

Addendum - 2 February 2006

Previously this project was named 'Harbour Bridge to City' project and there may be references in this document referring to this name or its abbreviation: HBTC.

The name of this project has since changed and is now referred to as 'Vic Park Tunnel'. Therefore, any reference to 'Harbour Bridge to City' or HBTC should now be taken to refer to Vic Park Tunnel or VPT.

▪ Technical Report No. 1

Harbour Bridge to City Motorway Capacity Improvements: Traffic Impact Assessment

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Harbour Bridge to City Motorway Capacity Improvements: Traffic Impact Assessment

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By
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Revision History

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1 Introduction

The Harbour Bridge to City (HBTC) Corridor of motorway forms the southern approach to the Auckland Harbour Bridge (AHB) and is therefore vital to the regional transportation network. It has significant impact on the local roading network and is key to the operation of the AHB corridor. The traffic demands on this section are sensitive to proposed upstream and downstream capacity improvements, especially the Northern Busway (including High Occupancy Vehicle (HOV) facility) and Central Motorway Junction (CMJ) projects. Similarly, the flows on these projects will be affected by the capacity of the HBTC Project.

The HBTC Corridor is currently heavily congested in both the morning and evening commuter periods. This congestion results from the demand flow on sections of the existing motorway network exceeding capacity, resulting in bottlenecks during peak periods. These bottlenecks also prevent vehicles reaching sections of the motorway that have spare capacity. Traffic Studies show that in order to address the existing congestion problems on this section of the motorway, it is necessary to provide the same number of lanes approaching and departing the AHB as on the bridge itself, particularly during the morning and evening peaks. This would remove the bottlenecks either side of the bridge and allow the full capacity of the bridge to be realised.

This report aims to bring together previously prepared reports that deal with traffic demand, operational behaviour, option assessment and model sensitivity. The following reports/ letters have been incorporated into this document:

The Harbour Bridge to City Transportation Strategy Study (January 2001);

- Harbour Bridge to City Motorway Capacity Improvements: Traffic Impact Assessment (January 2002);
- Harbour Bridge to City Motorway Capacity Improvements: Traffic Impact Assessment (April 2002);
- Traffic Component of the Scheme Assessment Report (October 2002); and
- Harbour Bridge to City Motorway Capacity Improvements: Traffic Impact Assessment (January 2003).

2 Existing Harbour Bridge to City Corridor

2.1 Introduction

The 2.4km long HBTC corridor extends from the southern side of the Auckland Harbour Bridge, south along the existing Southern Motorway (SH 1), through St Mary's Bay and across the Victoria Park Viaduct (VPV) to the Wellington Street overbridge in Auckland City. Included in the corridor are connections at Shelly Beach Road off ramp, Curran Street on ramp, Fanshawe Street on and off ramps, Cook Street off ramp and the Wellington Street on ramp.

The posted speed limit for this section of SH 1 is currently 80km/hr.

The HBTC corridor is the subject of an existing motorway designation included in the Auckland City Council District Plan: Central Area Plan 2004 and the Auckland City Council Operative District Plan 1999: Isthmus Section. The designation had been in place for a number of years and Transit New Zealand is the requiring authority.

The HBTC corridor can be divided into two distinct sections, the on-grade St Mary's Bay Section and the Victoria Park to Wellington Street Overbridge Section.

2.2 St Mary's Bay Section

The St Mary's Bay section of motorway starts at the southern abutment of the Auckland Harbour Bridge and extends 1.4km to the south towards the city to the start of the Victoria Park Viaduct.

The road is on grade and passes along a relatively narrow strip of reclaimed land bounded on the western side by a grassed reserve strip at the base of a cliff, on top of which are located residential properties. The eastern side of the corridor is bounded by, Westhaven Drive and Westhaven Marina.

The road follows a series of moderately tight curves along the former shoreline and is relatively flat in grade. The carriageways in each direction are separated by a median and are at slightly different levels around the curves where the super elevation of each carriageway is developed independently of each other.

Each carriageway direction carries four lanes of traffic. A bus priority lane extends from the Shelly Beach off ramp over the northern length of this section of motorway.

There is one bridge, the Shelly Beach overbridge, carrying off ramp traffic over the corridor towards the northern end. This is a multi span bridge. The existing lane arrangement fits neatly between the piers of the bridge. The bridge has recently been modified to fit one additional south-bound lane of traffic between the piers as part of the Shelly Beach Bus Priority Lane Project.

At the southern end of the St Mary's Bay section of the road, the traffic lanes split. Two lanes in each direction continue on SH1 over the VPV and the remaining two lanes continue for a short distance at grade alongside and beneath the Victoria Park Viaduct before joining the local street network at the Fanshawe/ Beaumont Street intersection.

2.3 Victoria Park to Wellington Street Overbridge Section of Road

This 1.0km length of road can be further split into two sections. These sections are, the Victoria Park Viaduct (VPV) continuing from the St Mary's Bay section and the southern 300m long section of road at grade between the VPV and the Wellington St overbridge.

2.3.1 *Victoria Park Viaduct (VPV)*

The VPV is a major concrete bridge. This moderately curved 590m long bridge carries SH1 over Victoria Park, Beaumont Street and Victoria Street and runs adjacent to three historic buildings. The viaduct was built during the period 1961 to 1964.

Significant lengths of the approach embankments are contained within reinforced concrete retaining walls located at either end of the viaduct.

The viaduct is made up of twin parallel carriageways each on separate decks. Each carriageway presently carries two lanes in each direction. The 50mm nominal width separation between decks has allowed the super elevation around the horizontal curves to be developed independently and minimise the height of the bridge above the ground.

A concrete barrier is provided on the inside edge of each of the decks to provide median separation between the carriageways. This is a relatively recent addition to the bridge. Edge protection is provided on the outside edge of the decks by the original lightweight steel post and rail system mounted on a concrete kerb.

The viaduct has a number of known deficiencies. A major seismic retrofit is required, the edge protection (barriers) does not meet current standards and alkali silica reactivity (ASR) damage is present in some sections of the bridge superstructure.

2.3.2 *Road South of VPV to the Wellington Street Overbridge*

This 300m length of road is at grade and climbs up a 3.3% grade as it continues south to join with the Central Motorway system. The Wellington Street Over Bridge passes over the road at the southern end of the HBTC corridor. An off ramp to Cook Street from the south-bound lanes of SH1 exits at the southern end of the VPV.

3 Problem Description

3.1 Transportation Strategy Summary

The 'Harbour Bridge to City Transportation Strategy Study' was prepared by Beca in January 2001. The purpose of this report was to set the strategic framework for the more detailed investigations of the Harbour Bridge to City Project. This strategic framework has the following specific aims:

- To determine the long-term role of the HBTC Project and the strategy to accommodate the demands in the context of local and regional priorities based on the assumption that the HBTC project will be an automated highway with full ATMS capabilities.
- The overall HBTC study aim is to balance and utilise the full capacity of the existing Harbour Bridge in a managed way.

The following Strategic Policies were identified by this Study:

1. Based on the predicted level of Passenger Transport usage and the retention of the existing AHB configuration, the HBTC project will need to provide lane configurations as detailed below:

	Northbound			Southbound		
	AM Period	Interpeak Period	PM Period	AM Period	Interpeak Period	PM Period
Auckland Harbour Bridge	3	4	5	5	4	3
St Mary's Bay	3	4	5	5	4	3
Victoria Park Viaduct	2	3	3	3	3	2

2. The design of options for the HBTC project should not consider the needs or implications of a future harbour crossing. However, in evaluating competing options for the HBTC project, some weight should be given to options, which clearly demonstrate a greater flexibility for expansion to accommodate components of a future crossing. Other tangible and intangible benefits identified should take precedence over any weighting for potential compatibility with future crossings;
3. Transit to consider adopting a policy that ramp metering strategies (or other demand management techniques) be provided with any additional capacity;
4. It is recommended that in the detailed investigation of the HBTC project, no specific requirements for exclusive bus (or other mode) facilities be considered on the motorway proper other than the southbound bus shoulder lane from Shelly Beach to Fanshawe Street;

5. Given that they all serve different catchments and spread the access movements to the AHB corridor, all three connections (Shelly Beach, Fanshawe St and Cook/Wellington Streets), are believed to be important to the system and should be retained;
6. To maintain optimal efficiency of and success of the bus priority philosophy for the corridor, a policy should be adopted to ensure all exit points are designed to accommodate the expected exit flows resulting from maximising the Auckland Harbour Bridge vehicle capacity, without queues interfering with the operation of the motorway proper;
7. It is recommended that demand management facilities (i.e. ramp metering) be included in the design of access arrangements to this section of motorway to maintain optimal operating conditions. Ramp meters are proposed for Wellington Street and Curran Street. As the high traffic volume from Fanshawe Street accesses the Northern Motorway as two new lanes the through St Marys Bay section it is not recommended that ramp metering be implemented on Fanshawe Street on ramp;

4 Existing Traffic Flows

The 2001 traffic flows (peak hour flows and Annual Average Daily Traffic (AADT)) for this section of motorway are shown in **Figure 4.0**. These have not been updated from 2001 to 2004 as a number of the traffic counting loops within this project have not been working since 2001 due to CMJ construction activity. Also the 2001 traffic flows are compatible with 2001 demand figures used in the impact assessment below. As the northern motorway has been at capacity since 1994 the flow of traffic within the study area (across the Auckland Harbour Bridge, through St Marys Bays and across the Victoria Park Viaduct) has not changed in the peak hour. Therefore the use of 2001 year traffic flows is relevant and robust.

This Figure 4.0 shows the counted supply of traffic to each motorway ramp and section, as opposed to the traffic demand for that ramp or section. The traffic demand, that is the volume of traffic that desires to travel on a particular link, is shown in **Tables 4.0 and 4.1**, along with the calculated volume/ capacity ratios. The 2001 northbound demand figures have been obtained from the EMME2 Central Motorway Improvements (CMI) network demand model, while the southbound demand figures are derived from the Saturn demand model developed by Beca/ Opus International Consultants in 2001 for the North Shore Priority Bus Lane project.

Simply stated, traffic demand is the number of unconstrained vehicles arriving at a section, whereas supply is the number of vehicles exiting that section. The maximum supply rate (throughput) is the capacity of that section.

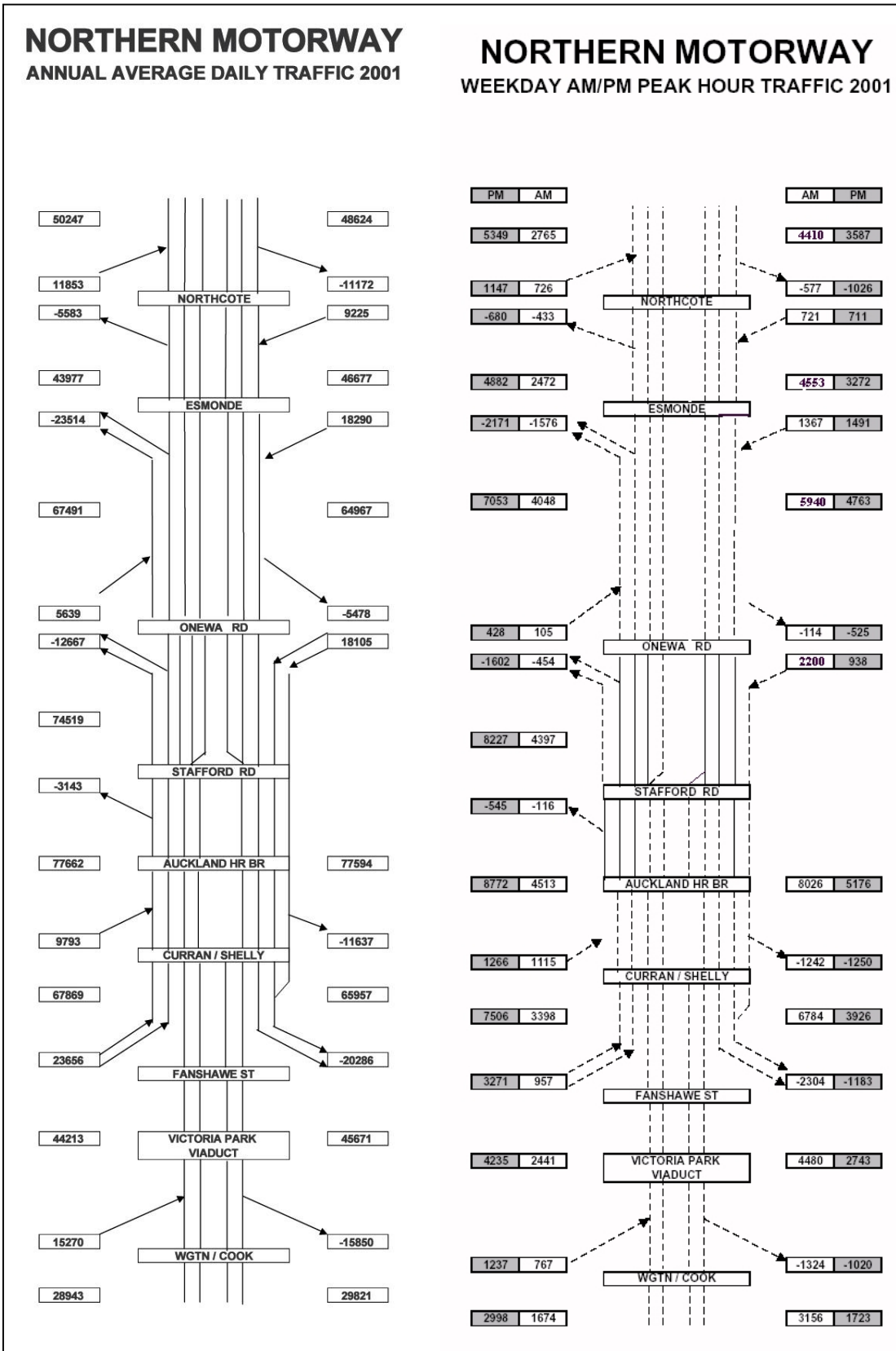


Figure 4.0 Existing HBTC Corridor Traffic Flows 2000/2001

When the demand for travel exceeds the capacity of a motorway section then that section is said to be congested (or over capacity). This is reflected in a Volume to Capacity (V/C) Ratio greater than 1.0. It should be noted that even though the demand for travel on a particular section may exceed the capacity of that section, the demand flow might not be able to reach the said section due to the restricted capacity of upstream or downstream bottlenecks. In this respect, the actual operational volume/ capacity ratio cannot exceed 1.0 in practice. Tables 4.0 and 4.1 show the existing capacity of each of ramp/ link along the corridor compared with the 2000/ 2001 supply and demand flows.

Table 4.0 Existing 2000/01 Peak Hour Volume to Capacity Ratio for Motorway Section between Wellington Street and Esmonde Road Northbound

Direction		Northbound AM			Northbound PM		
Northbound	Capacity	Demand Flow	Supply Flow	V/C Ratio	Demand Flow	Supply Flow	V/C Ratio
		(AM, vph)	(AM, vph)	(AM)	(PM/ vph)	(PM/ vph)	(PM)
South of Wellington Street	4300	1700	1700	0.40	3350	3000	0.78
Wellington St On Ramp	1700	750	750	0.44	1250	1250	0.74
Wellington Street to Fanshawe Street	4300	2450	2450	0.57	4600	4250	1.07
Fanshawe Street On Ramp	3400	950	950	0.28	3450	3250	1.01
Fanshawe Street to Curran Street	8600	3400	3400	0.40	8050	7500	0.94
Curran Street On Ramp	1700	1100	1100	0.65	1650	1300	0.97
AHB, Curran Street to Stafford Road Off Ramp *	10500	4500	4500	0.43	9700	8800	0.92
Stafford Road Off Ramp	2100	100	100	0.05	550	550	0.26
Stafford Road Off ramp to Onewa Road Off ramp	10500	4400	4400	0.42	9150	8250	0.87
Onewa Road Off Ramp	2100	450	450	0.21	2150	1600	1.02
Onewa Road Off Ramp to Onewa Road On Ramp	8600	3950	3950	0.46	7000	6650	0.81
Onewa Road On Ramp	2100	100	100	0.05	450	450	0.21
Onewa Road to Esmonde Road	8600	4050	4050	0.47	7450	7100	0.87
Esmonde Road Off Ramp	4200	1600	1600	0.38	2450	2200	0.58
North of Esmonde Road Off Ramp	6450	2450	2450	0.38	5000	4900	0.78

* The full capacity of the five northbound lanes of the AHB cannot currently be achieved due to the approach capacity and vehicle interaction at the Curran Street on ramp.

Those sections where existing demand is approaching capacity (V/C ratio => 0.8) are shown **bold** in the table above, whereas those sections where existing demand exceeds capacity (V/C ratio =>1.0) are shown **bold** and **shaded**.

Table 4.1 Existing 2000/01 Peak Hour Volume to Capacity Ratio for Motorway Section between Esmonde Road and Wellington Street Southbound

As can be seen in the above tables, the worst congestion on the network occurs in the

Direction		Southbound AM			Southbound PM		
Southbound	Capacity	Demand Flow	Supply Flow	V/C Ratio	Demand Flow	Supply Flow	V/C Ratio
		(AM, vph)	(AM, vph)	(AM)	(PM/ vph)	(PM/ vph)	(PM)
North of Esmonde Road	6450	5850	4550	0.91	3300	3300	0.51
Esmonde Road On Ramp	2100	1350	1350	0.64	1500	1500	0.71
Esmonde Road to Onewa Road	6450	7200	5900	1.1	4800	4800	0.74
Onewa Road Off Ramp	2000	100	100	0.05	550	550	0.28
Onewa Road Off Ramp to Onewa Road On Ramp	6450	7100	5800	1.10	4250	4250	0.66
Onewa Road On Ramp ¹	2200 ¹	2600	2200	1.00	950	950	0.37
Onewa Road to Shelly Beach Road (AHB)*	10500	9700	8000	0.92	5200	5200	0.50
Shelly Beach Off Ramp	2100	1700	1250	0.81	1250	1250	0.60
Shelly Beach Road to Fanshawe Street	8600	8000	6750	0.93	3950	3950	0.46
Fanshawe Street Off Ramp	3400	3000	2300	0.88	1200	1200	0.35
Fanshawe Street to Cook Street	4450	5000	4450	1.12	2750	2750	0.64
Cook Street Off Ramp	2000	1800	1300	0.90	1000	1000	0.50
South of Cook Street	4300	3200	3150	0.74	1750	1750	0.41

* The full capacity of the five southbound lanes of the AHB cannot currently be achieved due to the approach capacity and vehicle interaction at the Onewa Road southbound on ramp.

southbound direction during the morning peak period and in the northbound direction during the evening peak period. During these periods many of the ramps/ links are either approaching capacity in relation to demand, or exceed capacity. With the growth in traffic volumes from 2001 to 2005 the demand has resulted in capacity being exceeded for longer.

The capacity values shown above have been estimated using the methodology contained within the Transportation Research Boards Highway Capacity Manual. In addition, these

¹ The capacity of the one lane Onewa Road southbound on ramp is high due to the two-lane approach on Onewa Road (which merges to one lane prior to entering the on ramp), and the signal configuration at the Onewa Sylvan Road Intersection. This estimate of capacity has been made from observing historical supply flow counts on the ramp (see **Figure 4.0**).

estimated capacities were compared against historic flows to ensure compatibility. As the recorded flow rates (approximately 2200 vph during the 2001 morning peak) on the Onewa Road southbound on ramp frequently exceed the theoretical capacity. The capacity of that ramp has been adjusted to 2200 vph. In reality capacity is a dynamic property that can change day-to-day and even period-to-period depending on traffic composition/behaviour and vehicle interaction at critical bottlenecks.

The capacities shown in **Tables 4.0 and 4.1** therefore represent theoretical mean values.

During the period between the morning and afternoon commuter peaks (the Interpeak (IP)) traffic demand is noticeably less than during the commuter peaks. This can clearly be seen in **Figures 4.2 and 4.3**, which show all day flow vs. speed profiles for each direction of travel on the section of motorway immediately south of the Wellington Street underpass.

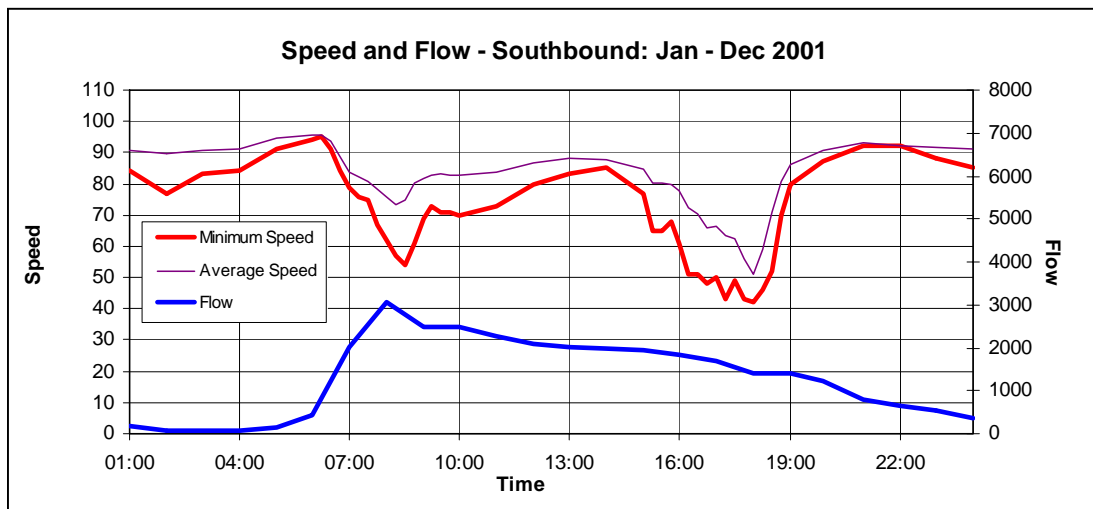


Figure 4.2 Southbound Daily Flow Profile south of the Wellington Street underpass

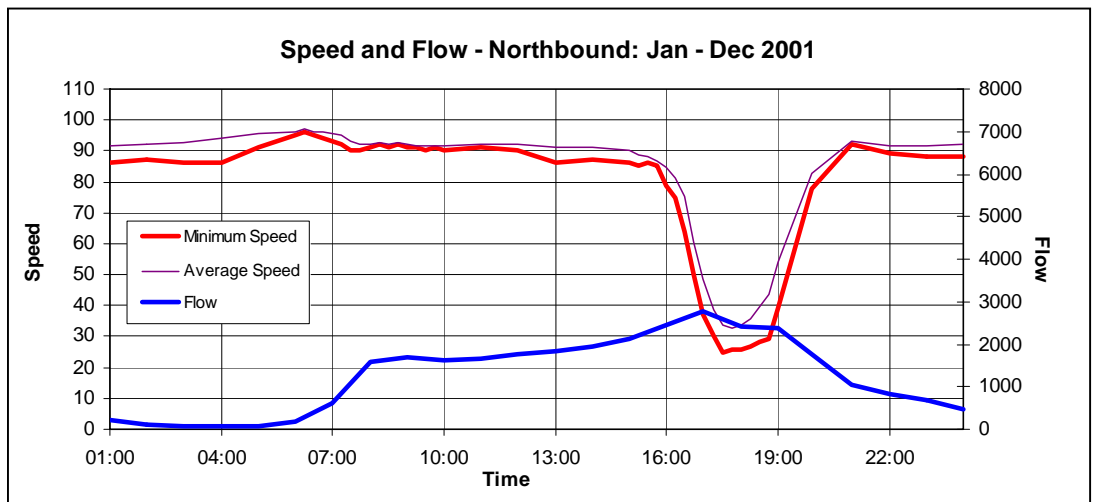


Figure 4.3 Northbound Daily Flow Profile south of the Wellington Street underpass

A sharp volume peak at around 8am typifies the southbound traffic profile on the VPV as commuter traffic from the North Shore approaches the city. This peak flow rate is accompanied by a reduction in mean travel speed as the facility approaches and then reaches capacity.

Preceding this morning peak, traffic volumes increase steadily from lower overnight volumes. This increase tends to start around 6am. After reaching a peak flow rate at around 8am the flow rates then decrease steadily for the rest of the day. A noticeable decrease in mean vehicle speeds is evident in the southbound direction from approximately 2pm, however this is not accompanied by an increase in flow rate. This decrease in speed was attributed to blocking back from downstream bottlenecks, principally associated with the on and off ramps between Hobson Street and Gilles Ave. The completion of the CMJ Stage 1 and 2 works from Hobson Street on ramp to the Newmarket Viaduct have resulted in this issue reducing significantly. A bottleneck still occurs at Newmarket Viaduct in the southbound direction, but the proposed widening of the Newmarket Viaduct to four southbound lanes through to at least Green Lane East will address this issue.

Mean vehicle speeds in the northbound direction remain generally constant at 80 km/h to 90 km/h for much of the day, except during the evening peak period when vehicle speeds decrease to 20 km/h to 30 km/h. This reduction in speed results from the VPV reaching capacity and the interaction with the bottleneck associated with the Wellington Street northbound on ramp. With the opening of the Port and Northwestern Motorway to Northern Motorway link it is considered that this bottleneck would only get worse. It is therefore proposed that this motorway link plus the Wellington Street and Curran Street on ramps will be ramp metered to stop the motorway proper traffic from breaking down significantly.

5 Existing Traffic Conditions

The critical directions of travel (where travel demand is the greatest) have been identified to be southbound during the morning peak period and northbound during the evening peak period. The existing traffic conditions during these periods are discussed below.

5.1 Southbound (AM Peak)

The supply of southbound traffic to the corridor is restricted by the capacity of the motorway and ramps at Esmonde and Onewa Roads to the north of the AHB.

Although the peak hour supply of traffic flow immediately south of Esmonde Road in the morning peak has decreased from 6600 vph in 1994 to 5500 vph in 2001. This has reduced further to 5,000 in 2002 due to poor lane discipline, resulting in a continued reduction in capacity and resulting in a southbound bottleneck at this location. Likewise, the capacity of the Onewa Road on ramp merge weave¹ is exceeded by demand during the morning peak, creating an additional southbound bottleneck. The result of these bottlenecks (and interaction with bottlenecks to the south of the bridge that block back) is to limit the southbound supply of vehicles to the AHB to approximately 8000 vph (8800 vph in 1994). As the existing capacity of the AHB, with five lanes operating in the direction of travel, is estimated to be 2100 vph per lane (or 10,500 vph total) these bottlenecks therefore prevent the bridge from realising its full capacity.

During the morning peak period, the southbound section of the Victoria Park Viaduct is a major contributor to southbound traffic congestion through the corridor as it currently has only two lanes for traffic travelling to the city via Cook St and further south, with a capacity in the order of 4450 vph (2225 vph/ lane). The southbound demand during this period is approximately 5000 vph, exceeding capacity by approximately 550 vph. This bottleneck often results in vehicles blocking back from the viaduct and onto the Harbour Bridge. This blocking back in turn reduces the supply of vehicles to the Fanshawe Street off ramp, which then contributes to blocking back across the AHB.

The reduction in supply of vehicles to the AHB over recent years has resulted from the worsening bottleneck at Victoria Park Viaduct, Esmonde and Onewa Roads from poor lane discipline. The CMJ Stage 1 and 2 works have addressed the bottleneck at Hobson Street, but a new bottleneck at the four to three lane merge onto the Newmarket Viaduct has been created.

The traffic flow on the Fanshawe Street southbound off ramp has also consistently reduced during the morning peak between 1994 (3250 vph) and 2001 (2300 vph). This flow reduction is a combination of the lower traffic flow over the AHB in the peak hour and a reduction in the green time allocated to the off ramp movement at the Fanshawe/ Beaumont Street signalised intersection (due to increased volumes on Beaumont Street

¹ The Onewa Road on ramp weave is caused by traffic from south of Esmonde Road weaving across from lane 2 to access lane 1 on to the bridge to exit at Shelly Beach off ramp and Onewa Road on ramp traffic weaving across from lane 1 to lane 3 to travel south across the Victoria Park Viaduct.

associated with the western reclamation development), in conjunction with trip reassignment to Cook Street and further south.

5.2 Northbound (PM Peak)

In the evening peak period, the northbound supply of vehicles to the corridor is restricted by the capacity of the Wellington Street northbound on ramp merge area and the VPV (4300 vph).

The northbound traffic demand on the VPV during the same period is in the order of 4600 vph during the evening peak, resulting in upstream blocking back from the Wellington Street merge, and slow vehicle speeds across the Viaduct. Queuing back from this bottleneck can reach as far as the Newmarket Viaduct during peak periods, thus restricting traffic flow to the northbound off ramps between Gilles Avenue and Nelson Street, and increasing the queue back to Greenlane interchange on the southern motorway.

The northbound evening peak supply flows on the AHB have been fairly constant at between 8,600 vph to 8,800 vph from 1996 to 2001, apart from a low point in 1997/98 when 8,300 vph were recorded on the AHB. This is despite increasing the number of northbound lanes between Onewa Road and Esmonde Road to four in 2001. This lane increase resulted in the capacity of this section of motorway exceeding demand, but failed to significantly increase northbound volumes on the AHB during the evening peak, further indicating that upstream bottlenecks control the supply of flow to the AHB.

5.3 Interpeak Period

During the period between the AM and PM Peak Periods (the Interpeak) the capacity of all sections of the motorway and ramps from Esmonde Road to Wellington Street over-bridge exceed current demand.

It is assumed that during the Interpeak period there is a dynamic capacity reduction on the VPV from 4300 vph to 3760 vph due to the change in vehicle classification from predominantly commuter vehicles to a high mix of heavy and light commercial vehicles, visitors travelling through the city and recreational/ social/ shopping purpose trips. By 2011 it is expected that the two lanes across the VPV will be at capacity and traffic demand will be approximately 4200 vph during the Interpeak period.

5.4 Bus lanes/ HOV

A bus shoulder lane was constructed southbound from Shelly Beach off ramp to approximately 400m south in 2001 and extended to Fanshawe Street in 2005. Prior to this, southbound Lane 1 of the AHB formed a lane drop at Shelly Beach southbound off ramp, resulting in under utilisation of this lane by through traffic. The newly constructed facility allows buses only to travel straight through to St. Mary's Bay from Lane 1 in the morning

peak period, with the Shelly Beach off ramp acting as a diverge. During all other periods this lane is available to all vehicles, improving lane utilisation.

The shoulder lane allows buses to access a priority route over the bridge and through to Fanshawe Street off ramp, thereby bypassing the delays associated with queuing from the Fanshawe Street/ Beaumont Street signalised intersection.

6 Future Traffic Growth

The Annual Average Daily Traffic (AADT) on the AHB has historically been growing at between 2.2% and 2.6% in both directions of travel from 1994 to 2001, as shown in **Figure 6.0**, below. The annual arithmetic growth rate has however been decreasing steadily over the same period, as shown in **Figure 6.1**. This growth is the increase in supply of vehicles to the corridor and has been assumed to be 2.5% per annum. As the historic growth rate has been decreasing over recent years the adopted growth rate is expected to provide a higher estimate of future travel supply.

The growth in traffic demand for the corridor has been calculated from the Auckland Regional Transport (ART) model. This model predicts future land use and assigns predicted traffic generation and attraction accordingly. This demand is shown in **Tables 4.0 and 4.1**, for the year 2001, and in **Tables 6.0 and 6.1** for the year 2011, with the HBTC and CMJ capacity improvements operating.

The traffic demand growth rate as predicted by the ART model is somewhat different than the historic traffic supply growth rate, equating to 0.52% per annum southbound (0.41% northbound) on the AHB and 1.8% southbound (3.7% northbound) on the VPV.

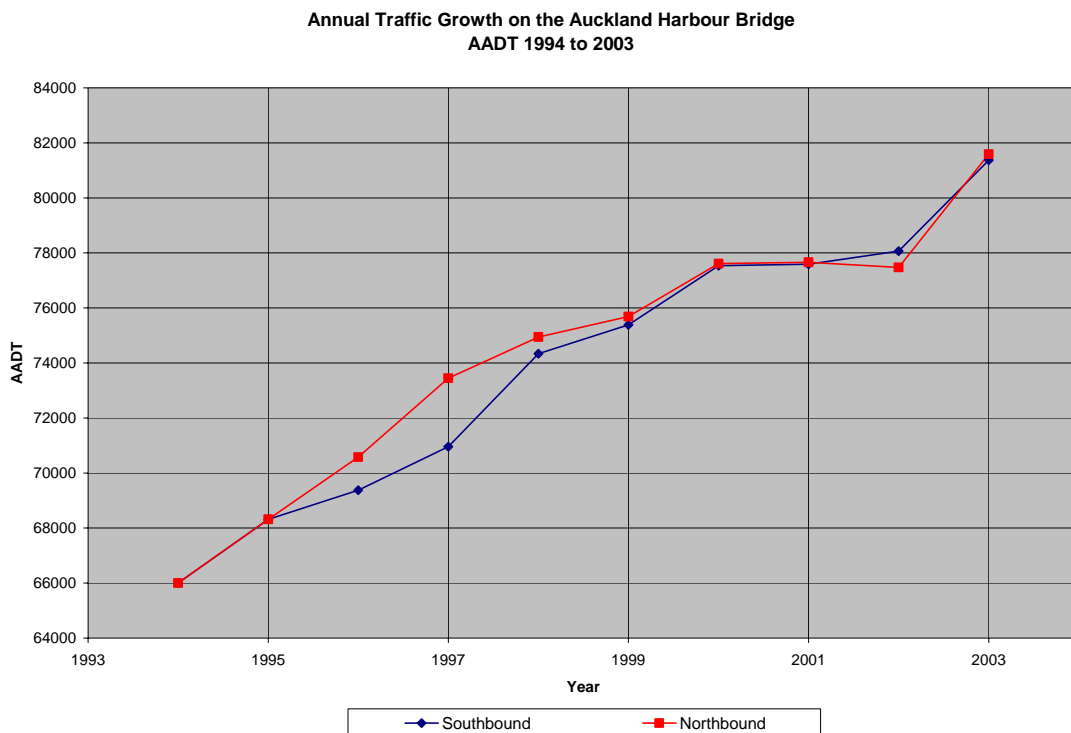


Figure 6.0 Historic Traffic Growth (AADT) on the Auckland Harbour Bridge

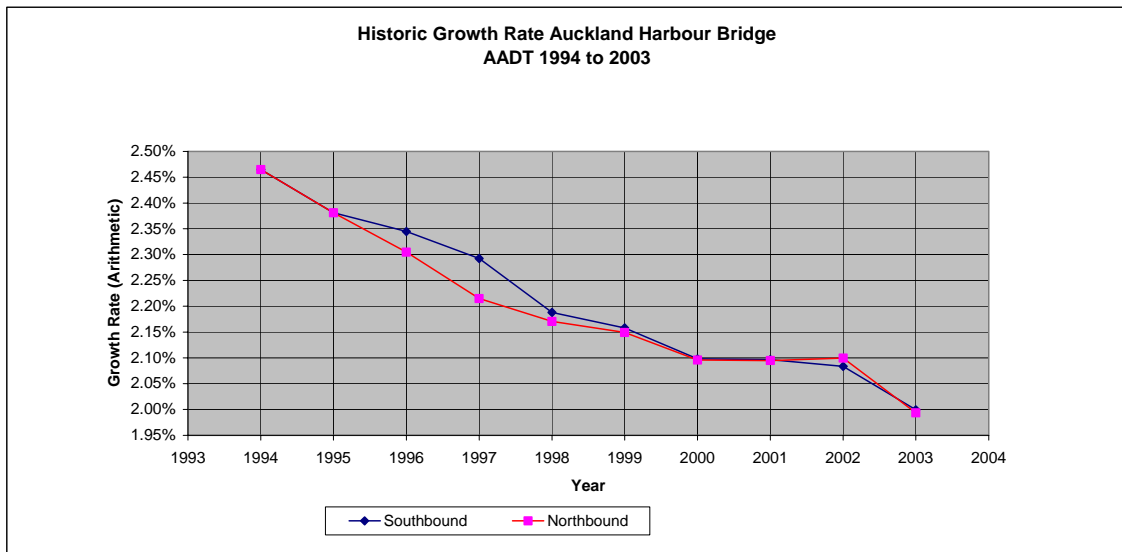


Figure 6.1 Historic Traffic Growth rate (AADT) on the Auckland Harbour Bridge

Population growth within Rodney and the North Shore is predicted to increase at approximately 1.2% per annum, and traffic growth has historically grown at approximately twice the population growth rate. This further supports the adoption of a 2.5% arithmetic growth rate per annum for traffic demand. With this growth rate the predicted 2011 demand flows for the various ramp and motorway sections along the corridor were calculated and are shown in **Tables 6.0** and **6.1**. It should be noted that although the capacity of a single lane merge onramp may be in the order of 1700 vph (as calculated from the Highway Capacity Manual 2000), the capacity of the onramp/ motorway merge area may in fact be less than this figure (1200 to 1500 vph) due to vehicle interaction between vehicles entering from the on ramp and vehicles in Lane 1 of the motorway. The merge area capacity reduces as the flow in Lane 1 of the motorway increases.

Only 2011 traffic demand flow have only been used in the impact assessment, as projected demand 2021 flows are similar to 2011 traffic flows. This is due to the impact of the Northern Busway, which attracts the growth in person movements across the Auckland Harbour Bridge, and accommodates these by both HOV and bus operations.

Based on the projected 2011 demand traffic flows the following sections could be at or near capacity following construction of the HBTC project:

- PM Peak Northbound Fanshawe Street on ramp
- Auckland Harbour Bridge (merge at the Curran Street on ramp will need to be managed through ramp metering)

AM Peak Southbound

- Esmonde to Onewa
- Onewa on ramp
- Auckland Harbour Bridge
- Shelly Beach Road to Fanshawe Street

- Fanshawe Street

The bottleneck at Esmonde Road on ramp will reduce the supply of traffic southbound and therefore affect the V/C ratio south of Esmonde Road on ramp. Therefore only the provision of High Occupancy Vehicle using the Northern Busway that bypasses this bottleneck will allow the Auckland Harbour Bridge full capacity to be reached.

Table 6.0 Predicted 2011 Peak Hour Demand Flows for Motorway Section between Wellington Street and AHB Northern Abutment Northbound (with improvements)

<i>Direction</i>		<i>Northbound PM</i>	
<i>Northbound</i>	<i>Capacity</i>	<i>Demand Flow 2011 (PM/ vph)</i>	<i>V/C Ratio 2011 (PM)</i>
South of Wellington Street	6450	5000	0.78
Wellington St On Ramp	1700	700	0.41
Wellington Street to Fanshawe Street	6450	5700	.88
Fanshawe Street On Ramp ²	3200	3400	1.06
Fanshawe Street to Curran Street	10500	9100	0.86
Curran Street On Ramp	1700	1000	0.60
AHB, Curran Street to Stafford Road Off Ramp	10500	10100	0.96

Table 6.1 Predicted 2011 Peak Hour Demand Flows for Motorway Section between Onewa Road and Wellington Street Southbound (with improvements)

<i>Direction</i>		<i>Southbound AM</i>	
<i>Southbound</i>	<i>Capacity</i>	<i>Demand Flow 2011 (AM, vph)</i>	<i>V/C Ratio 2011 (AM)</i>
Esmonde to Onewa Road On Ramp	6450	6700	1.04
Onewa Road On Ramp	2600 ³	3500	1.35
Onewa Road to Shelly Beach Road (AHB)	10500	10200	0.97
Shelly Beach Off Ramp	2100	1000	0.48
Shelly Beach Road to Fanshawe Street	10500	9200	0.88

² The capacity of the Fanshawe Street on ramp will reduce between 2001 and 2011 due to an additional signal phase to accommodate traffic generation from the Western reclamation.

³ The capacity of the Onewa Road On ramp in 2011 will increase by approximately 400 vph due to the addition of an HOV lane.

Direction		Southbound AM	
Southbound	Capacity	Demand Flow2011 (AM, vph)	V/C Ratio 2011 (AM)
Fanshawe Street Off Ramp	3400 + Buslane	3200 + 100 buses/hr	0.94
Fanshawe Street to Cook Street	8400	5900	.70
Cook Street Off Ramp	2000	1500	0.75
South of Cook Street	6450	4400	0.68

7 *Preliminary Design of Northbound Tunnel Option*

7.1 Description of Northbound Tunnel Option

The following is a description of the proposed alignment changes to the HBTC Corridor, which is shown in Appendix A.

7.1.1 *St Mary's Bay*

Through the SMB section of the corridor the new alignment remains generally within the existing motorway corridor. The carriageway will remain at grade with split carriageways similar to the existing motorway. The new motorway will consist of:

- 5 lanes southbound and a shoulder bus lane that will be marked as a peak hour bus shoulder lane.
- 5 lanes northbound, The motorway will be widened on both sides and a new median will be constructed to accommodate the additional lanes. Westhaven Drive will not be affected by the work.

There will generally be no encroachment beyond the existing fence line on the SMB side of the motorway (except for an area adjacent to the Shelly Beach overbridge and Ngapona) although some improvements such as landscaping, footpaths and noise walls will be located outside the existing motorway designation in some areas.

7.1.2 *Victoria Park to Wellington Street Overbridge*

The new northbound tunnel to the west of the existing viaduct structures will provide 3 lanes. The existing viaduct will be converted to carry southbound traffic only. The existing southbound viaduct will carry 2 lanes of traffic with destinations for Cook Street and the new links to the Port and Northwestern Motorway. The existing northbound viaduct will be converted to carry 2 lanes that continue southbound through Central Motorway Junction (CMJ). As part of the widening works, seismic strengthening and ASR rehabilitation will also be carried out. Between the Wellington Street overbridge and the Hobson Street on ramp the two southbound alignments cross over in a "braided" arrangement.

The Cook Street off ramp alignment does not change.

Three lanes come from the south (2 lanes from SH1 and 1 lane from the Northwestern and Port) will continue northbound using the NBT. The Wellington Street northbound on ramp remains in its present location, but will be ramp metered with the Northwestern and Port motorway link to avoid a bottleneck on the Southern Motorway.

7.2 Interface with Adjoining Projects

The physical extent of the project is from the southern abutment of the AHB to the Wellington Street overbridge. The main project interface is with the Central Motorway Junction Project to the south and the North Shore Busway to the north.

7.2.3 *Central Motorway Junction*

The construction and timing of the physical works will be integrated between the two Central Motorway Improvement (CMI) projects - HBTC and CMJ, which will lead to different contracts for the northbound and southbound work between the Cook Street off ramp and Wellington Street overbridge.

7.2.4 *North Shore Busway*

Although the Busway does not physically connect with the HBTC works, operationally it is an important part of the project. In the southbound direction buses travel in the normal traffic lanes over the AHB and will then move into a dedicated bus shoulder lane from near the Sails restaurant through to Fanshawe Street to connect with the Auckland City bus lane. In the northbound direction the bus lane on Fanshawe Street will not change, and will effectively merge with Fanshawe Street on ramp traffic to use lane 1 through St Mary's Bay and across the AHB.

7.2.5 *ATMS*

Other project interfaces are with the Advance Traffic Management System project, which covers the HBTC corridor.

7.2.6 *Connections*

All existing on and off ramps remain in operation and no additional ramps are provided by the project. Therefore Curran Street on ramp, Shelly Beach off ramp, Fanshawe Street off ramp and on ramp, Cook Street off ramp and Wellington Street on ramp will remain the connections between the motorway and local traffic network within the HBTC corridor.

As part of the project, the Fanshawe / Beaumont Street intersection will be upgraded to provide additional capacity and cater for bus priority measures and accommodate increased traffic generation from the western reclamation.

7.3 Dangerous Goods Vehicles

The proposed construction of a northbound tunnel under Victoria Park could potentially result in vehicles carrying dangerous goods having to exit the motorway prior to the northbound tunnel and travel on the local road network. Currently approximately 5% of

the traffic flow over the Auckland harbour bridge is heavy vehicles with approximately 1% of those being dangerous goods. Based on the current northbound traffic flow crossing Victoria Park of approximately 46,000 vehicles per day the proportion of dangerous vehicles would be 23 per day. The impact of these dangerous vehicles using the local road network is less than minor.

8 Predicted Future Traffic Conditions

The proposed traffic conditions following commissioning of the proposed improvements are discussed below. This discussion has been divided into southbound and northbound directions of travel for simplicity.

8.1 Southbound Traffic Conditions

The Northern Busway project is expected to increase the southbound supply north of Onewa Interchange by 1,550 vph (comprised of 1400 High Occupancy Vehicles and 150 buses per hour). The capacity of the Onewa Road southbound on ramp will remain at approximately 2200 vph. Including the supply of 6450 vph from north of the Onewa interchange, this will result in maximum southbound supply rate of 10,200 vph to the AHB, an increase of approximately 2200 vph over the recorded 2001 supply rate of 8000 vph. By the year 2011 the southbound demand on the AHB during the morning peak is expected to have increased to approximately 10,200 vph, leaving no spare capacity.

As previously discussed, the southbound supply of vehicles to the AHB is controlled by the Esmonde Road and Onewa Road bottlenecks to the north of the AHB. In addition, queuing back from the southbound VPV bottleneck can reduce supply to both the Fanshawe Street southbound off ramp and the AHB.

The proposed additional southbound lane (from 4 to 5 lanes) from the AHB to Fanshawe Street, and an additional southbound lane (from 2 to 4 lanes) on the VPV will increase capacity, alleviating these bottlenecks and reducing the blocking back effect that currently reduces flow on the AHB during the morning peak period. In addition, proposed improvements to the Fanshawe Street off ramp, and Fanshawe Street itself, will maximise the capacity of the off ramp and reduce blocking back through St. Mary's Bay.

The bus shoulder lane facility completed in 2001 would be improved to provide a full southbound lane for buses from the AHB to Fanshawe Street. This facility will reduce bus travel times as well as decreasing congestion on the motorway proper by removal of buses from the main traffic stream.

In order to predict the operational behaviour of the motorway corridor following completion of the proposed capacity improvements a micro-simulation model¹ was created to simulate traffic conditions. This model uses flows predicted for the year 2011 by the CMI model, and the output is therefore predictive of the conditions in that year. The simulation model assumes that the western reclamation would be fully developed and so includes flows associated with that development. The results of the southbound micro-simulation model are discussed below.

¹ Micro-Simulation model created using GETRAM simulation environment and AIMSUN 2 graphical interface.

8.1.1 *A note on the Southbound Micro-Simulation Model Construction*

In order to accurately simulate the decision making that is made by southbound motorists the location of 'section joins' within the micro-simulation is critical. As vehicles within the model can only look ahead two joins to make lane change decisions these joins must be located so as to allow this decision making to occur in the correct location.

For the southbound model, section joins are located at the merge between the Onewa Road southbound on ramp and the motorway, at the Shelly Beach off ramp diverge, and at the Fanshawe Street off ramp diverge. This configuration allows vehicles to select a lane with a view to exiting at Shelly Beach or Fanshawe Street, once they have passed the Onewa Road on ramp. This effectively allows vehicles to select an appropriate lane before entering the Auckland Harbour Bridge, in addition to the zone between the southern bridge abutment and Fanshawe Street. Without this configuration, the majority of lane change decisions would be made upon exiting the bridge, and this turbulence would create unrealistic restrictions on lane capacity through St Mary's Bay on the approach to the Fanshawe Street off ramp.

The results of the southbound micro-simulation model are discussed in the following sections.

8.1.2 *Auckland Harbour Bridge*

The simulation model for the year 2011 indicates that all southbound lanes of the AHB would be running near capacity between 7am and 9am. During this period approximately 10,000 vph would be crossing the bridge (see **Figure 8.1**), and mean vehicle speeds would be between 65 km/h and 70 km/h, as shown in **Figure 8.2**.

It is expected that as a result of the North Shore Busway and Priority Lane the percentage split of vehicles exiting the motorway at Fanshawe Street would reduce from 34-39% to approximately 29%.

Southbound vehicles heading towards the CBD from Onewa Road and further north have two 'zones' in which lane choice is made. The first of these is immediately south of the Onewa Road Interchange, on the northern approach to the AHB. At this point, vehicles approaching from north of the Onewa Road interchange may decide to change into Lanes 1 and 2 with a view to exiting at Shelly Beach or Fanshawe off ramps. In addition, some vehicles may change to lanes 3 to 5, with a view to exiting at Cook Street or further south. These decisions are made in this area due to the limited lane changes that can be made on the bridge (i.e. Vehicles in Lanes 1 and 2 cannot change into Lanes 3 to 5, and likewise). This lane change zone creates some turbulence in this area, however this is not likely to result in flow breakdown, as a further chance to select lanes is available south of the bridge. This second lane choice zone is located between the southern abutment of the AHB and the Fanshawe Street off ramp, and is discussed below.

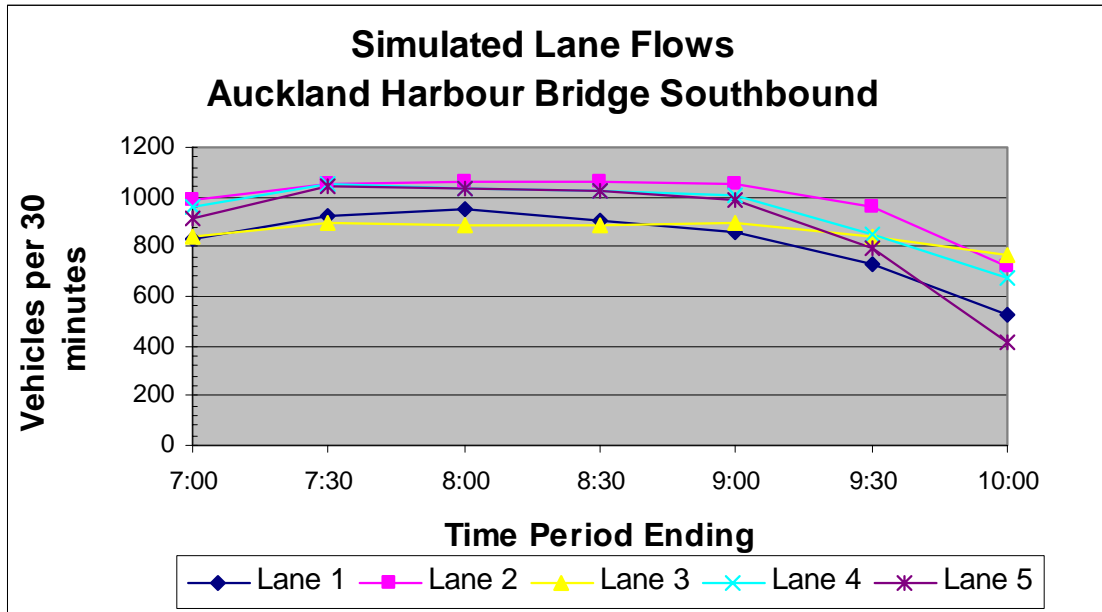


Figure 8.1 Predicted southbound vehicle flow by lane on the AHB (2011 AM Peak)

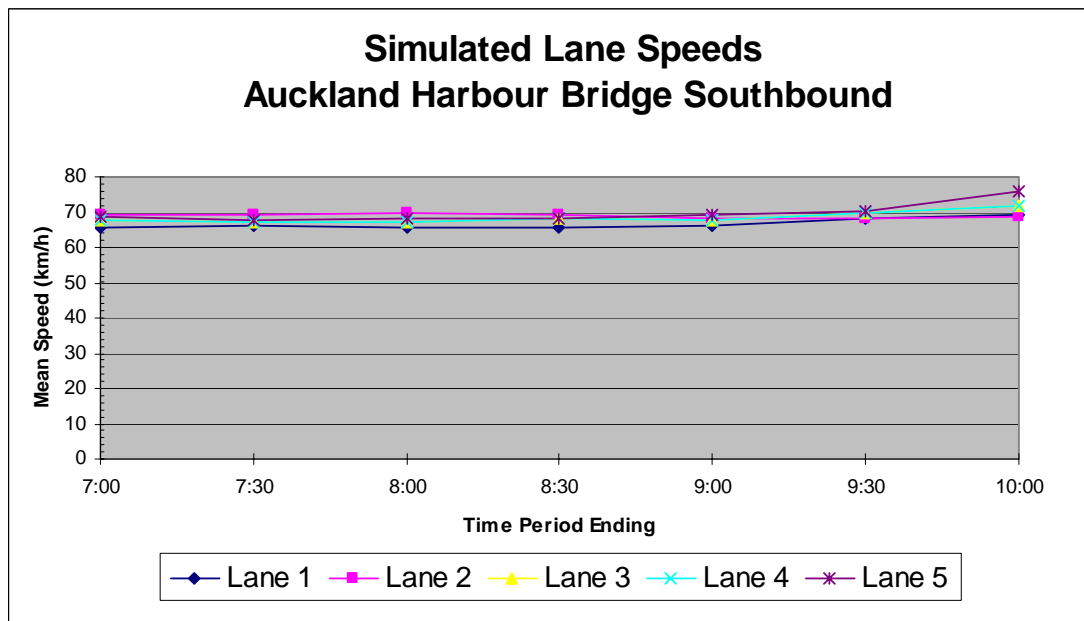


Figure 8.2 Predicted southbound vehicle speed by lane on the AHB (2011 AM peak)

8.1.3 St. Mary's Bay

This second lane choice zone is located between the southern abutment of the AHB and the Fanshawe Street off ramp. In this area those vehicles that are not in the desired lane (Lanes 1 and 2 to exit at Fanshawe Street and Lanes 3 to 5 to exit at Cook Street or further south) will make a more urgent lane change manoeuvre to select the desired lane. Once again this results in some flow turbulence at this location, however as many vehicles have already selected the correct lane north of the bridge, flow breakdown is not expected.

The simulation model indicates that morning peak flows through St. Mary's Bay will occur over the same period as the AHB (7am to 9am) with mean vehicle speeds in the range 65 km/h to 75 km/h (see Figures 8.3 and 8.4). The highest flow rates and lowest speeds (approximately 65 km/h) are predicted for Lane 3 as vehicles select this lane prior to changing into Lanes 1 and 2 (to the Fanshawe off ramp) or to exit at Cook Street.

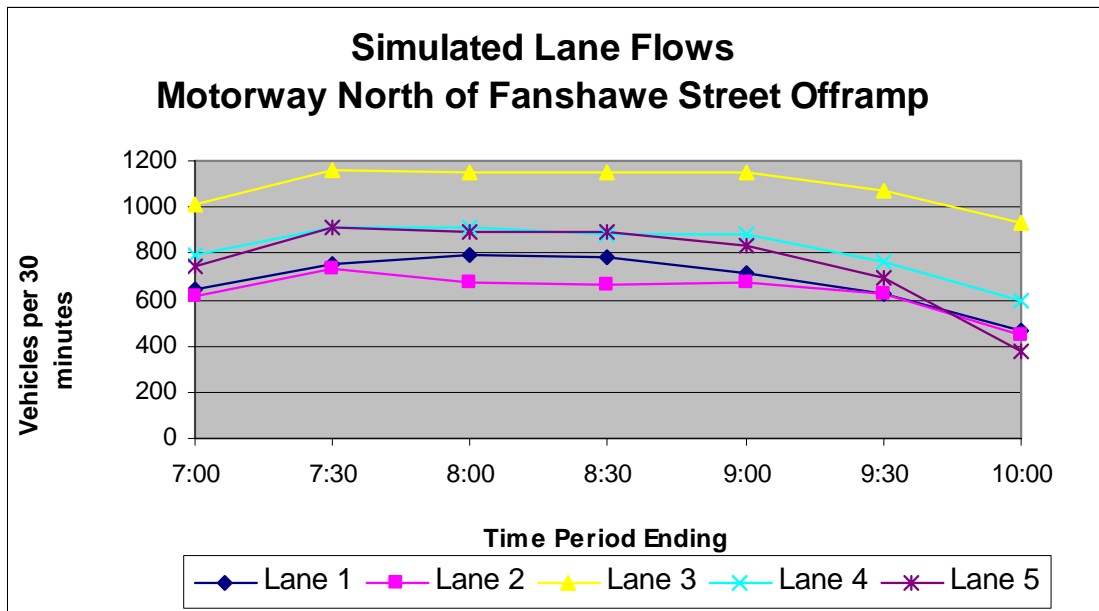


Figure 8.3 Predicted southbound vehicle flow by lane through St.Mary's Bay (2011 AM peak)

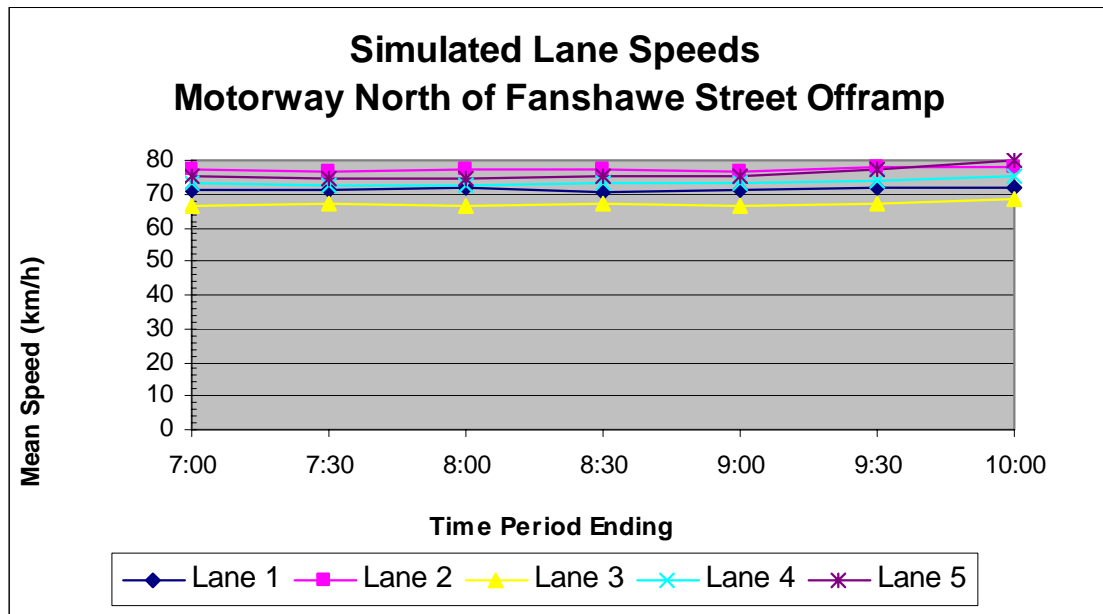


Figure 8.4 Predicted southbound vehicle speed by lane through St.Mary’s Bay (2011 AM peak)

8.1.4 Fanshawe Street Off ramp

The capacity of the Fanshawe Street southbound off ramp would be approximately 1700 vph per lane following proposed improvements to the off ramp. These improvements will include widening of the off ramp itself to provide two general use traffic lanes plus a bus only shoulder priority lane. This lane arrangement will be modified on the immediate off ramp approach to the Fanshawe Street/ Beaumont Street signals to accommodate three general use lanes and a bus only lane to Fanshawe Street, a short right turn lane to Beaumont Street south and a separate, give way controlled, left turn slip lane to Beaumont Street north. This arrangement will require modification of the signal phasing and will accommodate the development of the Western reclamation development and improvements to the operational capability of Fanshawe Street proposed by the Auckland City Council, including a bus priority lane.

To accommodate the predicted increase in traffic volumes crossing Fanshawe Street to access the Western Reclamation development it is considered that grade separation of Halsey Street will be required. In addition, the right turn manoeuvre from Fanshawe Street into Beaumont Street north should be banned, and an improved right turn facility into Daldy Street should be provided. The banning of this right turn manoeuvre into Beaumont Street north will allow the implementation of a separate phase for vehicles turning from Beaumont Street north to the Fanshawe Street on ramp while still providing sufficient green time to accommodate off ramp flows. The right turn manoeuvre to the on ramp is currently filtered through the Beaumont Street south to north manoeuvre, however as these volumes increase and two right turn lanes are required, as a result of the western reclamation development, it will not be possible to filter this movement safely.

These improvements will provide spare capacity of 200 vph per lane over predicted 2011 traffic demand. As a result of this spare capacity, and modifications to the Fanshawe Street/ Beaumont Street signal phasing mean vehicle speeds on the off ramp are predicted to be 70 km/h to 80 km/h during the am peak period, as shown in Figures 8.5 and 8.6.

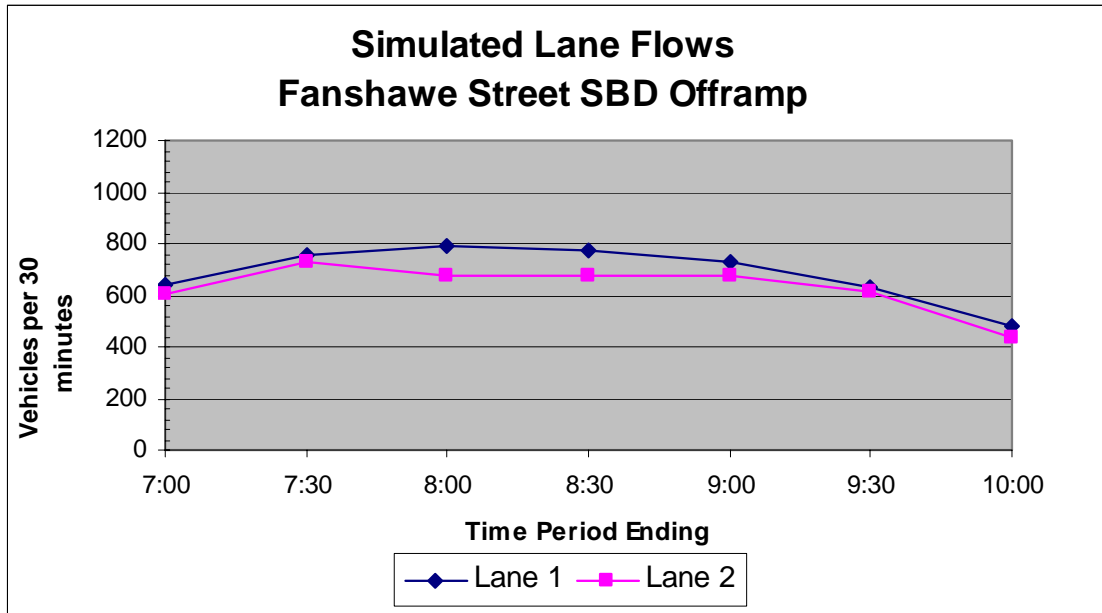


Figure 8.5 Predicted southbound vehicle flow by lane, Fanshawe Street Off ramp (2011 AM peak)

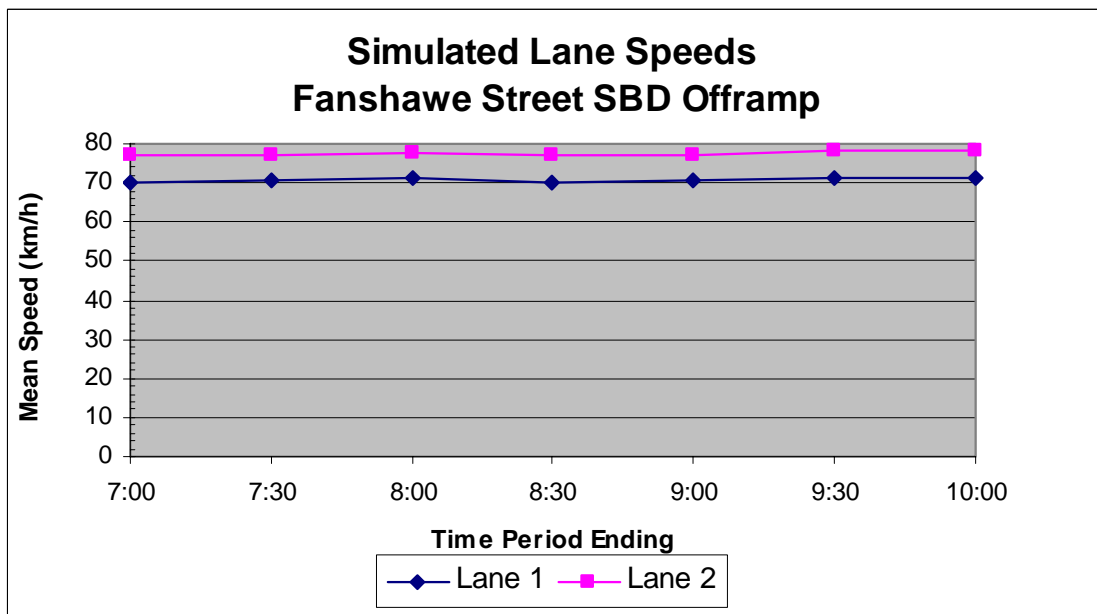


Figure 8.6 Predicted southbound vehicle speed by lane, Fanshawe Street Off ramp (2011 AM peak)

The current southbound bus shoulder lane through St. Mary's Bay would connect with the current Fanshawe Street bus only lane and allow buses flexibility to bypass the queue from the Fanshawe Street signalised intersection, further reducing congestion on the on ramp.

8.1.5 Victoria Park Viaduct

It is predicted that traffic growth/ reassignment resulting from the proposed improvements to the Central Motorway Junction (including a north to northwest motorway link) would see the southbound traffic demand on the VPV increase to approximately 5900 vph in the morning peak period by 2011. The proposed improvements to the VPV would increase the number of southbound lanes from two to four, increasing the southbound capacity from 4450 vph to approximately 8400 vph. As the capacity of the VPV would exceed 2011 demand under current predictions, mean vehicle speeds should remain high at between 70 to 80 km/h.

During the AM peak hour the demand for the two southbound lanes through CMJ is approximately 3100 vph, with the two southbound lanes feeding the Cook Street off ramp and the port and Northwestern motorway links carrying 2000 vph. The traffic flow using both viaduct structures will be below their capacity of 4200 per two lane viaduct.

It has been deduced from observation of Interpeak traffic flow patterns that the Interpeak capacity across Victoria Park Viaduct is currently approximately 1880 vph per lane. This reduced capacity during the Interpeak is due to the higher proportion of Heavy Commercial Vehicles, tourists, shoppers and elderly/inexperienced drivers using this section of motorway compared with the morning and evening peak periods. These Interpeak motorists desire greater headways than those accepted by commuters during the morning and evening peaks.

Based on this capacity and a conservative 1.5% estimate of traffic growth, the existing two lanes across Victoria Park Viaduct would be at capacity by 2011 during the Interpeak period if the northbound tunnel was not constructed.

8.1.6 Existing Cook Street Off ramp

It is proposed that the existing Cook Street off ramp is not modified.

8.1.7 Local Road Impacts

As additional capacity is provided for traffic travelling through CMJ to travel south, west or to the port there will be minimal impacts on the surrounding road network and these impacts should be positive. These positive impacts are due to traffic to the Port, eastside of the CBD, Grafton and the Northwestern Motorway that travel from north over the Auckland Harbour Bridge can now use the North to Port and North to Northwestern motorway links therefore reducing traffic exiting to Fanshawe Street and Cook Street off ramps.

8.1.8 *Summary*

In summary, the proposed improvements to the southbound corridor will effectively remove the southbound bottleneck that occurs as a result of the VPV being under capacity during the morning peak period. This will allow the AHB to take the additional supply of vehicles from the North Shore bus priority system and maximise capacity.

8.2 Northbound Traffic Conditions

The proposed HBTC improvements will increase the capacity of the northbound approach to the AHB by reducing the impact of the Wellington Street on ramp bottleneck and removing the VPV bottleneck, as well as providing additional capacity through St.Mary's Bay.

As discussed for the southbound direction of travel a micro-simulation model was created to assess the operational behaviour of the motorway corridor following completion of the proposed capacity improvements.

The results of the northbound micro-simulation model are discussed below.

8.2.1 *A note on the Northbound Micro-Simulation Model Construction*

As previously discussed for the southbound micro-simulation model, the location of 'section joins' within the micro-simulation is critical to accurately simulate the decision making made by motorists. As vehicles within the model can only look ahead two joins to make lane change decisions these joins must be located so as to allow this decision making to occur in the correct location.

For the northbound model, section joins are located at the merge between the Fanshawe Street on ramp and the motorway, the Curran Street on ramp merge and the Onewa Road off ramp diverge. This configuration allows vehicles travelling northbound to the Onewa Road off ramp to select lanes one and two of the AHB prior to the Curran Street on ramp. In order to allow this decision making to take place prior to the bridge it was necessary to compromise on the model layout at the Stafford Road off ramp. If a section join were present at the Stafford Road off ramp then decision making by northbound vehicles could not take place until vehicles had already passed the Curran Street on ramp and entered the bridge span proper. This would not accurately simulate the decision-making behaviour of northbound vehicles. Vehicles heading to the Stafford Road off ramp are therefore removed from the main traffic stream once they are adjacent to the off ramp location, rather than diverging from the motorway. While this represents a compromise over the actual off ramp layout the decision making is critical to the operational behaviour of the corridor, and the volumes exiting at Stafford Road are historically relatively low (maximum of 545 vph in 2001).

The results of the northbound micro-simulation model are discussed in the following sections.

8.2.2 *Wellington Street Northbound On Ramp*

The capacity of Wellington Street on ramp merge area will be increased by the addition of a third approach lane, from the Port and Northwestern link, through the northbound tunnel under Victoria Park, thereby increasing the northbound capacity to approximately 6450 vph (from 4300 vph). The reassignment of traffic from the Northwestern motorway to the Northern motorway by having their own link will significantly reduce the demand from Wellington Street to around 500vph. At predicted 2011 flow rates the mean speeds on the motorway immediately upstream of the Wellington Street on ramp are expected to range from 20 km/h to 40 km/h in Lane 1 (due to merging traffic) and from 35 km/h to 65 km/h in Lanes 2 and 3, as shown in **Figure 8.7**. The predicted flow rates in each lane upstream of the on ramp are shown in **Figure 8.8**.

With the 2011 PM Peak flow on the combined Port and Northwestern Motorway to Northern motorway link estimated at between 1300 to 1700 vph, and the link configured as a lane gain, the capacity of the Wellington Street on ramp would be restricted to 800vph by the implementation of a single lane ramp meter. It would be possible to further improve the capacity of the Wellington Street on ramp merge area by configuring the combined Port and Northwestern to North link to enter the motorway as two lanes, including a single lane gain plus merge lane, similar to the existing Hobson Street/ Northwestern motorway four lane to three lane merge. This is expected to reduce the volume of vehicles in Lane 1 immediately upstream of the Wellington Street on ramp to approximately 650 to 850 vph.

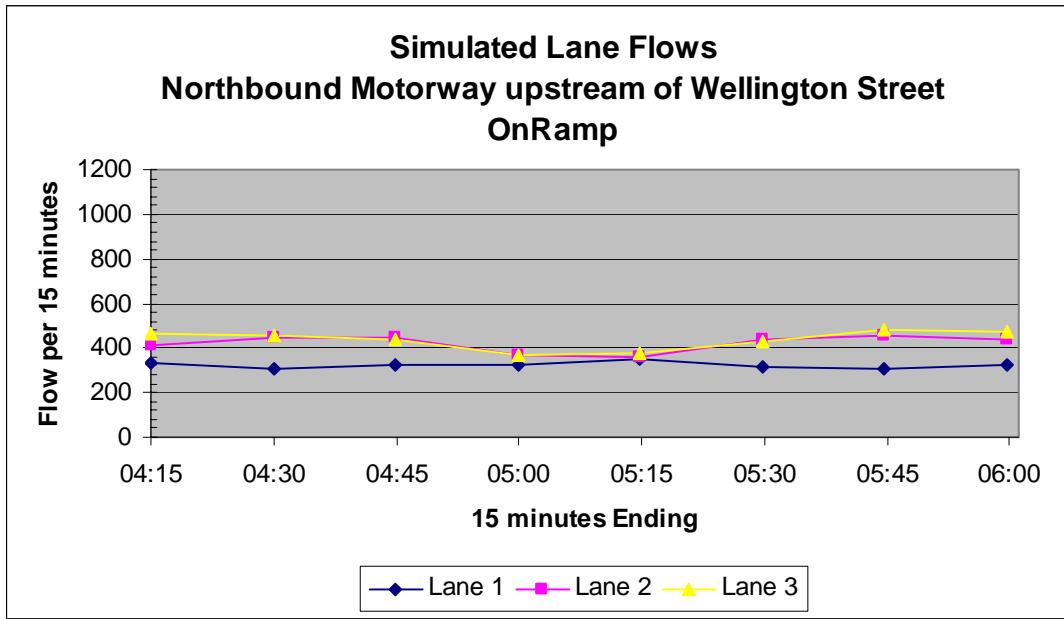


Figure 8.7 Predicted Northbound vehicle flow by lane, Upstream of Wellington Street On Ramp (2011 PM peak)

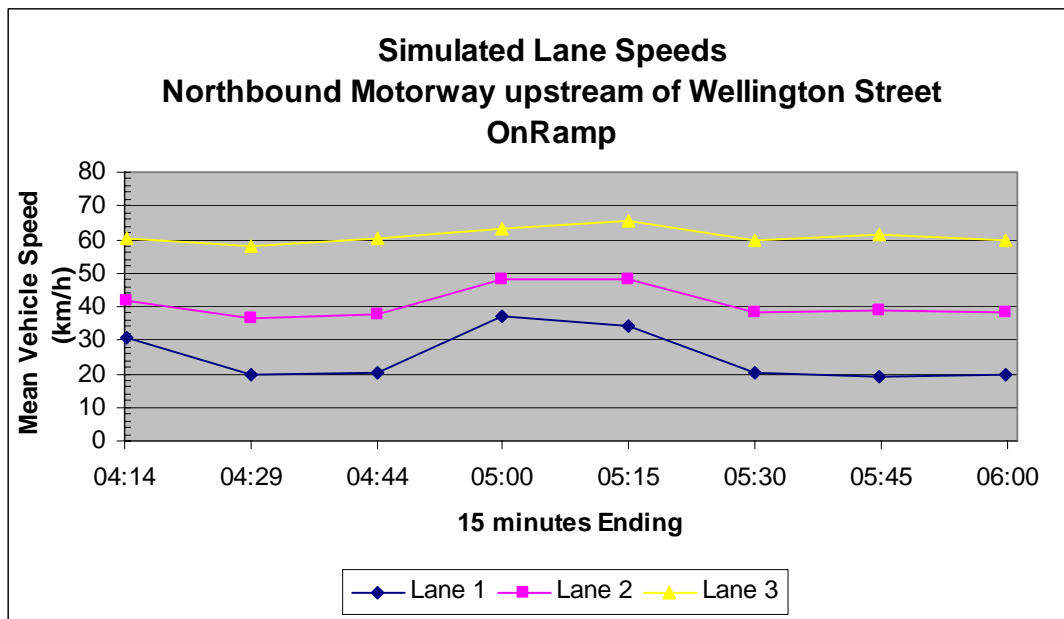


Figure 8.8 Predicted Northbound vehicle speed by lane, Upstream of Wellington Street On Ramp (2011 PM peak)

8.2.3 Victoria Park Tunnel

As the 2001 northbound traffic flow demand is approximately 4600 vph during the PM peak period, spare capacity of 1850 vph would be provided over 2001 flows by the proposed capacity improvements, which would increase the northbound capacity to 6450 vph. By 2011 the northbound traffic demand during the evening peak period is expected to have increased to approximately 6200 vph, consisting of 5500 vph from the upstream motorway and 800 vph from the Wellington Street on ramp. These increases in upstream supply are as a result of the removal of upstream bottlenecks by the CMJ and Grafton Gully improvement projects, and the provision of a link between the Northwestern motorway and Grafton Gully to the Northern motorway. The proposed improvements would therefore provide spare northbound capacity of approximately 150 vph over predicted 2011 demand flows. The predicted 2011 peak flow rates and mean speeds in each lane of the northbound tunnel during the evening peak period are shown in **Figures 8.9 and 8.10**. These figures show that lane utilisation is generally balanced and mean speeds are in the range 60 km/h to 75 km/h.

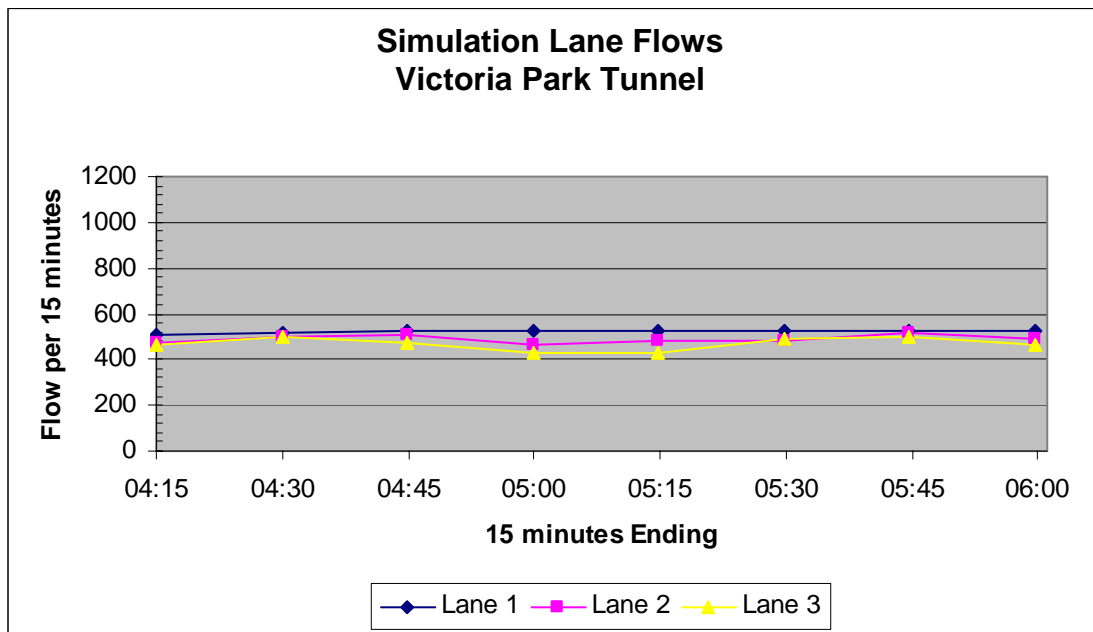


Figure 8.9 Predicted Northbound vehicle flow by lane, Victoria Park Tunnel (2011 PM peak)

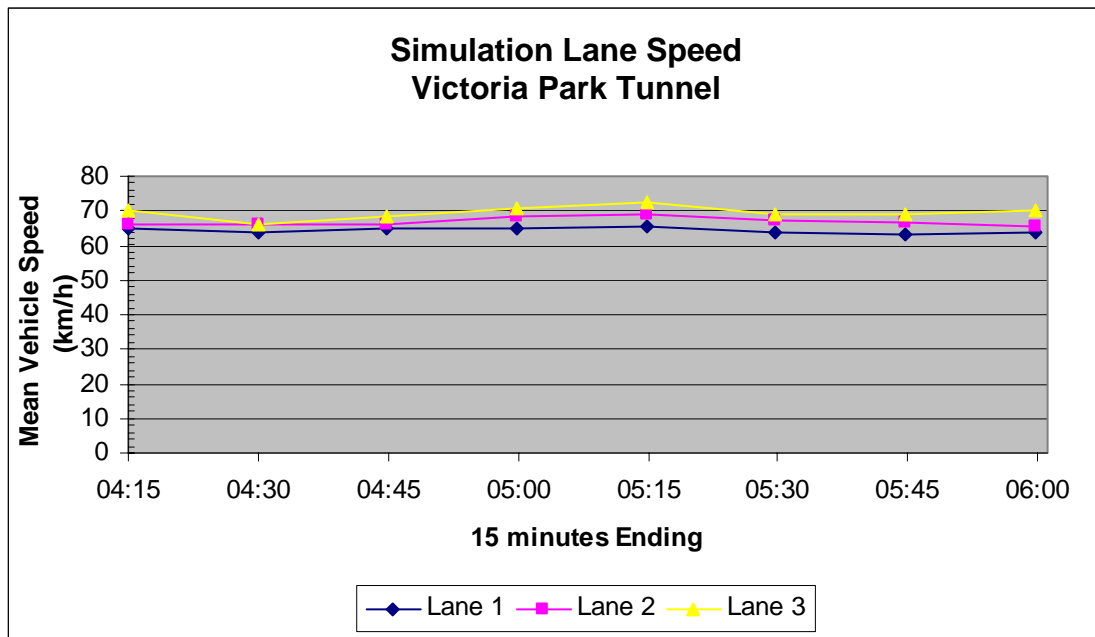


Figure 8.10 Predicted Northbound vehicle speed by lane, Victoria Park Tunnel (2011 PM peak)

8.2.4 Fanshawe Street Northbound On Ramp

The improvements proposed to the Fanshawe Street northbound on ramp would result in a theoretical on ramp capacity of 3200 vph, comprising two lanes at 1600 vph per lane. This theoretical capacity is based on implementation of a separate signal phase for the Beaumont Street northern approach, to accommodate the increased traffic generation resulting from the redeveloped western reclamation. This movement currently runs at the same time as the left turn from Beaumont Street south to the on ramp, however following development of the western reclamation the flows from Beaumont Street north would make this signal arrangement hazardous and inefficient.

The ability of the on ramp to reach this capacity is dependant on the cycle length and phasing arrangement, and lane configuration, adopted at the Fanshawe Street/ Beaumont Street signalised intersection. It has been assumed for the purposes of the simulation model that sufficient green time would be allocated to manoeuvres to the on ramp to allow the full capacity of the ramp to be realised. If this were not the case then on ramp flows would be reduced, resulting in more queuing in Fanshawe Street and adjoining local streets. The impact of this on the motorway would be beneficial as less vehicles would use the on ramp per hour, thereby increasing its level of service. This would however be reflected by increased congestion on the adjacent local network.

8.2.5 Fanshawe Street Corridor

As previously discussed, it is considered that grade separation of the Halsey Street is required to allow vehicles to enter and exit the Western reclamation during peak periods without interacting with Fanshawe Street traffic. In addition, the banning of the right turn

manoeuvre from Fanshawe Street into Beaumont Street north would allow a separate signal phase to be allocated to the two lane movement from Beaumont Street north to the on ramp, while still maintaining sufficient green time to be allocated to the westbound Fanshawe Street movement to the on ramp. The Fanshawe Street westbound approach to the Beaumont Street signals would include two general use lanes to the on ramp, and a shared lane for buses to enter the on ramp and for vehicles to turn left to Beaumont Street south.

In addition to the grade separation of Halsey Street, further improvements (grade separation) to the right turn facility into Daldy Street would allow turning volumes to be accommodated while not reducing capacity of the Fanshawe Street/ Beaumont Street intersection.

8.2.6 St Mary's Bay

The existing capacity of the northbound four lane motorway through St. Mary's bay is in the order of 8600 vph, comprised of four lanes at approximately 2150 vph per lane. The proposed improvements to St. Mary's Bay (increase from four to five northbound lanes) would increase the northbound capacity to approximately 10,500 vph. The proposed five lanes through St. Mary's Bay would consist of the three northbound tunnel lanes and two lanes from Fanshawe Street that would enter the motorway as a double lane gain. The predicted northbound demand flow during the evening peak period is expected to increase from 8050 vph in 2001 to 9700 vph in 2011. The predicted 2011 traffic flow rate would result in mean vehicle speeds in the order of 65 km/h to 80 km/h as shown in Figure 8.12. The predicted flow rates in each lane are shown in Figure 8.11.

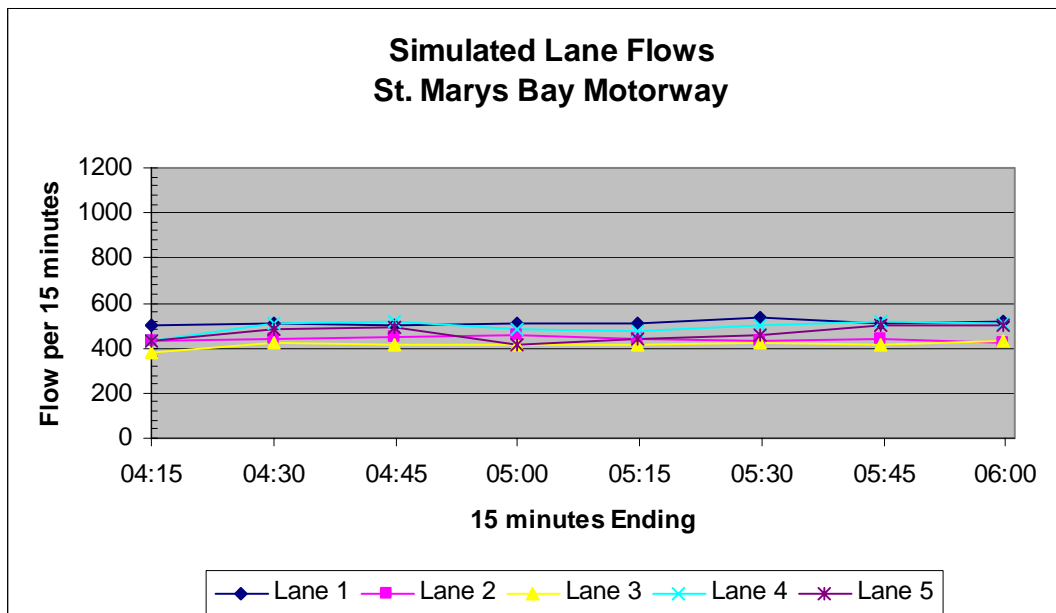


Figure 8.11 Predicted Northbound vehicle flow by lane, St. Mary's Bay (2011 PM peak)

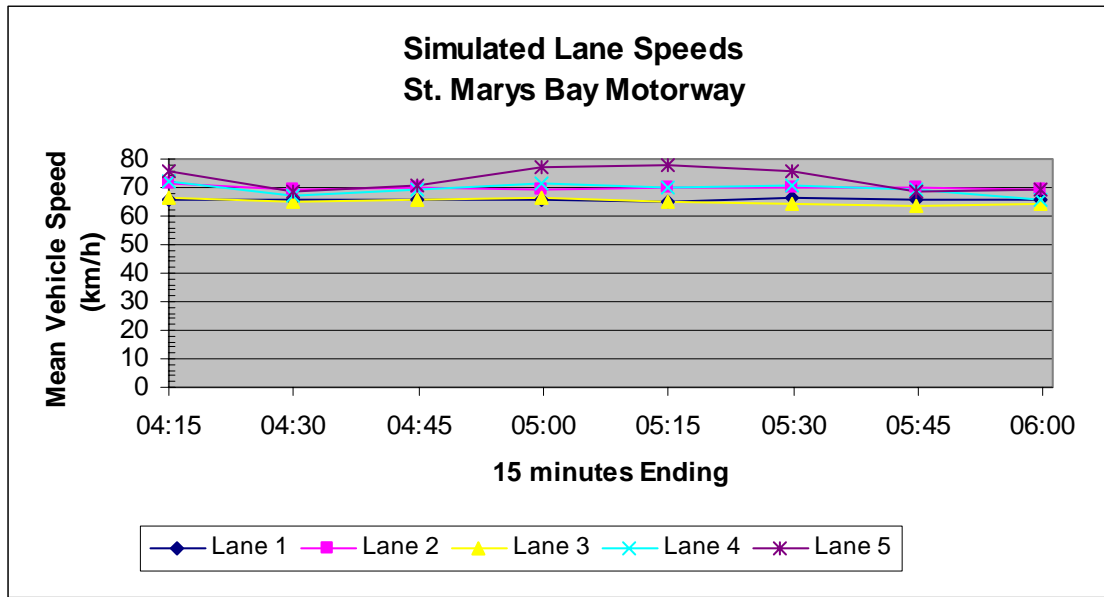


Figure 8.12 Predicted Northbound vehicle speed by lane, St. Mary's Bay (2011 PM peak)

The capacity of this section of motorway is influenced by vehicle interaction at the Curran Street on ramp merge area. As can be seen from **Table 6.0**, and discussed in **Section 8.2.7**, the predicted 2011 Curran Street on ramp flows are expected to decrease as a result of trip reassignment. This reduction in flow would reduce the effect of the on ramp merge area on the upstream motorway, and provide the flow conditions shown in **Figures 8.1.5** and **8.1.6**. If this flow reduction does not eventuate then the influence of the on ramp merge area on the upstream motorway would be more pronounced. As part of the Travel Demand Management project implemented by Transit, the Curran Street on ramp will be metered to control the potential flow break down at the Curran Street merge.

8.2.7 Auckland Harbour Bridge

The existing theoretical capacity of the five lane northbound AHB is estimated to be 10,500 vph, comprising capacity of 2100 vph per lane. This capacity cannot currently be achieved due to upstream bottlenecks, however as previously discussed the proposed improvements will ease these bottlenecks, increasing flow to the AHB. The simulation indicates that Lane 1 of the bridge would carry less flow during the evening peak period than the other bridge lanes, due to interaction with on ramp traffic at Curran Street.

The CMI model predicts that demand for the Curran Street on ramp will decrease from 1650 vph in 2001 to 1000 vph in 2011 as a result of route diversion. These diversions would primarily be a result of the construction of a link between the Northwestern and Northern Motorways, as part of the CMJ works. As a consequence of the construction of this link, vehicle trips generated around Western Springs, and surrounding suburbs, would enter the Northwestern Motorway to cross the bridge northbound, rather than travel congested local roads and enter at Curran Street. This drop in demand will minimise the congestion

currently encountered at the Curran Street on ramp merge. To further manage the on ramp merge ramp metering of this on ramp is proposed.

The simulation model indicates that the supply of vehicles to the bridge in the evening period would be in the range 9900 vph to 10,000 vph. As the theoretical capacity of estimated at 10,500 vph, spare capacity of approximately 500 vph would therefore be provided. As the bridge would be operating marginally below capacity, mean vehicle speeds of 65 km/h to 75 km/h are predicted. The simulated flows and mean vehicle speeds are shown by lane in **Figures 8.13** and **8.14**, below.

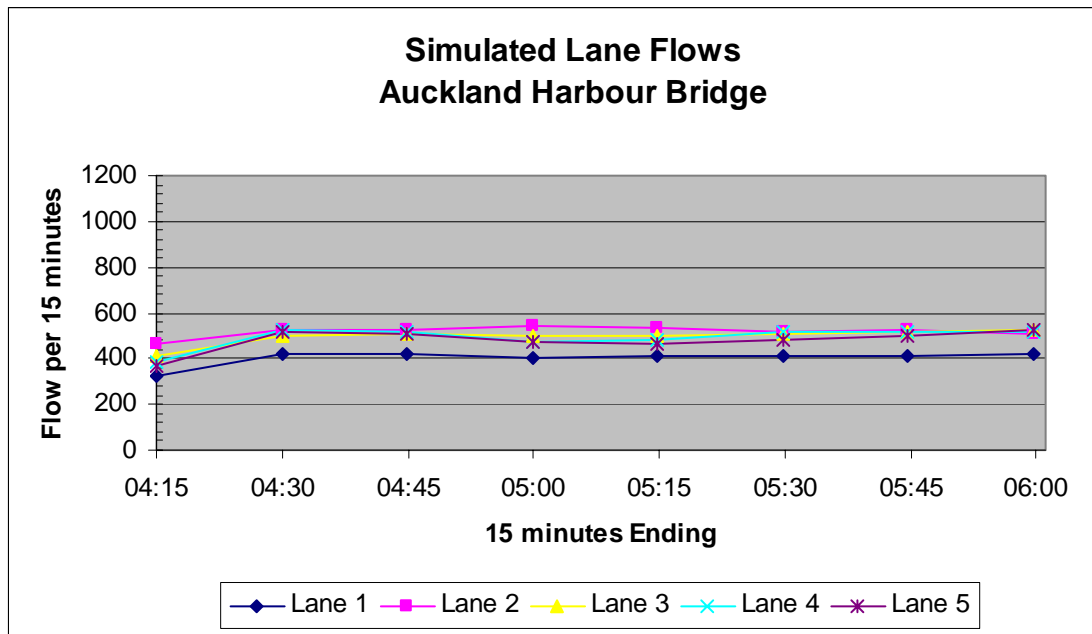


Figure 8.13 Predicted Northbound vehicle flow by lane, Auckland Harbour Bridge (2011 PM peak)

An auxiliary lane will be constructed in 2006/7 from the Northcote Interchange to merge with an existing auxiliary at the Sunnynook Road bridge. This will help mitigate northbound congestion through the Northcote interchange lane drop, thus assisting clearance of the northbound traffic stream in the PM peak.

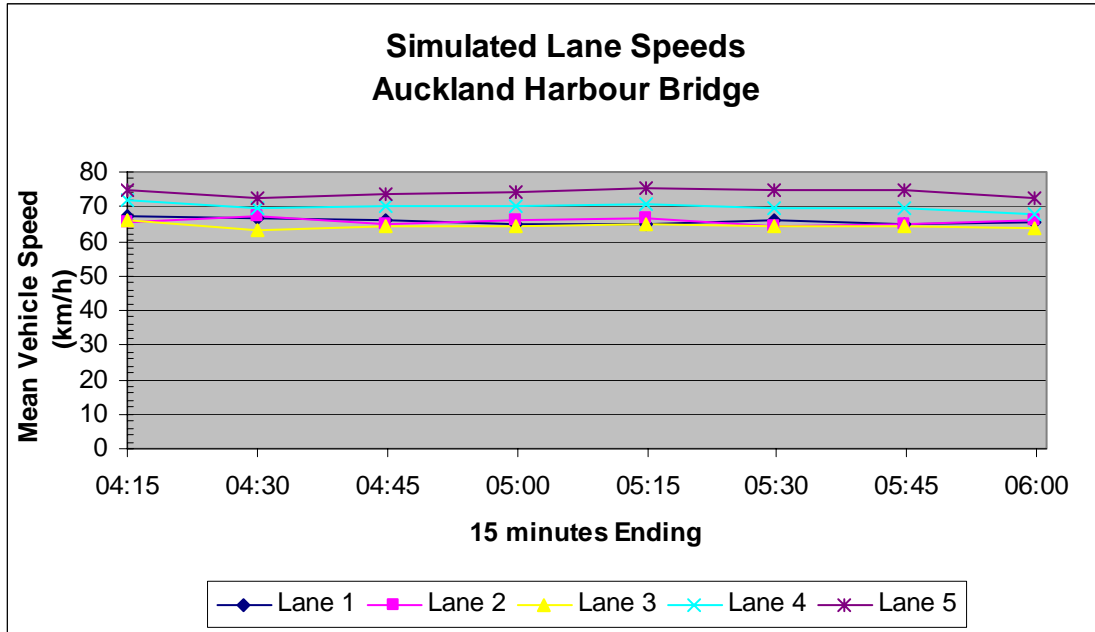


Figure 8.14 Predicted Northbound vehicle speed by lane, Auckland Harbour Bridge (2011 PM peak)

8.2.8 Local Road Impacts

As additional capacity is provided for traffic travelling through CMJ from the south, west and from the port there should be minimal impacts on the surrounding road network and these impacts should be positive. These positive impacts are due to traffic from the Port, eastside of the CBD and Grafton that wants to travel north over the Auckland Harbour Bridge can now use the Port to North motorway link therefore reducing traffic from Wellington Street and Fanshawe Street on ramps.

8.2.9 Summary

The simulation model indicates that the proposed capacity achieved by increasing the number of lanes across Victoria Park addresses the current northbound bottleneck and resulting queue that affects the southern motorway upstream to the Newmarket Viaduct. Mean traffic speeds through the northbound tunnel and St.Mary’s Bay motorway are predicted to remain above 60 km/h, under predicted demand flows.

The provision of a two lane link from the Northwestern Motorway and Grafton Gully, merging with the two lanes from the Southern Motorway prior to the on ramp to become three lanes, would reduce the vehicle density in Lane 1 prior to the on ramp merge, thereby merge conditions for the Wellington Street on ramp and reducing the effect on the upstream motorway.

The impact of the HBTC project on the local road network should be positive.

In conclusion, the proposed improvements will increase the capacity of the motorway corridor upstream of the AHB and allow the bridge to carry flows up to its estimated capacity of 10,500 vph. Mean speeds on the upstream approaches will be significantly improved and as a result the level of service through the corridor will be significantly improved.

9 *Additional Micro-Simulation Tests*

These additional micro-simulation tests were undertaken in response to issues raised by the peer reviewer (Andrew O'Brien and Associates) in regard to the initial micro-simulation reports.

9.1 Model Calibration

The peer reviewer suggested that by inputting 2001 flows into the micro-simulation model and comparing the mean vehicle speeds with those recorded by ATMS that a measure of the simulation calibration could be obtained. We therefore altered the lane configuration in the 2011 post-implementation model to match the existing PM peak period layout and input 2001 traffic flows to determine what mean speeds would result northbound on the Auckland Harbour Bridge. The results of this test are shown in **Figure 9.1**.

This figure shows that the mean northbound speeds recorded by ATMS in 2001 on the AHB remain generally constant throughout the day at between 70 km/h and 90 km/h, despite a posted speed restriction of 80 km/h. The results of the micro-simulation test indicate mean vehicle speeds of between 70 km/h and 80 km/h during the PM peak period. While this is lower than the mean speeds recorded by ATMS, the compliance of vehicles to speed restriction in the micro-simulation model is set on a vehicle type basis. This means that all vehicles of the same type have a tolerance to speed restriction set within the same bounds, although the compliance of individual vehicles is distributed within those bounds. The result is that if tolerance of a particular vehicle type is increased then higher vehicle speeds will result throughout the entire model. Furthermore, **Figure 9.1** shows that as the flow rate increases the rate of speed decrease in the micro-simulation model is similar to that recorded by ATMS. We therefore believe that the micro-simulation model is producing realistic results given the limitations of the software package.

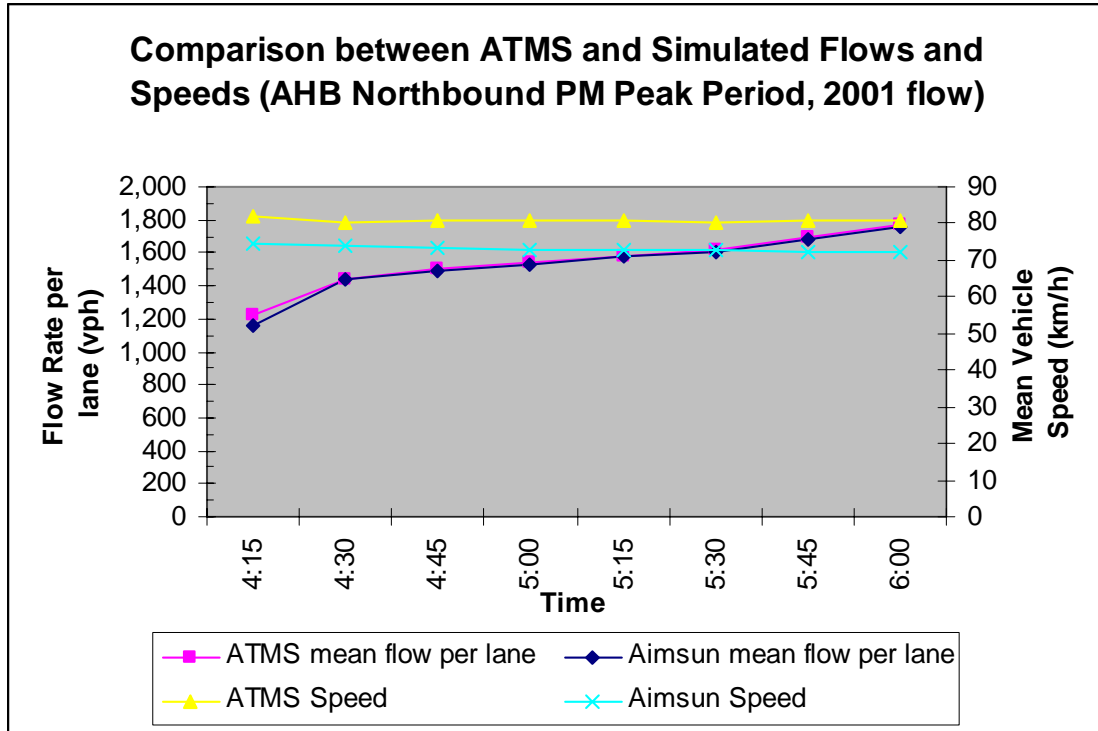


Figure 9.1. Flow and Mean Vehicle Speed Comparison (Recorded vs. Simulated)

9.2 Northbound Bus Priority Shoulder Lane (St Mary's Bay)

An alternate arrangement for the northbound section of Motorway between the Fanshawe Street and Curran Street northbound on ramps has been suggested by the Auckland City Council to provide a northbound bus priority facility. This arrangement involves utilising lane 1 of the northbound carriageway as a bus-only lane during the evening peak period. This would leave four northbound lanes for other vehicle types, and marginally improve bus travel times through this section of the corridor.

To accommodate this arrangement the two-lane Fanshawe Street northbound on ramp would be modified to include one bus-only lane, and one lane for other vehicle types, in order to remain within the existing motorway designation, and minimise the impact on adjacent land use. This would reduce the capacity of the Fanshawe Street on ramp for vehicle types other than buses to approximately 1600 to 1700 vph. This reduction in capacity would likely result in re-assignment of vehicle trips from the Fanshawe on ramp to the Wellington Street and Curran Street on ramps, and result in a reduction in the number of vehicles on the northbound motorway between Fanshawe and Curran Streets.

In order to assess the operational behaviour of the motorway under this scheme the northbound micro-simulation model was modified to include one bus lane and four vehicle lanes through St. Mary's Bay between Fanshawe Street and Curran Street.

The reassignment of 1700 vehicle trips per hour from the Fanshawe Street on ramp was proportioned as follows:

- Wellington Street on ramp: Additional 400 vph (to a total of 1700 vph); and
- Curran Street on ramp: Additional 1300 vph (to a total of 1700 vph).

This is seen as a worst-case scenario, as it is expected that a proportion of motorists would change to bus travel.

In addition, it was assumed that 100 buses per hour would use the bus priority lane. All of these buses would enter the motorway at the Fanshawe Street on ramp.

As previously discussed the theoretical capacity of the Wellington Street on ramp is 1700 vph, however maximum peak flow rates of only 1200 to 1400 vph would be achievable due to vehicle interaction at the on ramp merge area. The reassignment of vehicles from Fanshawe Street to Wellington Street does not therefore increase the flow rate on the Wellington Street on ramp, rather queuing for the on ramp is increased as the ramp would be at capacity.

The flow rate on the VPV did not change as a result of this reassignment with northbound peak flows remaining at approximately 6300 vph.

As the flow entering the on ramp at Fanshawe Street would be restricted to 100 buses per hour and 1700 (non-bus) vph the flow rates through St. Mary's Bay would reduce to approximately 8100 vph, consisting of 6300 vph from the motorway upstream of Wellington Street and the Wellington Street on ramp and 1800 vph from the Fanshawe Street on ramp (1700 vph plus 100 buses per hour).

The simulated flow rates and mean vehicle speeds, by lane, with the bus lane operating are shown in **Figures 9.2 and 9.3**.

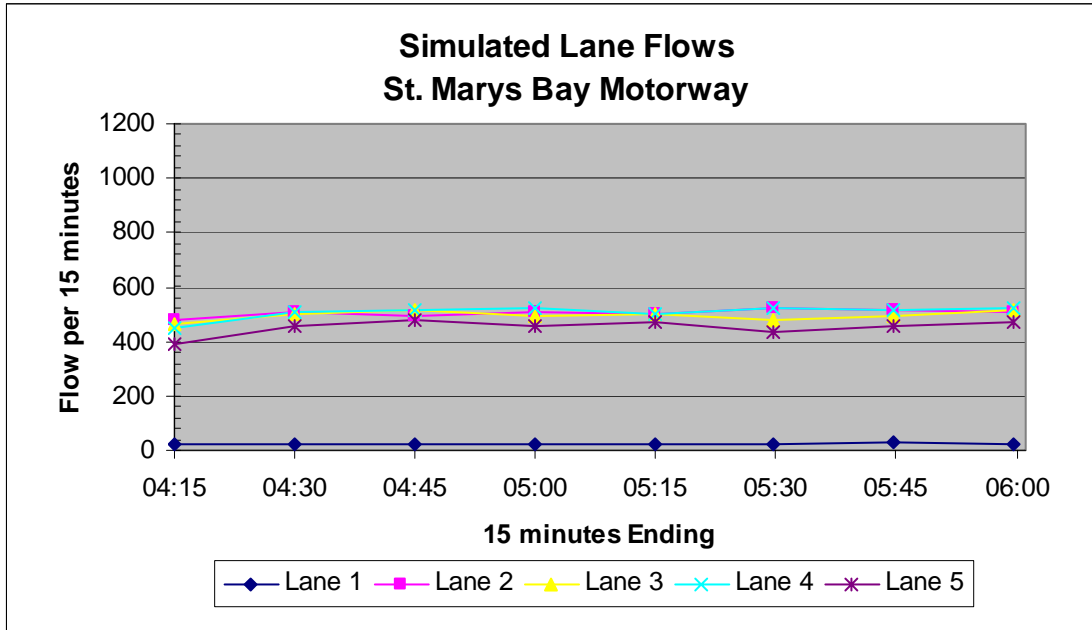


Figure 9.2. Predicted Northbound vehicle flow by lane, St. Mary’s Bay (2011 pm peak with 4 lanes plus bus lane)

Although the flow rates through St Mary’s Bay would reduce as a result of the restricted capacity of the Fanshawe Street on ramp the flow rates entering the motorway at Curran Street on ramp would increase from approximately 400 vph to approximately 1700 vph as a result of trip reassignment. This additional flow at the Curran Street on ramp results in increased vehicle interaction at the Curran Street merge area. The negative effect of this increased flow on the operational behaviour of the motorway upstream of the on ramp is reduced due to the low vehicle densities in Lane 1 approaching the on ramp, as this lane would be utilised by 100 buses per hour only. The merge arrangement as simulated is shown in **Figure 9.4**.

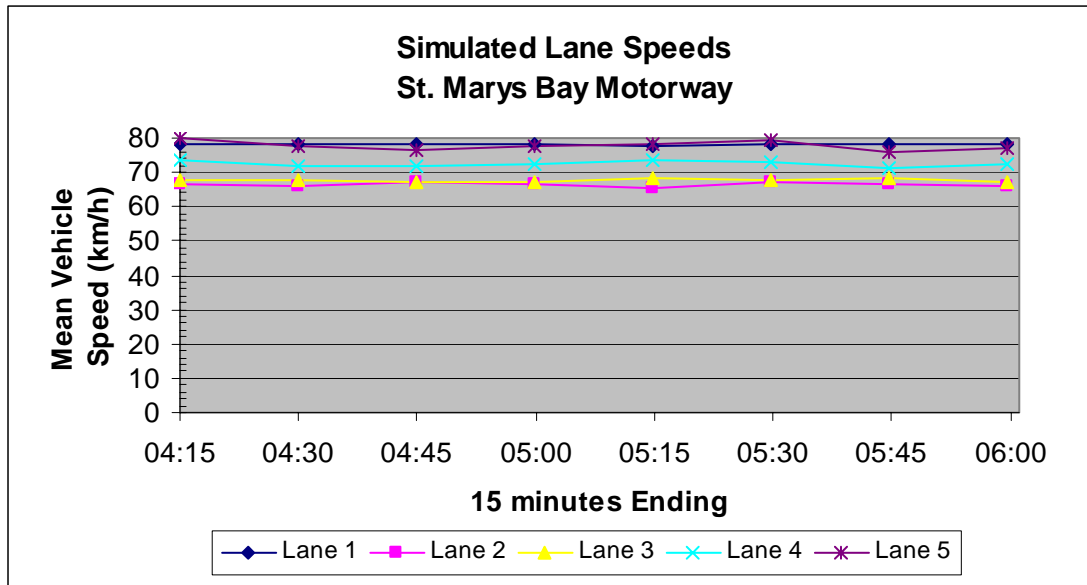


Figure 9.3. Predicted Northbound vehicle speed by lane, St. Mary's Bay (2011 pm peak with 4 lanes plus bus lane)

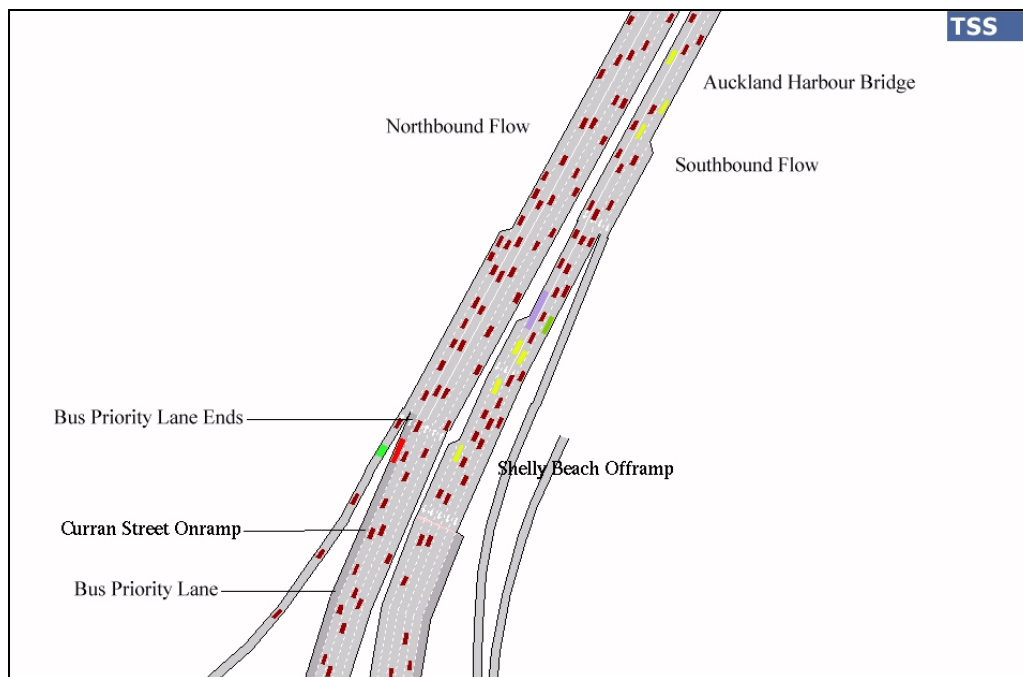


Figure 9.4. Simulated layout of Bus Priority Lane/ Curran Street On Ramp Merge¹

As shown in **Figure 9.4**, the northbound bus priority lane has been modelled to join Lane 1 of the Auckland Harbour Bridge. This effectively allows easier merging from the Curran Street on ramp due to reduced vehicle density in Lane 1, adjacent to the on ramp.

¹ It is not possible for vehicles to change between Lanes 2 and 3 (and vice versa) when on the AHB. The micro-simulation model has been coded to prevent this movement.

The reduction in flow through St. Mary’s Bay that would result from the reduced capacity of the Fanshawe Street on ramp is somewhat offset by the increased flow at the Curran Street on ramp (resulting from trip reassignment). Maximum flow rates of 1600 to 1700 vph were recorded on the on ramp during the simulation, with corresponding mean vehicle speeds in the range 55 km/h to 65 km/h. This flow, along with the flow from ST. Mary’s Bay (approximately 8100 vph) results in maximum flow rates of approximately 9700 to 9800 vph northbound on the Auckland Harbour Bridge, as shown in **Figure 9.5** (compared with approximately 10000 vph without the northbound bus lane). The corresponding mean vehicle speeds are shown in **Figure 9.6**. As the capacity of the northbound AHB during the PM lane configuration (five northbound lanes) is estimated to be approximately 2100 vph per lane, or 10500 vph total, the bridge would be operating below capacity, with mean vehicle speeds near freeflow speed (80 km/h).

When all vehicle types are permitted to use Lane 1 through ST. Mary’s Bay, mean vehicle speeds in that lane are predicted to be in the range 65 km to 75 km/h, with an average speed of 69 km/h (see **Figure 9.3**). With only buses operating in that lane, mean speeds would be approximately 65 km/h to 80 km/h (mean speed 73 km/h). The travel time benefit that could be achieved per bus between Fanshawe Street and Curran Street would therefore be approximately 2.9 seconds at mean speed.

As can be seen from **Figures 9.3 and 9.6**, modifying Lane 1 through St. Mary’s Bay for use by buses only would not have a significant detrimental effect on the operational behaviour and mean vehicle speeds on the motorway through the corridor, however as the micro-simulation model includes only a small part of the adjoining local road network, what cannot be shown is the delay to vehicles on that network resulting from the reduced capacity of the Fanshawe Street on ramp and subsequent trip reassignment.

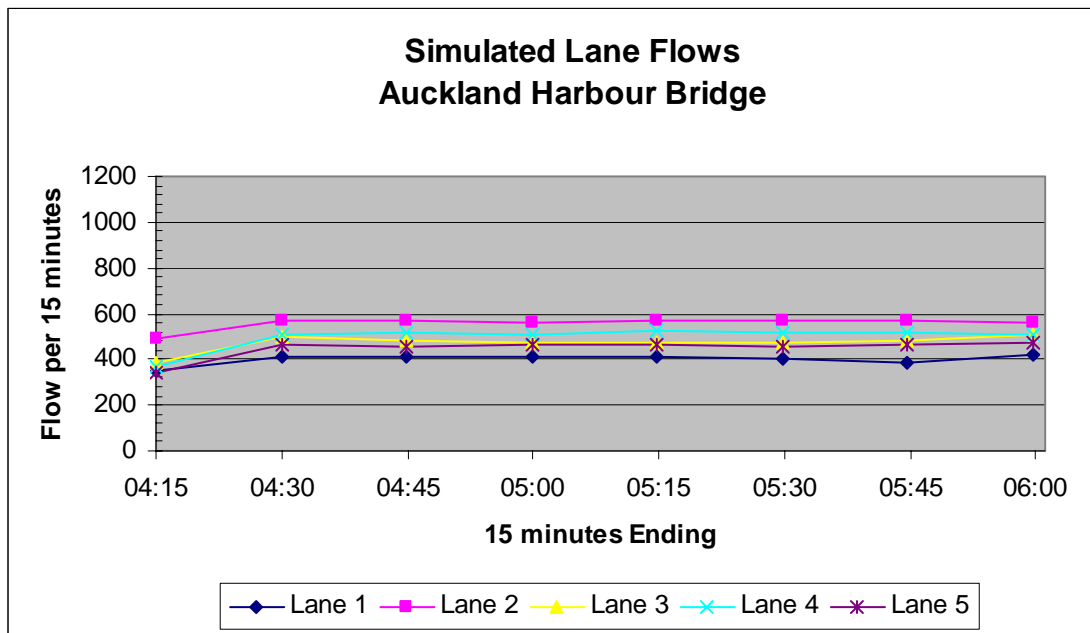


Figure 9.5. Predicted Northbound vehicle flow by lane, St. Mary’s Bay (2011 PM peak with 4 northbound lanes plus bus lane)

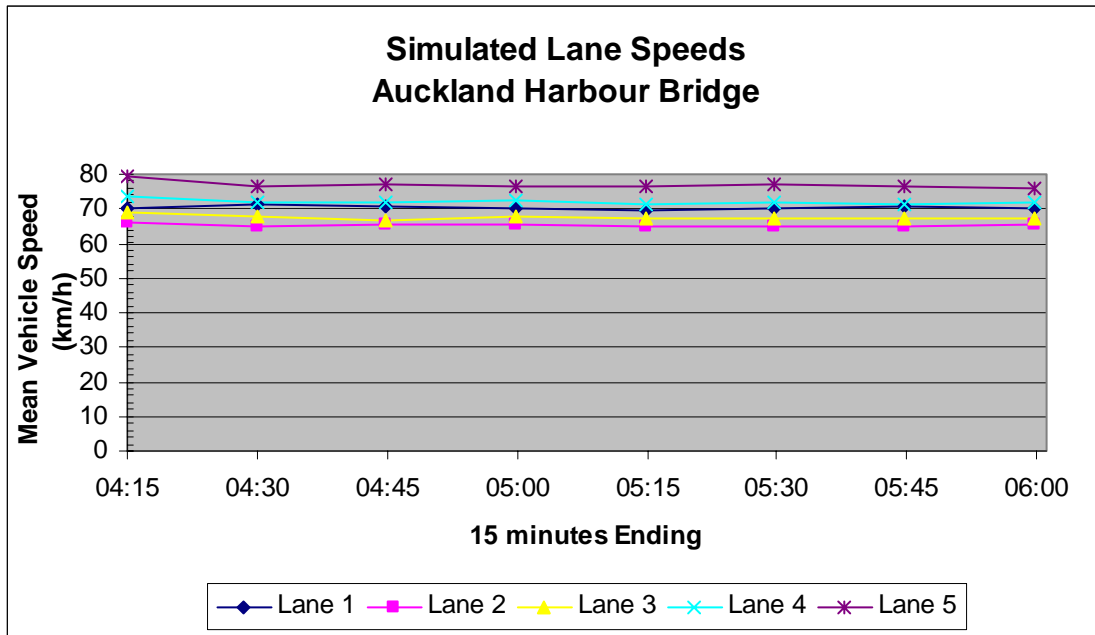


Figure 9.6. Predicted Northbound vehicle speed by lane, AHB (2011 PM peak with 4 northbound lanes plus bus lane)

10 Construction Traffic and Traffic Management Impacts

10.1 Traffic Management During Construction

Construction of the improvements through St Marys Bay will require specific traffic management to both protect the work site and minimise adverse traffic effects. Typical management measures include lane width variation, lane shifting, temporary lane/shoulder closures and barriered edge protection. The recent CMJ Stage One and Two works have used similar management measures and their effects on adjacent traffic are well understood. Some short-term disruption will occur as motorists adjust to new traffic layouts and controls. For the local road network, traffic management measures could include diversions, lane narrowing, temporary lane closures or total closures for short-duration activities.

The adverse effects on both motorway and local road networks will be mitigated by carefully planning. Specific actions would include advance publicity of diversions and closures, limiting closures to periods of lower traffic flow, maintaining an equivalent number of lanes through work sites, sign posting of diversion routes and regular traffic management publicity in newspapers, on radio and the Transit website. Experience from recent motorway improvements shows that advance publicity of management measures is effective in reducing their adverse effects. Road closures would be implemented only when traffic flows fall below pre-set levels. These would generally occur at night-time

10.2 Construction Traffic

The construction related traffic during the project will vary as activities proceed across the site. It is not possible to currently estimate of the number of trips generated with a degree of accuracy as the overall programme is still under development. The major trip generating activities are listed in Table 10.1, together with a range of likely daily trips. This estimate is based on recent experience from the CMI project works and is subject to further confirmation during the specimen design stage.

Activity	Range of daily trips to/from site
Excavation of the tunnel	50 to 150
Delivery of materials	20 to 100 at peak
Daily staff travel	Up to 150
Traffic management	25 to 50
Site administration and management	50 to 150

11 Conclusions

11.1 Southbound Corridor

The proposed southbound capacity improvements will increase the supply of flow to the Auckland Harbour Bridge during the AM Peak period to approximately 10,200 to 10,500 vph, thereby permitting the bridge to reach its operational capacity. This supply rate would be made up from approximately 6450 vph from the motorway north of Onewa Road, 1550 vph (including buses and HOV's) from the proposed North Shore Bus Priority Project, and 2200 vph from the Onewa Road on ramp.

Mean southbound vehicle speeds through the corridor should remain in the range 60 km/h to 80 km/h, with significantly reduced congestion being experienced south of the Esmonde Road bottleneck.

Modifications to the Fanshawe Street off ramp will allow buses to bypass any queuing associated with the signals at the end of the off ramp, and the signal arrangement would be modified to manage increased flows associated with the development of the Western Reclamation.

The existing Cook Street off ramp alignment would not change.

The proposed improvements will reduce congestion and increase operating speeds through the southbound corridor during all periods, with the most noticeable benefit during the AM peak period. Bus travel times will be reduced by the implementation of bus priority facilities on the motorway and adjacent local network (Fanshawe Street).

11.2 Northbound Corridor

The proposed capacity improvements to the northbound corridor will increase the flow that can reach the AHB during the PM peak period to approximately 9,900 to 10,000 vph, leaving spare capacity of approximately 500 vph.

Mean northbound vehicle speeds through the corridor should be in the range 60 km/h to 80 km/h, except for the section of motorway immediately upstream of the Wellington Street on ramp.

The provision of a two lane link from the Northwestern Motorway and Grafton Gully, merging with the two lanes from the Southern Motorway prior to the on ramp to become three lanes, would reduce the vehicle density in Lane 1 prior to the Wellington Street on ramp merge, thereby increasing the achievable capacity of the on ramp and reducing the effect on the upstream motorway. In addition, it is believed that the onramp should be constructed with the ability for future ramp metering to reduce the likelihood of flow breakdown on the motorway proper.

Ramp metering of the Curran Street on ramp is proposed to mitigate the potential flow breakdown that may occur from high traffic volumes using this on ramp.

The proposed improvements will reduce congestion and increase operating speeds through the northbound corridor during all periods, with the most noticeable benefit during the PM peak period.

11.3 Fanshawe St/ Beaumont St Intersection

Proposed improvements to the Fanshawe Street on and off ramps, along with modifications to the intersection lane assignment and signal phasing will allow the intersection to accommodate flows exiting the motorway, and increased flows associated with the development of the western reclamation.

No queuing back from the Fanshawe Street/ Beaumont Street intersection to the motorway is expected.

Proposed bus priority facilities will allow buses exiting the motorway to bypass any queuing associated with the signals.

11.4 Northbound Bus Priority Shoulder Lane

The modification of Lane 1 through St. Mary's Bay for use by buses only would not have a significant detrimental effect on the operational behaviour and mean vehicle speeds on the motorway through the corridor, however as the micro-simulation model includes only a small part of the adjoining local road network, what cannot be shown is the delay to vehicles on that network resulting from the reduced capacity of the Fanshawe Street on ramp and subsequent trip reassignment.

The micro-simulation tests indicate that mean bus speeds through St. Mary's Bay could be increased by approximately 4 km/h. The travel time benefit that could be achieved per bus between Fanshawe Street and Curran Street would therefore be approximately 2.9 seconds at mean speed.

This option would require ramp metering of the Wellington Street and Curran Street on ramps.