

Shoulder Bus Lanes Along Auckland Motorways Study

June 2018

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1. Introduction

1.1. Background to Review

Customer journeys, using public transport in Auckland can suffer from long delays on Motorways and at on and off ramps due to heavy traffic volumes during peak times. During peak periods, many part of the motorway network and their ramps are operating at or near capacity.

Improving the efficiency of people movements can be achieved by improving movements of high occupancy vehicles like buses. Each bus can carry up to 70 people, which is equivalent to approximately 50 car - movements. Creating dedicated space for buses to run on existing motorway shoulders, where possible, can dramatically improve people movements and efficiency across the Auckland motorway network. This step change in managing motorway space will strongly communicate the customer based approach adopted by the NZ Transport Agency (the Transport Agency) and Auckland Transport (AT) in a highly visible fashion.

As such, the Transport Agency and AT are working in conjunction to understand whether additional bus shoulder running on the motorway network can enable buses to achieve more efficient and reliable journey time for buses.

The Auckland Motorway Alliance (AMA) had undertaken an assessment in 2012 on bus shoulder running on the network. In 2015, another assessment for bus shoulder running on State Highway 20 (SH20) to improve travel time to the Airport was also carried out by AMA.

On 11th May 2018, a meeting was held between the Transport Agency, AT, and the AMA to clarify the need for the AMA to undertake further analysis of the potential to introduce additional bus shoulder running on the AMA network.

This report is based on that request to undertake the analysis. The Transport Agency had also prepared a Demonstration Project Brief which defined the problem and identified a number of success factors. This brief is provided in **Appendix A**.

The success factors are defined as an improved number of people movements during peak periods and the travel time reliability for the public transport. In addition, there will be improvements in:

1. Customers' satisfaction
2. Mode shift (in favour of Public Transport)
3. Public Transport Travel Time
4. Operating cost savings
5. Resilience.

1.2. Scope and Study Area of Review

The scope of this study is to assess the potential benefits of improved and/or additional bus routing through shoulder lanes on the Auckland motorway network and bus priority measures at motorway intersections/ramps, and to develop concept treatments.

This study includes the Auckland Motorway network but excludes areas within the network where:

- No scheduled bus services operate, i.e.:
 - State Highway 1 (SH1) south of Ellerslie-Panmure Highway (EPH)
- Improvement works are currently ongoing, i.e.:
 - State Highway 16 (SH16) Westgate to Lincoln Road

- SH1 Constellation Drive to Albany
- SH1 from the SH20/SH1 connection at Manukau to Papakura
- Sectors which have a Busways:
 - SH1 North – Constellation to Akoranga.

The study area is shown in **Figure 1** below:

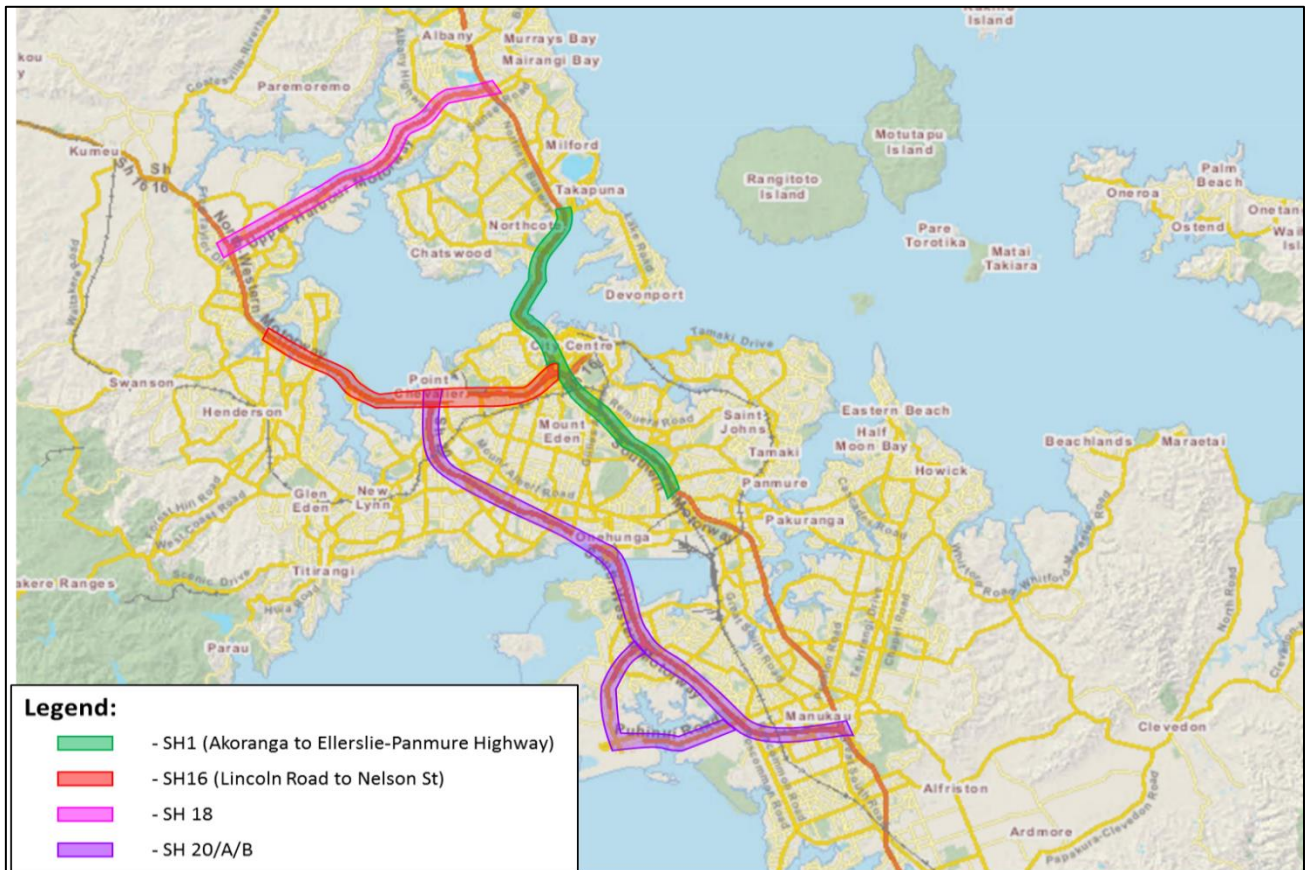


Figure 1: Area of Study along the Motorway Network

1.3. Exclusions

The following task are excluded from the scope of this project:

- Economic evaluation of options
- Analysis of use by and benefits to private coaches
- Bus route amendment/s
- Analysis of passenger volumes (i.e. all analyses is to be based on bus volumes only)
- Analysis of bus delays/potential solutions located >10m beyond motorway intersections.
- Options to convert existing transit lanes to bus lanes (including at ramps)
- Options to narrow traffic lanes or to widen shoulder lanes/provide additional refuge areas (in the short term)
- Detailed consideration of any Intelligent Transport System (ITS) elements
- Detailed design / preparation of CAD drawings of options.

1.4. Report Purpose and Structure

The purpose of the report is to summarise the initial concept development work.

The structure of the rest of the report is as follows:

- Chapter 2 and 3 identifies the existing shoulder bus lane provisions and any issues associated with them.
- Chapter 4 presents additional shoulder bus lane options on the motorway network and the analyses conducted to justify them.
- Chapter 5 prioritises the options to identify an implementation timeline
- Chapter 6 concludes the project details and makes recommendations for option implementation and the next steps forward.

2. Existing Situation

2.1. Shoulder Provision

Shoulder bus lanes are generally provided at the left-most side of the motorway to cater to emergency scenarios such as breakdowns, to provide an emergency lane for emergency vehicles and to provide storage for accident vehicles away from the main traffic lanes. However, there are certain areas along the motorway which do not have shoulder lanes provided, usually at sections where there is a bridge overpass, for example, on SH1 both directions at the Market Road bridge overpass between the Greenlane and Gillies Avenue interchanges.

Schematic plans are provided in **Appendix B** showing shoulder lane provisions along the Motorways.

2.2. Shoulder Bus Lane Provision

Existing shoulder bus lanes are provided at the following sectors of the State Highway network:

- SH1 (North)
 - Southbound between Greville Road and Constellation Drive
 - Bi-directional between Esmonde Road and Onewa Road
 - Southbound between Onewa Road and Stafford Road
 - Southbound between Shelly Beach Road and Fanshawe Street
- SH1 (South)
 - Northbound between Mount Wellington Highway and EPH
- SH16
 - Bi-directional between Hobsonville Road and Great North Road
- SH18
 - Northbound SH18 on-ramp into SH1 North
- SH20
 - Bi-directional between Coronation Road/Walmsley Road and Orpheus Drive/Gloucester Park Road.

Figure 2 shows the approximate overview of where the existing shoulder bus lanes are.

Transit lanes (T2/T3) exist at a number of other locations, such as on SH20 between Orpheus Drive and Queenstown Road (westbound only).

Shoulder bus lanes also exist in certain intersection ramps, as an extension of the motorway to allow for bus priority over on-ramp signals, for example, at the Greville Road onramp into southbound SH1. They also exist at some motorway off-ramps such as the SH16 westbound off-ramp into Te Atatu Road.

Transit lanes are provided at a number of other motorway intersection ramps.

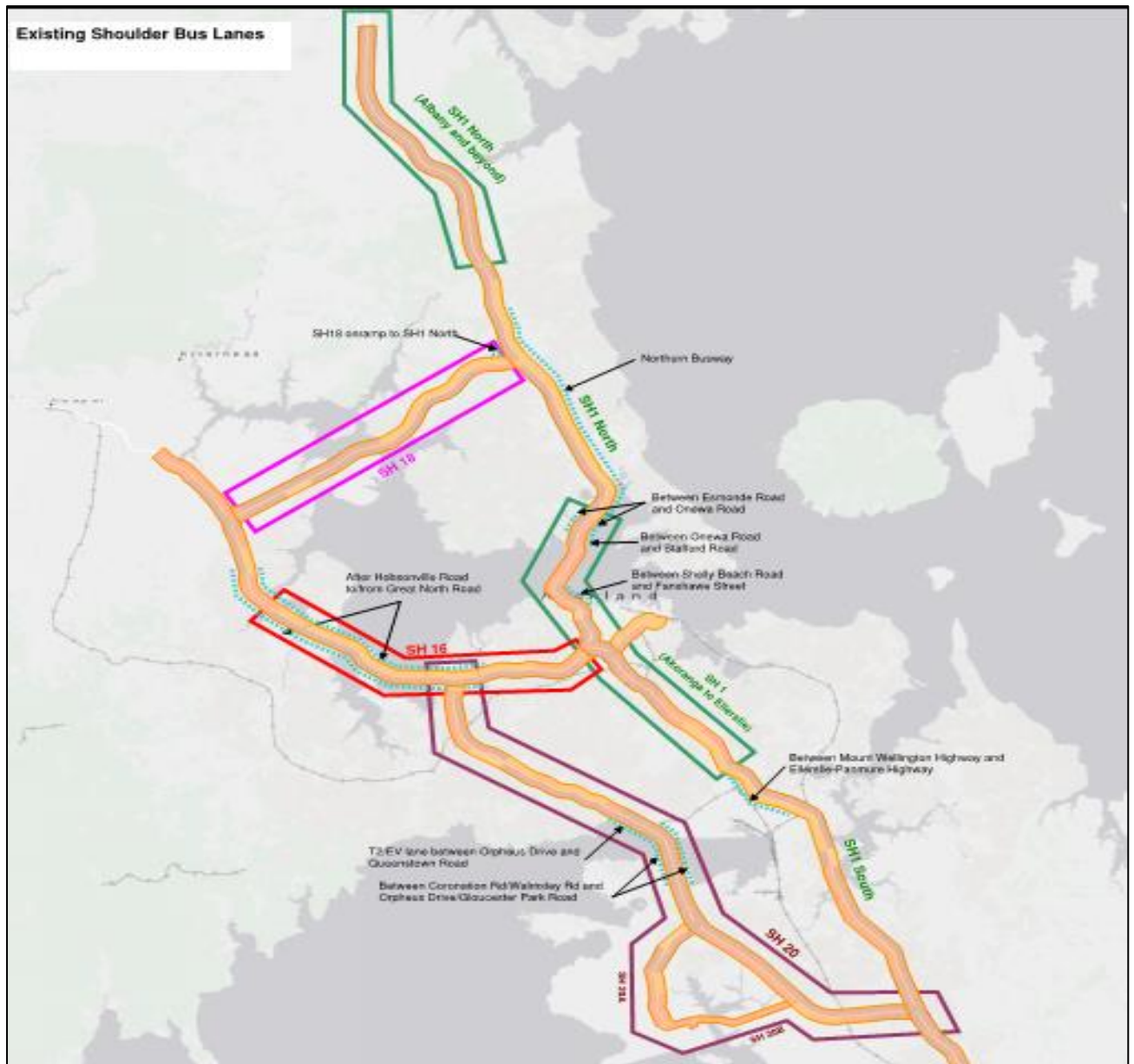


Figure 2: Existing Shoulder Bus Lanes

Detailed schematic layouts of the respective State Highways are provided in **Appendix B**.

2.3. Use of the Motorway Network by Buses

AT Metro had provided a network plan of bus services using the Motorways and their respective frequencies for the Years 2018 and 2028. In summary, the number of buses using State Highway 1 ranks the highest amongst all the other Motorways, followed by SH16, 20 and 18, in descending order.

The detailed bus routes maps and peak period bus volumes are contained in **Appendix C**.

3. Observations and Issues

In order to gain an understanding of the issues and the factors behind them, a number of data sources were reviewed.

3.1. Crash Analysis

An analysis has been undertaken to identify the number of crashes involving buses on the Auckland Motorway Network over the last five years from 2013 to 2017. A summary of the findings on average number of bus crashes per year is shown in Figure 3.

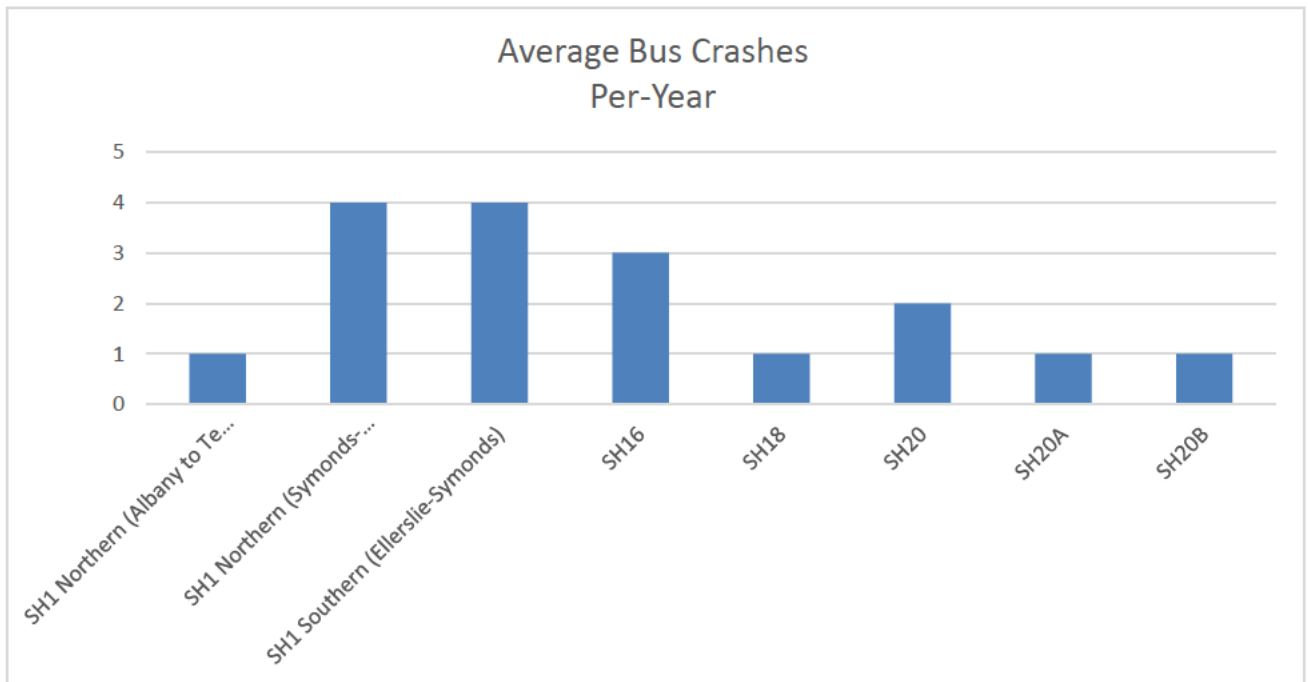


Figure 3: Average Bus Crashes Per Year

Figure 4 shows the summary of the types of bus crashes (total over 5 years) along the different State Highway sections.

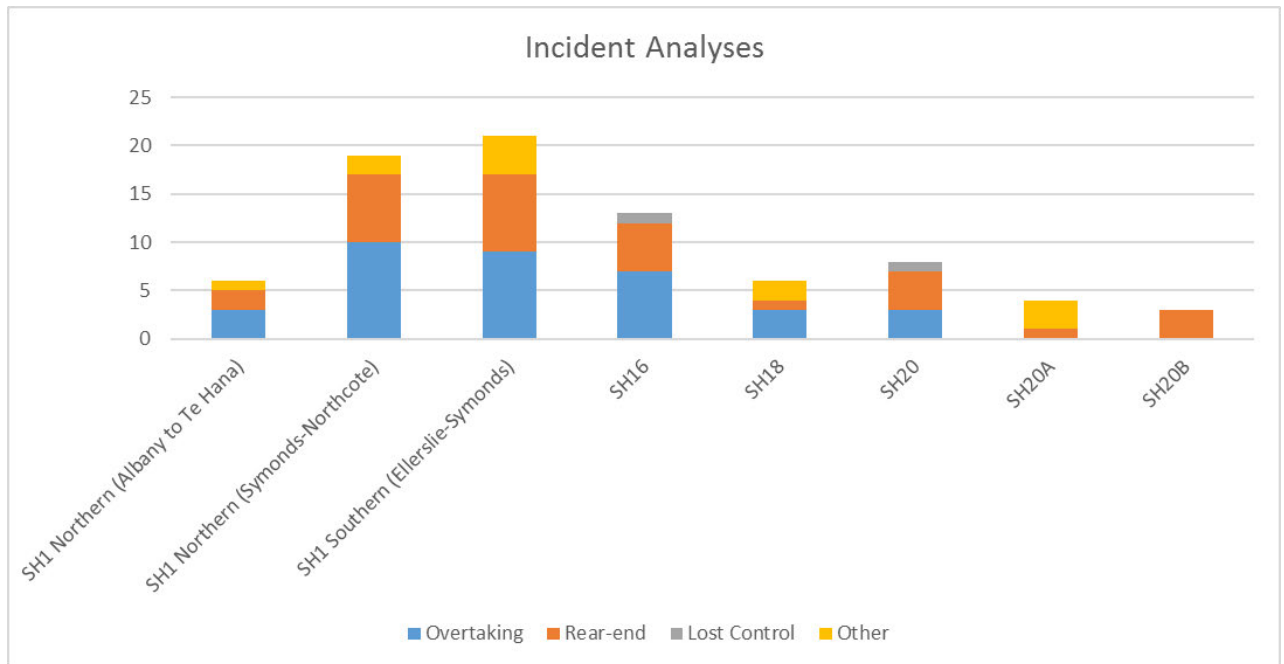


Figure 4: Crash Incidents by Type

It can be seen from the analysis of crash data that the number of bus crashes on each State Highway network is generally low but with the most incidents occurring along SH1 (Akoranga to Eilerslie-Panmure Highway), followed by SH20 and then the rest.

The root cause for most of these accidents are due to overtaking, which indirectly indicates that in view of safety, it may be beneficial if buses were designated their own lanes for operation, to minimise the need to overtaking along the main motorway roads. Allowing buses to run on a dedicated lane with fewer traffic could also possibly result in fewer rear-end collisions, which is the next biggest type of incident for buses on the motorway.

3.2. Traffic Level of Service along the Motorways

The AT Code of Practice (ATCOP) 2013 sets out quality standards to ensure that the function, condition and useful service life of transport assets are consistently achieved throughout the region. With reference to this, **Table 1** below defines the Level of Service (LOS) for the motorways which have speed limits of either 80km/h or 100km/h.

Table 1: LOS Definition for General Traffic

Level of Service (LOS)	Characteristics of traffic movement
A	Generally free flow traffic conditions with operating speeds usually at 90% of the free flow speed (or sign-posted speed limit). Vehicles are unimpeded in manoeuvring in the traffic stream, with little travel delays.
B	Relatively unimpeded operation with average speeds of about 70% of the sign-posted speed limit. Manoeuvring in the traffic stream is only slightly restricted and travel delay is low.
C	Stable operating conditions but with manoeuvring becoming more restricted and motorists experience some driver discomfort and delays. Average travel speeds are at about 50% of the sign-posted speed limit.
D	Conditions border on becoming unstable with increased delay and lower travel speeds of about 40% of the sign-posted speed limit. Manoeuvring is becoming difficult.
E	Conditions are unstable and characterised by queuing and significant delays with average travel speeds reduced to about 33% of the sign-posted speed limit or lower. Manoeuvring is very restricted. Stop-go conditions are typical.
F	Conditions are characterised by excessive congestion and delays with average travel speeds of 25% of the sign-posted speed limit and below.

Based on data provided by AT, the LOS for March 2018 morning (AM) and evening (PM) peak one-hour periods are shown in **Figures 5 and 6**, respectively.

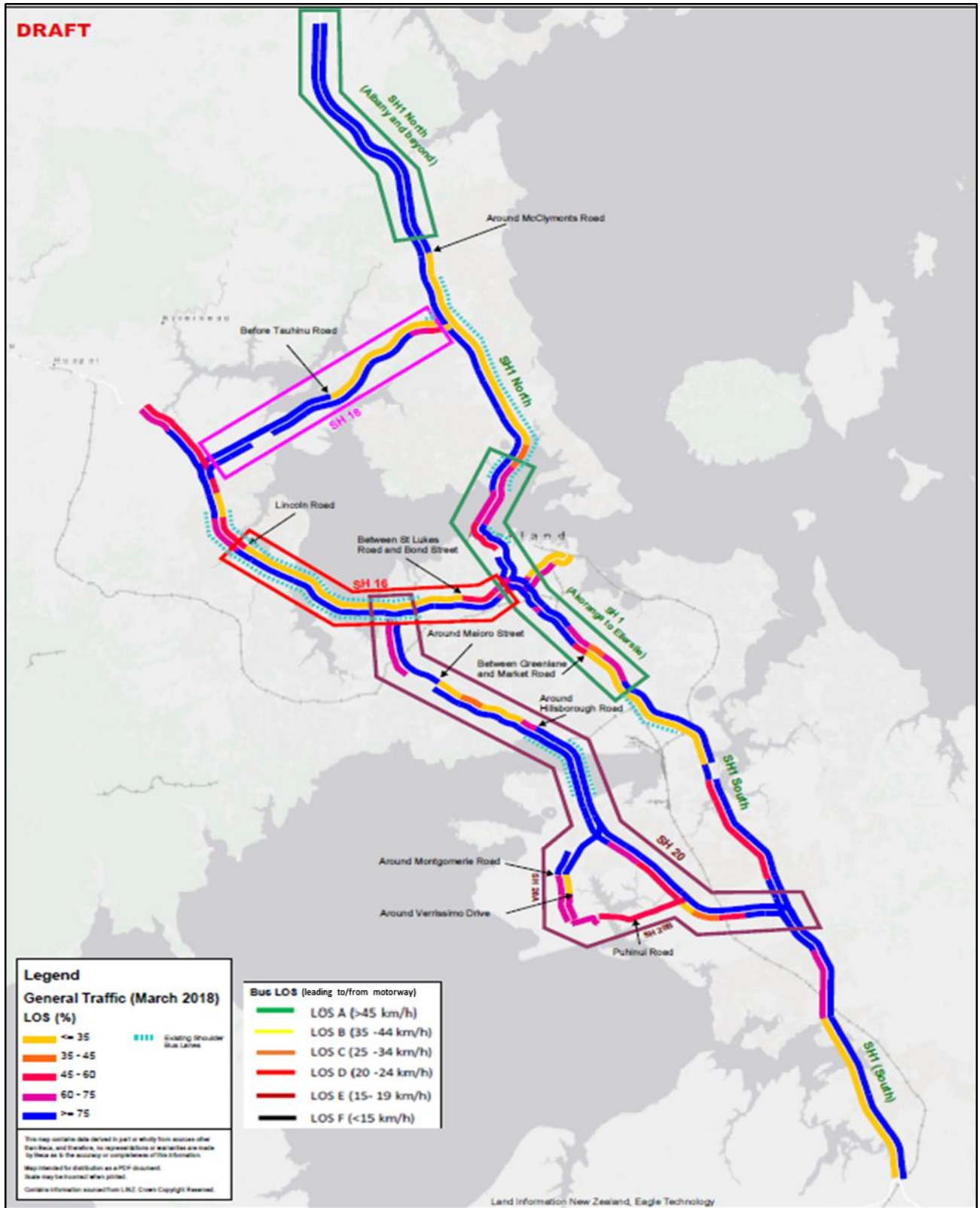


Figure 5: LOS During AM Peak Period (Mar 2018)

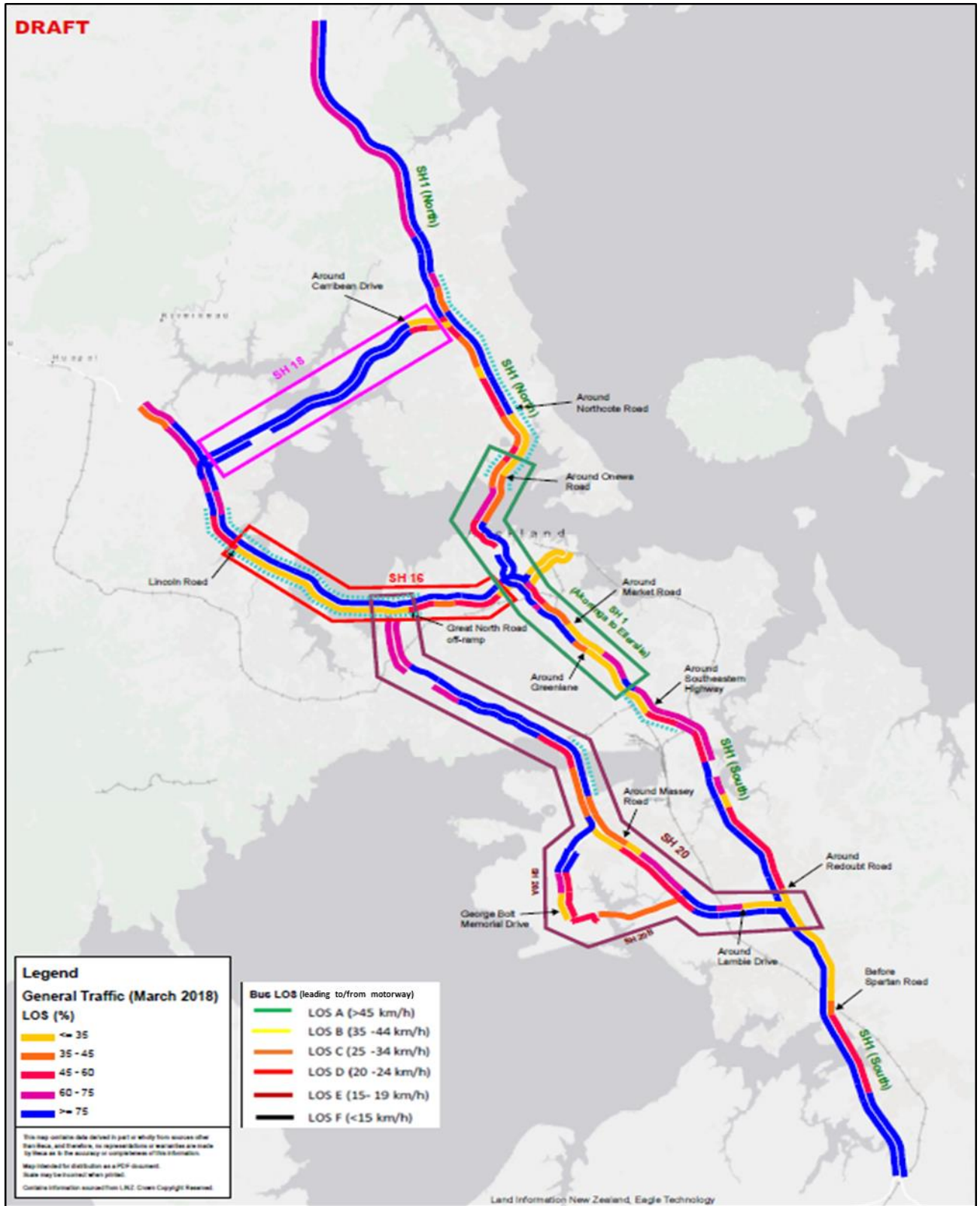


Figure 6: LOS During PM Peak (Mar 2018)

Hence, motorway sections with average speeds of about 35km/hour and below would be regarded as between LOS D, E and F.

3.3. Bus Level of Service along the Motorways

Bus Level of Service (LOS) along the Motorways are closely linked to the traffic LOS. However, on road sections leading up to/from the Motorway, including on- and off-ramps, the average speeds of buses can be linked closely instead with the actual traffic speeds along these sections, and bus LOS is categorised differently from the traffic LOS. **Table 2** reflects the LOS for buses along these road stretches.

Table 2: Definition of LOS for Buses only

Bus LOS	Average Speed
A	>45 km/h
B	35 - 44 km/h
C	25 - 34 km/h
D	20 - 24 km/h
E	15 - 19 km/h
F	<15 km/h

This data has been used to identify where shoulder bus lanes could be beneficial.

3.4. Shoulder Bus Lane Standards

A few issues with regard to existing bus shoulder lanes exist across the existing motorway network that require standardisation or resolution, they relate to:

- Speed differential between buses on shoulder and other traffic
- Roadside obstacles (e.g. lighting, bridges, sign structures etc.)
- Weaving movements at interchanges
- Pinch points with limited shoulder, such as under the SH1 Market Road bridge overpass between Greenlane and Gillies Avenue Interchanges in both directions
- Emergency use of road shoulder conflicting with bus movement

- Materials used for paving shoulder lanes
- Driver awareness of the existence of buses in the shoulder area
- Use of shoulder lanes by High-Occupancy Vehicles, trucks and all other traffic
- Bus shoulder lanes hours of operations.

Resolution of some of these issues is discussed further in Section 4.2.

4. Improvement Options

4.1. Additional Shoulder Bus Lanes

To help improve bus travel speeds and hence people productivity, and bus service reliability / user satisfaction, the potential to provide additional shoulder bus lanes between intersections and at intersections with ramps, and additional bus priority at intersections, have been investigated across the Auckland Motorway network, **Table 3** refers and shows the constraints associated with each proposal.

Sketches of a number of proposed improvements are contained in **Appendix D**.

Table 3: Options for Additional Bus Lanes

Direction	Title	Description	Potential Issues
SH1 (North)			
NB	Before & After Stafford Road On-ramp	Close the Stafford Road onramp and convert the on-ramp lane into a dedicated bus lane in conjunction with a shoulder bus lane on the approach	Removing the Stafford Road Onramp will require consultation with the police control centre and safety issues with removing the merge
NB	Onewa Road to Harbour Bridge	Convert the dedicated Onewa Rd offramp into a bus lane and construct an auxiliary bus lane across the gore area of the Onewa Rd offramp to connect to the existing shoulder bus lane	Constraints in connecting the midblock bus lane across the onramp to create a continuous bus lane
SB		Extend the existing bus lane to before the Harbour Bridge	Existing shoulder constrained by the boundary of the edge of the water and may not be able to be widened without reclaiming land.
NB & SB	Albany to Silverdale	Convert the shoulders along the motorway into bus lanes	Localised areas can be challenging to widen due to steep slopes and bridge columns without major groundworks.
NB	Offramp onto Silverdale Interchange	Implement bus lane on the approach to the northbound offramp by converting the existing two-lane off-ramp to a diverge and bus exit lane. (Services the NX1 buses)	To extend the northbound bus lane further up the mainline approach, pavement widening will need to be conducted. Similarly, the southbound mainline shoulders are too narrow unless the pavement is widened into the grass verge.

SH1 (South)			
NB	Ellerslie-Panmure Highway Roundabout Interchange	Split the single wide circulating lane into a general traffic lane and dedicated bus lane	Bus lane will be very short as there is insufficient space on the northbound onramp to continue the bus lane onto. There will also be issues with the northbound onramp right-turn traffic illegally utilising the proposed bus lane to avoid queues on the inner circulating lane
NB	Ellerslie Panmure Highway Onramp onto SH1	Construct a bus lane on the shoulder of the on-ramp. Install fence between road and railway	Severely space constrained, removal of trees and vegetation will leave limited physical separation between the proposed bus lane and the railway line. May have to terminate at the mainline due to space constraints.
SH16			
EB	Great North Road Offramp	Extend the existing bus lane on the eastbound mainline up the Great North Road offramp until the lane split into left/right turn lanes.	For buses that continue through the mainline, it will be difficult to merge them across the dedicated offramp lanes to keep them on the mainline
EB & WB	Patiki Road to Te Atatu Road Interchanges	Convert the shoulders on the Patiki Road onramp and offramp into a bus lanes and connect existing bus lanes along the motorway	Patiki Road Eastbound offramp is a flyover and is difficult to be widened. The Patiki westbound onramp presents issues with merging bus and general traffic
WB	St Lukes Road to Great North Road Offramp	Construct a shoulder bus lane along the westbound offramp and approach by repainting the existing wide chevroned shoulder (700m in advance at the Advance Exit overhead gantry)	Space constraints due to the retaining wall limits the length of the offramp bus lane, so the bus lane will need to terminate early. Buses will need to merge across 2 lanes of traffic to continue westbound
SH18			

EB & WB	Between Trig and Brigham Creek Roads	Implement a bus lane on the wide shoulders along the westbound mainline, between the Trig Road on-ramp and Brigham Creek Road offramp	Localised widening may be required on the westbound shoulder
EB WB	Hobsonville Interchange	Implement a shoulder bus lane along the eastbound onramp and continue onto the mainline until the Trig Road offramp Implement a shoulder bus lane on the Brigham Creek eastbound onramp until the Tauhinu Road Onramp (Greenhithe) Construct a shoulder bus lane along the westbound onramp and continue onto the wide shoulders on the mainline until the Trig Road offramp	Operational effects of adding a bus lane to the operations on the ramp signalling and motorway traffic, especially during peak periods. Operational effects of adding a bus lane to the operations on the ramp signalling and motorway traffic, especially during peak periods.
EB WB	Squadron Dr On and Offramps	Construct a shoulder bus lane along the eastbound onramp. The bus lane can continue on the mainline shoulder a short distance further downstream, across Sunset Bay bridge and terminating at Tauhinu Road offramp Construct a shoulder bus lane on westbound Squadron Dr offramp (Exit 8), and on approach to offramp for approximately 800m.	Eastbound bus lane must terminate at the gore as there is no room to widen the shoulder against the fence line. Environmental effects and property designation will need to be checked. Bus lane cannot extend beyond the Sunset Bay bridge
EB	Bridge between Hobsonville and Greenhithe	Implement a bus lane along the wide shoulders on the eastbound main line, between the Brigham Creek on-ramp and the bridge. The low-speed lane on the bridge can be converted into a bus lane.	General traffic operation issues of removing the low-speed lane, as heavy vehicles will now occupy the adjacent lanes

WB		Implement a bus lane along the wide shoulders on the Tauhinu on-ramp and the westbound mainline	General traffic operation issues with merging the bus lane at the pinch point of the bridge
SH20			
SB	Dominion Road to Hillsborough Road Interchange	Construct a new dedicated bus lane on the onramp to SH20 and continue bus lane onto the mainline shoulder until Hillsborough Road Offramp	Operational effects of adding a bus lane to the operations on the ramp signalling and motorway traffic, especially during peak periods; and continuing the bus lane onto the mainline shoulder will require extensive widening and shifting the existing barrier
SB	Hillsborough Road Interchange to SH20	Install shoulder bus lane on the on-ramp and the mainline after the onramp	Operational effects of adding a bus lane to the operations on the ramp signalling and motorway traffic; and retaining structures along the route and may not be feasible to implement, and proximity to the property boundary towards the gore of the onramp
SB	SH20 to Gloucester Park Road On-ramp	Install shoulder bus lane in between the southbound Neilson Street offramp and Gloucester Park Road Onramp, tying in with the existing bus lane on Mangere Bridge	Unable to completely tie in to the existing bus lane on Mangere bridge due to the on-ramp merge. The effects of the East-West Link alignment to be considered
WB	SH20 to Coronation Road Off-ramp	Implement a bus lane in the northbound shoulder, continuing from the SH20 interchange until the Coronation Road offramp.	Pinch point at the Hall Ave footbridge, where the abutments are close to the barrier. The interchange merge between SH20 and SH20A means buses will need to merge across two lanes if they are to continue on the mainline
SB & WB	SH20-20A Road Interchange	Construct southbound shoulder bus lane after the gore area of the SH20/20A (EXIT 9). Construct northbound shoulder bus lane after the Bader Dr offramp up to the SH20 northbound merge point.	Northbound shoulder appears slightly narrower than the southbound. Sight distance will be limited for buses in the new lane, especially as they navigate the bend. Safety issue with merging buses onto mainline conflicting with general traffic intending to exit at Coronation Road.
SH20A			

NB & SB	Landing Drive to SH20 Interchange	Convert the wide shoulders and (currently) unassigned lanes into bus lanes.	Possible conflict with future projects in the area such as Light Rail to the Airport. Currently still under construction and road works.
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Notes:

NB – Northbound, SB – Southbound, EB – Eastbound, WB – Westbound, BB – Both directions

5. Implementation of Options

A “Scoring” system was implemented to identify the priorities in implementing the proposed shoulder bus lanes. The categories, criteria and assumptions of the scores are provided in **Table 5** as follows:

Table 4: Criteria/Assumptions for Scoring

	Short-term	Short-Medium Term	Medium-term	Medium-Long Term	Long-term
Score	5	4	3	2	1
Structural	Wide shoulders, lane likely ready for use / Lowest estimated cost	Removal of signposts + lane marking changes / Low-Medium estimated cost	Structural Changes + Lane widening / Medium estimated cost	Major structural changes (e.g. bridge) / Medium to High estimated cost	Major structural changes and possible land acquisition / High estimated cost
Bus Volumes (buses per hour)	> 19 bph	15 to 19 bph	10 to 14 bph	5 to 9 bph	<5 bph
Bus Level of Service (LOS) / Median Speed (MS)	E to F	D	C	B	A
Bus Lane Continuity	Very Good	Good	Average	Poor	Very Poor

The final scores were tabulated and are shown in **Table 6** below:

Table 5: Overall Scores for Each Option

State Highway	Location	Structural Score / Est. Cost	Bus Volume Score	LOS / MS Score	Bus Lane Continuity	TOTAL
16	SH16 EB - Great North Road Offramp	3	5	5	2	15
16	SH16 WB - St Lukes Road to Great North Road Offramp	4	5	3	3	15
20A	SH20A BB - Landing Drive to SH20 Interchange	4	3	5	4	15
1	SH1 NB - Before & After Stafford Road On-ramp	5	5	3	2	15
1	SH1 BB - Onewa Road to Harbour Bridge	3	5	3	4	14
20	SH20 SB - Dominion Road to Hillsborough Road Interchange	3	2	5	3	13
1	SH1 NB - Ellerslie-Panmure Highway Roundabout Interchange	3	3	5	1	12
1	SH1 NB - Offramp onto Silverdale Interchange	3	5	1	3	12
16	SH16 BB - Between Patiki Road and Te Atatu Road Interchange	3	5	2	2	12
1	SH1 NB - Ellerslie Panmure Highway Onramp onto SH1	2	3	5	1	11
18	SH18 BB - Bridge between Hobsonville and Greenhithe	4	2	1	4	11
1	SH1 BB - Albany to Silverdale	2	5	2	3	11
18	SH18 BB - Hobsonville Interchange	3	2	1	5	11
18	SH18 BB - Between Trig and Brigham Creek Roads	3	2	1	5	11
18	SH18 BB - Squadron Dr On and Offramps	3	2	1	4	10
20	SH20 BB - SH20-20A Road Interchange	3	3	1	2	9
20	SH20 SB - SH20 to Gloucester Park Road On-ramp	3	4	1	1	9
20	SH20 SB - Hillsborough Rd Interchange to SH20	2	3	2	2	9
20	SH20WB - SH20 to Coronation Road Off-ramp	3	3	1	1	8

	- Priority
	- Medium-term
	- Longer Term

5.1. Short Term (in 6–9 months)

Based on the ranking system adopted, proposals that are recommended to be implemented in the short-term generally score high on bus volumes, low-cost of implementation as a result of minimal changes required structurally and generally a poor existing LOS. These are:

- SH16 EB - Great North Road Offramp (up to existing wide shoulders along off-ramp)
- SH16 WB - St Lukes' Road to Great North Road Offramp
- SH20A BB - Landing drive to SH20 Interchange
- SH1 NB - Before & After Stafford Road On-ramp
- SH1 BB - Onewa Road to Harbour Bridge

5.2. Medium Term (in 8–18 months)

The medium-term proposals have a more average score for bus volumes and ease of implementation structurally. There is a mix of scores for existing LOS and bus lane continuity. These are:

- SH20 SB - Dominion Road to Hillsborough Road Interchange
- SH1 NB - Ellerslie-Panmure Highway Roundabout Interchange
- SH1 NB - Offramp onto Silverdale Interchange
- SH16 BB - Between Patiki Road and Te Atatu Road Interchanges
- SH1 NB - Ellerslie Panmure Highway Onramp onto SH1
- SH18 BB - Bridge between Hobsonville and Greenhithe
- SH1 BB - Albany to Silverdale
- SH18 BB - Hobsonville Interchange
- SH18 BB - Between Trig and Brigham Creek Roads.

5.3. Longer Term (18 months+)

Proposals grouped under the “Longer-term” category generally experience minimal issue along the existing Motorway network currently and has low forecasted bus volumes. They are:

- SH18 BB - Squadron Dr On and Offramps
- SH BB - SH20-20A Road Interchange
- SH20 SB - SH20 to Gloucester Park Road On-ramp
- SH20 SB - Hillsborough Road Interchange to SH20
- SH20 WB - SH20 to Coronation Road Off-ramp.

Notes:

NB – Northbound, SB – Southbound, EB – Eastbound, WB – Westbound, BB – Both directions

6. Recommendations and Next Steps

6.1. Recommendations

The top five priorities which are recommended to be implemented in the short-term (within nine months approximately), are as follows:

- SH16 EB - Great North Road Offramp (up to existing wide shoulders along off-ramp)
- SH16 WB - St Lukes' Road to Great North Road Offramp
- SH20A BB - Landing drive to SH20 Interchange
- SH1 NB - Before & After Stafford Road On-ramp
- SH1 BB - Onewa Road to Harbour Bridge

Other sites were also identified for medium- to long-term implementation:

Medium term (within nine to 18 months approximately):

- SH20 SB - Dominion Road to Hillsborough Road Interchange
- SH1 NB - Ellerslie-Panmure Highway Roundabout Interchange
- SH1 NB - Offramp onto Silverdale Interchange
- SH16 BB - Between Patiki Road and Te Atatu Road Interchanges
- SH1 NB - Ellerslie Panmure Highway Onramp onto SH1
- SH18 BB - Bridge between Hobsonville and Greenhithe
- SH1 BB - Albany to Silverdale
- SH18 BB - Hobsonville Interchange
- SH18 BB - Between Trig and Brigham Creek Roads.

Longer term (> 18 months approximately):

- SH18 BB - Squadron Dr On and Offramps
- SH BB - SH20-20A Road Interchange
- SH20 SB - SH20 to Gloucester Park Road On-ramp
- SH20 SB - Hillsborough Road Interchange to SH20
- SH20 WB - SH20 to Coronation Road Off-ramp.

Notes:

NB – Northbound, SB – Southbound, EB – Eastbound, WB – Westbound, BB – Both directions

With regard to the existing shoulder bus lanes on the Motorway network in Auckland, it is recommended to standardise the lane surfaces, operating hours and other relevant aspects for these lanes to provide better clarity to non-bus users and to enhance safety. Further work is required to be undertaken to determine what changes need to be made.

6.2. Next Steps

the proposals identified in this report are recommended to proceed to the next stage to carry out outline design works for the proposals targeted to be implemented in the short term, and with detailed cost figures.

Concurrently, outline designs for the medium- to long-term options can be further developed.

When developing potential additional shoulder bus lane options there are several considerations that need to be taken into account in any further work. These have been identified based on our knowledge of UK Highways Agency Smart Motorways projects and on information contained in the American Transportation Guide for Implementing Bus on Shoulder Systems.

These are summarised in **Table 4**.

Table 6: Recommended General Improvements to Shoulder Lanes

Issues	Considerations	Recommendations
Speed differential between buses on shoulder and other traffic	Buses travelling along the shoulder may be travelling at higher speeds than general traffic. Bus speeds need to be suitable for narrow widths in sections and to not create perception of being a hazard to motorists and passengers.	Set a maximum speed differential. Typical acceptable differentials are 15 to 20Km/hr. May need signs (or ITS) to help enforce this Some training of drivers will be necessary to ensure compliance.
Required Shoulder Width	3.0 metres is generally regarded as the absolute minimum width for buses to safely run along the shoulder, however the ideal width is 3.5 metres.	Where existing shoulders are less than 3.0m widen to 3.5m ideally, otherwise widen to maximum extent possible.
Roadside Obstacles	In narrow shoulder sections (3.0m to 3.5m), the proximity to roadside obstacles (lighting, sign structures, bridges etc.) run the risk of being sideswiped.	Ensure roadside obstacles are set back as per design standards to avoid being hit or clipped by buses running on shoulder.
Weaving Movements at Interchanges	Buses may need priority over other motorists along the length of the scheme. Weaving movements at ramp interfaces (general traffic into, out of and through shoulder bus lane) can be reduced by allowing buses to cross the ramp in one movement from the shoulder between ramps to the shoulder on the ramp.	Provision of auxiliary shoulder lanes to give sufficient length for vehicles to merge with buses before they merge with general traffic. Use loops, ramp metering and signals to detect buses and enable general traffic to be warned of the presence of buses on the shoulder.
Need for ITS	The mainline could have the bus shoulder implemented using static signage and have buses merge into the general traffic to get through interchanges A high-level review of overseas	Provide bus on shoulder operation for mainline between interchanges. Provide for geometry of running buses through shoulder, with a view to open when ITS is available.

	operations indicate that ITS is usually preferred to allow buses to safely navigate conflict areas at ramp locations and through interchanges.	
Pinch Points	Narrow sections with restricted lateral clearance at underpasses and bridge piers.	Provide upstream warning for buses to merge into mainline.
Emergency Use of Shoulder	<p>Need to clarify use of the shoulder for emergencies in times of operation.</p> <p>US operation appears to have the shoulder always available for emergencies and buses are permitted to use the shoulder only during congested periods.</p> <p>Various UK documentation provides different spacing requirements for emergency refuge areas:</p> <p>@ 500 m spacing (required under UK Hard Shoulder Running IAN11/09 guidance – temporary shoulder use as a lane)</p> <p>@2500m spacing (required under UK All Lanes Running IAN161/13 guidance – permanent conversion of shoulder to a running lane)</p>	<p>Provide emergency refuge areas</p> <p>US operation would not impose additional costs to widening requirements.</p>
Existing Shoulder Pavements	Shoulder pavements may need strengthening/resealing to be capable of withstanding expected additional heavy traffic now and into the future.	Further test pits are required to confirm this assumption.
Driver Awareness	Need to ensure that motorists understand the operation and importantly when buses are operating on the shoulder.	<p>Provide VMS warnings at ramps and along mainline.</p> <p>Public Information Campaign will be critical.</p>
Use of shoulder by HOVs / trucks / all other traffic	If more than buses use the shoulder, additional pavement	Consideration should be made for the use by other vehicles (both now and in the future) as

	strengthening may be required.	they may prove to be more cost effective. However, the design should be progressed on the assumption that the shoulder is only used by buses for the time being.
Bus Shoulder Operation Times	May impact on ITS requirements.	Resolve at a later stage in the design process.

- Appendix A – NZ Transport Agency Demonstrator Project Brief**
- Appendix B – Existing Motorway Network Schematic**
- Appendix C – Future Bus Volumes on Motorway**
- Appendix D – Concept Options for Additional Shoulder Bus Lanes**