Revision History

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<td>Caroline Clear</td>
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<td>Geoff Brown</td>
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<td>Beca Infrastructure Ltd</td>
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<td>David Hoffman</td>
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Executive Summary

Introduction

The Ngauranga to Aotea Quay Project (the “Project”) has been identified as one of eight sections within the Wellington Northern Corridor (State Highway 1 from Levin to the Wellington Airport) which is a Road of National Significance (RoNS) in terms of the 2009 Government Policy Statement (GPS) on Land Transport Funding. The upgrading of the Wellington Northern Corridor and the other six RoNS across the country are to be substantially progressed in the next 10 years.

The Project includes the three kilometre section of State Highway 1 between Ngauranga Gorge and the Aotea Quay on and off-ramps which forms part of the Wellington Urban Motorway. This is the most congested part of the Wellington motorway network, particularly during morning and evening peak periods. As such it has been identified for improvement measures as part of the RoNS programme.

The current Project objectives are:

- Improve journey efficiency through journey time reliability, reducing congestion and driver stress;
- Making best use of the asset by delivering a value for money and flexible solution;
- Improving compliance through influencing driver behaviour;
- Maintain or improve safety for all users;
- Adverse effects on the environment are no more than minor;
- The solution can be delivered effectively; and
- The solution fits with NZTA's economic strategy.

The New Zealand Transport Agency (NZTA) awarded Fletcher Construction Company Ltd (Fletcher) the ECI Contract No 446PN: Ngauranga to Aotea Quay: Wellington Active Traffic Management, to carry out the investigation, design and construction of the Project. The ECI Team comprises of Fletcher, Beca Infrastructure Ltd (Beca), Parsons Brinkerhoff (PB), TERNZ and Tyco.

The ECI Contract will be delivered in three Separable Portions:

- Separable Portion 1 (SP1): Scoping and Scheme Assessment Reporting;
- Separable Portion 2 (SP2): Specimen design; and
- Separable Portion 3 (SP3): Detailed design and construction works.

SP1 began with the “scoping stage” in November 2010. In November 2011 the Scoping Report was published. The Scoping Report concluded that to accommodate the forecast traffic flow, relieve congestion and improve travel time reliability; four lanes are required on SH1 from Ngauranga to Aotea Quay in each direction. The option development and assessment process confirmed that it is feasible to provide four lanes in each direction on SH1 from Ngauranga to Aotea Quay. Through development and assessment of a corridor management framework and workshops with NZTA it was confirmed during the scoping stage that the operational strategy for this stretch of SH1 would be a fully-managed motorway.

While developed overseas such as in the United Kingdom and Australia, a managed motorway project is new to New Zealand. As such the Project team has used overseas examples, case studies and research to help develop the Project.

This Scheme Assessment Report (SAR) is a key deliverable of SP1 and marks the end of the Investigation and Reporting phase of the Project. This SAR further develops the options identified in the Scoping Report, develops and evaluates the preferred scheme and recommends a staged approach for implementing improvements.

Early Works

During the scoping stage it was identified that there was potential to implement “early works” to provide some mitigation of the problems associated with the merge and diverge at the Ngauranga interchange.
For the northbound direction, a 600m additional lane was provided from the SH1/SH2 diverge split to start around the Southern Rail Overbridge. The 3.5m wide lanes with a 2.5m left hand shoulder were remarked to provide four 3.3m wide lanes plus a 0.6m right and left hand shoulder. This extended the diverge some 600m to allow the SH1 traffic to bypass the queue back from the SH2/Hutt Road on-ramp merge during the PM peak period.

For the southbound direction the merge between SH1 and SH2 was shortened by implementing a 200mm wide solid while line 100m from the merge point to provide better lane discipline and merging.

The data from the Bluetooth travel time survey, traffic volume counts and CCTV have all demonstrated that the north and southbound Early Works resulted in benefits in both the AM and PM peak periods. In the southbound direction in the AM peak, the early works have increased capacity, reduced weaving, and reduced peak travel times by 1.5 minutes from Ngauranga to Hobson Street (the SH1 movement) and two minutes from Petone to Hobson Street (the SH2 movement). In the northbound direction in the PM peak, the capacity of the diverge is higher as throughput has increased, the peak travel time from Hobson Street to Ngauranga (the SH1 movement) has reduced by two minutes, and the peak travel time from Hobson Street to Petone (the SH2 movement) has reduced by four minutes.

Based on this assessment the early works have resulted in significant benefits to both SH1 and SH2. A staged approach to delivering early benefits such as the early works will be sought as the Project progresses.

**Design Development Considerations**

During this scheme assessment stage, a preferred option has been developed for the implementation of the four lanes with full management. Further design and assessment of the following issues has been undertaken:

- Full time versus part time management;
- Development of the proposed cross section including shoulder and lane widths and locations of Emergency Breakdown Areas;
- Development of an Enforcement Strategy and Driver Awareness Strategy; and
- Further work to determine the feasibility of widening the Thorndon Overbridge.

The scheme assessment was undertaken in stages, which allowed the project team to discuss and agree specific elements of the scheme with the stakeholders. Consultation was carried out throughout the scheme assessment stage, which provided greater focus for the later stages of the assessment. Each of these stages is summarised below.

**Full time versus Part Time**

This stage investigated whether the new fourth lane should be operated during the peak periods only, i.e. “part time” or whether the new fourth lane should be utilised full time. This assessment included an economic analysis of the options, a hazard log assessment, a review of the operational strategies and the potential issues, and a driver behavioural assessment. The conclusion of this assessment was to recommend managing the fourth lane as a full time fourth lane because it is considered to be safer, easier to operate, and realises greater benefits.

**Cross Section / “Physical Solution”**

This stage considered the physical layout options and provided a recommendation for the preferred ‘physical solution’. Five cross sections were identified, with varying shoulder and lane widths. These cross sections were evaluated using a hazard log process, a crash cost savings assessment and a project cost assessment, which helped to identify the preferred cross section. A detailed sight distance assessment was undertaken which identified mitigation measures so that sight distance was not adversely affected compared to the existing situation. An assessment of the location and design of the Emergency Breakdown Areas (EBAs) was also completed at this stage.

The preferred cross section is to use four 3.5m lanes with 1.0m shoulders because the cross section is generally able to be accommodated within the existing footprint and anticipated sight distance issues can be mitigated with localised widening. Providing four 3.5m lanes will involve the replacement of the central median barrier from the northern end of the Thorndon Overbridge to the Ngauranga interchange. This is to accommodate the additional width required for the fourth lane without widening in the Coastal Marine Area. It is proposed to reduce the lane widths to 3.3m over the Thorndon Overbridge to minimise the widening of this
structure. Emergency Breakdown Areas will be provided (one northbound and two southbound) where space permits and which can also be used as maintenance bays.

**Enforcement Strategy and Driver Awareness Strategy**

The hazard log assessment undertaken during the second stage highlighted the importance of education and enforcement to the safety improvements for the scheme. A concept of enforcement for the Project was then developed. A draft enforcement strategy was developed in consultation with the Police. It was confirmed that speed and lane use can be legally enforced. Enforcement will be undertaken digitally through the ATMS technology. A draft driver awareness strategy has been prepared. It is considered that a driver awareness strategy must accompany the improvement of the ATMS system.

**Thorndon Overbridge Widening**

A report was produced documenting the assessment of the Thorndon Overbridge. The report investigated the feasibility of the clip-on structure to the Thorndon Overbridge and summarises the structural form and concept, design loads, parameters, material characteristics, construction methodology and risks for the proposed clip-on widening deck. The report also revisited the geotechnical assessments undertaken as part the 1990’s seismic retrofit by comparison against current seismic loading standards and current understanding of liquefaction/lateral spreading.

That assessment confirmed that it is structurally feasible to design and construct the clip-on widening deck to the existing Thorndon Overbridge given the current site constraints. However the geotechnical assessment has indicated that the return period for which movements of the ground due to liquefaction and lateral spreading become excessive for the structure to accommodate (greater than 500mm) may be as low as 250 years, compared to 500 years originally estimated at the time of the 1990’s seismic retrofit. It is therefore concluded that subject to further detailed geotechnical study and discussion with NZTA, it will be necessary to consider ground improvement options to mitigate liquefaction or resist lateral spread forces as part of the proposed widening scheme, in order to provide overall structural stability, at least in line with the intent of the original 1990’s retrofit design.

**Project Cost**

Cost Estimates were developed for the preferred scheme which were prepared to the NZTA’s Scheme Estimate specification described in the Cost Estimation Manual (SM014). Scheme estimates were also prepared for several of the components of the preferred scheme for use in developing the staging plan. These components include:

- SH2 Ngauranga Northbound On Ramp Improvements;
- Emergency On-ramp at Ngauranga;
- Upgrade of existing ATMS system;
- Widen northbound to four lanes; and
- Widen southbound to four lanes.

The Expected estimate and the 95th percentile estimate for the preferred scheme and components is shown in Table i below.

<table>
<thead>
<tr>
<th>Item and Description</th>
<th>Base Estimate ($M)</th>
<th>Expected Estimate ($M)</th>
<th>95th Percentile Estimate ($M)</th>
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<tr>
<td>Full Scheme (Includes all of the components below)</td>
<td>$78.2M</td>
<td>$87.3M</td>
<td>$100.5M</td>
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<tr>
<td>SH2 Ngauranga Northbound On Ramp Improvements (Geometric improvements to On-Ramp)</td>
<td>$3.3M</td>
<td>$3.7M</td>
<td>$4.3M</td>
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<tr>
<td>Item and Description</td>
<td>Base Estimate ($M)</td>
<td>Expected Estimate ($M)</td>
<td>95th Percentile Estimate ($M)</td>
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<tr>
<td>--------------------------------------------------------------------------------------</td>
<td>-------------------</td>
<td>------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Emergency On-ramp at Ngauranga</td>
<td>$2.3M</td>
<td>$2.5M</td>
<td>$2.9M</td>
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<tr>
<td>Upgrade of existing ATMS system</td>
<td>$13.3M</td>
<td>$14.7M</td>
<td>$17.0M</td>
</tr>
<tr>
<td>(New ATMS equipment and enforcement)</td>
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<tr>
<td>Widen northbound to four lanes</td>
<td>$19.8M</td>
<td>$22.1M</td>
<td>$25.4M</td>
</tr>
<tr>
<td>(Includes Aotea Quay On-Ramp improvements and replacement of central median barrier)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Widen southbound to four lanes</td>
<td>$39.6M</td>
<td>$44.2M</td>
<td>$50.9M</td>
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<tr>
<td>(Includes widening of Thorndon Overbridge)</td>
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**Project Risks**

A risk workshop for the Project was held on 10 May 2012 and was attended by representatives from NZTA, Fletcher Construction, Beca, and WT Partnership (cost estimate peer reviewers). The risk workshop was facilitated under the guidelines of NZTA Risk Management Manual AC/Man/1 and the output of the workshop was the updating of the single project risk register to reflect the increased understanding of the Project threats and opportunities.

The key risks that have been identified and assessed at the risk workshop are:

- Upgrade existing (old) Aotea off ramp or rebuild ramp structure (currently 1:100 year return period). It was decided that the upgrade of the existing off ramp was outside the scope of this Project;
- Thorndon Overbridge geotechnical improvements. The risk is that ground improvements are required before any clip-on structures are added. It was decided that ground improvements were outside the scope of this Project;
- Use of Waterloo Quay rail crossing hampers the effectiveness of the Project;
- Land designation: additional designation required during design and/or for construction (including temporary site working areas);
- Access requirements and future development of the Port prevent or interfere with the Project. KiwiRail objections results in revisions to Port Access plans. The risk is additional time and cost to resolve access issues;
- Constructability: working within requirements of existing stakeholders. Risk is design or construction methodology to be modified to meet stakeholder requirements;
- Existing Thorndon Overbridge southbound on-ramp: foundations cannot be re-used and will require new (or modified) substructure; and
- SH1 shoulder pavement capacity: rebuild existing shoulder pavement material to cope with traffic volumes. The risk is rutting of pavements. The capacity of the shoulder pavement will need to be assessed during the design phase.

**Assessment of Preferred Scheme**

The scheme assessment report has assessed the transport performance of the preferred scheme, considered statutory planning and environmental issues, and NZTA funding policy issues. The conclusions of these assessments are:

- The Project will result in significant travel time savings, relieve congestion and improve travel time reliability on SH1 in the Project area;
- There are no significant environmental issues raised by the Project;
An alteration to designation may be required for the Thorndon Overbridge widening and an alteration to designation will be required for the proposed emergency on ramp at Ngauranga; and The Project has a funding profile of HHL.

Economic Assessment

The economic assessment of this Project has been undertaken in accordance with the requirements of the Economic Evaluation Manual, First Edition (EEM). The results of the economic analysis indicate that the Project has a BCR of 1.1.

A post-implementation study of the M42 ATMS and hard-shoulder running operating regime reported a 22% reduction in the variability of travel times. Based on this, and approaches taken for similar motorway projects involving providing additional capacity, travel time reliability benefits have been assessed as 5% of the travel time benefits. This is likely to underestimate the trip reliability benefits given the highly congested nature of this section of the motorway, so the economic assessment is considered to be conservative in respect to the trip reliability benefits.

The results of the economic analysis indicate that the full scheme is expected to realise benefits greater than its cost. Additional benefits not captured in this assessment (such as congestion relief and benefits for non-motorway traffic) are likely to increase the benefits further, resulting in a BCR above the 1.1 assessed.

Project Staging

It is intended to implement the full scheme in stages to create the opportunity to realise early benefits and prove the concept of full management on three lanes before investing in four lanes. The implementation of the Early Works in 2011 has already realised benefits for both SH1 and SH2 traffic. The proposed Project stages are:

- Stage 1: Improvements to the SH2 northbound on-ramp at Ngauranga;
- Stage 2: Improvements to the ATMS system;
- Stage 3: Widening SH1 to four lanes northbound; and
- Stage 4: Widening SH1 to four lanes southbound.

A staged economic assessment was undertaken for the four stages and the resulting BCRs for each stage were:

- Stage 1: 1.2;
- Stage 2: 1.9;
- Stage 3: 2.5; and
- Stage 4: 0.8.

The results of the economic assessment indicate that the first three stages are economically viable to progress now. Stage 4, the widening of the southbound carriageway to four lanes, has a BCR of only 0.8 which indicates that it is ahead of its time. Stage 4 should therefore be deferred until other factors such as the future of the Interislander, Terrace Tunnel duplication, and the seismic risk considerations of the Thorndon Overbridge are further developed and their impact on the proposed four-lanes southbound are better understood.

Recommendations

Based upon the assessments in this report, it is recommended that:

- The Project is implemented in stages. The proposed stages are:
  - Stage 1: Improvements to the SH2 northbound on-ramp;
  - Stage 2: Improve the existing ATMS system;

---

- Stage 3: Four lane SH1 northbound; and
- Stage 4: Four lane SH1 southbound.

- Stages 1 to 3 are implemented as soon as possible and that Stage 4 is deferred until other factors such as the future of the InterIslander, Terrace Tunnel duplication, and the seismic risk considerations of the Thorndon Overbridge are further developed and their impact on the proposed four-lanes southbound are better understood.

- It is recommended that these improvements are included in the Project scope and implemented at an early stage:
  - The Glover Street intersection;
  - Ngauranga intersection signals; and
  - The SH2 off ramp at Ngauranga.

- NZTA continue to work with WCC to confirm the designation for SH1 in the vicinity of the Thorndon Overbridge. An alteration to designation may be required for the Thorndon Overbridge Widening;

- Stages 1 through 3 are taken forward to specimen design.

- Stage 4 is deferred until other identified factors and their impact on the proposed four-lanes southbound is better understood.
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1. Introduction

1.1. General

The Ngauranga to Aotea Quay Project (the “Project”) has been identified as one of eight sections within the Wellington Northern Corridor (State Highway 1 from Levin to the Wellington Airport) which is a Road of National Significance (RoNS) in terms of the 2009 Government Policy Statement (GPS) on Land Transport Funding. The upgrading of the Wellington Northern Corridor and the other six RoNS across the country are to be substantially progressed in the next 10 years. The GPS identifies the RoNS as New Zealand’s most essential routes that carry high traffic volumes and require solutions to reduce congestion, improve safety and support economic growth. The location of the Ngauranga to Aotea Quay project within the Wellington Northern Corridor RoNS is shown in Figure 1.1 below.

Figure 1.1 Wellington Northern Corridor RoNS
The Project includes the three kilometre section of State Highway 1 between Ngauranga Gorge and the Aotea Quay on and off-ramps which forms part of the Wellington Urban Motorway. This is the most congested part of the Wellington motorway network, particularly during morning and evening peak periods. As such it has been identified for improvement measures as part of the RoNS programme.

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### 1.2. RoNS & Project Specific Objectives

#### 1.2.1. RoNS Objectives

The Wellington RoNS objectives are:

- to enhance inter regional and national economic growth and productivity;
- to improve access to Wellington’s CBD, key industrial and employment centres, port, airport and hospital;
- to provide relief from severe congestion on the state highway and local road networks;
- to improve the journey time reliability of travel on the section of SH1 between Levin and the Wellington airport; and
- to improve the safety of travel on State highways.

#### 1.2.2. Project Specific Objectives

The Ngauranga to Aotea Quay Project specific objectives set at the start of the project (in the RFP) are summarised in Table 1.1
### Table 1.1 – RFP Project Objectives

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<th>Goal</th>
<th>Objective</th>
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<td>Improve Journey Efficiency</td>
<td>- Contribute to improved journey time reliability&lt;br&gt;- Improve driver ambience&lt;br&gt;- Integrate with the existing road network</td>
</tr>
<tr>
<td>Ease Congestion</td>
<td>- Smooth traffic flows&lt;br&gt;- Increase capacity when needed</td>
</tr>
<tr>
<td>Flexibility</td>
<td>- Operate as required (24/7)&lt;br&gt;- Operate independently in each direction&lt;br&gt;- Be capable of automatic operation&lt;br&gt;- Controllable from any Traffic Operations Centre</td>
</tr>
<tr>
<td>Compliance</td>
<td>- Compliance through intuitive systems&lt;br&gt;- Legally enforceable (at time of opening and future-proof hardware)&lt;br&gt;- No NZTA liability</td>
</tr>
<tr>
<td>Maximise Asset</td>
<td>- Make best use of existing asset&lt;br&gt;- Minimal additional infrastructure&lt;br&gt;- Value for Money&lt;br&gt;- Consider maintenance and renewal requirements</td>
</tr>
<tr>
<td>Knowledge Transfer</td>
<td>- Develop ATM capabilities in NZ&lt;br&gt;- Repeatable (Pilot Scheme)&lt;br&gt;- Demonstrate &amp; prove new operating regimes&lt;br&gt;- Prove new technologies&lt;br&gt;- Extend capabilities of operators</td>
</tr>
<tr>
<td>Integration</td>
<td>- Use latest technology&lt;br&gt;- Integrate with existing ATMS&lt;br&gt;- Use existing NZTA operating systems&lt;br&gt;- Fit with adjacent State Highway and local road network&lt;br&gt;- Sustainability of operations (operator ownership)</td>
</tr>
<tr>
<td>Improve Safety</td>
<td>- Improve safety for road users&lt;br&gt;- Improve safety for network maintenance&lt;br&gt;- Improve safety for Emergency Services</td>
</tr>
<tr>
<td>Early Delivery</td>
<td>- Consider staged delivery to achieve early project delivery</td>
</tr>
<tr>
<td>Customers First</td>
<td>- Minimise construction disruption&lt;br&gt;- Innovation&lt;br&gt;- Traveller Information&lt;br&gt;- Positive Marketing</td>
</tr>
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</table>
The Project objectives were reviewed during the course of the scoping stage. The current objectives for the Project are:

- Improve journey efficiency through journey time reliability, reducing congestion and driver stress;
- Making best use of the asset by delivering a value for money and flexible solution;
- Improve compliance through influencing driver behaviour;
- Maintain or improve safety for all users;
- Adverse effects on the environment are no more than minor;
- The solution can be delivered effectively; and
- The solution fits with NZTA's economic strategy.

The Project objectives have not changed during the scheme assessment stage.

1.2.3. NZTA Macroscope

On 16 December 2010, NZTA’s Value Added Committee (VAC) met to discuss the macroscope definition of the Project. The VAC noted that the Project will be delivered in terms of how SH1 is operated rather than its physical characteristics. The VAC defined the Project macroscope as:

“A preferred concept of operations (operational strategy)” which is:

- Physically possible;
- Has an acceptable BCR; and
- No overall safety disbenefits.

1.3. Scoping Report Summary

The scoping stage is the first stage in the typical investigation and reporting phase of NZTA project development. In broad terms, the purpose of the scoping stage is to identify and undertake a high level assessment of options which meet the project objectives, and recommend feasible options to take forward to more detailed assessment in the scheme assessment stage.

The first step in the scoping stage was an analysis of existing traffic conditions in the study area and an analysis of projected future conditions without the project in place. Supporting this analysis was a public survey of the public’s view on how the stretch of motorway from Ngauranga to Aotea Quay operates and consultation with stakeholders. Together this work formed a problem definition for the Project.

The Scoping Report investigations found that the section of SH1 between Ngauranga Gorge and Aotea Quay experiences high levels of congestion during both the AM and PM peaks. This congestion results in high levels of queuing and low traffic speeds along this section of SH1 and on the surrounding state highway and local road networks. Based on the scoping stage assessments, engagement with the Traffic Operations Centre, key stakeholders, and the public survey, the problems with SH1 from Ngauranga to Aotea Quay can generally be summarised as relating to congestion and travel time reliability.

The second step in the scoping stage was an options development process. This was generally carried out through a series of workshops between the ECI team and NZTA, including a “Blue Sky Workshop.” This process defined a number of options for the Project and also a number of options to improve “specific points” in the general vicinity of the project area which would improve the flow of traffic on SH1.

Options were put through an evaluation process which included traffic modelling, a multi-criteria assessment, and assessment against project objectives. Following the multicriteria assessment workshop a corridor management framework was developed to confirm a strategy for the Ngauranga to Aotea Quay section of SH1 to be a “fully managed system.” The scoping stage assessments found that providing four lanes in each direction with full management met the project objectives.

Following the assessment of options and confirmation of a preferred operational framework, an envelope of considerations for implementing four lanes with full management was developed. The result of the scoping stage was the recommendation of a preferred operational framework for SH1 to be further developed in the Scheme Assessment stage.
The scoping report concluded that to accommodate the forecast traffic flow, relieve congestion and improve travel time reliability four lanes are required on SH1 from Ngauranga to Aotea Quay in each direction. The option development and assessment process confirmed that it is feasible to provide four lanes in each direction on SH1 from Ngauranga to Aotea Quay. Through development and assessment of a corridor management framework and workshops with NZTA it was confirmed during the scoping stage that the operational strategy for this stretch of SH1 would be a fully-managed motorway.

1.4. Legislative Context

A number of policies and procedures currently exist against which transportation projects are to be evaluated within New Zealand. Many of these procedures are legislated and are required to be carried out to satisfy funding requirements and the government’s obligations. A brief summary of each, relevant to its interaction with the Ngauranga to Aotea Quay project is provided below:

1.4.1. Land Transport Management Act

The Land Transport Management Act (LTMA) provides the legal framework for managing and funding land transport activities. The purpose of the LTMA is to contribute to the aim of achieving an affordable, integrated, safe, responsive and sustainable land transport system. The LTMA:

- provides an integrated approach to land transport funding and management;
- improves social and environmental responsibility in land transport funding, planning, and management;
- provides the NZTA with a broad land transport focus;
- improves long-term planning and investment in land transport; and
- ensures that land transport funding is allocated in an efficient and effective manner; and
- improves the flexibility of land transport funding by providing for alternative funding mechanisms.

1.4.2. New Zealand Transport Strategy

The New Zealand Transport Strategy (NZTS) sets out the government’s vision for transport to 2040 and the strategic approach to be taken. The vision is that: ‘People and freight in New Zealand have access to an affordable, integrated, safe, responsive, and sustainable transport system.’

The vision is supported by five transport objectives:

- ensuring environmental sustainability;
- assisting economic development;
- assisting safety and personal security;
- improving access and mobility;
- protecting and promoting public health; and
- maintaining and improving international links.

1.4.3. Government Policy Statement

The Government Policy Statement on Land Transport Funding (GPS) sets out the government’s priorities for expenditure from the National Land Transport Fund over the next 10 years. Under the LTMA:

- NZTA must give effect to the GPS in developing the National Land Transport Programme and take account of the GPS when approving funding for activities;
- Regional Land Transport Strategies must take account of the GPS; and
- Regional Land Transport Programmes must be consistent with the GPS.

In the GPS the government has listed seven initial Roads of National Significance (RoNS) as a statement of national road development priorities, of which the Wellington Northern Corridor (SH1 from Levin to Wellington) is one.
1.4.4. Regional Land Transport Strategy

The Ngauranga Interchange section of SH1 and SH2 is identified in the Hutt Corridor Plan, the Ngauranga to Airport and Western Corridor Plans within the Wellington Regional Land Transport Strategy as a significant and influential area of congestion. The RLTS and the Plans contained within it identify the long term vision for each of these key corridors.

The Ngauranga to Airport Corridor Plan (2008) includes the Ngauranga to Aotea Quay Project. The Corridor Plan identifies the Project as being undertaken in parallel with the implementation of bus lanes on Hutt Road. The ECI project team is investigating improvements to SH1 and the implementation of bus lanes is a separate project which will be led by Wellington City Council.

1.4.5. Resource Management Act

The purpose of the Resource Management Act (RMA) is to promote the sustainable management of natural and physical resources. Sustainable management means managing the use, development and protection of natural and physical resources in a way, or at a rate, that enables people and communities to provide for their social, economic and cultural wellbeing and for their health and safety, while:

- sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations;
- safeguarding the life-supporting capacity of air, water, soil and ecosystems; and
- avoiding, remediying or mitigating any adverse effects of activities on the environment.

The RMA sets out the functions, powers and duties of local government, and the resource consent and designation process. When building or maintaining state highways, the RMA requires the NZTA to avoid, remedy or mitigate adverse environmental effects caused by the highway infrastructure.

1.5. Scheme Assessment Report Structure

The content of the Scheme Assessment Report is summarised as follows:

- Section 1 provides an introduction to the Project;
- Section 2 discusses the existing conditions of the study area, provides a problem description, and describes the “Early Works” implemented in 2011;
- Section 3 discusses the process of developing the preferred scheme;
- Section 4 provides an evaluation of the preferred scheme;
- Section 5 documents the consultation and stakeholder engagement undertaken during the scheme assessment stage;
- Section 6 summarises the cost estimates;
- Section 7 discusses the risk assessment process and the outcome of risk workshops;
- Section 8 presents the economic assessment of the Project;
- Section 9 discusses the proposed staged approach to implementing the Project; and
- Section 10 contains the conclusions and recommendations.

This Scheme Assessment Report further develops the options identified in the Scoping Report, develops and evaluates the preferred scheme and recommends a staged approach for implementing improvements.
2. Site Description and Problem Definition

2.1. Definition of Study Area

The project study area comprises approximately 3km of SH1 in both the northbound and southbound directions. In both directions the study area stretches between the Ngauranga interchange in the north, where SH1 and SH2 meet, and the Aotea Quay on/off-ramps in the south.

The features of the study area are discussed below and illustrated in Figure 2.1. Further detail of the existing (Pre-“Early Works”) study area is shown on the A3 plans in Appendix A.

2.2. Physical Description of Study Area

2.2.1. State Highway 1 Southbound

At the Ngauranga interchange where SH1 and SH2 meet, both State Highways have two lanes on the approach to the merge point. These four lanes then merge into three lanes (lanes 2 and 3 merge) over a distance of approximately 250m.

Heading south along SH1 from Ngauranga there are three traffic lanes plus an additional 2.5m shoulder in place up until the area of reclaimed land adjacent to the Interislander Ferry Terminal. At this point the road transitions onto the Thorndon Overbridge. At this point the shoulder narrows then expands again on the
viaduct, where an unused merge stub exists. Past this point however, the shoulder quickly narrows again and a shoulder of 0.5m in width is provided up to the Aotea Quay off-ramp.

2.2.2. State Highway 1 Northbound

The Aotea Quay on ramp rises up to the Viaduct over the railway branch line into the Interislander Ferry Terminal. The on ramp lane merges onto SH1 northbound at a slight right hand bend on the Thorndon Overbridge.

Heading north from the on-ramp merge, a shoulder begins that widens to 3.5m at the end of the merge and then tapers away over the next 100m to become narrow. Approximately 300m north of this point a 3.5m wide shoulder forms again and runs continuously to the SH1 and SH2 diverge at Ngauranga.

Over the length of the study area SH1 undulates vertically and horizontally. From Thorndon Overbridge it descends, before it rises again over the North Island Main Truck railway line to descend prior to splitting at Ngauranga where SH1 rises up the Gorge and SH2 continues along the harbour.

2.2.3. Connections to the Local Area Network

Although the study is focused on the section of SH1 described above there are a number of interactions with the local area road network that impact upon the study area.

Hutt Road runs parallel to SH1 for the length of the study corridor, providing two lanes of traffic in each direction (northbound and southbound), with connections to Aotea Quay in the south and the Ngauranga Interchange in the north.

Aotea Quay connects the Interislander ferry terminal with the city centre. It is not possible to access the ferry terminal from the motorway at Aotea Quay (access to Aotea Quay southbound from SH1 southbound only). Therefore, all traffic heading towards the Interislander terminal from SH1 and SH2 (southbound) has to use Hutt Road. The ferry terminal and Aotea Quay have access to SH1 northbound only.

The Hutt Road / Centennial Highway intersection has four entry roads - Hutt Road, Jarden Mile, Centennial Highway and the SH2 off ramp. There are no pedestrian facilities provided at the intersection, although a number of cycle lanes pass through the site. Left turn slip lanes are provided on all entrances to the intersection with the exception of Jarden Mile. The intersection exit on Centennial Highway links onto SH1 approximately 500m west of the intersection. Similarly the Hutt Road exit provides an entrance onto SH2 travelling north, approximately 500m north of the intersection.

South of the study area there are a number of on and off ramps which may impact upon the project. The Murphy Street off ramp is the next opportunity to exit SH1 after the Aotea Quay southbound off ramp and provides links with the Thorndon area and the CBD.

2.2.4. ATMS Operation

The project area is currently managed using overhead mounted mandatory variable speed control signs between Ngauranga Interchange and the Terrace Tunnel. All ramps have side mounted speed control signs and there are a limited number of motorway variable message signs.

The ATMS 2 project extended the ability to manage traffic on State Highway 1 through speed management from Ngauranga to the Terrace Tunnel. The ATMS hardware is managed through the DYNAC system which allows the Traffic Operations Centre (TOC) operators to manage congestion, incident and weather related events by reducing the speed limit, informing motorists of the incidents ahead and provides the ability to close a lane or lanes due to either a crash, incident or for maintenance.

2.3. Current Traffic Volumes

Figures 2.2 and 2.3 present current year (2012) flow profiles for SH1 and SH2 at the interchange. These demonstrate a very similar profile on each of the two state highways with significant peaks of flow during both

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2 Note that these flow profiles are post “Early Works” which are discussed in Section 2.4.
AM (07:00 – 09:00) and PM (16:00 – 18:00) peak periods. During the AM peak, southbound flow on SH2 peaks at about 3700 vehicles per hour, which is likely to be very close to the capacity of the road. On SH1 traffic flows peak at around 3000 vehicles per hour. Between 07:00 and 08:30 the SH1 flow level plateaus indicating that capacity is constrained at the merge (with SH2 achieving a greater level of priority).

During the PM peak, flow on SH2 northbound peaks at 3000 vehicles per hour at around 17:00. The PM peak flow on SH1 northbound occurs around half an hour later with a peak demand just shy of 3500 vehicles per hour. This indicates that the maximum northbound flow through the study area (between Aotea Quay and Ngauranga) will reach around 6000 vehicles per hour (or 2000 per lane). As the balance between the two State Highways is relatively even, it is likely that the section of road south of the interchange will be operating close to capacity during the PM peak, regulating the flow north of the interchange.

Figure 2.2 – Southbound Traffic Flows

Figure 2.3 – Northbound Traffic Flows
2.4. Improvements to the SH1 Merge and Diverge

During the scoping stage it was identified that there was potential to implement “early works” to provide some mitigation of the problems associated with the merge and diverge at the Ngauranga interchange.

For the northbound direction, a 600m additional lane was provided from the SH1/SH2 diverge split to start around the Southern Rail Overbridge. The 3.5m wide lanes with a 2.5m left hand shoulder were remarked to provide four 3.3m wide lanes plus a 0.6m right and left hand shoulder. This extended the diverge some 600m to allow the SH1 traffic to bypass the queue back from the SH2/Hutt Road on-ramp merge during the PM peak period.

For the southbound direction the merge between SH1 and SH2 was shortened by implementing a 200mm wide solid while line 100m from the merge point to provide better lane discipline and merging.

The data from the Bluetooth travel time survey (discussed further in Section 2.5 below), traffic volume counts and CCTV have all demonstrated that the north and southbound Early Works resulted in benefits in both the AM and PM peak periods including:

- Reduced queues;
- Decreased travel times;
- Increased capacity;
- Improved merge behaviour; and
- Better traffic flows and network operations.

In the southbound direction in the AM peak, the early works have increased capacity, reduced weaving, and reduced peak travel times by 1.5 minutes from Ngauranga to Hobson Street (the SH1 movement) and two minutes from Petone to Hobson Street (the SH2 movement). In the northbound direction in the PM peak, the capacity of the diverge is higher as throughput has increased, the peak travel time from Hobson Street to Ngauranga (the SH1 movement) has reduced by two minutes, and the peak travel time from Hobson Street to Petone (the SH2 movement) has reduced by four minutes.

Based on this assessment the early works have resulted in significant benefits to both SH1 and SH2. A staged approach to delivering early benefits such as the early works will be sought as the Project progresses.

A report was prepared documenting the Early Works which is contained in Appendix B.

2.5. Current Journey Times

Current journey times for the corridor, post early works, have been derived using data collected using Bluetooth technology. This works such that Bluetooth enabled devices (such as mobile telephones) are identified passing a series of detection devices. If the same Bluetooth device is picked up at more than one location, inferences can be made regarding journey times. Three Bluetooth transverses were installed for the Project to collect data on travel times. The devices are located on:

- SH1 Ngauranga Gorge Motorway VMS;
- SH2 Petone Weighbridge VMS; and
- SH1 Hobson Street VMS.

Table 2.1 summarises the average off peak and peak hour journey times and differences.
Table 2.1 – Bluetooth Journey Time Information

<table>
<thead>
<tr>
<th>Routes</th>
<th>Distance (km)</th>
<th>Peak Period</th>
<th>Inter-Peak Travel Time (mins)</th>
<th>Average Peak Travel Time (mins) 4</th>
<th>Per cent Increase Off Peak to Average Peak Travel Time 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>SH1 Ngauranga Gorge to SH1 Hobson Street</td>
<td>5.7</td>
<td>AM</td>
<td>03:39</td>
<td>09:44</td>
<td>167%</td>
</tr>
<tr>
<td>SH2 Petone Weighbridge to SH1 Hobson Street</td>
<td>5.8</td>
<td>AM</td>
<td>03:32</td>
<td>06:24</td>
<td>81%</td>
</tr>
<tr>
<td>SH1 Hobson Street to SH1 Ngauranga Gorge</td>
<td>5.7</td>
<td>PM</td>
<td>03:35</td>
<td>05:43</td>
<td>59%</td>
</tr>
<tr>
<td>SH1 Hobson Street to SH2 Petone Weighbridge</td>
<td>5.8</td>
<td>PM</td>
<td>03:32</td>
<td>06:16</td>
<td>78%</td>
</tr>
<tr>
<td>SH1 Ngauranga Gorge to SH2 Petone Weighbridge</td>
<td>3.7</td>
<td>PM</td>
<td>02:50</td>
<td>05:16</td>
<td>85%</td>
</tr>
<tr>
<td>SH2 Petone Weighbridge to SH1 Ngauranga Gorge</td>
<td>3.7</td>
<td>PM</td>
<td>03:29</td>
<td>04:19</td>
<td>24%</td>
</tr>
</tbody>
</table>

Table 2.1 shows that there is a significant increase in journey time for all peak direction movements during peak periods. This indicates that the additional traffic is resulting in slower speeds through the corridor. This increase in journey times is more pronounced during the AM peak than the PM peak. It is also worth noting that traffic from SH1 travelling southbound towards the city centre during the AM peak appears more disadvantaged than traffic travelling from SH2 (average journey times are over three minutes longer for a similar length of highway), this is likely to be due to the SH1/SH2 merge prioritising the movement from SH2.

2.6. Current Journey Time Variability

Travel time reliability is an important factor in the efficiency and comfort of the travel experience. Unreliable journey times result in issues such as increased driver stress and corresponding changes in driving style. While the total journey time is an important measure, the consistency and reliability of the same journey day to day is also important both for private motorists and business travel.

The Bluetooth data for the Project area in March 2012 has been analysed to provide an understanding of the variability of journey times across all periods of the day. Journey time variability is normally calculated in terms of how long it takes to undertake the same journey at the same time on different days. Research indicates that, up to a point, journey time variability increases with congestion. Therefore, it is to be expected that journey times along the corridor will be most variable during the AM and PM peak periods. Journey time variability is calculated using standard deviations. However it is important to note that standard deviations vary along with average journey times so a coefficient of variability(CV) can be produced to facilitate comparison between routes and times of day. This coefficient is derived by dividing the standard deviation of the journey time by the mean journey time. The larger the coefficient, the greater the amount of travel time variability. Peak CVs are presented in Table 2.2 for the key journey segments below.

3 Bluetooth travel time data is from post implementation of the “Early Works” (changes to the SH1 / SH 2 merge / diverge areas. Preliminary analysis showed that the Early Works has resulted in travel time savings. A separate technical note was produced documenting the travel time impacts of the Early Works.

4 Journey times are based on average peak hourly flow over a two week period post the implementation of the early works.

5 Difference between free flow (off peak) and average peak hour travel time.
Table 2.2 – Travel Time Variability by Segment

<table>
<thead>
<tr>
<th>Routes</th>
<th>Distance (km)</th>
<th>AM Peak CV</th>
<th>Interpeak CV</th>
<th>PM Peak CV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Southbound</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SH1 Ngauranga Gorge to SH1 Hobson Street</td>
<td>5.7</td>
<td>0.51</td>
<td>0.05</td>
<td>0.10</td>
</tr>
<tr>
<td>SH2 Petone Weighbridge to SH1 Hobson Street</td>
<td>5.8</td>
<td>0.31</td>
<td>0.05</td>
<td>0.18</td>
</tr>
<tr>
<td>SH1 Hobson Street to SH1 Ngauranga Gorge</td>
<td>5.7</td>
<td>0.42</td>
<td>0.05</td>
<td>0.27</td>
</tr>
<tr>
<td><strong>Northbound</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SH1 Hobson Street to SH2 Petone Weighbridge</td>
<td>5.8</td>
<td>0.31</td>
<td>0.06</td>
<td>0.42</td>
</tr>
<tr>
<td>SH1 Ngauranga Gorge to SH2 Petone Weighbridge</td>
<td>3.7</td>
<td>0.73</td>
<td>0.40</td>
<td>0.62</td>
</tr>
<tr>
<td>SH2 Petone Weighbridge to SH1 Ngauranga Gorge</td>
<td>3.7</td>
<td>0.61</td>
<td>0.33</td>
<td>0.44</td>
</tr>
</tbody>
</table>

This demonstrates that, as expected, variability is most significant in the peak periods in the peak directions (southbound in the AM peak, northbound in the PM peak). In general, interpeak travel time variability is low. Traffic travelling between SH1 and SH2 experiences a large amount of variability throughout the day. It is worth noting that there is a significant amount of variability for northbound journeys in the AM peak as well. Through interrogation of the Bluetooth data, it became apparent that this was caused by a number of outlying events during the AM peak.

Further analysis was undertaken to isolate the impact of these outlying events. This further demonstrated the correlation between journey time variability and congestion along the corridor. Figure 2.4 and Figure 2.5 show the mean travel time and the 10th percentile and 90th percentile travel times for the routes along the state highway between Hobson Street and Petone. The percentile lines show the range of journey times within which 80% of journey times fall. This demonstrates that, for northbound traffic, 80% of journeys are between 200 and 250 seconds between these two points for most of the day. During the PM peak, variability increases such that 80% of journeys are between 200 and 600 seconds. For southbound traffic, for most of the day journey times between the Petone Weighbridge and Hobson Street are between 200 and 250 seconds. During the AM peak, variability increases such that journey times are typically between 250 and 550 seconds. A similar pattern is observed for journey times on the other routes.
Figure 2.4 Hobson Street to Petone Travel Time Variability

Figure 2.5 Petone to Hobson Street Travel Time Variability
2.7. Crash History and the Hazard Log Baseline

2.7.1. Reported Crash History

To understand the existing number and pattern of crashes within the study area, the NZTA’s Crash Analysis System (CAS) was sourced to obtain the five year (2005 – 2009) crash data. The reported crash history is summarised in Table 2.3, which shows that there was one recorded fatality and 19 serious injury crashes during this period.

<table>
<thead>
<tr>
<th>Severity</th>
<th>Year 2005</th>
<th>Year 2006</th>
<th>Year 2007</th>
<th>Year 2008</th>
<th>Year 2009</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Serious</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Minor</td>
<td>17</td>
<td>20</td>
<td>28</td>
<td>28</td>
<td>21</td>
<td>114</td>
</tr>
<tr>
<td>Non-Injury</td>
<td>48</td>
<td>70</td>
<td>67</td>
<td>45</td>
<td>54</td>
<td>284</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>66</strong></td>
<td><strong>93</strong></td>
<td><strong>101</strong></td>
<td><strong>79</strong></td>
<td><strong>79</strong></td>
<td><strong>418</strong></td>
</tr>
</tbody>
</table>

Table 2.4 provides a summary of accidents by type. The data shows that the most common cause of accident is through rear end collision (33.7%), of which around one third resulted in minor injury. The other major causes of accidents were through driver error through overtaking or loss of control whilst cornering.

<table>
<thead>
<tr>
<th>Movement Code / Type</th>
<th>Fatal</th>
<th>Serious</th>
<th>Minor</th>
<th>Non-injury</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rear End</td>
<td>0</td>
<td>2</td>
<td>46</td>
<td>93</td>
<td>141</td>
<td>33.7%</td>
</tr>
<tr>
<td>Overtaking</td>
<td>0</td>
<td>9</td>
<td>20</td>
<td>77</td>
<td>106</td>
<td>25.4%</td>
</tr>
<tr>
<td>Lost Control - Cornering</td>
<td>1</td>
<td>4</td>
<td>25</td>
<td>70</td>
<td>100</td>
<td>23.9%</td>
</tr>
<tr>
<td>Lost Control - Straight</td>
<td>0</td>
<td>1</td>
<td>15</td>
<td>18</td>
<td>34</td>
<td>8.1%</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>10</td>
<td>14</td>
<td>3.3%</td>
</tr>
<tr>
<td>Crossing/Turning</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>9</td>
<td>2.2%</td>
</tr>
<tr>
<td>Collision with Obstruction</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>8</td>
<td>1.9%</td>
</tr>
<tr>
<td>Merging</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>1.2%</td>
</tr>
<tr>
<td>Head On</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0.2%</td>
</tr>
</tbody>
</table>

Table 2.5 compares the crash rate for each direction on State Highway 1 between Ngauranga merge/diverge and the Aotea Quay ramps. A typical crash rate for a motorway and four-lane divided rural road has been sourced from the NZTA Economic Evaluation manual. Based on the data this section has a lower crash rate than would be typically expected - around 24% lower than typical for northbound movements and 42% lower for southbound movements.

Reviewing the total crash history by year there appears to be a peak in 2007 with a slight reduction in 2008 and then remaining constant. Similarly if the non-injury accidents are discounted, which are likely to have some under-reporting issues due to the possibility of vehicles being able to continue on with their journey, then there is a peak in incidents in 2007 and 2008 with a slight reduction in 2009.
Table 2.5 Crashes per 100 Million Vehicle Kilometres Travelled (VKT) Per Year

<table>
<thead>
<tr>
<th>Type</th>
<th>Northbound</th>
<th>Southbound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Area Injury Crashes</td>
<td>3.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Typical Injury crash rate – Motorway</td>
<td>4.3</td>
<td>4.3</td>
</tr>
<tr>
<td>Typical Injury crash rate – Four-Lane Divided Rural Road</td>
<td>5.2</td>
<td>5.2</td>
</tr>
</tbody>
</table>

2.7.2. The Hazard Log Approach

As many elements of the proposed scheme (as described in the next section) will be the first of their kind to be implemented in the New Zealand context, the usual methods of assessing safety impacts have been supplemented by using the hazard log to assess operational safety.

A risk profile for the base case was created in order to identify the existing hazards which are currently applicable to the study area\(^6\). These hazards were then ranked in terms of importance, with regard to safety. This methodology has been developed in the UK and successfully applied by the UK Highways Agency as part of their ‘managed motorway’ projects.

As part of the scoping stage the hazard log and baseline risk profile was developed and validated by the ECI Team\(^7\) and updated with the crash data from the period 2005-2009 inclusive. The ‘baseline’ scenario represents the current hazards and scores identified for the area without the Project in place.

Hazards in the study were identified and separated into ‘event’ and ‘state’ hazards. An event is a hazard which occurs momentarily, e.g. a vehicle carrying out a high risk lane change. A state is a hazard which is present for a period of time e.g. a vehicle stopped on the hard shoulder. The longer a state hazard is present the greater the risk of an incident occurring.

For hazardous events identified a risk score was evaluated by adding together a score for each of the following three factors:

- The rate at which the hazard is expected to occur;
- The probability that the hazard causes an incident; and
- The severity of the incident.

Table 2.6 presents the scores assigned for the probability of events in terms of the nominal value of occurrences per year per kilometre. The index scores presented are shown to the nearest 0.5, however index scores used in the hazard log were not rounded.

<table>
<thead>
<tr>
<th>Classification</th>
<th>If this hazard occurs then:</th>
<th>Index Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certain</td>
<td>A collision is certain</td>
<td>4</td>
</tr>
<tr>
<td>Probable</td>
<td>A collision is probable</td>
<td>3</td>
</tr>
<tr>
<td>Occasional</td>
<td>A collision will occasionally happen</td>
<td>2</td>
</tr>
<tr>
<td>Remote</td>
<td>There is a remote chance of a collision</td>
<td>1</td>
</tr>
<tr>
<td>Improbable</td>
<td>A collision is improbable</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2.7 presents the classification of index scores and the corresponding frequency of occurrence.

---

\(^6\) Wellington Active Traffic Management Scheme- Ngauranga to Aotea Quay – Project Safety Baseline and Risk Profile for the Before Case, Mouchel, November 2010.

\(^7\) Ngauranga to Aotea Quay – Project Safety Baseline Validation Report, Beca, July 2011.
Table 2.7 Classification and Scores of Frequency of Events

<table>
<thead>
<tr>
<th>Frequency Classification</th>
<th>Nominal Value: Occurrences per year per km</th>
<th>Nominal Value: Frequency of Occurrence per year per km</th>
<th>Index Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very frequent</td>
<td>600.0000</td>
<td>1.6 times per day</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>200.0000</td>
<td>once every 2 days</td>
<td>5.5</td>
</tr>
<tr>
<td>Frequent</td>
<td>60.0000</td>
<td>once every 6 days</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>20.0000</td>
<td>once every 18 days</td>
<td>4.5</td>
</tr>
<tr>
<td>Probable</td>
<td>6.0000</td>
<td>once every 2 months</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>2.0000</td>
<td>once every 6 months</td>
<td>3.5</td>
</tr>
<tr>
<td>Occasional</td>
<td>0.6000</td>
<td>once every 1.5 years</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>0.2000</td>
<td>once every 5 years</td>
<td>2.5</td>
</tr>
<tr>
<td>Remote</td>
<td>0.0600</td>
<td>once every 17 years</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>0.0200</td>
<td>once every 50 years</td>
<td>1.5</td>
</tr>
<tr>
<td>Improbable</td>
<td>0.0060</td>
<td>once every 167 years</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>0.0020</td>
<td>once every 500 years</td>
<td>0.5</td>
</tr>
<tr>
<td>Incredible</td>
<td>0.0006</td>
<td>once every 1667 years</td>
<td>0.0</td>
</tr>
</tbody>
</table>

For hazardous states, a risk score was evaluated by adding together a score for each of the following three factors:
- Frequency - the likelihood that the hazardous state is present;
- Probability - the rate at which incidents occur if the hazardous state is present; and
- Severity - the severity of the incident.

Table 2.8 and Table 2.9 present the scores assigned for the probability and frequency of states in terms of the nominal value of occurrences per year per kilometre.

Table 2.8 Classification and Scores of Frequency of States

<table>
<thead>
<tr>
<th>Likelihood Classification</th>
<th>Interpretation</th>
<th>Nominal value per km of Highway</th>
<th>Index Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very frequent</td>
<td>At least 1 occurrence present at any one time per Highway km.</td>
<td>1.00000000</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>Present 115 days per year per Highway km</td>
<td>0.3160000</td>
<td>5.5</td>
</tr>
<tr>
<td>Frequent</td>
<td>Present 36.5 days per year per Highway km</td>
<td>0.1000000</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>Present 11.5 days per year per Highway km</td>
<td>0.0316000</td>
<td>4.5</td>
</tr>
<tr>
<td>Probable</td>
<td>Present 3.65 days per year per Highway km</td>
<td>0.0100000</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Present 1.15 days per year per Highway km</td>
<td>0.0031600</td>
<td>3.5</td>
</tr>
<tr>
<td>Occasional</td>
<td>Present 9 hours per year per Highway km</td>
<td>0.0010000</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>Present 3 hours per year per Highway km</td>
<td>0.0003160</td>
<td>2.5</td>
</tr>
<tr>
<td>Remote</td>
<td>Present 50 minutes per year per Highway km</td>
<td>0.0001000</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Present 15 minutes per year per Highway km</td>
<td>0.0000316</td>
<td>1.5</td>
</tr>
<tr>
<td>Improbable</td>
<td>Present 5 minutes per year per Highway km</td>
<td>0.0000100</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Present 90 seconds per year per Highway km</td>
<td>0.0000031</td>
<td>0.5</td>
</tr>
<tr>
<td>Incredible</td>
<td>Present 30 seconds per year per Highway km</td>
<td>0.0000010</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Table 2.9 Classification and Scores of Probability of States

<table>
<thead>
<tr>
<th>Classification</th>
<th>This hazard, if present, will:</th>
<th>Index Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certain</td>
<td>Definitely causes a collision</td>
<td>4</td>
</tr>
<tr>
<td>Probable</td>
<td>Frequently causes a collision</td>
<td>3</td>
</tr>
<tr>
<td>Occasional</td>
<td>Occasionally causes a collision</td>
<td>2</td>
</tr>
<tr>
<td>Remote</td>
<td>Infrequently causes a collision</td>
<td>1</td>
</tr>
<tr>
<td>Improbable</td>
<td>Rarely causes a collision</td>
<td>0</td>
</tr>
</tbody>
</table>

With the hazard log developed and validated for the baseline scenario it served as a tool for evaluating the safety impacts of various options, allowing for comparison between options as well as against the baseline.

2.8. Summary of Problem Definition

Investigations during the scoping study stage found that the study area experiences very high levels of tidal congestion in both the AM and PM peaks for the southbound and northbound directions respectively. This congestion results in:

- Excessive queuing;
- Low traffic speeds;
- Differential speeds between lanes resulting from queuing back from off-ramps; and
- Stop/start condition resulting from queue rippling up stream.

From the initial investigation the “root causes” of traffic congestion, safety related issues and poor trip reliability were identified that affect traffic using SH1 between Ngauranga and Aotea Quay. The root causes are illustrated in Figure 2.6. Three of these root causes are the immediately vicinity of the Project area but are not currently included in the Project scope:

- The Glover Street intersection;
- The Ngauranga intersection signals; and
- The SH2 off ramp at Ngauranga.

A detailed assessment of the traffic modelling outputs during the scoping stage indicated that southbound during the AM peak, more than 3 lanes of capacity are currently demanded at the Ngauranga merge. Traffic modelling forecasts showed that there are approximately 550 vehicles queued upstream of the merge.

In addition, traffic along the Aotea Quay off ramp was found to queue back onto the motorway as a result of the poor off ramp geometry and the trains using the Waterloo Quay rail crossing. Observation via CCTV cameras, and data recorded from vehicle detecting radar, showed that drivers regularly miss the end of the Aotea Quay off ramp queue. Those who cannot find a gap to pull into prior to the off ramp, stop in lane two near the off ramp and force a lane change to exit, which results in significant speed differentials between the three lanes.

During the PM peak one of the root causes of congestion is the Hutt Road SH2 on-ramp merge, which causes the mainline to breakdown through forced and unnecessary lane changes. This results in traffic queuing back along SH1 towards the Aotea Quay on ramp. Currently the high PM peak Aotea Quay on ramp flow dominates the merge and causes the mainline traffic breakdown similar to SH2 Hutt Road on ramp. Traffic modelling undertaken during the scoping stage indicates that with future traffic volumes this high traffic flow will remain, even with the duplication of the Terrace Tunnel.
2.8.1. Summary

It was concluded in the Scoping Report that the problems with SH1 from Ngauranga to Aotea Quay can generally be related to congestion and travel time reliability. The section of SH1 between Ngauranga Gorge and Aotea Quay experiences high levels of congestion during both the AM and PM peaks. This results in high levels of queuing and low traffic speeds along this section of SH1 and on the surrounding state highway and local road network.

The problems with SH1 from Ngauranga to Aotea Quay can generally be described as congestion and travel time reliability due to the:

- SH1 / SH2 merge / diverge;
- SH2 Hutt Road on-ramp merge;
- Merge from Aotea Quay on ramp;
- Geometry of Aotea Quay off ramp; and
- Traffic backing up from Hutt Road off ramp.
3. Preferred Scheme Development

3.1. Scheme Assessment Process

The scoping stage concluded that it is feasible to provide four lanes in each direction as a fully managed motorway. During this scheme assessment phase, a preferred option has been developed for the implementation of the four lanes with full management. Further design and assessment of the following issues has been undertaken:

- Full time versus part time management;
- Development of the proposed cross section including shoulder and lane widths and locations of Emergency Breakdown Areas;
- Development of an Enforcement Strategy and Driver Awareness Strategy; and
- Further work to determine the feasibility of widening the Thorndon Overbridge.

The scheme assessment was undertaken in stages, which allowed the project team to discuss and agree specific elements of the scheme with the NZTA and stakeholders. Consultation was carried out throughout the scheme assessment stage, which provided greater focus for the later stages of the assessment. The stages of the scheme assessment are shown in Figure 3.1.

Figure 3.1: Scheme Assessment Process

<table>
<thead>
<tr>
<th>Stage</th>
<th>Scope</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>Assess Full Time vs Part Time Operation of Fourth Lane</td>
<td>Recommendation on Full Time vs Part Time Operation (Technical Note 1)</td>
</tr>
<tr>
<td>Stage 2</td>
<td>Assess “Physical Solution” including: Lane Widths/Shoulder Widths, Emergency Breakdown Areas, Hazard Log Assessment</td>
<td>Recommendation of Preferred Cross-Section (Technical Note 2)</td>
</tr>
<tr>
<td>Stage 2A</td>
<td>Enforcement Assessment</td>
<td>Draft Enforcement Strategy</td>
</tr>
<tr>
<td>Stage 2D</td>
<td>Assessment of Thorndon Overbridge Widening</td>
<td>Thorndon Overbridge Scheme Assessment Report</td>
</tr>
<tr>
<td>Stage 4</td>
<td>Staging of Full Scheme</td>
<td>Staging Plan</td>
</tr>
</tbody>
</table>

Scheme Assessment Report
The first stage investigated whether the new fourth lane in each direction should be operated during the peak periods only, i.e. “part time” or whether the new fourth lane should be utilised full time. This assessment included an economic analysis of the options, a hazard log assessment, a review of the operational strategies and the potential issues, and a driver behavioural assessment.

The second stage considered the physical layout options and provided a recommendation for the preferred ‘physical solution’. Five possible cross sections were identified, with varying shoulder and lane widths. These cross sections were evaluated using a hazard log process, a crash cost savings assessment and a project cost assessment, which helped to identify the preferred cross section. For the preferred cross section, a sight distance assessment was undertaken which identified measures to mitigate adverse effects on sight distance as a result of the Project compared to the existing situation. An assessment of the location and design of the Emergency Breakdown Areas (EBAs) was also completed at this stage. The hazard log assessment undertaken during the second stage highlighted the importance of education and the enforcement of safety improvements for the scheme. A concept of enforcement for the project was then developed.

The third stage was option refinement, which included preliminary design work to confirm a preferred option for widening the Thorndon Overbridge (clip-on or separate structure).

The fourth stage concentrated on the staging options available for the preferred option, and the production of this scheme assessment report which documents the investigations and recommendations.

The proposed scheme plans are contained in Appendix C.

3.2. Full Time vs. Part Time Operation

3.2.1. General

The Scoping Report identified that the fourth lane could be operated either part time (during peak hours only) or full time. Full time and part time operation both:

- Provide improvements to the ATMS system;
- Provide improvements to the Aotea Quay on and off ramps; and
- Provide additional driver information in Wellington City, and improve the Hutt Road SH2 northbound on ramp (to be confirmed during scheme assessment stage).

This section summarises the assessments undertaken to arrive at a preferred option for full time versus part time operation. Further detail is provided in Technical Note 1 which is contained in Appendix D.

3.2.2. Characteristics of Full Time and Part Time Operation

Key characteristics of part time operation include:

- Shoulder utilised as a fourth lane during peak periods when required and managed by the ATMS system;
- Requires opening/closing of the shoulder as a lane;
- Provides automatic detection for stopped vehicles, debris or pedestrians, which assists in safety checking prior to opening of the hard shoulder;
- Additional gantries and Variable Message Signs are required to operate the shoulder lane; and
- Additional input from Traffic Operations Centre (TOC) operators is required to open and close the lane in response to traffic demands.

Key characteristics of full time operation include:

- A fourth lane is provided full time and managed by the ATMS system;
- A hard shoulder may not be provided;
- Emergency Recovery Areas (ERAs) may be provided for breakdowns as mitigation if required; and
- Automatic detection could be utilised to mitigate issues with no hard shoulders and to improve incident detection.
3.2.3. Scoping Stage Economic Analysis

The scoping stage economic analysis showed that the NPV costs of implementing four lanes plus management are broadly similar for both the part time and full time options. The NPV benefits calculated showed that full time control produces $23.1M more in benefits than part time control, due to additional inter-peak benefits and the assumption that during the time when part time control is implemented the speed limit is reduced from 100km/h to 80km/h. The additional benefits in the interpeak from the full-time operation indicate that the fourth lane needs to be operational beyond the morning and afternoon peak periods, supporting the need for a full-time fourth lane.

3.2.4. Safety

The Hazard Log was used to assess the comparative safety risks of the part time and full time four laning (with full management) against the base case.

The baseline risk profile was developed and validated by the ECI Team as part of the scoping study. The ‘baseline’ scenario represents the current hazards and scores identified for the area without the Project in place.

A number of Hazards were anticipated to be affected by the implementation of four lanes plus management. The composite index scores for the baseline, as well as four lanes with part time and full time operation, are presented in Table 3.1.

<table>
<thead>
<tr>
<th>Hazard Code</th>
<th>Hazard</th>
<th>Base Line Score</th>
<th>Part Time Score</th>
<th>Full Time Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZ08S</td>
<td>Debris</td>
<td>8</td>
<td>7.74</td>
<td>7.89</td>
</tr>
<tr>
<td>NZ10E</td>
<td>Events associated with driver losing control of vehicle</td>
<td>8.5</td>
<td>8.3</td>
<td>8.3</td>
</tr>
<tr>
<td>NZ12E</td>
<td>Events associated with driving too fast</td>
<td>7</td>
<td>6.8</td>
<td>6.8</td>
</tr>
<tr>
<td>NZ12S</td>
<td>Hazardous states around driving too fast</td>
<td>8.62</td>
<td>8.42</td>
<td>8.42</td>
</tr>
<tr>
<td>NZ16E</td>
<td>Events associated with pedestrians</td>
<td>7.62</td>
<td>7.62</td>
<td>7.74</td>
</tr>
<tr>
<td>NZ21E</td>
<td>Unsafe lane changing</td>
<td>8.5</td>
<td>8.4</td>
<td>8.4</td>
</tr>
<tr>
<td>NZ26S</td>
<td>Tailgating</td>
<td>8.5</td>
<td>8.3</td>
<td>8.3</td>
</tr>
<tr>
<td>NZ28E</td>
<td>Merging and diverging</td>
<td>7.62</td>
<td>7.47</td>
<td>7.47</td>
</tr>
<tr>
<td>NZ30E</td>
<td>Events associated with vehicles obstructing the carriageway</td>
<td>7.54</td>
<td>7.63</td>
<td>7.82</td>
</tr>
<tr>
<td>NZ31E</td>
<td>Change in vehicle speed</td>
<td>8.54</td>
<td>8.39</td>
<td>8.39</td>
</tr>
<tr>
<td>NZ32E</td>
<td>Vehicle drifts off carriageway or out of lane</td>
<td>8.12</td>
<td>8.16</td>
<td>8.20</td>
</tr>
</tbody>
</table>

As well as changes to the base line scores there were also a number of additional hazardous events and states which were identified to occur in some options, which were not present in the baseline scenario. These are included in Table 3.2.

<table>
<thead>
<tr>
<th>Hazard Code</th>
<th>Hazard Type</th>
<th>Hazard</th>
<th>Part Time</th>
<th>Full Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZ02E</td>
<td>Event</td>
<td>Events associated with the opening or closing of the shoulder</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>NZ02S</td>
<td>State</td>
<td>Hazardous states around the opening or closing of the shoulder</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>NZ03E</td>
<td>Event</td>
<td>Events associated with Managed Motorway operational</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>NZ03S</td>
<td>State</td>
<td>Hazardous states around Managed Motorway operational</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>NZ04E</td>
<td>Event</td>
<td>Events associated with EBAs</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
From evaluation of the hazard log it is predicted that full time operation would provide more safety benefits than part time operation, due to the number of additional hazards created by the part time operation option.

### 3.2.5. Operation Strategy / Issues

Part time and full time operation present different operational issues and will subsequently require differing operational strategies.

The day to day operation of a fourth lane with either full or part time operation would be undertaken by the TOC located in Johnsonville. The TOC would assume responsibility for operations that would include:

- Implementation of ATMS operational plans;
- Observation of the network using CCTV;
- Setting Variable Speed Limits; and
- Using the ATMS system to respond to incidents.

It was concluded that whilst the TOC could manage either part time or full time operation, the requirement for a significant level of additional work for the TOC to effectively manage the part time operation option has been identified. Representatives from the TOC indicated a preference for full time operation with EBAs provided.

### 3.2.6. Driver Behavioural Assessment

A driver behaviour assessment for both part time and full time operation was undertaken by TERNZ Transport Research. From this assessment it is predicted that part time operation will lead to a higher level of stress or workload for drivers than full time operation. It is noted that the performance of both systems will depend on their design and integration with the current system, and that the part time operation will require greater active management.

### 3.2.7. Recommendations

A recommendation outlined from the Stage 1 Technical Note was that the full time operation for four lanes plus management should be progressed. The benefits of a full time operation, compared to part time, were identified as:

- Greater economic benefits;
- Fewer safety risks;
- Simpler to operate for the TOC; and
- Better understanding by drivers.

### 3.3. Physical Solution

#### 3.3.1. General

The second stage of the assessment was to identify the preferred physical solution which included an evaluation of the following aspects:

- Cross-section;
- Geometry;
- Median barrier;
- Sight distance assessments;
Hazard Log assessments;
Emergency Breakdown Areas (EBA's); and
Thorndon Overbridge Widening.

Technical Note 2 and an addendum have been produced summarising the elements of the Stage 2 assessment, which can be found in Appendix E. The findings of this technical note are summarised below.

### 3.3.2. Hazard Log Assessments

As discussed in Section 2.7.2 a hazard log was developed to identify the hazards currently applicable to the study area. This hazard log was then used to test the impact on safety for a number of different cross section options. The options tested were:

- Option A: 3.3m lanes with 0.5m shoulders;
- Option B: 3.3m lanes with 1.0m shoulders;
- Option C: 3.5m lanes with 0.5m shoulders;
- Option D: 3.5m lanes with 1.0m shoulders; and
- Option E: 3.3m lanes with 2.5m shoulders.

Every hazard identified was debated at the ‘hazard log workshop’ on the 5th and 6th December 2011, with representatives from Beqa, Mouchel and NZTA. Around half of the hazards were found to be affected by the proposed managed four lane scheme. Following agreement that the hazard log score would change as a result of the options, the log was updated based on international research and experience from Mouchel in the UK.

Each score that was changed was recorded in a new hazard log that included the size of, and reason for, the change.

The reasons for the score changes for each affected hazard are summarised in Tables 3.3 and 3.4. Table 3.3 below summarises the hazards which have been given a reduced risk score with the options implemented.

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Reason for Score Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous states around maintenance</td>
<td>Enforcement of the red X supported by driver awareness reduces risk of crashes with roadworks.</td>
</tr>
<tr>
<td>Debris</td>
<td>Queue detection and increased CCTV coverage would give the TOC operators greater visibility of the project area, allowing them to better manage debris on the road and inform drivers of its location.</td>
</tr>
<tr>
<td>Events associated with driver losing control of vehicle</td>
<td>Enforcement of posted speed limit on the existing gantries plus three additional gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions.</td>
</tr>
<tr>
<td>Events and states associated with driving too fast</td>
<td>Enforcement of posted speed limit on the existing gantries plus three additional gantries would reduce this event by reducing excessive speed drivers during off peak periods and adverse environmental conditions. In addition the Advance Driver Information signs on the existing plus three additional gantries will improve compliance of drivers to travel at the posted speed limit.</td>
</tr>
<tr>
<td>Events associated with motorcyclists</td>
<td>Increased capacity will reduce the need for motorcyclists to travel between the lanes as traffic will be flowing at an improved level of service.</td>
</tr>
<tr>
<td>Events associated with slip roads</td>
<td>Vehicles changing lanes on Aotea Quay ramps occurs less frequently as there is more capacity with on and off ramps having their own lanes.</td>
</tr>
<tr>
<td>Unsafe lane changing</td>
<td>Increased capacity, geometric layout, speed enforcement and advance driver information should make an improvement to the frequency. Lane drop at Aotea Quay may confuse some drivers creating additional unsafe lane changes. Overall net reduction in this risk.</td>
</tr>
<tr>
<td>Incidents of congestion caused in other lanes or carriageway due to rubber-necking</td>
<td>Based on experience from the UK that managed motorways have resulted in a 30 - 50% reduction in crashes it is considered that the frequency of the hazard would reduce.</td>
</tr>
</tbody>
</table>
Tailgating
Better operational regime around the setting of variable speed limits as approaching bottlenecks, increased capacity, enforcement of the variable mandatory speed limits plus improved advanced driver information (VMS on every gantry) is expected to reduce this hazard.

Merging and diverging
Increased capacity and eliminating the 2+2 into 3 merge and the 3 into 2 + 2 diverge at Ngauranga interchange is expected to reduce this hazard.

Change in vehicle speed
Greater compliance of variable mandatory speed limits from speed enforcement cameras, improved operational regimes and education is considered to reduce the frequency of this hazard

Vehicle stops on the shoulder (not open to traffic)
For Options A – D there is no shoulder so the risk is zero.

From Table 3.3 it is evident that there are a number of significant hazards which are anticipated to be reduced with the implementation of any of the options.

Table 3.4 below summarises the hazards which have been given a new or increased risk score with the options implemented.

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Reason for Score Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazards associated with EBAs</td>
<td>The introduction of EBAs creates some new hazards, mainly regarding vehicles entering and exiting the EBAs. All of the hazards associated with EBAs have been assessed as low based on UK information and research.</td>
</tr>
<tr>
<td>Excessively slow moving vehicle in running lane</td>
<td>There is no shoulder in which very slow moving vehicles can travel.</td>
</tr>
<tr>
<td>Events associated with pedestrians</td>
<td>Narrowing the shoulder is expected to increase the frequency of the sub-hazard &quot;Pedestrian in running lane: live traffic&quot; as there is not a full shoulder present, there are likely to be more pedestrians in the carriageway.</td>
</tr>
<tr>
<td>Events associated with terrorism and vandalism</td>
<td>Frequency increases as there is more ITS equipment on the network that could be vandalised.</td>
</tr>
<tr>
<td>Health deterioration of vehicle occupant</td>
<td>Probability increases for this hazard with a narrow shoulder, as drivers will not have a shoulder to quickly pull onto and be required to drive to an EBA to stop safely.</td>
</tr>
<tr>
<td>Events associated with vehicles obstructing carriageway</td>
<td>The reduction in shoulder width is expected to increase the frequency of vehicles stopping in lane 1. The probability of this hazard would decrease as drivers would be given information via the VMS signs that a vehicle was stopped ahead in a lane and the overhead variable speed limits signage would be enforced. Overall a net increase is expected, apart from Option E which improves as the increase in frequency associated with a narrow shoulder is not applicable.</td>
</tr>
<tr>
<td>Vehicle drifts off carriageway or out of lane</td>
<td>The reduction in shoulder width is expected to increase the frequency of vehicles drifting off the carriageway.</td>
</tr>
</tbody>
</table>

It is apparent from Table 3.4 that there are less hazards which are expected to experience an increase in risk scores with the options implemented, than are expected to see a reduction. The size of the score changes and the full reasoning for the scores given are available in Technical Note 2 and its Addendum in Appendix E.

The overall reduction in the safety risk score from the baseline scenario as identified in the hazard log assessment, and a summary of the geometric differences between the options evaluated, is summarised in Table 3.5.

<table>
<thead>
<tr>
<th>Option</th>
<th>Shoulder width (m)</th>
<th>Lane width (m)</th>
<th>Safety Risk Score</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.5</td>
<td>3.3</td>
<td>-22.2%</td>
<td>Could generally be built within existing carriageway width</td>
</tr>
<tr>
<td>B</td>
<td>1.0</td>
<td>3.3</td>
<td>-25.6%</td>
<td>Widening required</td>
</tr>
</tbody>
</table>
From Table 3.5 it is notable that all of the options provide a significant reduction in the safety risk score when compared to the baseline scenario. There is a general trend that the options with greater carriageway width provide the larger reduction in the safety risk score (i.e. the assessed safety of the option improves as the safety risk score decreases). Based on the hazard log assessment it is evident that all of the physical layout options would lead to a decrease in the safety risk score of between 20-30% from the baseline. The hazard log assessment therefore indicates that whichever physical layout option is selected for the Project would meet the objective of having no safety dis-benefits.

a. Hazard Log Option Tests

In addition to testing the main options, the hazard log was also used to identify the impacts of different aspects of the options.

A test was run using the hazard log to see how large a proportion of the safety benefit for Option A would be related to the provision of EBAs. It was found that with EBAs Option A is expected to result in a 22% reduction in the overall Safety Risk Score. Without EBAs Option A would still be expected to result in a 19.5% reduction in the overall Safety Risk Score.

Another test was run to identify the amount of safety benefit of Option A that would be achieved without enforcement but with improved driver awareness. Additionally a further test was undertaken to assess the impacts of the management without enforcement and without improved driver awareness. Table 3.6 presents the effects of removing certain elements included in the original Option A score. The effects of removing EBAs, the improved driver awareness element and both the driver awareness and enforcement elements are summarised.

Table 3.6 Summary of Safety Risk Score for Option A without Features

<table>
<thead>
<tr>
<th>Option</th>
<th>Safety Risk Score</th>
<th>Crash Cost Savings $M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option A</td>
<td>-22.2%</td>
<td>5.8</td>
</tr>
<tr>
<td>Option A – No EBAs</td>
<td>-19.5%</td>
<td>5.1</td>
</tr>
<tr>
<td>Option A – No Enforcement</td>
<td>-14.9%</td>
<td>3.9</td>
</tr>
<tr>
<td>Option A – No Education or Improved Driver Awareness</td>
<td>-7.1%</td>
<td>1.8</td>
</tr>
</tbody>
</table>

As summarised in Table 3.6, the improvement in the overall safety risk score is lower (becomes worse) if the option is implemented without improving driver awareness and enforcement.

b. Hazard Log Score Summary

It has been concluded that all options would lead to a decrease in the safety risk score of between 20-30% from the baseline. The hazard log assessment therefore indicates that whichever physical layout option is selected for the Project it would meet the objective of having no safety dis-benefits.

The different options require different physical changes to the carriageway and therefore have different construction costs. Option A could be built within the existing barriers, Options B and C would both require widening, and Options D and E would require widening and the replacement of the median barrier.

Table 3.7 provides information regarding the costs and crash savings associated with each option.
Table 3.7 shows that the difference in NPV costs between Option A and the other options is significantly larger than the corresponding difference in crash cost savings. This indicated that the additional width needed to achieve the greater safety benefits of Options B – E is not economically justifiable based on the crash cost savings alone.

Following the Hazard Log assessment and completion of the Draft Scheme Assessment Report the recommendation was made to NZTA to further develop Option A, based on the safety risk score improvements and the economic justifiability of this option based on the crash cost savings. Option A was then taken forward to two safety reviews:

- Safety Control Review Group of the Safety Management System; and
- Stage 2 Road Safety Audit.

The outcomes of these safety reviews are discussed below.

### 3.3.3. Safety Control Review Group

NZTA formed the “Project Safety Control Review Group” (PSCRG\(^8\)) to review the Hazard Log assessment and endorse the safety management system for the Project.

The scope of the PSCRG is to assure the approach of the NTAQ Project in managing significant hazards and significant operational safety challenges is appropriate. This is to be achieved through review and endorsement of the following:

- The identification and assessment of significant hazards; and
- The safety requirements to mitigate significant hazards.

The PSCRG reviewed the Hazard Log for Option A and found no significant issues with the analysis. The PSCRG comments against the Hazards and the Project team responses to the comments are included in Appendix F.

It is anticipated that the PSCRG will have an ongoing role in the Project to assess the safety management system as the Project is further developed.

### 3.3.4. Stage 2 Road Safety Audit

A Stage 2 Road Safety Audit (RSA) was undertaken on Option A. An RSA is a formalised process to:

- identify potential road or traffic safety concerns for all road users and others affected by a road project; and

\(^8\) The NPV costs are based on Scoping Stage estimates

\(^9\) The PSCRG members include Fergus Tate (NZTA), Lucy Wickham (Mouchel), Sam Charlton (University of Waikato), and Shane Turner (Beca).
ensure that the measures to eliminate or reduce the concerns are fully considered.

The aim of the RSA was to identify potential road safety concerns and bring them to the notice of the project designers and the client. The recommendations are intended to be indicative only to focus the designers on the type of improvements that may be appropriate. They are not intended to be prescriptive and other ways of improving the road safety concerns identified should also be considered. The identified road safety concerns and recommended improvements do not mean that the scheme is fundamentally unsafe, but rather that there may be ways of improving road safety which should be duly considered.\footnote{SH1: Ngauranga to Aotea Quay Managed Motorway Scheme design Road Safety Audit, TPC, June 2012.}

The potential safety concerns identified in the RSA were grouped as follows:

- **Serious Concern** – a major safety concern that should be addressed and requires changes to avoid serious safety problems;
- **Significant Concern** – a significant safety concern that requires consideration of changes to improve safety;
- **Minor Concern** – a safety concern of lesser significance, but which should be addressed as it may improve overall safety; and
- **Comment** – a concern or an action that may be outside the scope of the road safety audit, but which may improve overall design or be of wider significance.

Concerns which were considered by the RSA to be serious or significant with Option A are summarized in Table 3.8 along with the changes made to the scheme.

**Table 3.8 – Results of RSA for Serious and Significant Concerns**

<table>
<thead>
<tr>
<th>Concern</th>
<th>Change to Scheme Design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Serious</strong>: Substandard overall design for the proposed speed environment</td>
<td></td>
</tr>
<tr>
<td>a. Provide 1.0m shoulders and adequate forward sight distance for 100 km/h (preferably 110 km/h) operation through additional carriageway widening (including replacement of the existing kerbed median and barrier with a standard concrete barrier), or</td>
<td></td>
</tr>
<tr>
<td>b. Reduce the speed limit to that commensurate with the design, or</td>
<td></td>
</tr>
<tr>
<td>c. Develop an alternate scheme that has 3 lanes appropriately designed for 100 km/h operation in the off-peak periods and a substantial hard shoulder lane that operates in the peak traffic period only with the motorway speed limit reduced to the safe speed of the hard shoulder lane during the peak periods when the hard shoulder is in use.</td>
<td></td>
</tr>
<tr>
<td>Safety analysis carried out using the hazard log process concluded that 3.3m lanes / 0.5m shoulders scheme provides no overall safety disbenefits in comparison to the existing carriageway – an explicit project objective endorsed by NZTA VAC.</td>
<td></td>
</tr>
<tr>
<td>Following discussion with NZTA’s regional safety team, the safety team expressed preference to adopt a wider lane configuration which will require the replacement of the central median barrier.</td>
<td></td>
</tr>
<tr>
<td>Therefore, the preferred scheme option will be revised to: 3.5m lanes / 1.0m shoulders which will require replacement of the central median barrier. Note, where Thorndon Overbridge requires widening to accommodate the fourth lane (700m), 3.3m lanes / 0.5m shoulders will used as this is a relatively short section and additional width can’t be provided by widening the existing structure (new structure would be required).</td>
<td></td>
</tr>
<tr>
<td><strong>Significant</strong>: Inappropriate lighting adjacent to central median</td>
<td></td>
</tr>
<tr>
<td>a. Replace the existing central median barrier with a concrete barrier and centrally mounted street lighting (refer also recommendation a. in item 2.2).</td>
<td></td>
</tr>
<tr>
<td>b. Widen the median shoulder so that the edge line does not fall within the shadow of the median barrier.</td>
<td></td>
</tr>
<tr>
<td>Adopt 3.5m lanes / 1.0m shoulders and replace the central median barrier as per above.</td>
<td></td>
</tr>
<tr>
<td>Conduct a detailed lighting assessment as part of the SP2 Specimen Design phase and address any issues associated.</td>
<td></td>
</tr>
</tbody>
</table>
## Concern | Change to Scheme Design
--- | ---
### Serious: Southbound trap lane at Aotea Quay off-ramp
a. Provide additional gantry and overhead signage on the straight prior to the Aotea Quay off-ramp (approx. ch 4050) to reinforce the exit only. (NB a gantry in this location could also assist with speed management on the motorway when there are queues forming back onto the motorway from the Aotea Quay and downstream off-ramps.).
b. Develop an auxiliary/deceleration lane in advance of the off-ramp so that vehicles do not have to slow (or ultimately queue) in the main traffic stream to negotiate the first curve on the off-ramp.
- Accept Recommendation a. Provide additional signage as per the Designer’s comment.
- Reject Recommendation b. The southbound left lane on Thorndon Overbridge will form a dedicated exit lane for Aotea Off Ramp - provide additional signs, gantries and delineation to be provided (as per 2.5a above).
- Continue developing solution as part of the SP2 Specimen Design and SP3 Detailed Design and Construction phases.

### Significant: No advisory speed sign for Aotea Quay off-ramp
Include advisory speed signage for the first curve on the Aotea Quay off-ramp exit.
- Accept Recommendation. Provide additional signage at the Aotea Quay off ramp. Detail to be confirmed and discussed with NZTA safety team during the design phase.

### Significant: Design of Aotea Quay on-ramp and “bull-run” lane
a. Construct the added lane contiguous with the existing mainline to eliminate both the ‘false’ diverge and the need for post barrier separation.
b. Provide sufficient width to accommodate a broken down vehicle and facilitate emergency access to the motorway (see also item 2.12).
- Accept Recommendation a. Amend Thorndon Overbridge northern abutment and bridge structure to accommodate as part of the preferred scheme option.
- Continue developing solution as part of the SP2 Specimen Design and SP3 Detailed Design and Construction phases.
- Recommendation b not applicable following acceptance of above.

### Significant: Transitions between old and new barriers
Ensure that the transitions between the existing sand filled barrier and the concrete barrier are designed by a barrier expert and accepted by the NZTA.
- Recommendation Not Applicable. Adopt 3.5m lanes / 1.0m shoulders and replace the central median barrier as per above.

### Significant: Flow breakdown at the Hutt Road N’bd on-ramp
Consider the provision of ramp metering on the Hutt Road northbound on-ramp to alleviate the flow breakdown at the merge in the pm peak.
- Provision of ramp signalling is not currently part of the Project however the ramp will be future-proofed for signalling by providing duct work.

### Significant: Provision for recovery vehicles
a. Provide for rapid and safe access for emergency, recovery and other service vehicles to both motorway carriageways.
b. Provide a location for the stationing of recovery and service vehicles close to the motorway to facilitate appropriate response.
- Accept Recommendation a. Provide additional emergency service access as per Designer’s comment. Consider contraflow access on SH1 as part of the central median barrier replacement.
- Reject Recommendation b. Agree with Designer’s comment. Adopt 3.5m lanes / 1.0m shoulders and replace the central median barrier as per 2.3a above – provides additional space on the carriageway for recovery vehicle access.

Following the completion of the Draft Scheme Assessment Report, the SCRG review and the Stage 2 Road Safety Audit the NZTA adopted the following cross sections for the Ngauranga to Aotea Quay Project:
From Ngauranga to the Thorndon Overbridge: Four 3.5m lanes with 1.0m shoulders; and
From the north end of the Thorndon Overbridge to the Aotea Quay off ramp: Four 3.3m lanes with 0.5m shoulders.

The RSA Report and Decision Tracking Form is contained in Appendix G.

3.3.5. Final Scheme Hazard Log

This cross section related to the Options scored during the hazard log workshop, with the Ngauranga to the Thorndon Overbridge area correlating to Option D and the north end of the Thorndon Overbridge to the Aotea Quay off ramp correlating to Option A.

It has been considered appropriate that different safety risk scores be attributed to the Thorndon Overbridge area and the rest of the Project area, with the Option A score representing the Thorndon Overbridge area (25%) and Option D representing the rest of the Project area (75%).

Combining the Option D and Option A scores for their respective lengths, the overall Safety Risk Score for the adopted cross section is -26.85% from the baseline.

3.3.6. Sight Distance Assessments

a. Sight Distance Assessment Process

A sight distance assessment was undertaken to determine the sight distance impacts of the proposed cross section compared to the existing situation. The assessment was able to identify areas where sight distance was either reduced or improved. Where sight distance was reduced, potential options were identified to mitigate adverse effects on sight distance compared to the existing situation.

The assessment was undertaken using the MX Roads software for the proposed cross section and compared to the existing situation. The sight distance criteria were discussed and agreed with NZTA and are summarised in Table 3.9.

Table 3.1 – Sight Distance Criteria

<table>
<thead>
<tr>
<th>Sight Distance Criteria</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Speed</td>
<td>110 (km/h)</td>
</tr>
<tr>
<td>Reaction Time</td>
<td>2 seconds</td>
</tr>
<tr>
<td>Deceleration Coefficient Rate</td>
<td>0.36</td>
</tr>
<tr>
<td>Sight Distance Requirement</td>
<td>193m</td>
</tr>
<tr>
<td>Eye Height</td>
<td>1.1m</td>
</tr>
<tr>
<td>Target Height</td>
<td>0.65m</td>
</tr>
</tbody>
</table>

The results of the sight distance assessment indicated the proposed cross section improves and also decreases sight distance in a number of areas. Where sight distance was reduced, potential mitigation options were identified. Table 3.10 summarises the key areas where sight distance significantly decreases as a result of the proposed cross section and suggests mitigation where appropriate. The full results of the assessment are contained in the Technical Note 2 Addendum in Appendix E.
### Table 3.10 - Results of Sight Distance Assessment

<table>
<thead>
<tr>
<th>Lane</th>
<th>Location (Chainage)</th>
<th>Change in Sight Distance vs Existing</th>
<th>Comment</th>
<th>Potential Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>North-bound Right</td>
<td>1790-1730</td>
<td>-21 - 62m</td>
<td>Sight Distance is restrained by the median barrier on the descent from the Southern Rail Overbridge. Existing sight distance immediately upstream to this location is deficient and meets criteria for 80-90kph. With reduction in sight distance at this location it is consistent with upstream sight distance and the 80-90kph criteria is lengthened by some 60m.</td>
<td>Widening not feasible within existing carriageway width due to Southern Rail Overbridge. In detailed design, consider minor shift in lanes towards the west to improve sight distance.</td>
</tr>
<tr>
<td>North-bound Left</td>
<td>3750-3580</td>
<td>-13 – 51m</td>
<td>Sight Distance restrained by roadside barrier.</td>
<td>Sufficient sight distance can be achieved by widening the shoulder in this area to 2.5m.</td>
</tr>
<tr>
<td>North-bound Left</td>
<td>2490-2330</td>
<td>-12-50m</td>
<td>Sight Distance restrained by roadside barrier.</td>
<td>Sufficient sight distance can be achieved by widening the shoulder in this area to 1.5m.</td>
</tr>
<tr>
<td>North-bound Left</td>
<td>2250-2140</td>
<td>-11-52m</td>
<td>Sight Distance restrained by roadside barrier.</td>
<td>Sufficient sight distance can be achieved by widening the shoulder in this area to 1.5m.</td>
</tr>
<tr>
<td>South-bound Right</td>
<td>1980-2050</td>
<td>-16-41m</td>
<td>Sight Distance is restrained by the median barrier on the descent from the Southern Rail Overbridge. Existing sight distance immediately upstream to this location is deficient and meets criteria for 90kph. With reduction in sight distance at this location it is consistent with upstream sight distance and the 90kph criteria is lengthened by some 70m.</td>
<td>Currently modelled with inside shoulder width of 1.5m. Consider minor shift of lanes to the east in detailed design.</td>
</tr>
<tr>
<td>South-bound Right</td>
<td>2160-2300</td>
<td>-15-65m</td>
<td>Central median barrier restrains sight distance on existing sharp curve to the left. Sight distance for design speed of between 80-100kph achieved over this short length.</td>
<td>Currently modelled with inside shoulder of 1.5m. Consider minor shift of lanes to the east in detailed design.</td>
</tr>
<tr>
<td>South-bound Right</td>
<td>3400-3580</td>
<td>-24-80m</td>
<td>Central median barrier restrains sight distance on existing curve approaching the Thorndon Overbridge. Sight distance for design speed of generally 90kph achieved for this section which is similar to existing however is lengthened by some 50m.</td>
<td>Available width/position of 3.5m lanes is driven by proposed width of Thorndon Overbridge (with four 3.3m lanes). Repositioning lanes will require further widening of Thorndon Overbridge.</td>
</tr>
<tr>
<td>South-bound Left</td>
<td>1540-1620</td>
<td>-10-41m</td>
<td>Roadside barrier restrains sight distance.</td>
<td>Consider localised widening of shoulder to improve sight distance.</td>
</tr>
<tr>
<td>South-bound Left</td>
<td>2430-2560</td>
<td>-13-42m</td>
<td>Roadside barrier restrains sight distance.</td>
<td>Widen shoulder to 2.0m over this section.</td>
</tr>
<tr>
<td>South-bound Left</td>
<td>2800-3090</td>
<td>-11-35m</td>
<td>Roadside barrier restrains sight distance.</td>
<td>Widen shoulder to 2.0m over this section.</td>
</tr>
</tbody>
</table>

As summarised in Table 3.10, there are a number of areas where the proposed Option D cross section will reduce sight distance from existing. For areas in the northbound and southbound right lanes, the sight distance deficiencies are generally at existing curves to the right. The deficiencies due to the proposed cross section are generally in the vicinity of existing areas of deficiency of which the length of deficiency is increased by the proposal, but with a consistent speed environment to the existing. During detailed design it is...
recommended to undertake further detailed geometric modelling to test the effects of minor widening and shifting of lanes to improve sight distance.

For areas in the northbound and southbound left lanes, there are deficiencies generated by the proposed cross section due to these lanes moving closer to the roadside barrier. These deficiencies can be mitigated by localised increases in the shoulder width and relocation of the barrier.

Overall, it is considered that it is feasible to provide the proposed cross section without significant adverse effects on sight distance. Minor widening and shifting of lane positions on the carriageway would be required to improve sight distance on existing right hand curves. Further geometric modelling and sight distance assessment should be undertaken at detailed design stage prior to finalising the proposed lane positions.

### 3.3.7. Emergency Breakdown Areas (EBAs)

a. **Design Guidance**

Emergency Breakdown Areas (EBAs) are areas where drivers can pull off the main carriageway and stop in an emergency. EBAs can also serve as maintenance areas for gantries.

The design for the EBAs has been based on the updated UK guidance set out in the *Managed Motorways All Lanes Running - Interim Advice Note 161/12* published by the UK Highways Agency.

The EBAs proposed for the project are discussed below.

b. **Proposed EBAs**

Four EBAs are proposed as part of the project:

- Northbound, from chainage 3,440 to 3,300;
- Northbound, from chainage 2,090 to 1,950;
- Southbound, from chainage 2,100 to 2,210; and
- Southbound, from chainage 3,200 to 3,400.

c. **EBA Location**

i) **EBA Spacing**

The Highways Agency guidance sets out that in managed motorway schemes in the UK, EBAs will be spaced ‘such that a driver is never more than 2.5km from a refuge’. The spacing is to be between the stopping areas of the EBAs, rather than the start/end of the taper.

The spacing of the EBAs for the Project meets the requirements as set out in the guidance; the design in fact exceeds the guidance as drivers are generally no more than 2km from an EBA.

ii) **EBA Relation to Exits**

The guidance suggests that in the UK an EBA must always be upstream of the ½ mile or ⅓ mile [≈0.5km] sign. This requirement is to minimise the possibility of the EBA being confused with an off-slip.

All of the EBAs in the Project meet the guidance in relation to distance from exits and signage.

iii) **EBA Relation to Gantry**

The updated guidance does not specifically dictate the relationship between EBAs and gantries, however each EBA designed is located downstream of a gantry as set out in the previous Highways Agency guidance.

d. **EBA Dimensions**

The guidance specifies a width of 4.6m for the EBA, though accepts that in exceptional circumstances, where the cost of construction is prohibitively expensive, the width of the EBA may be reduced to a minimum of 4.0m.

For the project all of the EBAs are designed with a width of 4.6m and therefore comply with the UK guidance.
The design length specified for an entry taper is 25m, for the stopping area should be 30m, and for the exit taper is 45m. All of the EBAs in the Project meet these minimum design lengths, and where possible longer exit tapers have been provided to allow vehicles exiting to build up as much speed as possible to enter lane 1.

e. EBA Signage

The Highways Agency guidance sets out requirements for signage on entry and exit of EBAs. The signage consists of a combination of signs warning ‘no stopping except in emergency’, advising of ‘emergency refuge area (with SOS phone)’ and advanced warning signs of ‘SOS phone’ at ½ and 1 mile spacing’s. The signage for the Project will be completed in detailed design, and it will be based on the UK guidance, with the appropriate New Zealand signage used.

### 3.4. Thorndon Overbridge Widening Assessment

Thorndon Overbridge comprises twin three lane (2 x 3 lanes) elevated concrete bridges located on the reclaimed foreshore of Wellington Harbour. Constructed between 1967 and 1972, the Overbridge forms part of an important link from Wellington City to the north. It is 1.3km long and carries State Highway 1 over the main trunk railway, an extensive area of rail yards, the Inter Islander Ferry Terminal and three important access roads into Wellington City, Hutt Road, Aotea Quay and Thorndon Quay. On and off ramps provide access to Aotea Quay about midway along the bridge. Thorndon Overbridge was retrofitted in the 1990’s to improve its seismic performance.

A report was produced documenting the assessment of the Thorndon Overbridge which can be found in Appendix H. The report investigated the feasibility of the clip-on structure to the Thorndon Overbridge and summarises the structural form and concept, design loads, parameters, material characteristics, construction methodology and risks for the proposed clip-on widening deck. The report also revisited the geotechnical assessments undertaken as part the 1990’s seismic retrofit by comparison against current seismic loading standards and current understanding of liquefaction/lateral spreading.

The southbound carriageway over Thorndon Overbridge is proposed to be increased from the current three lanes to four lanes from the northern abutment to the Aotea Quay off-ramp. The northbound carriageway will not require widening between the Aotea Quay on-ramp and the northern abutment as the additional width can be accommodated within the existing structure width because of the wider existing shoulder on the northbound carriageway.

It was found that the existing structure has sufficient capacity to carry the additional dead and live loads associated with the clip-on deck widening. It was further found that the widening to the proposed extent, would not compromise the 500 year APE adopted for the structure in the 1990’s seismic retrofit works.

It was concluded that the additional gravity and seismic force on the substructure is within the existing capacity of piles and foundations. It was further concluded that the proposed widening has minimal impact on the geotechnical seismic vulnerability of the site.

As the site performance under large earthquakes was a governing factor, it was considered appropriate to revisit the earlier assessments by comparison against current seismic loading standards and current understanding of liquefaction/lateral spreading.

Re-analysis utilising current liquefaction assessment methods indicated that the analysis in 1994 (state of the art at that time) gave a higher return period for initiation of widespread liquefaction and a lesser extent and magnitude of lateral spreading. Current analyses indicated that the return period for excessively large deflections (greater than 500mm) of some piers may be as low as 250 years, a reduction of around 50% in the return period for such events.

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11 Exact signage requirements can be found in section 5.39 of Managed Motorways All Lanes Running - Interim Advice Note 161/12
The most significant change resulted from using current liquefied shear strength values which resulted in the potential for ‘flow’ lateral spreading (ie continuing ground movement after earthquake shaking ceases) which was not indicated based on understanding current at the time of the retrofit design.

The report concludes that it is structurally feasible to design and construct the clip-on widening deck to the existing Thorndon Overbridge given the current site constraints. However the geotechnical assessment has indicated that the return period for which movements of the ground due to liquefaction and lateral spreading become excessive for the structure to accommodate (greater than 500mm) may be as low as 250 years, compared to 500 years originally estimated at the time of the 1990’s seismic retrofit.

It is therefore concluded that subject to further detailed geotechnical study, it will be necessary to consider ground improvement options to mitigate liquefaction or resist lateral spread forces as part of the proposed widening scheme, in order to provide overall structural stability, at least in line with the intent of the original 1990’s retrofit design. This should be discussed with NZTA to understand their future requirements for the seismic performance of this structure.

3.5. Operational Strategy for Full Management

3.5.1. Current Operational Plan

To gain an understanding of the current operational strategy the project team met with the Traffic Operations Centre (TOC) operators in January 2011.

Currently operational plans are implemented by the TOC operators. The implementation of the stages of the operational strategy are reactive to TOC operators witnessing queuing at certain points on the network using the CCTV cameras.

From discussions with the TOC it was evident that the implementation of the operational strategy was reactive to TOC operators witnessing queuing at certain points on the network using the CCTV cameras. The existing operational strategies for the AM and PM peak periods are discussed below.

a. AM Peak Plan

The AM peak plan consists of two main steps to gradually lower the speed limit to 60kph, the implementation of these steps is based on the TOC operators witnessing queuing at two ‘trigger points’.

- **Trigger Point A:** The trigger point for implementing the first step of the am peak plan is at the merge point where the on slip from SH1 meets SH2, marked as A on Figure 3.3.
- **Trigger Point B:** The second trigger point for implementing the next step of the am peak plan is further up the slip on SH1, marked as B on Figure 3.3.
AM Implementation Step 1
When a TOC operator witnesses queuing at point A the first step of the plan is introduced with the following sign changes implemented concurrently:

- VMS 18 and 19 ‘South of Kiwi Point Southbound’ display an 80kph sign;
- VMS 25 ‘Ngauranga Ramp SB’ displays an 80kph sign; and
- VMS 26 ‘Ngauranga SB’ displays an 80kph sign.

AM Implementation Step 2
When a TOC operator witnesses queuing at point B the second step of the plan is introduced with the following sign changes implemented concurrently:

- VMS 25 ‘Ngauranga Ramp SB’ displays a 60kph sign; and
- VMS 26 ‘Ngauranga SB’ displays an 60kph sign.

AM Additional Signage Changes
The implementation steps 1 and 2 are the extent of the planned operational strategy for the am peak, however the TOC operators will often choose to lower the speed limit at other VMS signs during the peak period dependent on traffic flows and the queuing observed as well. The following changes are often made during the am peak period:

- VMS 28 ‘Rail Crossing’ to display an 80kph sign;
- VMS 30 ‘Placemakers SB’ to display an 80kph sign; and
- VMS 32 ‘Kaiwharawhara’ to display an 80kph sign.

b. PM Peak Plan
The PM peak plan includes more steps than the AM peak as there are more queuing ‘trigger points’ the TOC operators are monitoring. The plan however follows one action, which is to change the VMS to 60kph on the sign which the queue is observed approaching, and setting the speed limit at 80kph for the preceding VMS.

There are four ‘trigger points’ used for the PM peak plan, as described below and illustrated in Figure 3.4:

- Trigger Point C: The trigger point for the first step of the PM peak plan is when queuing is observed at PTZ 201, marked as C on Figure 3.4;
- Trigger Point D: The trigger point for the second step of the PM peak plan is when queuing approaches VMS 29 ‘Rail Crossing NB’, marked as D on Figure 3.4;
- Trigger Point E: The trigger point for the third step of the PM peak plan is when queuing approaches VMS 31 ‘Placemakers NB’, marked as E on Figure 3.4; and
- Trigger Point F: The trigger point for the fourth step of the PM peak plan is when queuing approaches VMS 33 ‘Kaiwharawhara NB’, marked as E on Figure 3.4.
PM Implementation Step 1
When a TOC operator witnesses queuing at point C the first step of the plan is introduced with the following sign changes implemented concurrently:
- VMS 27 ‘Ngauranga NB’ displays a 60kph sign
- VMS 29 ‘Rail Crossing NB’ displays an 80kph sign

PM Implementation Step 2
When a TOC operator witnesses queuing at point D the second step of the plan is introduced with the following sign changes implemented concurrently:
- VMS 29 ‘Rail Crossing NB’ displays a 60kph sign
- VMS 31 ‘Placemakers NB’ displays an 80kph sign

PM Implementation Step 3
When a TOC operator witnesses queuing at point E the third step of the plan is introduced with the following sign changes implemented concurrently:
- VMS 31 ‘Placemakers NB’ displays a 60kph sign
- VMS 33 ‘Kaiwharawhara NB’ displays an 80kph sign

PM Implementation Step 4
When a TOC operator witnesses queuing at point E the fourth step of the plan is introduced with the following sign changes implemented concurrently:
- VMS 33 ‘Kaiwharawhara NB’ displays a 60kph sign
- VMS 35 ‘Hobson Street NB’ displays an 80kph sign
PM Operational Plan Removal

When the peak is subsiding the reverse occurs so when the TOC operators observe the queues receding past the same ‘trigger points’ they sequentially revert back to 100kph.

c. Current Operational Plan Summary

The AM operational plan has only two set stages, lowering the speed limit to 80kph based on queuing on the SH1 on slip, as well as ad hoc lowering of the speed limit to 80kph in other areas.

The PM peak has four main stages lowering the speed limit down to 60kph, with an intermediate 80kph speed limit at the previous VMS based on observed queuing. The operational plan is removed at the end of the peak period, by increasing the speed limit incrementally in reverse of the implementation plan.

It is notable that the current operation plans are strongly reliant on the observation and judgement of the TOC operators, which is in turn dependent on the CCTV coverage of the region.

d. Problems Confirmed with Current Operational Plans

Through discussions with the TOC staff a number of operational problems were identified. These were:

- Due to the curvilinear alignment of SH1 between Ngauranga and Aotea Quay the existing CCTV coverage is not sufficient and there are a number of blind spots. In addition, the single camera is restrictive when trying to view queue progression from congestion bottlenecks and incidents;
- International experience suggests that 30 seconds between receiving the information and reaching the incident is sufficient time to perform all necessary tasks in comfort in most circumstances. The number of variable message signs in the current ATMS system are not sufficient to provide information within this internationally recognised 30 seconds before an incident or traffic management event;
- Insufficient information is provided to motorists to inform them on the change in the variable speed limit signs or lane management signs; and
- The current operational plans implement a speed limit reduction once a queue is observed. This is too late as the build-up of traffic will then happen anyway, given the speed and distance away of approaching traffic. It would be better to determine the traffic speed / volumes which are an indicator of queue build up and then to implement the speed reduction to prevent or stave off the queue build up.

The NZTA (through Colmar Brunton) undertook an online public survey over March and April 2011 to better understand driver behaviour and how the stretch of highway is perceived and used by the public. The customer satisfaction survey identified that there is a lack of information and understanding of how the existing ATMS system operates. This leads to the driver not understanding or complying with the existing variable mandatory speed limit (VMSL) sign as part of the existing speed management system.

The public survey highlighted the respondents’ view of problems within the study area which include:

- congestion
- lack of understanding of the ATMS signs
- lack of enforcement of the ATMS signs
- driver education

In summary, the current operational plan is based on queue protection, not queue prevention followed by queue protection.

The results of the public survey are further discussed in the Ngauranga to to Aotea Quay Scoping Report (November 2011).

The Driver Awareness Plan will look for new and effective ways to promote the ‘management of traffic’ concept to road users, stakeholders and the public. It is envisaged that the Plan will be developed and implemented in partnership with a range of key stakeholders involved with the safe and efficient operation of the highway, including the Automobile Association.
3.5.2. Future Operational Strategy

The Ngauranga to Aotea Quay ATM Scoping Report confirmed the desire to operate this section of the State Highway 1 under full management. The key principles behind the implementation of an appropriate concept of operation that would provide a fully managed system with four lanes in each direction are:

- to provide the ability to maximise the efficiency of SH1;
- to improve access to travel information;
- to improve the management of congestion and secondary incidents; and
- to provide for the management and response to broken down vehicles.

The active traffic management of urban motorways requires a commitment to on-going operational efforts to manage and optimise the performance of the motorway. These operational efforts are central to sustaining and building upon the benefits achieved through the application of managed motorway tools.

a. Fully Managed Elements

Fully managed or Managed Motorway (MM) systems use the control interventions speed, queue, lane and access management to optimise the motorway performance and maximise safety, reliability and capacity.

Managed Motorway systems have a combination of Speed, Lane and Access management interventions to best achieve the optimum performance outcomes.

The systems will be complex and require a high level of training for operators and analysts. Operators would be required to watch, respond and actively implement peak period operational plans as well as complex incident management plans that would use the full carriageway width to maximise capacity. A full time traffic operations centre would be required to provide the optimum performance outcome.

A Fully Managed System would include the following elements.

Vehicle Detection Equipment

Vehicle detection equipment provides volume, speed, occupancy (density) and classification on a lane by lane basis. The information is the basis of monitoring and control for motorways and can be made available to third parties for incorporating in commercial applications.

The vehicle detection proposed for the Ngauranga to Aotea Quay area is likely to include radar or inductive loops. Seven new vehicle detection positions are proposed along the length of the study area, positioned in each lane approximately 200m – 400m before and after each gantry. These will be used by the Dynac system to detect congestion and incidents, the Dynac software will be configured to automatically implement strategies such as a reduction in speed limit, based on the information received from these detectors.

This is designed to reduce the workload for TOC operators who currently monitor queues manually, allowing a greater focus on incident management.

CCTV

CCTV provides operators with a view of the motorway, enabling more detailed assessment of conditions than provided by vehicle detection equipment. This allows the operator to manage unusual conditions such as incidents and planned special events. This is a useful tool in congestion management, such as assessing queuing and queue lengths and conditions on arterial roads on the approaches to motorway on ramps. This is also a useful tool to allow the operator to assess the performance of ramp metering system changes. Web cameras are normally installed and made available to third parties for incorporating in commercial applications.

There are a number of existing CCTV cameras in the study area, however these do not provide full coverage of the study area and have a limited directional range.

New CCTV cameras will be installed to complement the existing camera coverage. Each gantry will have two cameras to provide adequate coverage in both directions. These cameras will also be bi-directional to allow full coverage of each carriageway in both directions.
Motorway Emergency Telephones

Motorway emergency telephones enable motorists to advise the Traffic Operations Centre of an incident or broken down vehicles. This is of most use to drivers without access to mobile phones and provides direct access to the appropriate response agency.

It is proposed that emergency phones be provided at each EBA in our study area, with two provided in each direction.

Travel time tracking equipment

Travel time tracking equipment tracks vehicle movements for travel time calculations. It is also useful for determining origin-destination patterns.

To monitor the vehicle travel time patterns and variations three Bluetooth devices have been installed to track travel times within the study area at:

- SH1 Hobson Street gantry
- SH1 Ngauranga Gorge gantry
- SH2 Weigh Station gantry

These units will be used to provide before and after information on the impact of travel time and variability as the project is implemented in stages.

The information from these units could be part of a wider installation to provide travel time estimations on the network to drivers via VMS.

Variable Message Signs

Variable message signs (VMS) allow information to be conveyed to motorists once they are on the motorway. This information can warn them of hazards or disruptions, why speed limits have changes under a speed management system and detail actions to be taken (e.g. “Merge right left lane closed due to incident”) as part of a lane management system.

These signs can be used to provide travel time information when not required for incident management.

In the Ngauranga to Aotea Quay area there are currently three VMS on the state highway, plus a VMS on the Hutt Road just south of the Hutt Road/Jardin Mile/Centennial Highway intersection. Two of these VMS are provided in conjunction with variable mandatory speed limit signs, with the other two provided independently.

It is proposed that additional VMS be provided at all the gantries in the area, which is to be increased to nine locations. The form and size of the VMS is yet to be confirmed, but the current thinking is to use the Highway Agency MS4 sign as shown in Figure 3.5, except this sign would be located on the full width motorway gantry above lane one.

Figure 3.5: Proposed Supplementary VMS

It is proposed that the VMS be fully configurable to display both symbols/graphics and/or three lines of text. The messages displayed on the VMS are intended to provide a variety of information which is likely to include:
unplanned traffic incidents and unexpected road conditions e.g. a crash;
closures and diversions;
weather affecting road use;
planned road works and special events;
real time travel time services;
future planned traffic events such as road closures and diversions for upcoming road works and special events; and
road safety campaign messages

The information on the VMS will include information on the location of the congestion/incident, which lanes are affected and the action which the driver should take, e.g. “Congestion at Aotea Quay Off Ramp, in Lane 1, Queue 200m ahead” or “Vehicle broken down, in lane 1, Move Right”.

Traveller Information Signs

Traveller information signs are variable message signs located on arterial roads on the approach to motorway on ramps. These signs provide travel times and other motorway condition information and enable motorists to make route choice decisions before entering the motorway. Additionally the use of driver information panels has the potential for improving flows around off ramps, through providing additional information to road users so that they get into the most appropriate lane for their destination.

A parallel project proposes to install small Type D VMS signs on the approaches to the on-ramp within Wellington City and on selected local city streets to provide traveller Information so drivers can make better informed decisions.

b. Level of Management within Fully Managed Elements

Speed Management (Variable Mandatory Speed Limits)

Speed management can assist in maximising safety in adverse conditions, such as heavy rain, high winds, incidents and road works. Speed management is designed to minimise the risk of flow breakdown and reduce accidents, thereby producing more reliable journey times and can assist in maximising capacity during heavy demand periods. Speed management can also be provided as part of an integrated Speed and Lane Management System.

Public education and enforcement are necessary to gain the full benefits of introducing speed management. It is expected that to gain the necessary level of compliance that digital enforcement of the mandatory variable speed limit and a high level of driver awareness would be required. As part of the driver awareness additional side mounted signs should be installed to inform drivers why the speed limit has changed to encourage compliance.

Operators would be required to watch, respond and actively implement operational management plans to set variable speed limits to manage congestion effects resulting from incidents and peak traffic flow conditions. An MOU will be required with the Police to enforce mandatory variable speed limits.

In the Ngauranga to Aotea Quay area there are currently six Variable Mandatory Speed Limit (VMSL) gantry locations in both directions, including SH1 and SH2 prior to the Ngauranga merge, with an extra sign northbound on the Aotea Quay on ramp. Currently only two of these VMSL locations are accompanied by VMS signs to provide additional information to drivers.

It is proposed that three additional gantries with Lane Control Units (LCU) are added on this stretch of road, which would result in a total of nine locations, over the 4km stretch.

With the addition of these gantries the distances between the LCU would generally be around 600m, which will provide greater consistency for drivers. It is also proposed that supplementary VMS signs would be added to each gantry to provide supplemental information to encourage compliance.

The VMSL signs would be set automatically based on the automated processing of information from the inductive loops, during times of congestion and incidents.
Queue Detection

Queue detection is implemented typically through the use of inductive loops (although other forms of vehicle detection can be used). The loops generate data relating to vehicle speed, flow and occupancy and, through the use of an algorithm, can automatically display reduced advisory speeds on message signs upstream of an incident or congestion location. Given that traffic speed will decrease and a queue form at or around an incident, the speed limit set will automatically decrease towards the rear of the queue. This allows queue protection to take place.

The queue detection is typically connected to a wider road management and transmission system, rather than being standalone, and can therefore be used to automatically set VMSL, therefore forming part of a Managed Motorway (MM) system, as well as providing general queue protection.

In a MM environment, messages relating to downstream road conditions can be displayed to drivers via VMS. Similarly, queue protection messages can be displayed on the VMS, along with VMSL on the LCU. Typically, queue protection systems display advisory speed limits and therefore enforcement is not undertaken. In an MM environment, the queue protection would use mandatory speed limits and therefore enforcement could take place, depending on whether the actual speed limit set was part of the VMSL system.

To introduce automatic queue protection in the Project area a number of detection sites will be added to complement the existing infrastructure, and the Dynac software will be configured to automatically detect a queue and take the appropriate action to protect it. The operator would only be required to watch, as these systems are usually automated in terms of detecting queues and setting a response. An operator would be required to be trained to analyse the performance of the automated system and calibrate as required.

Taking all the above into account, there is a need to consider the different uses of both systems – VMSL and queue protection - and therefore to ensure that the system architecture is appropriately designed.

Lane Management

Lane Management of urban motorways refers to the allocation and management of available road space to achieve desired performance outcomes during an incident or maintenance. The most common application for urban motorways is expected to be Integrated Speed and Lane Management. Other applications include dynamic use of the shoulder between on and off ramps, exit queue storage and priority applications for specified road user classes.

A moderate level of enforcement and public education is necessary to ensure the appropriate level of safety and compliance.

Operators would be required to watch, respond and actively implement incident management plans by set lane control signs during incidents. For maintenance activities the operator would be required to liaise with the STMS when implementing temporary traffic management. There will be a need for 24 hour operation.

In the Project area lane management is currently in use during incidents and road works, with the existing LCU showing a Red X over the closed lane, and the LCU showing a lower speed limit. The additional LCU proposed will allow for greater consistency for drivers, as they will receive information more regularly. The supplementary VMS will be able to complement the lane closures by providing instructions i.e. ‘Merge Right’, or providing additional information on the reason for the lane closure to encourage compliance and lane discipline.

Access Management

Motorway Ramp Signals manage access to the motorway, to prevent capacity being exceeded (causing flow breakdown) and breaking up on ramp vehicle platoons that temporarily overload the merge area. Motorway Ramp Signals are most effective when implemented as a corridor wide dynamic system, providing full control of the motorway and allowing effective management of the queues at the ramps.

This level of management would require a moderate level of driver awareness prior to the construction and opening. These systems usually have a high level of compliance when operated efficiently and drivers view that the ramp signals are providing an overall improvement in the reliability of their journey and require only directed enforcement when a large number of non-compliances are detected.
Operators would only be required to respond and adaptively control the system if queues on the local network exceed maximums, as the access management system (SCATS RMS) will be automated. TOC staff would be trained to monitor the operations and analyse traffic data to optimise the system settings.

Currently ramp metering of the Hutt Road SH2 on-ramp is being investigated as part of a separate project.

**Congestion Management**

The operational strategy for congestion management will be similar to that currently implemented, in terms of the setting of the LCU, namely that when queuing is detected at a certain location the previous VMSL will be lowered to protect the back of the queue and smooth flow.

The main difference will be that rather than reacting once a queue has built up, the system will identify traffic flow/volumes which are an indicator of queue build up and implement the speed reduction proactively. Also the system will be largely automated and therefore require significantly less TOC input.

**Incident Management**

Vehicle detection equipment will be utilised for automatic incident detection, which will be complemented by manual identification of incidents through public use of emergency phones at the EBAs and TOC operator surveillance of the area through the increased CCTV coverage.

The strategy implemented upon detection of an incident is likely to include, closure of the lane in which the incident took place by displaying a RED X over the lane, upstream of the lane closure displaying an arrow to indicate that traffic should merge into the other lanes and lowering the speed limit of the adjacent lanes to an appropriate limit of 80kph or less.

It is noted that currently the RED X is used to close a lane for road works or for an incident, however it is known that some vehicles do not obey the RED X and have been observed to travel in a closed lane. The enforcement of the RED X will be an essential part of the enforcement strategy developed for the Project.

Operational strategies and procedures for managing incidents will be developed as part of the Project in consultation with the NZTA and the TOC.

**3.5.3. ITS Infrastructure**

The new and existing ITS infrastructure to be utilised for the managed motorway from North to South is detailed in Table 3.11 below.

<table>
<thead>
<tr>
<th>Chainage</th>
<th>Equipment</th>
<th>New / Existing</th>
<th>Distance from Previous Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SH1 Prior to the SH1/SH2 Merge/Diverge</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glover St</td>
<td>Gantry + CCTV + VMS + VMSL</td>
<td>All New</td>
<td></td>
</tr>
<tr>
<td>900 (sbound only)</td>
<td>Ground Mounted VMSL</td>
<td>Existing</td>
<td></td>
</tr>
<tr>
<td><strong>SH2 Prior to the SH1/SH2 Merge/Diverge</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>Vehicle Detection Equipment (Loops)</td>
<td>New</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>Vehicle Detection Equipment (Radar)</td>
<td>Existing</td>
<td>100m</td>
</tr>
<tr>
<td>700</td>
<td>Vehicle Detection Equipment (Loops)</td>
<td>New</td>
<td>300m</td>
</tr>
<tr>
<td>900</td>
<td>Gantry + CCTV + VMS + VMSL (Radar)</td>
<td>Modifications to Existing</td>
<td>200m</td>
</tr>
<tr>
<td>Chainage</td>
<td>Equipment</td>
<td>New / Existing</td>
<td>Distance from Previous Equipment</td>
</tr>
<tr>
<td>----------</td>
<td>-----------</td>
<td>----------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>1100</td>
<td>CCTV</td>
<td>Existing</td>
<td>200m</td>
</tr>
<tr>
<td>1200-1300</td>
<td>Vehicle Detection Equipment (Loops)</td>
<td>New</td>
<td>350m</td>
</tr>
<tr>
<td>1500</td>
<td>Vehicle Detection Equipment (Radar)</td>
<td>Existing</td>
<td>250m</td>
</tr>
<tr>
<td>1500</td>
<td>Gantry + CCTV + VMS + VMSL</td>
<td>All New</td>
<td>250m</td>
</tr>
<tr>
<td>1700</td>
<td>Vehicle Detection Equipment (Loops)</td>
<td>New</td>
<td>200m</td>
</tr>
<tr>
<td>2100</td>
<td>Gantry + CCTV + VMS + VMSL (Radar)</td>
<td>Modifications to Existing</td>
<td>400m</td>
</tr>
<tr>
<td>2400</td>
<td>Vehicle Detection Equipment (Loops)</td>
<td>New</td>
<td>300m</td>
</tr>
<tr>
<td>2500</td>
<td>Vehicle Detection Equipment (Radar)</td>
<td>Existing</td>
<td>100m</td>
</tr>
<tr>
<td>2800 - 2900</td>
<td>Gantry + CCTV + VMS + VMSL (Radar)</td>
<td>Modifications to Existing</td>
<td>350m</td>
</tr>
<tr>
<td>3000</td>
<td>Vehicle Detection Equipment (Radar)</td>
<td>Existing</td>
<td>100m</td>
</tr>
<tr>
<td>3200</td>
<td>Vehicle Detection Equipment (Loops)</td>
<td>New</td>
<td>200m</td>
</tr>
<tr>
<td>3400-3500</td>
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<td>Modifications to Existing</td>
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</tr>
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<td>New</td>
<td>250m</td>
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</tr>
<tr>
<td>4200 (sbound only)</td>
<td>CCTV</td>
<td>Existing</td>
<td>300m</td>
</tr>
<tr>
<td>4300-4400</td>
<td>Gantry + CCTV + VMS + VMSL</td>
<td>New</td>
<td>150m</td>
</tr>
</tbody>
</table>

Note that this list includes the equipment in the Project area and does not include all of the equipment currently associated with the existing ATMS (i.e. the equipment extending up Ngauranga Gorge, or into the CBD.)

Enforcement Strategy.

The current Wellington Advanced Traffic Management System (ATMS) is mandatory and all variable speed limits set include the red roundel (red circle around the numerical speed limit) to signify this. However, at present the system is not enforced with permanent speed cameras and there is limited success with achieving driver compliance with the posted speeds.

It is considered that enforcement is an important requirement of the scheme in order to achieve compliance, improve the management of the traffic flows and to realise the possible safety benefits in full. The following summarises the enforcement strategy developed for the project. Further detail is available in Appendix I.

3.5.4. Implementation

The Wellington TOC will continue to control the VMSL system using the Dynac system, though the variable speed limit regime will normally be automated using the Motorway Incident Detection and Automatic Signalling (MIDAS) system. As the Police speed policy requires speed enforcement to be under their control the
enforcement of that system would need to be seen to be under Police authority. A memorandum of understanding or operational agreement should be drawn up between the Police and NZTA, detailing the NZTA and Police roles and responsibilities explicitly. Consideration should be given to how the operation of this combined approach is communicated to the public.

Consideration will need to be given to the time lag between a posted speed limit being set and enforcement commencing i.e. drivers need to be given the time to adjust their speed before it can be considered that they have infringed and can therefore be prosecuted. Similarly, the protocols for setting lane diversion arrows and Red X should be examined in relation to the enforcement of a Red X as a stop sign. In order to be able to prosecute fairly, vehicles need to be given adequate time to change lanes so they do not proceed past a mandatory Red X.

3.5.5. Roadside Equipment

The equipment required to operate a VMSL system (with lane management) is described in Section 3.4. To enforce the system an enforcement kit comprising camera, flash and cabling (Redflex enforcement cameras are to be used) is also required. The enforcement equipment can be used for enforcing both the VMSL and a Red X.

It is proposed that, at any given gantry location, one set of enforcement equipment is used on one carriageway direction, enforcing up to four lanes of traffic in one direction only. The enforcement equipment would be mounted to the rear of the gantry and would face downstream.

As the Police do not have to publish details of speed camera locations, it is proposed that each gantry site be equipped with the necessary infrastructure to be able to install speed enforcement equipment. This may also include the provision of fake enclosures to mimic the appearance of the actual camera.

Compliance would be monitored to evaluate whether additional active enforcement equipment should be added or whether active enforcement sites need to be moved to more effective locations.

For the enforcement of the Red X, unless all the LCUs displayed a Red X, there would need to be some development and testing of the Dynac system with the NZTA protocol for the Redflex camera.

3.5.6. Testing and Calibration

Site Acceptance Testing (SAT) will be required on installation and should be a requirement of the installer. Testing of the overall system will be required in order to optimise the enforcement thresholds.

The existing gantries have not been designed to allow for the design requirements of the proposed enforcement equipment (e.g. structural capacity, vibration, connection detail). Testing should be undertaken to ensure that the cameras can still operate successfully with the vibration and climatic conditions encountered in the Wellington ATMS area.

All processing of evidence is undertaken by the Police Infringement Bureau (PIB). The PIB already has a significant workload processing infringement notices from existing cameras. The intent of the system would be to issue sufficient infringement notices to achieve compliance only. The Police have stated that they would require funding support to process additional infringement notices arising as a result of the VMSL system.

3.5.7. Visual Confirmation of Signage

Discussions have taken place with regard to the need to visually confirm the speed setting displayed on an LCU when enforcement is taking place. There are two main considerations:

- The Redflex cameras take two images using Doppler and ranging radar speed detection. In a fixed speed limit situation this would provide adequate evidence that the vehicle had exceeded the speed limit as there could be no dispute over what speed limit was communicated to a driver; and
- The Dynac database can be considered sufficiently robust to be presented as evidence in court (i.e. it is not necessary for an NZTA representative to attend court to attest that they had posted a speed limit of xxkm/h at a given time.

Neither of these two cases provides visual evidence of what was actually displayed on the LCU at the time of the infringement. Under the relevant NZ legislation, the onus is on the driver to prove that the speed limit was
not displayed correctly, therefore the current proposals do not include a visual confirmation of the displayed speed, although the Dynac system will set a zero state on detection of specific faults and this will disable enforcement. Given that the Dynac database is sufficiently robust to be produced as evidence, it is also likely that it will be sufficient to demonstrate that the sign was lit and that the speed was visible. It is likely a visual confirmation of any vehicle travelling beyond a Red X would be required, showing any specific cause for a vehicle to need to do this. These issues will need to be confirmed during detailed design.

3.5.8. Legislative Methodology

The legal opinions provided to date by the Kensington Swan / Brookfields alliance are provided as part of the Enforcement Strategy in Appendix I. A selection of conclusions from their report is presented below:

- The NZTA is empowered to implement variable lane use under Traffic Control Devices (TCD) Rule 7.13 provided the other requirements of that Rule are met. It should be noted that under the Rule a blank display can be used to indicate that a lane is available for use. The risk of power outages or other issues affecting the overhead signs should therefore be considered;
- The NZTA is empowered to set a variable speed limit under Speed Limits Rule 6.1. However, this is only where the ‘safe speed limit’ needs to vary. Therefore, it will be necessary to show that there are conditions along Aotea Quay itself that require a variable speed limit for safety reasons;
- Provided the Redflex camera system is gazetted and approved as an ‘approved vehicle surveillance equipment’, driving in excess of the variable speed limit will fall within the definition of a moving vehicle offence;
- Either legislative or regulatory amendment will be required to ensure that inappropriate lane use can be prosecuted as a moving vehicle offence; and
- Section 145 of the LTA does not require the Redflex camera system to produce an actual image showing the overhead sign in situ. It will be sufficient that the evidence produced by Redflex system records, whether in pictorial or digital format, the colour and form of the overhead sign.

The Redflex camera enforcement system was gazetted by the Police Calibration Service in December 2011 for fixed speed enforcement. In order to be used for the enforcement of variable speeds, a further gazetting process is required. This will again be undertaken by the PCS and is anticipated to take approximately six months. The Police will require a request to carry this out.

3.5.9. Enforcement Methodology Conclusions and Recommendations

The following factors are critical in the decision-making process for implementing enforcement in a managed motorway situation involving VMSL and mandatory lane-use:

- Operational – approved speed enforcement equipment (comprising both speed detection equipment and lane-specific signalling) together with the necessary system integration and operational procedures to safely implement the required regimes;
- Legislative – legality of both setting and being able to enforce variable speed limits, production of infringement notices which will satisfy evidential requirements and the legality of being able to prosecute inappropriate lane use as a moving vehicle offence; and
- Costs – assessment and analysis of the most cost-effective deployment regime for enforcement equipment, taking into account whole life costs.

Taking the above into account, and following discussions with the Police, NZTA and NZTA legal advisors, it can be concluded that:

- Existing equipment and control systems can be installed or developed to enforce VMSL and will provide a sufficiently robust evidential trail;
- Variable speed limits are legally enforceable in New Zealand;
- Lane use enforcement will require a legislative or regulatory amendment;
- Over an assumed design life of 15yrs, the least whole life cost can be achieved through the deployment of two sets of enforcement equipment at a single gantry location, to be moved as required; and
- The NZTA need to request the involvement and cooperation of the NZ Police both prior to and during the scheme implementation and that some form of memorandum of understanding be implemented between the NZTA and the Police for operation of the system

### 3.6. Driver Awareness

This project is about changing driver behaviour to help ease congestion, smooth traffic flows and provide greater journey time reliability. Transport Engineering Research New Zealand Limited (TERNZ) has been engaged to develop a Driver Awareness Strategy to help ensure that the NtAQ project is communicated, designed and delivered in a manner that reflects current knowledge of driver behaviour principles and requirements, to maximise the likelihood of achieving the project objectives.

The road user is an important focus of this Project in terms of the influence driver behaviour will have on the success of the solution chosen. The Driver Awareness Strategy will be staged in three phases to reflect the different key influence points of driver behaviour. It is likely that these three phases will be applied to each ‘stage’ of the project as it is implemented over time. The three stages of the strategy and what they mean are summarised in Table 3.12.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-situational</td>
<td>Making drivers aware of the project, why it is happening and the manner in which the project will be implemented. In order to achieve this, typically communication and education activities would be designed and delivered as needed. These activities are important for achieving motorist ‘buy-in’ to the project and priming them for the changes that will be implemented as the project progresses. Non-situational messaging can also be useful for helping motorists to plan their trips (for example avoiding the area if roadworks and delays are expected, evidenced by the Newmarket Viaduct closure in Auckland).</td>
</tr>
<tr>
<td>Pre-situational</td>
<td>Driver awareness also includes an awareness of the system motorists are about to use on any given day via strategically timed messages (eg radio or variable messaging within the road environment prior to driving through NtAQ). These types of messages tend to have a greater effect on driver behaviour than non-situational messages because they inform drivers within a directly relevant context, ie when drivers are about to drive through the motorway.</td>
</tr>
<tr>
<td>Situational</td>
<td>Information and education alone are unlikely to significantly change actual driver behaviour while they travel through the NtAQ motorway section. Motorists mostly respond to the environment that is presented before them as they drive (in addition to long-term learned behaviours) and the design of that environment is crucial to influencing driver behaviour. As motorists experience the environment repeatedly over time, expectations of appropriate behaviour are formed. These environmental influences may include variable mandatory speed limits, road design improvements and speed/lane enforcement. For these reasons, a key part of the Driver Awareness Strategy will be informing motorists about these key principles, evidence for the likely effectiveness of the project stages and also carrying out monitoring and feedback to check that the physical project elements are having the desired effect as the project stages are delivered. Evidence of desired driver awareness and behaviour will hinge on the pre and post project driver behaviour data that will be available for analysis.</td>
</tr>
</tbody>
</table>

The driver awareness report prepared by Hamish Mackie is contained in Appendix J.
The preferred scheme for the Project can be summarised as:

- Four lanes with full management from Ngauranga to Aotea Quay;
- Ngauranga to the Thorndon Overbridge cross section of four 3.5m lanes with 1.0m shoulders;
- North end of the Thorndon Overbridge to the Aotea Quay off ramp cross section of four 3.3m lanes with 0.5m shoulders;
- Full-time use of the fourth-lane;
- The provision of a fourth lane in the southbound direction will include widening of the Thorndon Overbridge;
- Improvements to the SH2 northbound on-ramp and provision of an emergency on ramp at Ngauranga; and
- Improvements to the ATMS system including new gantries and signage as well as electronic enforcement, supported by a driver awareness strategy.

The preferred scheme will involve speed and lane enforcement and be supported by a driver awareness strategy.
4. Preferred Scheme Evaluation

This section documents the various assessments of the preferred scheme that were undertaken including:

- Traffic modelling;
- Statutory planning; and
- Transport policy.

Costing of the preferred scheme, risk assessment, and economic evaluation are documented in subsequent chapters.

4.1. Traffic Modelling

4.1.1. Traffic Modelling Overview

Operational models are used to assess localised issues in more detail than is possible in the wider area strategic models. They are used primarily to investigate specific design issues such as likely length of queues and performance of motorway merge and weave areas. The operational model used to assess the Ngauranga to Aotea Quay project is a simulation model developed by Traffic Design Group in the S-Paramics micro-simulation software. The model covers SH1 between Ngauranga Gorge and the Terrace Tunnel, SH2 from Petone interchange to the city and also includes Hutt Road and Aotea Quay. Further details are included in the separate validation report prepared by Traffic Design Group.

This model obtains travel demands, in the form of origin-destination trip tables, from the Wellington Transport Strategy Model (WTSM). These trip tables are then loaded as flow rates into the simulation models, along with assumed flow profiles to represent the build-up and dissipation of peak traffic flows.

Whilst the operational model can provide a more detailed assessment, it is noted that they are still only a ‘simulation’ of the potential operation of the road network during these peak periods. The aim of ‘simulation’ modelling is therefore to identify any potentially significant issues associated with the road network operation in a generic set of network operating conditions for the different assessment scenarios in order that design modification or any further mitigation can be identified. Whilst the models give consideration to the influence of factors such as driver behaviour and other operational and design factors, there will inevitably be fluctuations in the day-to-day operation of the road network, as well as across different times of year, depending on the specific road operating conditions at that time.

It is noted that the geographic extent of the operational model makes it more difficult to assess the effects of the scheme in the vicinity of the central city. Route choice through this area is taken from the WTSM which means that the choice of on/off-ramp at the city is restricted. This has the potential to exaggerate any adverse effects at the Aotea Quay off-ramp, where traffic may otherwise divert to a different inner-city off-ramp.

Consequently, whilst some optimisation of signalised intersections has generally been incorporated in the future year operational models, further improvements in network performance may be able to be achieved at certain locations with further refinement to the network.

This assessment identifies the operational performance of the scheme, with the full economic assessment based on these results discussed in Section 8.

4.1.2. Scenarios Modeled

The Project team provided a scope of modeling requirements for Traffic Design Group. Included in the scope was a requirement to model the full scheme as well as the component parts so as to enable the Project team to understand how parts of the full scheme performed as well as to assess the incremental benefits of the component parts. The modeling scenarios which were taken forward for analysis in this report include:

- The base model (includes “Early Works”);
- Base minus “Early Works” (this is the Do-Minimum for the Project);
- Base + four lanes northbound and southbound + ATMS + SH2 northbound on ramp (the full scheme);
- Base + ATMS;
- Base + Four lanes northbound + ATMS;
- Base + Four lanes southbound + ATMS; and
- Base + SH2 northbound on ramp geometric improvements.

### 4.1.3. Model Inputs and Assumptions

A base year of 2011 has been modelled, along with two forecast years of 2021 and 2031.

The operational model covers morning, inter peak and evening periods, as follows:

- **AM Peak (06:00 – 09:30)**
- **Inter-peak (11:00 – 13:00)**
- **PM Peak (15:00 – 19:30)**

The Do Minimum scenario represents the minimum investment needed in the study corridor to maintain operations and for this analysis includes the Early Works. It is however assumed to include new projects and upgrades outside the study corridor, and these assumptions are common to the ‘no project’ and ‘project’ scenarios.

The Wellington Transport Strategy Model (WTSM) is the regional transport planning and forecasting tool. Inputs from the WTSM were used in the development of the operational model demand matrices. These were developed for 2021 and 2031 forecast years for both the Do Minimum and Option scenarios using the “High” land use growth.

**Table 4.1** details the projects that have been assumed to be in place in each or the future modelled years for the Do-Minimum scenario and the Option. The Option networks also include widening from Ngauranga to Aotea Quay.

<table>
<thead>
<tr>
<th>RoNS Traffic Scheme</th>
<th>Do Minimum and Option</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Otaki to north of Levin</strong></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Peka Peka to Otaki</strong></td>
<td>✓</td>
</tr>
<tr>
<td><strong>MacKays to Peka Peka</strong></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Linden to MacKays (Transmission Gully)</strong></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Terrace Tunnel Duplication</strong></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Basin Reserve</strong></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Airport to Mt Victoria Tunnel</strong></td>
<td>✓</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>✓</td>
</tr>
</tbody>
</table>

Table 4.1 WTSM Model Assumptions

The expected effects of the key network changes in the 2031 Do Minimum as outlined in **Table 4.1** are briefly outlined below:

- **Petone to Grenada**: the direct connection between SH1 and Hutt Valley provided by the Petone to Grenada link will remove the need for vehicles travelling between these destinations from using SH1 at Ngauranga Gorge and the Hutt Road / Centennial Highway intersection. The removal of this traffic will allow southbound vehicles to arrive at the SH1/SH2 merge faster. The queuing from this
merge will hold these vehicles back from the merge itself so the actual arrival rate at the merge is likely to be unchanged. However the length of any queue back up the gorge is likely to be reduced.

- Terrace Tunnel: the removal of the capacity constraint imposed by the single lane through the terrace tunnel will decrease the travel time from SH1 through to Willis St. This will make travelling by car to these destinations more attractive leading to an increase in the number of vehicles travelling through this part of the network. As most of these vehicles also have to travel along the length of SH1 from Ngauranga Gorge the volume of traffic southbound through the scheme area is likely to increase. The removal/reduction of queues associated with the merge may also make accessing some of the southbound off ramps easier, making these destinations slightly more attractive as well. In the northbound direction there is no change to the capacity or the likely costs of travel so traffic volumes are unlikely to change significantly.

- Transmission Gully and Other RoNS – The schemes implemented at Transmission Gully and the other RoNS projects north of this are unlikely to change the arrival pattern or rate at the top of Ngauranga Gorge.

Separate Do Minimum and Option forecasts have been produced to account for the induced traffic that may be produced by the scheme. Additional trips can be made on the network due to the extra capacity and reduced delay provided by the widening scheme.

The induced traffic levels are reliant on predictions from WTSM, which includes relationships between land-use and trip-making patterns. The WTSM forecasts show that there is little difference in the total demand matrix volume passing through the network between the Do Minimum and Option scenarios, with around 1% additional traffic in each period (this is roughly around 500 trips in the AM and PM periods). There are more noticeable changes on specific movements through the network between the Do Minimum and Option demands which appear to be associated with localised route choice in WTSM.

The percentage growth in demand, compared to 2011, is included in the Table 4.2 below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Forecast Growth</th>
<th>Option vs Do Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do Minimum</td>
<td>Option</td>
</tr>
<tr>
<td><strong>Morning Period (6:00-9:30)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>44,800</td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td>47,300 5.6%</td>
<td>47,800 6.6%</td>
</tr>
<tr>
<td>2031</td>
<td>49,300 10.0%</td>
<td>50,000 11.5%</td>
</tr>
<tr>
<td><strong>Inter-Peak Period (11:00-13:00)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>20,100</td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td>22,200 10.6%</td>
<td>22,300 11.0%</td>
</tr>
<tr>
<td>2031</td>
<td>22,700 12.9%</td>
<td>22,900 14.0%</td>
</tr>
<tr>
<td><strong>Evening Period (15:00-18:30)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>50,300</td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td>52,700 4.7%</td>
<td>53,000 5.3%</td>
</tr>
<tr>
<td>2031</td>
<td>54,400 8.0%</td>
<td>54,900 9.0%</td>
</tr>
</tbody>
</table>

A simple version of the proposed ATMS system has been simulated in the option model, which consists of introducing reduced speed limits (with full compliance) as traffic volumes approach specified speed / flow thresholds over the specified loop positions. The speed is reduced/increased in increments of 20kph, down to a minimum of 60kph, as per the operational strategy. The speed and flow thresholds used within the models vary according to the nature of the traffic congestion. The thresholds used are as follows:
- Reduction from 100kph to 80kph speed limit: speeds of 82-93 kph / flow of 4200-5340 vph
- Reduction from 80kph to 60kph speed limit: speeds of 70-72 kph / flow of 6120-6600 vph
- Increase from 60kph to 80kph speed limit: speeds of 50-52 kph / flow of 4620-5100 vph
- Increase from 80kph to 100kph speed limit: speeds of 65-70 kph / flow of 3900 - 4800

4.1.4. Traffic Demands

The traffic demands in the models are based on the matrices from the strategic model as discussed above. The demands for the southbound routes in the AM and the northbound routes in the PM are presented below in Table 4.3 and Table 4.4 respectively.

Table 4.3 Model Traffic Demands on Southbound Routes in AM

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>2011</th>
<th>2021</th>
<th>2031</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do Minimum</td>
<td>Option</td>
<td>Do Minimum</td>
<td>Option</td>
</tr>
<tr>
<td>SH1</td>
<td>CBD</td>
<td>7,000</td>
<td>7,190</td>
<td>7,440</td>
</tr>
<tr>
<td>SH2</td>
<td>CBD</td>
<td>5,560</td>
<td>5,640</td>
<td>6,090</td>
</tr>
<tr>
<td>SH1</td>
<td>Quays</td>
<td>1,460</td>
<td>1,490</td>
<td>1,990</td>
</tr>
<tr>
<td>SH2</td>
<td>Quays</td>
<td>2,800</td>
<td>2,770</td>
<td>2,490</td>
</tr>
<tr>
<td>SH1</td>
<td>CBD via Hutt Road</td>
<td>1,410</td>
<td>1,440</td>
<td>1,130</td>
</tr>
<tr>
<td>SH2</td>
<td>CBD via Hutt Road</td>
<td>670</td>
<td>730</td>
<td>720</td>
</tr>
</tbody>
</table>

The main points regarding the southbound traffic demands in the morning period from Table 4.3 are:

- The routes from SH1 and SH2 into the CBD are the busiest routes.
- In 2011, SH1 into the CBD has higher traffic volumes than from SH2 into the CBD, with a difference of around 1,500 vehicles. This difference reduces to around 1,100 vehicles in 2031. The smaller difference between the two routes shows that the flows from SH2 into the CBD are expected to experience greater growth, and this flow is likely to increase in dominance.
- A notable increase in traffic volumes occurs between SH1 and the Quays in the 2031 forecast year.
- With the exception of SH2 to the Quays, demand is higher on routes using the state highway in the option than in the do minimum, and it can be assumed that trips have rerouted onto the state highway as a result of the option being implemented.
- Hutt Road is shown to experience a growth in traffic volumes between 2011 and 2031.

Table 4.4 Model Traffic Demands on Northbound Routes in PM

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>2011</th>
<th>2021</th>
<th>2031</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do Minimum</td>
<td>Option</td>
<td>Do Minimum</td>
<td>Option</td>
</tr>
<tr>
<td>CBD</td>
<td>SH1</td>
<td>6,310</td>
<td>6,550</td>
<td>7,040</td>
</tr>
<tr>
<td>CBD</td>
<td>SH2</td>
<td>6,550</td>
<td>6,480</td>
<td>6,810</td>
</tr>
<tr>
<td>Quays</td>
<td>SH1</td>
<td>2,190</td>
<td>2,430</td>
<td>2,670</td>
</tr>
<tr>
<td>Quays</td>
<td>SH2</td>
<td>1,830</td>
<td>1,990</td>
<td>1,990</td>
</tr>
<tr>
<td>CBD</td>
<td>SH1 via Hutt Road</td>
<td>1,620</td>
<td>1,680</td>
<td>1,370</td>
</tr>
<tr>
<td>CBD</td>
<td>SH2 via Hutt Road</td>
<td>820</td>
<td>830</td>
<td>630</td>
</tr>
<tr>
<td>SH1</td>
<td>SH2</td>
<td>1,510</td>
<td>1,520</td>
<td>1,420</td>
</tr>
</tbody>
</table>
The main points regarding the northbound traffic demands in the PM from Table 4.4 are identified as:

- The routes from the CBD to SH1 and SH2 are the busiest and experience equal levels of demand.
- In 2021 the demand on the routes from the CBD to SH1 and SH2 and the route from the Quays to SH1 via the state highway are all predicted to increase. The alternative routes via Hutt Road for these destinations experience a reduction in flows, this demonstrates some rerouting onto the highway as a result of the scheme. The reduction in flows on Hutt Road is not equivalent to the increase on the State Highway which is potentially due to the removal of constraints in the study area which are allowing a higher total of traffic through.
- There is a significant decrease in demand for the movements between SH1 and SH2 northbound in 2031 do minimum and option, as a result of the Petone-Granada scheme which is included in the 2031 model.

As discussed in the problem description there are currently areas of congestion on the network which constrain the capacity of the scheme area. The modelling predicts that higher traffic flows will be accommodated at many points in the network with the implementation of the scheme. Table 4.5 and Table 4.6 show the three hour traffic flows in the peak direction at selected locations in the network for the do minimum and option in the current and future years.

**Table 4.5** shows that the southbound traffic throughput at most locations are higher in the option than in the do minimum. The differences in throughput are small in 2011, however 2021 and 2031 forecast models show significantly higher southbound throughput. In 2031 a comparison of the option and do minimum models shows that around 2800 more vehicles pass the SH1/SH2 Merge, with approximately 2400 additional vehicles passing the Aotea Quay off ramp in the morning period. There are also increases in throughput of around 1000 vehicles on SH2 and Ngauranga Gorge before the merge in 2031.

**Table 4.6 AM 3 Hour Traffic Flow Throughputs at Points on Southbound Route**

<table>
<thead>
<tr>
<th>Location</th>
<th>2011 Do Minimum</th>
<th>2011 Option</th>
<th>2021 Do Minimum</th>
<th>2021 Option</th>
<th>2031 Do Minimum</th>
<th>2031 Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>SH2 East of Ngauranga Gorge</td>
<td>10,320</td>
<td>10,270</td>
<td>9,560</td>
<td>10,320</td>
<td>10,430</td>
<td>10,810</td>
</tr>
<tr>
<td>Ngauranga Gorge</td>
<td>11,430</td>
<td>11,870</td>
<td>11,210</td>
<td>11,420</td>
<td>12,410</td>
<td>12,210</td>
</tr>
<tr>
<td>SH1 after SH1/2 Merge</td>
<td>14,950</td>
<td>15,130</td>
<td>15,390</td>
<td>15,290</td>
<td>16,260</td>
<td>17,870</td>
</tr>
<tr>
<td>Hutt Road</td>
<td>3,850</td>
<td>4,070</td>
<td>4,380</td>
<td>3,510</td>
<td>3,620</td>
<td>4,570</td>
</tr>
<tr>
<td>SH1 before Aotea Quay Off Ramp</td>
<td>14,960</td>
<td>15,140</td>
<td>15,310</td>
<td>15,300</td>
<td>16,280</td>
<td>17,870</td>
</tr>
<tr>
<td>SH1 after Aotea Quay Off Ramp</td>
<td>11,440</td>
<td>11,600</td>
<td>11,350</td>
<td>11,440</td>
<td>12,280</td>
<td>13,720</td>
</tr>
<tr>
<td>Aotea Quay Off-Ramp</td>
<td>3,540</td>
<td>3,540</td>
<td>3,960</td>
<td>3,880</td>
<td>4,010</td>
<td>4,150</td>
</tr>
</tbody>
</table>

**Figure 4-1** shows that in the do minimum (shown in red) traffic flows are at capacity, constrained at approximately 5,200 vehicles per hour from around 6:30am through until 9:00am. In the option scenario, this capacity is reached at around 6,000 vph from approximately 6:45-8:00am. This indicates that whilst the capacity and throughput is higher, the flows still reach the capacity but for a shorter period of time.

After 8:00 the throughput decreases in the option for 2011 and 2021, indicating that the peak demand is getting through and the section of motorway is below capacity. In 2031 the option remains at capacity through to 9:00am. This can be attributed to a higher demand and an increase in lane change movements prior to the Aotea Quay off-ramp.
Figure 4-1 shows that not only is the total throughput higher over the whole period, but the throughput in the peak period is significantly higher in the option and there is less impact of flow constraints on those arriving towards the end of the morning period.

Table 4.6 PM 3 Hour Traffic Flow Throughputs at Points on Northbound Route

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2021</th>
<th>2031</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do Minimum</td>
<td>3,580</td>
<td>4,130</td>
<td>4,440</td>
</tr>
<tr>
<td>Option</td>
<td>3,600</td>
<td>4,270</td>
<td></td>
</tr>
<tr>
<td>SH1 Before Aotea Quay On Ramp</td>
<td>11,500</td>
<td>12,040</td>
<td>13,450</td>
</tr>
<tr>
<td>Do Minimum</td>
<td>11,490</td>
<td>12,360</td>
<td></td>
</tr>
<tr>
<td>Option</td>
<td>11,480</td>
<td>12,040</td>
<td></td>
</tr>
<tr>
<td>SH1 After Aotea Quay On Ramp</td>
<td>15,080</td>
<td>16,500</td>
<td>17,740</td>
</tr>
<tr>
<td>Do Minimum</td>
<td>15,100</td>
<td>16,410</td>
<td></td>
</tr>
<tr>
<td>Option</td>
<td>15,250</td>
<td>17,400</td>
<td></td>
</tr>
<tr>
<td>Hutt Road</td>
<td>3,920</td>
<td>4,420</td>
<td>4,200</td>
</tr>
<tr>
<td>Do Minimum</td>
<td>3,900</td>
<td>4,200</td>
<td></td>
</tr>
<tr>
<td>Option</td>
<td>4,070</td>
<td>4,200</td>
<td></td>
</tr>
<tr>
<td>SH1 Before SH1/SH2 Diverge</td>
<td>15,090</td>
<td>16,340</td>
<td>17,740</td>
</tr>
<tr>
<td>Do Minimum</td>
<td>15,100</td>
<td>16,340</td>
<td></td>
</tr>
<tr>
<td>Option</td>
<td>15,230</td>
<td>17,740</td>
<td></td>
</tr>
<tr>
<td>Ngauranga Gorge</td>
<td>12,240</td>
<td>12,360</td>
<td>12,130</td>
</tr>
<tr>
<td>Do Minimum</td>
<td>12,240</td>
<td>13,260</td>
<td></td>
</tr>
<tr>
<td>Option</td>
<td>12,760</td>
<td>12,130</td>
<td></td>
</tr>
<tr>
<td>SH2 East of Gorge</td>
<td>10,190</td>
<td>10,310</td>
<td>10,710</td>
</tr>
<tr>
<td>Do Minimum</td>
<td>10,190</td>
<td>10,310</td>
<td></td>
</tr>
<tr>
<td>Option</td>
<td>10,120</td>
<td>10,710</td>
<td></td>
</tr>
<tr>
<td>SH2 On Ramp</td>
<td>2,710</td>
<td>2,450</td>
<td>2,150</td>
</tr>
<tr>
<td>Do Minimum</td>
<td>2,710</td>
<td>2,450</td>
<td></td>
</tr>
<tr>
<td>Option</td>
<td>2,760</td>
<td>2,150</td>
<td></td>
</tr>
</tbody>
</table>

As presented in Table 4.6 higher flows are accommodated at a number of key points on the northbound route in the three hour PM period in the option than in the do minimum. The main differences in throughput are on SH1 in the vicinity of Aotea Quay on-ramp and prior to the SH1/2 diverge. The 2011 throughputs are generally similar, but in 2021 and 2031 the option performs better, with a higher throughput (up to 1,000vph greater) achieved at these key locations.

Figure 4.2 shows that in the do minimum scenario the traffic flow is constrained by the consistency of flow from around 16:15pm until the end of the period. As well as the option lines showing that a greater number of vehicles get through in the peak period, the curve of the flows also shows that the flow is not artificially constrained.
In Table 4.6 it was shown that the total flows at this point are higher across the three hour period. Figure 4.2 shows that not only is the total throughput higher over the whole period, but the throughput in the peak period is significantly higher and there is less impact of flow constraints on those arriving towards the end of the morning period.

4.1.5. Travel Times

The operational modelling has focused on the effect of the project on travel times, as there is minimal induced traffic in the corridor. The assessment considers both the 2021 and 2031 future year operating conditions with and without the scheme in place, as well as the baseline 2011 year.

In relation to the average travel times, the routes extracted from the operational model, shown in Figure 4.3 and Figure 4.4 include routes along SH1 and SH2 to and from the city and Aotea Quay, as well as routes along Hutt Road.
Figure 4.3 Journey Time Routes for SH1

- **SH1 to Aotea Quay**
- **SH1 to CBD**
- **SH1 to Aotea Quay (via Hutt Road)**
- **SH1 to CBD (via Hutt Road)**

Southbound journey Time Routes extend north to include existing roaP1 approx. 1km north of Gorge.
Detailed modelling of the Project area has been undertaken to gain an operational understanding of the Project route. Two 2011 models were produced using the same demands, the first is a 2011 model which does not include the Early Works or the right turn rule change implemented in March 2012, the second includes both the Early Works and the rule change.

Table 4.7 summarises the average journey times on the Southbound routes in the AM peak period in these two 2011 models.

<table>
<thead>
<tr>
<th>Journey Path</th>
<th>Pre-Early Works 2011</th>
<th>Do Minimum 2011 (Post Early Works and Rule Change)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SH1 – CBD</td>
<td>17.8</td>
<td>17.1</td>
</tr>
<tr>
<td>SH1 – Quays</td>
<td>20.7</td>
<td>20.0</td>
</tr>
</tbody>
</table>
4.1.6. Comparison of Pre Early Works and Do Minimum Models

The average journey times shown in Table 4.7 show that the micro-simulation modelling predicts that the early works and rule change result in a decrease in journey times of up to half a minute on routes from SH1 into the CBD and the Quays, along the SH1 route. The journey times on routes from SH2 are predicted to stay fairly consistent between the two models. Both routes along the Hutt Road to the Quays are also predicted to experience small decreases in journey time.

4.1.7. Comparison of Do Minimum model to Bluetooth Data

The journey time routes in the model represent a different path from those extracted from the Bluetooth data and therefore the journey times are not comparable though the patterns and relationships between different routes can be broadly compared. From the Bluetooth data it is indicated that the journey time from SH2 into the CBD is approx. 50% shorter than from SH1, the pre early works modelling supports the finding that the route from SH2 is quicker, however the difference is slightly more pronounced than shown in the Bluetooth data, due to the different route lengths covered.

Table 4.8 summarises the average journey times on the Northbound routes in the PM peak period in the two 2011 models. It should be noted that the routes recorded northbound cover a shorter length north of Ngauranga Gorge, than the southbound routes.

<table>
<thead>
<tr>
<th>Journey Path</th>
<th>Pre-Early Works 2011</th>
<th>Do Minimum 2011 (Post Early Works and Rule Change)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SH2 – CBD</td>
<td>5.7</td>
<td>5.8</td>
</tr>
<tr>
<td>SH2 – Quays</td>
<td>9.1</td>
<td>8.9</td>
</tr>
<tr>
<td>SH1 – CBD via Hutt Rd</td>
<td>16.2</td>
<td>16.0</td>
</tr>
<tr>
<td>SH1 – Quays via Hutt Rd</td>
<td>20.8</td>
<td>20.4</td>
</tr>
<tr>
<td>SH2 – CBD via Hutt Rd</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td>SH2 – Quays via Hutt Rd</td>
<td>10.5</td>
<td>10.1</td>
</tr>
</tbody>
</table>

4.1.8. Comparison of the Pre Early Works and Do Minimum Models

The average journey times presented in Table 4.8 show that the modelling predicts a very small impact on travel times of the Early Works and rule change on the northbound routes. The journey times from the CBD
along the State Highway routes are predicted to experience small decreases in journey times. All other journey times are expected to remain broadly consistent.

4.1.9. Comparison of Do Minimum and Bluetooth Data

Again as the journey time routes in the model are not the same length as the Bluetooth data the journey times are not comparable though the patterns and relationships between different routes can be broadly compared. The Bluetooth data indicates that the journey time from the CBD to SH1 is slightly quicker than the journey to SH2, which is a similar pattern to the modelling for both the pre early works and the do minimum models.

4.1.10. Summary of Do Minimum

The results presented throughout the rest of the report are based on the Do Minimum modelling as this is what currently existed at the time of preparing the report; from the above comparisons it is apparent that the Do Minimum scenario includes some improvements as a result of the Early Works and rule change, however the changes are fairly equal across the different routes and do not affect the integrity of the model. The patterns and relationships of journey times in the Do Minimum broadly match the Bluetooth data.

Table 4.9 summarises the changes in average journey time in the Do Minimum scenario from 2011 to 2031 on the main routes in the AM and PM peak periods.

| Table 4.9 Comparison of Do Min Journey Times in Future Years Peak Periods |
|-----------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Direction of travel               | AM Peak Period Do Min |                         |                      | PM Peak Period Do Min |                         |                      |
|                                   | 2011 | 2021 | 2031 | 2011 | 2021 | 2031 |
| SH1 – CBD                         | South | 17.1 | 18.6 | 28.2 | 13.8 | 13.9 | 13.9 |
| SH1 – Quays                       | South | 20.0 | 19.8 | 29.9 | 15.1 | 15.0 | 15.1 |
| SH2 – CBD                         | South | 5.8  | 6.2  | 7.3  | 3.7  | 3.7  | 3.7  |
| SH2 – Quays                       | South | 8.9  | 7.8  | 9.0  | 5.0  | 4.9  | 5.0  |
| SH1 – CBD via Hutt Rd             | South | 16.0 | 16.6 | 31.3 | 14.8 | 14.8 | 14.8 |
| SH1 – Quays via Hutt Rd           | South | 20.4 | 18.9 | 21.4 | -    | -    | -    |
| SH2 – CBD via Hutt Rd             | South | 5.5  | 5.5  | 11.7 | 4.4  | 4.5  | 4.4  |
| SH2 – Quays via Hutt Rd           | South | 10.1 | 7.7  | 8.4  | -    | -    | -    |
| CBD – SH1                         | North | 3.0  | 3.0  | 3.0  | 4.5  | 5.7  | 5.8  |
| Quays – SH1                       | North | 4.2  | 4.1  | 4.1  | 5.0  | 5.8  | 8.1  |
| CBD – SH2                         | North | 3.5  | 3.6  | 3.6  | 4.9  | 6.3  | 5.9  |
| Quays – SH2                       | North | 4.8  | 4.7  | 4.7  | 5.7  | 6.7  | 8.6  |
| CBD – SH1 via Hutt Rd             | North | 5.1  | 5.1  | 5.1  | 7.8  | 10.4 | 10.2 |
| Quays – SH1 via Hutt Rd           | North | -    | -    | -    | -    | 8.3  | -    |
| CBD – SH2 via Hutt Rd             | North | 7.2  | 9.3  | 9.6  | 7.3  | 7.4  | 10.0 |
| Quays – SH2 via Hutt Rd           | North | -    | -    | -    | -    | -    | -    |
| SH1 – SH2                         | North | 13.0 | 13.7 | 21.5 | 13.6 | 12.8 | 12.5 |
AM Peak:

Generally the journey times along southbound routes are shown to get progressively longer from 2011 to 2031 in the do minimum scenario. In the AM peak the southbound routes to the Quays both by SH1 and the Hutt Road, are predicted to see a decrease in journey times from 2011 to 2021 which is due to improvements to the signal timings at the intersections on Aotea Quay. These journey times are then expected to increase from 2021 to 2031. The exception to this is SH1 – Quays via Hutt Road which gets slightly shorter in 2021 and then longer again by 2031, this is likely to be due to minor signal changes, however very few vehicles use this route.

For the northbound routes the journey times using both SH1 and Hutt Road are predicted to stay consistent from 2011 to 2031. Two northbound routes show an increase in journey time. From the CBD to SH2 via the Hutt Road an increase in 2021 is predicted, this is due to increased congestion on the Hutt Road On Ramp where vehicles on the on ramp struggle to assert themselves against flows on the mainline. The movement from SH1 – SH2 is predicted to stay reasonably constant to 2021 but then increases in 2031, this is due to vehicles making this movement being caught in the queuing from the merge which extends beyond the off ramp and so delays those wishing to exit at the off ramp. By 2031 far less vehicles make this movement due to the Petone to Granada link being opened.

PM Peak:

On all of the northbound routes the journey times are predicted to increase between 2011 and 2021. For all but one route this trend continues from 2021 to 2031. For the route from the CBD to SH2 the journey times are predicted to decrease from 2021 to 2031, this is due to there being less disruption on SH2 around the Hutt Road on ramp, due to less traffic making the SH1 – SH2 movement as a result of the Petone – Granada scheme.

The journey times on the southbound routes are predicted to remain consistent between 2011 and 2031.

Inter-peak:

In the inter-peak period the travel times remain consistent from 2011 to 2031 with no notable changes.

Comparison of Do Minimum and Option Scenarios

Table 4.10 provides a summary of the predicted average travel times (minutes) southbound in the network, comparing the 2011 operational model outputs with the predicted operation in each forecast scenario for the morning peak period.

<table>
<thead>
<tr>
<th>Journey Path</th>
<th>2011</th>
<th>2021</th>
<th>2031</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do Minimum</td>
<td>Option</td>
<td>Do Minimum</td>
</tr>
<tr>
<td>SH1 – CBD</td>
<td>17.1</td>
<td>15.4</td>
<td>18.6</td>
</tr>
<tr>
<td>SH2 – CBD</td>
<td>5.8</td>
<td>4.2</td>
<td>6.2</td>
</tr>
<tr>
<td>SH1 – Quays</td>
<td>20.0</td>
<td>17.6</td>
<td>19.8</td>
</tr>
<tr>
<td>SH2 – Quays</td>
<td>8.9</td>
<td>6.5</td>
<td>7.8</td>
</tr>
<tr>
<td>SH1 – CBD via Hutt Rd</td>
<td>16.0</td>
<td>15.8</td>
<td>16.6</td>
</tr>
<tr>
<td>SH2 – CBD via Hutt Rd</td>
<td>5.5</td>
<td>5.2</td>
<td>5.5</td>
</tr>
<tr>
<td>SH1 – Quays via Hutt Rd</td>
<td>20.4</td>
<td>-</td>
<td>18.9</td>
</tr>
<tr>
<td>SH2 – Quays via Hutt Rd</td>
<td>10.1</td>
<td>10.1</td>
<td>7.7</td>
</tr>
</tbody>
</table>

The main points relating to the southbound travel times in the morning peak from Table 4.10 are identified as:
2011 Scenarios

- Southbound travel times on both the state highway and Hutt Road are predicted to decrease or be unchanged with the implementation of the option.
- Improvements of between 1.5 and 2.5 minutes are predicted for routes from SH1 using the State Highway network. The improved journey time on SH1 diverts traffic heading to Aotea Quay off Hutt Road and onto the motorway.
- The routes from SH2 are predicted to see decreases in journey time of around 1.5 minutes.

2021 Scenarios

- With the exception of the routes to the Quays via Hutt Road, all of the travel times in 2021 are expected to be lower or unchanged with the implementation of the option than in the do minimum.
- The routes from SH1 and SH2 to the city are predicted to see the greatest decreases in journey time, with the journey from SH1 expected to be two minutes quicker, and the journey from SH2 expected to be over a minute and a half quicker.
- A small increase in travel time from SH1 to the Quays via Hutt Road is predicted in the option, above the do minimum travel time. This is due to the fact that this route is only used by a small number of vehicles, who re-route during a short period when the State Highway network experiences a peak, therefore the only results are during the peak period rather than reflecting the operation of the Hutt Road over the modelled time period.
- The other travel times via the Hutt Road are anticipated to remain consistent or slightly decrease between the do minimum and the option.

2031 Scenarios

- Travel times from SH2 to both the CBD and the Quays are predicted to be lower with the option than in the do minimum by approximately two minutes.
- The routes from SH1 to both the CBD and the Quays are predicted to be lower with the option than in the do minimum by over five minutes.
- Travel times along Hutt Road in this morning peak are predicted to stay consistent or decrease between the do minimum and the option.

Table 4.11 provides a summary of the predicted average travel times (minutes) on the Northbound routes for the Do Minimum and Option in each of the modelled years for the PM period.

**Table 4.11 Comparison of Evening Peak Northbound Travel Times (Mins)**

<table>
<thead>
<tr>
<th>Journey Path</th>
<th>2011</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do Minimum</td>
<td>Option</td>
<td>Do Minimum</td>
<td>Option</td>
<td>Do Minimum</td>
</tr>
<tr>
<td>CBD – SH1</td>
<td>4.5</td>
<td>3.3</td>
<td>5.7</td>
<td>4.5</td>
<td>5.8</td>
</tr>
<tr>
<td>CBD – SH2</td>
<td>4.9</td>
<td>4.1</td>
<td>6.3</td>
<td>4.9</td>
<td>5.9</td>
</tr>
<tr>
<td>Quays – SH1</td>
<td>5.0</td>
<td>4.4</td>
<td>5.8</td>
<td>5.0</td>
<td>8.1</td>
</tr>
<tr>
<td>Quays – SH2</td>
<td>5.7</td>
<td>5.2</td>
<td>6.7</td>
<td>5.7</td>
<td>8.6</td>
</tr>
<tr>
<td>CBD – SH1 via Hutt Rd</td>
<td>7.8</td>
<td>7.4</td>
<td>10.4</td>
<td>7.8</td>
<td>10.2</td>
</tr>
<tr>
<td>CBD – SH2 via Hutt Rd</td>
<td>7.3</td>
<td>8.4</td>
<td>7.4</td>
<td>7.3</td>
<td>10.0</td>
</tr>
<tr>
<td>Quays – SH1 via Hutt Rd</td>
<td>7.5</td>
<td>-</td>
<td>8.3</td>
<td>7.5</td>
<td>5.8</td>
</tr>
<tr>
<td>Quays – SH2 via Hutt Rd</td>
<td>-</td>
<td>-</td>
<td>10.9</td>
<td>-</td>
<td>6.8</td>
</tr>
<tr>
<td>SH1 – SH2</td>
<td>13.6</td>
<td>14.9</td>
<td>12.8</td>
<td>13.6</td>
<td>12.5</td>
</tr>
</tbody>
</table>

The main points regarding the northbound journey times in the PM from Table 4.11 are identified as:
2011 Scenarios
- Travel times on SH1 and SH2 are predicted to improve with the implementation of the scheme.
- Significant reductions in travel times are predicted on the routes from the CBD to SH1 and SH2.
- Traffic from Aotea Quay to SH1 and SH2 travel via the motorway to take advantage of the improved motorway times and avoid the SH2 Hutt Road on-ramp.
- An increase in travel time (in the option) is predicted for routes using the SH2 Hutt Road on-ramp. Additional queuing on the on-ramp is noted due to the higher volumes of traffic on the mainline making merging more difficult.

2021 Scenarios
- All of the routes on the state highway are predicted to experience lower journey times with the implementation of the option than in the do minimum. The journey times are predicted to be between one and two minutes quicker.
- As with the 2011 scenario, the improvements on the state highway are expected to result in rerouting of vehicles from Hutt Road in the do minimum, to use the state highway in the option.
- Vehicles making the movement from SH1 – SH2 are predicted to experience a small increase in journey time, due to queuing on the Hutt Road on-ramp. With the four-laning in place, the modelling predicts that vehicles will transfer onto SH1/SH2 from the Hutt Road. The increase in traffic on SH1/SH2 makes it more difficult for vehicles from the on-ramp to merge with SH2, thereby increasing delay for these vehicles.

2031 Scenarios
- With the exception of the movement from SH1 to SH2 northbound, all routes are predicted to experience lower journey times in 2031 with the scheme implemented than in the do minimum.
- The largest decreases in journey time are predicted on the routes from the Quays to SH1 and SH2 using the state highway. Travel times are predicted to be over three minutes quicker with the option than in the do minimum due to a combination of the Aotea Quay on-ramp improvements and widening.
- Improvements on the state highway are expected to result in rerouting of the vehicles from Hutt Road onto the state highway.
- Travel times from SH1 to SH2 are predicted to be slightly higher with the option than in the do minimum, however the difference is much less pronounced in 2031 when the Petone-Grenada link is assumed to be open. This reduces the traffic volumes on this movement, and the travel time is less than the travel time in the 2011 do minimum scenario.

4.1.11. Journey Time Variability
To replicate aspects of the day to day variability in driver behaviors and to reduce potential bias each micro-simulation model was run ten times. The multiple model runs also allow for the variability of journey times to be ascertained by comparing the journey times between each model run, which approximate different driver behaviors on different days. In reality the traffic flows will also vary day to day and seasonally. As the model runs all use the same traffic demands, this element of the variability will not be fully captured in the micro simulation modelling.

Figure 4.5 and Figure 4.6 present the mean travel time and the 10th percentile and 90th percentile travel times for the routes along the state highway between the Terrace Tunnel and Petone for the do minimum and full option. The percentile lines show the range of journey times within which 80% of journey times fall.
Figure 4.5 and Figure 4.6 show that in the do minimum, in the peak period for each direction the mean journey time increases due to the increased congestion. The difference between the 10th, 50th and 90th percentile vehicles also increases, indicating that some of the journey time variability expected in the peak periods is captured by the model. When comparing Figures 4.5 and 4.6 against Figures 2.4 and 2.5 above (observed travel time variability), however, it becomes apparent that the model is only capturing a small component of the total variability.

In the case of the option tests, the amount of variability is lower than in the do minimum with much less difference observed between the 10th and 90th percentile journey times. This is likely to be a combination of the lower congestion and journey times achieved with the option and the implementation of ATMS which will have
smoothed out traffic speeds. Research indicates that there is a strong positive correlation between level of congestion and level of travel time variability. Therefore, with reductions in mean journey time attributed to the scheme, corresponding reductions in variability should be expected. This analysis indicates a 15% reduction in variability.

As mentioned above, the variability from the micro-simulation modelling captures the different driver behaviours well, but not daily fluctuations in traffic flow. Therefore, this modelled reduction is likely to represent an under-estimate. Data from the M42 motorway in the United Kingdom demonstrates that a 22% reduction in variability can be directly attributed to the introduction of ATMS alone.

Operational Model Observations

Observations from the micro-simulation modeling of the key aspects of the scheme area are discussed below. To replicate the day to day variability in driver behaviors and to reduce potential bias each micro-simulation model was run ten times. The observations below are based on reviewing a small number of runs and therefore the extent of queuing in certain areas will be subject to some variability, however the causality will be the same across the runs.

Morning Period Observations

In the weekday morning period there are three distinct areas which influence the southbound movement across the models. The explanations of these areas and the extent to which they are relieved or aggravated by the implementation of the option are discussed below:

a) SH1/SH2 Merge (Current Issue)

The do minimum modelling for 2011 shows that there is a significant issue at the SH1/SH2 merge where the outside lane from SH1 and the inside lane from SH2 merge into a single lane. This queuing from the merge is observed to affect SH1 to a greater extent than SH2, with queuing extending up the Ngauranga Gorge. Platoons of queuing vehicles are observed on both SH1 and SH2, primarily from the inner lanes at the merge.

The do minimum models for 2021 and 2031 show this merge continuing to cause problems, with the queuing on SH1 propagating increasingly further back up the gorge. In both forecast years queuing is observed to extend back from the merge as far as the model extent on SH1, with some queuing occurring outside of the model network.

This congestion resulting from the SH1/SH2 merge in the do minimum models is not apparent in the option models, where the merge occurs in a four lane section.

b) Aotea Quay Off-Ramp Weave (Current Issue)

In the 2011 do minimum model a notable weave occurs prior to the Aotea Quay off-ramp, where vehicles weave across to exit at Aotea Quay. All vehicles travelling from SH2 to the Aotea Quay off ramp undertake this weave, as do vehicles from SH1 that travel in the middle lane. The 2011 do minimum model shows the queuing from this weave propagates back to the SH1/SH2 merge and interacts with the congestion caused by the merge.

The do minimum forecasts for 2021 and 2031 show the weave causing slightly less congestion than in 2011; however this is likely as a result of the worsening merge regulating the flow which gets through to the weave point.

The converse is observed in the option forecasts, whereby the congestion at the merge is alleviated and the bottleneck moves downstream to the off-ramp weave. The additional lane between Ngauranga and Aotea Quay also creates additional weaving movements, as Aotea Quay becomes a lane drop. This adds an additional lane change to vehicles travelling from SH2, and requires any vehicles travelling from SH1 towards the city to move out of the outside lane.

The 2011 and 2021 option model shows localised congestion between Ngauranga and Aotea Quay as a result of weaving vehicles and queuing is not observed further upstream on either SH1 or SH2. The 2031
forecast of the option scenario shows a breakdown of traffic flow over the distance where the weave for the Aotea Quay off-ramp occurs. This queue extends back up Ngauranga Gorge and results in some traffic heading to Aotea Quay diverting onto Hutt Road.

This is an issue which will legitimately be occurring on site, however it is likely that the operational model may be overstating the extent of the weave issue as the area over which vehicles can weave is artificially constrained. Lane selection is also likely to occur at an earlier point as those on SH1 and SH2 may choose the most appropriate lane further north to minimise the amount of lanes which need to be crossed in a single movement closer to the off-ramp.

c) Hutt Road Congestion (Future Issue)

An increase in congestion is observed southbound on Hutt Road in both 2031 scenarios. Additional queuing is noted at the Kaiwharawhara signalised intersection, above model observations from 2011 and 2021. This queuing is predicted with both the do minimum and option scenarios, with little difference between the two.

Queuing is also observed for the right turn movement from Hutt Road to the SH2 on-ramp in 2031. Further optimisation of the signal timings at this intersection would alleviate this congestion.

The additional congestion on Hutt Road is likely to be due to a combination of the additional traffic growth in 2031 and the increase in congestion noted on SH1.

Evening Period Observations

In the weekday evening period there are five distinct areas of focus which affect the northbound movement across the study area. The explanations of these issues and the extent to which they are relieved or aggravated by the implementation of the option are discussed below:

a) Aotea Quay On Ramp Merge

In the 2011 do minimum the Aotea Quay on ramp merge area is observed to cause queuing back on the on-ramp, with queues observed to extend back under the motorway. At the start of the evening peak, traffic on the on ramp has problems finding gaps in the traffic on SH1 and queuing builds up on the on ramp. This queuing begins to dissipate as congestion builds on SH1 northbound and slows traffic upstream of the on-ramp merge.

The 2021 and 2031 do minimum models show a similar pattern of queuing from the Aotea Quay on ramp merge, with the queuing on the on ramp shown to get progressively worse over time.

In the option models for 2011 and 2021 the queuing on the on ramp is significantly reduced from the do minimum as a result of the Aotea Quay on-ramp joining as a lane gain.

b) Weaving Prior to SH1/SH2 Diverge

In all three of the do minimum models queuing is shown to originate from the weave area prior to the SH1/SH2 diverge. Lane changes are required for a proportion of vehicles heading to both SH1 and SH2, depending on the lane that they originate in.

The 2011 model shows queuing from this weave area propagating back downstream and this is observed to get progressively worse in each of the forecast years. In 2021 and 2031 the queuing shockwaves from the weave area are shown to interact with the Aotea Quay on-ramp merge, with traffic on the on-ramp finding opportunities to merge into queuing traffic due to this effect.

The option models show that in each modelled year some weaving issues remain with the option implemented, however the weave is shown to cause less queuing in each forecast year than in the corresponding do minimum scenario.
c) Hutt Road Queuing

Hutt Road is shown to operate at similar levels in the 2011 and 2021. There is some queuing noted at the signalised intersections but it is generally transitory, with both the do minimum and option models performing similarly.

By 2031 substantial queuing is predicted on Hutt Road in both the do minimum and option models. The modelling shows that nearly all of the traffic using the Hutt Road in 2031 is heading to SH1, with much of this traffic having originated from the Tinakori Road/Thorndon Quay ‘CBD’ area in the model. It is noted that this movement through the model does not have the option of rerouting onto the state highway; rather the route choice is taken directly from WTSM. It is likely that alternative options for accessing SH1 from this area would be utilised, with a proportion of vehicles rerouting onto the state highway.

d) SH1 Northbound On-Ramp at Ngauranga Gorge

The do minimum models show queuing on the Hutt Road SH1 on-ramp due to the two to one lane drop. The queuing is shown to extend back to just prior to the signalised intersection, but is not observed to block back through the signals in the models. The signal timings work effectively and hold back traffic that is heading for the on-ramp, but for which there is no storage space. This issue is predicted to be relatively stable from 2011 to 2021. In the 2031 model the queuing on the on-ramp is lower due to lower traffic volumes from SH2 to SH1 (Petone to Grenada is opened) and further optimisation of signal timings would balance queuing on the on-ramp and Hutt Road.

The option models for each modelled year show a very similar pattern and level of queuing to the corresponding do minimum year as the scheme does not specifically target this area.

e) Hutt Road On-Ramp to SH2

The 2011 do minimum model predicts queuing on the Hutt Road on-ramp, but very little impact on the SH2 mainline at the merge area which is shown to be busy but with free flowing traffic. The level of traffic flows and traffic speeds on the SH2 mainline makes it difficult for traffic on the on-ramp to find suitable gaps in traffic resulting in queuing on the on-ramp.

In the 2021 do minimum model the queuing on the Hutt Road on-ramp is predicted to have decreased significantly from the 2011 model as the queuing on Hutt Road holds back traffic from the on-ramp, regulating the flow and resulting in less queuing. By 2031 virtually no queuing is predicted on the on-ramp due to the extent of the queuing on Hutt Road and rerouting of traffic to the mainline.

The 2011 option model predicts the queuing on the on-ramp to be slightly worse than in the do minimum model, as the increased throughput on SH2 make it increasingly difficult for traffic on the on-ramp to merge into the SH2 traffic. The geometric changes to the on-ramp mean there is more stacking room for the increased queuing and the queue is not observed in the models to extend as far as the signals.

In the 2021 option model the queuing at the on-ramp is predicted to be significantly worse than in the do minimum model, which is largely due to the increased throughput on SH2 making it difficult for on-ramp traffic to find appropriate gaps. It is also notable that in this model there is less queuing on the Hutt Road, therefore some of the increased queuing seen at the on-ramp may simply be displaced queuing from the adjacent signals.

Similar to the do minimum model, by 2031 the option model shows very little queuing at the on-ramp due rerouting of traffic destined for SH2 onto the state highway.

4.2. Statutory Planning

4.2.1. Introduction

As an overall summary, this project is more ‘operational’ in nature with the physical works being relatively minor and able to be undertaken within the existing highway footprint and designation boundary. There will be
some physical works staged over time, as described in Section 9; however the social and environmental effects generated by these works will be no more than minor and in fact should result in an overall long-term positive effect for the road user and the environment (for example air quality) as those works help to ease congestion, smooth traffic flows and provide greater journey time reliability.

4.2.2. Planning Approvals

Planning approvals are expected to be relatively straightforward in nature and are summarised as follows:

<table>
<thead>
<tr>
<th>Table 4.12: Statutory Planning Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consenting Authority</strong></td>
</tr>
<tr>
<td>Wellington City Council</td>
</tr>
<tr>
<td>Greater Wellington Regional Council</td>
</tr>
</tbody>
</table>

Consenting requirements for works in proximity to the Coastal Marine Area (CMA), for the construction of the retaining wall, will be confirmed during detailed design. At this stage it is envisaged that the actual structure will not be located in the CMA, and falls within the designation boundary, however a consent for disturbance of the CMA may be required for the construction of the retaining wall.

The preliminary assessment indicates that the storm water design will meet the permitted activity standards of the relevant regional plan; this will be confirmed at the detailed design stage.

4.2.3. Social and Environmental Management

A full social and environmental management form (PSF13) is provided at Appendix K. That form shows that there are no significant social and environmental issues for this project and all effects identified can be sufficiently avoided, remedied and/or mitigated. The key social and environmental matters are summarised in Table 4.13 below.

<table>
<thead>
<tr>
<th>Table 4.13: Key Social and Environmental Management Matters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Issue</strong></td>
</tr>
<tr>
<td>Construction effects – Noise, Air Quality, Spill</td>
</tr>
<tr>
<td>Water Resources</td>
</tr>
</tbody>
</table>
### 4.2.4. Designation Boundary

As discussed above the NZTA continues to work with WCC to confirm the designation boundary in the area of the Thorndon Overbridge. The designation boundary as currently understood by NZTA is shown on the scheme plans. Depending on the outcome of the designation boundary confirmation, an alteration to designation may be required for the widening of the Thorndon Overbridge. Excluding the area of the Thorndon Overbridge, the physical extent of the highway and proposed improvements are within the existing designation boundary.

### 4.2.5. Property Acquisition

Additional property will not be required to accommodate the preferred scheme as proposed. If the emergency on-ramp is to be constructed at Ngauranga, property will be required from Kiwirail. To date no property discussions have taken place with Kiwirail.

### 4.3. Transport Policy Assessment

During the scoping stage, the Project was assessed against the Government Policy Statement objectives, the New Zealand Transport Strategy, and the Land Transport Management Act and was found to be consistent with each of these government policies.

A funding profile assessment is required in order for the Project to be funded by NZTA. It is understood that NZTA have moved away from the PPFM to the Planning and Investment Knowledge Base (Knowledge Base).

The Project was assessed against the criteria for new and improved state highway infrastructure. This assessment is summarised below.

#### 4.3.1. Strategic Fit

The Project has a **High** Strategic Fit because it is a Road of National Significance.

#### 4.3.2. Effectiveness

The effectiveness assessment factor considers the contribution that the proposed solution makes to achieving the potential identified in the strategic fit assessment, and to the purpose and objectives of the Land Transport Management Act. Higher ratings are provided for those proposals that provide long-term, integrated and enduring solutions. There is no default rating for effectiveness and therefore an assessment must be undertaken to determine if the Project meets a Low, Medium, or High Effectiveness Rating. The assessment of the Project against the Effectiveness criteria is documented below.

To achieve a Low Effectiveness rating, the Project must meet each of the following criteria:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Effect/ Degree of effect</th>
<th>Assessment and Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural</td>
<td>Low</td>
<td>Accidental discovery protocol for Construction Management Plan</td>
</tr>
<tr>
<td>Public Health, including driver stress and security</td>
<td>Low – likely to be a positive effect as traffic management is implemented</td>
<td>This is the most congested part of Wellington’s motorway network and the project objective is to ease congestion and smooth traffic flows as well as improve safety, route security and provide greater journey time reliability. This should result in less stress and higher personal security for road users.</td>
</tr>
</tbody>
</table>
**Table 4.14: Low Effectiveness Criteria Assessment**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>■ the potential impact or outcome identified in the 'strategic fit' assessment</td>
<td>The Project has a High Strategic Fit</td>
</tr>
<tr>
<td>■ an agreed level of service</td>
<td>As a RoNS the Project seeks to achieve a high level of service.</td>
</tr>
<tr>
<td>■ the purpose and objectives of the LTMA</td>
<td>The Project was assessed against the purpose and objectives of the LTMA and found to be highly consistent with the LTMA.</td>
</tr>
<tr>
<td>■ has considered or will consider:</td>
<td>The Project through the scoping and scheme assessment stage has considered the existing and forecast problems on SH1 and connecting roads within the study area, developed options for addressing those problems, and assessed the effects of those options.</td>
</tr>
<tr>
<td>– all relevant problems, issues and opportunities</td>
<td>The Project has sought opportunities for collaboration and has worked collaboratively with Wellington City Council, Greater Wellington Regional Council, Centreport, InterIslander, and Kiwirail on addressing Port access. Further collaboration with Centreport and the InterIslander will occur in the design phase to minimise adverse effects on the operation of their facilities due to the widening of the Thorndon Overbridge.</td>
</tr>
<tr>
<td>– all appropriate alternatives and options</td>
<td></td>
</tr>
<tr>
<td>– opportunities for collaboration</td>
<td></td>
</tr>
<tr>
<td>– any adverse effects or impacts</td>
<td></td>
</tr>
<tr>
<td>■ is an affordable solution with a funding plan</td>
<td>The Project is included in the Wellington Regional Land Transport Plan and so is considered to have a funding plan. NZTA ultimately will determine if the Project is affordable when a construction funding application is made.</td>
</tr>
<tr>
<td>■ avoids duplication of activities</td>
<td>The Project is not duplicated with other transport activities</td>
</tr>
<tr>
<td>■ the scale of the proposed solution is appropriate to the potential impact or outcome in the strategic fit assessment</td>
<td>The scale of the activity is considered appropriate: it meets the objectives of the RoNS while making best use of the existing corridor.</td>
</tr>
<tr>
<td>■ includes a monitoring and review framework in plans and strategies, and other activities where appropriate.</td>
<td>The Project will include ongoing review of the ATMS operation and safety management system.</td>
</tr>
</tbody>
</table>

Based on the assessment above the Project meets the criteria for a Low Effectiveness rating.

The Project may be given a Medium rating for Effectiveness if evidence is provided to demonstrate that it meets each of the following criteria:
Table 4.15: Medium Effectiveness Criteria Assessment

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>all the low effectiveness criteria</td>
<td>The Project meets all of the low effectiveness criteria</td>
</tr>
<tr>
<td>is part of or will contribute to an NZTA supported strategy, endorsed</td>
<td>The Project is part of the NZTA endorsed Ngauranga to Airport Corridor Plan and is a</td>
</tr>
<tr>
<td>programme or plan (for inclusion to the NLTP a completed strategy that</td>
<td>RoNS project as part of the Wellington Northern Corridor.</td>
</tr>
<tr>
<td>will be presented to the NZTA for support in the near future may be</td>
<td></td>
</tr>
<tr>
<td>considered sufficient)</td>
<td></td>
</tr>
<tr>
<td>is significantly effective (will deliver a measurable impact or outcome</td>
<td>The Project is significantly effective in that it delivers significant travel time</td>
</tr>
<tr>
<td>in achieving the potential impact or outcome identified in the ‘strategic</td>
<td>savings and improves reliability while remaining within the existing corridor.</td>
</tr>
<tr>
<td>fit’ assessment.</td>
<td></td>
</tr>
<tr>
<td>provides a long term solution with enduring benefits appropriate to the</td>
<td>The Project provides long term benefits as demonstrated by the traffic modelling and</td>
</tr>
<tr>
<td>scale of the solution</td>
<td>economic analysis.</td>
</tr>
<tr>
<td>provides a solution that responds to land use strategies and</td>
<td>As part of the Ngauranga to Airport Corridor Plan (which was responsive to the Wellington</td>
</tr>
<tr>
<td>implementation plans, where appropriate to the activity</td>
<td>Transport and Urban Growth Strategies) the Project is an integral part of an integrated</td>
</tr>
<tr>
<td>provides a solution that makes a contribution to multiple GPS impacts,</td>
<td>land use and transport plan. Further, the Project has sought to be consistent with plans</td>
</tr>
<tr>
<td>where appropriate to the activity</td>
<td>for the redevelopment of the InterIslander Ferry Terminal and Centreport.</td>
</tr>
</tbody>
</table>

The Project meets the criteria for a Medium Effectiveness rating based on the assessment above.

Knowledge Base states that a High rating for Effectiveness must only be given if evidence is provided to demonstrate that the activity or combination of activities delivers on each of the following:

Table 4.16: High Effectiveness Criteria Assessment

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>covers all of the low and medium effectiveness criteria</td>
<td>The Project meetings all of the low and medium effectiveness criteria.</td>
</tr>
<tr>
<td>is a key component of an NZTA-supported strategy, endorsed package,</td>
<td>The Project is part of the NZTA endorsed Ngauranga to Airport Corridor Plan and the</td>
</tr>
<tr>
<td>programme or plan (for inclusion to the NLTP a completed strategy that</td>
<td>Wellington Northern Corridor RoNS.</td>
</tr>
<tr>
<td>will be presented to the NZTA for support in the near future may be</td>
<td></td>
</tr>
<tr>
<td>considered sufficient)</td>
<td></td>
</tr>
<tr>
<td>is part of a whole-of-network approach</td>
<td>The Ngauranga to Airport Corridor Plan was a whole-of-network strategy and as a key</td>
</tr>
<tr>
<td></td>
<td>component of that Corridor Plan, it is considered that the Project is part of a</td>
</tr>
<tr>
<td></td>
<td>whole-of-network approach.</td>
</tr>
<tr>
<td>improves integration within and between transport modes, where</td>
<td>The Project is a key component of the Ngauranga to Airport multi-modal transport strategy.</td>
</tr>
<tr>
<td>appropriate to the activity</td>
<td>The Project delivers the state highway component of the package will also included bus</td>
</tr>
<tr>
<td></td>
<td>lanes on the Hutt Road. It is considered that the Project improves integration within and</td>
</tr>
<tr>
<td></td>
<td>between</td>
</tr>
</tbody>
</table>
## Criteria and Comment

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>provides a strategic approach that successfully integrates land transport, land use, other infrastructure and activities, where appropriate to the activity.</td>
<td>As discussed above the Project is part of a multimodal transport strategy which was consistent with the Wellington Transport and Urban Growth Strategies.</td>
</tr>
<tr>
<td>supports networks from a national perspective, where appropriate to the activity.</td>
<td>As a RoNS, and by providing significant travel time savings, it is considered that the Project supports the network from a national perspective.</td>
</tr>
<tr>
<td>provides a strategic approach that makes a significant contribution to multiple GPS impacts, where appropriate to the activity.</td>
<td>As discussed above, the Project makes a strong contribution to the GPS impacts.</td>
</tr>
<tr>
<td>is optimised against multiple transport outcomes and objectives.</td>
<td>The Project meets the objectives of the GPS, LTMA, and NZTS. By taking a staged approach to delivery, it is considered that the Project is optimised.</td>
</tr>
<tr>
<td>adopts a collaborative approach to the development of studies, strategies and plans.</td>
<td>As discussed above, the Project is part of a multi-modal transport strategy for Wellington and has worked collaboratively with Port stakeholders to resolve Port access issues.</td>
</tr>
</tbody>
</table>

Based on the assessment above the Project has an Effectiveness rating of **High**.

### 4.3.3. Efficiency

The Efficiency rating of the Project is based on the benefit-cost ratio (BCR). As described later in the report the Project has a BCR of 1.1. Therefore the Efficiency rating of the Project is **Low**.

### 4.3.4. Summary

During the scoping stage the Project was found to be highly consistent with the policies and objectives of the GPS, LTMA, and NZTS. During the scheme assessment stage the Project was assessed against the funding profile criteria contained in Knowledge Base. Based on the assessment of the funding profile criteria contained in Knowledge Base, the Project has a funding profile of:

- **High** Strategic Fit;
- **High** Effectiveness; and
- **Low** Efficiency

The evaluation of the preferred scheme has found that:

- The Project will deliver significant travel time savings and improved journey time reliability;
- There are no significant adverse environmental effects generated by the Project;
- An alteration to designation may be required for the Thorndon Overbridge Widening depending on the outcome of discussions between NZTA and WCC; and
- The Project has an NZTA funding profile of High, High, Low (HHL).
5. Consultation and Engagement

5.1. Introduction
As an overall summary, this project is more ‘operational’ in nature with the physical works being relatively minor and able to be undertaken generally within the existing highway footprint. The project should in fact have a predominantly positive long-term effect on all stakeholders and consultation has not identified any significant stakeholder conflicts or fatal flaws in relation to the preferred scheme. The widening of the Thorndon Overbridge will temporarily affect the operation of the InterIslander during construction. Further consultation with the Interislander and CentrePort will be required during detailed design with the aim of reducing and mitigating adverse effects during construction.

5.2. Purpose of Consultation for Scheme Assessment
During the scheme assessment stage, the purpose of consultation was to work with relevant stakeholders to identify important issues, constraints and opportunities to help inform the consideration and identification of a preferred scheme.

A focus was to build on the good level of consultation already undertaken prior to the scheme assessment stage. This included a series of workshops between February and June 2010 with NZTA; Greater Wellington Regional Council (GWRC); Wellington City Council (WCC); Kiwirail; Interislander; and CentrePort to help understand the wider context and strategic fit for this project. That consultation continued during the scheme assessment stage, with the NtAQ Project Team consulting with a range of operational and footprint stakeholders as outlined below.

Equally, this project has a relatively low-level of stakeholder impact and therefore stakeholder consultation has been limited compared to other RoNS projects. Consultation for this project has rather needed to be targeted more towards the ‘operational’ stakeholders to consider how the scheme would operate and also towards developing a project-specific Driver Awareness Strategy to help influence driver behaviour.

5.3. Stakeholder Management and Communications Strategy
Consultation and stakeholder activities are set out in a separate Stakeholder Management and Communications Strategy. This Strategy is focussed on undertaking an appropriate level of consultation to support the Project and meet statutory consultation requirements. The desired outcomes of this Strategy are:

1. Driver behaviour is influenced positively - improving driver behaviour to help ease congestion, smooth traffic flows and provide greater journey time reliability;
2. There is good awareness and understanding of the benefits of the Project and the need for the improvements; and
3. All stakeholders and the public feel well informed and listened to throughout the duration of the Project.

5.4. Stakeholder Groups
Stakeholders were engaged with broadly in terms of ‘operational’ and ‘footprint’ groups as summarised in Table 5.1. The engagement was important to ascertain how the scheme may integrate with the surrounding environment and land uses and also to gauge the main issues for the management of traffic, such as enforcement and the safe provision of emergency services.
### Table 5.1: Project Stakeholder Groups

<table>
<thead>
<tr>
<th>Stakeholder Group</th>
<th>Key Stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>NZ Police</td>
</tr>
<tr>
<td></td>
<td>NZTA - Traffic Operations Centre (TOC)</td>
</tr>
<tr>
<td></td>
<td>Wellington City Council</td>
</tr>
<tr>
<td></td>
<td>Greater Wellington Regional Council</td>
</tr>
<tr>
<td></td>
<td>Wellington Free Ambulance</td>
</tr>
<tr>
<td></td>
<td>NZ Fire Service</td>
</tr>
<tr>
<td></td>
<td>Road Users</td>
</tr>
<tr>
<td>Footprint</td>
<td>KiwiRail, including InterIslander</td>
</tr>
<tr>
<td></td>
<td>CentrePort</td>
</tr>
<tr>
<td></td>
<td>Golden Bay Cement</td>
</tr>
<tr>
<td></td>
<td>Holcim Cement</td>
</tr>
<tr>
<td></td>
<td>Mobil</td>
</tr>
<tr>
<td></td>
<td>Trelissick Park Group</td>
</tr>
</tbody>
</table>

#### 5.4.1. Operational Stakeholders

Consultation with operational stakeholders focussed on enhancing the understanding of issues around traffic management and how the scheme will be operated and maintained over time. At a broader level, stakeholders with an important role in Wellington’s transport network strategy were engaged with to ensure a strategic fit for this project with other initiatives such as the Ngauranga to Airport Strategy Study (2008). Discussions with Greater Wellington Regional Council and Wellington City Council in particular provided a good understanding of the network issues and initiatives, including developing proposals by Wellington City Council for improving access to the Port.

At a more detailed level, operational stakeholders such as the NZ Police, Emergency Services and the TOC were engaged with to better understand how these stakeholders manage traffic and driver behaviour within the study area. A good level of information was obtained relating to the management of traffic along the Ngauranga to Aotea Quay study area to inform the scheme assessment.

The main interests of operational stakeholders in relation to this project are summarised in Table 5.2. The outcome of stakeholder consultation is also summarised.

### Table 5.2: Operational Stakeholder Interests and Outcomes

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Main Interest</th>
<th>Outcome of Consultation</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZ Police</td>
<td>The safe and efficient operation of the highway, particularly in terms of emergency response times, incident control and enforceability</td>
<td>The project objectives and scheme are consistent with the interests of NZ Police. The scheme can be legally enforced. A new emergency on-ramp is proposed as part of the scheme to provide for additional ease of access of the police onto the highway. The scheme includes a number of new emergency breakdown areas.</td>
</tr>
<tr>
<td>NZTA - Traffic Operations Centre</td>
<td>The safe and efficient operation of the highway, particularly in terms of managing and operating the traffic operations systems, maintenance and accessibility of the system, positively</td>
<td>The project objectives and scheme are consistent with the interests of the TOC. The scheme design has carefully considered the needs of the TOC in terms of effectively and efficiently operating the system and</td>
</tr>
<tr>
<td>Stakeholder</td>
<td>Main Interest</td>
<td>Outcome of Consultation</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Wellington City Council</td>
<td>The safe and efficient operation of the highway, particularly integration with local roads and land uses and the effective flow of traffic through Wellington City. The strategic fit of the scheme in relation to road network strategies, including the Ngauranga to Airport Strategy Study.</td>
<td>The scheme is to integrate well with the local road network and surrounding land uses and has a good strategic fit in terms of seeking to help ease traffic flows on the most congested part of the City’s highway at present. The scheme design has considered the Council’s intentions to help improve access to the Ferry Terminal area (roundabout at Aotea Quay) and the scheme does not conflict with those plans.</td>
</tr>
<tr>
<td>Greater Wellington Regional Council</td>
<td>The safe and efficient operation of the highway, particularly in terms of regional land use and transport integration and strategic fit.</td>
<td>The scheme has a good regional fit in terms of seeking to help ease traffic flows on the most congested part of the City’s highways at present. Access to and from the Airport and the Port is a regional land use and transport issue of significance to GWRC. The scheme design has considered a proposed roundabout at Aotea Quay and does not conflict with those plans.</td>
</tr>
<tr>
<td>Emergency Services: Wellington Free Ambulance St John’s Ambulance NZ Fire Service</td>
<td>The safe and efficient operation of the highway, particularly in terms of emergency response times, incident control and positively influencing driver behaviour.</td>
<td>The project objectives and scheme are consistent with the interests of Emergency Services and is operational in nature to help provide for the safe and efficient operation of the highway. The ATMS approach allows for lanes to be safely managed (for example closed) to provide for Emergency Services. A new emergency on-ramp is proposed as part of the scheme to provide for additional ease of access of emergency services onto the highway. The scheme includes a number of new emergency breakdown areas.</td>
</tr>
<tr>
<td>Road Users</td>
<td>A safe and intuitive driving environment; low-stress driving; reliable journey times; less frustrating stop-start driving through the project area.</td>
<td>The scheme has been designed to be safe and intuitive. A specific Driver Awareness Strategy has been developed to help ensure that the NtAQ project is communicated, designed and delivered in a manner that reflects current knowledge of driver behaviour principles and requirements, to maximise the likelihood of achieving the project objectives.</td>
</tr>
</tbody>
</table>

5.4.2. Footprint Stakeholders

Consultation with footprint stakeholders focussed on understanding the issues around integrating the scheme with surrounding land uses and activities. The scheme can be accommodated within the existing highway footprint and as a consequence any adverse physical effect on stakeholders as a result of this project will be no more than minor. The most significant effect is likely to be the temporary disruption generated during the construction phase as the project is built over time. The widening of the Thorndon Overbridge will temporarily affect the operation of the InterIslander during construction. Further consultation with the InterIslander and...
Centreport will be required during detailed design with the aim of reducing and mitigating adverse effects during construction. These construction effects can be sufficiently managed and mitigated through standard construction methodology, which can be formalised and controlled through Construction Management Plans. It is recommended that the Construction Management Plan includes the requirement to appropriately inform and consult with footprint stakeholders where any works may impact on their land, operations and/or interests.

The main interests of footprint stakeholders in relation to this project are summarised in Table 5.3. The outcome of stakeholder consultation is also summarised.

### Table 5.3: Footprint Stakeholder Main Interests and Outcomes

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Main Interest</th>
<th>Outcome of Consultation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kiwirail and Interislander</strong></td>
<td>Kiwirail (who own the Interislander Line) lease land from the Government for the operation of its rail shunting yard. It also owns land at the existing Ferry Terminal buildings and also leases land from CentrePort for ferry operations. Kiwirail has been investigating options to reconfigure the port and improve access. Kiwirail and Interislander have a common interest in maintaining access to their sites and maintaining their 24 hour, 7 day operations.</td>
<td>The project objectives and scheme are consistent with the interests of Kiwirail and Interislander and will not conflict with the safe access to and from rail and ferry sites. The project aims to help ease traffic flows on the most congested part of the City’s highway at present will benefit access to and from the rail yards and ferry terminal. Special attention and care will be required during construction to ensure no significant adverse effects are generated on the safe and efficient access to rail and ferry sites. The Construction Management Plan should appropriately inform and consult with Kiwirail and Interislander where any works may impact on their land, operations and/or interests. Further discussions are taking place between WCC; GWRC; and Kiwirail/Interislander stakeholders around a potential roundabout option at Aotea Quay.</td>
</tr>
<tr>
<td><strong>CentrePort</strong></td>
<td>CentrePort owns the existing wharf and some land under the ferry terminal buildings as well as the area of reclaimed land to the north east of Thorndon Overbridge. It also owns land adjacent to the Aotea off-ramp which is currently leased to Golden Bay Cement who on-lease to Holcim Cement. CentrePort is interested to ensure that the NtAQ project does not hinder the safe and efficient access to and from the wharf, terminal buildings and operations.</td>
<td>The project objectives and scheme are consistent with the interests of CentrePort and will not conflict with the safe access to and from CentrePort sites. Special attention and care will be required during construction to ensure no significant adverse effects are generated on the safe and efficient access to CentrePort sites. The Construction Management Plan should appropriately inform and consult with CentrePort where any works may impact on their land, operations and/or interests.</td>
</tr>
<tr>
<td><strong>Golden Bay Cement &amp; Holcim Cement</strong></td>
<td>Golden Bay Cement owns the existing cement silos located in close proximity to the Aotea off-ramp. Holcim Cement lease the cement silos from Golden Bay Cement. Both are interested to ensure that the NtAQ project does not hinder the safe and efficient access to and from the silos and surrounding site.</td>
<td>The project objectives and scheme are consistent with the interests of Golden Bay Cement &amp; Holcim Cement and will help improve access to and from the cement silos and surrounding site by helping to ease traffic congestion and improve journey times Special attention and care will be required during works around the Aotea off-ramp to ensure no significant adverse effects are generated on the safe and efficient access to</td>
</tr>
</tbody>
</table>
### Stakeholder Management

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Main Interest</th>
<th>Outcome of Consultation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>and from the silos and surrounding site. The Construction Management Plan should appropriately inform and consult with Golden Bay Cement &amp; Holcim Cement where any works may impact on their land, operations and/or interests.</td>
<td>Mammoth own the existing oil pipeline that runs from Aotea Quay wharf along the top of the existing sea wall and across from the ferry terminal carpark. Mammoth is interested to ensure that the NtAQ project does not hinder the safe and efficient access to the pipeline and does not present a risk in terms of damaging the pipeline. The scheme does not interfere with the existing oil pipeline. The Construction Management Plan should appropriately inform and consult with Mammoth where any works may impact on their land, operations and/or interests.</td>
</tr>
<tr>
<td></td>
<td>The environmental and social effects of the scheme on Kaiwharawhara Stream and the surrounding area, over and above the existing highway effects, are no more than minor. The proposed works will be compliant with the relevant Regional Plans (including stormwater management) and no resource consents are expected to be required. Special attention and care will be required during construction works around the Kaiwharawhara Stream and surrounding area (including the Coastal Marine Area) to ensure no significant adverse effects are generated on the environment. The Construction Management Plan should appropriately inform and consult with Trelissick Park Group where any works may impact on their key interest to protect the Kaiwharawhara Stream and surrounding area.</td>
<td>Trelissick Park Group has a specific interest in protecting and enhancing the Kaiwharawhara Stream which runs through Trelissick Park in the Ngaio Gorge and enters the harbour at Kaiwharawhara Point.</td>
</tr>
</tbody>
</table>

### Tangata Whenua

In terms of iwi, groups whose rohe (tribal area) are generally within the project area are Ngati Toa; Te Atiawa and Taranaki Whanui ki Whanganui a Tara (Port Nicholson Block Settlement Trust). Ngati Tama, as previous occupants of the Kaiwharawhare Marae may also have an interest in the project. Nga Uranga (the landing place) is within the project area and is noted in the District Plan as a significant site.

This project is largely ‘operational’ in nature with no adverse effects on identified sites of significance to iwi. The scheme can be accommodated within the existing highway designation boundary and will not be located within the Coastal Marine Area or any site of special environmental or historic protection.

The scheme plans for this project were sent to all iwi groups above for comment in June 2012. Given the operational nature of this project, the likely traffic benefits and the limited environmental effects, iwi have not raised any specific concern in terms of cultural values or otherwise in relation to this project. The iwi representative for Port Nicholson Block Settlement Trust further commented that “this proposal will make the journey safer and more enabling for the route to Wellington Airport and the Tertiary Hospital in Newtown making this scheme compelling”.

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Beca | Fletcher
As an overall summary, this project is more ‘operational’ in nature with the physical works being relatively minor and able to be undertaken generally within the existing highway footprint. The project should in fact have a predominantly positive long-term effect on all stakeholders and consultation has not identified any significant stakeholder conflicts or fatal flaws in relation to the preferred scheme.
6. Cost Estimates

Cost Estimates have been developed for the preferred scheme described in Chapter 4. The estimates were prepared to the NZTA’s Scheme Estimate specification described in the Cost Estimation Manual (SM014). Scheme estimates were also prepared for several of the components of the preferred scheme for use in developing the staging plan. These components include:

- SH2 Ngauranga Northbound On Ramp Improvements;
- Emergency On-ramp at Ngauranga;
- Upgrade of existing ATMS system;
- Widen northbound to four lanes; and
- Widen southbound to four lanes.

The Base, Expected, and the 95th percentile estimates for the preferred scheme and components is shown in Table 6.1 below:

<table>
<thead>
<tr>
<th>Item and Description</th>
<th>Base Estimate ($M)</th>
<th>Expected Estimate ($M)</th>
<th>95th Percentile Estimate ($M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Scheme (Includes all of the components below)</td>
<td>$78.2M</td>
<td>$87.3M</td>
<td>$100.5M</td>
</tr>
<tr>
<td>SH2 Ngauranga Northbound On Ramp Improvements (Geometric improvements to On-Ramp)</td>
<td>$3.3M</td>
<td>$3.7M</td>
<td>$4.3M</td>
</tr>
<tr>
<td>Emergency On-ramp at Ngauranga</td>
<td>$2.3M</td>
<td>$2.5M</td>
<td>$2.9M</td>
</tr>
<tr>
<td>Upgrade of existing ATMS system (New ATMS equipment and enforcement)</td>
<td>$13.3M</td>
<td>$14.7M</td>
<td>$17.0M</td>
</tr>
<tr>
<td>Widen northbound to four lanes (Includes Aotea Quay On-Ramp improvements and replacement of central median barrier)</td>
<td>$19.8M</td>
<td>$22.1M</td>
<td>$25.4M</td>
</tr>
<tr>
<td>Widen southbound to four lanes (Includes widening of Thorndon Overbridge)</td>
<td>$39.6M</td>
<td>$44.2M</td>
<td>$50.9M</td>
</tr>
</tbody>
</table>

The above scheme estimates include risks identified in the risk register which are discussed in Section 7. The scheme estimates do not include the cost of ground improvements for the Thorndon Overbridge or Aotea Quay off-ramp. It is noted that the sum of the stages does not equal the total cost of the Project. This is due to each stage being priced as a stand along Project Scheme estimates are contained in Appendix L.

The preferred scheme has an Expected Scheme Estimate of $87.3M.
7. Risk Assessment

A risk workshop for the Project was held on 10 May 2012 and was attended by representatives from NZTA, Fletcher Construction, Beca, and WT Partnership (cost estimate peer reviewers). The risk workshop was facilitated under the guidelines of NZTA Risk Management Manual AC/Man/1 and the output of the workshop was the updating of the single project risk register to reflect the increased understanding of the Project threats and opportunities. The risk register is included in Appendix M.

The key risks that have been identified and assessed at the risk workshop, along with their controls are summarised in Table 7.1.

Table 7.1 – Significant Project Risks and Controls

<table>
<thead>
<tr>
<th>Risk</th>
<th>Risk Priority</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Risks Excluded from Project Scope</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upgrade existing (old) Aotea off ramp or rebuild ramp structure (currently 1:100 year return period) may be required</td>
<td>Extreme Threat</td>
<td>Currently excluded from Project scope. Determine scope of potential work required in Design Phase.</td>
</tr>
<tr>
<td>Thorndon Overbridge geotechnical improvements. The risk is that ground improvements are required before any clip-on structures are added</td>
<td>Extreme Threat</td>
<td>Further geotechnical work will be required before designing Thorndon Overbridge widening. These improvements are excluded from the Project scope.</td>
</tr>
<tr>
<td>Use of Waterloo Quay rail crossing hampers the effectiveness of the Project</td>
<td>Very High Threat</td>
<td>Outside of Project control and excluded from Project scope. Mitigation could be flyover to be implemented by WCC or Kiwirail to reduce queuing.</td>
</tr>
<tr>
<td><strong>Risks Included in Project Scope</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land designation: additional designation required during design and/or for construction (including temporary site working areas).</td>
<td>Very High Threat</td>
<td>NZTA currently discussing designation with WCC. It is likely that an alteration to designation will be required for the Thorndon Overbridge widening.</td>
</tr>
<tr>
<td>Access requirements and future development of the Port prevent or interfere with the Project. KiwiRail objections results in revisions to Port Access plans. The risk is additional time and cost to resolve access issues.</td>
<td>Very High Threat</td>
<td>The GWRC Port Access Study. Project staging may delay southbound widening, allowing more time for the Port to finalise redevelopment and access plans.</td>
</tr>
<tr>
<td>Constructability: working within requirements of existing stakeholders. Risk is design or construction methodology to be modified to meet stakeholder</td>
<td>Very High Threat</td>
<td>Construction team to meet with stakeholders and discuss.</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Risk</th>
<th>Risk Priority</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>requirements.</td>
<td></td>
<td>methodology.</td>
</tr>
<tr>
<td>Existing Thorndon Overbridge southbound on-ramp: foundations cannot</td>
<td>Very High</td>
<td>None currently. Will require further investigation during Design Stage.</td>
</tr>
<tr>
<td>be re-used and will require new (or modified) substructure</td>
<td>Threat</td>
<td></td>
</tr>
<tr>
<td>SH1 shoulder pavement capacity: rebuild existing shoulder pavement</td>
<td>Very High</td>
<td>Re-build sub-base and resurface. Potential for rehabilitation at end</td>
</tr>
<tr>
<td>material is required to cope with traffic volumes. The risk is</td>
<td>Threat</td>
<td>of defects liability (if rutted). Inspect and test to confirm.</td>
</tr>
<tr>
<td>rutting of pavements.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A risk workshop for the Project was held and facilitated under the guidelines of the NZTA Risk Management Manual. The output of the workshop was the updating of the single project risk register to reflect the increased understanding of the project threats and opportunities.
8. Economic Assessment

The economic assessment of this Project has been undertaken in accordance with the requirements of the Economic Evaluation Manual, First Edition (EEM). The full economic worksheets are provided in Appendix N, with the main points presented below. The economics were peer reviewed by Opus and the results of the peer review are contained in Appendix O.

The base date for the analysis is 1 July 2011 and time zero is 1 July 2012.

The construction time for the full option has been assumed to be one year, with construction commencing at the start of the 2013/14 year.

8.1. Traffic Model Background

As reported earlier, traffic modelling has been undertaken to assess the operation of the various Options. These models also form the basis for the economic assessment, with outputs such as travel times and vehicle speeds being used to determine the cost to road users of each Option.

8.1.1. Economic Base and Do Minimum Models

The models used as the starting point for the economic assessment will be the Base or Do Minimum models pre-early works. This is to allow the benefits of the early works to be recognised as part of this project, as these improvements were identified and implemented during the early stages of this investigation.

8.1.2. Forecast Year Modelling Assumptions

The number of vehicle trips modelled, and their origins and destinations in the micro-simulation model, have been derived from the strategic WTSM model. The assumptions relating to improvements to the greater Wellington road and passenger transport network have been reported earlier. Of most significance to this Project are the following two improvements:

- Duplication of the Terrace Tunnel is expected between 2021 and 2031, significantly increasing the southbound capacity of the motorway; and
- The Petone to Grenada link is also expected between 2021 and 2031, routing traffic between SH1 and SH2 out of the area covered by the micro-simulation model.

The first network improvement increases the volume of traffic using the motorway to travel southbound to the end of the motorway, as the Terrace Tunnel bottleneck has been removed. As the second network improvement removes traffic travelling between SH1 and SH2 from the model, capacity is freed up on SH1 in the Ngauranga Gorge, through the interchange with Hutt Road and on SH2 between Ngauranga and Petone.

8.2. Time Periods

The traffic models represent three weekday periods separately, the morning and afternoon commuter peaks, and the inter-peak period between them. Table 8.1 shows the length of the modelled time periods and the time within each of these time periods that the economic inputs are collected for.

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Modelled Period</th>
<th>Economic Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM Peak</td>
<td>6:00 – 9:30</td>
<td>6:30 – 9:30</td>
</tr>
<tr>
<td>Inter-peak</td>
<td>11:00 – 13:00</td>
<td>11:30 – 12:30</td>
</tr>
<tr>
<td>PM Peak</td>
<td>15:00 – 18:30</td>
<td>15:30 – 18:30</td>
</tr>
</tbody>
</table>
For the AM and PM peak periods, the full modelled period is 3½ hours, but only the last 3 hours are used to determine the economic benefits. This allows 30 minutes for the modelled network to fill up with traffic (a warm-up period), so the results used for this economic analysis are all collected whilst conditions in the network are representative of the vehicle interactions that occur in reality.

For the inter-peak period, this has a relatively flat profile, so vehicles are released onto the network without any distinctive peak being present. The two hour inter-peak period also represents the average conditions across the middle of the day, from the end of the AM peak period at 9:30 through to the start of the PM peak period at 15:00. Using the middle hour to gather the network outputs for this assessment allows for the network to warm-up during the first 30 minutes of the modelled period.

The Options which have been tested have all been designed to aid the movement of traffic in the busiest part of the day, so produce little or no benefit when traffic volumes are significantly lower. The inter-peak period has traffic volumes which are up to 48% lower than the traffic volumes recorded during the peak PM hour, and 44% lower than for the peak AM hour.

Weekend traffic volumes are similar to those during the weekday inter-peak period, although up to 15% higher. The comparison between these relative traffic volumes can be seen in Figure 8.1, which shows traffic volumes passing through the SH1/SH2 Ngauranga Interchange in 15 minute intervals for an average weekday and an average weekend day.

![Figure 8.1 – Annualisation Graph](image)

As none of the Options tested have a noticeable effect on vehicle speeds or routing during the inter-peak period, assessment of the benefits of the Options over the weekend has not been undertaken.

### 8.3. Annualisation Factors

The annualisation factors used to expand the results from the model periods to a full year for the economic assessment are shown in Table 8.2.
### Table 8.2 - Expansion Factors used for Economic Assessment

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Model Period Used</th>
<th>Modelled Period Length (hours)</th>
<th>Periods Per Day</th>
<th>Days Per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekday Morning Commuter Peak</td>
<td>AM Peak</td>
<td>3</td>
<td>1</td>
<td>245</td>
</tr>
<tr>
<td>Weekday Inter-Peak</td>
<td>IP</td>
<td>1</td>
<td>6</td>
<td>245</td>
</tr>
<tr>
<td>Weekday Afternoon Commuter Peak</td>
<td>PM Peak</td>
<td>3</td>
<td>1</td>
<td>245</td>
</tr>
<tr>
<td>Weekday Evening/Night-time</td>
<td>None</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Weekend/Holiday</td>
<td>None</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

#### 8.4. Variable Trip Matrix Assessment

WTSM has been used to produce cordon matrices both with and without the full scheme in place. The number of trips in these cordon matrices differs between the with and without cases, due to two effects:

- Traffic rerouting on the wider transport network within WTSM to travel in the SH1/SH2 corridor, taking advantage of the improvements in travel conditions brought about by the full scheme; and
- Induced traffic, whereby tripmakers change their mode or time of travel, or their destination, as a result of the decrease in travel costs along the SH1/SH2 corridor.

Both of these effects are likely to increase the number of vehicles using the SH1/SH2 corridor with the full scheme in place, necessitating the use of variable trip matrix (VTM) assessment methods. Without specifically accounting for the change in the number (and origin or destination) of trips, a standard economic assessment will underestimate the benefits of a scheme, as the total road user costs with the induced (increased) demand are likely to be higher than for the Do Minimum, even though average travel times or distances have fallen.

To account for the variable trip matrix effects, two separate approaches have been used:

1. The individual road user costs for each vehicle on each path (travel time, delay, VOC, variability) were calculated for each scenario based on the trips in that scenario. The total road user costs for the scenario were then based on the number of vehicles on each path in the Do Minimum scenario, so for the purposes of the economic evaluation there is the same number of trips, and any difference in the total road user costs is due to changes in the operation of the network.

   This method will tend to underestimate the benefits of a scenario, as the benefits to the extra (induced) traffic in the option which takes advantage of the improved travel conditions, is not considered in the evaluation.

   This approach was used for the first draft version of this report.

2. Appendix A11.as of the EEM also specifies a methodology for conducting cost benefit analyses using VTM methods. A variant on the matrix-based approach has been used to account for the differences in the trip matrices, and is detailed below.

   This second approach has been used for this version of the report.

#### 8.4.1. Economic Assessment Traffic Demands

For the second approach, the matrix based approach specified in Appendix A11.12 of the EEM has been adapted for use with the path data output from the Paramics model runs.

Rather than using matrix information (trips, travel times, VOC, etc) for individual origin-destination pairs, each path is used. Each path is similar to a single origin-destination pair, located within the model rather than at the model extremities.
The form of the benefit calculation is shown below:

\[
B_{pi} = \left( R^{DM}_{pi} - R^{OFT}_{pi} \right) + \frac{1}{2} \left( U^{DM}_{pi} + U^{OFT}_{pi} \right) \times \left( T^{DM}_{pi} - T^{OFT}_{pi} \right)
\]

where:

- \( B_{pi} \) = Total road user Benefit of Option.
- \( T^{DM}_{pi}, T^{OFT}_{pi} \) = Number of trips on path \( p \) in time interval \( i \) in Do Minimum and Option.
- \( R^{DM}_{pi}, R^{OFT}_{pi} \) = Resource costs on path \( p \) in time interval \( i \) in Do Minimum and Option (calculated separately for Travel Time, Travel Delay, VOC and Reliability).
- \( U^{DM}_{pi}, U^{OFT}_{pi} \) = User costs on path \( p \) in time interval \( i \) in Do Minimum and Option (calculated separately for Travel Time, Travel Delay, VOC and Reliability).

8.5. Ramp Metering Benefits

The SH2 Ngauranga On-Ramp Ramp Metering option has not been well modelled in the Paramics model, with a simplistic algorithm used to control the signals on the on-ramp. The model results from this option do not show the improvements that would be expected. As a consequence, an alternative methodology has been employed to assess the benefits of this option.

The methodology is based on the approach used for the economic evaluation of ramp signalling on the Western Ring Route\(^\text{12}\). In this report a relationship was determined between the travel time benefits to traffic on the mainline and disbenefits to those on the on-ramp, based on experience in the UK and US. This relationship was further calibrated against modelling from the Auckland Southern Motorway.

Vehicles on the mainline are expected to have a 7% travel time saving immediately downstream of the merge, whilst those on the on-ramp are expected to experience a delay totalling an additional 25% of their travel time on the on-ramp.

This approach has only been applied to estimate the benefits of the SH2 Ngauranga On-Ramp option relative to the pre-early works model – it has not been applied to give any additional benefits for the full option.

8.6. Determination of Benefits

The benefits calculated for the benefit cost ratio (BCR) as set out in the EEM include benefits arising from travel time savings, vehicle operating cost (VOC) savings, crash reductions, CO\(_2\) emission reductions and improvements in trip reliability. These are discussed in detail below.

8.6.1. Travel Time Benefits

Travel time benefits are likely to be the largest benefit component of the model output. Composite values of base travel time for light and heavy vehicles have been determined for the Urban Arterial road category and used in the economic evaluation for each of these vehicle classes separately. All delay associated with the network being over-capacity has been included as ‘bottleneck’ delay.

8.6.2. Vehicle Operating Cost Benefits

Vehicle operating cost (VOC) benefits have been calculated in accordance with the EEM (Appendix A5.2) for Base Running costs, which are a function of speed, distance and gradient. For the purposes of this assessment, the effects of gradient have been ignored, as the majority of the travel routes used to calculate the road user costs are generally flat, with the exception of Ngauranga Gorge, which comprises only a small segment of the travel routes starting or ending on SH1.

Additional VOC benefits related to travelling in congested conditions have not been assessed as it is not possible to easily calculate the volume capacity ratios required by the EEM methodology from micro-simulation models.

Additional VOC benefits due to bottleneck delay have also not been calculated, as it is not possible to determine stopped time from the Paramics outputs.

8.6.3. Trip Reliability Benefits

Trip reliability benefits capture the economic benefits of reducing the variability of travel times for trips undertaken at broadly the same time each day. The variability in travel times assessed for trip reliability is not intended to account for the effects of major incidents on the road network. Rather it is the day to day differences in travel times that occur as a result of the random interaction of all the other vehicles on the road network. These changes in daily travel times are particularly prevalent on highly congested parts of the road network, such as the Ngauranga to Aotea Quay corridor at peak times.

Two approaches have been used to assess trip reliability benefits. The first has been used only for assessing the benefits of Stage 2, the ATMS implementation by itself. The second has been used to determine the trip reliability benefits for the remaining Stages.

Trip Reliability – Method 1

The implementation of ATMS in the Paramics model has not been able to replicate the behaviour of vehicles under a managed motorway regime. Model results from the first round of modelling showed travel time disbenefits from the ATMS, as the speed of modelled vehicles was capped without an improvement in vehicle throughput (as would be expected with the operation of ATMS).

A post-implementation study of the M42 ATMS and hard-shoulder running operating regime reported a 22% reduction in the variability of travel times\(^{13}\). Based on this, and approaches taken for similar motorway projects involving providing additional capacity, travel time reliability benefits have been assessed as 5% of the travel time benefits. This is likely to underestimate the trip reliability benefits given the highly congested nature of this section of the motorway, so the economic assessment will be conservative in respect to the trip reliability benefits.

This method has only been applied to determining the trip reliability benefits for the Stage 2 ATMS implementation.

Trip Reliability – Method 2

This second approach uses outputs from the Paramics model to determine the trip reliability benefits for the Do Minimum and Options (excluding the Stage 2 implementation of ATMS).

The methodology used is different to that contained in the EEM, due to the differences in the information reported from micro-simulation models compared to equilibrium-type assignment models. In particular, the EEM methodology requires link volume capacity ratios, which it is not practical to determine from the Paramics model. The methodology used determines the trip variability for each individual journey against the average journey time from the 10 Paramics runs.

As per the EEM\(^{14}\), the value of reliability claimed uses a factor of 0.8 for light vehicles and 1.2 for heavy vehicles. As most trips assessed in the Paramics model start and end outside the extents of that model, an adjustment has been made to account for the change in trip variability over the entire journey. It has been assumed that 75% of the variance in travel times is outside the study area, so a factor of 50% has been used for the benefit calculation.


\(^{14}\) EEM, Page A4-13
8.6.4. Crash Reduction Benefits

A safety hazard analysis was undertaken which informed the crash benefit analysis. The hazard analysis involved using the Safety Baseline to calculate a percentage change to safety hazards for each option. The Safety Baseline was developed by Mouchel and subsequently validated by the ECI team. The hazard analysis was then verified by Mouchel.

For the five options the Baseline hazard logs were reviewed and the change in risk profile that would be expected for each hazard was estimated based on experience from other assessments. The risk profile for each hazard was mostly reduced but there were a few hazards where the risk increased.

The same crash costs calculated for 2011 have been used for each modelled future year, with the change in the risk profile for each particular option then applied. The resulting option (and Do Minimum with no change in the risk profile) crash costs are then discounted.

The use of the 2011 crash costs has been adopted due to significant difficulties in calculating the future year crash costs. It is noted that this approach will introduce some inaccuracies into the calculations due to:

- Crash costs will not account for changes in traffic volumes (likely to be increases on the motorway and decreases on Hutt Road); and
- Decreases in crash costs due to safety improvements in vehicle design over time will not be reflected in the future year crash costs.

However, it is considered that this approach will produce results which are consistent between the Do Minimum and the Options being assessed over the length of the assessment period.

8.6.5. CO2 Emissions

As per the EEM A9.7, CO2 emission costs have been calculated as 4% of the vehicle operating costs.

8.6.6. Project Costs and Construction Period

Expected construction costs have been used for this assessment, as detailed in Section 6. For all Options, a construction period of one year has been used, with construction commencing at the start of the 2013/14 year.

It is noted that different staging strategies will reduce the present value of the costs of the Options, as the start of construction is deferred to later years. However, the effects of different staging options have not been undertaken as part of this assessment.

8.6.7. Project Benefit Cost Ratio

The economic evaluation for this project was undertaken in September 2012. As detailed earlier, the base date for the project is July 2011 and the time zero is 2012. The assessment has been undertaken over a 30 year assessment period, with an 8% discount rate.

Table 8.3 reports the present value of the benefits for the full scheme.

<table>
<thead>
<tr>
<th>Option</th>
<th>Travel Time</th>
<th>Congestion Benefits</th>
<th>Trip Reliability Benefits</th>
<th>Vehicle Operating Cost Benefits</th>
<th>CO2 Benefits</th>
<th>Crash Costs</th>
<th>Total Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Scheme (Northbound and Southbound Widening with ATMS)</td>
<td>54.8</td>
<td>15.0</td>
<td>10.2</td>
<td>-7.5</td>
<td>-0.3</td>
<td>7.0</td>
<td>79.1</td>
</tr>
</tbody>
</table>

The benefit cost ratio for the full scheme is shown in Table 8.4.
Table 8.4 shows that the full scheme has a BCR above 1, indicating that from the modelling results alone the full scheme is justified from travel time, trip reliability, vehicle operating cost and crash cost savings. However, as noted above the method used will not capture benefits associated with changes in the performance of the network outside the 17 defined paths. It is likely that this will underestimate the benefits of the full scheme – for instance, improvements in travel conditions on Hutt Road for vehicles not coming from or going to SH1 or SH2 will not be included in these benefits.

An alternative assessment methodology, using model outputs from the entire network (as opposed to just on the 17 paths), was trialled initially. However, changes in how the model network operated well outside the area of the effect of the Project (particularly within the Hutt Valley) skewed the results. As a consequence, the decision was made to exclude the effects of this model “noise” by only using the outputs gathered from the 17 defined paths, even though this would also exclude benefits occurring on the network outside these paths.

In addition, the decrease in travel time benefits (resulting from the capped speed for vehicles) with the ATMS implemented within the model, combined with the cost of the ATMS, results in the full scheme having a lower BCR than would be expected.

The results of the economic analysis indicate that the full scheme is expected to realise benefits greater than its cost. Additional benefits not captured in this assessment (as noted earlier in this section) are likely to increase the benefits further, resulting in a BCR above the 1.1 reported here.

8.6.8. Sensitivity Tests

As a sensitivity test, the cost benefit analysis has also been undertaken with alternative discount rates of 6% and 4%, instead of the current 8%.

With a discount rate of either 4% or 6%, the BCR of the full scheme improves (as would be expected). These results are reported in Table 8.5.

8.6.9. Staging of Scheme Elements

An assessment of each stage of the full scheme has been undertaken. For the ATMS stage, only trip reliability benefits (based on Method 1 described earlier) and crash benefits have been included, with no attempt made to quantify the travel time and congested travel benefits that could be expected from a managed motorway regime.

For the two widening stages, the approach used differs from the standard economic methodology, in that the costs of the ATMS have been excluded from the assessment. This has been done on the basis that as the Paramics model does not produce positive benefits associated with the implementation of the ATMS, so the cost of that stage should not be included either. In addition, the cost of the ATMS could be considered a sunk cost by the time widening is undertaken.

Table 8.6 reports the present value of the benefits for the stages comprising the full scheme.
Table 8.6 Present Value of Benefits for Staged Elements of Full Scheme [$M]

<table>
<thead>
<tr>
<th>Option</th>
<th>Travel Time</th>
<th>Congestion Benefits</th>
<th>Trip Reliability Benefits</th>
<th>Vehicle Operating Cost Benefits</th>
<th>CO₂ Benefits</th>
<th>Crash Costs</th>
<th>Total Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>SH2 Ngauranga On-Ramp</td>
<td>4.2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>4.2</td>
</tr>
<tr>
<td>Do Minimum with ATMS</td>
<td>0.0</td>
<td>0.0</td>
<td>18.5</td>
<td>0.0</td>
<td>0.0</td>
<td>6.2</td>
<td>24.7</td>
</tr>
<tr>
<td>Northbound Widening with ATMS</td>
<td>28.2</td>
<td>7.5</td>
<td>4.8</td>
<td>3.1</td>
<td>0.1</td>
<td>3.8</td>
<td>47.6</td>
</tr>
<tr>
<td>Southbound Widening with ATMS</td>
<td>26.6</td>
<td>7.6</td>
<td>5.4</td>
<td>-10.6</td>
<td>-0.4</td>
<td>3.1</td>
<td>31.6</td>
</tr>
</tbody>
</table>

The benefit cost ratios for the separate stages of the full scheme are shown in Table 8.7.

Table 8.7 Benefit Cost Ratios for Staged Elements of Full Scheme

<table>
<thead>
<tr>
<th>Option</th>
<th>PV Benefits</th>
<th>PV Costs</th>
<th>BCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>SH2 Ngauranga On-Ramp</td>
<td>4.2</td>
<td>3.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Do Minimum with ATMS</td>
<td>24.7</td>
<td>13.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Northbound Widening with ATMS</td>
<td>47.6</td>
<td>19.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Southbound Widening with ATMS</td>
<td>31.6</td>
<td>37.9</td>
<td>0.8</td>
</tr>
</tbody>
</table>

The analysis of the staged elements of the full scheme shows that implementation of geometric improvements and ramp metering on the SH2 Ngauranga on-ramp has a BCR of 1.2, although this is likely to underestimate the benefits due to the fairly simplistic assessment method used.

Implementing ATMS on the current three lane motorway is expected to have a BCR of 1.9, although this is likely to underestimate the BCR as no benefits have been claimed for travel time and congested travel savings.

Given implementation of the ATMS in stage 2, the northbound widening has a BCR of 2.5.

Although the southbound widening has a BCR of 0.8, it is noted that this element completes the full scheme, which overall has a BCR of 1.1. It is also likely that this additional capacity will be required to enable the full benefits of the northbound widening to be realised, as drivers benefitting from the northbound widening have to travel southbound at some time to complete their round trips.

It is again noted that congestion relief benefits have not been evaluated for any of the stages assessed, nor for the full scheme. The resulting BCR's are therefore all likely to be conservative.
The economic assessment has found that the complete Project has a BCR of 1.1.
The staged elements comprising the full scheme have the following BCR’s:

- SH2 Ngauranga On-Ramp: 1.2
- ATMS: 1.9
- Northbound Widening: 2.5
- Southbound Widening: 0.8
9. Staging

It is intended to implement the full scheme in stages to create the opportunity to realise early benefits and prove the concept of full management on three lanes before investing in four lanes. The development of a staging plan has considered:

- Getting better use out of the existing ATMS system (including improving education and enforcement) before investing in four lanes;
- Timing of four laning between Ngauranga and Aotea Quay relative to the implementation of other RoNS schemes in Wellington such as Terrace Tunnel duplication;
- Whether the implementation of the “specific solutions” such as improvements to the northbound Hutt Road On-Ramp / SH2 merge will significantly delay the need to four lane between Ngauranga and Aotea Quay;
- The timing of potential improvements to the Interislander terminal and the impact it will have on choosing between a clip on or separate structure for Thorndon Overbridge;
- Whether to implement four laning in one direction first (i.e. northbound four lanes and southbound three lanes for an interim period);
- Improvement in journey time reliability to be obtained;
- Cashflow for the Wellington RoNS; and
- Economic efficiency: matching investment to when justified by economic benefits.

As discussed in Section 3, the preferred scheme can be broken down in a number of component parts including:

- Improving the SH1 merge and diverge (the “Early Works” completed in August 2011);
- Improvements to the SH2 northbound on-ramp at Ngaurauga;
- Improvements to the ATMS system;
- Widening SH1 to four lanes northbound; and
- Widening SH1 to four lanes southbound.

The implementation of the Early Works in 2011 has already realised benefits for both SH1 and SH2 traffic and is considered to be the initial “stage” of the Project.

As described in Section 8 an economic assessment was undertaken of the full scheme and separately for the component parts. The economic assessment found that the full scheme “package” had a BCR of 1.1, and the ATMS and northbound widening stages have BCR’s above 1.0. In economic efficiency terms all of the stages could be progressed immediately.

Although the southbound widening element by itself has a BCR of less than 1.0, it provides the capacity to meet the additional traffic demands likely to be drawn to the widened northbound section. In addition, it completes the full scheme, which as noted in the previous paragraph has a BCR of 1.1.

There are other considerations in determining the order of potential stages such as timing of other projects, upstream/downstream or land use constraints, and managing the cashflow expenditure of the Project. Figure 9.1 illustrates the proposed staging plan which is described in Table 9.1.

During the scoping stage, through the development and assessment of a corridor management framework and workshop with NZTA it was confirmed that the strategy for this stretch of SH1 is a fully-managed motorway. The upgrade of the ATMS system (including additional gantries, signage, cameras, and enforcement supported by a driver awareness strategy) is required for full management. To achieve NZTA’s strategy of full management the upgrade of the ATMS system should be completed at an early stage.

There is also an opportunity to incorporate improvements to other issues which will help improve the performance of the Project as discussed in Section 2. These improvements include:

- The Glover Street intersection;
- The Ngauranga intersection signals; and
- The SH2 off ramp at Ngauranga.
It is recommended that these improvements are included in the Project scope and implemented at an early stage.

**Figure 9.1: Proposed Project Staging**

![Figure 9.1: Proposed Project Staging](image)

**Table 9.1 – Proposed Project Stages**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Considerations</th>
<th>Proposed Timing</th>
</tr>
</thead>
</table>
| 1     | Improvements to the SH2 on-ramp at Ngauranga.                                | ■ Is the least costly of all of the component stages;  
■ Has a BCR of 1.2;  
■ Reduces delays and queuing; and  
■ Is not constrained by other projects or stages.                                                                                                  | 2012-2013         |
| 2     | Improvements to the SH1 ATMS system with three lanes in each direction.      | ■ Essential to fulfil NZTA’s strategy of full management;  
■ Improving the ATMS system on the current three-lane motorway allows the concept of full management to be “proved” before investing in four-lanes in each direction. This includes the ability to manage congestion and improve travel time reliability as well as implementing enforcement and improving driver awareness; and  
■ Has a BCR of 1.9.                                                                                                                                   | 2013-2014         |
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<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Considerations</th>
<th>Proposed Timing</th>
</tr>
</thead>
</table>
| 3     | Four-lane SH1 northbound | - Has a staged BCR of 2.5; and  
- Four-laning northbound is not constrained by other bottlenecks in the Project area and is not constrained by other land use developments.                                                                                                                                                                             | 2014-2015        |
| 4     | Four-lane SH1 southbound | - It is proposed that four-laning southbound is the last stage as it involves widening the Thorndon Overbridge which has implementation challenges as described earlier;  
- Implementing Stage 4 at a later date allows certainty on Port and InterIslander redevelopment plans and for seismic risk considerations of the Thorndon Overbridge to be further developed prior to widening the Thorndon Overbridge; or prior to considering other alternatives for the Aotea Quay off ramp;  
- Could be implemented at or close to the same time as the Terrace Tunnel duplication which would remove a further bottleneck for southbound traffic; and  
- Has the greatest cost.  
- Has a staged BCR of 0.8.                                                                                                                                                                                                                      | Beyond 10 years  |

It is recommended that Stages 1, 2 and 3 be implemented in the short term as funding permits. Stage 4 is proposed to be deferred until other factors such as the future of the InterIslander, Terrace Tunnel duplication, and the seismic risk considerations of the Thorndon Overbridge are further developed and their impact on the proposed four-lanes southbound are better understood.

It is intended that the Project is implemented in stages. The proposed stages are:
- Stage 1: Improvements to the SH2 northbound on-ramp;
- Stage 2: Improve the existing ATMS system;
- Stage 3: Four lane SH1 northbound; and
- Stage 4: Four lane SH1 southbound.

It is recommended that Stages 1 to 3 are implemented as soon as possible and that Stage 4 is deferred until other factors such as the future of the InterIslander, Terrace Tunnel duplication, and the seismic risk considerations of the Thorndon Overbridge are further developed and their impact on the proposed four-lanes southbound are better understood.

There is also an opportunity to incorporate improvements to other issues which have an impact on the performance of the Project including:
- The Glover Street intersection;
- Ngauranga intersection signals; and
- The SH2 off ramp at Ngauranga.

It is recommended that these improvements are included in the Project scope and implemented at an early stage.
10. Conclusions and Recommendations

The section of SH1 between Ngauranga Gorge and Aotea Quay experiences high levels of congestion during both the AM and PM peaks. This congestion results in high levels of queuing and low traffic speeds along this section of SH1 and on the surrounding state highway and local road networks and high journey time variability giving low reliability. To accommodate the forecast traffic flow and relieve congestion four lanes are required on SH1 from Ngauranga to Aotea Quay in each direction.

The scoping stage concluded that it is feasible to provide four lanes in each direction as a fully managed motorway. During this scheme assessment phase, a preferred option has been developed for the implementation of the four lanes with full management. Further design and assessment of the following issues has been undertaken related to:

- Full time versus part time management;
- Development of the proposed cross section including shoulder and lane widths and locations of Emergency Breakdown Areas;
- Development of an Enforcement Strategy and Driver Awareness Strategy; and
- Further work to determine the feasibility of widening the Thorndon Overbridge.

The conclusions of these design assessments are:

- **Full time versus part time management**: The preferred option is to manage the fourth lane as a full time fourth lane because it is considered to be safer, easier to operate, and realises greater benefits;
- **Development of cross section**: The preferred cross section is to use four 3.5m lanes with 1.0m shoulders from Ngauranga to the Thorndon Overbridge and then four 3.3m lanes with 0.5m shoulders on the Thorndon Overbridge to the Aotea Quay off ramp. Emergency Breakdown Areas will be provided (two northbound and two southbound) where space permits and which can also be used as maintenance bays;
- **Enforcement Strategy**: A draft enforcement strategy has been developed in consultation with the Police. Speed and lane use can be legally enforced. Enforcement will be undertaken digitally through the ATMS technology;
- **Driver Awareness Strategy**: A draft driver awareness strategy has been prepared. It is considered that a driver awareness strategy must accompany the improvement of the ATMS system; and
- **Thorndon Overbridge Widening**: It is structurally feasible to design and construct the clip-on widening deck to the existing Thorndon Overbridge given the current site constraints. However the geotechnical assessment has indicated that the return period for which movements of the ground due to liquefaction and lateral spreading become excessive for the structure to accommodate (greater than 500mm) may be as low as 250 years, compared to 500 years originally estimated at the time of the 1990’s seismic retrofit. It is therefore concluded that subject to further detailed geotechnical study and discussion with NZTA, it will be necessary to consider ground improvement options to mitigate liquefaction or resist lateral spread forces as part of the proposed widening scheme, in order to provide overall structural stability, at least in line with the intent of the original 1990’s retrofit design.

The scheme assessment report has assessed the transport performance of the preferred scheme, considered statutory planning and environmental issues, and NZTA funding policy issues. The conclusions of these assessments are:

- The Project will result in significant travel time savings and relieve congestion on SH1 in the Project area;
- There are no significant environmental issues raised by the Project;
- An alteration to designation may be required for the Thorndon Overbridge widening and an alteration to designation will be required for the proposed emergency on ramp at Ngauranga; and
- The Project has a funding profile of HHL.
Cost estimates were developed in accordance with NZTA's Cost Estimation Manual. The expected scheme estimate for the full scheme is $87.3M and the 95th percentile estimate is $100.5M. An economic assessment of the scheme was undertaken which concluded that based on the current modelling results the Project has a BCR of 1.1.

Based upon the assessments in this report, it is recommended that:

- The Project is implemented in stages. The proposed stages are:
  - Stage 1: Improvements to the SH2 northbound on-ramp;
  - Stage 2: Improve the existing ATMS system;
  - Stage 3: Four lane SH1 northbound; and
  - Stage 4: Four lane SH1 southbound.

- Stages 1 to 3 are implemented as soon as possible and that Stage 4 is deferred until other factors such as the future of the InterIslander, Terrace Tunnel duplication, and the seismic risk considerations of the Thorndon Overbridge are further developed and their impact on the proposed four-lanes southbound are better understood.

- It is recommended that these improvements are included in the Project scope and implemented at an early stage:
  - The Glover Street intersection;
  - Ngauranga intersection signals; and
  - The SH2 off ramp at Ngauranga.

- NZTA continue to work with WCC to confirm the designation for SH1 in the vicinity of the Thorndon Overbridge. An alteration to designation may be required for the Thorndon Overbridge Widening;

- Stages 1 through 3 are taken forward to specimen design.

- Stage 4 is deferred until other identified factors and their impact on the proposed four-lanes southbound is better understood.
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