

**Active, Integrated and  
Intelligent  
Management System  
(AIIMS)**

SH16/20 Posted Speed Review

**New Zealand Transport  
Agency (NZTA)**

Reference: 239930

Revision: 1.0

15 November 2017

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# Document control record

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<b>Report title</b>		SH16/20 Posted Speed Review					
<b>Document ID</b>		<b>Project number</b>			239930		
<b>File path</b>		\\Aurecon.info\shares\NZAKL\Projects\B000\B289\Transport Planning Project Progress\05 Operational Assessments\25 Managed Motorways_VSL Review_Reports\Master Report.docx					
<b>Client</b>		New Zealand Transport Agency (NZTA)					
<b>Client contact</b>		Kathryn Musgrave			<b>Client reference</b>		
<b>Rev</b>	<b>Date</b>	<b>Revision details/status</b>	<b>Author</b>	<b>Reviewer</b>	<b>Verifier (if required)</b>	<b>Approver</b>	
0	6 November 2017	Initial Draft	R. Lauren	J. Payne			
1.0	15 November 2017	Final	R. Lauren	J. Payne	E. Monk	B. Monk	
<b>Current revision</b>		<b>1.0</b>					

Approval			
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# 1 Introduction

## 1.1 Purpose of the report

Aurecon has been commissioned by NZ Transport Agency to review the recently commissioned Variable Speed Limit (VSL) Zone on both SH16 and SH20 in the vicinity of the SH20 Waterview Tunnel. This review work is part of the Active, Integrated and Intelligent Management System (AIIMS) project.

The purpose of this review is to assess the potential to increase the current maximum posted speed limit of 80km/h to 100km/h and the affects any increase would have on the safety and operation of this section of the motorway network.

This review is not going to include the current VSL Zone through the SH20 Waterview Tunnel which will remain with the current maximum posted speed of 80km/h.

## 1.2 Previous Studies

Two previous studies have been carried out by Aurecon on this section of the Motorway Network in regards to the maximum posted speed limit and the implementation of a VSL as follows:

- Posted Speed Limit Study – 2013
- Variable Speed Limit Study - 2015

The initial 2013 study was limited to SH16 and identified several existing issues which could be mitigated through the reduction of the posted speed limit, which at the time was set to a static 100km/h typical of most motorways.

The 2013 study noted that depending on prevailing traffic conditions a posted speed limit as low as 60km/h could be appropriate but was not practicable as a permanent static speed limit and therefore a VSL was suggested resulting in the 2015 study and the currently implemented VSL system.

### 1.2.1 2013 Study

The 2013 study reviewed the geometry, crash statistics and traffic volumes between Lincoln Rd interchange and the Central Motorway Junction (CMJ). The data used in this study was from the years 2008 to 2012 assessing SH16 in its previous condition before significant construction started on SH16. At the time of the 2013 review the design of the SH16 Causeway upgrade, Great North Rd and St Lukes Interchanges was known and therefore the review took into consideration the expected geometric and capacity improvements.

The 2013 study was conducted on the basis that the speed limit was to be static in nature and therefore the recommendation was based on providing a suitable speed restriction for all hours of the day. The result of the study was that SH16 would retain a 100km/h maximum speed limit excluding a unique section between St Lukes Rd and the Great North Rd Interchange as shown in Figure 1.

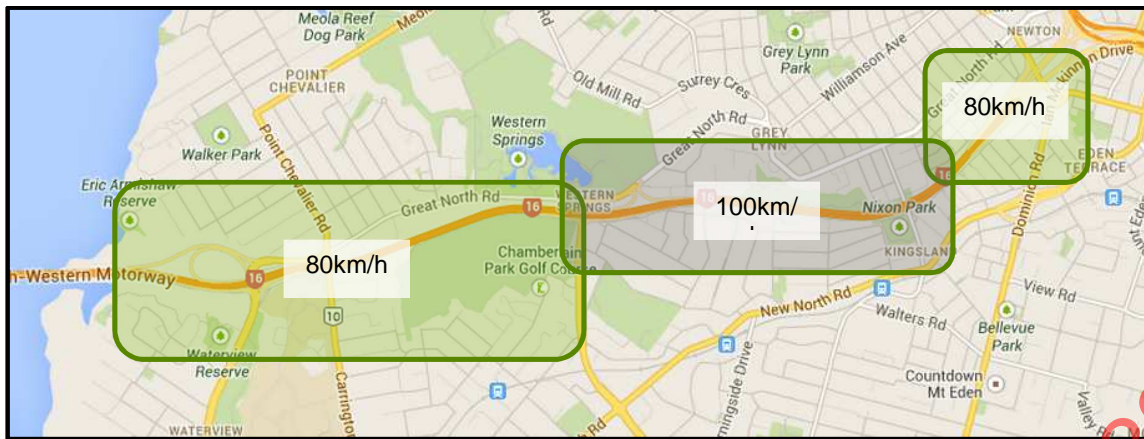


Figure 1 - 2013 Study Recommended Speed Limits

### 1.2.2 2015 Study

The key issue identified in the 2013 report was the substandard ramp separations and the high weaving volumes resulting in flow breakdown and crashes.

The 2015 study investigated the capacity constraints further identifying variances in lane capacities between 2300 and 2400pcu/h/l due to insufficient ramp separations as shown in Figure 2 based on the Highway Capacity Manual (HCM).

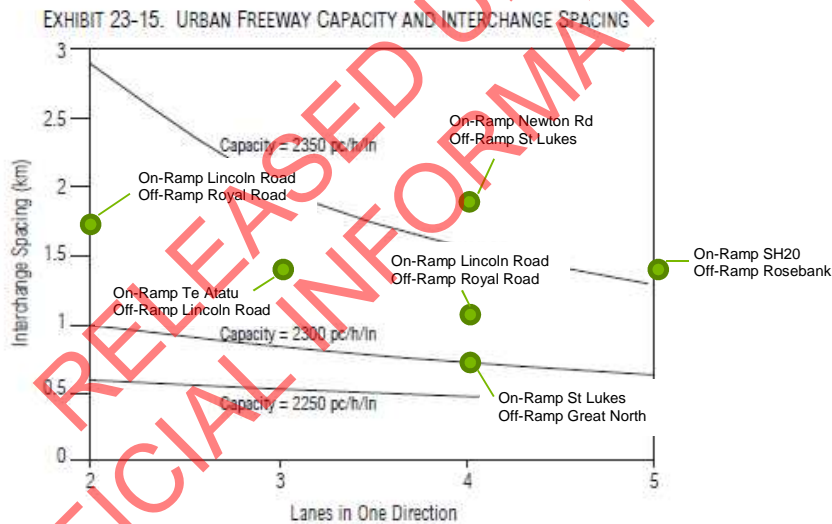


Figure 2 - HCM, Urban Freeway Capacity and Interchange Spacing

In conjunction with the variation in lane capacity is the exponential increase in the probability of flow breakdown as the traffic flow approaches the theoretical lane capacity as shown in Figure 3.

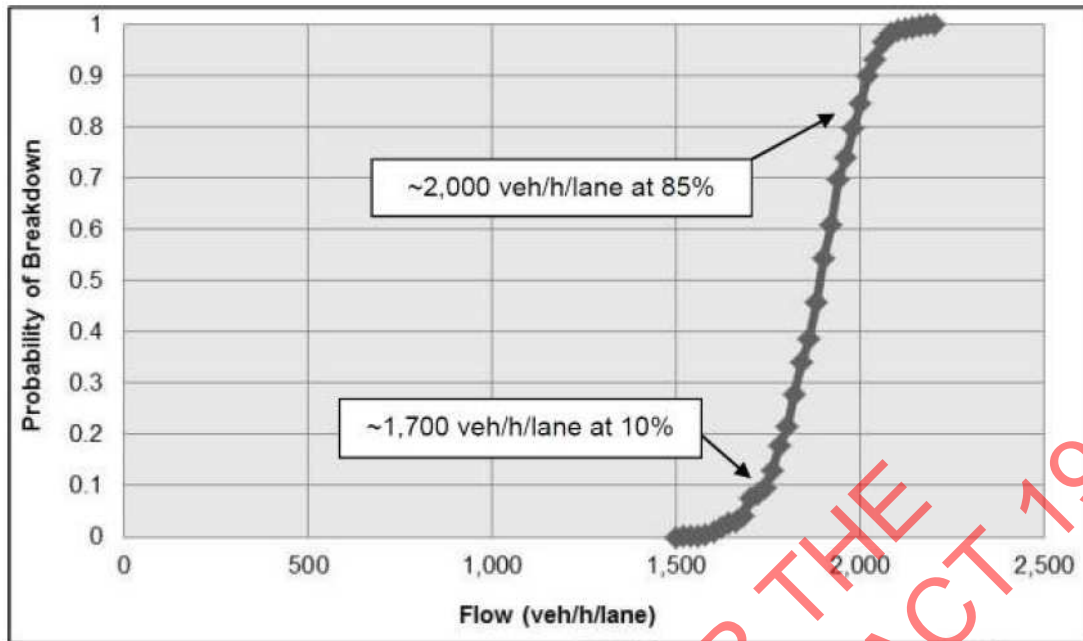


Figure 3 - Probability of Flow Breakdown

The section of SH16 between St Lukes and Great North Rd interchange was of concern due to the high flow demands on the ramps and their substandard spacing leading to a high concentration of traffic in the lane 1 (LHS) based on the predicted 2026 traffic volumes as of 2013.

### 1.2.3 Post Opening Operation

Since opening of the Waterview Tunnel there has been continual monitoring of the operational performance of the network, safety and driver behaviour in and around the study area including through the SH20 Tunnel, SH16 (Central Motorway Junction (CMJ) to Rosebank Road) and SH20 (Dominion Road to the SH20 Tunnel).

A summary of the observations since the opening of the Waterview Tunnel are as follows:

- Currently the design speed of both SH16 and SH20, excluding the SH20 Tunnel, meets or exceeds 100km/h. The current extent of the 80km/h speed restriction is out of context with the environment and driver expectations, particularly on SH16 where the motorway was previously posted at 100km/h before it was upgraded.
- There is a wide range of vehicle speeds in the 80km/h zones of both SH16 and SH20 with vehicles choosing to travel between 75 and 100km/h. The large differential in vehicle speeds results in driver frustration, additional weaving and increased potential for conflict.
- Increased tail-gating is being observed on the southbound ramps into the tunnel, this is likely due to a range of factors such as the tight geometry, the downhill grade, the approaching merge and the presence of speed enforcement.
- High levels of weaving and lane changing have been occurring both due to the need for drivers to be in the correct lane and perceived travel time improvements. This results in both a reduction in safety and increased flow breakdown.
- Each section of motorway is unique as to how flow breakdown and the reduction in average speeds occurs; for some sections of motorway the carriageway capacity is exceeded resulting in congestion across all lanes and a generally uniform reduction in vehicle speeds whereas other sections have uneven flow breakdown with wide disparities in speed between lanes.
  - St Lukes to Great North Rd in the westbound direction experiences early flow breakdown in lanes 1 & 2 (LHS) whereas the lanes 3 & 4 (median) take longer to reach capacity.



- Great North Rd to Rosebank in the westbound direction remains within the capacity of the carriageway however flowbreak down caused by the Te Atatu interchange can extend back onto the causeway.
- SH20 Dominion to Maioro in the northbound direction experiences flow breakdown across all lanes because the local road network is not able to accommodate the Maioro St off-ramp demand. The limited amount of space SH20 means all 3 lanes become congested resulting in lower speed disparities than what would occur on a wider carriageway.
- Maioro to Dominion in the southbound direction operates adequately until congestion between Hillsborough and Neilson St extends back to Dominion and Maioro St resulting in uniform congestion across all lanes.
- The northbound link from SH16 onto SH1 is experiencing increased demand since the tunnel opened resulting in queuing back onto SH16 during the evening peak when the adjacent lanes are uncongested.

#### 1.2.4 Asset Observations

Although not strictly part of this review some observations have been made of the existing assets as follows:

- The 'pull through' sign by the St Lukes off-ramp was intended to advise users to use the left two lanes to gain access to the SH20 Tunnel, the installed sign however is a standard Advance Exit sign measuring the distance to the exit.
- The advance warning signage for the SH16 westbound exit into the SH20 tunnel only provides users with approximately 300m of advance warning in contrast to the standard 1-2km. This gives very little time for users to react in what is already a demanding environment, supplementary line marking could aid in advising users that the left most lane is a trapped lane going onto SH20.
- The current line marking at the diverge of SH16 onto SH20 in the westbound direction is missing the standard ReflectORIZED Raised Pavement Markers (RRPMs) making the line marking difficult to see during wet and low light situations.

## 2 Safety Review

### 1.3 Introduction

A detailed safety review of the SH16 alignment was conducted as part of the previous 2013 Speed Limit Study which identified several issues that were existing at the time and were likely to be mitigated as part of the project works.

The predominant forms of crashes at the time were 'rear end' and 'side swipe' type crashes that were seen to be associated with the high traffic volumes and weaving demands. In addition, 'loss of control' type crashes were occurring in clusters around the sub-standard curves through the Patiki-Rosebank Peninsula and between Great North Road and St Lukes.

The SH16 upgrade improved the geometry through the Patiki-Rosebank Peninsula and St Lukes and therefore a reduction in the number of 'loss of control' type crashes were expected. The geometry between Carrington Road and Great North Road was to remain as existing, so no notable changes were expected along this section.

When the 2013 study was conducted a static speed limit was planned. The recommendation at this stage was to post the section of SH16 between St Lukes and Great North Road at 80km/h due to the high weaving demands and the lower standard of geometry.

Standard practice for reviewing crash data is to have 5 years of complete information so that the information is statistically relevant. As this section of motorway has only been operating for a few months' crash data is very limited and will not be statically relevant. Therefore, this safety review will be based on observations of driver behaviour and traffic flows with judgements being made on where excess risk exposure is most apparent.

### 1.4 SH16 Geometry

In the 2013 study a sight distance check was conducted along SH16 to access how the levels of sight distance provided varied along the route. At the time of this study, sight distance for multi-lane roads was based on a coefficient of deceleration of 0.26. This has since been increased to 0.36 resulting in a reduction in the level of sight distance required for a given design speed as shown in Table 1.

The use of this value now requires specific approval by the RCA and is only intended for use on high value, and primarily rural, roads.

Table 1 - Austroads Sight Distance Requirements

Design Speed (km/h)	Previous Sight Distance Value using 0.26 (m)	New Sight Distance Value using 0.36 (m)
100	221	179
80	152	126
60	96	81

The change in sight distance requirements has resulted in an increase in the design speed of SH16 although no physical changes have been made. This change in resultant design speed is noted in several key sections as shown in Table 2.

Table 2 - Changes in Effective Design Speed

Location	Sight Distance (m)	Previous Design Speed using 0.26 (km/h)	New Design Speed using 0.36 (km/h)
St Lukes	165	85	95
Rosebank	175	85	100
Patiki	175	85	100

A sight distance check has been conducted using a target sight distance value of 300m, however it should be noted that on any horizontal or vertical curve that is designed for 100km/h the available sight distance can be expected to drop to 179m.

The resultant sight distance check of SH16 shows that most the route exceeds the 100km/h sight distance requirement. However, there are several exceptions namely the reverse curve between Carrington Road and Great North Road where the sight distance is momentarily reduced to 80km/h as shown in Figure 4, refer to Appendix B for a larger version.

These two reductions in sight distance bring the effective design speed down to 80km/h, a localised drop in design speed is not uncommon on the Auckland motorway network and these two sections were improved as part of the Great North Rd interchange upgrade.

There is no real precedent to lower the speed limit of an entire section of road due to an isolated geometric reduction; generally geometric reductions have their risk mitigated through enhanced signage and line marking, however in the context of motorways such measures are seldom used.

It should be noted that these reductions in sight distance are generally a result of the horizontal alignment and are based on the most restricted lane. As the reduction in sight distance is minor, it can be expected that the adjacent traffic lanes will exceed the requirement for 100km/h.



Figure 4 - SH16 Sight Distance

## 1.5 SH20 Geometry

The section of SH20 between Dominion Road and the Waterview Tunnel was recently designed and constructed in accordance with the Waterview Minimum Requirements. These requirements stipulated a minimum design speed of 100km/h based on a 0.36 coefficient of deceleration. This has been carefully checked throughout the design process and it is confirmed that this entire section of the SH20 exceeds these requirements. To a similar extent, the preceding SH20 alignment from Hillsborough to Dominion Road was also designed for a 100km/h design speed. This section, however, was designed in accordance with the TNZ State Highway Geometric Design Manual (SHGDM) and therefore 170m of sight distance was required in contrast to the current Austroads requirement of 179m. It should also be noted that the sight distance criteria for off-ramps became significantly more onerous under Austroads and as such the sight distance provided to off-ramps on the older Mt Roskill Extension section of SH20 is to a lesser level than that provided on the newer sections.

## 1.6 Site Observations

Using both site observations and CCTV footage various sections of both SH16 and SH20 have been assessed in terms of traffic behaviour. The issues identified for each section are discussed as follows.

### 1.6.1 SH20 Tunnel Observations

#### Vehicle Speed

Road users are generally complying with the 80km/h posted speed limit within the tunnel. However, there are notable issues on the approach with increased weaving and tailgating. There is also a notable reduction in the speed of vehicles at the northern tunnel portal where vehicles both entering and exiting the tunnel reduce their speed to approximately 70km/h. This adherence to the posted speed limit is likely to be heavily influenced by vehicles not changing lanes within the tunnel and most traffic using lane 2.

Although the adherence to the 80km/h speed limit within the tunnel is desirable in terms of safety within the tunnel itself, the slowing of traffic on the exit may contribute to driver frustration as some users may feel restrained and make erratic manoeuvres once leaving the tunnel. If the posted speed limit were to be increased to 100km/h directly outside the tunnel this situation would likely be exacerbated as the uphill grade would limit ability of some vehicles to accelerate.

#### Lane Usage

Approximately 70% of traffic within the tunnel uses lane 2.

#### Lane Changing

Very few vehicles change lanes within the tunnel, which, in combination with the high usage of lane 2, limits vehicle speeds to that of the slowest vehicle.

#### Northern Bifurcation

Initially there was a high incidence of weaving in the northern bifurcation area due to vehicles entering the tunnel in the wrong lane and then not wanting to change lanes within the tunnel. This late weaving has reduced in frequency due to most users becoming more experienced at driving the route. New or infrequent users are still likely to perform late weaves. In addition to vehicles weaving to select the correct exit there is additional weaving on the two exit ramps from users trying to overtake slow moving vehicles they have been stuck behind in the tunnel.

## Wrong Way Drivers

Some users are mistakenly taking SH16 westbound off-ramp onto SH20 southbound and then trying to correct this by performing a U-turn onto the SH16 eastbound off-ramp onto SH20 southbound. This results in wrong way drivers on SH16 eastbound. This is likely to be occurring due to inattentive or unfamiliar drivers using the left most lane of SH16.

### Summary of Observations:

- Majority of tunnel traffic use the middle lane.
- Limited lane changing within the tunnel.
- Vehicle speeds within the tunnel are limited due to the restriction on lane changing.
- High levels of weaving in the northern bifurcation and exit ramps.
- High speed variations outside of tunnel, between 75 & 100km/h on the 80km/h sections.
- Users taking SH16 westbound ramp onto SH20 southbound by mistake.

## 1.6.2 SH16 Observations

### CMJ to St Lukes Weaving

A large amount of weaving occurs between the CMJ and St Lukes, this is said to have improved with the extension of the 80km/h speed limit. This suggests the 80km/h speed restriction has helped smooth the traffic flow.

### St Lukes Westbound off-ramp

Prior to the opening of the SH20 Waterview Tunnel the St Lukes off-ramp frequently queued back onto the motorway blocking lane 1. This queue was caused due to the low capacity of the left turn movement onto St Lukes Road as well as the downstream capacity being limited. Since the opening of the tunnel this issue appears to have been mitigated with peak hour volumes on the off-ramp being approximately 1200vph inclusive of both left and right turners.

### St Lukes Westbound On-Ramp

It has been noticed that during the shoulder peak before the ramp meter signals are activated, platoons of vehicles being released onto the on-ramp are having trouble merging with lane 1 resulting in flow breakdown. This issue is caused by the high demand for the Great North Road westbound off-ramp and its sub-standard separation resulting in lane 1 being near capacity prior to the on-ramp merge.

It has also been noticed users coming on at St Lukes are having trouble joining the through traffic as they are required to weave into a lane that is operating at significantly higher speeds than the lane they are leaving.

### Great North Road westbound off-ramp

The queue for the Great North Road off-ramp can queue back to St Lukes at times blocking the St Lukes off-ramp. The issue here is that the Great North Road off-ramp is only a single lane both at the nose and for its 1km length prior to joining Great North Road. With the peak hour volume approaching 1700vph the single lane ramp is simply not able to provide for the demand without flow breakdown which results as queues.

In addition to the limited capacity, the Great North Road off-ramp has a constrained cross section with the shoulders reducing to 1m in width which reduces lane capacity and can result in the ramp becoming blocked in the event of a crash or vehicle breakdown.

### **SH16 westbound link Ramp onto SH20**

The ramp connecting SH16 to SH20 does not appear to have any capacity issues in itself, however, the approach lane often becomes blocked by traffic attempting to exit at Great North Road. This often results in an underutilised lane allowing for high speed differentials and erratic weaving movements.

### **SH16 Causeway - Westbound**

The primary issue noticed on the SH16 causeway is the wide range of speeds vehicles choose to travel at across the five westbound lanes. A common observation during off-peak situations is traffic leaving the tunnel stays close to the posted speed limit of 80km/h and being undertaken by traffic coming from the city centre on SH16 travelling close to 100km/h. This creates a difficult situation for slower users to move to the left and discourages faster users to move to the right.

### **SH16 (eastbound) Rosebank to SH20 Link**

With the current 80km/h VSL extending to the Rosebank Road on-ramp significant speed differentials start to be experienced as far back as Patiki Road. The 80km/h speed limit is highly out of context with the environment and results in users choosing a range of speeds. This makes it difficult for users travelling at the speed limit to enter the correct lane as it will often require them to move in front of a vehicle traveling notably faster. This high speed differential results in additional weaving manoeuvres which were identified to be the principle cause of crashes on this route in the 2013 study.

### **Great North Rd Eastbound-On-ramp**

Flow breakdown often occurs where the Great North Road eastbound on-ramp merges with SH16.

## **1.6.3 SH20 Observations**

### **SH20 Dominion Road to Maioro Street**

Queues on the Maioro Street off-ramp frequently extend back to May Road and are caused due to insufficient capacity westbound capacity on Maioro Street. Construction is currently progressing to increase the capacity of the Maioro-Richardson Road intersection with an additional lane being added from the Maioro Street off-ramp to Richardson Road to add additional storage capacity.

With the Maioro Street off-ramp being two lanes at the nose the queues for the off-ramp blocking two of the three lanes on SH20 resulting in congestion and low speeds across all three lanes. This is seen to be desirable from a safety perspective as it keeps the speed differentials low limiting the severity of any crashes. As the congestion caused by the Maioro Street off-ramp is reduced the flow of the three lanes will be improved uniformly keeping the speed differentials low.

Some users appear to have been confusing the congestion of the Maioro Street off-ramp with congestion of SH20 and the tunnel. This is resulting in through traffic joining the exit queue and then weaving back to the through lanes once they find it is the off-ramp that is congested. VMS displaying messages alerting users that it is the Maioro Street off-ramp causing the congestion, has improved the situation.

## **1.7 Post Opening Safety Audit**

A post-opening Road Safety Audit (RSA) was recently completed with the findings provided in Appendix D.

The RSA covered a range of issues, however, several notable issues were related to the current speed limit and the Variable Speed Limit system as follows in Table 3.

**Table 3 - Post Opening Safety Audit Key Findings**

<b>Item</b>	<b>Ranking</b>	<b>Description</b>
3.1	Moderate	Brightness of variable speed limit signs (refer item 5.5)
5.1	Moderate	80km/h speed limit on SH16  Extent of 80km/h restriction is too great, resulting in dangerous driver behaviour.
5.2	Moderate	80km/h speed limit on SH20  Extent of 80km/h restriction is too great, resulting in dangerous driver behaviour.
5.3	Moderate	'Cry wolf' speed limits during incident management  Excessive speed restrictions during incident management extending too far beyond incident
5.4	Minor	Variable speed limits in adjacent lanes during incident  Inconsistent use of red roundels on speed limit signs
5.5	Moderate	Brightness of variable speed limit signs  Lane Signal Units (LSU's) are too bright and are detracting from other signs messages that are often on the same sign gantry.

Many of the RSA findings have been identified as part of the post opening monitoring and stakeholder feedback and relate directly to the issues being investigated as part of this study. Therefore, any outcomes from this study will need to take these on-board.

### 1.7.1 Key RSA Findings:

The key recommendations / suggestions of the RSA that will apply to any outcomes of this study are as follows:

#### **Maximum Speed Limit**

The preference of the Safety Auditors is to increase the maximum speed limit to 100km/h on both SH16 and SH20 when the traffic conditions are suitable.

#### **Speed Restriction Extent**

If a lower speed limit is to be applied due to excess congestion, or an incident, the speed limit should only apply to the area in need and not for excessive lengths before or after the problem area.

#### **Brightness of Variable Speed Limit Signs**

The brightness of any VSL signs should be reduced as to not distract drivers. This could be further mitigated by not using all VSL signs.



## 3 Operational Review

### 1.8 Introduction

This operational review is going to assess the current traffic conditions within the study area comparing traffic volumes, vehicle speeds and observations of traffic behaviour since the opening of the SH20 Waterview Tunnel and the current Variable Speed Limit (VSL) Zone.

This assessment will be subjective and is not the typical way a speed limit is determined. This location is unique with very high traffic volumes and multiple closely spaced ramps. The NZ Transport Agency's Speed Management Guide, as discussed under the 'Conventional Assessment' Section 4, is not necessarily intended for complex sections of urban motorway and therefore an alternative approach is being used.

### 1.9 Methodology

The operational assessment will look at the following factors to determine a safe operating speed:

- Traffic Volumes.
- Vehicle Speeds.
- Weaving Segment Performance.
- Observed Driver Behaviour.

This assessment is based on current weekday traffic flows that are subject to variation.

### 1.10 Traffic Volumes & Vehicle Speeds

Traffic volumes and speed data has been provided by the Auckland Motorway Alliance (AMA) through count stations and Tom-Tom data. The traffic data being used is based on weekday values including Monday and Friday.

Vehicle speeds have been generated through Tom-Tom data as there are no in-ground assets to accurately measure speeds within the study area. This Tom-Tom information provides an approximation on vehicle speeds and like other data sources, is limited due to the short duration over which the data has been captured.

The speed profiles shown are percentile speeds; therefore, the lower 5% line indicates that 95% of vehicles will be traveling faster than this speed and the 95% line indications that only 5% of users are exceeding this speed.

It is noted that the wide variation in vehicle speeds that is generally seen during peak periods does not necessarily imply high speed disparities on a regular basis but could be caused due to peak conditions being worse on some days than others. The variation shown during off-peak periods, however, is likely to be somewhat representative of the normal conditions.

Capacity is based on nominal 1800pcu/h per lane, actual lane capacity varies based on the total number of lanes available, ramp spacing and side friction and can be as high as 2350pcu/h per lane on wide multi-lane carriageways with large ramp spacings.



### 1.10.1 SH16 - Newton Gully to St Lukes Road

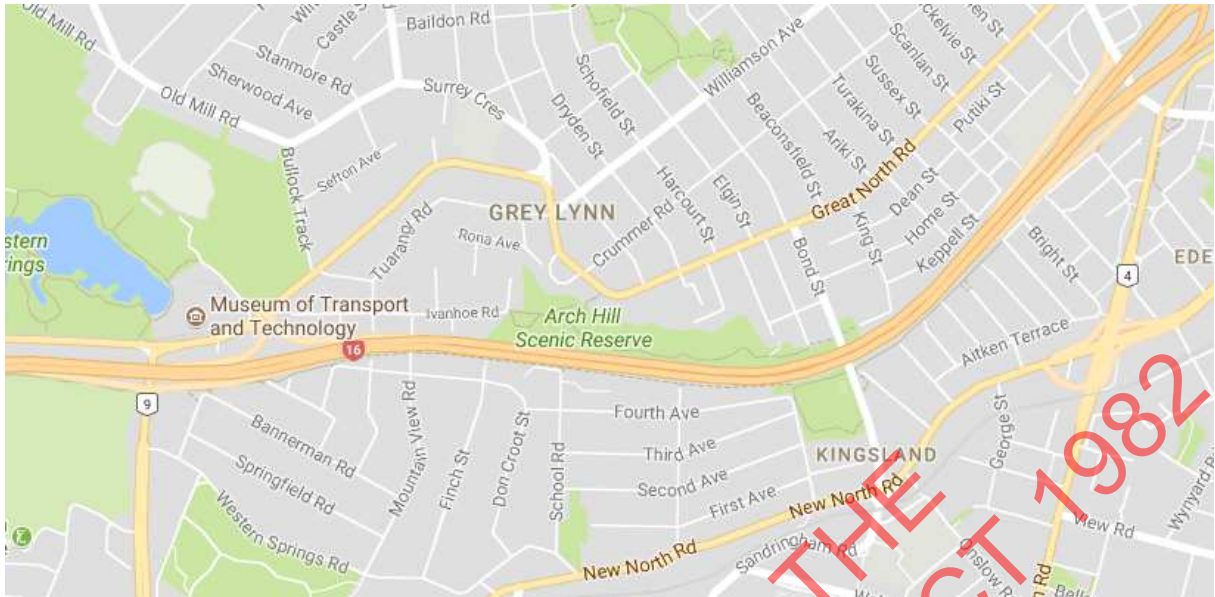


Figure 5 - Newton Gully to St Lukes Road Locality Plan

#### Westbound

Up until recently the section of SH16 between the CMJ ramps and St Lukes Road was posted at 100km/h. As part of the opening of the SH20 Waterview Tunnel, the 80km/h speed restriction was extended to encompass this area. The speed data shows a wide variation in vehicle speeds between 75km/h and 100km/h.

During peak periods the average speed reduces, however, not to the same extent as the St Lukes to Great North Road section. It is noted that the reduction in vehicle speed occurs as the total four lane capacity of the carriageway is reached. In addition, although the volume of traffic using the St Lukes off-ramp does not exceed the capacity of the off-ramp nose, it may exceed the capacity of the receiving local road network.

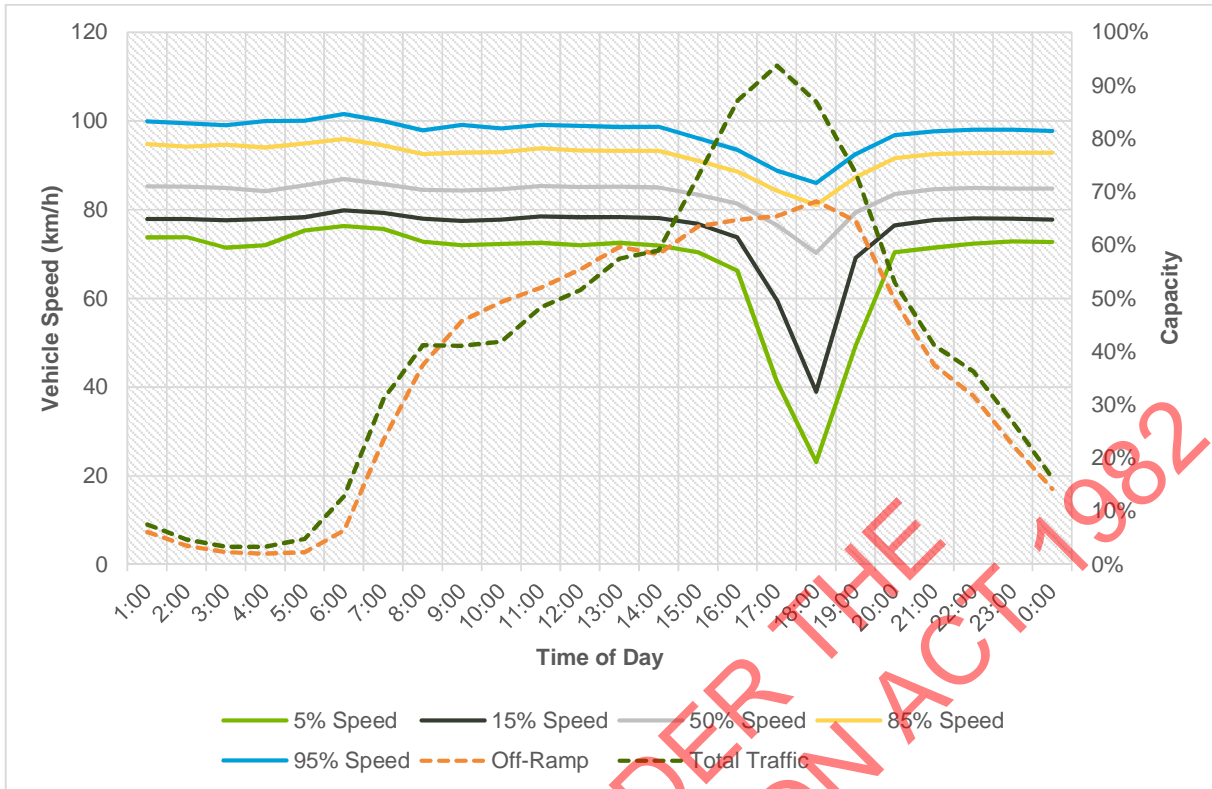


Figure 6 - Port to St Lukes Vehicle Speeds

1.10.2 SH16 - Great North to Rosebank

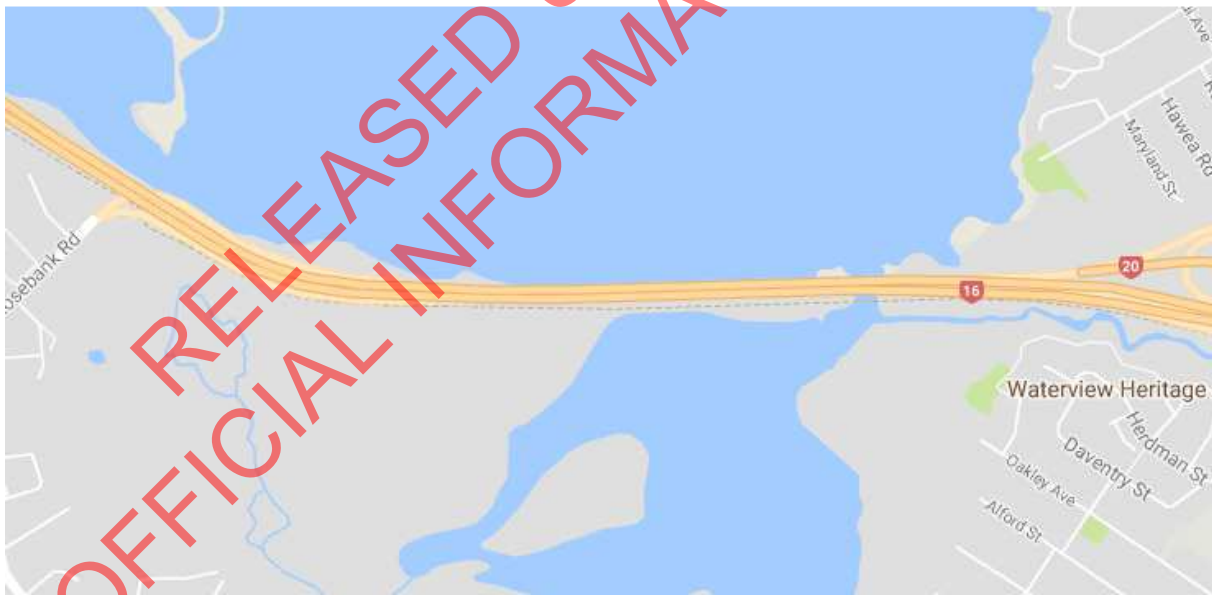
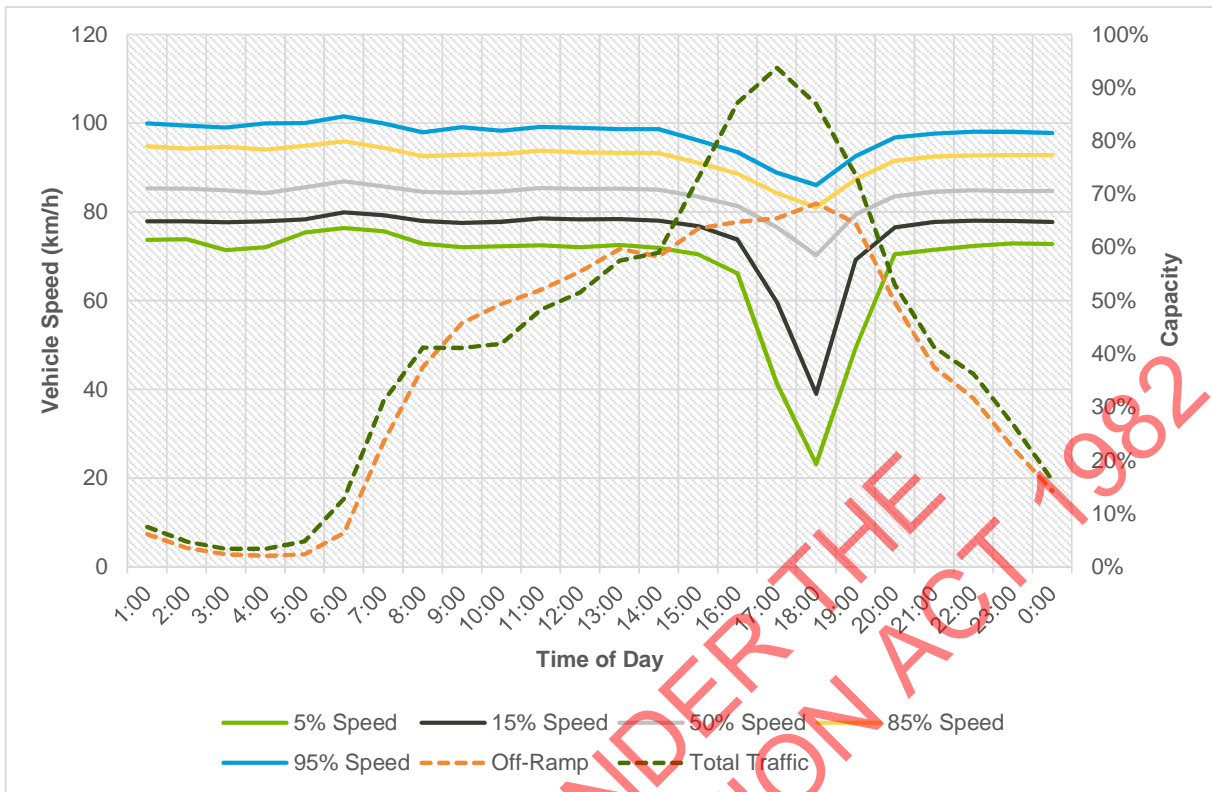


Figure 7 - Great North Road to Rosebank Locality Plan

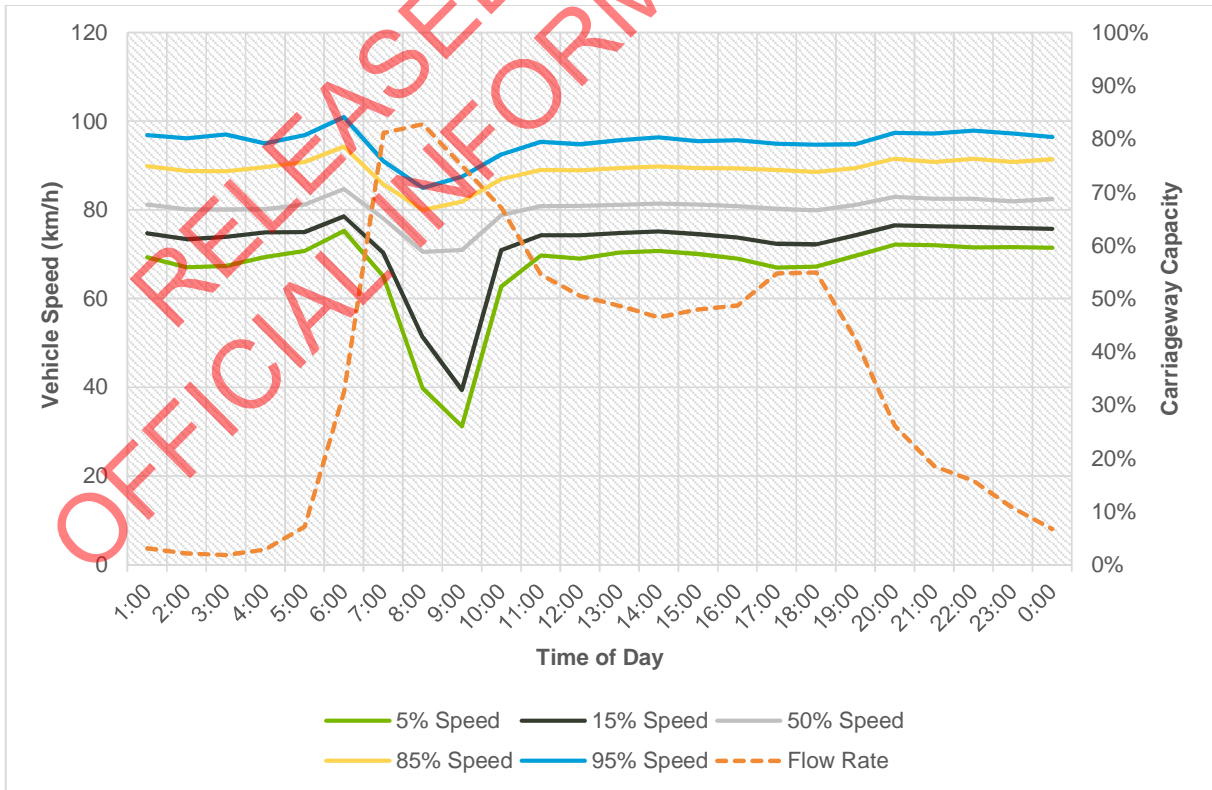
The speed data for the SH16 causeway sections shows a wide range in vehicle speeds varying between 70km/h and 100km/h during free flow conditions. Although the capacity of the carriageway in the westbound direction only reaches 60% of capacity, flow breakdown occurs during the evening peak which is usually seen to be a result of the high demand at the Te Atatu Interchange.

**Westbound**



**Figure 8 - Great North Road to Rosebank Traffic Flow**

**Eastbound**



**Figure 9 - Rosebank to Great North Road Traffic Flow**

## 1.11 Weaving Segment Performance

Weaving is defined as the crossing of two or more traffic streams traveling in the same direction without the aid of traffic control devices such as traffic signals. A weaving segment is created when a merge segment is closely followed by a diverge segment. The procedures available are only intended for use on typical entry and exit ramps and are not suited for major connections or locations where there are multiple entry/exit ramps within the immediate vicinity of each other. It is for this reason neither the SH16 Causeway nor the SH16 Newton Gully section have had their weaving performance assessed.

The performance of weaving segments has been assessed using the methodology prescribed in the Highway Capacity Manual (HCM) 2010 Chapters 12 and 13. This method is generally designed to assess isolated elements with typical flow rates; as such more complex situations with multiple closely spaced ramps or high ramp flows generate less reliable results.

The performance of a weaving length is primarily affected by the following values:

- Volume of weaving traffic.
- Number of weaving movements required.
- Weaving length.

### 1.11.1 SH16 - St Lukes to Great North Road



Figure 10 - St Lukes to Great North Road Locality Plan

#### Westbound

The 430m separation between the St Lukes Road on-ramp and the Great North Road off-ramp is significantly less than the desirable values prescribed in Austroads as shown in Table 4. This substandard separation, and the flow demands on both ramps results in frequent flow breakdown and queues forming on the nearside (LHS) lane.

The flow breakdown in the nearside lanes creates a notable speed differential between the through traffic in the offside (RHS) lanes increasing the potential for 'rear-end' and 'side-swipe' type crashes.

Table 4 - Austroads Guide to Traffic Management Part 6 Recommended Ramp Separation

Number of Lanes	Recommended Ramp Separation (m)
2	900
3	1200
4	1500

**St Lukes to Great North Rd Layout**

4

430

As part of the design of the St Lukes Interchange upgrade provision was made for an auxiliary lane to be installed linking the St Lukes on-ramp and the Great North Road off-ramp. The weaving performance of both the existing '4-lane' configuration and the potential '5-lane' layout has been assessed using the current traffic volumes and the results are shown in Figure 11 and Figure 12.

What can be noted in Figure 11 is that the capacity of the Great North Road diverge is exceeded between the hours of 1pm and 8pm with demand peaking at 5pm at 160% of ideal capacity. The poor performance of the diverge area is due to the proximity of both the St Lukes on-ramp and the SH16 to SH20 link which results in a large portion of vehicles needing to use the nearside lanes.

The auxiliary lane layout is shown to perform significantly better than the existing layout with demand peaking at 97% of capacity at 5pm. It should be noted however that the method used to assess an auxiliary lane weave does not have a provision to include the impact of other nearby ramps such as the SH16 to SH20 link.

It should also be noted that both methods assume there are no additional downstream constraints. In the case of the auxiliary lane layout, the improved weaving performance will likely result in the Great North Road off-ramp becoming over capacity which may then queue back into the auxiliary lane.

It is noted that the peak hour demand for the Great North Rd off-ramp exceeds the single lane design capacity of the ramps as shown in Table 5. Great North Rd itself does not appear to be presenting as a constraint as conditions on Great North Rd have improved significantly since the opening of the SH20 Tunnel.

**Table 5 - Austroads Guide to Traffic Management Part 6 - Lane Warrants**

<b>Volume Range</b>	<b>Ramp Layout</b>
DHV <1000 pcu/h	Single lane ramp
1000 < DHV < 1800 pcu/h	Single lane at nose, two lanes on ramp
DHV > 1800	Two lanes at nose, two lanes on ramp
<b>Great North Rd Off-Ramp Layout</b>	
1700 pcu/h	Single lane ramp

DHV = Desired Hourly Volume



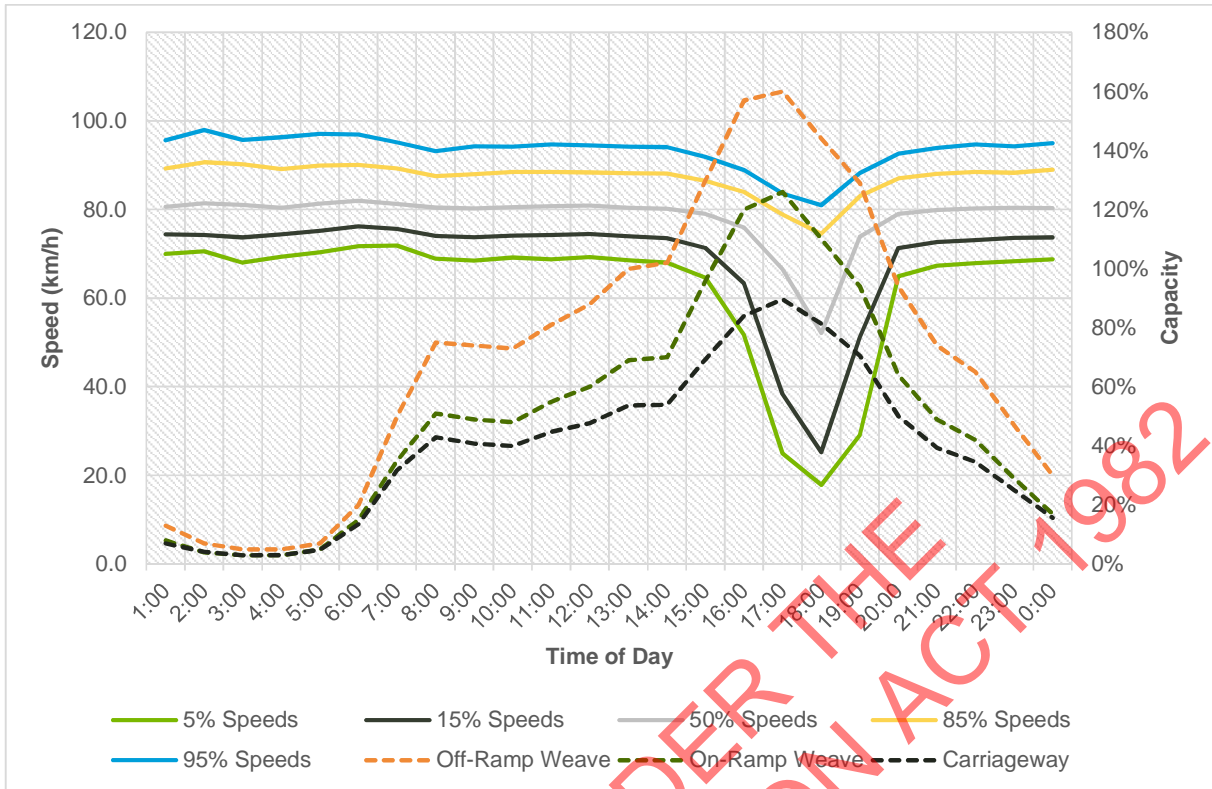


Figure 11 - St Lukes to Great North Road Weaving Performance - 4-Lane Layout

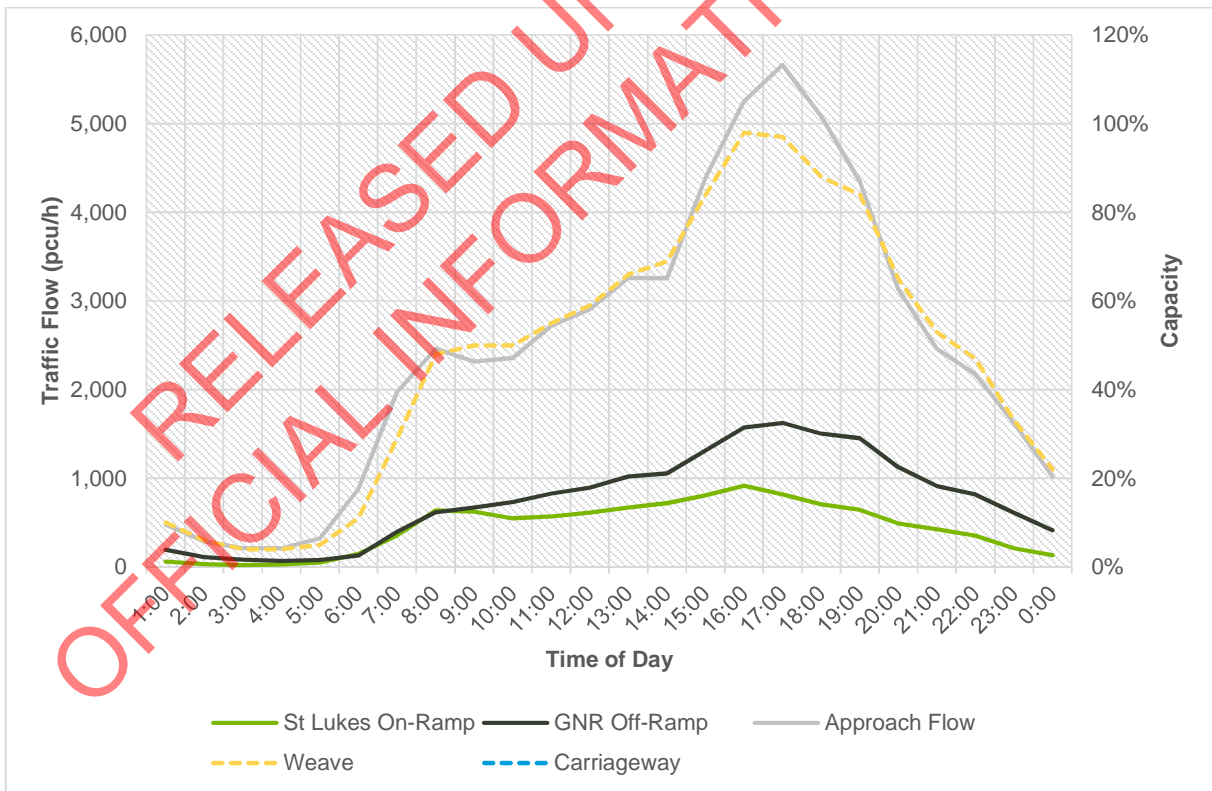


Figure 12 - St Lukes to Great North Road Weaving Performance - 5-Lane Layout

**Eastbound**

On SH16 in the eastbound direction by the St Lukes (Western Springs) ramps, flow breakdown occurs as the total traffic volume approaches the capacity of the main carriageway as shown in Figure 13 and Figure 14

During the morning peak the flow breakdown is caused mainly by the volume of through traffic in conjunction with the moderate demand on the eastbound on-ramp. Demand on the eastbound on-ramp remains high throughout the day with approximately 1000pcu/h using the ramp between the hours of 8am and 6pm. It is noted that there have been plans to convert the eastbound on-ramp into a lane-gain which would improve the performance of this section.

The flow breakdown shown by the eastbound off-ramp appears to be spill over from the on-ramp with demand on the off-ramp only reaching approximately 35% of capacity. It is noted that the peak demand for the eastbound off-ramp is during the PM peak where only a slight drop in vehicle speeds is observed.

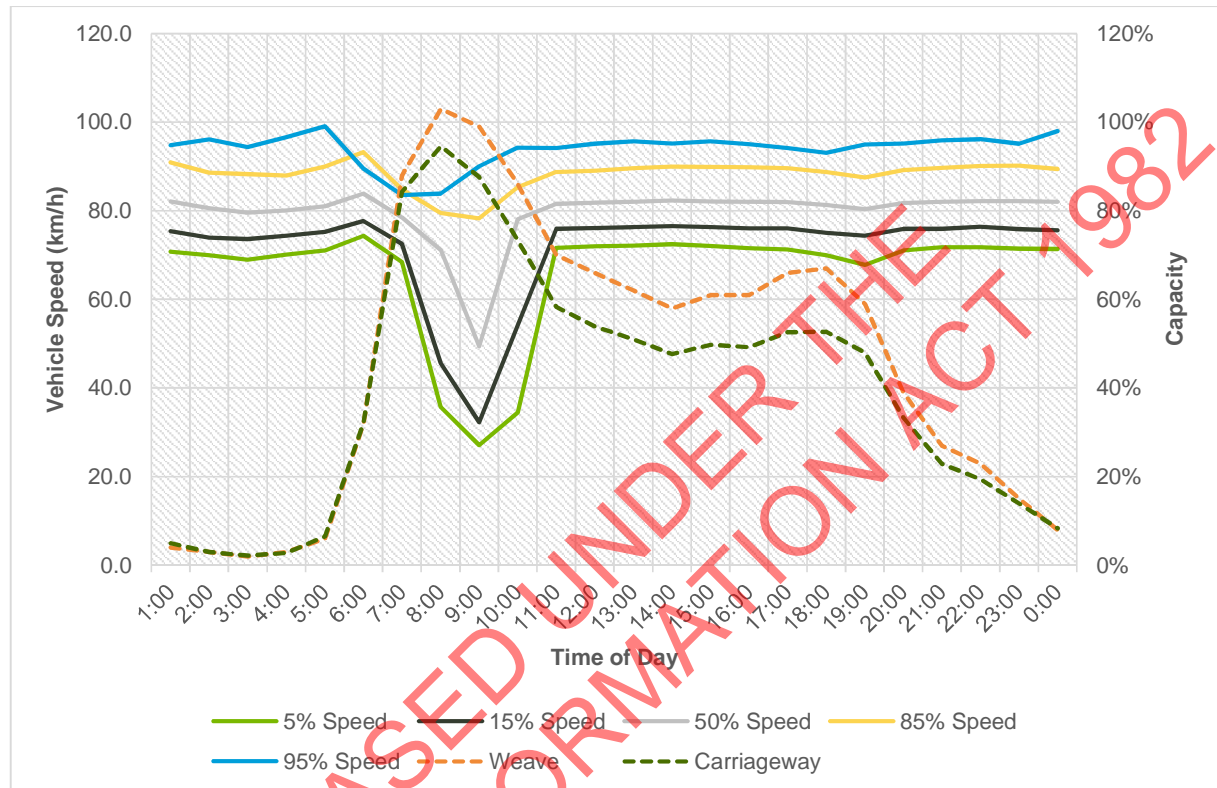


Figure 13 - St Lukes Eastbound Off-Ramp

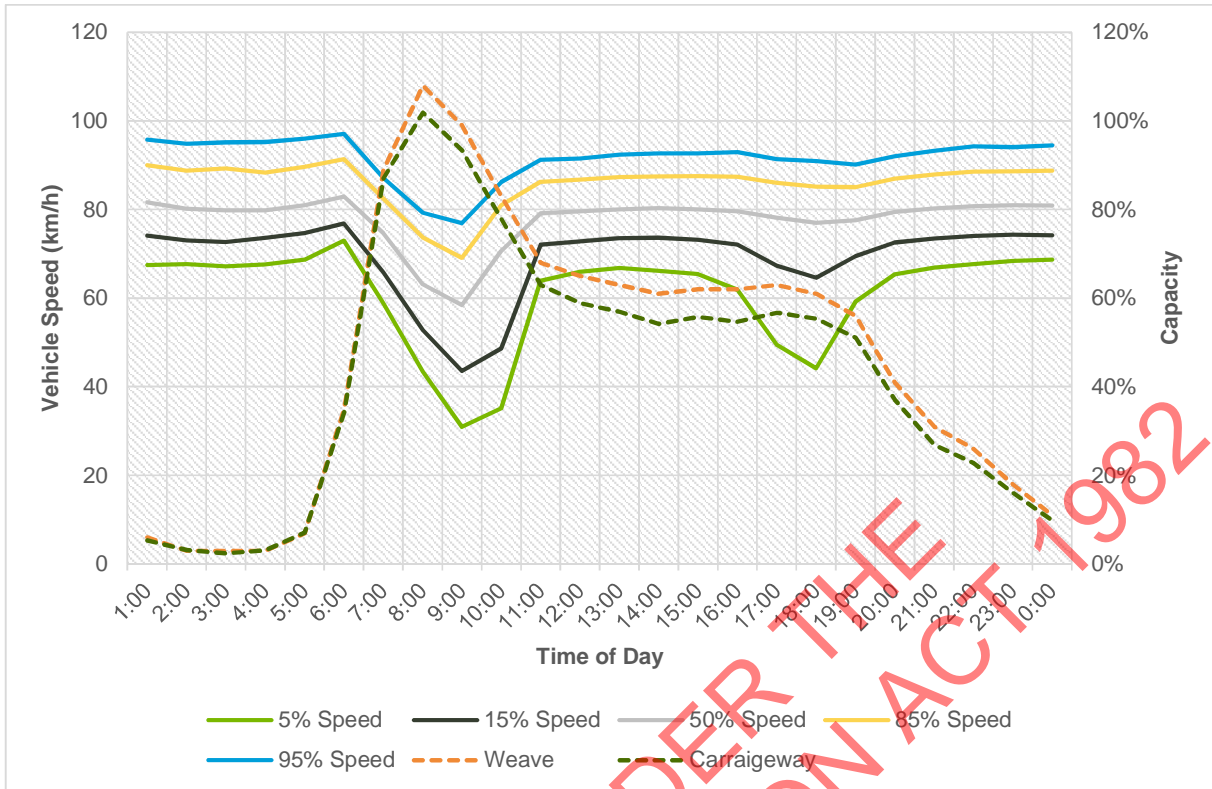


Figure 14 - St Lukes Eastbound On-Ramp

### 1.11.2 Great North Road Eastbound On-Ramp

The Great North Rd eastbound on-ramp continues to experience significant demand during the morning peak with the main carriageway being unable to accommodate the on-ramp demand without flow breakdown. This capacity constraint was intentional as it acts as a throttle to free up downstream capacity for users existing the SH20 Tunnel.

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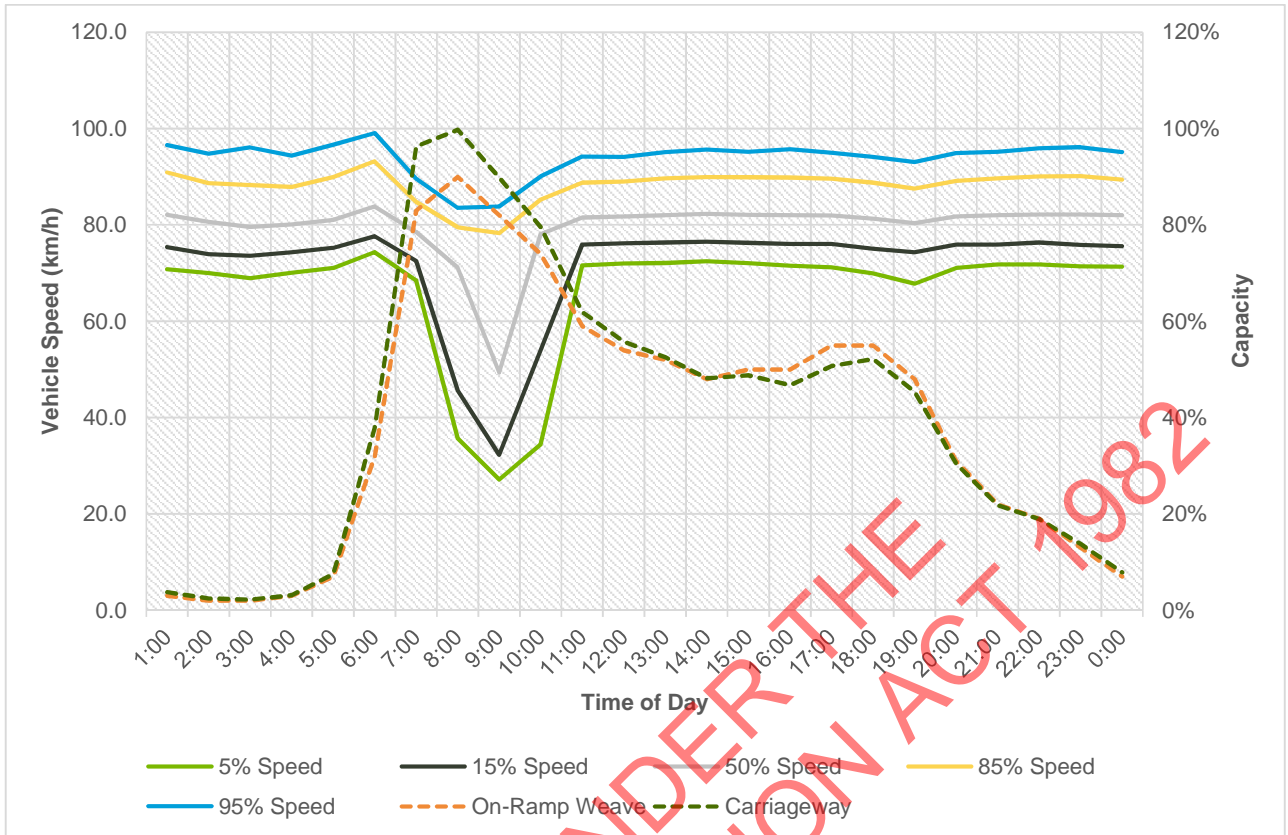


Figure 15 - Great North Road Eastbound On-Ramp Weaving Performance

1.11.3 SH20– Maoro Street to Dominion Road

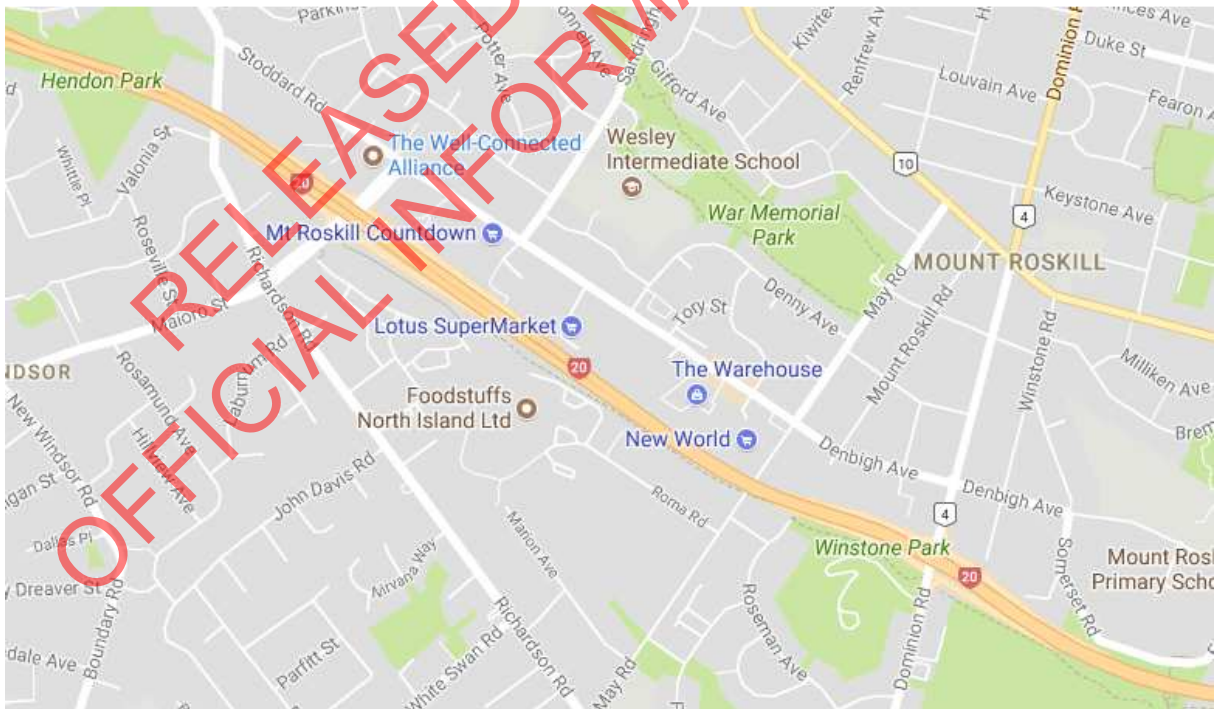


Figure 16 Maoro Street to Dominion Road Locality Plan

Northbound

The SH20 northbound weaving segment between Dominion Road and Maoro Street is shown to only reach 60% of capacity and therefore should in theory be operating satisfactorily. The reduction in vehicle speeds

and the congestion observed onsite must therefore not be a result of the weaving movements associated with the ramp but the ability of the off-ramp to take the demand flow.

With the peak hour capacity being circa 1,600pcu/h only a single lane off-ramp is required. However, a two-lane off-ramp has been provided and, therefore, the constraint is the capacity of the local road network.

Maioro St is currently being upgraded to provide improved westbound capacity and therefore the performance of this section is expected to improve.

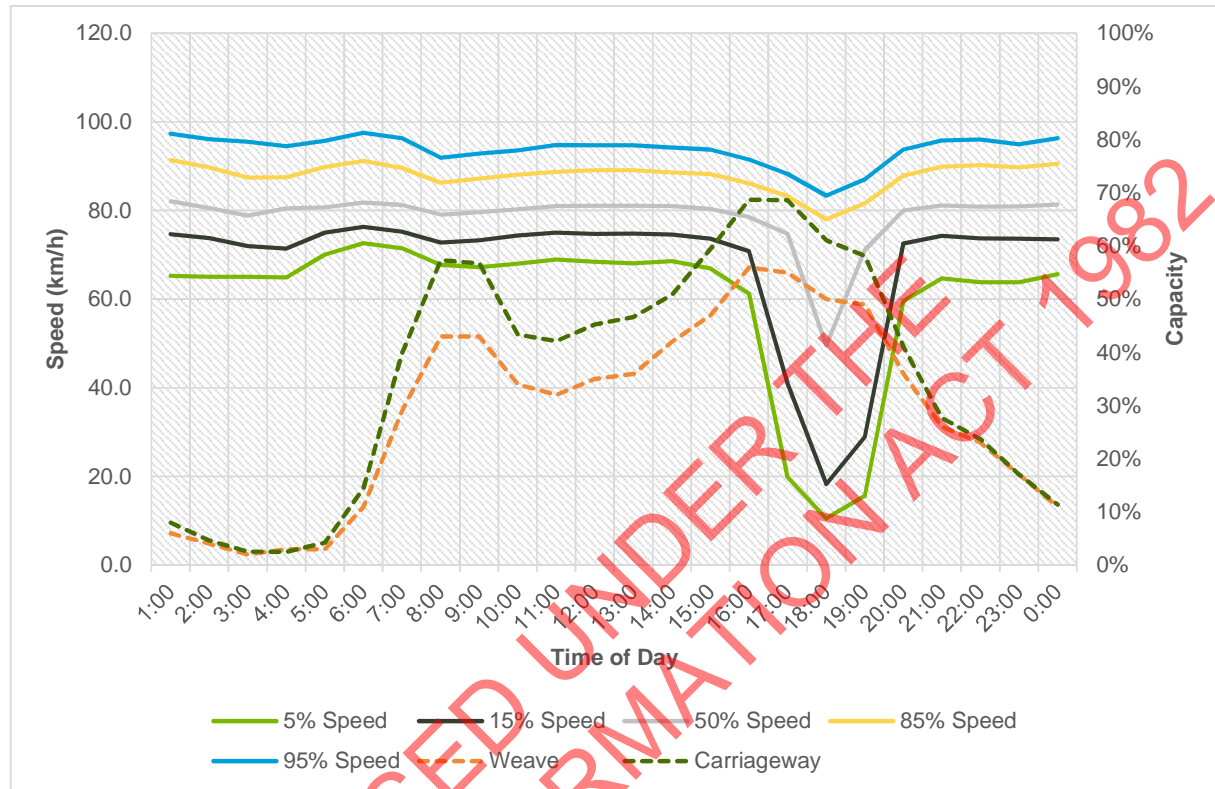


Figure 17 - Dominion to Maioro Northbound Weaving Performance

### Southbound

Like the northbound weave the SH20 southbound weave between Maioro Street and Dominion Road only reaches 70% of capacity. What is most notable is that while 70% of capacity is reached during the morning peak there is no notable reduction in the operating speed however, during the evening peak when 60% of capacity is reached there is a significant reduction in vehicle speeds.

During this evening peak, there is less traffic on the road, 3,700 versus 3300pcu/h, however the performance is much worse implying there are other downstream effects at play. The Dominion Road on and off ramps do not appear to be presenting a constraint with 350 and 620 pcu/h during the peak hour respectively and therefore the constraint is likely to be closer to Hillsborough.

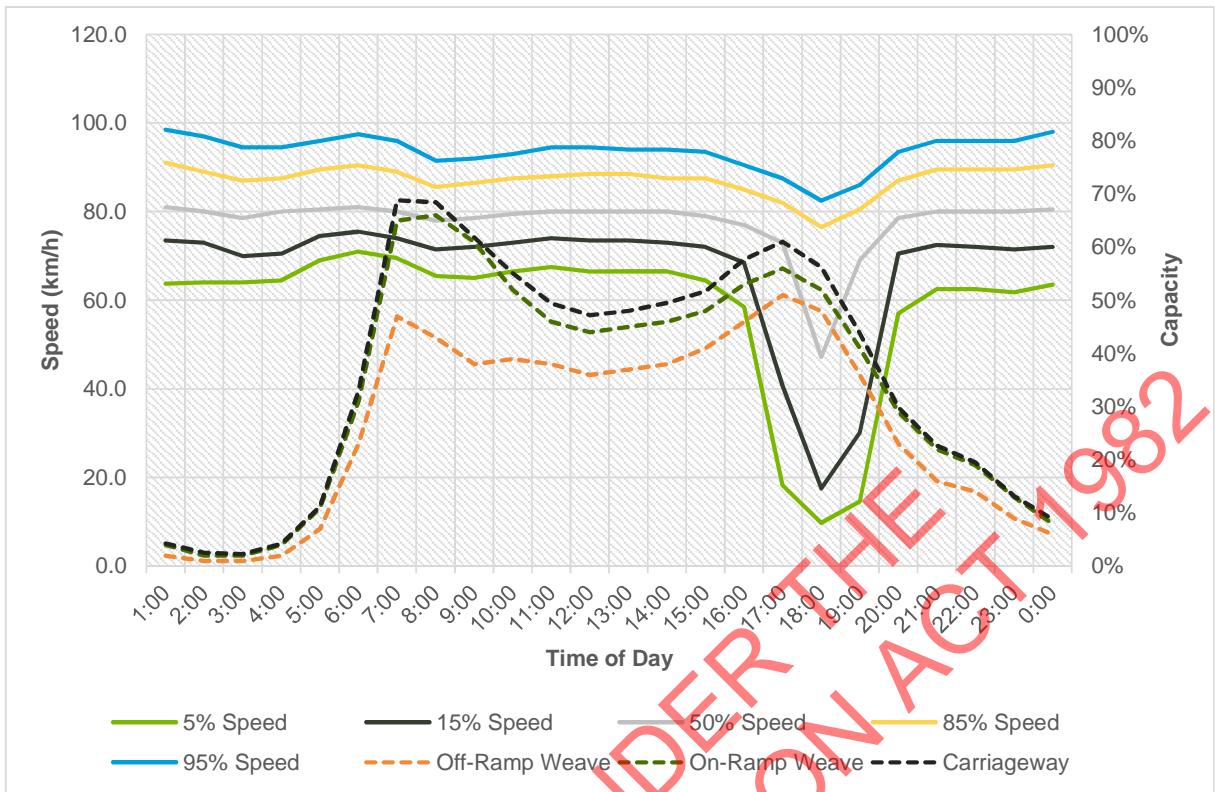


Figure 18 - Maioro to Dominion Southbound Weaving Performance

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## 4 Conventional Assessment

### 1.12 Methodology

#### 1.12.1 Land Transport Rule 54001/2017

The Ministry of Transport has recently revised the 'Setting of Speed Limits' (SSL) rule as of 21<sup>st</sup> August 2017, superseding the 2003 rule that was used in the previous studies. The new rule is designed to produce a safer travelling experience by using a modern and consistent approach to setting speeds limits with the intention of managing speeds in the greater context of a roads purpose and environment.

The 2017 SSL rule sets out the legal requirements for speed limits with the Road Controlling Authorities (RCAs) being responsible for both setting and managing speed limits. The Transport Agency both acts as the RCA for the State Highway Network and provides guidance to be used by other RCA's in setting their respective speed limits.

The 2017 SSL rule endorses the use of the NZ Transport Agency Speed Management Guide (2016) as the tool to be used for the assessments speed limits.

#### 1.12.2 Speed Limit Requirements

Within the 2017 SSL rule there are several key requirements for which any proposal will need to take account of; these are discussed as follows.

##### Range of Speed Limits

The posted speed limit must be a multiple of 10km/h between the values of 10km/h and 110km/h.

##### Road Lengths for speed limits

A road must satisfy the following minimum lengths to have the corresponding posted speed limit:

- 50km/h = 500m.
- 60km/h = 500m.
- 80km/h = 800m.
- 100km/h = 2000m.

##### Default Speed Limit

The default speed limit for a motorway is 100km/h. To set a speed other than 100km/h the RCA must comply with Section 4.2 of the 2017 SSL rule.

##### Setting of Non-Default Speed Limits

2017 SSL rule Section 4.2 (2)

To set a speed limit other than the 100km/h default of the motorway NZTA must do so regarding the following:

- The information about speed management developed by NZTA.
- Any relevant speed management provided by NZTA.
- The function and use of the road.
- Crash risk for all road users.
- The characteristics of the road and roadside.
- Adjacent lane use.
- The number of intersections and property access ways.
- Traffic volumes.
- Any planned modification to the road.
- The view of interested persons and groups.

## 1.12.3 Signage Requirements

### General Signage Requirements

The signage requirements for both static and variable speed limits are set out within the SSL Rule with additional requirements within the 'Land Transport Rule: Traffic Control Devices (2004)'.

The primary requirements are set out in Section 9 of the SSL and are as follows:

- A road controlling authority must install a speed limit sign on the left-hand side of a road under its jurisdiction at or near, and not more than 20 m from, the point on the road where a speed limit changes.
- If the estimated two-way annual-average daily traffic at the point where a speed limit changes exceeds 500 vehicles, the road controlling authority must also install a speed limit sign on the right-hand side of the road, or on the central median where appropriate, at or near, and no more than 20 m from, that point.
- If a road user might not easily see, or readily understand or react to, a sign that is installed within 20 m of the point on the road where a speed limit changes, a road controlling authority may, install speed limit signs more than 20 m, but as close to it as reasonably practicable, from that point.
- A speed limit sign may be installed otherwise than as required if:
  - authorised under this Rule or any other enactment; or
  - a road user might not easily see, or readily understand or react to, a sign that is installed on the left-hand side of the road; or
  - the sign would be more effective if installed above a lane.

### Variable Speed Limit (VSL) Signage Requirements

When it comes to setting VSLs it appears that NZTA has full discretion over how signage, if any, is installed. It is not clear to what extent NZTA can prescribe their own signage requirements when it comes to VLSs or what adherence, if any, to the standard requirements of Rule 54001 is required.

Setting of Speed Limits (Rule 54001 / 2017) – Section 9.4(1)

*“A road controlling authority, when setting a variable speed limit approved by the Agency, must install signs as specified by the Agency.”*

### Existing Waterview VSL Signage Requirements

The current signage requirements for the existing Waterview VSL are in 'New Zealand Gazette Notice No. 19 – 3 March 2016' and are summarised follows:

- at least two VSL signs at the beginning of the length of road to which a VSL applies,
- on single lane on-ramps, at least one VSL sign at the beginning of the length of road to which the VSL applies,
- at least two VSL repeater signs installed with a spacing of no more than 1.5km between VSL signs for each section of road to which a VSL applies; and
- two standard (static) speed limit signs at the end of a section of road to which a VSL applies.

## 1.12.4 Speed Management Guide (2016)

The Speed Management Guide (SMG) provides a range of tools and procedures to be used in the setting of the permanent speed limit. As SH16/SH20 is a VSL zone these tools will be used, taking into consideration the changing nature of SH16 and SH20 as the traffic flows and demands vary throughout the day.

The SMG has two target areas when it comes to speed management:

- To reduce death and serious harm as well as to improve economic productivity.
- To improve the credibility of speed limits.

The SMG considers various economic and safety considerations as well as community perspectives and preferences as shown in Figure 19.





Figure 19 - Key elements to be considered in speed management

### One Network Road Classification

The SMG has a generalised road function/classification matrix for determining appropriate speed ranges. With both SH16 and SH20 being high volume national highways, and urban motorways, giving them a recommended speed range of 100 to 110km/h as shown in Figure 20. This however, is only a basic approach and a more detailed assessment is warranted.

It is noted that the methodology prescribed in the SMG limits the maximum speed limit of urban roads, including urban motorways, to 80km/h. Advice from Richard Bean of the NZTA is that motorways are a special case and their default speed limit is 100km/h.

Several anomalies were discovered while working through the SMG and were feed back to NZTA and in turn onto Abley, the consultants who made the SMG. Advice from Abley was that the SMG was intended to be as simple as possible and therefore was not overlay suited to complex urban motorways with closely spaced ramps and high traffic volumes.

Classification	Straight open road /urban motorways	Curved open road	Winding open road	Urban (not motorway)
<b>Class 1</b> High volume national	<b>100-110km/h<sup>4</sup></b>  Depends on design and safety risk (e.g. divided 4-5 star, grade separated intersections, safety barriers) and factoring in enforcement thresholds			
<b>Class 2</b> National, Regional, Arterial	<b>80-100km/h</b>  Depends on safety risk and whether volumes justify investment to bring the road up to 3 star equivalent, also enforcement thresholds		<b>60-80km/h</b>	50km/h
<b>Class 3</b> Primary and secondary collector				60-80km/h where safety risk allows, e.g. fewer intersections, mode separation for active users
<b>Class 4</b> Access and low-volume access All winding/tortuous	<b>60-80km/h</b> Depending on roadside development, pedestrian and cyclist volumes, whether sealed or not			30-50km/h  30km/h if high volumes of cyclists/pedestrians  Recognise access and place  10km/h for Shared Spaces

Figure 20 - SMG Recommended Safe and Appropriate Speed Ranges for Road Classes

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## 1.13 Assessment

### 1.13.1 Study Area

This study covers the extents of the exiting VSL zone on both SH16 and SH20 with the addition of the Newton Gully section of SH16 approach to the Central Motorway Junction (CMJ) as shown in Figure 21.

For the purposes of the SMG assessment the study area has been subdivided into 4 sections that are geometrically unique and for which complete data is available. These sections are as follows:

1. SH16 Newton Gully – CMJ to Mountain Road
2. SH16 St Lukes Interchange – Mountain Road to Carrington Road
3. Great North Road Interchange – Carrington Road to Rosebank
4. Dominion Road Interchange – Somerset Road to May Road

Although the SH20 Waterview Tunnel is shown to be included in the study area, it is assumed that it will remain with a maximum posted speed limit of 80km/h.

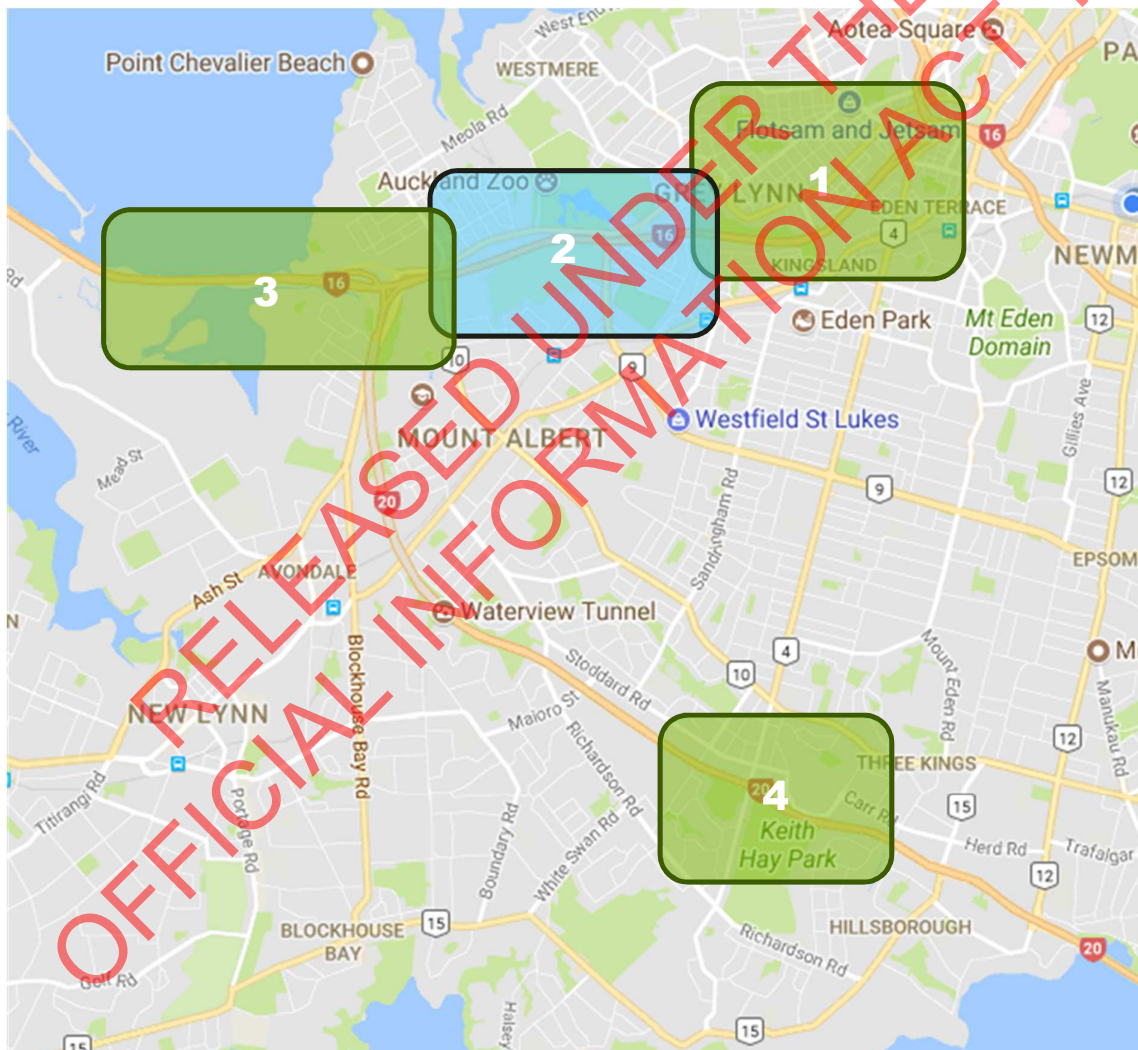


Figure 21 - Study Area

### 1.13.2 KiwiRAP Risk Maps

KiwiRAP provides both 'Personal' and 'Collective' risk maps, refer Appendix C, for most road corridors in the country. These maps are developed using historical data and therefore are based on the pre-opening condition of the study area. Both SH16 and SH20 are shown to have a low 'personal' risk (See Table 6



below) due to the generally high standard of the motorways. However, they have medium-high to high 'collective' risk (See Table 6 below) inherent of the high traffic volumes.

### KiwiRAP Personal Risk

Personal risk represents the crash exposure to each individual vehicle using a section of road. This is the governing factor in the determination of safe and appropriate speed limits.

Table 6 - Personal Risk Rating Summary

Location	Westbound Risk Rating	Eastbound Risk Rating
Great North Rd Interchange	Low Medium	Low
St Lukes Interchange	Low	Low
Newton Gully	Low	Low
Dominion Rd Interchange	Low-Medium	Low-Medium

### KiwiRAP Collective Risk

Collective risk is a measure of crash density and is one of the main factors used to prioritise sections of road where speed management is likely to reduce death and serious injury type crashes. It is also a secondary factor in determining a safe and appropriate speed limit.

Table 7 - Collective Risk Rating Summary

Location	Westbound Risk Rating	Eastbound Risk Rating
Great North Rd Interchange	High	High-Medium
St Lukes Interchange	High	High-Medium
Newton Gully	High	High-Medium
Dominion Rd Interchange	High	High

### 1.13.3 Infrastructure Risk Rating

The Infrastructure Risk Rating (IRR) is a methodology developed by NZTA to assess a road safety risk which is then fed back into the SMG to determine an appropriate posted speed limit.

The IRR assess 8 key features of a roads geometry. Both SH16 and SH20 have been assessed using this method with the results shown in Table 8 and Table 9 respectively and both come out with a low rating.

Table 8 - SH16 IRR Assessment

Category	Observation	IRR Metrix	Risk Rating
Road Stereotype	Motorway	Divided – non-traversable	1.0
Alignment Risk	R=680 – 700m	Curved	1.8
Carriageway Risk	3.5m traffic lane, 3.0 shoulder	3.5m lanes & >2.0m shoulders	0.66
Roadside Risk (left)	Concrete and steel barriers <5m	Minor	0.67
Roadside Risk (right/median)	Concrete barrier <5m	Minor	0.67
Land use risk	Motorway	No access	1.00
At-Grade intersection density	All grade separated connections	<1 intersection/km	1.00
Access Density risk	No at grade connections	<1 accesses/km	1.00

Traffic volume risk	120,000	12,000+ veh/day	3.00
<b>Total Risk Score</b>			0.38 (low)

Table 9 - SH20 IRR Assessment

Category	Observation	IRR Metrix	Risk Rating
Road Stereotype	Motorway	Divided – non-traversable	1.0
Alignment Risk		Curved	1.8
Carriageway Risk	3.5m traffic lane, 3.0 shoulder	3.5m lanes & >2.0m shoulders	0.66
Roadside Risk (left)	Concrete and steel barriers <5m	Minor	0.67
Roadside Risk (right/median)	Concrete barrier <5m	Minor	0.67
Land use risk	Motorway	No access	1.00
At-Grade intersection density	All grade separated connections	<1 intersection/km	1.00
Access Density risk	No at grade connections	<1 accesses/km	1.00
Traffic volume risk	60,000	12,000+ veh/day	3.00
<b>Total Risk Score</b>			0.38 (low)

IRR Score	Rural	Urban
0 to <0.8	Low	Low
0.8 to <1.2	Low-Medium	Low
1.2 to <1.6	Medium	Low
1.6 to <2.0	Medium-High	Low-Medium
2.0 to <2.4	High	Medium
2.4 to <2.8	High	Medium-High
2.8+	High	High

Figure 22 - IRR Risk Bands

### 1.13.4 SMG Proposed Safe and Appropriate Speeds Classification

Table 10 summaries the above assessment results and the recommended posted speed in accordance with the SMG.

Table 10 - SMG Assesement Summary

Location	Function / Feature	Road Safety Metric	Infrastructure Risk Rating	SMG Recommended Speed

<b>Great North Rd Interchange</b>	Class 1	Personal = low/ low-medium  Collective = high / high-medium	Low	110km/h*
<b>St Lukes Interchange</b>	Class 1	Personal = low  Collective = high / high-medium	Low	110km/h*
<b>Newton Gully</b>	Class 1	Personal = low  Collective = high / high-medium	Low	110km/h*
<b>Dominion Rd Interchange</b>	Class 1	Personal = low medium  Collective = high	Low	110km/h*

\*Based on 'high-medium' Collective Risk (Road Safety Metric)

## 1.14 Conclusion

### 1.14.1 Urban Road Classification

Under the SMG rural and urban roads are assessed using the same criteria, however urban roads have a maximum speed limit of 80km/h. For the purposes of the SMG assessment the distinction between urban and rural is based on geographic urban boundaries and as such motorways exist within both the urban and rural classification.

Although although the SMG suggests that 'urban motorways' can have posted speed limits as high as 110km/h, the prescribed methodology limits urban motorways to 80km/h due to their geographic location as shown in Figure 23.

Function / Feature	Road safety metric	Infrastructure Risk Rating	Safe and Appropriate Speed (km/h)
<ul style="list-style-type: none"> <li>ONRC is Class 1 or 2</li> <li>Identified as a Freight Priority Route in a Network Operating Framework</li> <li>Limited Access Road controls</li> <li>Median Divided</li> </ul>	<ul style="list-style-type: none"> <li>Personal Risk <math>\leq</math> Low-Medium;</li> </ul>	<ul style="list-style-type: none"> <li>'Low' or 'Low Medium'</li> </ul>	<ul style="list-style-type: none"> <li>80</li> </ul>

Figure 23 - SMG Proposed Safe Appropriate Speed Classification (urban)

### 1.14.2 Rural Road Classification

As an additional measure the 'urban motorway' sections have been tested as rural. The result of this is that SH16 in the eastbound direction can be posted at 110km/h and 80km/h in the westbound direction. For SH20 a speed limit of 80km/h is recommended in both directions. See Figure 24.

The controlling factor between the 80km/h and 110km/h recommended speed limits is the difference between 'medium-high' and 'high' collective crash risk. As collective crash risk is a secondary factor and influenced by traffic volumes if it were to be discounted both SH16 and SH20 would have recommended posted speed limits of 110km/h.

Function / Feature	Road Safety Metric	Infrastructure Risk Rating	Safe and Appropriate Speed (km/h)
<ul style="list-style-type: none"> <li>• ONRC is Class 1</li> <li>• Median Divided and at least 2 lanes in each direction</li> <li>• No direct property access</li> <li>• Grade separated intersections</li> </ul>	<ul style="list-style-type: none"> <li>• Personal Risk <math>\leq</math> Low-Medium;</li> <li>• Collective Risk <math>\leq</math> Medium-High;</li> </ul>	<ul style="list-style-type: none"> <li>• 'Low'</li> </ul>	<ul style="list-style-type: none"> <li>• 110<sup>7</sup></li> </ul>
<ul style="list-style-type: none"> <li>• ONRC is Class 1 - 3</li> <li>• Sealed road</li> </ul>	<ul style="list-style-type: none"> <li>• Personal Risk <math>\leq</math> Medium;</li> <li>• Collective Risk <math>\leq</math> Medium-High;</li> </ul>	<ul style="list-style-type: none"> <li>• 'Low' or 'Low-Medium'</li> </ul>	<ul style="list-style-type: none"> <li>• 100</li> </ul>
<ul style="list-style-type: none"> <li>• Any ONRC</li> </ul>	<ul style="list-style-type: none"> <li>• Personal Risk <math>\leq</math> Medium-High;</li> </ul>	<ul style="list-style-type: none"> <li>• 'Low' to 'Medium'</li> </ul>	<ul style="list-style-type: none"> <li>• 80</li> </ul>

Figure 24 - SMG Proposed Safe and Appropriate Speed Classification (rural)

### 1.14.3 Post Opening Layout

As noted above, the recommended posted speed limit based on the SMG for both SH16 and SH20 is either 80km/h or 110km/h dependant on the discretion of the 'medium-high' or 'high' collective crash risk. Except for the Newton Gully the study area has been under significant disruption for the past 5 years due to the construction of the Waterview Connection and the associated projects such as the SH16 Causeway Upgrade and the SH16 St Lukes Interchange upgrade. To this extent, the historical information that has been input into both the Personal and Collective Risk values may not be entirely representative of the post opening layout.

For most the works carried out on the SH16 and SH20 motorways significant upgrades have been conducted to improve safety. Based on this it can be expected that the KiwiRAP 'Personal' and 'Collective' risk ratings could be overstating the risk for these newly upgraded sections of road.

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# AIIMS Project Map

Appendix A  
AIIMS Project Map

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**B**

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# SH16 Sight Distance Chart

Appendix B  
SH16 Sight Distance Chart

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C

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# KiwiRAP Risk Maps

D

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# Road Safety Audit

Appendix D  
Road Safety Audit

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