenue Intersection and Keilor Road/Newman Street/Keilor Road On/Off-Ramps Intersection

The Floating Car method was used for travel time survey, where, a test vehicle attempts to simulate an "average" vehicle in the traffic stream. During the survey, one car fitted with GPS and video device starts the journey from one end of the route at the start of survey time and continue running between the two ends of the route for two-hour survey periods in both AM and PM peaks. Each trip was completed by crossing the stop line in a through lane.

A minimum of 20 runs per route were collected to determine the median journey time for model validation. Variation in median journey time to the 15th and 85th percentiles at 15-minute intervals for the survey did not vary by more than 20%. Median speed also showed little variation when compared to the 15th and 85th percentiles by not varying by more than 3 times between these percentile bands. As a result, the journey time validation was undertaken for the full peak periods.

Figure 9: Travel Time Routes

SCATS Signal Data

SCATS signal information has also been obtained from VicRoads to assist with the coding of signalised intersections, as well as to understand the current operation of signalised intersection in more detail. The data provides information on the following:

- phasing
- detector locations and numbers
- signal groups
- cycle and phase times
- pedestrian walk times and activation.
- IDM data and history files

This covered the pedestrian operated signals on Keilor Road near Elston Ave (TCS1366) and signalised intersection at Keilor Road/Matthews Avenue (TCS2720). These signals were important to ensure that the platooning of vehicles to the Keilor Road/Grange Road intersections was appropriately represented and ensure that coordination was considered when adopting signalised intersections as part of the upgrade.

Site Visit Observations

Two site visits were undertaken for both the AM and PM peak periods during the traffic survey date of 22/08/2017.

The key findings during the site visits were:

- Both unsignalised intersections of Keilor Road/Newman Street and Keilor Road/Grange Road are significantly constrained by lack of road reserve and tight geometry which affect the sight lines and moveability creating safety concerns. The turning speeds are therefore lower (Figure 10, Figure 11and Figure 12)
- Increase delay, confusion and increase risk taking for right turners
    - North-west right turners at Keilor Road/Grange Road find difficulty in picking gaps in the traffic which produces are larger variability in gap acceptance. The right turners also have to give way to the free-flowing left turners from the south approach, with the area only suitable for one car length. Longer vehicles would need to undertake the movements in one motion to ensure that the vehicle does not protrude onto oncoming vehicles (Figure 10).
    - West-south right turners at Keilor Road/Grange Road hesitate in making the turn due to through traffic from the north approach due to the limited line marking separation (Figure 11).
    - Right turners from Newman St are constraint by the high volume of right turns onto and from the Calder Freeway (Figure 12).

Figure 10: Aerial photo of Keilor Road/Grange Road (Source: Nearmap)

Figure 11: Aerial photo of Keilor Road/Newman Street (Source: Nearmap)

Figure 12: Site visit photo showing Keilor Road/Grange Road

3. Network Development

Development of Base Vissim Model

The base VISSIM model for the study was developed as per the existing layout of intersections and road elements in the study area as shown in Figure 13. It was extended from the intersection of Grange Road and Fullarton Road to the north, the intersection of Newman Street and Haldene to the south, the intersection of Keilor Road and The Avenue to the west and Keilor and Matthews Avenue to the east.

The network of the current operation was established utilising:

- Google Maps;
- Nearmap (Dated 22/8/2017); and
- Site Visit

Figure 13: Base model network and comparison against aerial imagery

Model Elements

The base model network details were enhanced by including geometrical details such as the correct number of lanes on each link, turn bays and appropriate lane connectivity so that the network geometry is suitable for the simulation of the existing operational conditions.

Existing signalised intersection within the model were controlled by fixed time control plans developed for the AM and PM peak periods, while Pedestrian Operating Signal (POS) at Ryder Street/Keilor Road was coded using VAP (Vehicle Actuated Program), a module with Vissim that assists in modelling demand driven pedestrian signal activation.

All public transport routes were coded in the base model traversing the study area to reflect the existing routes, timetables and bus stop locations. Default dwell time for bus have been considered.

The model elements are explored further in the following sections.

Links and Connectors

The model area network has been coded and a review was undertaken to ensure that the latest road network has been modelled (e.g. number of lanes, storage lengths, road curvatures etc.).

Links and connectors were coded to match the existing road network including the correct orientation and lane numbers. Specific details were also added to the model such as lane closures, vehicle type restrictions, lane change parameters, emergency stop distances, curve radii, and link specific assignment parameters.

Speed Limits

A review of the signposted speed limits has been undertaken at site to ensure it reflects on-site conditions and observations. The model includes 50kmph and 60kmph speed limits with the 50kmph area covering Keilor Road near Calder Freeway entry and exit ramps and Newman Street. VicRoads Simulation Modelling guidelines provides reference to speed profiles for arterials in respected municipalities between midnight and 6AM. Using the City of Moonee Valley, it is expected that for 60kmph posted speed that vehicles will travel 59kmph at the 50^{th} percentile with majority (85^{th} percentile) travelling at 67kmph or less. This has been taken into account when revising the speed profile for Keilor Road only section. The locations are shown in Figure 14 and Figure 15.

Figure 14: Vissim model showing number of lanes, reduced speed area locations and the desired speed locations with allocated speed profile for LV and HV (Keilor Road / Grange Road)

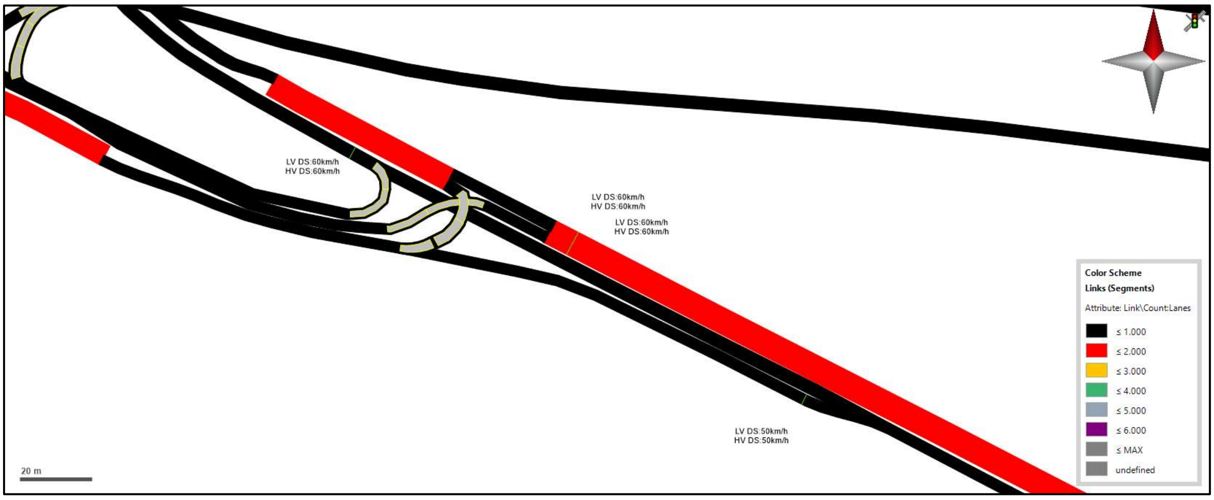


Figure 15: Vissim model showing number of lanes, reduced speed area locations and the desired speed locations with allocated speed profile for LV and HV (Keilor Road / Newton St)

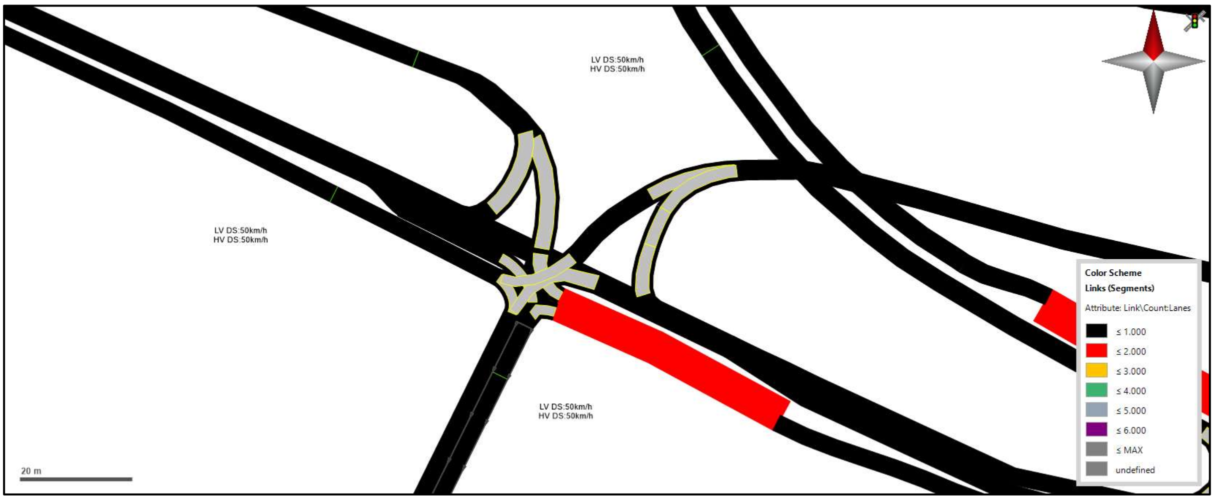
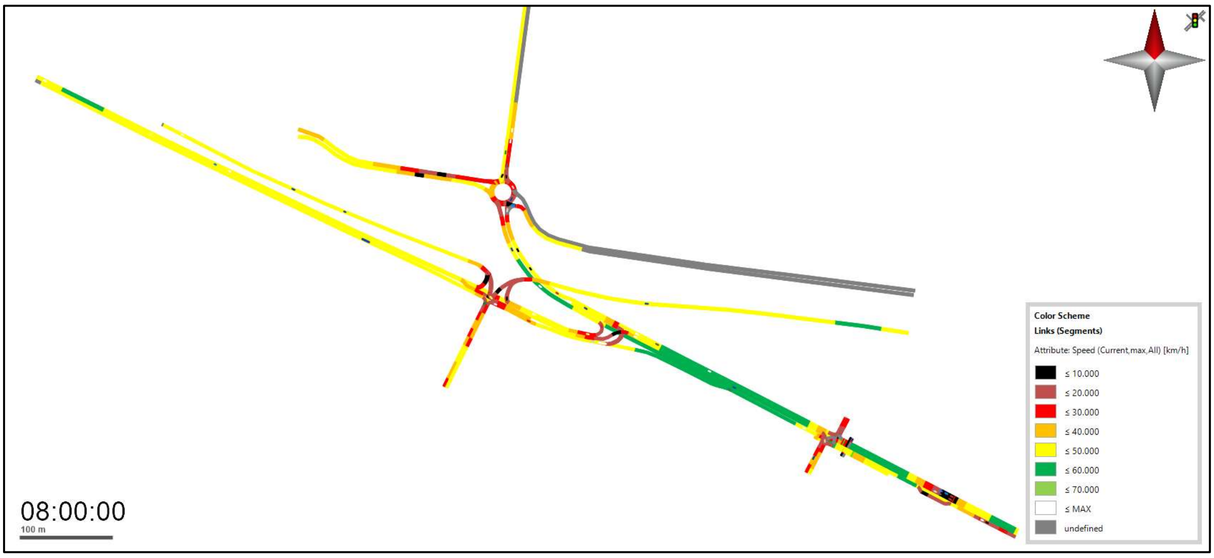


Figure 16 below demonstrates the maximum speed for AM Peak 7-8am using the VicRoads Simulation Modelling guidelines colour scheme 2 (7 classes). Other time intervals not provided as part of the demonstration.

Figure 16: Vissim model showing maximum speeds for the network for AM Peak 7-8am

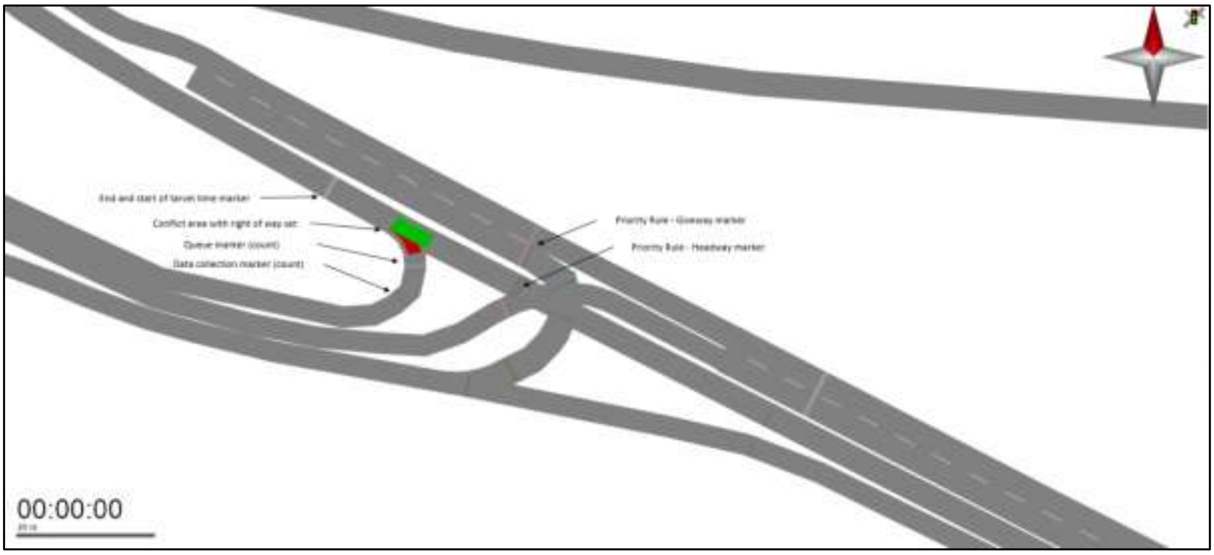


Priority Controls

Give way and turn priority controls have been coded to ensure correct priority movements at signalised and unsignalised intersections. Austroads Guide to Road Design (AGRD) Part 3 Table 3.5 has been used to determine appropriate critical acceptance gaps and follow-up headways which aligned closely to site observations. Priority rule has been adopted for all turns in the model except left turns which have conflict area activated.

Figure 17 shows an example of priority rules with give way lines, conflict areas and evaluation markers for the intersection of Keilor Road/Grange Road intersection. This demonstration does not provide for the entire network model.

Figure 17: Vissim model showing location of priority rules with give way lines, conflict areas and evaluation markers for the intersection of Keilor Road/Grange Road intersection



Reduced Speed Areas

Reduced speed area has been coded to ensure appropriate turn speeds are adopted at the intersections as well as bends on the road network. The chosen reduced speed areas included site observations and guidance from Austroads Guide to Road Design (AGRD) Part 4A Figure 5.2. In all cases the appropriate left turn speed was 15kmph for LV and 10kmph for HV and right turn speed was 30kmph for LV and 20kmph for HV. The locations are shown in Figure 14 and Figure 15.

Signal Control

Hourly fixed time signal controls (cycle times, phase times and phase arrangements) has been adopted for signalised intersection (Keilor Road/Matthews Avenue) within the modelled network. This is based on the SCATS Intersection Diagnostic Monitor (IDM) data provided by VicRoads. The purpose of this signals to ensure appropriate progression of vehicles to the Keilor Road/Grange Road intersection.

The Pedestrian Operating Signal (POS) at Ryder Street/Keilor Road was coded using VAP (Vehicle Actuated Program) in Vissim to mimic the current operational conditions at the site. It was important that the frequency of pedestrian activation was replicated in the base model.

Public Transport

Bus timetables and frequency has been coded per the latest available timetables, accessed from Public Transport Victoria (PTV) website on 22/82017. Refer to Figure 18 which show the location of the bus stops coded onto the network. Whilst

Figure 19 which shows the existing public transport routes and Table 2 provides an example of the schedule interpretation into the base model.

Figure 18: Vissim model showing the location of bus stops (yellow markers)

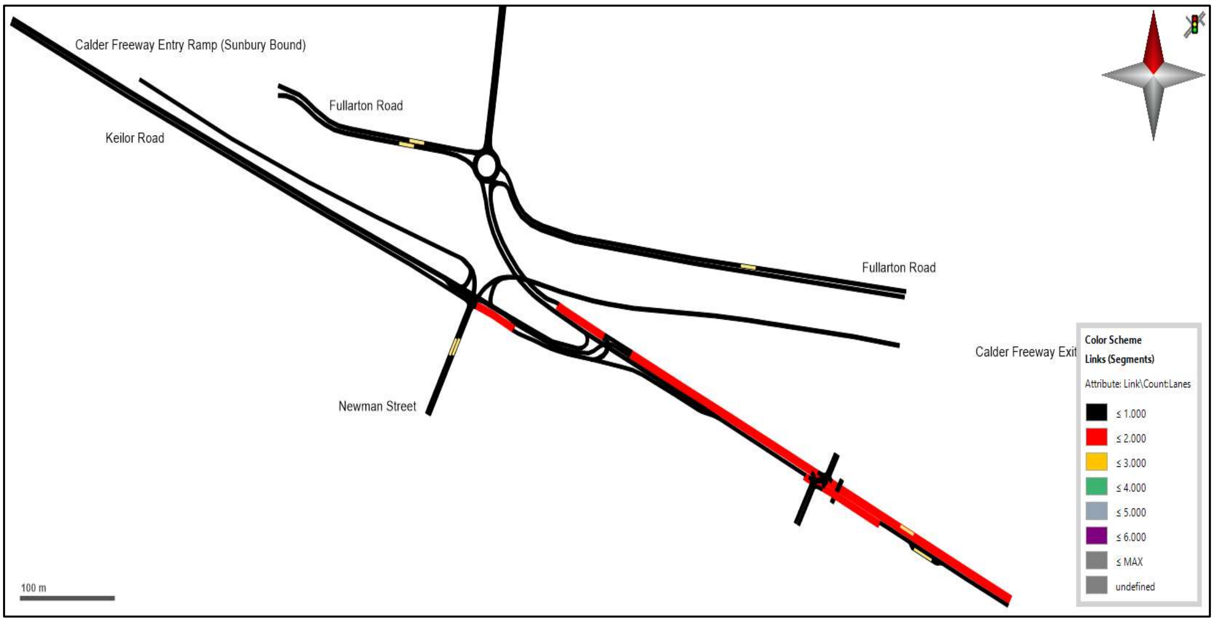


Figure 19: Existing Public Transport Route as coded in Vissim model

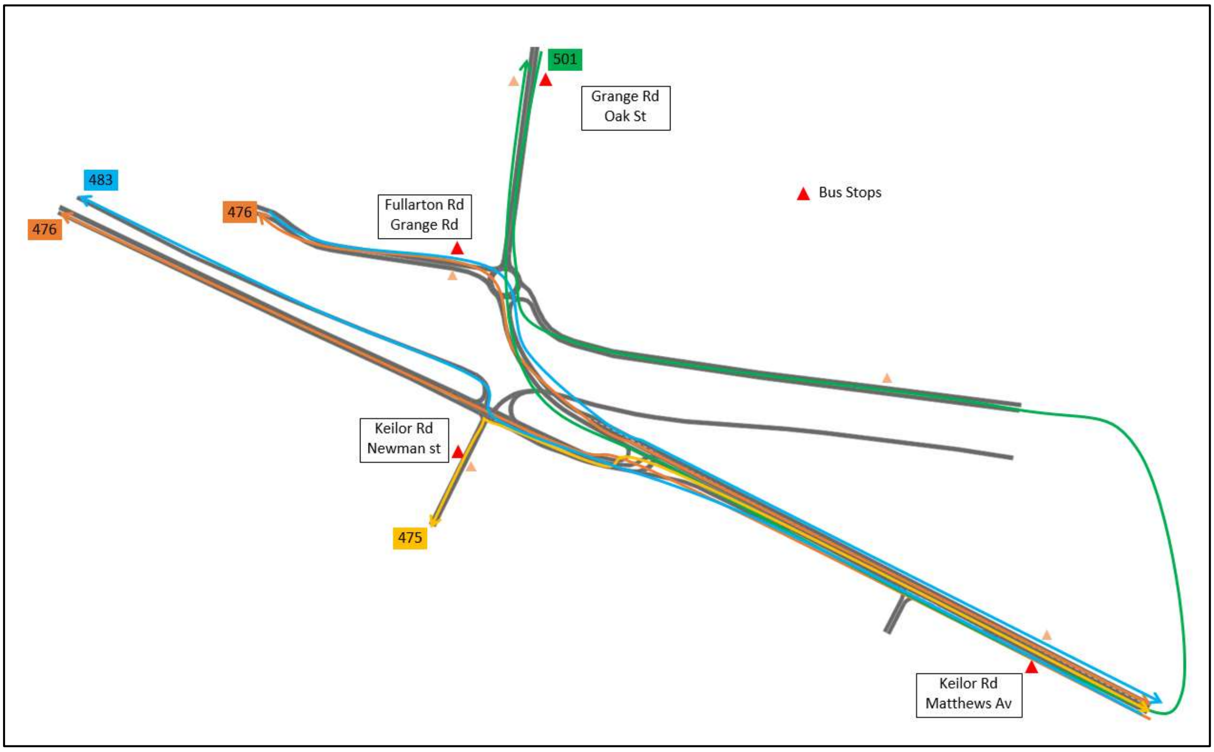


Table 2: Timetable inputs into Vissim model for Route 475 - Moonee Ponds - East Keilor via Niddrie

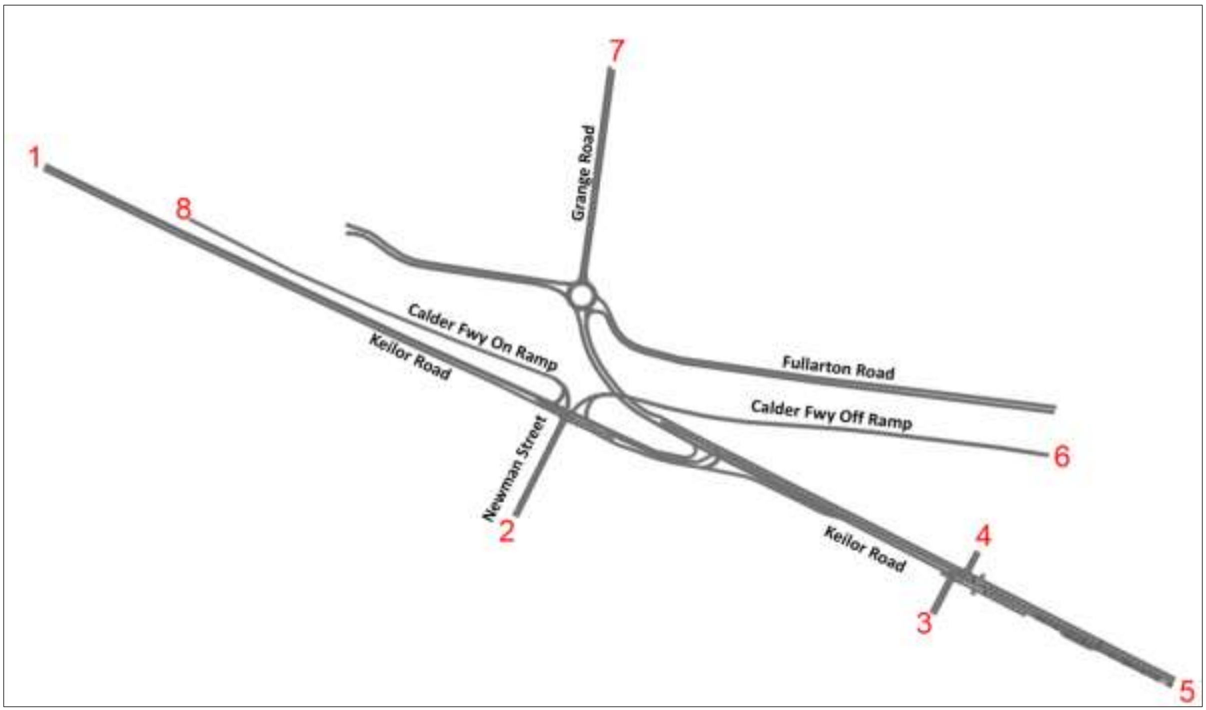
Keilor Road/Newman St (Source; PTV timetable)		Vissim Model (Simulation time equivalent)	
Eastbound Direction		Eastbound Direction	
AM	**PM**	**AM**	**PM**
6:37	3:37	420	420
6:57	3:57	1620	1620
7:17	4:17	2820	2820
7:37	4:37	4020	4020
7:57	4:57	5220	5220
8:17	5:22	6420	6720
8:42	5:37	7920	7620
8:57	6:02	8820	9120
9:17	6:22	10020	10320

Zoning System

The model zoning system comprises a total of eight origin and destination zones within the study area. For the purposes of micro-simulation modelling, it is pertinent that wherever possible, connections are made from the zone to the road section entrance or exit as this provides a more realistic behavioural representation of vehicle trips entering and exiting road networks, therefore each entry and exit point in the model is assigned to a Zone.

Figure 20 presents the zoning system used for the model within the study area.

Figure 20: Zoning System as coded in Vissim model



Demand Development

Following the development of the physical network, a demand matrix was formulated which formed the basis for the traffic volume undertaking origin to destination trips through the model.

Traffic demand is prepared using traffic survey counts. The demand matrices are then adjusted, as part of the model calibration process, to better correlate with the observed data prepared based on the intersection turning movement count data.

The traffic data used in the model was calibrated with the available traffic data and a demand matrix was prepared for both AM and PM for peak hours with 15-minute warm up and cool down period.

The proportion of traffic demand for each 15-minute interval was derived from the traffic profile and is based on the traffic survey data.

Static demand inputs were provided in the model for pedestrian volume in 15-minute intervals.

Fixed Bus departure schedule was prepared using the Public Transport Victoria (PTV) information and was coded in the network to match the scheduled entry into the model during peak hours.

The resulting demand profiles for the AM and PM peak periods are presented in Figure 21 and Figure 22 below.

Figure 21: Traffic Demand 15-minute Interval Profile (Light Vehicles) – AM Peak (7:00am-9:00am) for Zone 1

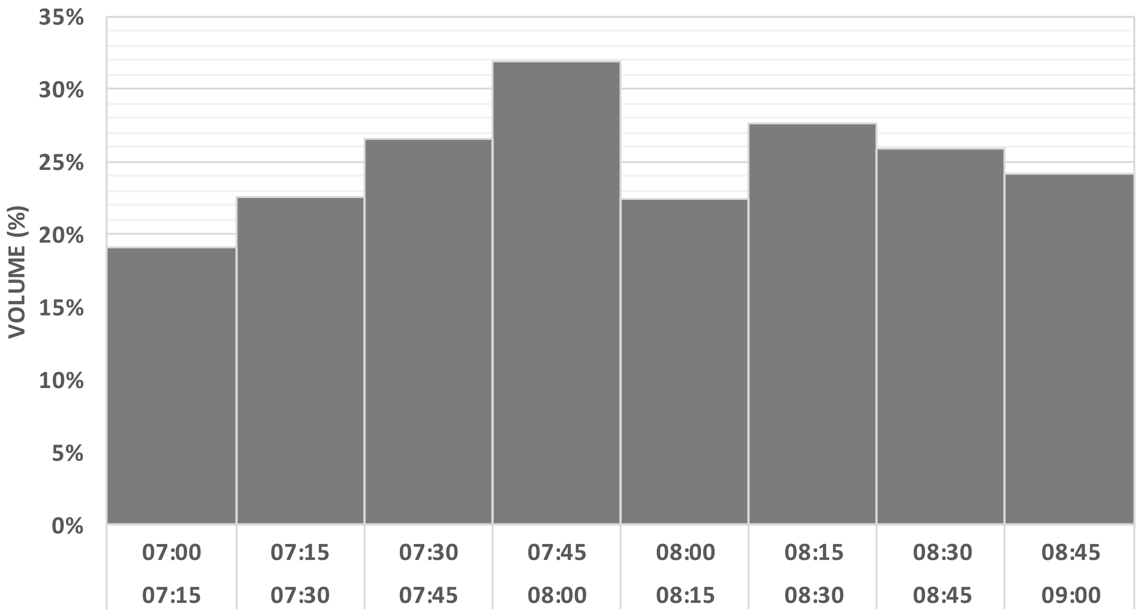
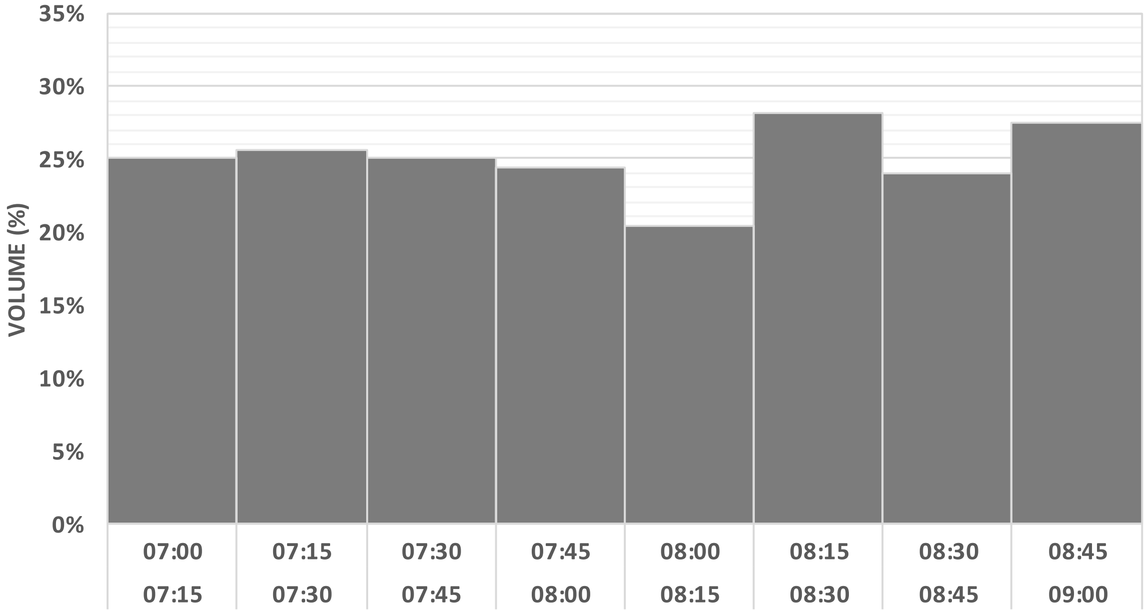


Figure 22: Traffic Demand 15-minute Interval Profile (Heavy Vehicles) – AM Peak (7:00am-9:00am) for Zone 1



Example demonstration not provided for other demand time profiles as the process is the same as for Figure and Figure for each zone and time period.

4. Calibration and Validation Process and Guidelines

Calibration and Validation Process

As simulation models are stochastic, they can produce different outcomes depending on their starting conditions. Due to this stochastic behaviour, it is necessary to assess how the model behaves under a variety of starting conditions (referred as seeds) using the same input parameters. The ability of a model to produce consistent results for a number of seed values is referred as the model stability, which has been assessed in Section 5.3.

The conventional method, as specified in the VicRoads Simulation Modelling Guidelines, in the calibration and validation of base models, is to process the models for five seed values and determine the median seed based on the vehicle hours travelled (VHT) network statistic. Further analysis with the use of vehicle kilometres travelled (VKT) statistic is required to show the robustness of the base models. The chosen median seed is then used to present the calibration and validation results.

The five seed values processed for both AM and PM peak period models are as follows:

- Seed Number 1: 42
- Seed Number 2: 292
- Seed Number 3: 542
- Seed Number 4: 792
- Seed Number 5: 1042

5.2 Calibration and Validation Guidelines

The aim of the microsimulation modelling is to obtain the best possible match between the model results and the field measurements. Calibration and validation targets were developed based on the performance requirements.

The calibration and validation process was carried out in accordance with the criteria set out in the VicRoads Simulation Modelling Guidelines. These guidelines represent the latest comprehensive set of guidelines released in Victoria.

Specifically, the targets set out in the guidelines are shown in Table 3 below.

Table 3: Simulation Modelling Calibration and Validation Criteria (Micro-simulation)

Item	Criteria
Network Wide Turn Volumes (Core criteria applies)	GEH tolerance limits for individual link and turn volumes: • 90% of individual link or turn volumes to have a GEH ≤ 5 • All individual link and turn volumes should have GEH ≤ 10 Volume category limits and for individual link and turn volumes: • 100% of individual link and turn volumes within 50 veh/h for Category 1 (<700 veh/h) • 100% of individual link and turn volumes within 15% for Category 2 (700 veh/h to 2,700 veh/h) • 100% of individual link and turn volumes within 400 veh/h for Category 3 (>2,700 veh/h) Plots of observed versus modelled hourly flows: • Slope value to be included with plots and be between 0.9 and 1.1 • R^2 value to be included with plots and be > 0.95
Visual Checks	Key locations to review in terms of queuing, pedestrian movements and vehicle-pedestrian interaction.
Median Travel Time	• Median modelled travel time to be within 10% median observed travel time for full length of route and for each section of the route.
Time Profile	• Modelled arrival time profile at critical approach(s) to be within 15% of observed arrival time profile.

The turn volumes and visual checks were utilised to calibrate the model, whilst the travel times and time profiles were used to validate the model.

5. Calibration and Validation Results

Model Calibration

Total Demand

The total volume of demand for AM and PM evaluation period are provided in Table 4 below.

Table 4: Total volume of demand for AM and PM evaluation periods

	Total Volume of Demand	
	AM	**PM**
All Vehicles	4503	6010
Heavy Vehicles (HV) (%)	5%	6%
Other (%)	0%	0%

AM Peak evaluation period: 07:00 to 09:00
PM Peak evaluation period: 16:00 to 18:00

Refer to Appendix A for demand matrices used in the model.

Travel Zones

Trips that are generated for each origin-destination pair is presented in Table 5 below. The focus is the trips in and out from each zone previous shown in Figure 23.

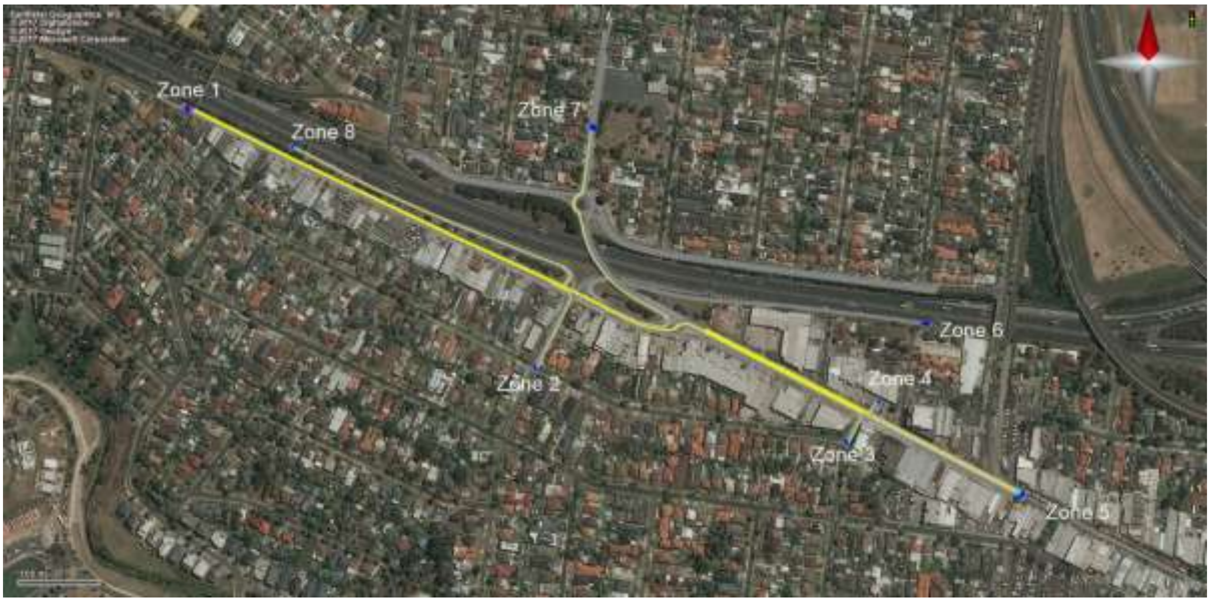
Table 5: Summary of total trips for AM evaluation period (7:00am to 9:00am)

Zone No	Trips In Totals		Trips Out Totals		Description
	Observed	Modelled	Observed	Modelled	
1	690	702	521	529	Keilor Road – West
2	122	120	143	144	Newman Street
6	360	354	0	0	Calder Freeway Exit Ramps at Keilor Road

Note: AM Peak evaluation period: 07:00 to 09:00
Note: Not all zones are provided for this demonstration

In addition to Table 6 show volume distribution between LV and HV.

Figure 23: Vissim model showing the available paths from Zone 1



For demonstration purposes only, Zone 1 paths are provided.

Table 6: Trips from Zone 1 during the AM evaluation period (7:00am to 9:00am) for each vehicle type (Example)

AM (Evaluation period: 7:00am to 9:00am)						
Zone Pair	All Vehicle Types (Volume)	Light Vehicles Only (Volume)	Heavy Vehicles Only (Volume)	All Vehicle Types (%)	Light Vehicles Only (%)	Heavy Vehicles Only (%)
1 to 1	0	0	0	0%	0%	0%
1 to 2	65	65	0	9%	9%	0%
1 to 3	48	47	1	7%	7%	2%
1 to 4	4	4	0	1%	1%	0%
1 to 5	145	139	6	21%	20%	6%
1 to 6	0	0	0	0%	0%	0%
1 to 7	292	292	0	42%	42%	0%
1 to 8	148	145	3	21%	21%	1%

For demonstration purposed only Zone 1 distribution is provided.

Turn Flows

Figure 24, shows the schematic distribution of flows for the AM Peak 7-8AM. Similar schematic is not provided for other hours or a summary schematic for this example as the process is the same.

Figure 24: Schematic showing turn flow comparison with GEH – AM Peak (8am to 9am)

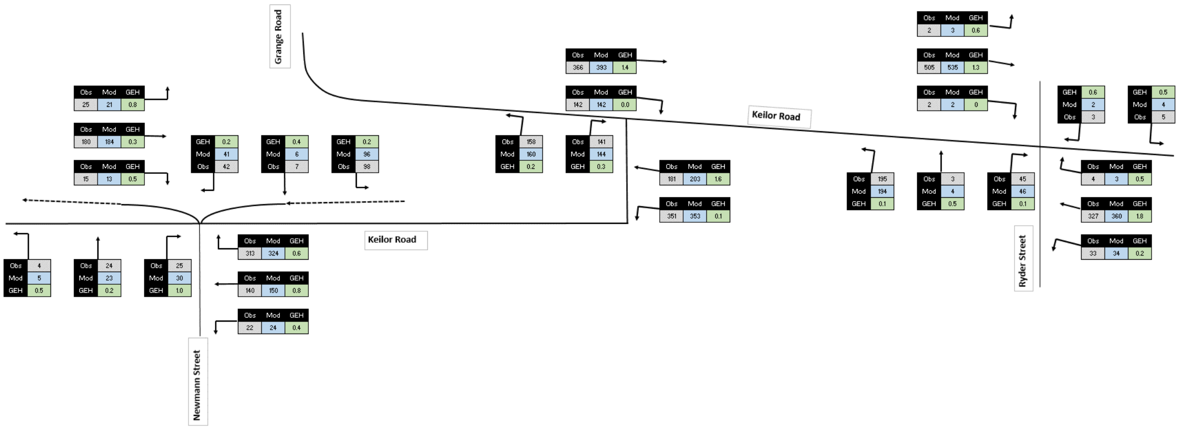


Table 7 summarises the comparison of the modelled turn flows against the surveyed (observed) turning movement counts, and how well they meet the network wide criteria specified in Section 5.3.

Table 7: Turn Flow Calibration Results

Peak	Time	Measure and Criteria				
		85% of individual Link or Turn Counts	All Individual Link or Turn Counts	R^2	Slope	Volume Category 1*
		GEH ≤ 5	GEH ≤ 10	> 0.90	0.9 – 1.1	< 50 veh/h
AM	7:00am to 8:00am	100%	100%	1.00	1.05	100%
	8:00am to 9:00am	100%	100%	1.00	1.02	100%
PM	4:00pm to 5:00pm	100%	100%	1.00	1.00	100%
	5:00pm to 6:00pm	100%	100%	1.00	0.99	100%

*Volume category 2 and 3 not included as no observed and modelled volume were above 700 veh/h

Table 7 indicates that the turn flow calibration criteria are met for all peak periods with more than 90% of turns having a GEH ≤ 5 for all peak hours, and all turns having a GEH ≤ 10. Also, all turns also met the volume category 1 criteria. As such, it is considered that there is a high level of correlation between the modelled and observed turn flows. Refer to Appendix B for full calibration table.

In addition to the above, a modelled versus observed traffic volume comparison has been undertaken in the form of a R^2 and scatter plot analysis for each of the peak hours. It is typically recommended that an R^2 value greater than 0.95 be achieved before a model is considered to be appropriately calibrated.

Figure 24 to Figure present the modelled versus observed traffic volume plots for AM and PM peaks, which indicate that the modelled traffic volumes have been calibrated against observed volumes to a suitable standard with all R^2 values above 0.95 and slope between 0.9 and 1.1 for both peak hours.

Figure 25: Turn Flow Comparison – AM Peak (7am to 8am)

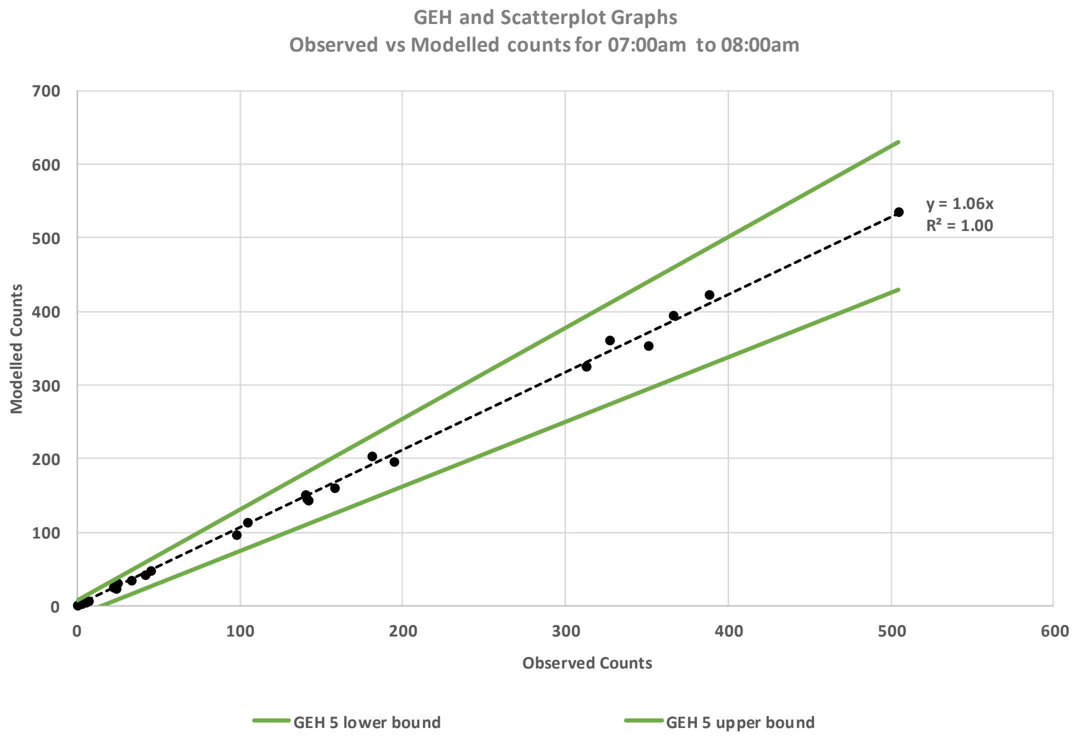


Figure 26: Turn Flow Comparison – AM Peak (8am to 9am)

Example demonstration not provided as the process is the same as in Figure 25*.*

Figure 27: Turn Flow Comparison – PM Peak (4pm to 5pm)

Example demonstration not provided as the process is the same as in Figure 25*.*

Figure 28: Turn Flow Comparison – PM Peak (5pm to 6pm)

Example demonstration not provided as the process is the same as in Figure 25*.*

Given the above, the results of the turn flow calibration are considered satisfactory for all peak periods and meet the network wide calibration criteria.

Model Stability

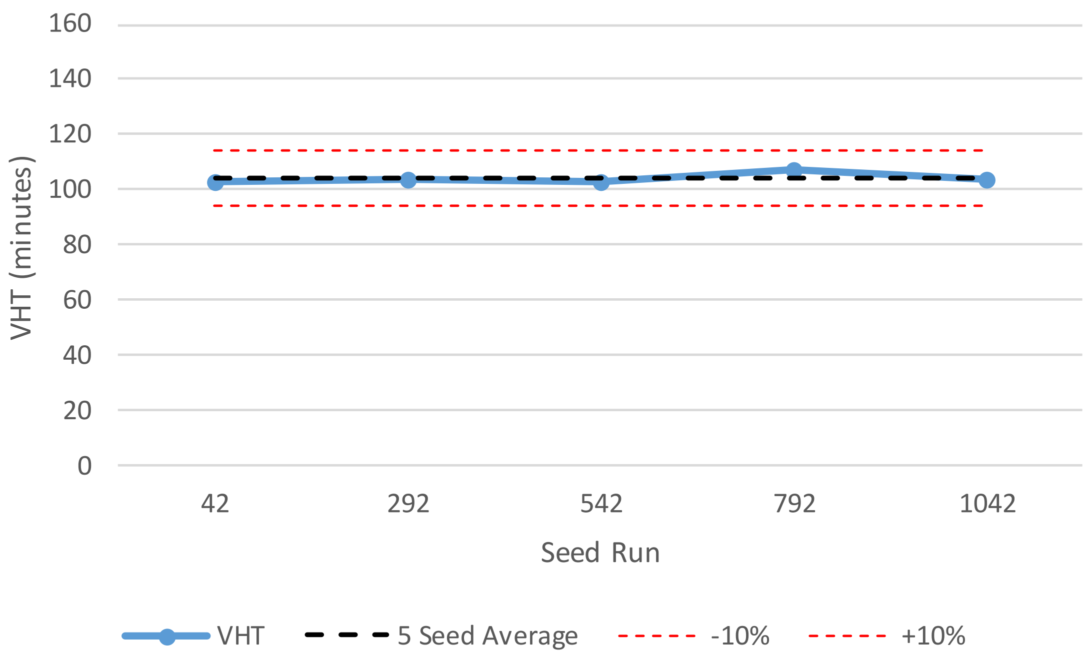
In order to demonstrate the stability of the model over five seed runs, an assessment of the five seeds has been undertaken which are based on the Vehicle Hours Travelled (VHT) and Vehicles Kilometres Travelled (VKT) network statistic.

The following sections provide stability results for both AM and PM peak periods and include:

- Plot results for the VHT and VKT for each peak period, with the respected descriptive statistical results.
- Plot showing the comparison between VHT and VKT for each seed run to show similarity between model runs.
- Coefficient of variation for VHT and VKT

AM Peak – VHT Analysis

Figure 29: AM Peak (7:00am to 9:00am) – Plot for VHT



Each seed run is within 10% of the mean value which shows satisfactory stability between model runs.

Table 8: AM Peak (7:00am to 9:00am) – Descriptive Statistical Results for VHT

Statistic	Results
Number of Runs	5
Mean	104.3
Standard Deviation	1.8
Range	4
Minimum	103.1
Maximum	107.5
95% Confidence Limit	1.6

Statistic	Results
Upper Confidence Limit	105.9
Lower Confidence Limit	102.7
Median	103.8

The results of the model stability analysis for AM peak illustrate some variation in the VHT results without large shifts in value which is in line with a typical variation in day-to-day traffic volumes (10%).

AM Peak – VKT Analysis

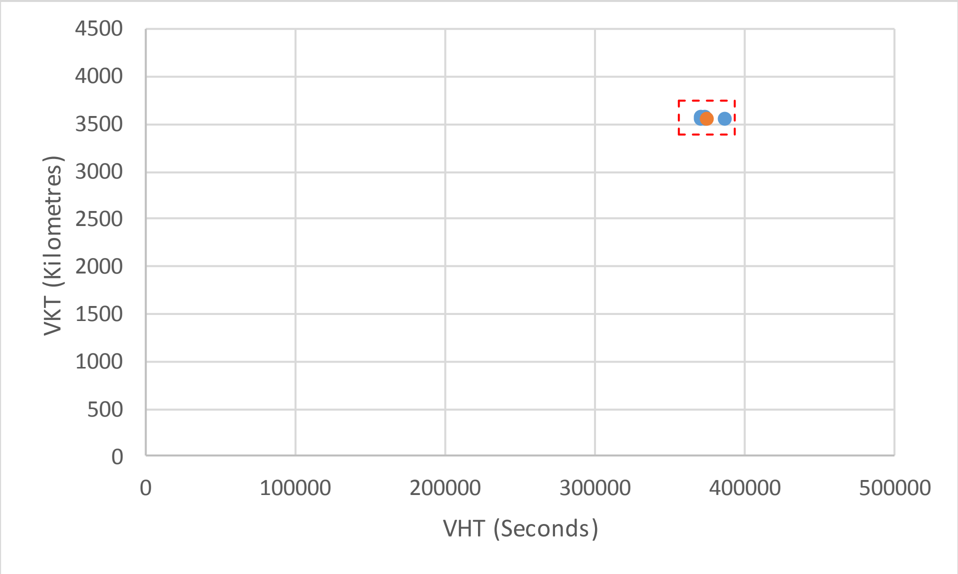
Example demonstration not provided as the process is the same.

PM Peak – VHT & VKT Analysis

Example demonstration not provided as the process is the same as for the AM peak period.

AM Peak – VHT vs VKT Analysis

Figure 30: AM Peak – VHT vs VKT plot showing model consistency



The analysis of the VHT vs VKT shows satisfactory stability between model runs and some evidence in one seed run suggesting journey travel time is higher for similar kilometres travelled which is expected for a congested model.

PM Peak – VHT vs VKT Analysis

Example demonstration not provided as the process is the same as for the AM peak period.

Coefficient of Variation Analysis

The level of correlation between VHT and VKT was assessed using COV formula as outlined below.

$$COV = \frac{SD}{\mu} \times 100$$

where SD = standard deviation

μ = mean.

The COV for the AM Peak was calculated to be 1.7% which is within the target of 3% for intersection and corridor studies.

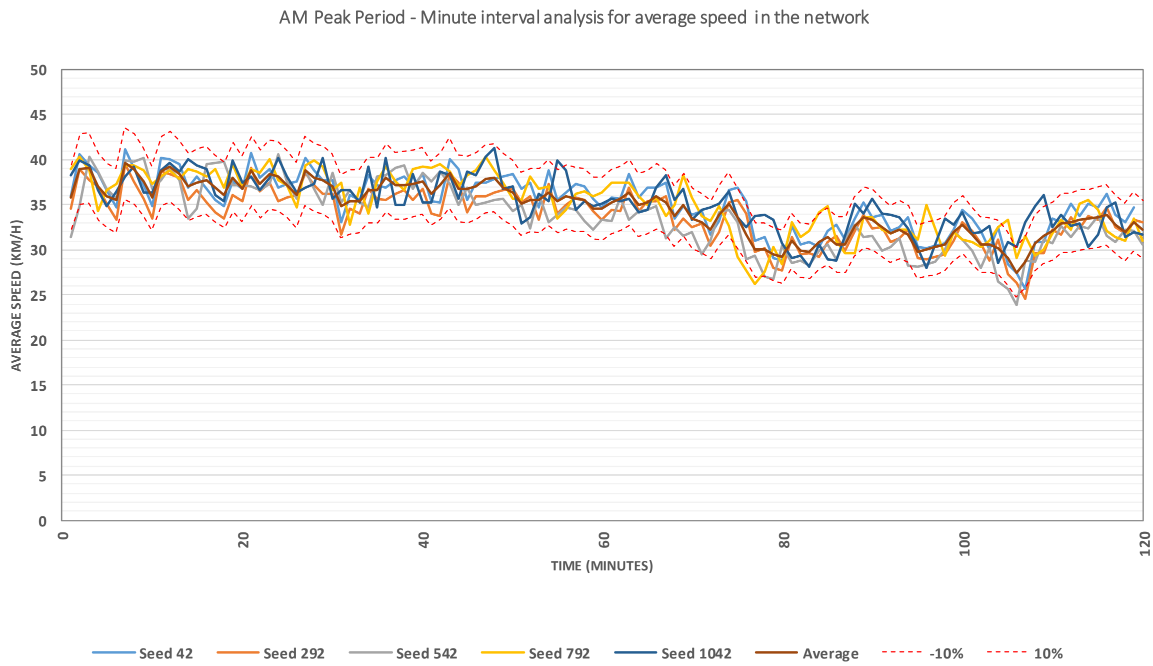
For PM peak, example demonstration not provided as the process is the same as for the AM peak period.

Adopted Seed Number

Based on the stability analysis undertaken, the adopted seed runs for the AM and PM peak period models where median seed no 292 and 792 respectively. These seed runs are appropriate to be used in the calibration and validation of the base models as the analysis indicated good correlation between the five seed runs. As a result, further model stability is considered not necessary, however model consistency plots are useful to show further stability analysis on a minute interval basis. Refer to Figure 31 below of a model consistency runs for the AM peak period base model for 'average speed'.

A consistency plot for 'number of vehicles in the network' is not demonstrated in this example.

Figure 31: AM Peak (7:00am to 9:00am) – Minute interval plot of 'average speed' in the network



It is noted that the adopted median seed value, and PM peaks will also be used as the seed number for upgrade options investigation to ensure consistency when undertaking comparisons.

Warm Up / Cool Down Periods

Warm up and cool down periods have been included in the model. The following figures show the network snapshot at the start of the evaluation (end of warm-up period) for both AM and PM evaluation periods. Due to the times surveyed the warm-up and cool down-periods adopted were a replica of the immediate adjacent 15min time slice for the evaluation period. This is acknowledged as not ideal, as such the SCATS data at Keilor Road/Matthew Avenue intersection was investigated to ensure that no peak spikes were present in the area during the warm-up and cool-down period.

Figure 32: Traffic conditions at the start of the AM evaluation period

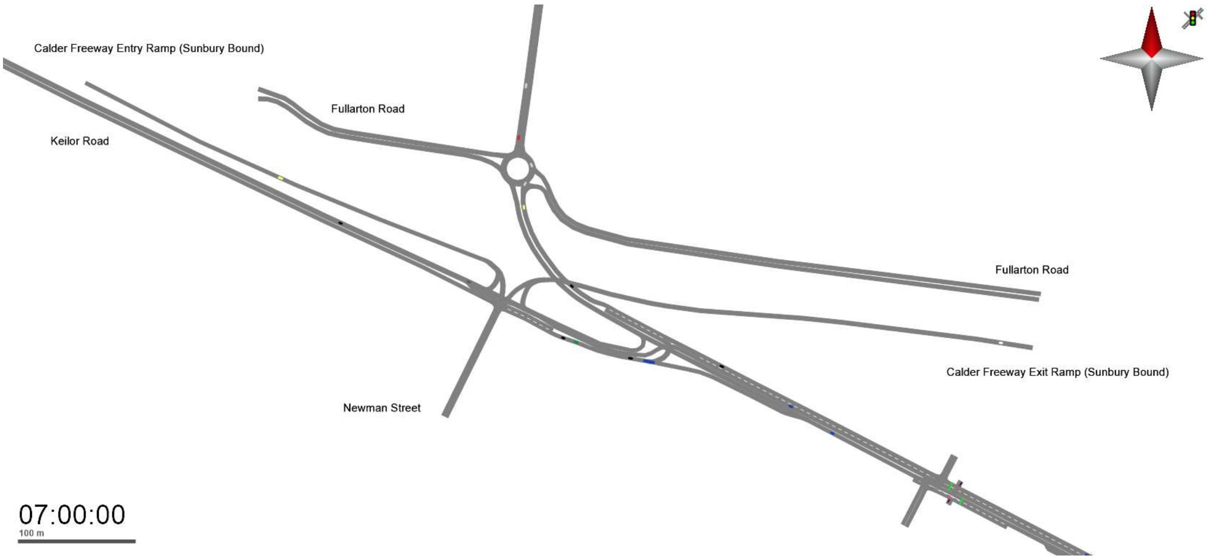
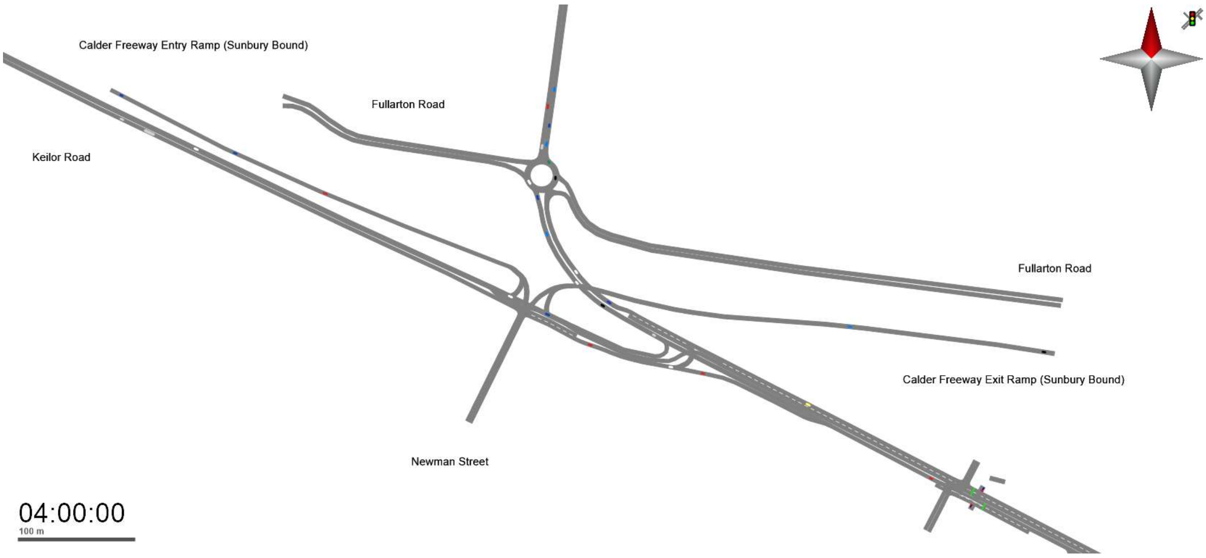


Figure 33: Traffic conditions at the start of the PM evaluation period



Model Validation Results

Travel Times

Travel times surveys were undertaken along two bi-directional routes within the study area as discussed in Section 2 of this report. The routes are described below:

- Route 1: Keilor Road/Grange Road between Keilor Road/Matthews Avenue Intersection and Grange Road/Fullarton Road Roundabout
- Route 2: Keilor Road between Keilor Road/Matthews Avenue Intersection and Keilor Road/Newman Street/Keilor Road On/Off-Ramps Intersection

The sections for each route have been identified as follows:

Route 1 Eastbound

- Fullarton Road to Keilor Road Intersection
- Keilor Road Intersection to Pedestrian Crossing E of Ryder Street
- Pedestrian Crossing East of Ryder Street to Matthews Avenue

Route 1 Westbound

- Matthews Avenue to Pedestrian Crossing E of Ryder Street
- Pedestrian Crossing E of Ryder Street to Keilor Road Intersection
- Keilor Road Intersection to Fullarton Road

Route 2 Eastbound

- The Avenue to Newman St
- Newman St to Pedestrian Crossing E of Ryder Street
- Pedestrian Crossing East of Ryder Street to Matthews Avenue

Route 2 Westbound

- Matthews Avenue to Pedestrian Crossing E of Ryder Street
- Pedestrian Crossing East of Ryder Street to Newman Street
- Newman Street to The Avenue

These routes have been used to undertake a comparison between the modelled and observed travel times to demonstrate that the base models closely represent the existing conditions in terms of travel times for vehicles within the study area.

The results of the travel time validation for cars along the routes is illustrated in Table 9, based on comparing the median modelled travel time for the full route against the observed median travel time for the full route. The 15^{th} and 85^{th} percentiles with the 10% tolerance limits from the median travel time have been provided for each route and time period.

Table 9: Travel Time Validation Summary

Peak	Route	Direction	Median Modelled Travel Time (s)	Median Observed Travel Time (s)	Percentage Difference (%)	Difference Absolute (s)	Within 10% of observed median (Yes/No)
AM	Route 1	Eastbound	50	52	3.8%	2	Yes
	Route 1	Westbound	48	49	2.0%	1	Yes
	Route 2	Eastbound	132	138	4.3%	6	Yes
	Route 2	Westbound	77	82	6.1%	5	Yes
PM	Route 1	Eastbound	72	69	4.3%	3	Yes
	Route 1	Westbound	57	55	3.6%	2	Yes
	Route 2	Eastbound	165	167	1.2%	2	Yes
	Route 2	Westbound	94	91	3.3%	3	Yes

Peak	Route	Direction	Median Modelled Travel Time (s)	Median Observed Travel Time (s)	Percentage Difference (%)	Difference Absolute (s)	Within 10% of observed median (Yes/No)

- **Route 1 – Eastbound – Fullarton Road to Matthews Avenue (Total length: 581m)**
- **Route 1 – Westbound – Matthews Avenue to Fullarton Road (Total length: 598m)**
- **Route 2 – Eastbound – Matthews Avenue to The Avenue (Total length: 950m)**
- **Route 2 – Westbound – The Avenue – Matthews Avenue (Total length: 950m)**

The results presented in Table 9, indicates that the travel times on all routes during the AM and PM peak period meets the requirements set out in the validation criteria. For each of the time periods in the AM peak, the modelled travel time routes for the entire route are all within ±60 seconds of the observed travel time which meets the requirements.

Figure 34 presents the travel time comparisons for both AM and PM peak hours, showing how the relationship compares against the 15th percentile, 85th percentile and 10% tolerance limits for each section.

Figure 34: Travel Time Comparison – Route 1 – Eastbound (AM Peak)

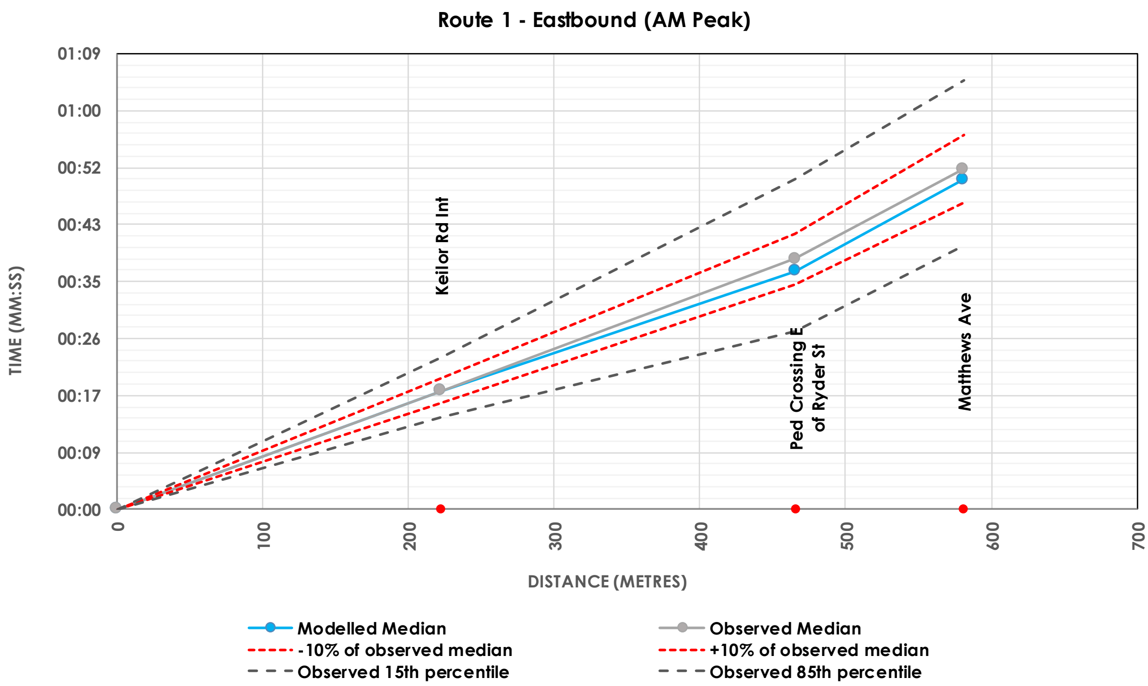


Table 10: Travel Time Comparison – Route 1 – Eastbound (AM Peak) Summary

Waypoint / Collection Marker	Accumulative Distance (m)	Modelled Median Travel Time (MM:SS)	Observed Median Travel Time (MM:SS)	15th Percentile Observed Travel Time (MM:SS)	85th Percentile Observed Travel Time (MM:SS)	10% of Observed Travel Time (Lower bound)	10% of Observed Travel Time (Upper bound)
Fullarton Road	0	00:00	00:00	00:00	00:00	00:00	00:00
Keilor Road Int	222.3	00:18	00:18	00:14	00:23	00:16	00:20
Pedestrian Crossing E of Ryder Street	465.4	00:36	00:38	00:27	00:50	00:34	00:42
Matthews Avenue	580.8	00:50	00:52	00:40	01:05	00:46	00:57

Figures 35 to 37 presents the cumulative travel times for the two travel time routes during the critical 7:00am to 9:00am peak hour, while Figures 38 to 41 presents the cumulative travel times for the two travel time routes during the critical 4:00pm to 6:00pm peak hour.

Figure 35: Travel Time Comparison – Route 1 – Westbound (AM Peak)

Example demonstration not provided as the process is the same

Figure 36: Travel Time Comparison – Route 2 – Eastbound (AM Peak)

Example demonstration not provided as the process is the same

Figure 37: Travel Time Comparison – Route 2 – Westbound (AM Peak)

Example demonstration not provided as the process is the same

Figure 38: Travel Time Comparison – Route 1 – Eastbound (PM Peak)

Example demonstration not provided as the process is the same

Figure 39: Travel Time Comparison – Route 1 – Westbound (PM Peak)

Example demonstration not provided as the process is the same

Figure 40: Travel Time Comparison – Route 2 – Eastbound (PM Peak)

Example demonstration not provided as the process is the same

Figure 41: Travel Time Comparison – Route 2 – Westbound (PM Peak)

Example demonstration not provided as the process is the same

Figure 35 to Figure 37 above indicate a high level of correlation between the modelled median travel times and the observed median travel times along Route 1 and Route 2 during AM peak hour of 7:00am to 9:00am and PM peak hour 4:00pm to 6:00pm. The graphs indicate that the delays experienced by cars within sections of the travel time routes have been captured appropriately in the model when compared to the observed conditions.

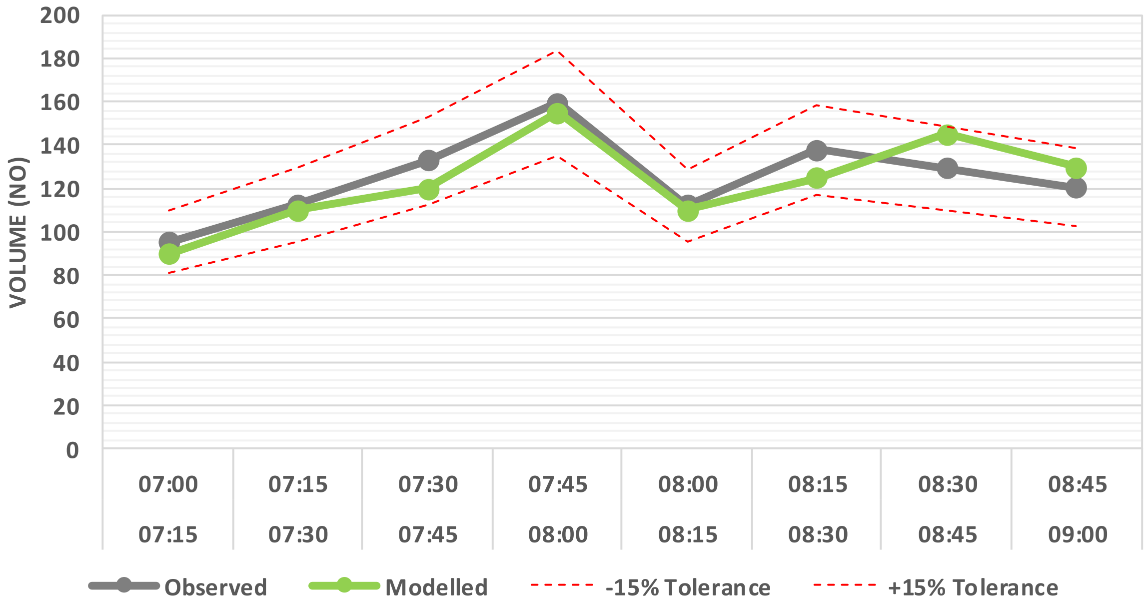
Time Profiles

In addition to the travel time validation, demand time profiles were validated against observed and modelled arrival patterns.

The critical location chosen was the Keilor Road / Newman Street East Approach as it is central to the core of the model and takes into consideration the important W-S right turn at Keilor Road/ Grange Road.

Figure 42 below shows the comparison of the arrival time profiles as observed and modelled and how they compare to the 15% tolerance level. As can be seen the time profile is within the tolerance of 15% however does experience some variability between 8-9am due to the relative high variability in gap acceptance for the W-S right turn at Keilor Road/ Grange Road.

Figure 42: Travel Time Comparison – Route 1 – Eastbound (AM Peak) Summary



Example demonstration not provided for the PM Peak as the process is the same as for Figure 42.

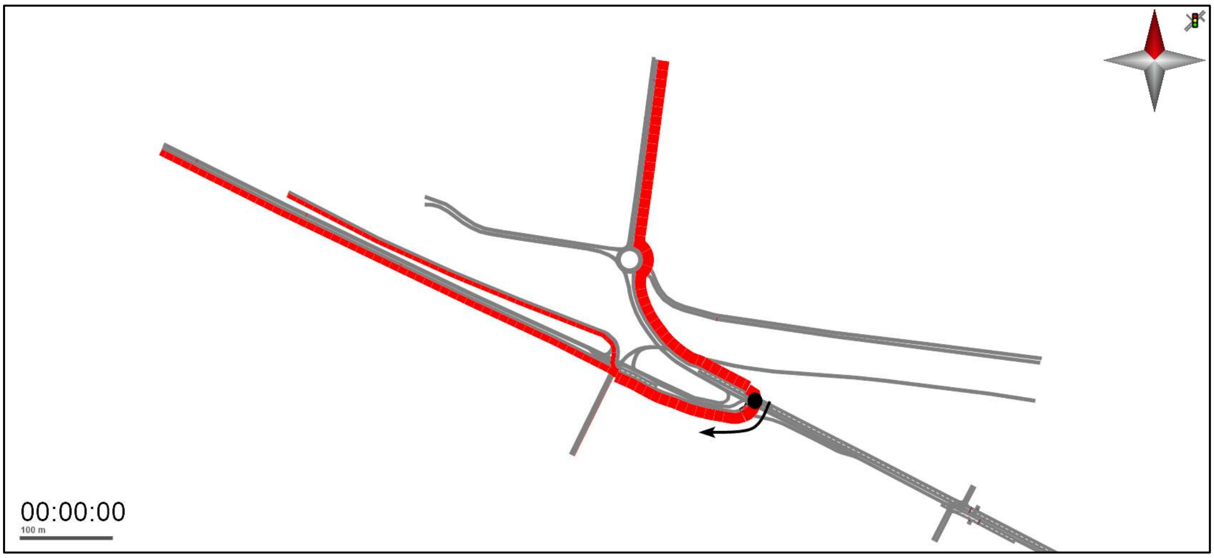
6. Performance Outputs

The following figures and tables provide the performance outputs from the base model. As this is a demonstration in some cases only initial time periods of the AM Peak are provided.

Flow Bundles

Flow bundle for the W-S right turn at Keilor Road/Grange Road is demonstrated for AM Peak period in Figure 43.

Figure 43: Flow bundles for the W-S right turn at Keilor Road/Grange Road (AM Peak period)



Intersection Performance

Intersection performance in terms of level of service (LoS) using HCM2016 criteria as outlined in VicRoads Simulation Modelling guidelines is provided in Table 11 below for the AM Peak 8-9am.

Table 11: Intersection performance using level of service (AM Peak 8-9am)

Intersection	Approach/Movement	Time Interval 8-9AM: Vehicle Delay (Seconds per vehicle)	Time Interval 8-9AM: LOS
Keilor Rd / Grange Rd	East/Through	0.72	A
	East/Left	1.31	A
	South/Left	3.8	A
	South Right	4.22	A
	West Through	8.94	A
	West/Right	14.48	B
Keilor Rd / Newman St	North/Left	1.87	A
	North/Through	20.3	C
	North/Right	12.73	B
	East/Left	0.89	A
	East/Through	0.19	A
	East/Right	12.31	B
	South/Left	12.15	B
	South/Through	21.4	C
	South/Right	12.31	B
	West/Left	2.5	A
	West/Through	0.38	A
	West/Right	0.79	A
Keilor Rd / Ryder St	North/Left	2.74	A
	North/Right	5.27	A
	East/Left	2.37	A
	East/Through	10.81	B
	East/Right	14.06	B
	South/Left	19.83	B
	South/Through	13.2	B
	South/Right	5.37	A
	West/Left	12.54	B
	West/Through	9.34	A
	West/Right	3.64	A

Network Wide Performance

Table 12: Network wide performance (AM Peak)

Average Delay	Average Stop Delay	Average Speed	Average Delay Stop	VKT	VHT	Total Delay
(s)	(no)	(km/h)	(s)	(km)	(s)	
22.56	0.74	34.4	8	3567	373587	101202
Total Stops	Total Delay Stop	Vehicle (Actual)[1]	Vehicle (Arrive)[2]	Latent Delay	Latent Demand	
(no)	(s)	(no)	(no)	(s)	(no)	
3339	35898	67	4419	0	0	

[1] *No of vehicles at the end of the evaluation period*

[2] *No of vehicles that completed their trip at the end of the evaluation period*

Example demonstration for PM peak not provided as it follows same process as Table 12 *.*

7. Calibration and Validation Conclusions

The results presented in the preceding sections show that the model demonstrates a satisfactory ‘goodness of fit’ with the observed traffic conditions indicating that the model performs well at the network wide level.

The traffic volume comparisons for each of the peaks indicate a high level of correlation between the modelled and observed traffic flows which is aligned with the criteria from VicRoads Simulation Modelling Guidelines.

The travel time analysis illustrates a reasonably high level of correlation between the modelled and observed travel times which is aligned with the criteria from VicRoads Simulation Modelling Guidelines.

The calibration and validation tasks results assure that model is well calibrated and validated and deemed fit to be used for its intended purpose, which is to assess the performance and operation of the road network with the proposed upgrade options.

8. Upgrade Options Investigation

Upgrade options investigation will involve the assessment of the five upgrade options provided by VicRoads from preliminary investigations. These options are as follows:

1. Traffic Signals at Keilor Road/Newman Street and Keilor Road/Grange Road;
2. Traffic Signals at Keilor Road/Newman Street and Standard Roundabout at Keilor Road/Grange Road;
3. Traffic Signals at Keilor Road/Newman Street and Cut-through Roundabout at Keilor Road/Grange Road;
4. Standard Roundabout at Keilor Road/Newman Street and Standard Roundabout at Keilor Road/Grange Road; and
5. Standard Roundabout at Keilor Road/Newman Street and Cut-through Roundabout at Keilor Road/Grange Road.

The options are intended to be revised with further input in the following areas:

- Seasonality adjustments with respect to the 30th busiest day as this modelling approach is focused on the current year design investigations
- Future growth consideration through sensitivity analysis on the preferred upgrade option
- Network configurations such as number of lanes at midblock and stop line locations, revised turning speeds, driver behaviour such as lane change decision points etc
- Signal configurations and operation, as well as optimisation of signal operation
- Redistribution of demand to any closed routes previously provided in the base model

The results of the modelling for upgrade options will only assess performance and operational impacts of each option. It is therefore recommended that before any endorsements of a preferred upgrade option is made that additional assessments related to the following are to be considered:

- Road safety
- Safe pedestrian accessibility to local amenities
- Impacts on local ground utilities
- Site suitability
- Construction cost
- Future road interventions in the area

In addition, select link analysis, network wide outputs (tables and graphs), intersection outputs and travel time outputs would be required when the base model is compared against the upgrade options.

Appendix A

The following table shows the demand matrix for AM Peak 7.30-7.45am.

For demonstration purposes only this matrix was provided but other matrices used in the model would be provided as well as a summary. Trip in and out matrices are not provided for this demonstration.

Table 13: Demand matrix for AM Peak 7.30-7.45am

Zone No	1	2	3	4	5	6	7	8	Total
1	0.0	2.9	3.7	0.5	18.6	0.0	25.2	11.2	**62**
2	1.1	0.0	0.0	0.0	2.9	0.0	3.7	6.4	**14**
3	9.6	1.3	0.0	0.0	11.9	0.0	18.3	22.0	**63**
4	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	**1**
5	17.0	2.9	8.8	0.0	0.0	0.0	30.3	36.1	**95**
6	11.2	1.9	1.3	0.0	10.4	0.0	13.5	0.0	**38**
7	10.6	1.6	23.6	0.8	72.0	0.0	0.0	25.2	**134**
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
Total	**50**	**11**	**37**	**1**	**116**	**0**	**91**	**101**	**407**

Appendix B

Table 14: Turn Flow comparison between observed and modelled outputs with GEH and Volume Category results

		Time Interval 7-8AM						
Intersection	Approach/Movement	Observed Counts	Modelled Counts	GEH	Volume Difference (Abs)	Volume Difference (%)	Volume Category	Criteria Check
Keilor Rd / Grange Rd	East/Through	181	203	1.6	22	12%	Category 1: <700 veh/hr	Category 1 Met
	East/Left	351	353	0.1	2	1%	Category 1: <700 veh/hr	Category 1 Met
	South/Left	158	160	0.2	2	1%	Category 1: <700 veh/hr	Category 1 Met
	South Right	141	144	0.3	3	2%	Category 1: <700 veh/hr	Category 1 Met
	West Through	366	393	1.4	27	7%	Category 1: <700 veh/hr	Category 1 Met
	West/Right	142	142	0.0	0	0%	Category 1: <700 veh/hr	Category 1 Met
Keilor Rd / Newman St	North/Left	98	96	0.2	2	2%	Category 1: <700 veh/hr	Category 1 Met
	North/Through	7	6	0.4	1	14%	Category 1: <700 veh/hr	Category 1 Met
	North/Right	42	41	0.2	1	2%	Category 1: <700 veh/hr	Category 1 Met
	East/Left	22	24	0.4	2	9%	Category 1: <700 veh/hr	Category 1 Met
	East/Through	140	150	0.8	10	7%	Category 1: <700 veh/hr	Category 1 Met
	East/Right	313	324	0.6	11	4%	Category 1: <700 veh/hr	Category 1 Met
	South/Left	4	5	0.5	1	25%	Category 1: <700 veh/hr	Category 1 Met
	South/Through	24	23	0.2	1	4%	Category 1: <700 veh/hr	Category 1 Met
	South/Right	25	30	1.0	5	20%	Category 1: <700 veh/hr	Category 1 Met
	West/Left	25	21	0.8	4	16%	Category 1: <700 veh/hr	Category 1 Met
	West/Through	180	184	0.3	4	2%	Category 1: <700 veh/hr	Category 1 Met
	West/Right	15	13	0.5	2	13%	Category 1: <700 veh/hr	Category 1 Met
Keilor Rd / Ryder St	North/Left	5	4	0.5	1	20%	Category 1: <700 veh/hr	Category 1 Met
	North/Right	3	2	0.6	1	33%	Category 1: <700 veh/hr	Category 1 Met
	East/Left	33	34	0.2	1	3%	Category 1: <700 veh/hr	Category 1 Met
	East/Through	327	360	1.8	33	10%	Category 1: <700 veh/hr	Category 1 Met
	East/Right	4	3	0.5	1	25%	Category 1: <700 veh/hr	Category 1 Met
	South/Left	195	194	0.1	1	1%	Category 1: <700 veh/hr	Category 1 Met
	South/Through	3	4	0.5	1	33%	Category 1: <700 veh/hr	Category 1 Met
	South/Right	45	46	0.1	1	2%	Category 1: <700 veh/hr	Category 1 Met
	West/Left	5	4	0.5	1	20%	Category 1: <700 veh/hr	Category 1 Met
	West/Through	388	421	1.6	33	9%	Category 1: <700 veh/hr	Category 1 Met
	West/Right	105	112	0.7	7	7%	Category 1: <700 veh/hr	Category 1 Met

Example shown for AM Peak 7-8am only.

AM Peak 8-9am and PM Peak 4-5pm and 5-6pm follow a similar process.

Appendix C

Figure 44: Base model network and comparison against aerial imagery

Figure 45: Vissim model showing number of lanes, reduced speed area locations and the desired speed locations with allocated speed profile for LV and HV (Keilor Road / Grange Road)

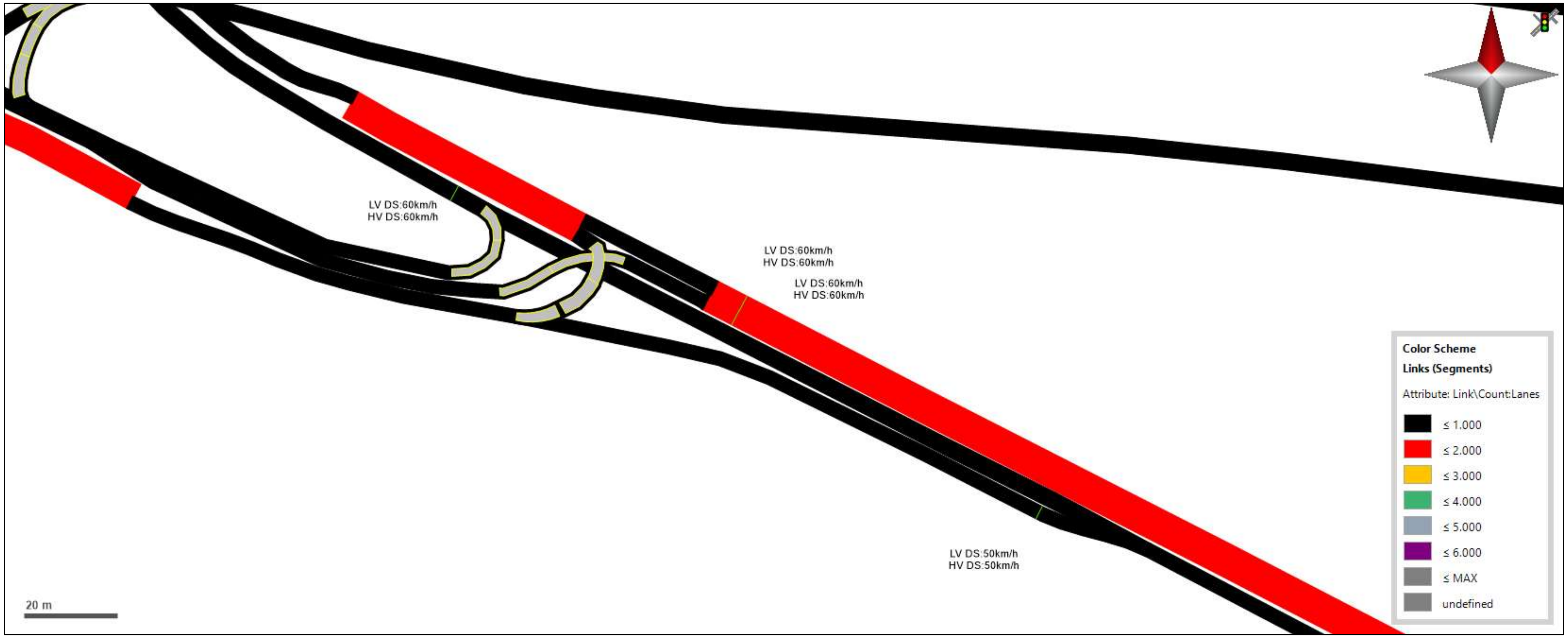


Figure 46: Vissim model showing number of lanes, reduced speed area locations and the desired speed locations with allocated speed profile for LV and HV (Keilor Road / Newton St)

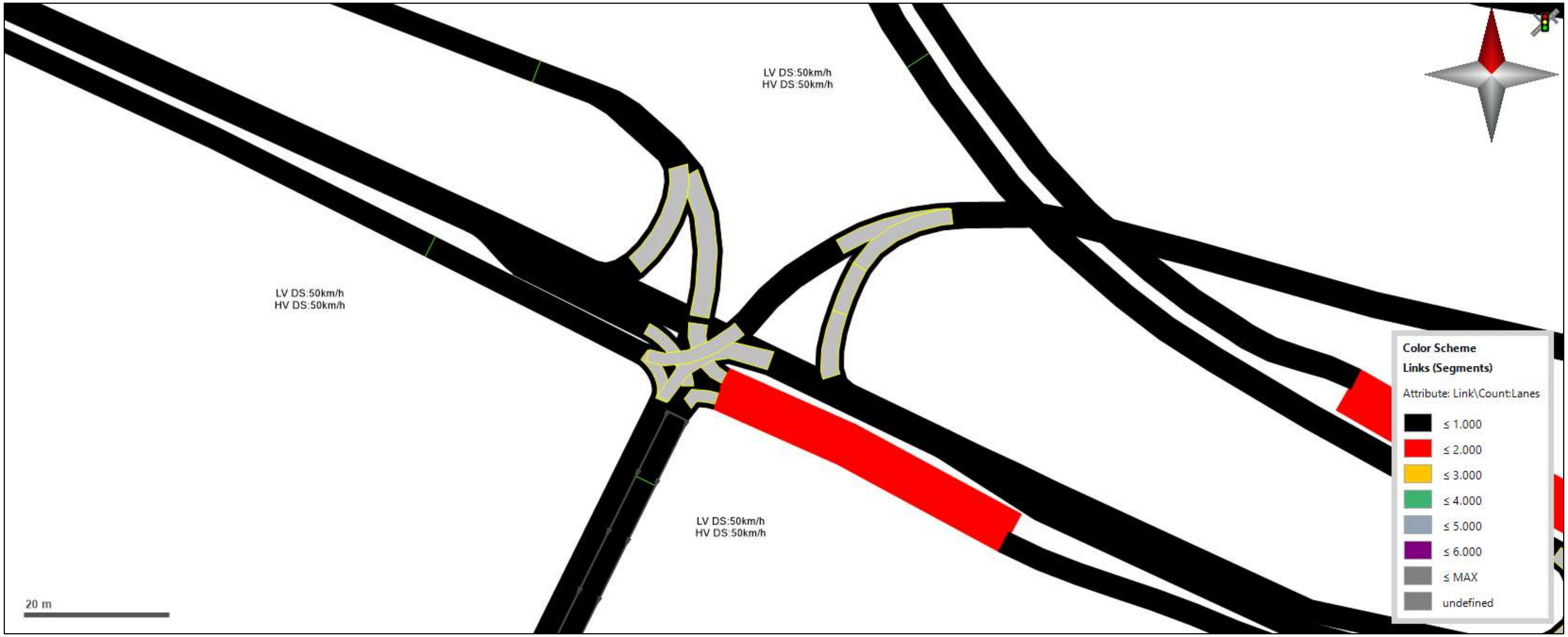


Figure 47: Vissim model showing maximum speeds for the network for AM Peak 7-8am

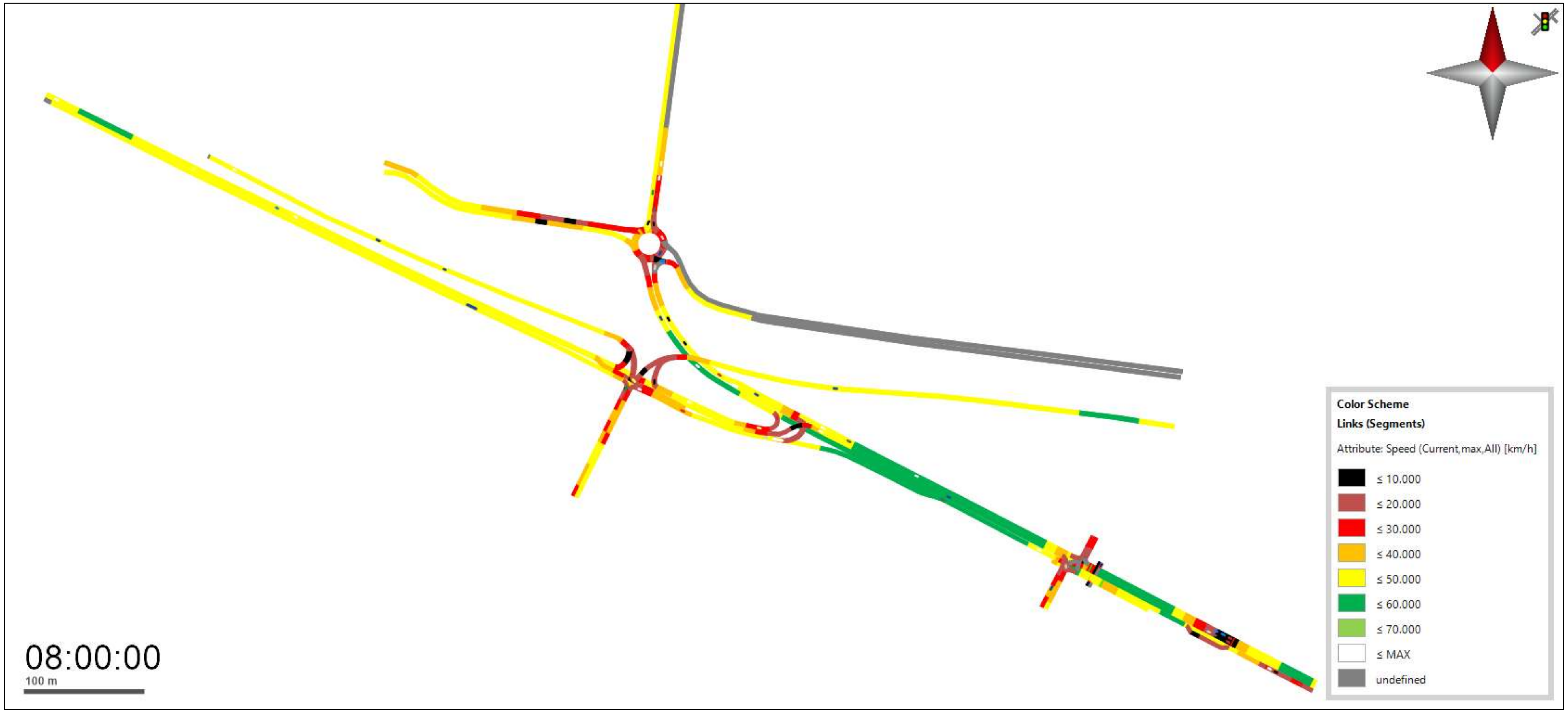


Figure 48: Vissim model showing location of priority rules with give way lines, conflict areas and evaluation markers for the intersection of Keilor Road/Grange Road intersection

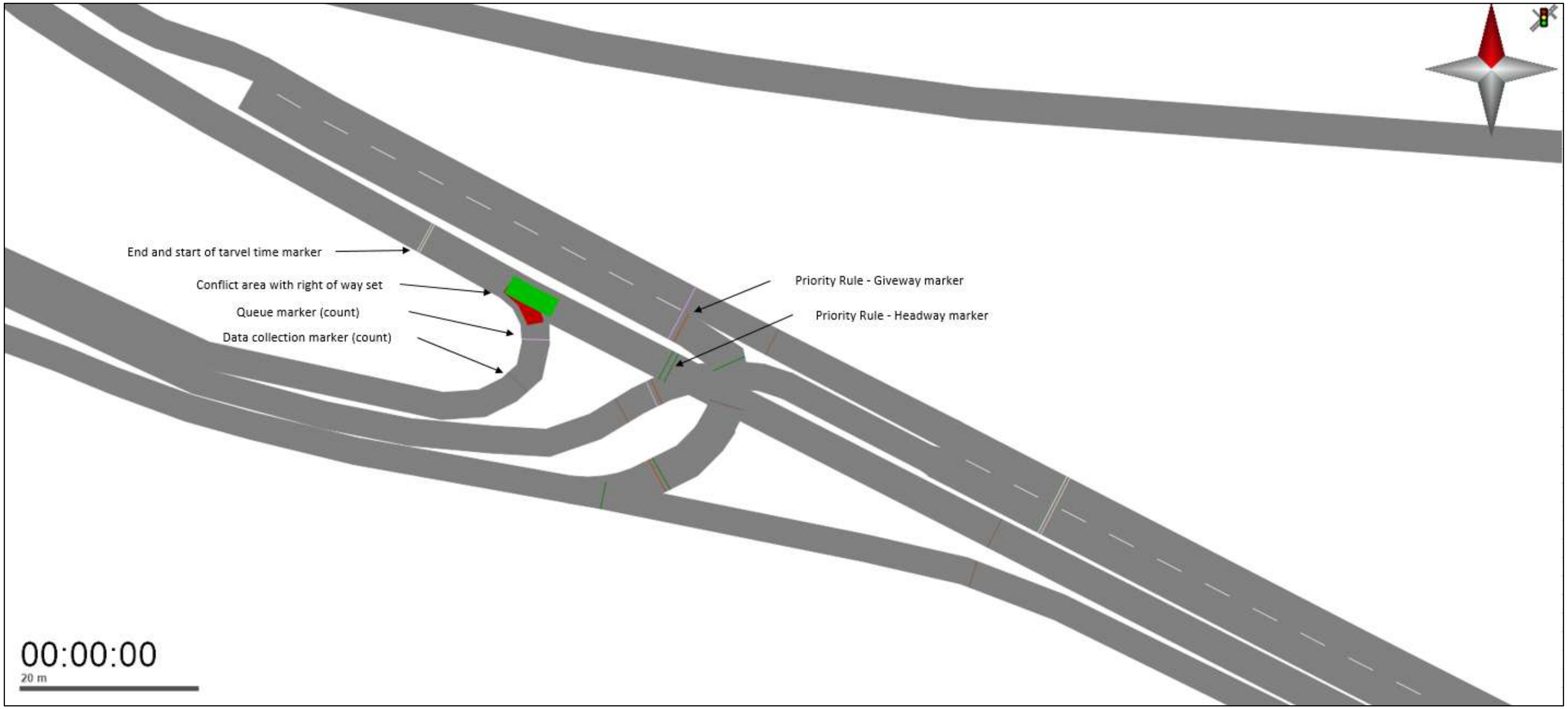


Figure 49: Vissim model showing the location of bus stops (yellow markers)

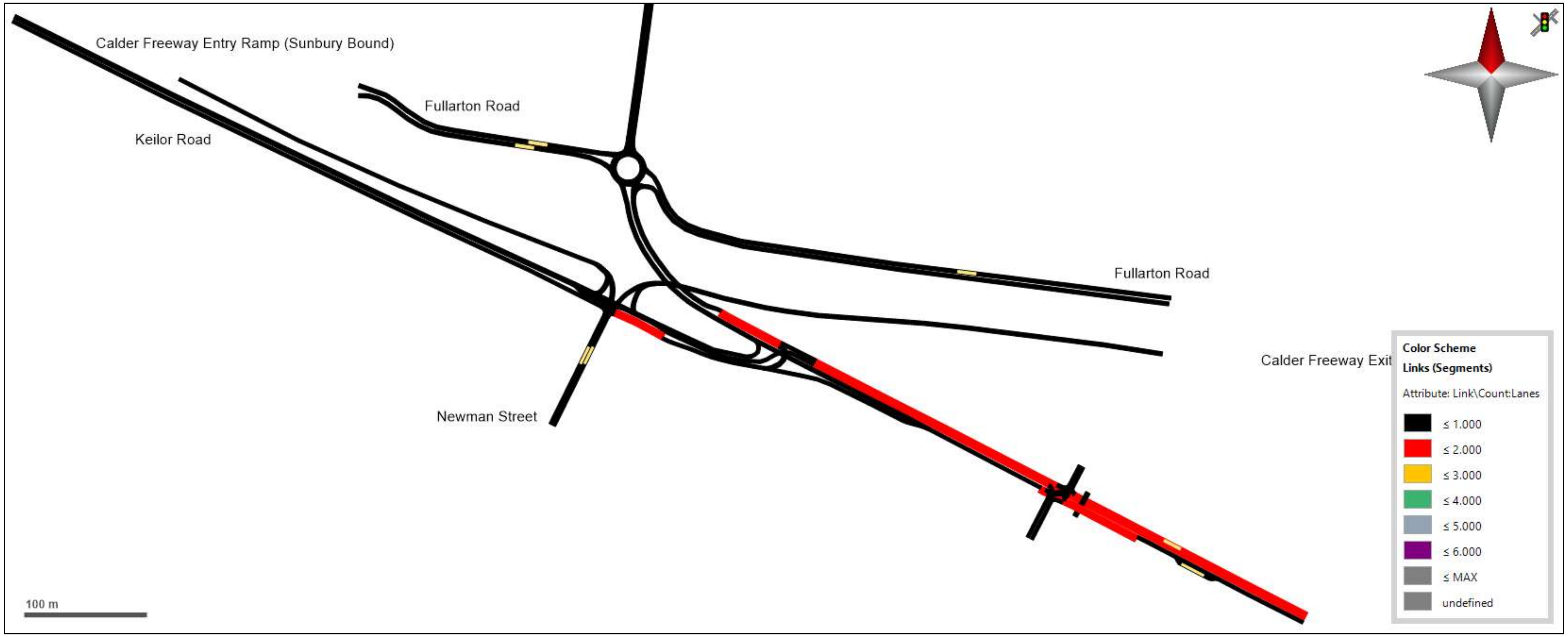


Figure 50: Existing Public Transport Route as coded in Vissim model

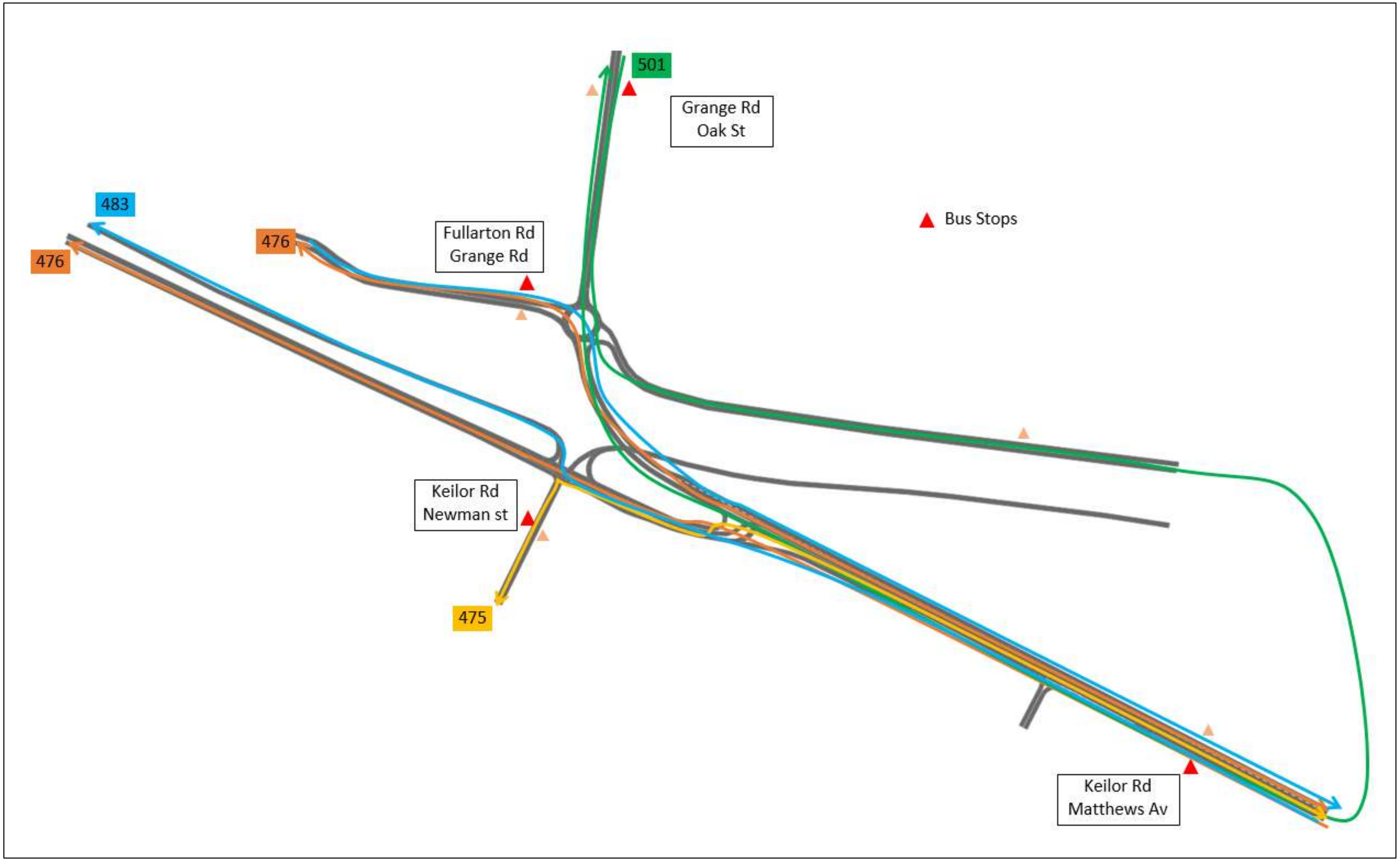


Figure 51: Zoning System as coded in Vissim model

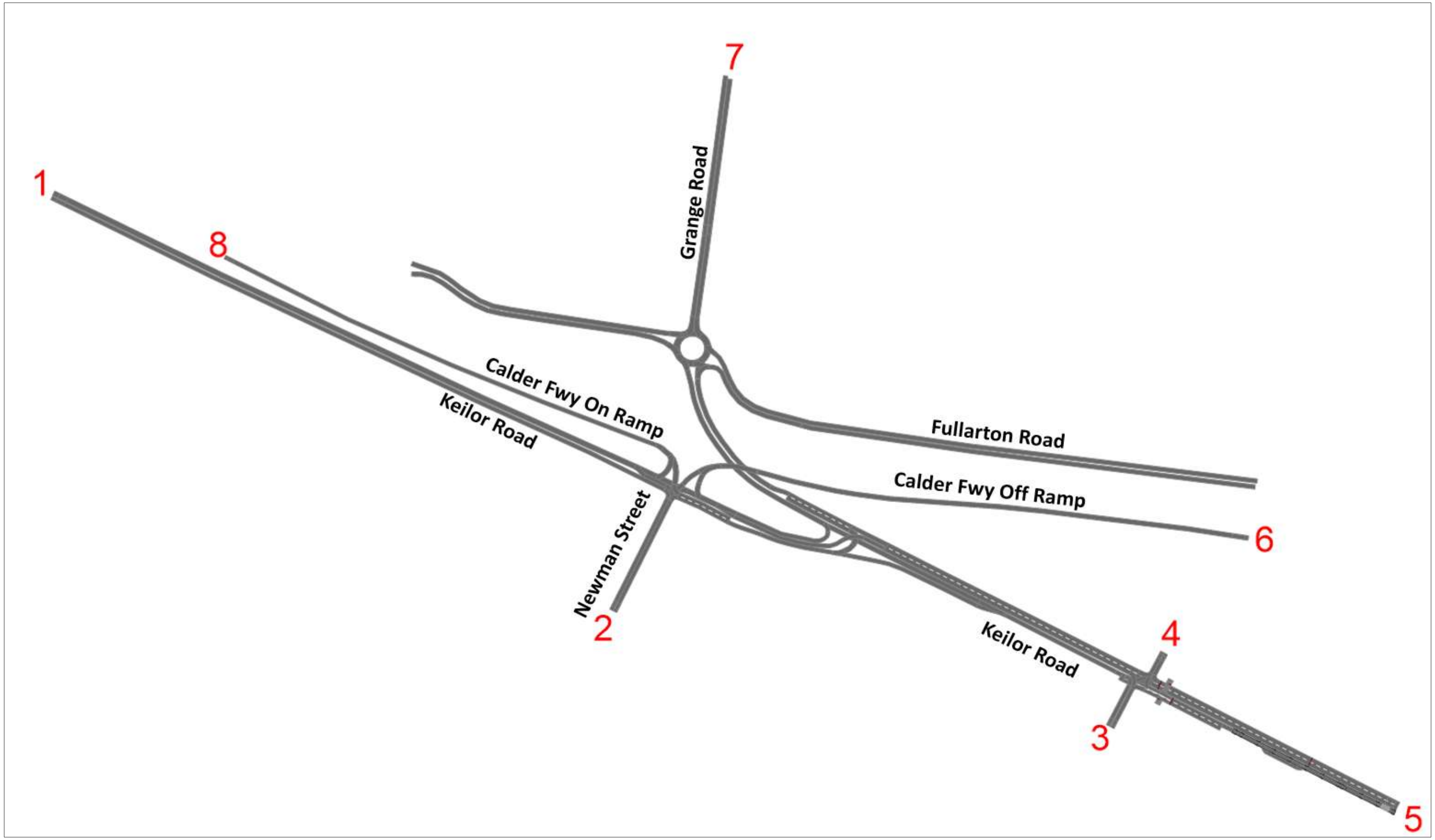


Figure 52: Vissim model showing the available paths from Zone 1

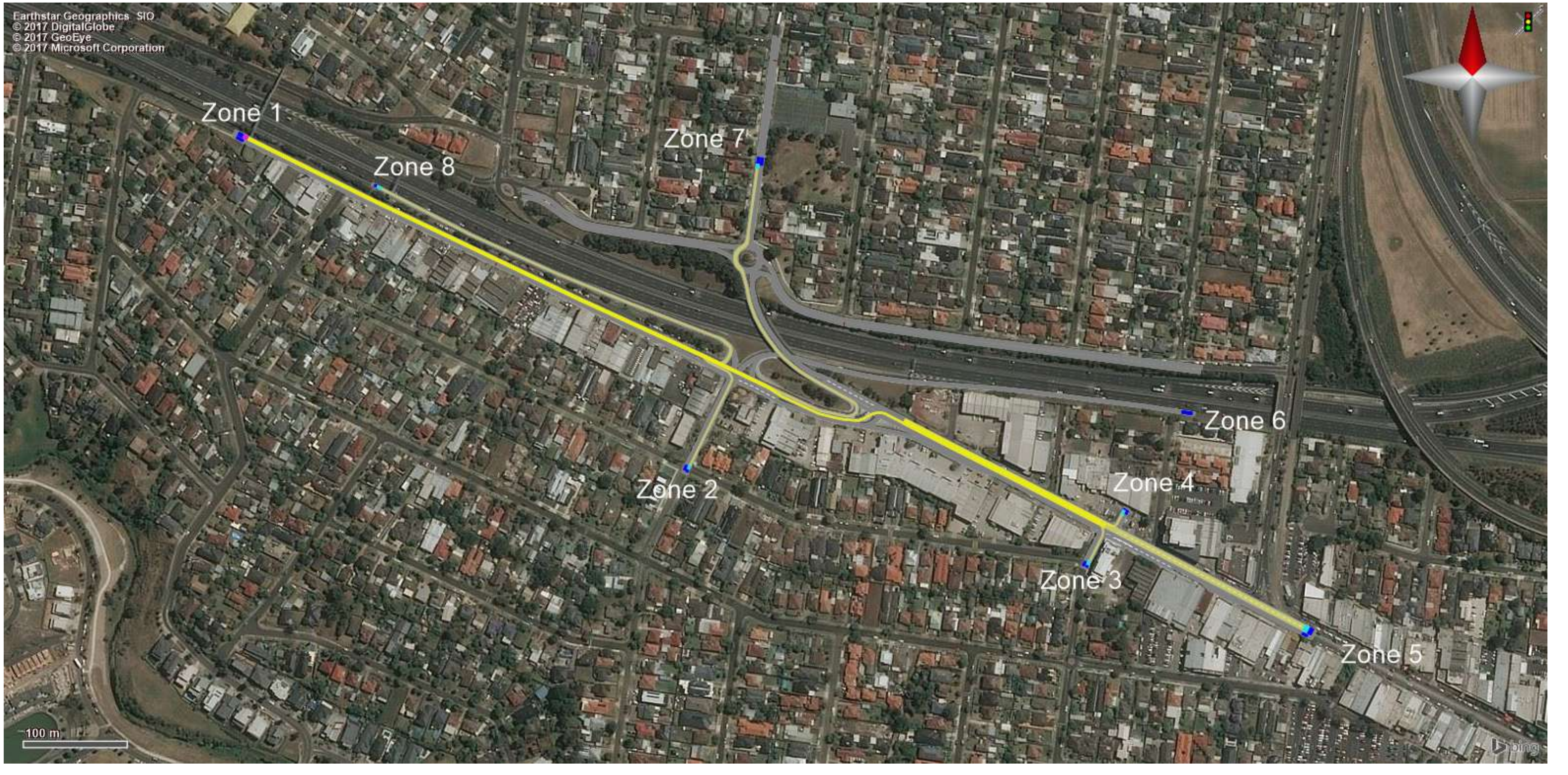


Figure 53: Schematic showing turn flow comparison with GEH – AM Peak (8am to 9am)

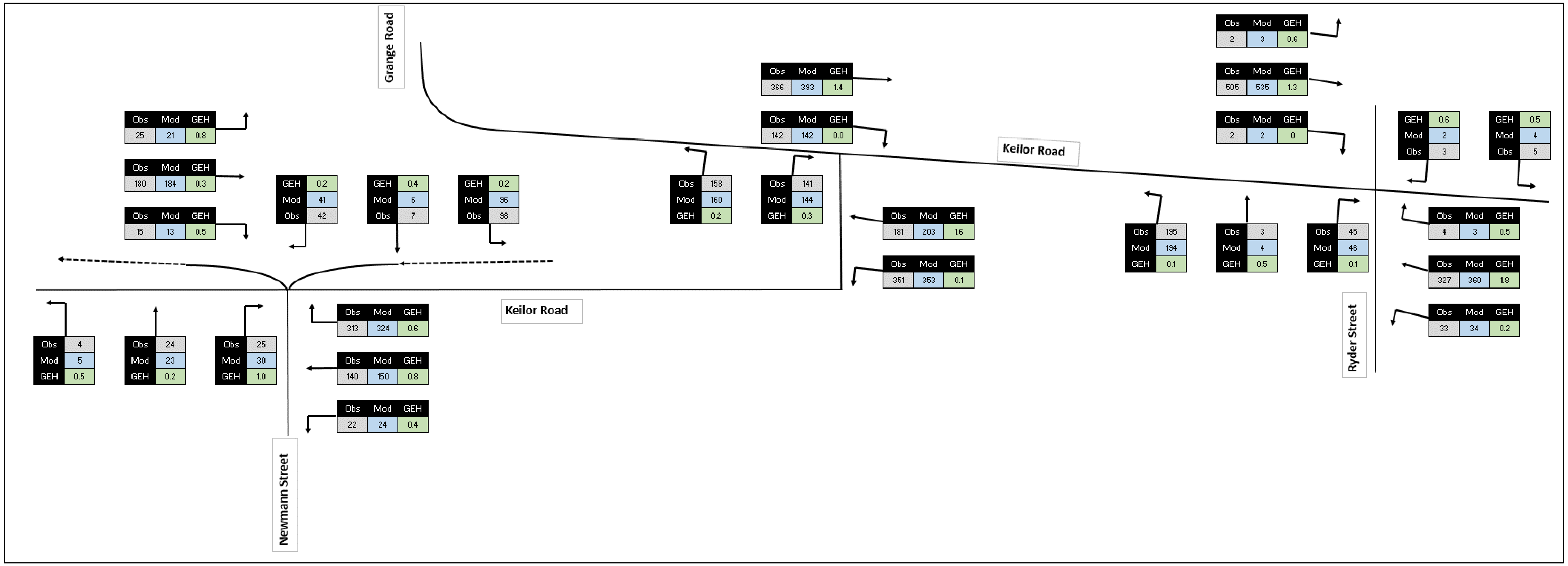


Figure 54: Traffic conditions at the start of the AM evaluation period

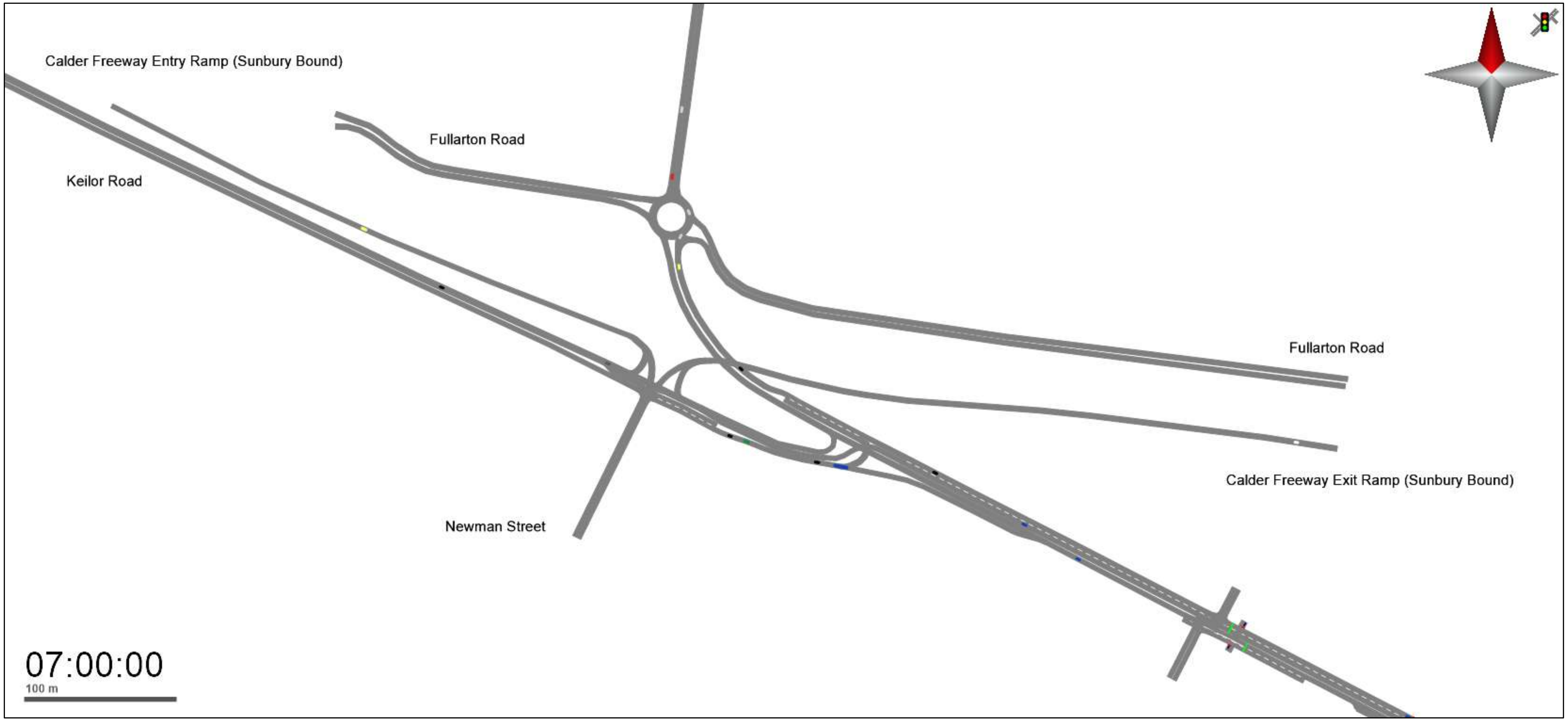


Figure 55: Traffic conditions at the start of the PM evaluation period

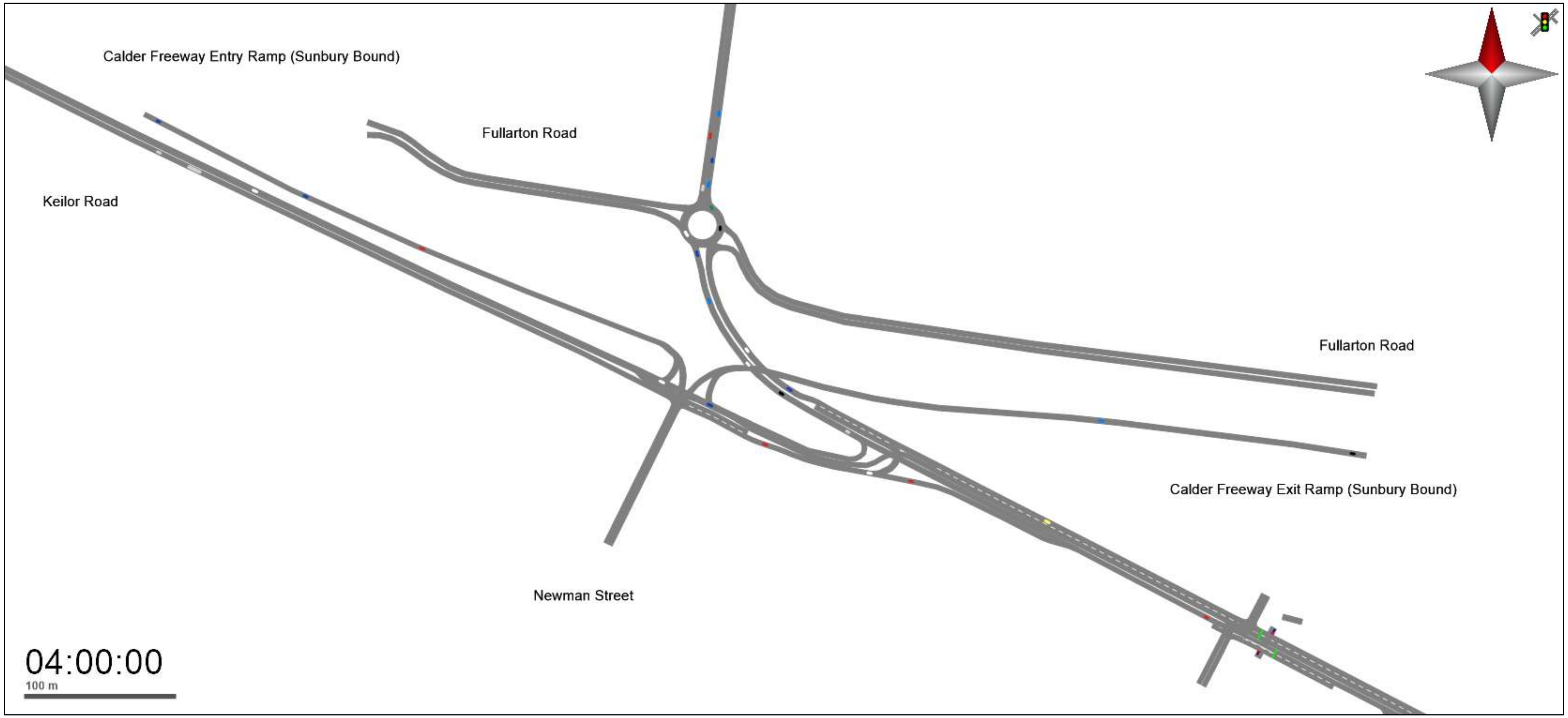


Figure 56: Flow bundles for the W-S right turn at Keilor Road/Grange Road (AM Peak period)