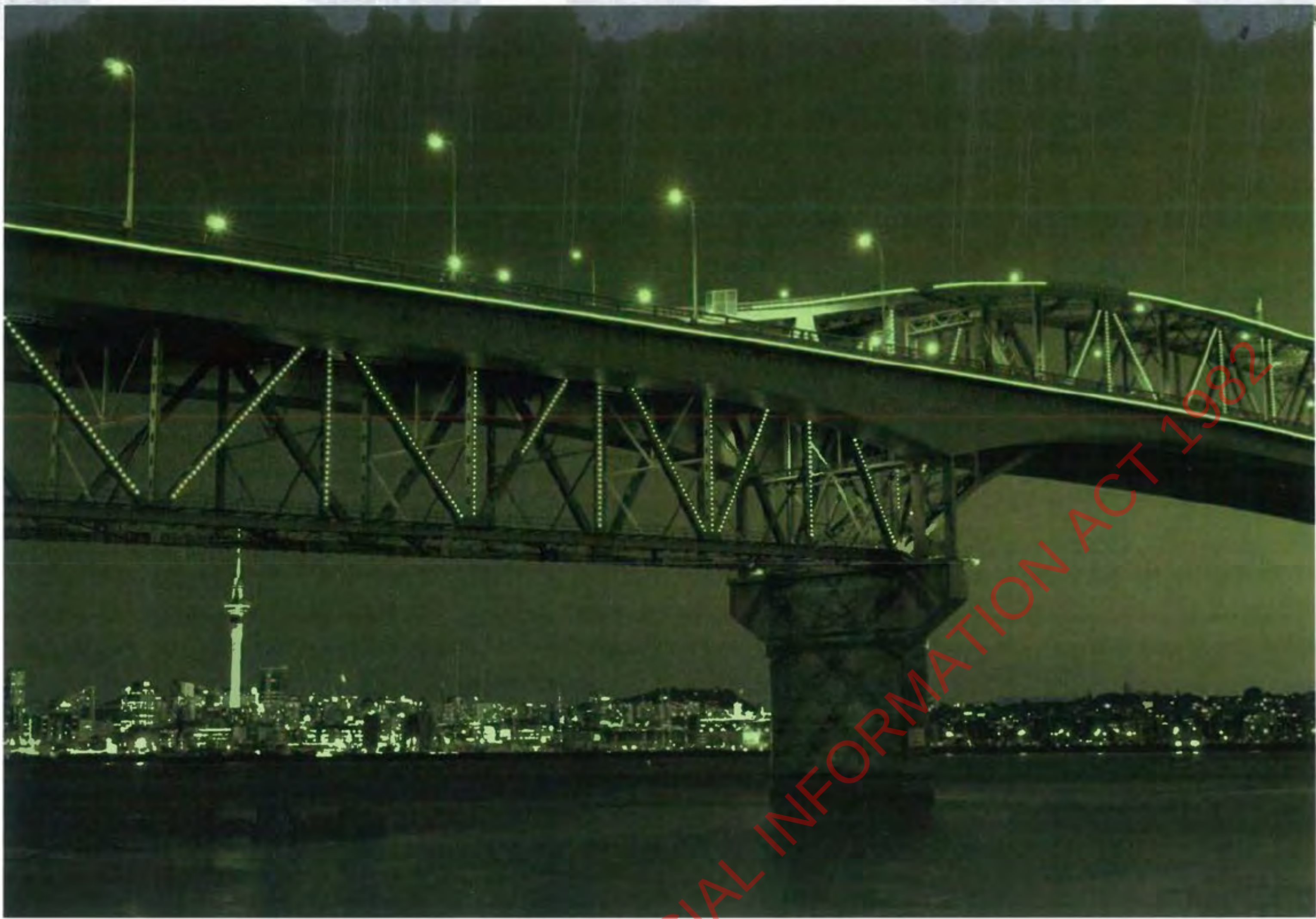

REPORT

AUCKLAND HARBOUR BRIDGE SHARED PATH OPTIONS ASSESSMENT

Prepared For: Waka Kotahi New Zealand Transport Agency

Prepared by: Resolve Group, Ltd.

Date: August 2021

Resolve GROUP

A CLIENT'S OWN CONSULTING TEAM

REPORT

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Date: August 2021

Action	Name	Signed	Date
Prepared by:	s 9(2)(a) [redacted]		06/10/2021
Reviewed by:			06/10/2021
Approved by:			06/10/2021

The analyses contained within this report are dependent upon the accuracy of information available during the study timeframes. Assumptions have been made in order to complete our assessment, so this report should be reviewed and revised as more information becomes available and circumstances change. Every attempt has been made to ensure that the information in this document is correct at the time of publication. Any errors should be reported as soon as possible so that corrections can be issued. Comments and suggestions for future editions are welcomed.

Contents

Executive Summary

The Auckland Harbour Bridge (AHB) is an iconic piece of the Auckland skyline, providing a network critical link between the North Shore and Auckland's Central Business District (CBD). While the AHB has undergone several modifications in its history, including the addition of four lanes and a moveable lane barrier to accommodate population growth and tidal flow demand, one constant has remained. The AHB is only accessible to vehicular traffic, leaving pedestrians and cyclists with limited options to travel between the North Shore and the CBD.

Recently, there has been increasing public interest to provide a pedestrian and cycle link between the North Shore and CBD. Several fit for purpose options have been evaluated and proposed, with the Northern Pathway Project planned as the ultimate solution. At the time of writing this report, planned completion of the Northern Pathway Project was scheduled for 2026/2027.

Over a brief one month period, Resolve Group was tasked with exploring possible options to utilise the existing structure to accommodate a shared path and create this pedestrian and cycle link, until the Northern Pathway Project is constructed.

This report explores 11 options at a high level, assessing each option's effect on:

- Shared path user safety and motorist safety on the AHB
- Traffic flows on the AHB
- Traffic flows throughout the Auckland motorway network
- Structural capacity of the AHB
- Traffic management and user management operations

High level costing (projected capital expenditure and projected yearly operating expenditure) and construction programmes for each option were also explored.

These options were developed with the following boundaries:

- **Temporary Configuration v. "Permanent" Configuration:**
  - Temporary Configuration: options would remain in place over weekend periods, and at all other times, traffic would remain as it currently is on the AHB.
  - "Permanent" Configuration: options would operate 7 days a week, "permanently", until the Northern Pathway Project is constructed.
- **1 Lane v. 2 Lane:** Almost all options were considered in a variation that repurposed either one or two existing traffic lanes for creation of a shared path.
- **Location within AHB Cross Section:** Due to the impact the path's location would potentially have on the motorway and local road networks and the possible need for complete ramp closures, the location of the proposed path was considered on the east side, west side, and centre of the AHB. Additionally, an option was considered which looked at locating two paths, one on each side of the AHB.

Understanding the residual risks associated with each option was paramount in the production of this report, and every option has effects on AHB users, motorway and local road networks and changes to the existing loading patterns of the AHB. This report did not aim to mitigate these risks, but rather, understand them for future option consideration and development. These residual risks include:

- user safety risks resulting from pedestrians and cyclists located in close proximity to traffic;
- network impacts resulting from ramp closures to accommodate a path; and
- operational risks stemming from no longer being able to shift the moveable lane barrier to a position where 5 lanes could accommodate traffic northbound out of the CBD.

Safety of both path users and motorists was a top priority in assessing the options. Width of the path was important when considering the risks to users, as the steep gradient will allow cyclists to gain speed rapidly if not mitigated, potentially endangering other path users. Due to limitations on the structure, the barrier separating active traffic from path users had to be robust and crash tested, but it could not be affixed to the bridge deck. Fencing had to be considered which would prevent path users from climbing the AHB structure and from climbing over the side. The ability of emergency vehicles to quickly respond to incidents along the path was also considered.

Potential effects on the Auckland motorway network were modelled using current traffic data as well as existing information from events which required lane closures on the AHB, such as the 2019 Auckland Marathon. These models were able to analyse the complexities between existing network demand, forecast future network demand, modal shift as people return to public transport following Covid lockdown, path usage, , and traffic suppression to produce heat maps of network impacts. These heat maps provide a view into the potential impacts a shared path on the AHB and its resulting lane closures, either temporary or permanent, would have on the Auckland motorway network. Impacts on the local road network were not modelled, however, any ramp closures involved in option implementation were anticipated to have a profound impact on the local road network. As a result, complete ramp closures were avoided in option development wherever possible.

Structural capacity of the existing AHB was considered in analysis of each of the options, as each option, the additional infrastructure required to safely operate the option, and its resulting shift in active traffic lanes produced varying effects. This analysis determined that most options are structurally viable, however, some restrictions on heavy vehicle loading and/or pedestrian and cyclist loading will be required.

After evaluating all options, it is evident that while constructing and operating any one of them is possible, all come with varying levels of risks and consequences. A high level analysis of findings revealed:

- When locating the path on the west extension, a partial or full closure to the Curran Street ramp would be required and this is expected to have a severe impact on traffic in the CBD;

- A two lane solution would provide greater width and improved safety for path users, but leads to detrimental traffic flow effects throughout the Auckland motorway network;
- Changes in loading patterns to the existing structure will result in heavy vehicle restrictions and/or pedestrian and cyclist restrictions for all options except for the two lane shared path options;
- Any permanent option which does not allow for tidal traffic flow utilising the moveable lane barrier exacerbates the impact on traffic flows across the Auckland motorway network; and
- While mitigation measures are available, path user safety will have to be closely evaluated for all options, particularly as it relates to protecting path users from active traffic as well as other path users on steep gradients.

This report does not make recommendations as to a preferred solution. Rather, it presents findings in an unbiased manner, highlighting the risks associated with each option. This will allow Waka Kotahi to make an informed decision regarding which option will best achieve the most desirable outcomes for the users of the AHB and the Auckland motorway and local road networks, and determine how to best mitigate each option's risks.

1 Introduction

1.1 Operational Context

The Auckland Harbour Bridge (AHB) is part of the Auckland motorway network. This network is comprised of five motorway corridors directly interconnecting with each other:

- SH1 Northern
- SH1 Southern
- SH6
- SH18
- SH20 (with spurs SH20A and SH20B connecting to the airport)

SH1 is the spine of the motorway network running south from Puhoi via the North Shore, Auckland City Centre and Manukau to Bombay where it enters the Waikato region. The AHB is a critical link in this spine.

Figure 1 – Auckland Motorway Network

1.2 Purpose of this Report

The current configuration of the AHB does not provide access for pedestrians and cyclists, and the construction of the Northern Pathway Project, a purpose built solution, is not scheduled to be complete until 2026/2027.

How can the AHB safely accommodate a shared path on the existing structure while the Northern Pathway project is being developed, and what impact would this path have on the wider Auckland network?

This report aims to achieve the following outcomes:

- Investigate feasible options to accommodate a shared path on the existing AHB;
- Assess each feasible option and determine its impact on users, the structure and the wider Auckland Network; and
- Provide Waka Kotahi with a comprehensive and unbiased analysis of feasible options to inform their decision making and/or further analysis.

This report does not provide a recommendation of a preferred option.

1.3 Summary of Approach

The following constraints were identified for the development of feasible options:

- **Temporary Configuration**: The Temporary options are intended to be utilised on weekends and public holidays only, allowing traffic to operate on the AHB in as it currently does during weekdays. These options will only have an impact on traffic flows during weekend periods.
- **Permanent Configuration**: The Permanent options are intended to be installed 24 hours a day, 7 days a week, allowing for a shared path to operate on the AHB at all times, until completion of the Northern Pathway Project. These options will have an impact on traffic flows at all times.

With few exceptions, each Temporary and Permanent option was considered in either a 1-Lane or 2-Lane Configuration. The 1-Lane options would repurpose one active traffic lane as a shared path, and the 2-Lane options would repurpose two active traffic lanes as a shared path

Various locations on the AHB were also considered, the west extension, the east extension as well as the centre of the truss bridge. An option to place a uni-directional path on the outer edge of both extensions was also considered. For reasons which will be explained more thoroughly in the discussion of each option, the centre options as well as uni-directional paths on both sides of the AHB option were only feasible in the permanent configuration. A summary of option construction is shown below, and further detail is provided in Sections 2 and 4:

Option	Configuration	Bridge Location	Number of Traffic Lanes Required
1	Temporary	Southbound	1
2	Temporary	Southbound	2
3	Temporary	Southbound	1
4	Temporary	Southbound	2
5	Permanent	Northbound	1
6	Permanent	Northbound	2
7	Permanent	Northbound	1
8	Permanent	Northbound	2
9	Permanent	Centre	1
10	Permanent	Centre	2
11	Permanent	Both Sides	0

1.4 Key Considerations

Several important considerations factored into our assessment and analysis of options. These considerations will be covered in greater detail in section 3, but are summarised here at a high level.

Health & Safety

The health and safety of shared path users as well as motorists was a paramount consideration when analysing each option. All option configurations involve a multi-mode shared path in close proximity to active traffic lanes, requiring mitigation as best possible of any potential interface between shared path users and vehicles. Additionally, the steep gradient of the bridge may create a hazard between types of shared path users (e.g. cyclists and pedestrians), so consideration was given to the risk associated with shared path operation under the various options.

Impact on AHB Traffic & Wider Network

Removal of one or more active traffic lanes on a critical link in the Auckland Motorway network, either temporarily or permanently, will result in impacts not only to vehicular users of the AHB, but also to users of the network as a whole, including public transport operations. These impacts were modelled under a variety of scenarios to aid in understanding the likely extent of these impacts, including the potential for users to shift their mode of transit due to resulting congestion

Operational Impacts

Any change to traffic flows on the AHB will result in changes to Temporary Traffic Management Plans, maintenance programmes, and general operation of the AHB, including tidal flow on the AHB and associated movement of the moveable lane barrier. These operations will be made further complex by the addition of a shared path on a structure that is currently only allowing vehicular traffic. Each option was assessed for high level potential operational risks and impacts, while considering tools currently at the disposal of Waka Kotahi.

Structural Impacts

Each option was assessed by structural engineers to determine the anticipated effect on the global structural capacity of the AHB. Engineers considered the addition of a distributed load due to additional barriers and users, as well as the redistribution of vehicular loading across the bridge which would result from the addition of a shared path. Any additional wind loading on the structure was not within the scope of this assessment.

2 Options Assessed

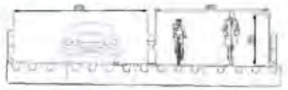
Note: The level of assessed traffic suppression has been based on the most likely scenario considered by ASM and varies across options from low suppression through high suppression. The level of suppression assumed is noted in the Summary of Network Impacts descriptions for each option.

OPTION 1

Summary
4m wide shared path & 4m wide traffic lane on the east clip-on on weekends, temporarily reducing traffic on the AHB by 1 Lane. Shared path separated from traffic by permanent installation of moveable lane barrier (not fixed to the deck). High fence installed on seaward side.

Duration
12 Months

Cross Section



Shared Path

Path Location	Temp / Perm
East	Temp
Path Width	**Traffic Lanes**
4m	1
North Access	**South Access**
Sulphur Beach Road / Underpass	Shelly Beach Offramp

Traffic Configuration

AM Peak	PM Peak
3N/5S	5N/3S
Interpeak	**Weekend**
4N/4S	4N/3S

Traffic Impact Summary Graph

Summary of Network Impacts
When modeling a medium level of traffic suppression, modal shift and traffic re-routing, this Option results in additional delays from approximately 9:00am until 8:00pm on weekend days in the southbound direction between SH18 and the Bridge.

Top Risks

Structural	TTM/Operational	Safety
Heavy vehicles would not be permitted to use east clip-on.	Large traffic shift across 2 lanes at Onewa on-ramp.	Pedestrians & cyclists in close proximity to active traffic.

Costs

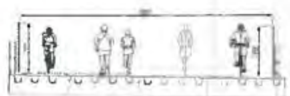
Total Capex	Total Opex /year
$14M-16M	$1M-2M

OPTION 2

Summary
8m wide shared path on the east clip-on on weekends, temporarily reducing traffic on the AHB by 2 Lanes. Shared path separated from traffic by steel barrier along the approaches and fence along the truss structure of the bridge. High fence installed on seaward side.

Duration
12 Months

Cross Section



Shared Path

Path Location	Temp / Perm
East	Temp
Path Width	**Traffic Lanes**
8m	2
North Access	**South Access**
Sulphur Beach Road / Underpass	Shelly Beach Offramp

Traffic Configuration

AM Peak	PM Peak
3N/5S	5N/3S
Interpeak	**Weekend**
4N/4S	3N/3S

Traffic Impact Summary Graph

Summary of Network Impacts
When modeling the highest level of traffic suppression modal shift and traffic re-routing, this Option results in additional delays from approximately noon until 8:00pm on weekend days in the northbound direction between Mt Wellington Highway and the Bridge Additional Delays will also occur southbound, north of the bridge, similar to Option 1.

Top Risks

Structural	TTM/Operational	Safety
East clip-on would have the capacity for this loading.	Large traffic shift across 2 lanes at Onewa on-ramp.	Truss structure more easily accessible structure to pedestrians.

Costs

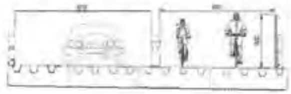
Total Capex	Total Opex
$5M-7M	$2M-3M

OPTION 3

Summary
4m wide shared path & 4m wide traffic lane on the east clip-on, permanently reducing traffic on the AHB by 1 Lane. Shared path separated from traffic by permanent installation of moveable lane barrier (not fixed to the deck). High fence installed on seaward side.

Duration
12 Months

Cross Section



Shared Path

Path Location	Temp / Perm
East	Perm
Path Width	**Traffic Lanes**
4m	1
North Access	**South Access**
Sulphur Beach Road / Underpass	Shelly Beach Offramp

Traffic Configuration

AM Peak	PM Peak
3N/4S	4N/3S
Interpeak	**Weekend**
4N/3S	4N/3S

Traffic Impact Summary Graph

Summary of Network Impacts
When modeling the lowest level of traffic suppression, modal shift and traffic re-routing this Option results in very little change to traffic flows during the AM peak period when compared to the existing traffic flows However, the PM peak period will experience increased delays on the Southern Motorway as far south as SH20. Due to the restriction created by the bridge, delays north of the bridge during the PM Peak will likely improve.

Top Risks

Structural	TTM/Operational	Safety
Heavy vehicles would not be permitted to use east clip-on.	Large traffic shift across 2 lanes at Onewa on-ramp.	Pedestrians & cyclists in close proximity to active traffic.

Costs

Total Capex	Total Opex
$9M-11M	$3M-5M

OPTION 4

Summary
8m wide shared path on the east clip-on, permanently reducing traffic on the AHB by 2 Lanes. Shared path separated from traffic by steel barrier along the approaches and fence along the truss structure of the bridge. High fence installed on seaward side.

Duration
12 Months

Cross Section

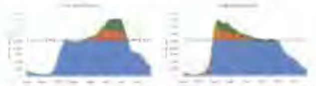
Shared Path

Path Location	Temp / Perm
East	Perm
Path Width	**Traffic Lanes**
8m	2
North Access	**South Access**
Sulphur Beach Road / Underpass	Shelly Beach Offramp

Traffic Configuration

AM Peak	PM Peak
3N/5S	5N/3S
Interpeak	**Weekend**
4N/4S	4N/3S

Traffic Impact Summary Graph



Summary of Network Impacts
When modeling the highest level of traffic suppression, modal shift and traffic re-routing, this Option results in additional delays throughout the greater Auckland Network In particular, northbound traffic will experience extensive delays during the PM Peak from south of the SH20 interchange through the Bridge restriction. However, the restriction created by the Bridge will relieve northbound delays north of the Bridge.

Top Risks

Structural	TTM/Operational	Safety
East clip-on would have the capacity for this loading.	Large traffic shift across 2 lanes at Onewa on-ramp.	Truss structure more easily accessible structure to pedestrians.

Costs

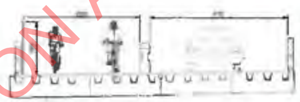
Total Capex	Total Opex
$6M-8M	$4M-5M

OPTION 5

Summary
4m wide shared path & 4m wide traffic lane on the west clip-on on weekends, temporarily reducing traffic on the AHB by 1 Lane. Shared path separated from traffic by permanent installation of moveable lane barrier (not fixed to the deck). High fence installed on seaward side.

Duration
12 Months

Cross Section



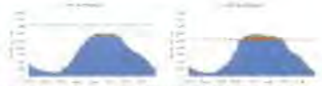
Shared Path

Path Location	Temp / Perm
West	Temp
Path Width	**Traffic Lanes**
4m	1
North Access	**South Access**
Sulphur Beach Road	Curran Street

Traffic Configuration

AM Peak	PM Peak
3N/5S	5N/3S
Interpeak	**Weekend**
4N/4S	4N/3S

Traffic Impact Summary Graph



Summary of Network Impacts
When modeling a medium level of traffic suppression, modal shift and traffic re-routing this Option results in additional delays from approximately 9:00am until 8:00pm on weekend days in the southbound direction between SH18 and the Bridge.

Top Risks

Structural	TTM/Operational	Safety
Heavy vehicles would not be permitted to use west clip-on.	Removes ability to shift the bridge into a 5/2 configuration to clear traffic from the city on weekends.	Pedestrians & cyclists in close proximity to active traffic.

Costs

Total Apex	Total Opex
$15M-17M	$2M-3M

OPTION 6

Summary
8m wide shared path on the west clip-on on weekends, temporarily reducing traffic on the AHB by 2 Lanes. Shared path separated from traffic by steel barrier along the approaches and fence along the truss structure of the bridge. High fence installed on seaward side.

Duration
12 Months

Cross Section

Shared Path

Path Location	Temp / Perm
West	Temp
Path Width	**Traffic Lanes**
8m	2
North Access	**South Access**
Sulphur Beach Road	Curran Street

Traffic Configuration

AM Peak	PM Peak
3N/5S	5N/3S
Interpeak	**Weekend**
4N/4S	3N/3S

Traffic Impact Summary Graph

Summary of Network Impacts
When modeling the highest level of traffic suppression, modal shift and traffic re-routing, this Option results in additional delays from approximately noon until 8:00pm on weekend days in the northbound direction between Mt Wellington Highway and the Bridge. Additional Delays will also occur southbound, north of the bridge, similar to Option 1.

Top Risks

Structural	TTM/Operational	Safety
West clip-on would have the capacity for this loading.	Closure of Curran Street ramp will result in pressure around the CBD.	Truss structure more easily accessible structure to pedestrians.

Costs

Total Apex	Total Opex
$6M-8M	$2M-3M

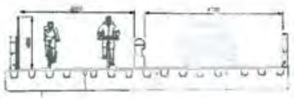
OPTION 7

Summary

4m wide shared path & 4m wide traffic lane on the west clip-on, permanently reducing traffic on the AHB by 1 Lane. Shared path separated from traffic by permanent installation of moveable lane barrier (not fixed to the deck) High fence installed on seaward side

Duration
12 Months

Cross Section



Shared Path

Path Location	Temp / Perm
West	Perm

Path Width	Traffic Lanes
4m	1

North Access	South Access
Sulphur Beach Road	Curran Street

Traffic Configuration

AM Peak	PM Peak
3N/4S	4N/3S

Interpeak	Weekend
4N/3S	4N/3S

Traffic Impact Summary Graph

Summary of Network Impacts

When modeling the lowest level of traffic suppression, modal shift and traffic re-routing this Option results in very little change to traffic flows during the AM peak period, However, the PM peak period will experience increased delays on the Southern Motorway as far south as SH20.

Top Risks / Opportunity

Structural	TTM/Operational	Safety
Heavy vehicles would not be permitted to use west clip-on and pedestrian/cyclist user numbers would have to be controlled.	Removes ability to shift the bridge into a 5/2 configuration to clear traffic from the city.	Pedestrians & cyclists in close proximity to active traffic.

Costs

Total Capex	Total Opex
$10M 12M	$3M-4M

OPTION 8

Summary

8m wide shared path on the west clip-on, permanently reducing traffic on the AHB by 2 Lanes. Shared path separated from traffic by steel barrier along the approaches and fence along the truss structure of the bridge High fence installed on seaward side

Duration
12 Months

Cross Section

Shared Path

Path Location	Temp / Perm
West	Perm

Path Width	Traffic Lanes
8m	2

North Access	South Access
Sulphur Beach Road	Curran Street

Traffic Configuration

AM Peak	PM Peak
3N/3S	3N/3S

Interpeak	Weekend
3N/3S	3N/3S

Traffic Impact Summary Graph

Summary of Network Impacts

When modeling the highest level of traffic suppression, modal shift and traffic re-routing this Option results in additional delays throughout the greater Auckland Network. In particular, northbound traffic will experience extensive delays during the PM Peak from south of the SH20 interchange through the Bridge restriction.

Top Risks / Opportunity

Structural	TTM/Operational	Safety
West clip-on would have the capacity for this loading.	Removes ability to shift the bridge into a 5/2 configuration to clear traffic from the city.	Truss structure more easily accessible structure to pedestrians

Costs

Total Capex	Total Opex
$6M-8M	$4M 5M

OPTION 9

Summary

2.75m wide shared path on the truss bridge, permanently reducing traffic on the AHB by 1 Lane. Shared path separated from traffic by permanent installation of 2 moveable lane barriers (not fixed to the deck) and high fence installed on top of barrier at both sides.

Duration
15 Months

Cross Section

Shared Path

Path Location	Temp / Perm
Centre	Perm

Path Width	Traffic Lanes
2.75m	1

North Access	South Access
Sulphur Beach Road Underpass	Fanshawe Street

Traffic Configuration

AM Peak	PM Peak
4N/3S	4N/3S

Interpeak	Weekend
4N/3S	4N/3S

Traffic Impact Summary Graph

Summary of Network Impacts

When modeling the highest level of traffic suppression, modal shift and traffic re-routing this Option results in additional delays throughout the greater Auckland Network. In particular southbound traffic will experience extensive delays north of SH18 for almost the entire day.

Top Risks / Opportunity

Structural	TTM/Operational	Safety
Load restrictions would be required in all traffic lanes as well as controlling pedestrian and cyclist loading.	No impact on ramp access to bridge.	Access via Tennyson Street underpass is not desireable due to pedestrian safety concerns and pedestrians and cyclists in close proximity to active traffic

Costs

Total Capex	Total Opex
$14M-16M	$4M-5M

OPTION 10

Summary

5.40m wide shared path on the truss bridge permanently reducing traffic on the AHB by 2 Lanes. Shared path separated from traffic by permanent installation of 2 moveable lane barriers (not fixed to the deck) and high fence installed in front of barrier on both sides.

Duration
15 Months

Cross Section

Shared Path

Path Location	Temp / Perm
Centre	Perm

Path Width	Traffic Lanes
5.40m	2

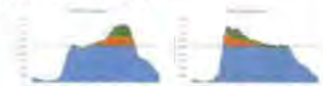
North Access	South Access
Sulphur Beach Road Underpass	Fanshawe Street

Traffic Configuration

AM Peak	PM Peak
3N/3S	3N/3S

Interpeak	Weekend
3N/3S	3N/3S

Traffic Impact Summary Graph



Summary of Network Impacts

When modeling the highest level of traffic suppression, modal shift and traffic re-routing, this Option results in additional delays throughout the greater Auckland Network In particular, northbound traffic will experience extensive delays during the PM Peak from south of the SH20 interchange through the Bridge restriction.

Top Risks / Opportunity

Structural	TTM/Operational	Safety
Pedestrian and cyclist loading would have to be controlled with no impact to traffic loading.	No impact on ramp access to bridge	Access via Tennyson Street underpass is not desireable due to pedestrian safety concerns and pedestrians and cyclists in close proximity to active traffic

Costs

Total Capex	Total Opex
$14M-16M	$4M-5M

OPTION 11

Summary

2.20m wide uni directional shared path on both the western edge of the west clip-on and the eastern edge of the east clip-on. The number of traffic lanes would not be reduced, lane width on both clip-ons reduced to 3.1m per lane. Shared path separated from traffic by permanent installation of moveable lane barrier (not fixed to the deck) High fence installed on seaward side.

Duration
15 Months

Cross Section

Shared Path

Path Location	Temp / Perm
Both Sides	Perm

Path Width	Traffic Lanes
2.2m	0

North Access	South Access
Sulphur Beach Road / Underpass	Shelly Beach Rd/ Curran St

Traffic Configuration

AM Peak	PM Peak
3N/5S	5N/3S

Interpeak	Weekend
4N/4S	4N/4S

Traffic Impact Summary Graph

Summary of Network Impacts

Luptaspit dignam fugiant eos consequid exereperumet ut omnitis expe simi, utat acim aperum ea corumquia sequid et eum fuga Nequam velessit repe lametur, quibea dolup-tas ut que vitatios debitis a senditaes aceataes sequa.

Top Risks / Opportunity

Structural	TTM/Operational	Safety
This option exceeds structural capacity even after considering removal of heavy vehicle loading from both clip-ons.	This option would have minimal impact on current bridge operations.	Pedestrians & cyclists in close proximity to active traffic

Costs

Total Capex	Total Opex
$20M-22M	$4M-5M

3 Option Assessment Considerations

3.1 Health & Safety

Waka Kotahi has a duty of care under the Health and Safety at Work Act (HSWA) to eliminate risks to health and safety of workers constructing, workers maintaining, and users using, the shared path so far as is reasonably practicable. If it is not reasonably practicable to eliminate risks, then Waka Kotahi aims to minimise those risks so far as is reasonably practicable.

Barrier Selection

Several of the options considered involve active traffic operating directly adjacent to shared path users, therefore, a barrier must be used to separate these modes for user safety. For 2-Lane options (options 2, 4, 6, and 8) the separation of shared path user and active traffic occurs from the approach to the overarch span, as the arch provides further protection. Steel barriers will be installed on the red chip utilising existing fixing points to provide protection on the approaches to the overarch span.

All 1-Lane options (options 1, 3, 5, and 7), the centre span options (option 9 and 10) and the option which involves a uni-directional path on both sides of the AHB (option 11) involve shared path users adjacent to active traffic on the overarch span. To achieve an appropriate level of compliance and safety considering the shared path width, as a minimum this barrier was required to meet the requirements of test level 3 (TL-3) under the Manual for Assessing Safety Hardware (MASH), the standard for crash testing temporary and permanent highway safety features.

Additionally, the orthotropic steel deck construction of the box girder extensions prevents fixation of a barrier to the deck, other than the existing fixing points within the red chip area of the bridge deck. Any barrier must also accommodate the movement of the expansion joints on the AHB. Therefore, any barrier installation to accommodate a shared use path is required to meet MASH TL-3 compliance while not relying on anchorage to the deck to provide deflection resistance. Two systems were considered as viable options which meet these criteria:

- *Concrete Moveable Barrier:* This barrier is the same mass concrete system currently utilised to allow tidal traffic flow on the AHB. Provided by Lindsay Transportation Systems, it relies on the mass and tensioning of the system to resist impact and minimise lateral deflections. For the purpose of a shared path installation, Lindsay's RTS guard would be installed on top of the concrete barrier. This RTS guard is a polyethylene height extension, resulting in a 1.0m barrier system. It complements the barrier's TL-3 performance and provides protection to pedestrians and cyclists who interact with the barrier. An image of the unit with installed RTS guard is shown in Figure 2:

Figure 2 - Proposed Concrete Barrier with RTS Guard

- *Steel HV2 Barrier*: The steel HV2 barrier is typically utilised as temporary protection for construction zones. Each barrier segment is constructed from steel with a concrete ballast, and each segment is linked together by an interlocking joining mechanism. This barrier system weighs less than the concrete system, which may result in more available structural capacity and lessen the need for heavy vehicle restrictions. However, the benefits of lighter barrier mass are offset by a greater lateral deflection after vehicular impact in testing results. An image of the steel HV2 barrier is shown in Figure 3:

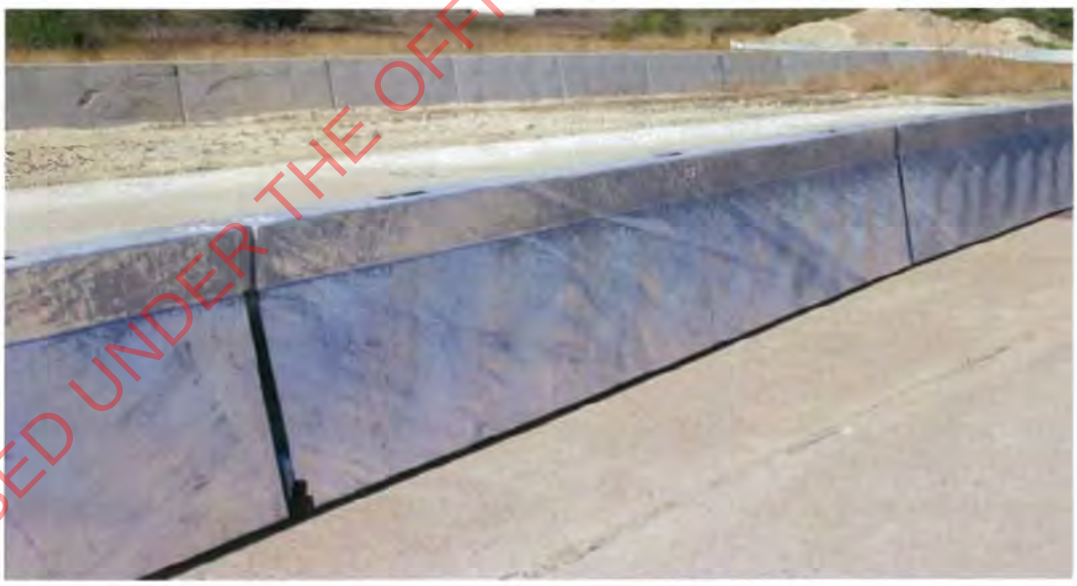


Figure 3 - Proposed Steel HV2 Barrier

Fencing

While either the concrete moveable barrier or the steel HV2 barrier discussed above will attempt to mitigate the risks of putting pedestrians adjacent to active traffic, there are additional hazards on the AHB which need to be mitigated prior to the operation of a shared path. All options except for the centre span options position the path on the extensions allowing shared path users access to the outside edges of the AHB. To attempt to prevent shared path users from entering the water or throwing objects off the AHB, a 1.8m high fence which would minimise opportunities for climbing would be installed in front of the existing AHB parapet. This fence would be highly porous to minimise additional wind loading on the structure.

This fence would also be installed on the parapet adjacent to the structural overarch for all 2-Lane options to discourage shared path users from accessing the structure.

General Risks & Issues

All proposed options have residual health and safety risks and issues which will require further assessment and mitigation planning if any of the options are developed further. These risks and issues include:

Risk/Issue	Potential Mitigations
Introducing shared path users to the bridge carriageway environment increases the risk of users entering a lane of active traffic, accessing the structure at the overarch, and climbing over the outer edge of the AHB.	Installation of fencing and barriers coupled with security monitoring and other technological installations.
Items being dropping on or near vessels travelling beneath the bridge, and debris entering the shared path from the motorway.	Installation of fencing and barriers coupled with security monitoring and other technological installations.
The steep gradient of the AHB (5%) will significantly increase the operating speed of cyclists, scooters, and other wheeled transport aids, posing a risk to other shared path users.	Speed calming devices and other technological speed reduction devices. Communication and engagement efforts around shared path use, including on path signage, markings and potentially delineation.
Wind gusts could cause cyclists to lose control.	Development of operational plans for closing the path in the event of forecast excessive wind speeds.
Vehicles could impact the barrier and encroach upon the shared path.	The proposed barrier installations have been crash tested to meet the requirements of MASH TL-3 and are considered most feasible to mitigate this risk. Consider vehicle speed limit reductions in adjacent lanes. Low vehicle approach angles for 1-Lane options reduces risk of lateral deflection of barrier into shared path space.
Shared path users potentially electing to continue along motorway through an active carriageway beyond area of closure resulting in emergency services response, closures and network impacts.	Installation of fencing and barriers coupled with security monitoring and other technological installations.
An incident or event occurs on the shared path requiring emergency response.	Emergency vehicle access to the location using adjacent AHB lanes. Potential for a dedicated response vehicle for the shared path.

3.2 Traffic & Network Modelling

Traffic Demand & Capacity – Current Operation

Prior to the impact of COVID-19 restrictions on movement, the AHB carried total daily traffic volumes of between 180,000 and 190,000 vehicles on typical weekdays and between 140,000 and 160,000 vehicles on weekends. At the time of analysis, current demand has returned to around 98% of pre-COVID restriction levels.

During weekend periods, the AHB remains in a 4-lane Northbound/ 4-lane Southbound configuration from Friday evening to Monday morning, and demand peaks at approximately 6,000 vehicles per hour in both directions. Existing weekend Northbound vehicle traffic volume is shown in 4 and existing weekend Southbound vehicle traffic volume is shown in Figure 5.

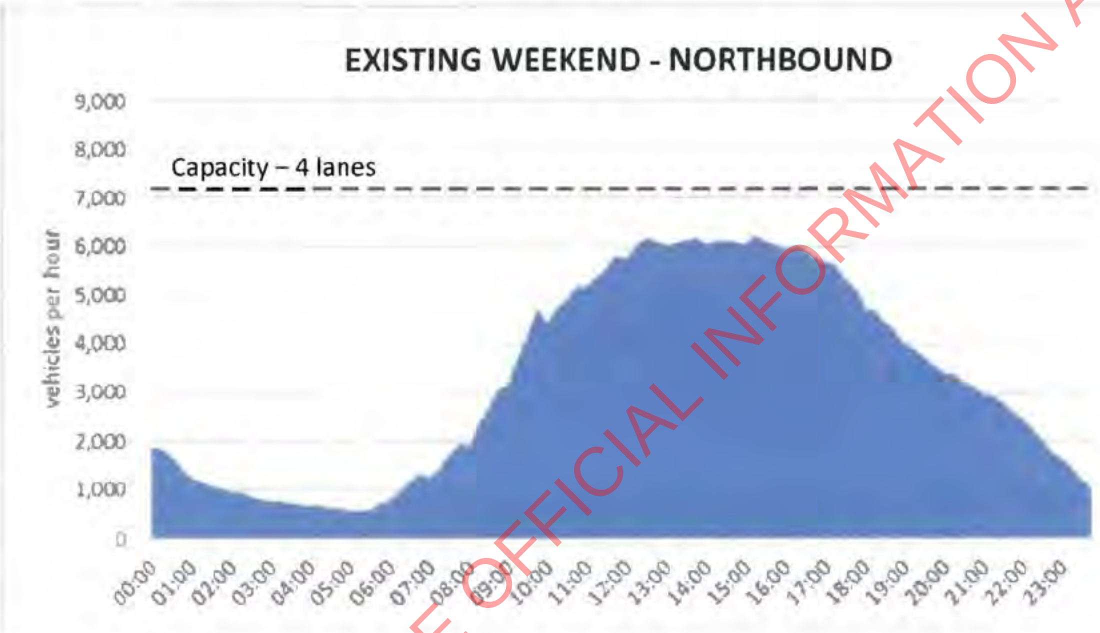


Figure 4 - Current Weekend NB Traffic Volume & AHB Capacity

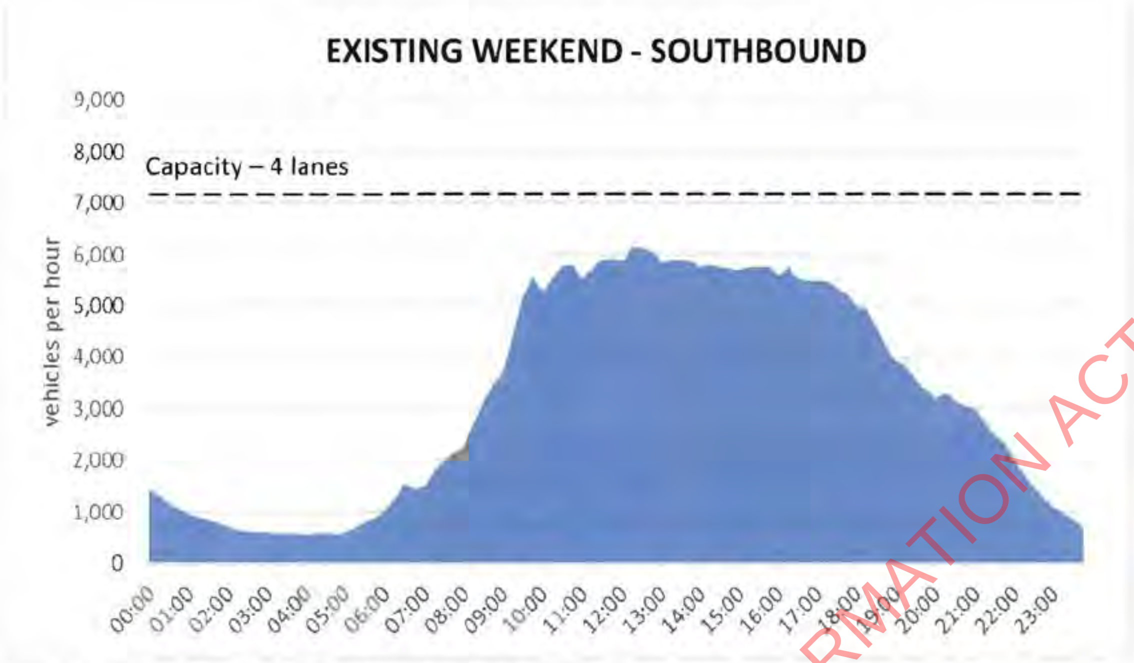
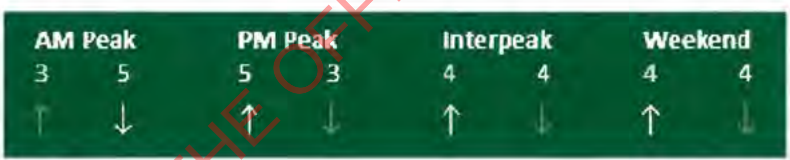


Figure 5 – Current Weekend SB Traffic Volume & AHB Capacity

During weekday periods, the AHB currently operates in a 3-Lane Northbound/ 5-Lane Southbound configuration during the AM peak period and a 5-Lane Northbound/ 3-Lane Southbound configuration during the PM peak period. At all other times, the moveable lane barrier partitions the AHB into a 4-Lane Northbound/ 4-Lane Southbound configuration, as shown in the figures below:



During the PM peak, the 5-Lane Northbound configuration allows the AHB to exceed the 5-Lane capacity of the St. Mary's Bay section of State Highway 1 due to the significant curvature and lane changing of vehicles within this section, as well as the gradient Victoria Park Tunnel exit. However, traffic entering from Curran Street merges into the segregated 2-Lane section leading up to the west extension. The additional input of demand from the Curran Street on-ramp routinely leads to this 2-Lane section reaching capacity during the PM peak. This results in localised flow breakdown and congestion on the west extension, while the 3 lanes on the main truss bridge northbound have residual capacity. This localised flow breakdown creates minor delays to peak public transport services which utilise general traffic lanes on approach to the AHB. Existing weekday Northbound flow is shown as Figure 6.

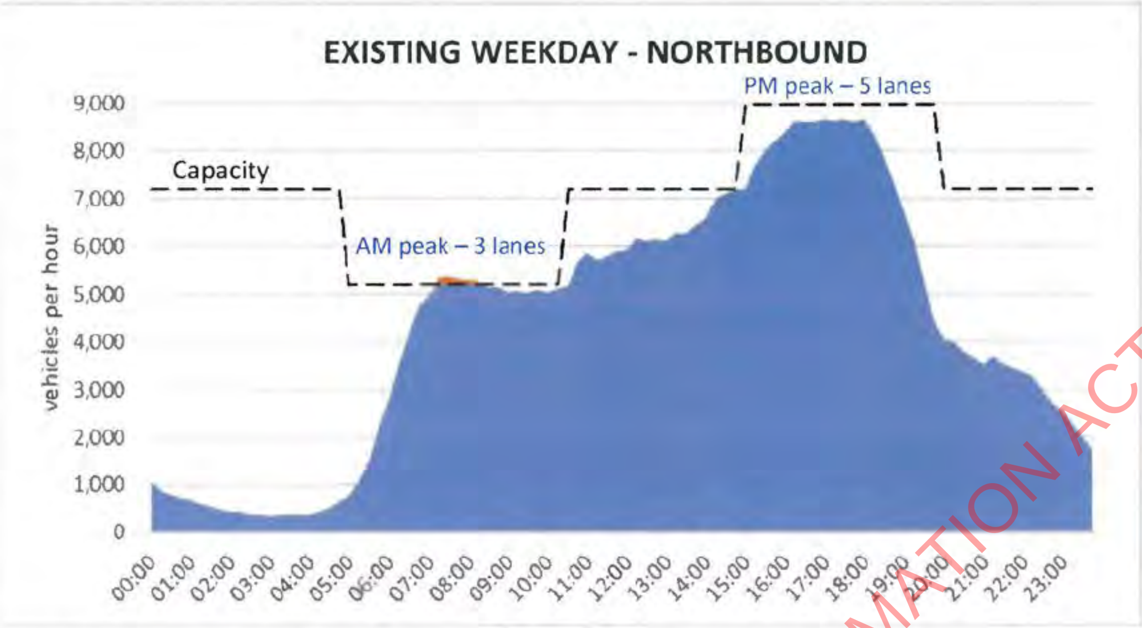


Figure 6 - Current Weekday NB Traffic Volume & AHB Capacity

During the AM peak, the 5-Lane Southbound configuration is fed by by four lanes upstream, three from downstream of Esmonde Road, plus a lane gain at Onewa Road on-ramp. The Esmonde Road on-ramp merge is one of the primary critical bottlenecks on the motorway network, and it acts with the 5-lane AM peak configuration on the AHB to minimise delays to AM peak public transport services which utilise general traffic lanes from Onewa Rd to Fanshawe Street. Existing weekday Southbound flow is shown as Figure 7.

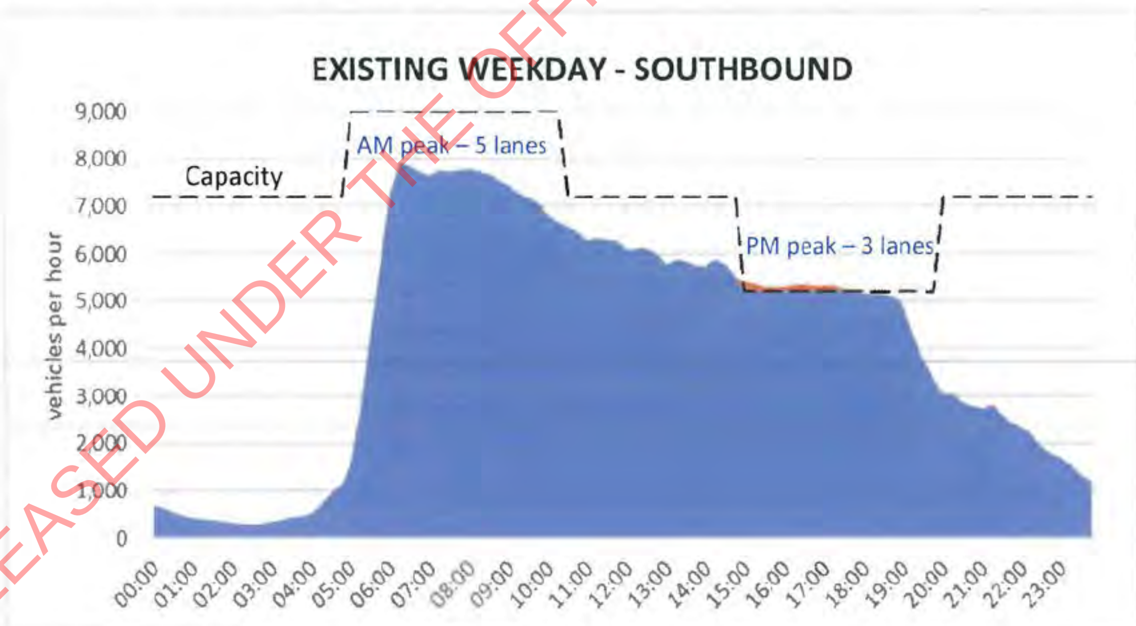


Figure 7 - Current Weekday SB Traffic Volume & AHB Capacity

In the peak direction during the AM and PM peak there are upstream capacity constraints where congestion forms, and this provides a measure of protection against bottlenecks forming at the foot of the AHB. Consequently, the flows shown in Figures 9 and 10 do not fully reflect demand at these times, but rather the rate at which traffic can reach the AHB.

Objectives of Traffic Modelling and Analysis

Traffic modelling and analysis attempts to predict what will happen to traffic volumes which exceed the capacity of the AHB for each option. This is reflected in two outcomes:

1. *Traffic congestion:* Congestion will occur on the approaches to the AHB, and will propagate upstream over time impacting adjoining sections of the motorway, city and local roads. The congestion will persist until there is available bridge capacity to clear the backlog.
2. *Demand reduction:* Some customers affected will choose to modify their trip behaviour to avoid the congestion and delays. This could include choosing the alternative route via SH18, SH16 and SH20, re-timing their trip to a less busy time, choosing an alternative mode of transport (including cycling or walking over the AHB on the new facility), utilising public transport, undertaking a different trip that doesn't require crossing the harbour, or cancelling their trip altogether.

While traffic congestion is demonstrated as an output of traffic models based on existing traffic data, demand reduction is a human behaviour which requires estimation as an input into traffic models. Four levels of demand reduction scenarios were utilised in modelling overall impact on the network from the AHB shared path option scenarios considered. These levels attempt to predict user behaviour and estimate the number of vehicles which will no longer contribute to congestion on the AHB due to:

- Motorists making their journeys via public transport rather than driving
- Motorists using the proposed shared path or other active modes rather than driving
- Motorists taking a route that doesn't use the AHB to complete their journey.

Specific numbers for each of these levels are provided in the Appendix.

Utilising Data Collected from Previous Lane-Reducing Events

The 2019 Auckland Marathon is a recent event involving multiple lane closures and provides some relevance to the options being considered in this report. It is also a planned event, and motorists are given advance notice that the two easternmost southbound lanes will be closed so they may plan their journey accordingly. Given the disruption to traffic demand due to COVID during 2020, observed data from the 2019 marathon has been used to review traffic demand and congestion impacts under normal operating conditions.

During the marathon the two easternmost southbound lanes are closed under Temporary Traffic Management (TTM) arrangements for several hours on a Sunday morning and reopen at 11am, leaving six total lanes for traffic until this time. Access to the AHB for runners is via the Northern Busway (which is also closed from Smales Farm station). To provide safe separation of motorway traffic from runners along the section of Southbound bus shoulder lane from Esmonde Road to Onewa Road. A lane reduction on the motorway mainline is introduced just before the Esmonde Road on ramp, and access via the Esmonde Road on ramp joins lane 2 under temporary arrangements. The Onewa Road on ramp then joins the mainline as a lane gain to provide the third available traffic lane across the AHB. As a result, the primary restrictions to southbound motorway traffic are at the lane reduction prior to the Esmonde Road on ramp, and the merge of the Esmonde Road on ramp with the remaining two lanes, rather than at the AHB itself.

In the northbound direction the AHB is reduced to three lanes of traffic and the Curran Street on ramp is closed, due to Curran Street forming part of the marathon route.

The traffic volume graphs and time-space speed heatmaps in Figure 8 and Figure 9 compare traffic on the day of the marathon (20 October 2019) with the prior Sunday.

No significant congestion was evident in the northbound direction, with all lanes being re-opened before traffic demand exceeded three lanes. Overall northbound traffic demand over 24-hours was down slightly from the prior Sunday, but still within the typical range.

In the southbound direction congestion was evident from around 7.30am to around 12pm, forming at the Esmonde Road lane drop and on ramp merge and extending past Northcote Road. Traffic volumes were significantly below normal between 8am and 11am with 24-hour demand 6% down on the previous week (at about the 20th-25th percentile level for Sundays in 2019). This demand suppression occurred almost entirely between 8am and 11am, and was at least in part due to the large efforts around pre-event communications and alerting motorists to the upcoming lane closures.

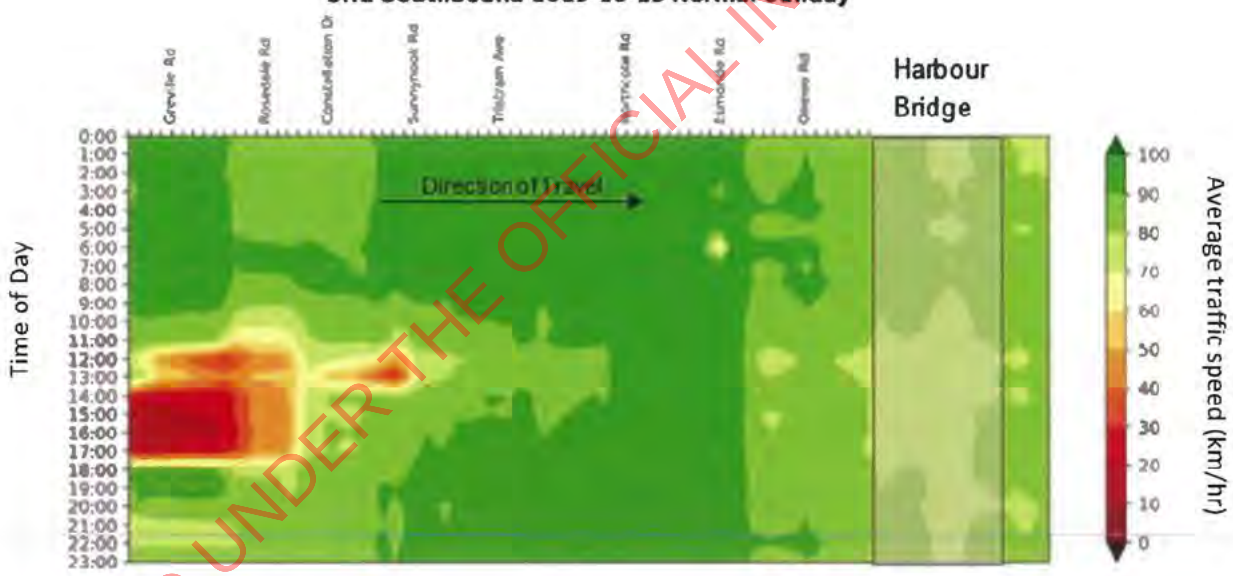


Figure 8 - Traffic Volume Heatmap, SH1 SB, Typical Sunday

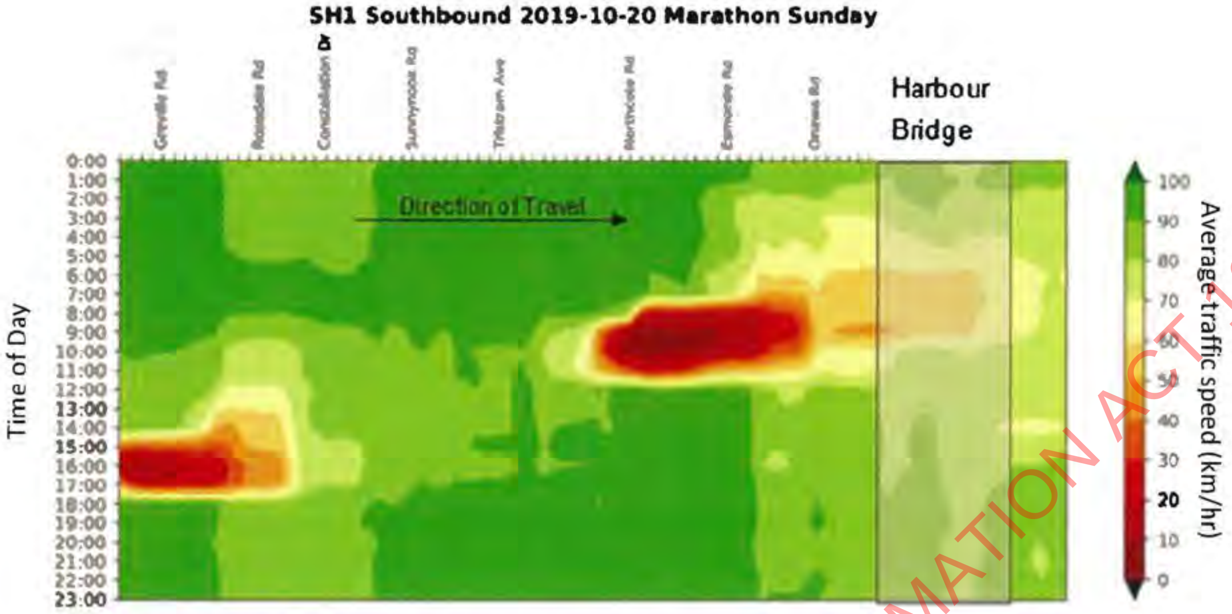


Figure 9 - Traffic Volume Heatmap, SH1 SB, 2019 Marathon Sunday

No significant congestion was evident in the northbound direction, with all lanes being re-opened before traffic demand exceeded three lanes. Overall northbound traffic demand over 24-hours was down slightly from the prior Sunday, but still within the typical range.

In the southbound direction congestion was evident from approximately 7.30am to 12pm, forming at the Esmonde Road lane drop and on ramp merge and extending past Northcote Road. Traffic volumes were significantly below normal between 8am and 11am with 24-hour demand 6% down on the previous week (at about the 20th-25th percentile level for Sundays in 2019). This demand suppression occurred almost entirely between 8am and 11am, and was at least in part due to the large efforts around pre-event communications and alerting motorists to the upcoming lane closures.

Analysis Tools and Limitations

There are a number of available traffic modelling tools that can help to visualise the impact on the network if a shared path was introduced on the AHB. Individually, no one tool is ideally suited to the job or can provide a fully robust answer. However, when assessing the outputs of the various traffic models and tools together, all can provide some assistance in understanding the potential impacts on the network.

The modelling tools used for this analysis were:

- Auckland Macro Strategic Model (MSM)
- Auckland Dynamic Traffic Assignment Model (ADTA)
- NCI – SATURN AWHC – SATURN
- Auckland Motorway Network Cell Transmission Model (CTM)
- AHB Queuing model (AHB-Q)

In addition, two historical data sources were also used:

- TomTom travel time system
- In-pavement traffic detectors

The single-result nature of most models encourages a false sense of accuracy and certainty in the results. Uncertainty over demand changes is the biggest risk to this traffic assessment. Acknowledging the uncertainty and testing multiple demand scenarios in multiple models to provide ranges of results will help present more robust modelling results.

CTM was the primary tool utilised for modelling analysis with multiple demand scenarios informed by MSM, ADTA and NCI SATURN. More detail is provided on each of these tools in the Appendix.

3.3 Operations

Auckland System Management (ASM) have developed a concept of operations to enable further discussion of the tactical operations required to enable active modes across the AHB. This concept of operations for each option was developed according to the following objectives and principles:

Existing Network Management Tools

The monitoring and management of the Auckland transport network involves a range of equipment and systems that can be utilised for different operating conditions and scenarios. Their function and coverage are summarised below:

Tool	Purpose	Potential Use
Traffic signals	Prioritise or optimise movements at intersections along a corridor.	Key interchanges/intersections on the state highway and local road networks.
Ramp Signals	Provide metered access onto the motorway in order to manage congestion and merge flow breakdown	At all on-ramps except Onewa Road, Stafford Road (SH1) and Wellesley St (SH16)
Variable message signs (VMS)	Display messages to inform customers of network conditions ahead or upcoming events.	Generally located in advance of key decision points on the state highway and local network.
Traffic response unit	Provides a rapid response service to manage traffic, clear damaged vehicles off the network and clean up after incidents.	State highway network in Auckland with an opportunity to utilise on the local network.
Emergency services	Respond to emergency situations to protect and preserve life, property, evidence and environment.	Network wide.
Traveller information	Provide real time traveller information/advice via Transport Agency's communication channels (e.g. Facebook, Twitter, radio, website). This includes road works, journey times, and webcams.	Network wide.
Detour routes	Provide an alternative route to get around an area of restricted access due to planned or unplanned events.	Network wide.
Variable speed management	Provides the ability to display different speed limits on a section of the motorway to better suit traffic conditions, protect the ends of queued traffic, and/or reduce arrival rates from further upstream.	Advisory speed limits on SH1 between Symonds St and north of Onewa Road and on SH16 to Bond St. Mandatory speed limits on SH16 between Rosebank Rd and St Lukes Rd and on SH20 between SH16 and May Rd
Road closures	Allow a corridor / section of a corridor to be closed off as part of the response plan for planned / unplanned events.	Network wide.

Tool	Purpose	Potential Use
Incident response coordination	Coordinate response for planned and unplanned events across multiple responding parties.	Network wide.
Lane control signals	Display symbols indicating lane use i.e. open, closed, divert left/right. Advisory speed limits can also be displayed.	On SH1 between Symonds St and north of Onewa Road and on SH16 to Bond St.
Closed Circuit Television (CCTV)	Provide the ability to monitor traffic operation and incidents in real time.	Full coverage on State Highway network. Coverage via the AT CCTV system available to ATOC at key intersections on the local road network.
Vehicle detection system	Allow vehicle speed and traffic volume to be recorded for monitoring and/or operational purposes.	Various locations.
Automatic Video Incident Detection (AVID)	Automatically detect incidents including breakdowns, queuing and/or debris on the motorway by sending an alarm to the operations centre.	SH1 Victoria Park Tunnel and SH20 Waterview Tunnel. An obsolete system exists on the AHB.
Customer and Stakeholder Feedback	Provides insights into our customers' perspective.	Network wide.
Traffic Monitoring System (TMS)	Collects and stores historical data on volumes, vehicle types and vehicle speeds at strategic points on the network, both on state highways and local roads (provided by RCAs).	Network wide.
Online Tool for Traffic Monitoring (e.g. Traffic Watcher, Google Traffic, Blip Track)	High level monitoring of network traffic conditions.	Network wide.

Proposed Network Management Tools

The following tools are proposed additions to the AHB which would aid in the operational adjustments required with the addition of a shared path:

Tool	Purpose	Potential Use
Variable message signs (VMS)	Display messages to inform customers of network conditions ahead or upcoming events.	Additional VMS establishment in advance of the options with temporary activation. With additional analysis/development this may mean that lanes could be opened reactively, should it be required to meet high level objectives.
Traffic response unit	Provides a rapid response service to manage traffic, clear damaged vehicles off the network and clean up after incidents.	Additional support for active traffic response operations would be mitigation for the impacts of minor incidents, particularly should something occur on 'captive lanes'.
Traveller information	Provide real time traveller information/advice via Transport Agency's communication channels (e.g. Facebook, Twitter, radio, website). This includes road works, journey times, and webcams.	Particular focus on development of active mode lane availability for temporary configurations, may include social media 'channel' or push notification for state of active mode access over the AHB.

General Risks & Issues

All proposed options have residual operational risks and issues which will require further consideration and assessment. These risks and issues include:

- ASM may be required to increase the frequency of programmed moveable lane barrier (MLB) movements or be required to be dynamic in MLB operations.
- 1-Lane options may result in traffic lane widths of differing dimensions.
- Speed management may be required for path users at the terminations of the AHB gradient.
- The current operational response to a person jumping over the side of the AHB includes use of deployable markers. A new plan would have to be implemented with the installation of high fencing.
- Placement of concrete barrier on the extensions may compromise the epoxy surfacing on the extensions. A modified renewal programme would require development, and also account for potential access challenges created by installation of the barrier.
- Litter management on the shared path may impact the ability to reopen a temporary option back to traffic in a timely manner.
- While in use, potential delays in travel time may impact emergency services response time.
- Construction programme for Northern Pathway will have to be evaluated if an option on the west side of the AHB is implemented, as the option could restrict construction access.

3.4 Structures

Engineers undertook a high-level structural review based on a load comparison approach. Approximate loading from traffic, shared use path, proposed barriers and proposed fencing was determined for each option and compared against the available live load capacity of the AHB. This available live load capacity of the AHB was calculated from previous AHB assessments and strengthening works.

Loading Assumptions & Limitations

Traffic live loads were used for this comparison from previous load assessments. Shared path loading was in accordance with the Design Manual for Roads and Bridges Standard BD37/01 as applicable to the box girder structure, which has been used in previous AHB assessment works.

For the critical Span 2 of the extensions, the unfactored equivalent distributed loads utilised in analysis are:

- 1.57 kPa for 2.5m wide shared use path concurrent with traffic
- 1.44 kPa for 4.0m wide shared use path concurrent with traffic
- 1.58 kPa for 8.9m wide shared use path without traffic

For the critical Span 1 of the truss bridge, the unfactored equivalent distributed loads utilised in analysis are:

- 1.20kPa for 2.75m wide shared use path concurrent with traffic
- 1.10kPa for 5.5m wide shared use path concurrent with traffic

For 1-Lane options, weights of the proposed new concrete barriers were provided by barrier manufacturer Lindsay Corporation. These weights are for a 680kg/m for a concrete barrier and 715kg/m for a SRTS barrier.

Each option's assessment is limited to the portion of the superstructure carrying the shared use path. All options propose some re-arrangement of existing traffic lanes which will result in an increase in loading on other portions of the superstructure as traffic redistributes, and the effects of this increase on other portions of the superstructure was not assessed as part of the scope of this review.

The effect of potential additional wind loads were not considered as part of this review. It is assumed the pedestrian barriers on top of traffic barriers will be lightweight with high porosity to minimise any increase in wind loading on the structure.

General Risks & Issues

All proposed options have residual risks and issues which will require further analysis and assessment. These risks and issues include:

- *Increase in Traffic Lane Loading*: Removal of one or more lanes of traffic from the AHB will likely result in an increase in traffic loading in the remaining lanes. Likewise, restricting heavy vehicles in some lanes will also likely result in an increase in traffic loading in the lanes which are available for their use. This increased traffic loading may cause global live loading and fatigue issues, which could result in requiring traffic loading restrictions and an increase in fatigue repairs on the AHB.

- *Shifting Vehicle Wheel Tracks*: For the options which propose a change in traffic lane position or width, the vehicle wheel tracks on the bridge deck will shift. This will increase the fatigue loading on the elements under the new wheel track positions and this may result in more fatigue repair work.
- *Overweight Permits*: Changing the lane width and lane arrangement will affect overweight or over-dimensional vehicles using the AHB. Adding new barriers, fencing and a shared path will affect the ability of the structure's capacity to carry overweight vehicles. Existing overweight permits will need to be re-evaluated for applicability with a selected option.
- *Impact on Truss Bridge Members*: Modifying lane arrangements on the truss bridge may result in an increased risk of vehicle impact on the truss members.
- *Vibrations due to Synchronous Pedestrian Excitation*: Box girder structures have a resonant natural frequency that is susceptible to excitation by groups of pedestrians walking in step. Further analysis and assessment is required to determine if dampers would be needed for shared use path options on the extensions to control pedestrian-induced vibrations. Vehicles can also cause vibrations and deflections of the box girders which may cause discomfort to pedestrians.
- *Wind Loading*: The porosity of any new fencing installation would need to be high to minimise additional wind loading. Wind loading could be significant if a solid fence or screen is required. Further assessment or wind tunnel testing may be required to quantify the effect.
- *Vehicle Weight Limit Compliance*: There are some vehicle weight limits currently in place on the AHB and regular non-compliance with the restrictions has been recorded. A strategy to enforce additional traffic load restrictions such as restricting heavy vehicle access from certain traffic lanes would require development.
- *Crowd Control Compliance*: For options 7, 9 and 10, practical and effective measures are required to control the number of pedestrians and cyclists using the AHB. An effective monitoring scheme may also be required.

3.5 Legal

The legal team has identified the following risks and issues with potential implementation of a shared path utilising the AHB:

- *Non-motorised vehicles and foot traffic on the* AHB

  The AHB road corridor is a motorway, therefore it is legal for Waka Kotahi to approve cyclists activities in this corridor. At present pedestrians and non-registered vehicles cannot be permitted to use the motorway, however, Waka Kotahi and the NZ Police can come to an agreement to not prosecute users of the shared path.

  Waka Kotahi and the NZ Police can agree to suspend enforcement of these particular roading laws for the parts of the AHB being used for the shared path. Advance consultation with the Police regarding this issue would need to be undertaken.

- *Animal usage of the shared path*

  The Waka Kotahi legal team notes that roading law places a strong legal expectation that the owner of any animal or thing that escapes onto a live motorway will be liable for the any damage resulting from that escape. Practical measures to reduce the risk of such accidental 'escape events' from the shared path into live traffic should be considered as part of the health and safety and operational assessment.

- *Privacy Requirements for High-Capability Cameras*

  Given the proposed shared path options may involve the use of high-capability cameras to mitigate security and related risks, the Privacy Commissioner will need to be consulted. Additionally, a privacy impact assessment will need to be carried out, likely by a consultant privacy expert. This expert would need to work closely with the project team.

4 Option Summary

1 Lane — Southbound
Temporary Configuration

Option
1

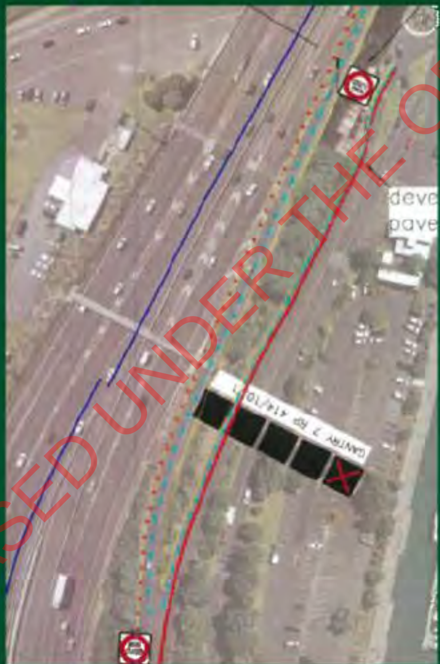
- Creation of a 4m wide shared path and 4m wide traffic lane, temporarily reducing traffic on the AHB by 1 lane on weekends.
- Permanent installation of moveable lane barrier not be connected to the bridge deck. This barrier will remain in place at all times, including when the lane is available for traffic.
- Installation of a high fence on the seaward side.

Traffic Management

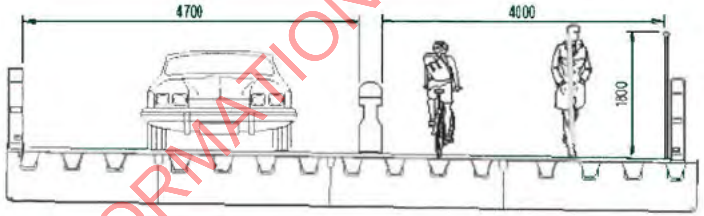
	AM Peak		PM Peak		Interpeak		Weekend	
North ↑	3	5	5	3	4	4	4	3
South ↓	↑	↓	↑	↓	↑	↓	↑	↓

North Access
via Sulphur Beach Road

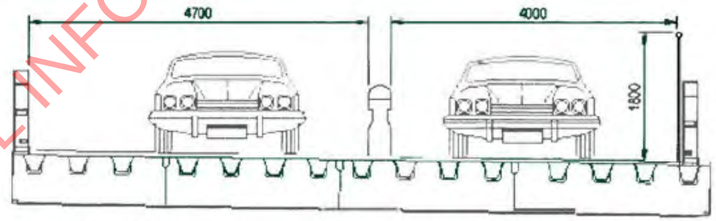
South Access
via Shelly Beach Road



Cross Sections



Weekends



Weekdays

Residual Risks

Top Structural Risks
- Restrictions on heavy vehicles (greater than 3.5 tonnes) and buses using the east extension.
- Increase in traffic loading in remaining lanes due to heavy vehicle restrictions on the east extension.

Top TTM/ Ops Risk
- Traffic utilising Shelly Beach off-ramp will need to be positioned in Lane 1 from Onewa Road.

Top Operational Safety Risk
- Pedestrians and cyclists would be in close proximity to active traffic.
- User safety will need to be assessed and mitigated due to 4m wide path with a 5% gradient.

Opportunity

Concrete barrier can be left in place, reducing TTM set-up time and costs.

Estimated Cost

Total Capex	Total Opex
$14M - $16M	$1M - $2M year

Construction Programme

12 Months

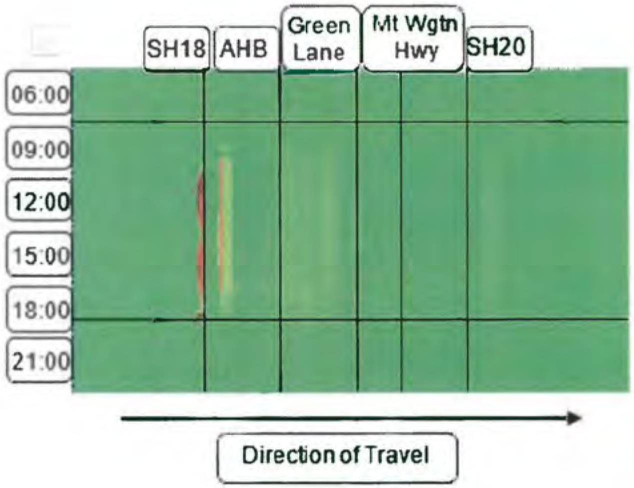
Resolve GROUP

1 Lane — Southbound
Temporary Configuration

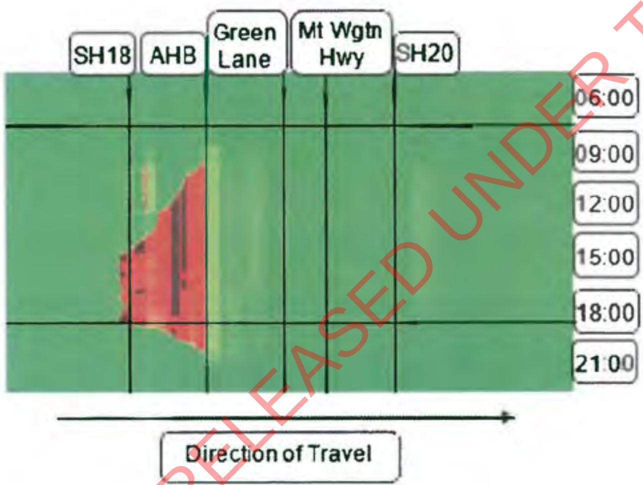
Option
1

Network Heat Map - SH1 Southbound - Weekends

Existing



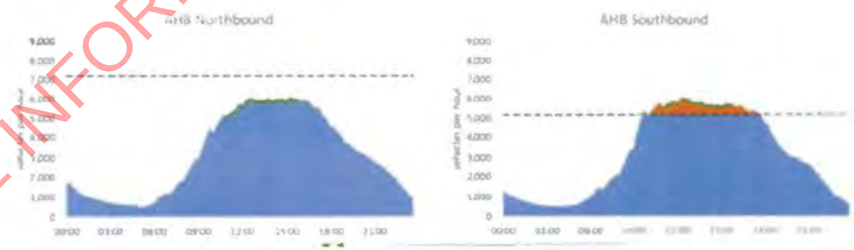
Option 1



Network Impact Summary

4 traffic lanes northbound, 3 traffic lanes southbound, during weekends

When modeling a medium level of traffic suppression, modal shift and traffic re-routing, this Option results in additional delays from approximately 9:00am until 8:00pm on weekend days in the southbound direction between SH18 and the Bridge



RESOLVE GROUP

2 Lane — Southbound
Temporary Configuration

- Creation of an 8m wide shared path temporarily reducing traffic on the AHB by 2 lanes on weekends.
- Shared path will be separate from traffic by a permanent installation of steel barrier on the approaches, and fencing along the truss structure of the AHB.
- This Option will include installation of a high fence on the seaward side, as well as adjacent to the truss along the overarch section.

Traffic Management

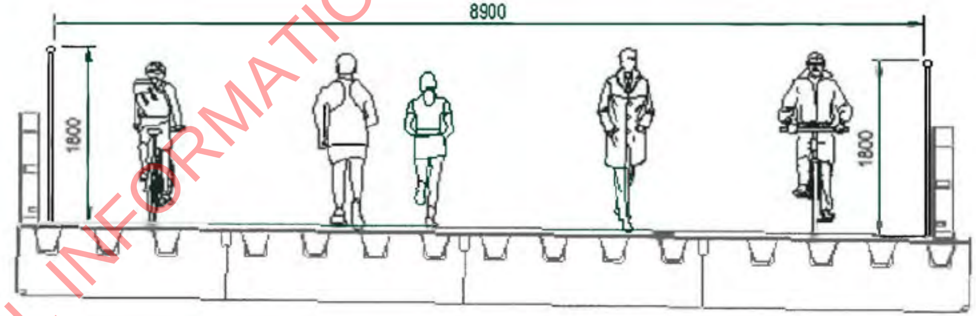
	AM Peak		PM Peak		Interpeak		Weekend	
North ↑	3	5	5	3	4	4	3	3
South ↓	↑	↓	↑	↓	↑	↓	↑	↓

North Access
via Sulphur Beach Road

South Access
via Shelly Beach Road

Option
2

Cross Section



Residual Risks

Top Structural Risks
- Increase in traffic loading in remaining lanes due to removal of traffic, including heavy vehicles, from the east extension.

Top TTM/ Ops Risk
- Increased traffic merge southbound at Onewa on-ramp.
- Potential closure of Shelly Beach off ramp to local traffic from Westhaven Drive will result in more pressure on Fanshawe Street.
- Steel barriers on AHB red chip reduce ability to use this as a hard shoulder in the event of break-down or other incident.

Top Operational Safety Risk
- Truss structure more accessible to shared path users.

Opportunity
Ability for steel barriers to remain in place on the AHB red chip areas, which will reduce TTM set-up time and costs.

Estimated Cost

Total Capex	Total Opex
$5M - $7M	$2M - $3M year

Construction Programme

12 Months

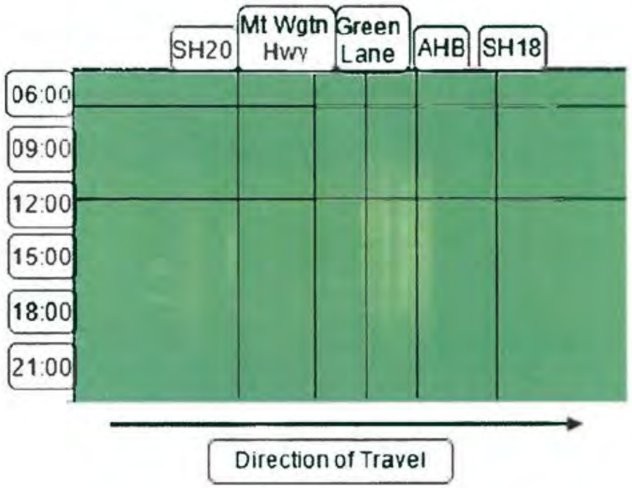
Resolve Group

2 Lane — Southbound
Temporary Configuration

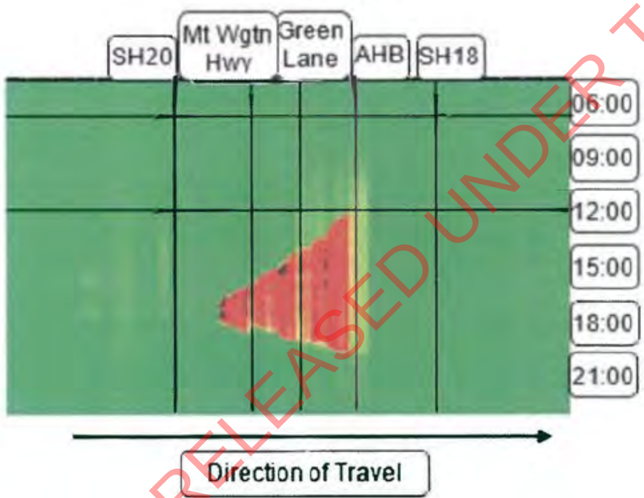
Option
2

Network Heat Map - SH1 Northbound - Weekends

Existing

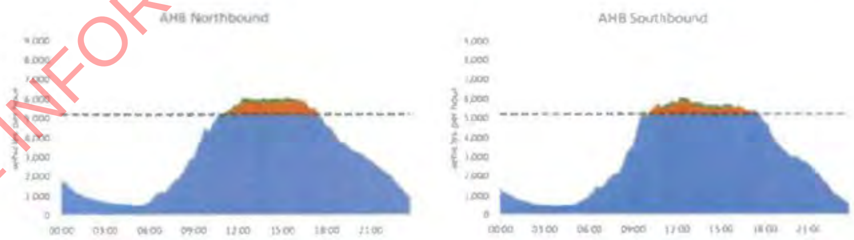


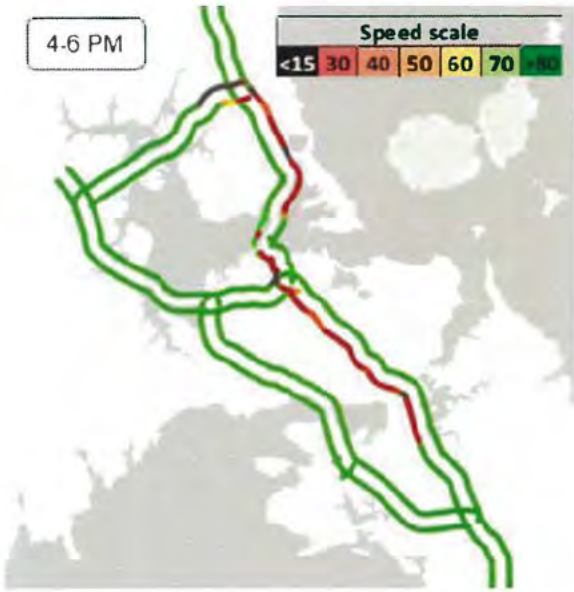
Option 2



Network Impact Summary

3 traffic lanes northbound, 3 traffic lanes southbound, during weekends
When modeling the highest level of traffic suppression, modal shift and traffic re-routing, this Option results in additional delays from approximately noon until 8:00pm on weekend days in the northbound direction between Mt Wellington Highway and the Bridge. Additional Delays will also occur southbound, north of the bridge, similar to Option 1.





RESOLVE GROUP

1 Lane — Southbound
Permanent Configuration

- Creation of a 4m wide shared path and 4m wide traffic lane, permanently reducing traffic on the AHB by 1 lane.
- Permanent installation of a moveable lane barrier which will not be connected to the bridge deck.
- This Option will include installation of a high fence on the seaward side.

Traffic Management

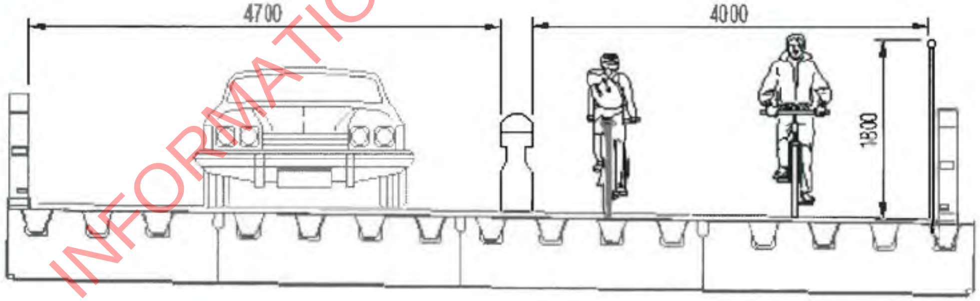
	AM Peak		PM Peak		Interpeak		Weekend	
North ↑	3	4	4	3	4	3	4	3
South ↓	↑	↓	↑	↓	↑	↓	↑	↓

North Access
via Sulphur Beach Road

South Access
via Shelly Beach Road

Option 3

Cross Section



Residual Risks

Top Structural Risks
- Restrictions on heavy vehicles (greater than 3.5 tonnes) and buses using the east extension.
- Increase in traffic loading in remaining lanes due to heavy vehicle restrictions on the east extension.

Top TTM/ Ops Risk
- Increased traffic merge at Onewa on-ramp.
- Potential closure of Shelly Beach off ramp to local traffic from Westhaven Drive will result in more pressure on Fanshawe Street.

Top Operational Safety Risk
- Pedestrians and cyclists would be in close proximity to active traffic.
- User safety will need to be assessed and mitigated due to 4m wide path with a 5% gradient.

Opportunity

This option will retain the ability to shift the MLB into a 5N/2S configuration if a situation arises where it is necessary to clear traffic out of the CBD.

Estimated Cost

Total Capex	Total Opex
$9M - $11M	$3M - $5M year

Construction Programme

12 Months

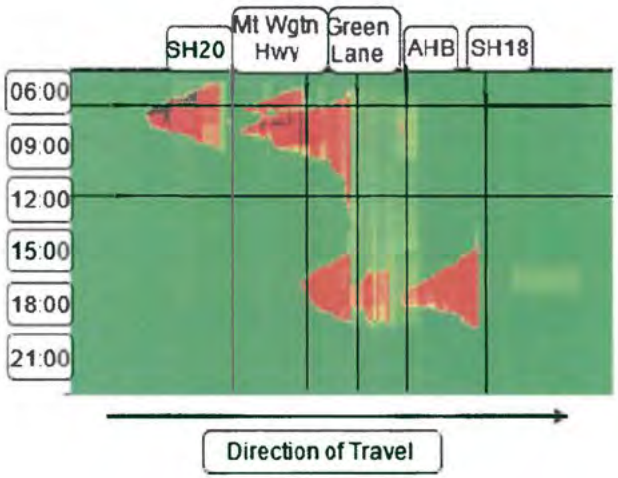
RESOLVE GROUP

1 Lane — Southbound
Permanent Configuration

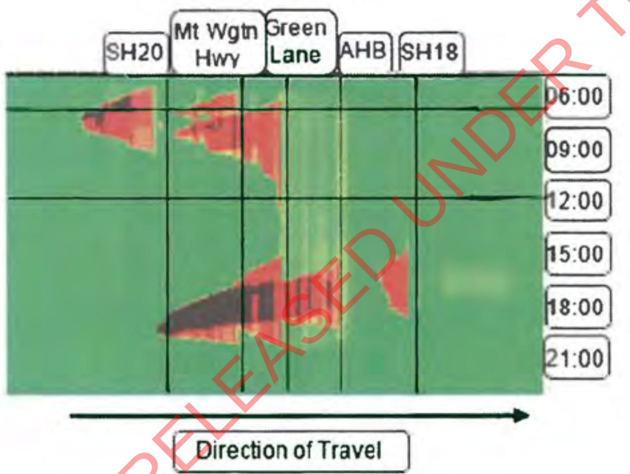
Option
3

Network Heat Map - SH1 Northbound - Weekdays

Existing



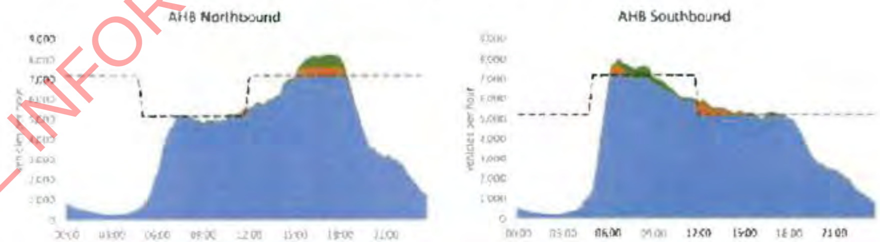
Option 3

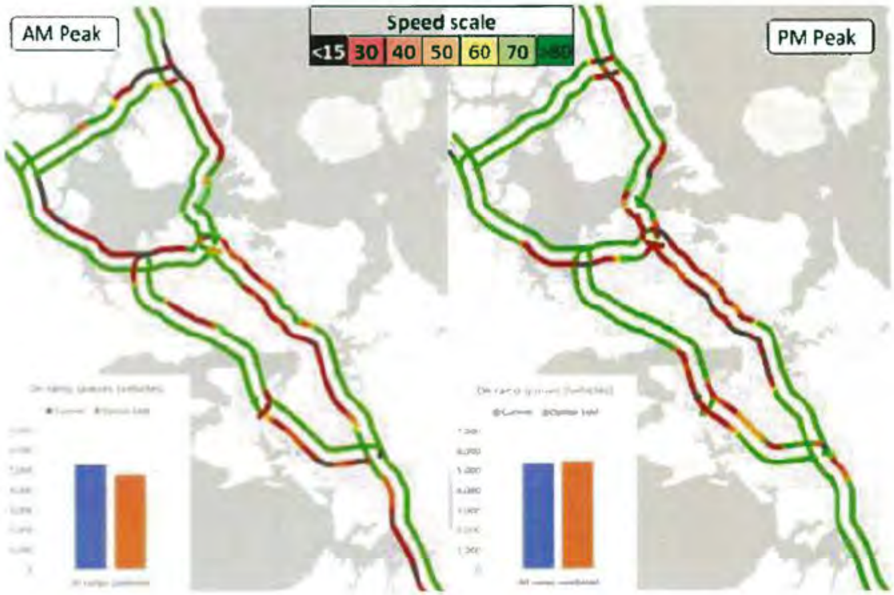


Network Impact Summary

4 traffic lanes in peak direction, 3 traffic lanes in counter peak direction

When modeling the lowest level of traffic suppression, modal shift and traffic re-routing, this Option results in very little change to traffic flows during the AM peak period when compared to the existing traffic flows. However, the PM peak period will experience increased delays on the Southern Motorway as far south as SH20. Due to the restriction created by the bridge, delays north of the bridge during the PM Peak will likely improve.





RESOLVE

2 Lane — Southbound
Permanent Configuration

- Creation of an 8m wide shared path which will permanently reduce traffic on the AHB by 2 lanes.
- Shared path will be separate from traffic by a permanent installation of steel barrier on the approaches, and fencing along the truss structure of the AHB.
- Installation of a high fence on the seaward side, as well as adjacent to the truss along the overarch section.

Traffic Management

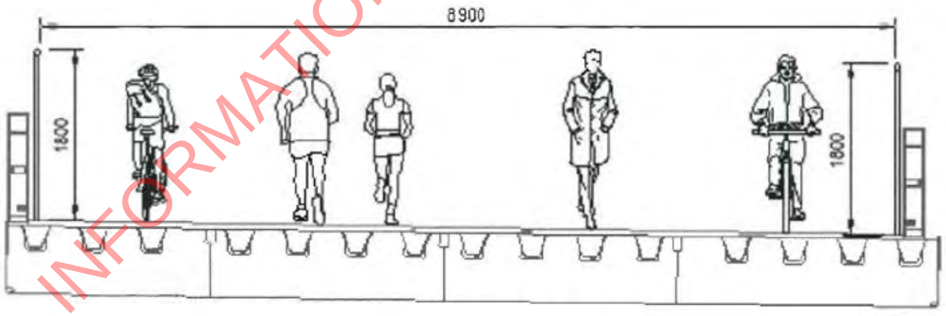
	AM Peak		PM Peak		Interpeak		Weekend	
North ↑	3	3	3	3	3	3	3	3
South ↓	↑	↓	↑	↓	↑	↓	↑	↓

North Access
via Sulphur Beach Road

South Access
via Shelly Beach Road

Option
4

Cross Section



Residual Risks

Top Structural Risks
- Increase in traffic loading in remaining lanes due to removal of traffic, including heavy vehicles, from the east extension.

Top TTM/ Ops Risk
- Increased traffic merge at Onewa on-ramp.
- Potential closure of Shelly Beach off ramp to local traffic from Westhaven Drive will result in more pressure on Fanshawe Street.
- Permanent steel barriers on the AHB red chip reduces the ability to use this as a hard shoulder in the event of a breakdown or other incident.

Top Operational Safety Risk
- Truss structure more accessible to shared path users.

Opportunity

This configuration provides the optimal user experience and its permanent nature results in minimised set-up time and costs.

Estimated Cost

Total Capex	Total Opex
$6M - $8M	$4M - $5M year

Construction Programme

12 Months

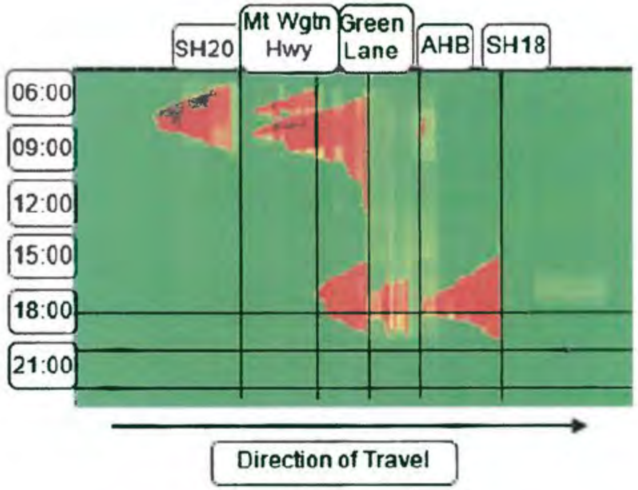
RESOLVE GROUP

2 Lane — Southbound
Permanent Configuration

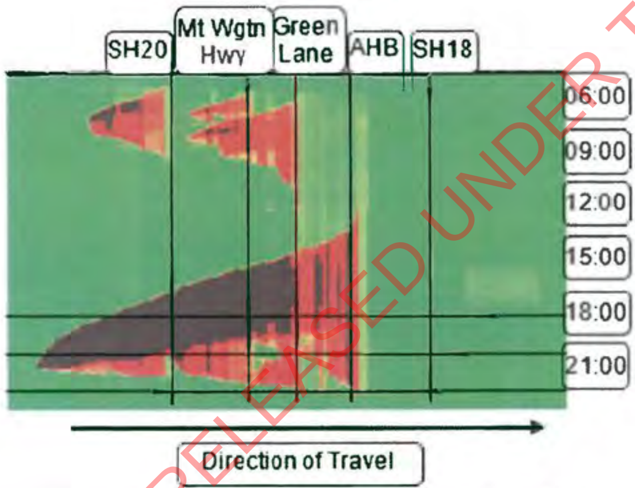
Option
4

Network Heat Map - SH1 Northbound - Weekdays

Existing



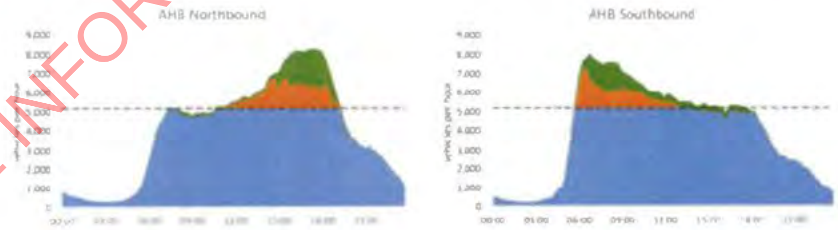
Option 4.

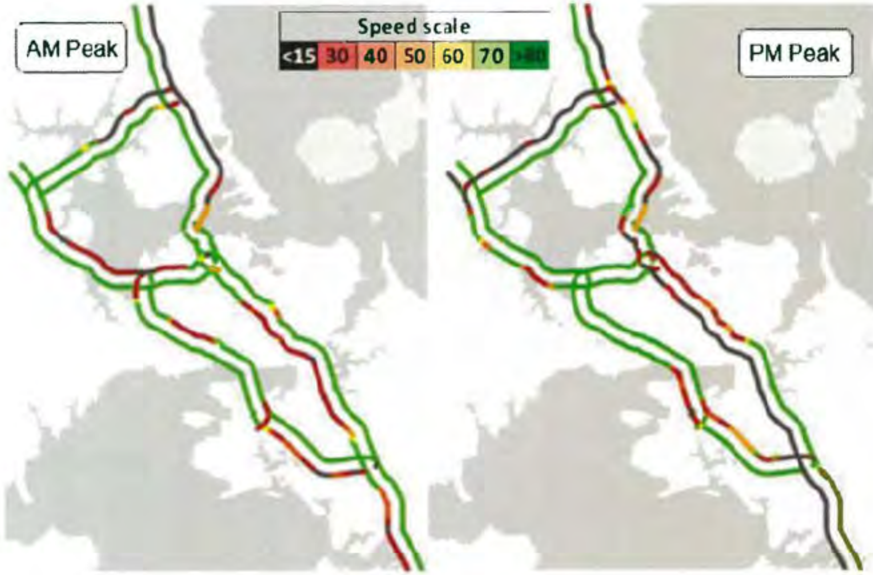


Network Impact Summary

3 traffic lanes northbound, 3 traffic lanes southbound at all times

When modeling the highest level of traffic suppression, modal shift and traffic re-routing, this Option results in additional delays throughout the greater Auckland Network. In particular, northbound traffic will experience extensive delays during the PM Peak from south of the SH20 interchange through the Bridge restriction. However, the restriction created by the Bridge will relieve northbound delays north of the Bridge.





Resolve
GROUP

1 Lane — Northbound
Temporary Configuration

- Creation of a 4m wide shared path and 4m wide traffic lane, temporarily reducing traffic on the AHB by 1 lane on weekends.
- Permanent installation of a moveable lane barrier which will not be connected to the bridge deck. The barrier will remain in place at all times, including when the lane is available for traffic.
- Installation of a high fence on the seaward side.

Traffic Management

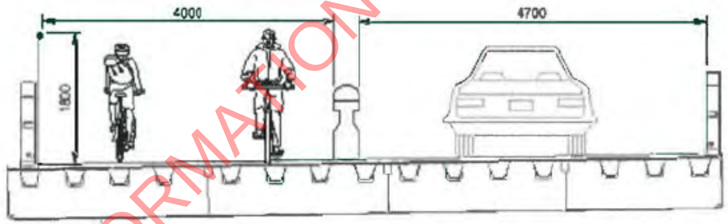
	AM Peak		PM Peak		Interpeak		Weekend	
	3	5	5	3	4	4	4	3
North ↑ South ↓	↑	↓	↑	↓	↑	↓	↑	↓

North Access
via Sulphur Beach Road

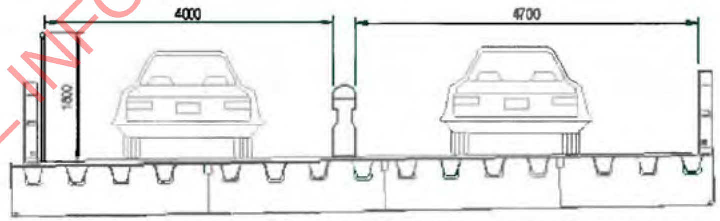
South Access
via Curran Street

Option
5

Cross Sections



Weekends



Weekdays

Residual Risks

Top Structural Risks
- Restrictions on heavy vehicles (greater than 3.5 tonnes) and buses using the west extension.
- Crowd loading restriction on shared path usage would be required.
- Increase in traffic loading in remaining lanes due to heavy vehicle restrictions on the west extension.

Top TTM/ Ops Risk
- Removes the ability to shift the Bridge into a 5N/2S configuration to clear traffic from the CBD on the weekend.

Top Operational Safety Risk
- Pedestrians and cyclists would be in close proximity to active traffic.
- User safety will need to be assessed and mitigated due to 4m wide path with a 5% gradient.

Opportunity
Concrete barrier can be left in place, reducing TTM set-up time and costs.

Estimated Cost

Total Capex	Total Opex
$15M - $17M	$2M - $3M year

Construction Programme
12 Months

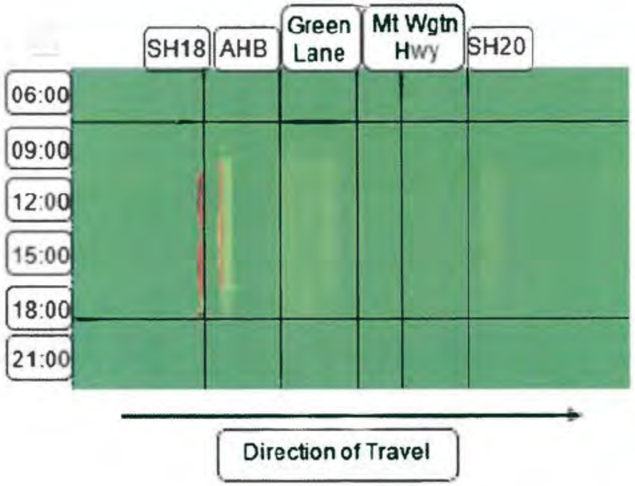
RESOLVE GROUP

1 Lane — Northbound
Temporary Configuration

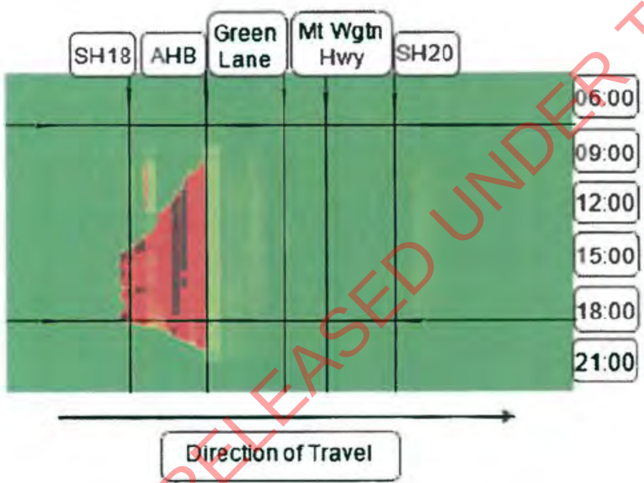
Option
5

Network Heat Map - SH1 Southbound - Weekends

Existing

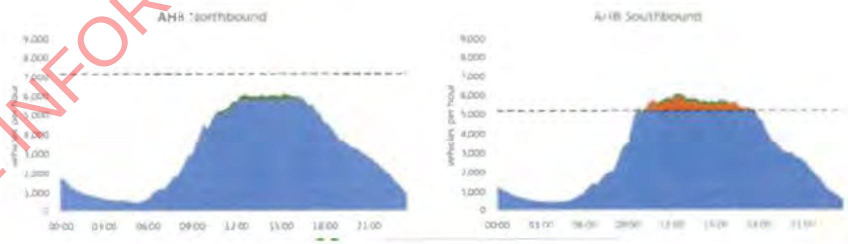


Option 5



Network Impact Summary

4 traffic lanes northbound, 3 traffic lanes southbound, during weekends
When modeling a medium level of traffic suppression, modal shift and traffic re-routing, this Option results in additional delays from approximately 9:00am until 8:00pm on weekend days in the southbound direction between SH18 and the Bridge.



RESOLVE GROUP

2 Lane — Northbound
Temporary Configuration

- Creation of an 8m wide shared path temporarily reducing traffic on the AHB by 2 lanes on weekends.
- Shared path will be separate from traffic by a permanent installation of steel barrier on the approaches, and fencing along the truss structure of the Bridge.
- Installation of a high fence on the seaward side, as well as adjacent to the

Traffic Management

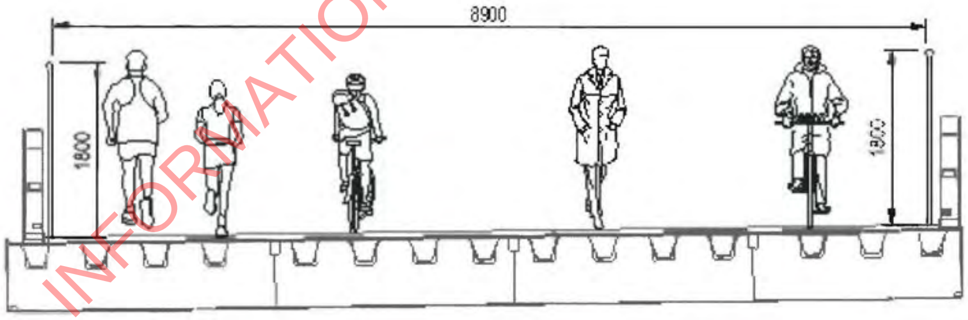
	AM Peak		PM Peak		Interpeak		Weekend	
	3	5	5	3	4	4	3	3
North ↑ / South ↓	↑	↓	↑	↓	↑	↓	↑	↓

North Access
via Sulphur Beach Road

South Access
via Curran Street

Option 6

Cross Section



Residual Risks

Top Structural Risks
- Increase in traffic loading in remaining lanes due to removal of traffic, including heavy vehicles, from the west extension.

Top TTM/ Ops Risk
- TTM at Stafford off-ramp would be challenging and a robost management plan would be required.
- Closure of Curran Street ramp will result in pressure around the CBD.
- Steel barriers on AHB red chip reduce ability to use this as a hard shoulder in the event of break-down or other incident.

Top Operational Safety Risk
- Truss structure more accessible to shared path users.

Opportunity
Ability for steel barriers to remain in place on the AHB red chip areas, which will reduce TTM set-up time and costs.

Estimated Cost

Total Capex	Total Opex
$6M - $8M	$2M - $3M year

Construction Programme
12 Months

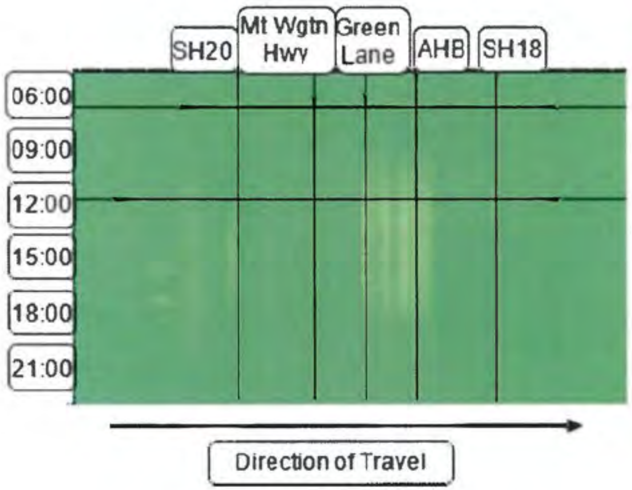
Resolve GROUP

2 Lane — Northbound
Temporary Configuration

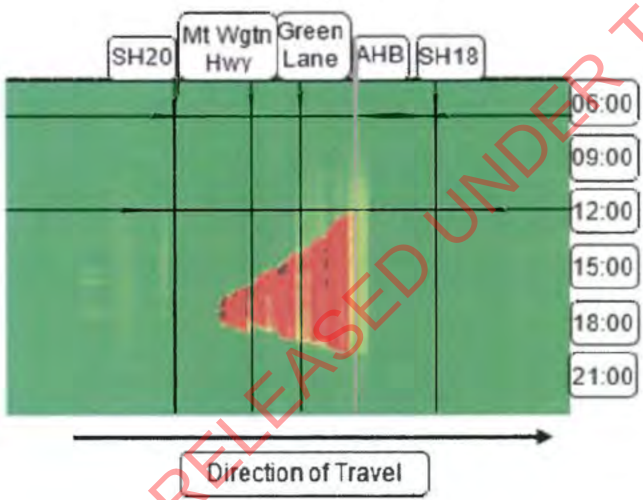
Option
6

Network Heat Map - SH1 Northbound - Weekends

Existing

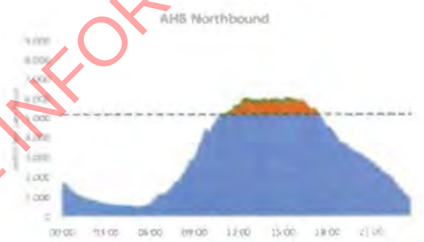


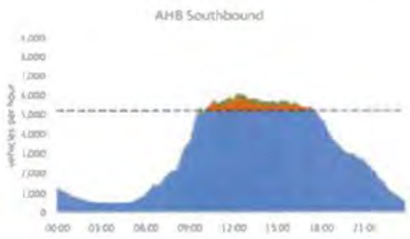
Option 6

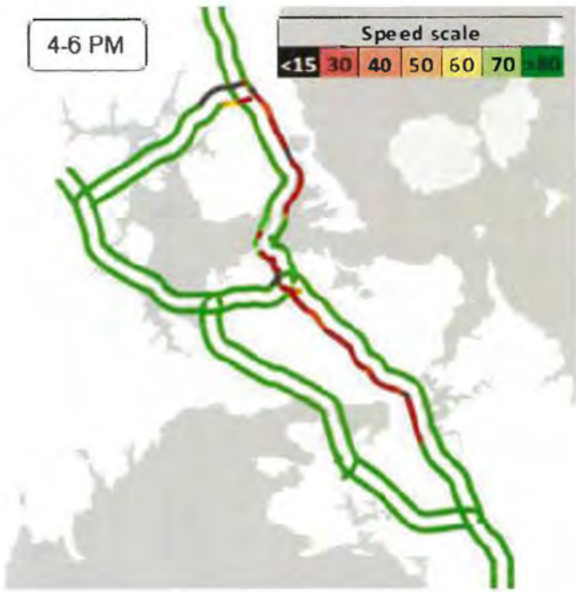


Network Impact Summary

3 traffic lanes northbound, 3 traffic lanes southbound, during weekends
When modeling the highest level of traffic suppression, modal shift and traffic re-routing, this Option results in additional delays from approximately noon until 8:00pm on weekend days in the northbound direction between Mt Wellington Highway and the Bridge. Additional Delays will also occur southbound, north of the bridge, similar to Option 5.







1 Lane — Northbound
Permanent Configuration

- Creation of a 4m wide shared path and 4m wide traffic lane, permanently reducing traffic on the AHB by 1 lane.
- Permanent installation of concrete moveable lane barrier which will not be connected to the bridge deck.
- Installation of a high fence on the seaward side.

Traffic Management

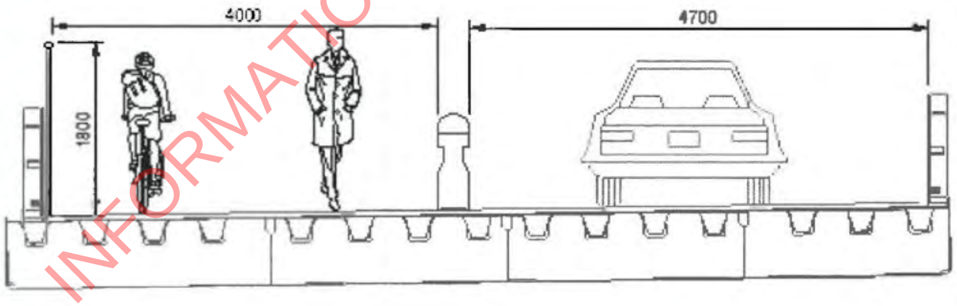
	AM Peak		PM Peak		Interpeak		Weekend	
	3	4	4	3	4	3	4	3
North ↑ South ↓	↑	↓	↑	↓	↑	↓	↑	↓

North Access
via Sulphur Beach Road

South Access
via Curran Street

Option
7

Cross Section



Residual Risks

Top Structural Risks
- Restrictions on heavy vehicles (greater than 3.5 tonnes) and buses using the west extension.
- Increase in traffic loading in remaining lanes due to heavy vehicle restrictions on the west extension.

Top TTM/ Ops Risk
- Removes the ability to shift the Bridge into a 5N/2S configuration to clear traffic from the CBD.

Top Operational Safety Risk
- Pedestrians and cyclists would be in close proximity to active traffic.
- User safety will need to be assessed and mitigated due to 4m wide path with a 5% gradient.

Opportunity
Permanent configuration minimises set-up and cost.

Estimated Cost

Total Capex	Total Opex
$10M - $12M	$3M - $4M year

Construction Programme
12 Months

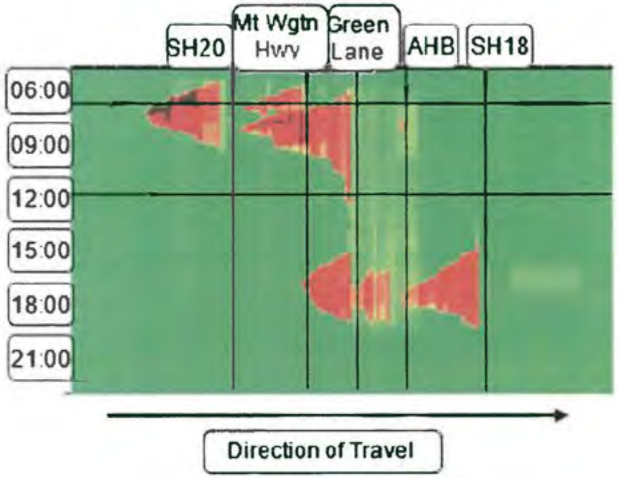
Resolve GROUP

1 Lane — Northbound
Permanent Configuration

Option
7

Network Heat Map - SH1 Northbound - Weekdays

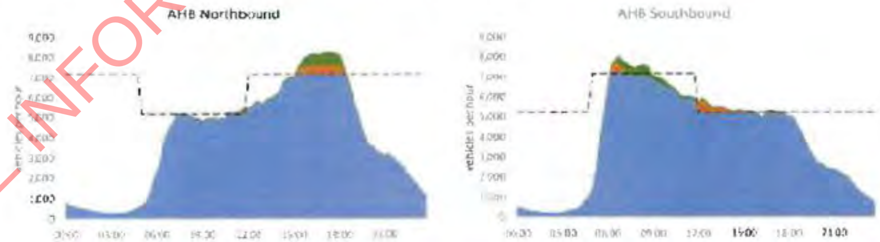
Existing

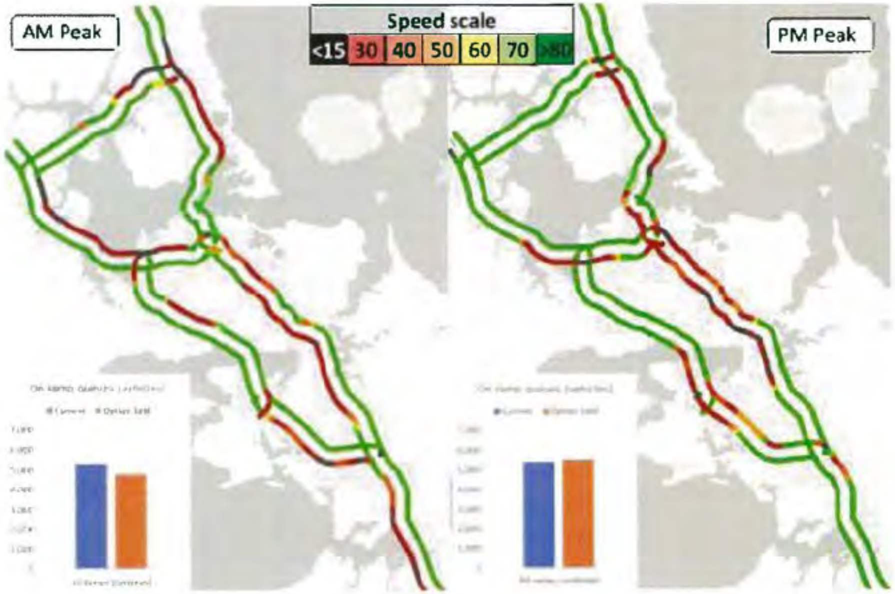


Option 7

Network Impact Summary

4 traffic lanes in peak direction, 3 traffic lanes in counter peak direction
When modeling the lowest level of traffic suppression, modal shift and traffic re-routing, this Option results in very little change to traffic flows during the AM peak period when compared to the existing traffic flows. However, the PM peak period will experience increased delays on the Southern Motorway as far south as SH20. Due to the restriction created by the bridge, delays north of the bridge during the PM Peak will likely improve.





2 Lane — Northbound
Permanent Configuration

- Creation of an 8m wide shared path which will permanently reduce traffic on the AHB by 2 lanes.
- Shared path will be separate from traffic by a permanent installation of steel barrier on the approaches, and fencing along the truss structure of the Bridge.
- Installation of a high fence on the seaward side, as well as adjacent to the truss along the overarch section.

Traffic Management

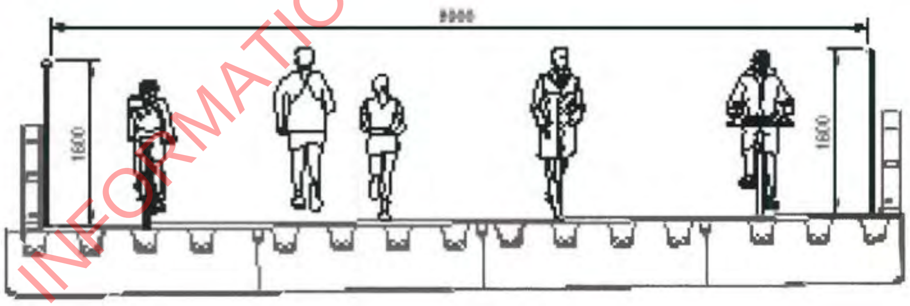
	AM Peak		PM Peak		Interpeak		Weekend	
North ↑	3	3	3	3	3	3	3	3
South ↓	↑	↓	↑	↓	↑	↓	↑	↓

North Access
via Sulphur Beach Road

South Access
via Curran Street

Option
8

Cross Section



Residual Risks

Top Structural Risks
- Increase in traffic loading in remaining lanes due to removal of traffic, including heavy vehicles, from the west extension.

Top TTM/ Ops Risk
- TTM at Stafford off-ramp would be challenging and a robost management plan would be required.
- Closure of Curran Street ramp will result in pressure around the CBD.
- Steel barriers on AHB red chip reduce ability to use this as a hard shoulder in the event of break-down or other incident.

Top Operational Safety Risk
- Truss structure more accessible to shared path users.

Opportunity
Permanent configuration minimises set-up and cost.

Estimated Cost

Total Capex	Total Opex
$6M - $8M	$4M - $5M year

Construction Programme
12 Months

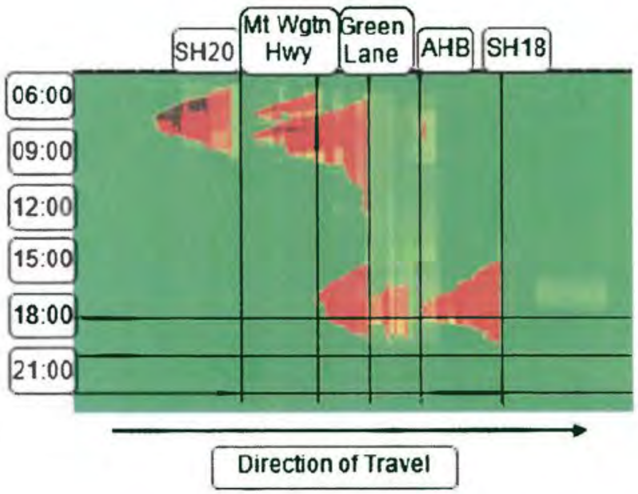
Resolve GROUP

2 Lane — Northbound
Permanent Configuration

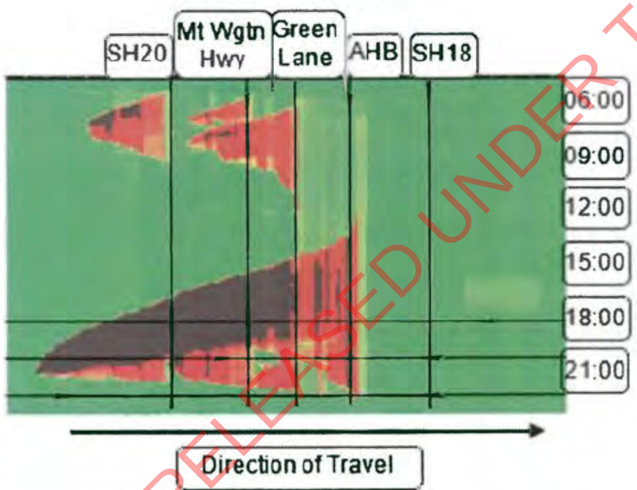
Option **8**

Network Heat Map - SH1 Northbound - Weekdays

Existing



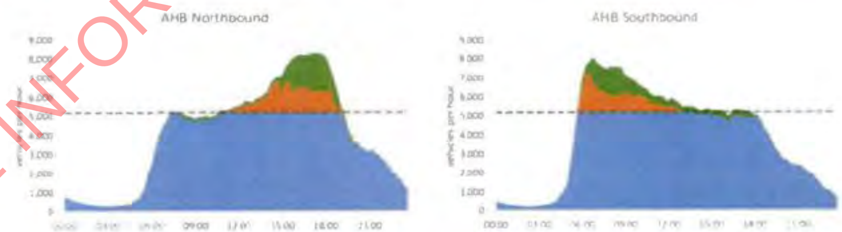
Option 8

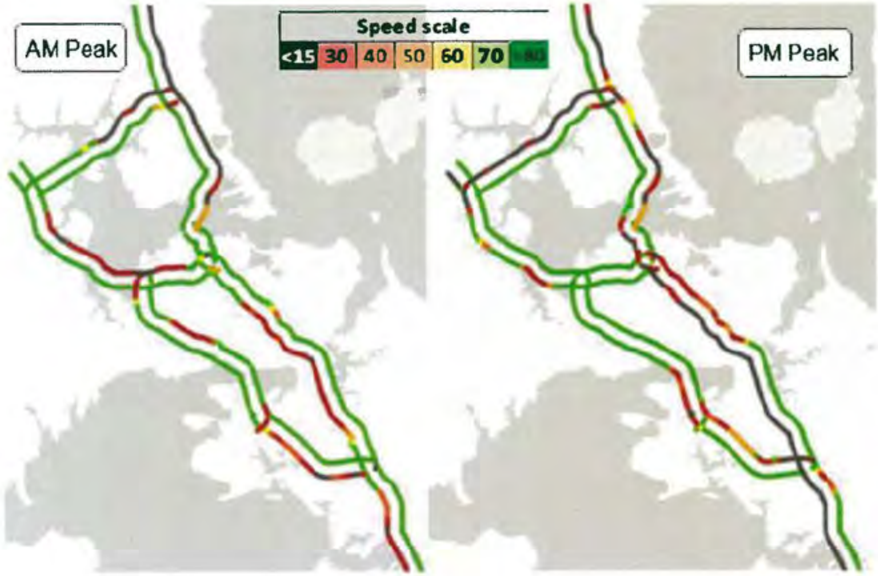


Network Impact Summary

3 traffic lanes northbound, 3 traffic lanes southbound at all times

When modeling the highest level of traffic suppression, modal shift and traffic re-routing, this Option results in additional delays throughout the greater Auckland Network. In particular, northbound traffic will experience extensive delays during the PM Peak from south of the SH20 interchange through the Bridge restriction. However, the restriction created by the Bridge will relieve northbound delays north of the Bridge.





1 Lane — Centre Span
Permanent Configuration

- Creation of a 5.40m wide shared path on the truss bridge, permanently reducing traffic on the AHB by 2 Lanes.
- Shared path separated from traffic by permanent installation of 2 moveable lane barriers (not fixed to the deck) and high fence installed in front of barrier on both sides of the shared path.

Traffic Management

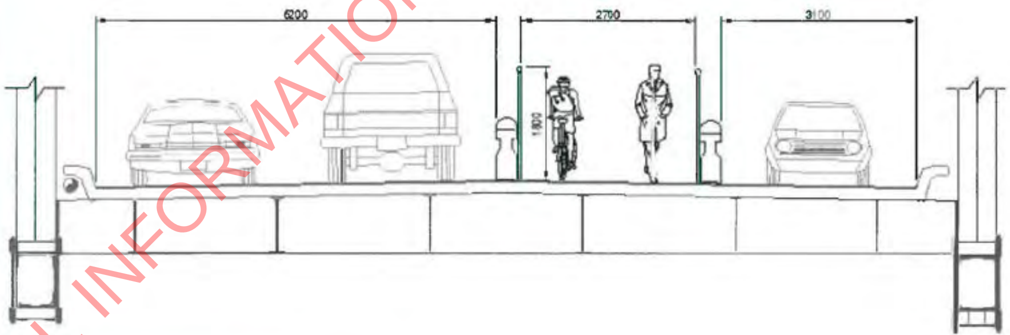
	AM Peak		PM Peak		Interpeak		Weekend	
North ↑	4	3	4	3	4	3	4	3
South ↓	↑	↓	↑	↓	↑	↓	↑	↓

North Access
via Sulphur Beach Underpass

South Access
via Fanshawe Street

Option
9

Cross Section



Residual Risks

Top Structural Risks
- Load restrictions would be required in all traffic lanes as well as controls on pedestrian and cyclist loading.

Top TTM/ Ops Risk
- Removes the ability to shift the Bridge into a 5N/2S configuration to clear traffic from the CBD.

Top Operational Safety Risk
- Pedestrians and cyclists would be in close proximity to active traffic.

Opportunity
No impact on ramp access to the bridge.

Estimated Cost

Total Capex	Total Opex
$14M - $16M	$4M - $5M year

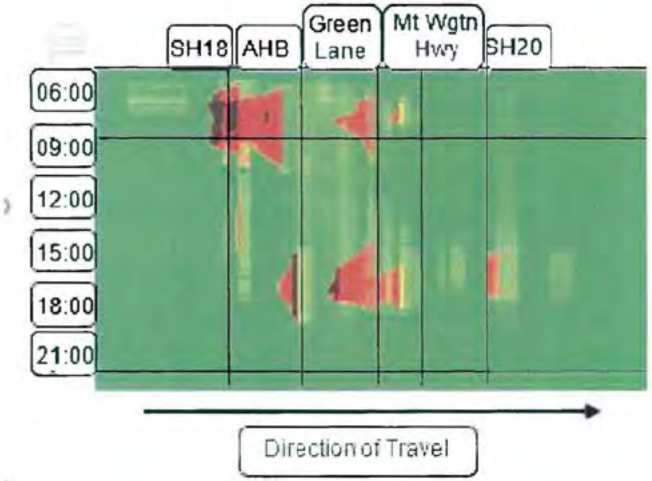
Construction Programme
15 Months

RESOLVE GROUP

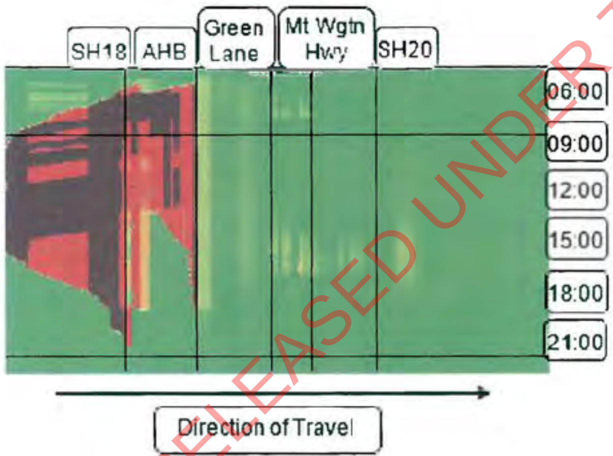
2 Lane — Centre Span
Permanent Configuration

Network Heat Map - SH1 Northbound - Weekdays

Existing



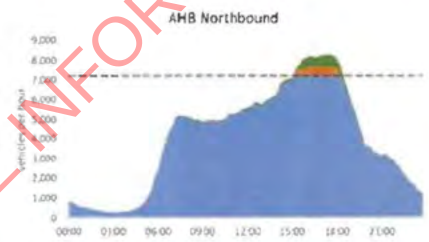
Option 9

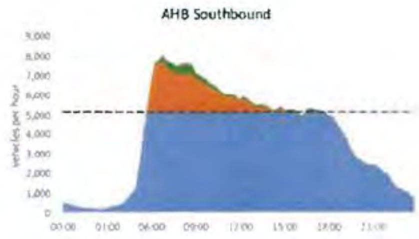


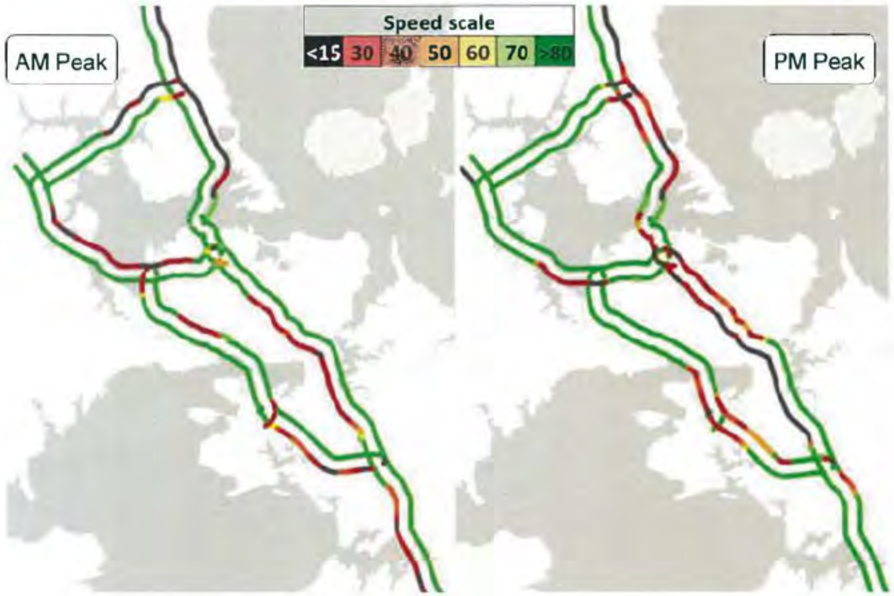
Network Impact Summary

4 traffic lanes northbound, 3 traffic lanes southbound at all times

When modeling the highest level of traffic suppression, modal shift and traffic re-routing, this Option results in additional delays throughout the greater Auckland Network. In particular, southbound traffic will experience extensive delays north of SH18 for almost the entire day.







2 Lane — Centre Span
Permanent Configuration

- Creation of a 5.40m wide shared path on the truss bridge, permanently reducing traffic on the AHB by 2 Lanes.
- Shared path separated from traffic by permanent installation of 2 moveable lane barriers (not fixed to the deck) and high fence installed in front of barrier on both sides of the shared path.

Traffic Management

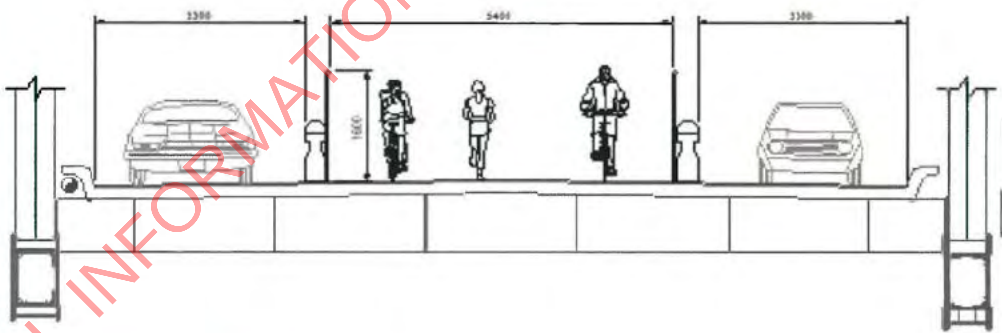
	AM Peak		PM Peak		Interpeak		Weekend	
North ↑	3	3	3	3	3	3	3	3
South ↓	↑	↓	↑	↓	↑	↓	↑	↓

North Access
via Sulphur Beach Underpass

South Access
via Fanshawe Street

Option
10

Cross Section



Residual Risks

Top Structural Risks
- Load restrictions would be required in all traffic lanes as well as controls on pedestrian and cyclist loading

Top TTM/ Ops Risk
- Removes the ability to shift the Bridge into a 5N/2S configuration to clear traffic from the CBD.

Top Operational Safety Risk
- Pedestrians and cyclists would be in close proximity to active traffic

Opportunity
No impact on ramp access to the bridge.

Estimated Cost

Total Capex	Total Opex
$14M - $16M	$4M - $5M year

Construction Programme
15 Months

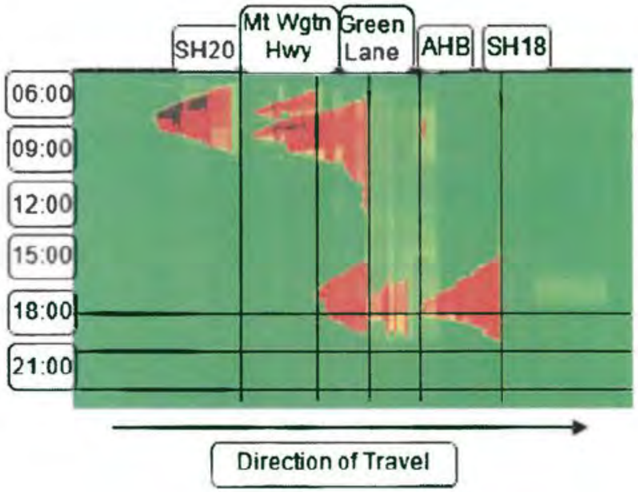
Resolve GROUP

2 Lane — Centre Span
Permanent Configuration

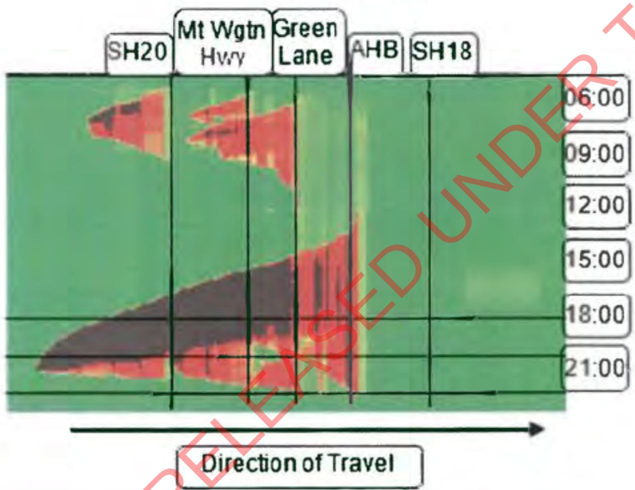
Option **10**

Network Heat Map - SH1 Northbound - Weekdays

Existing



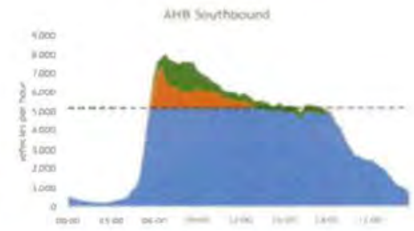
Option 10

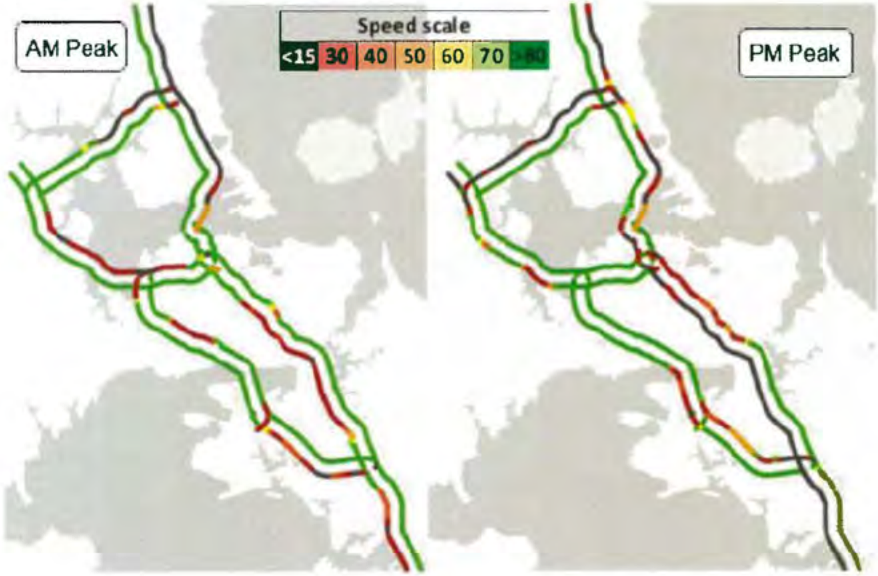


Network Impact Summary

3 traffic lanes northbound, 3 traffic lanes southbound at all times

When modeling the highest level of traffic suppression, modal shift and traffic re-routing, this Option results in additional delays throughout the greater Auckland Network. In particular, northbound traffic will experience extensive delays during the PM Peak from south of the SH20 interchange through the Bridge restriction. However, the restriction created by the Bridge will relieve northbound delays north of the Bridge.





0 Lane — NB/SB
Permanent Configuration

- 2.20m wide uni-directional shared path on both the western edge of the west clip-on and the eastern edge of the east clip-on.
- The number of traffic lanes would not be reduced, but the width of the lanes on both clip-ons would reduce to 3.1m per lane. Shared path separated from traffic by permanent installation of moveable lane barrier (not fixed to the deck).
- High fence installed on seaward side.

Traffic Management

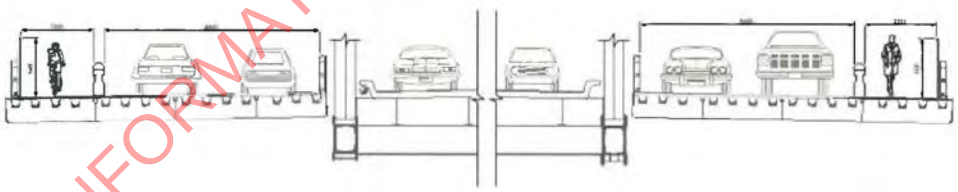
	AM Peak		PM Peak		Interpeak		Weekend	
North ↑	3	5	5	3	4	4	4	4
South ↓	↑	↓	↑	↓	↑	↓	↑	↓

North Access
via Sulphur Beach Road/Underpass

South Access
via Shelly Beach Road/Curran Street

Option 11

Cross Section



Residual Risks

Top Structural Risks
- This option exceeds structural capacity, even after considering removal of heavy vehicle loading from both extensions.

Top TTM/ Ops Risk
- Traffic shifts across ramps in both directions of traffic.

Top Operational Safety Risk
- Pedestrians and cyclists would be in close proximity to active traffic.

Opportunity

Minimal impact to current bridge operations.

Estimated Cost

Total Capex	Total Opex
$20M - $22M	$4M - $5M year

Construction Programme

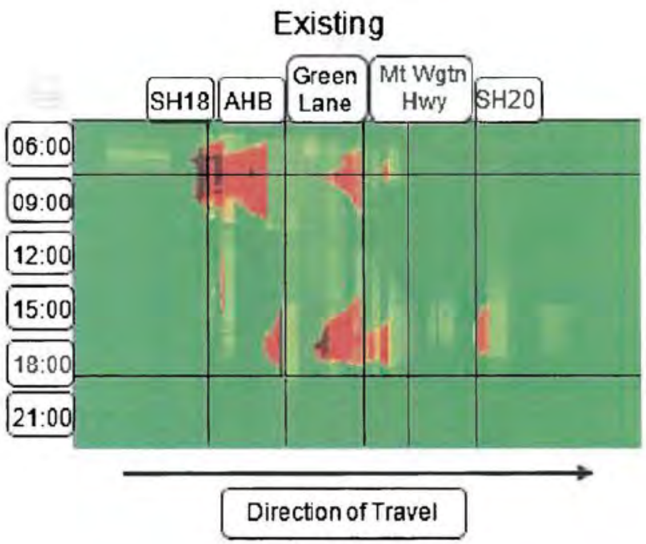
15 Months

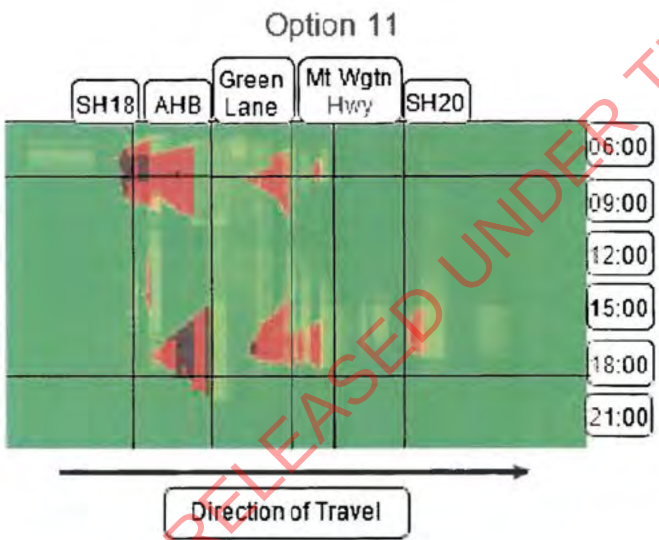
RESOLVE GROUP

0 Lane — NB/SB
Permanent Configuration

Option
11

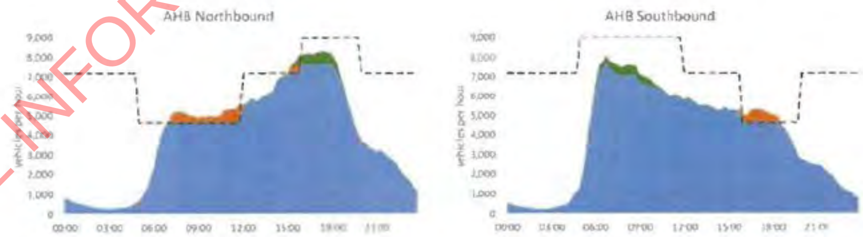
Network Heat Map - SH1 Southbound - Weekdays

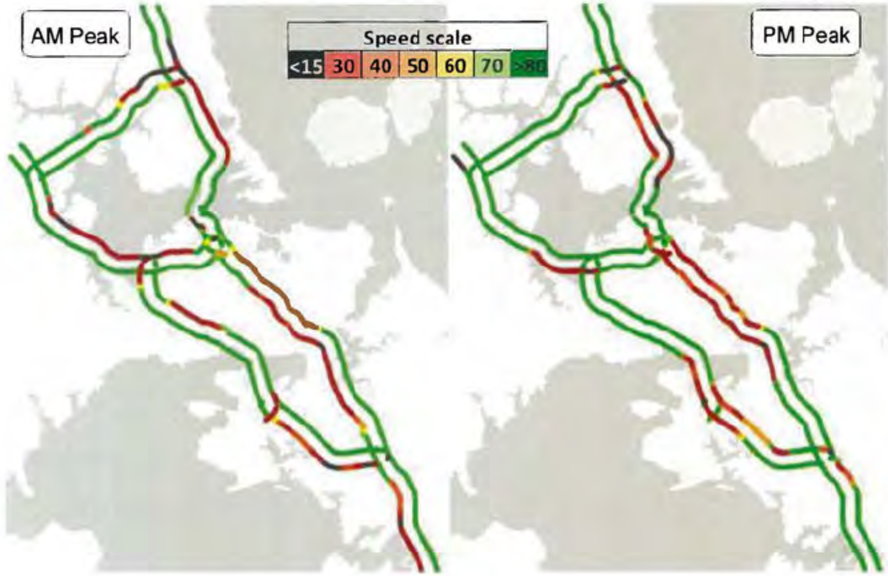




Network Impact Summary

No change to existing traffic flows
This option would result in minimal impact to current traffic volumes.





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5 Conclusion

This report attempts to assess, at a high level, viable options for implementing a shared path on the existing Auckland Harbour Bridge. The intent of this report was not to select a preferred option, but rather, present Waka Kotahi with a thorough and unbiased analysis of viable options. This analysis produced the following:

- Due to impacts on the wider network resulting from ramp closures, a shared path on the east side of the AHB is preferable when compared to the same configurations on the west side of the AHB.
- Impact on the wider motorway and local road networks is highly dependent on the level of demand reduction assumed. A significant change in motorist behaviour could result in minimal network impact, however, no change in motorist impact may result in significant network effects, particularly if weekday options are implemented.
- Structural capacity is an issue for some options, however, further refined analysis is required to determine the level of heavy vehicle management which will be required to manage any capacity constraints. Option 11 is not considered feasible due to current structural loading requirements.
- Further refined analysis of user safety systems (e.g. barriers, CCTV, security personnel) should be undertaken before implementing any option. These systems should work together to provide maximum protection for shared path users and motorists.
- Operationally, all options are viable with appropriate Temporary Traffic Management Plans and Operations Plans, although noting that option 11 is not feasible due to current structural loading requirements.
- All options carry some residual risks, however most of these risks can be mitigated to reduce likelihood and/or consequence to acceptable levels.

Due to the high-level analysis performed by this assessment, all consequences and risks presented portray a "worst case scenario" for each option. Selection of a preferred option will allow refined and detailed analysis to be undertaken. This will likely result in:

- Lower residual user safety risks as ideal safety measures are identified;
- Lower levels of heavy vehicle restrictions as a detailed assessment of the structure will be undertaken using refined data;
- Lower Capex and Opex costs as efficiencies are recognised;
- Decreased programme length upon a clear understanding of material lead times; and
- More confidence in traffic modelling as inputs are clarified.

Appendix: Traffic and Network Modelling

Description of Modelling Tools

Auckland Macro Strategic Model (MSM): This model covers the region's entire road network and Public Transport system. It is operated by the Auckland Forecasting Centre and its primary role is to understand how major changes to the transport network affect mode choice between private vehicles and public transport, and how private vehicles distribute themselves across the road network. The model evaluates the network in 2-hour blocks of time (there are three 2-hour blocks to cover AM peak, interpeak and PM peak). The representation of the motorway network is coarse, and congestion is represented through delays on individual links and intersections, which is better suited to large models used for strategic planning purposes. This type of model is not well suited to replicating small-scale operational changes because it does not provide realistic propagation of congestion and queues in a way that realistically affects performance of upstream sections of the network.

Northern Corridor Improvements (NCI) Simulation and Assignment of Traffic to Urban Road Networks (SATURN) Model: In summary, the primary role of this tool is to determine how traffic is distributed across a congested network. This tool determines how a fixed amount of traffic routes itself from a series of journey start locations (origins) to series of corresponding end locations (destinations), accounting for delays along the way. By accounting for capacity constraints of a network (primarily at intersections) SATURN incorporates "flow metering" which provides a realistic spread of congestion across a network, including how queues can block flows at upstream intersections. SATURN is normally used to model large areas (thousands of links), although it is capable of analysing the effects of relatively minor network changes. However, it is limited in relation to analysing motorway operation in two ways:

- It was not originally designed to model motorways and as such is limited in how motorway capacity can be represented. Additionally, most effort to calibrate a SATURN model is devoted to operation of intersections on the arterial network (which usually govern the routing if traffic). This often leads to the use of "typical" capacities across most motorway links, where in reality individual links may differ considerably from this.

- SATURN is normally used to model the peak hour as a single one-hour block of time, which limits the ability to accurately reflect the growth of congestion spatially across the network. The buildup of queues throughout the peak can be approximated through use of an additional 1-hour "pre-peak" model. This which effectively "loads" the network with queues before the peak model is run.

The NCI SATURN model has the added limitation that it only covers the Auckland network north of CMJ and the Waterview Tunnel – SH20 and the Southern Motorway are not included. This means any congestion impacts of modifying the lanes on the AHB on the southern motorway will not be represented.

Auckland Dynamic Traffic Assignment Model (ADTA): This model is operated by the Auckland Forecasting Centre. Dynamic Traffic Assignment models also determine the routing of traffic through and its resulting distribution across a network, but they consider the growth and spreading of congestion over time and space in a more realistic way, using multiple, smaller time periods. However, because of this they are extremely complex models and this is compounded when they are used to represent very large networks (the ADTA, like the MSM covers the entire of Auckland's road network).

They are very difficult to calibrate to observed data, which means that not all parts of large models will respond realistically.

Auckland Motorway Network Cell Transmission Model (CTM): This model shows realistic growth and recovery of congestion in both time and distance over the whole day. It models interaction between corridors due to realistic representation of "flow metering", where congestion at one location restricts flow that can arrive further downstream further downstream. This model provides simplicity and flexibility but doesn't provide coverage of arterial and local roads. However, realistic traffic response and coordinated operation of ramp signals is included, and the model keeps track of the number of vehicles queued at each on ramp at all times. This allows on-ramp queues to be used as proxy for likely arterial and local road impacts. This model has been calibrated in detail for all parts of the motorway network and validated extensively against 2018 data. A weakness of the CTM is that it only simulates the traffic impact of a given, fixed demand pattern and therefore does not reroute traffic when congestion delays get high. However, it is simple to incrementally modify demand patterns manually and run multiple scenarios quickly.

Network and Mode coverage

Representation of Congestion		No re-routing		Re-routing		Re-routing and PT mode shift
		AHB only	Motorway and on ramps	Motorways and local roads (partial network)	Motorways and local roads (whole network)	Motorways and local roads (whole network) plus PT
Less realistic	No upstream queuing					MSM
	Average upstream queuing - peak period only			SATURN		
	Growth and recovery of queues over peak period only				ADTA	
	Growth and recovery of queues over the whole day	AHB-Q				
More realistic	Growth and recovery of queues over the whole day, plus congestion responsive ramp signals operation		AMN-CTM			

Complexity and resource effort required

- (green) Very simple and quick - modify and execute in minutes
- (yellow) Simple and quick - modify and execute in under an hour
- (orange) Moderate - modify and exectue in under 1 day
- (red) Complex - modifying and executing can take several days

Figure 10 - Applicability of Network Models

How to Read Model Outputs

AHB Demand/Capacity Graphs:

These graphs show traffic demand and capacity on the AHB, and have been updated with information from modelling to indicate the level of demand reduction which would be required to produce a neutral impact on traffic (i.e., not produce more congestion than currently exists). It plots vehicles per hour along the y-axis against time of day on the x-axis.

A dashed line on the graph indicates where the capacity of the AHB and it varies depending on the lane configuration at that time of day. When the demand graph is above the dashed line indicating the capacity of the AHB, congestions occurs.

An example is shown below:

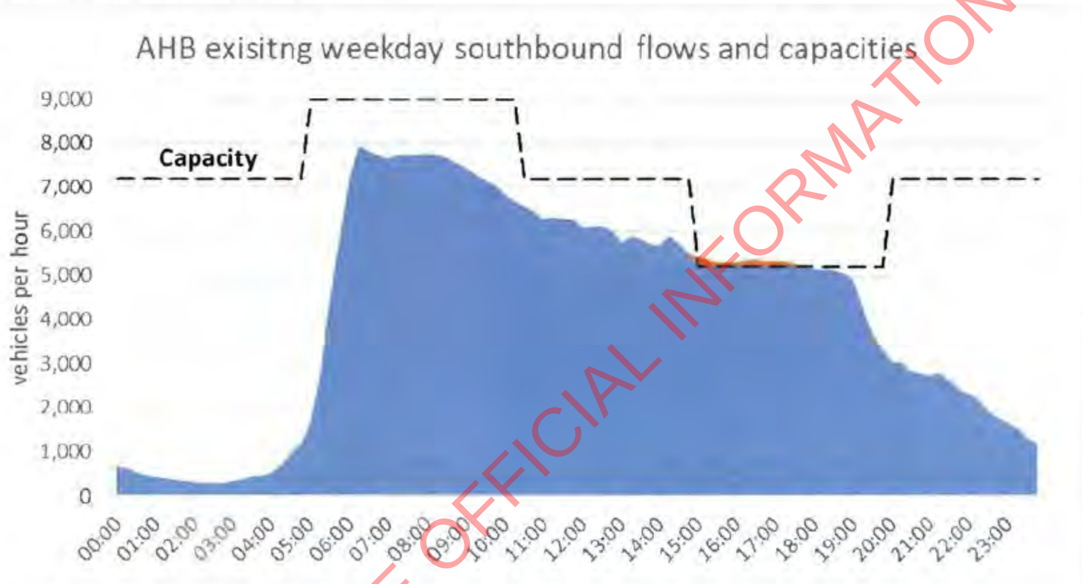

Figure 11 - AHB Demand/Capacity Example

Network Operating Conditions Maps:
These maps show the major arterial roads in the greater Auckland network (SH1, SH16, SH18, and SH20) represented by the average speed traffic is moving at a given time of day.

A legend is presented with each heat map, with green lines indicating free flowing traffic, and black lines indicating severe congestion. The time of day represented is shown in the upper left or right corner of the map.

An example is shown below:

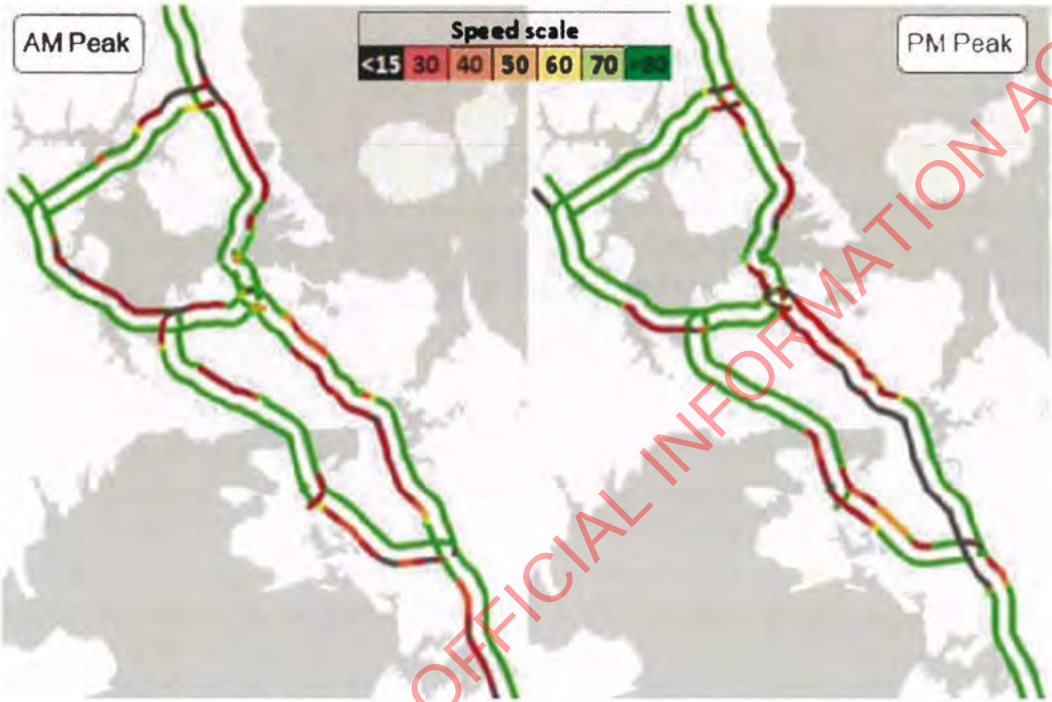

Figure 12 - Network Operating Condition Map Example

Network Heat Graphs:

These maps represent how traffic is flowing on SH1 in a particular direction throughout a particular day (generally weekday or weekend). Key interchanges are indicated along the particular direction of travel on the x-axis, and time of day is indicated along the y-axis.

Similar to the Network Operating Conditions Maps, speed is represented by colour, with green indicating free flowing traffic and black indicating severe congestion. The same scale is utilised, but is also reproduced below:

Figure 13 - Speed Scale

This graph indicates how changes to the lane configuration of the AHB will impact the remainder of SH1 in the direction indicated. A graph of existing conditions is shown next to the conditions which would result from the implemented option, for comparison purposes.

The example shown below indicates the daily traffic flow in the northbound direction. The heat graph of existing SH1 traffic is shown on the left, and the heat graph which would result from the implementation of a particular option is shown on the right. It shows that during the PM Peak on this day, congestion would become more severe than it currently is on SH1 from south of the SH20 interchange through the AHB. However, because of the restriction created by the AHB, traffic would become less severe than it currently is for traffic traveling north of the AHB.

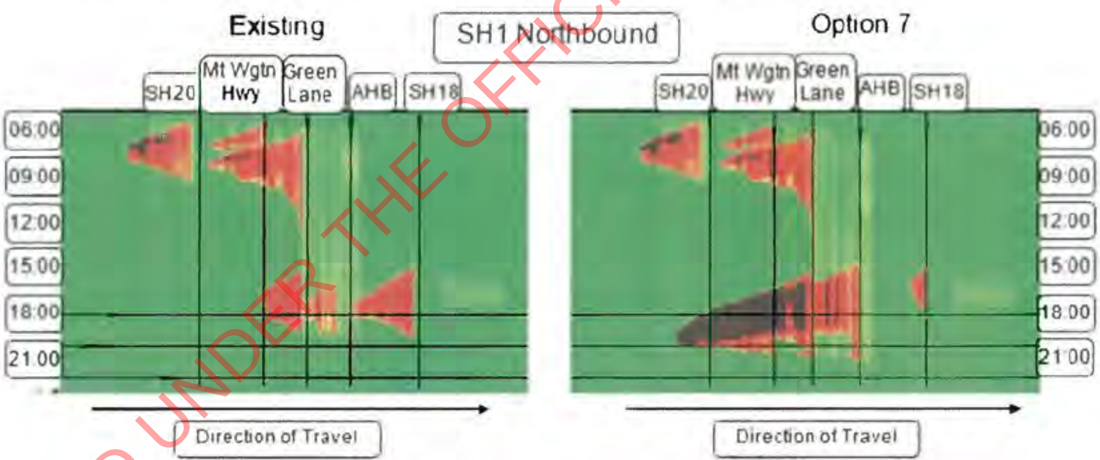

Figure 14 - Traffic Flow Example