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Let's GET Wellington MOVING

Appendix F - Golden Mile Traffic Assessment Report
October 2021

Golden Mile Single Stage Business Case | Contract No. 1851

Futuregroup

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Executive Summary

This report has been prepared to inform the assessment of the proposed changes to the Golden Mile. The project seeks to improve conditions for people who travel on foot or by bike through the central city. This report only deals with the traffic effects. Separate reports have been developed that summarise the benefits for people travelling by bus or on foot.

Three shortlist options were subject to stakeholder and community engagement. Two of the three short list options involved restricting access to the Golden Mile for general traffic. This report summarises the modelling that has been undertaken to explore the effect of these traffic restrictions.

Traffic volumes on the Golden Mile are low in comparison with parallel routes to / through the central city. It is expected that traffic restrictions included within the Golden Mile proposals will result in behaviour change. For some people that currently drive this is expected to include

- changing where they park;
- changing the time of day when they drive;
- changing the route they choose to reach their destination; or
- changing the way in which they travel.

This sort of travel behaviour will serve to mitigating any potential dis-benefits travel disbenefits for people that continue to drive and will generally contribute to the vision of Lte's Get Wellington Moving Vision of 'moving more people with fewer vehicles'.

Models with sufficient resolution to be used to forecast traffic effects show how motorists will change their routes in response network changes. They are not able to forecast potential changes to parking location, time of day or mode choice.

For this assessment "out of model" calculations were undertaken to inform alternative future demand scenarios responding to the likely travel behaviour change triggered by the traffic restrictions. The traffic effects have been forecast for two alternative scenarios:

- a worst-case demand scenario where traffic demand does not change and all motorists continue to travel as they do today
- an optimistic demand scenario where some people that currently drive adjust their behaviour in response to the changes proposed for the Golden Mile

The optimistic demand scenario was forecast by adjusting the do minimum demands using empirical relationships evidenced from studies in New Zealand and validated against overseas studies. This work found that the changes to the Golden Mile should result in a reduction in network-wide traffic volumes of between 1.3% and 2.2%. This reduction in traffic demand is triggered by an increase in average travel times for some journeys.

Both scenarios are summarised within this report. The scenarios should be treated as "bookends" with a 'more plausible' scenario somewhere between the two.

The assessment has concluded that even if only the worst-case scenario is accepted the network can accommodate the changes that are proposed. The network impacts are manageable.

A few locations and intersections have been identified where small adverse impacts for traffic are expected. These are:

- Featherston Street southbound
- Ghuznee Street eastbound and its intersections with Willis, Victoria and Taranaki Streets

- the intersection between Taranaki Street and Wakefield Street

The increases in traffic flow on Featherston Street are similar to the current flow for each direction on Lambton Quay. It is expected that some of the motorists that currently drive southbound on Lambton Quay will divert onto Featherston Street. The closure of side road intersections on Lambton Quay will mean that more traffic will use Featherston Street instead of driving round the block using Lambton Quay. It is likely however that some motorists travelling to destinations on Lambton Quay will choose more accessible parking places and walk to their final destination.

The increase in eastbound traffic flow on Ghuznee Street is created by the traffic restrictions to Willis Street northbound. Currently people driving from Brooklyn, Aro Valley, Highbury and Kelburn may drive to destinations in the northern parts of the central city via Willis Street. The proposed traffic restrictions mean that they must instead use Taranaki Street, Jervois and Waterloo Quays to access these parts of the central city.

The effects of the diverted traffic and increased delays at intersections will be lessened where there is a reduction in demand. Changes to the operation of intersections that are used by traffic diverting around Lambton Quay and Willis Street will help to further mitigate these adverse effects.

Travel times on the main traffic routes within the city are expected to increase by only a small amount as a result of the proposed changes to the Golden Mile. The largest increase in travel times is for journeys between Highbury or Kelburn and the central city. People who currently drive via Willis Street will instead need to travel via Ghuznee and Taranaki Streets adding up to five minutes to their journey by car. This additional travel time is expected to be realised if there is little or no change to travel behaviour.

It is expected that the changes to the transport system will cause some people to change where they park, when or how they travel. This change in the use of the transport system would reduce traffic demand and minimise the increase in travel times

1 Introduction

This traffic assessment report presents the forecast network and local traffic effects associated with implementing the recommended Golden Mile improvement option. The report summarises the work involved in forecasting the traffic effects and explains that the tools applied to inform the forecast.

1.1 Modelling Roles and Responsibilities

Traffic forecasting informing this assessment has been a collaborative effort involving members of the project team as well as officers from the LGWM partner organisations. The roles and responsibilities with regard to this analysis were as follows:

- FutureGroup project team developed the traffic design, completed initial assessment of key intersections on the Golden Mile using discreet intersection models (Sidra) and suggested traffic signal staging and phasing arrangements to WAU.
- Wellington Analytics Unit (WAU) were responsible for coding the Ngauranga to Airport (N2A) AIMSUN model, optimising the modelled traffic network, running the model tests and producing raw model outputs to FutureGroup for interpretation
- Wellington City Council (WCC) officers developed the evidence-based methodology for forecasting the traffic demand response to proposed changes to the Golden Mile.
- FutureGroup interpreted model outputs and used them as inputs to economic efficiency forecasts and reporting.

The Wellington Analytics Unit (WAU) is a team within GWRC that is responsible for servicing the region's transport analytics and forecasting needs. The WAU performs several functions including tools management, data/information management, forecasting quality assurance and supporting the growth of transport analytics capability within the Wellington region.

2 Models Applied

The traffic effects of the Golden Mile options have been forecast using the Ngauranga to Airport (N2A) AIMSUN model. The N2A model is a traffic assignment model with fixed traffic matrices. Future year traffic demands are derived from WTSM the regional four-stage multi-modal model. Sidra models for discrete intersections were used to inform the design of revised signal timings where affected by traffic changes proposed as part of the project.

2.1 N2A Model

The N2A was built as part of the Let's Get Wellington Moving (LGWM) initiative, jointly funded by NZTA, WCC and GWRC. It sought to address perceived limitations with previous modelling suites such as Saturn or s-Paramics. The model is being used to help understand traffic effects associated with land use and transport network changes within the city centre and surrounding suburbs. The N2A model, as a traffic assignment tool, does not include functionality to forecast trip distribution or mode choice response to changes.

There are three layers within the N2A model: static, meso and hybrids (see Figure 2-1). The model system relies on initial path assignment results being passed down from the upper layers to the lower layers.

Option tests can be modelled in one or more layers of the model depending on the purpose of the test and associated information needs. All the results described in this report have been developed using the meso layer which is best suited for generating inputs to economic efficiency forecasts. The way in which interactions between individual vehicles is simulated is less complex in the meso layer when compared with the hybrid layer.

2.2 Modelled Time Periods

Three time periods were used for the modelling, each 4 hours long (2-hour peaks with 1-hour pre and post peak).

- **Morning Peak** – 6am to 10 am
- **Inter Peak** – 10am to 2pm
- **Afternoon Peak** – 3pm to 7pm

Meso and Hybrid layers include release profiling in 15-minute time slices. Static and Meso layers assume fixed timings for traffic signals, although meso can have different timing within each time slice.

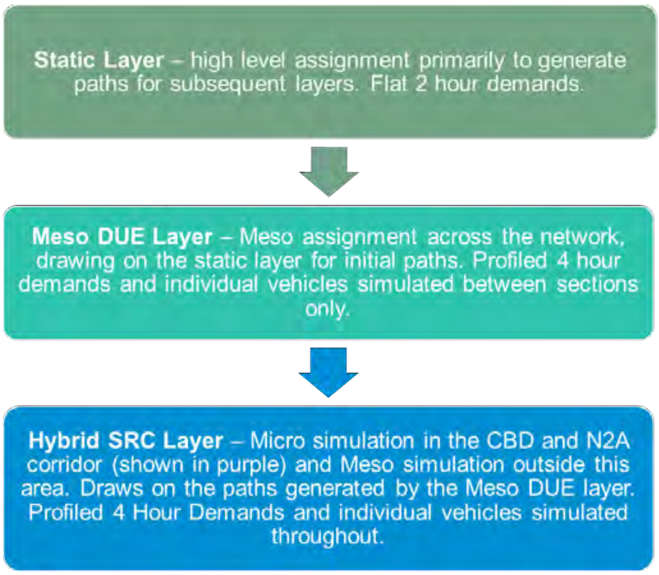


Figure 2-1: N2AM General Model Layer Structure

2.3 Geographic Coverage

Figure 2-2 (overleaf) shows the geographical extent of the N2A model, the area within the purple dotted lines is represented within the hybrid model's micro-simulation area.

2.4 Modelled Years

The N2A modelled base year was calibrated to 2016 data. Forecast year demands, derived from WTSM are for 2026. All model tests undertaken and described in this report relate to the 2026 forecast year.

2.5 N2AM Model Calibration

Traffic 'demand' and traffic flows in N2A model were calibrated to observed data (2016) on screenlines, individual links, turning flows and on the split between key route choices through the network.

Checks undertaken during the development of the model found that it replicates traffic volumes well at the aggregate (screenline) level. As with all models there were some differences when examining individual link and turning movements for selected time slices. Overall the model calibration satisfactorily met the acceptance criteria for a model developed for this purpose.

The degree to which the model replicated observed conditions is expressed as a GEH statistic. The GEH is a formula used in transport modelling to compare two sets of traffic volumes: the observed and the modelled. The lower the GEH value, the smaller the difference between the two data sets.

Figure 2-3 shows the 2 hours calibration statistics for link flows for the three peak periods. Green represents a good match (GEH of less than 5). Orange and Blue represent an acceptable match (GEH between 5 and 10), where Orange indicates modelled volumes are too high (compared to observed) and blue indicates modelled volumes are too low (compared to observed). Red and Pink would represent an unacceptable match (GEH of over 10).

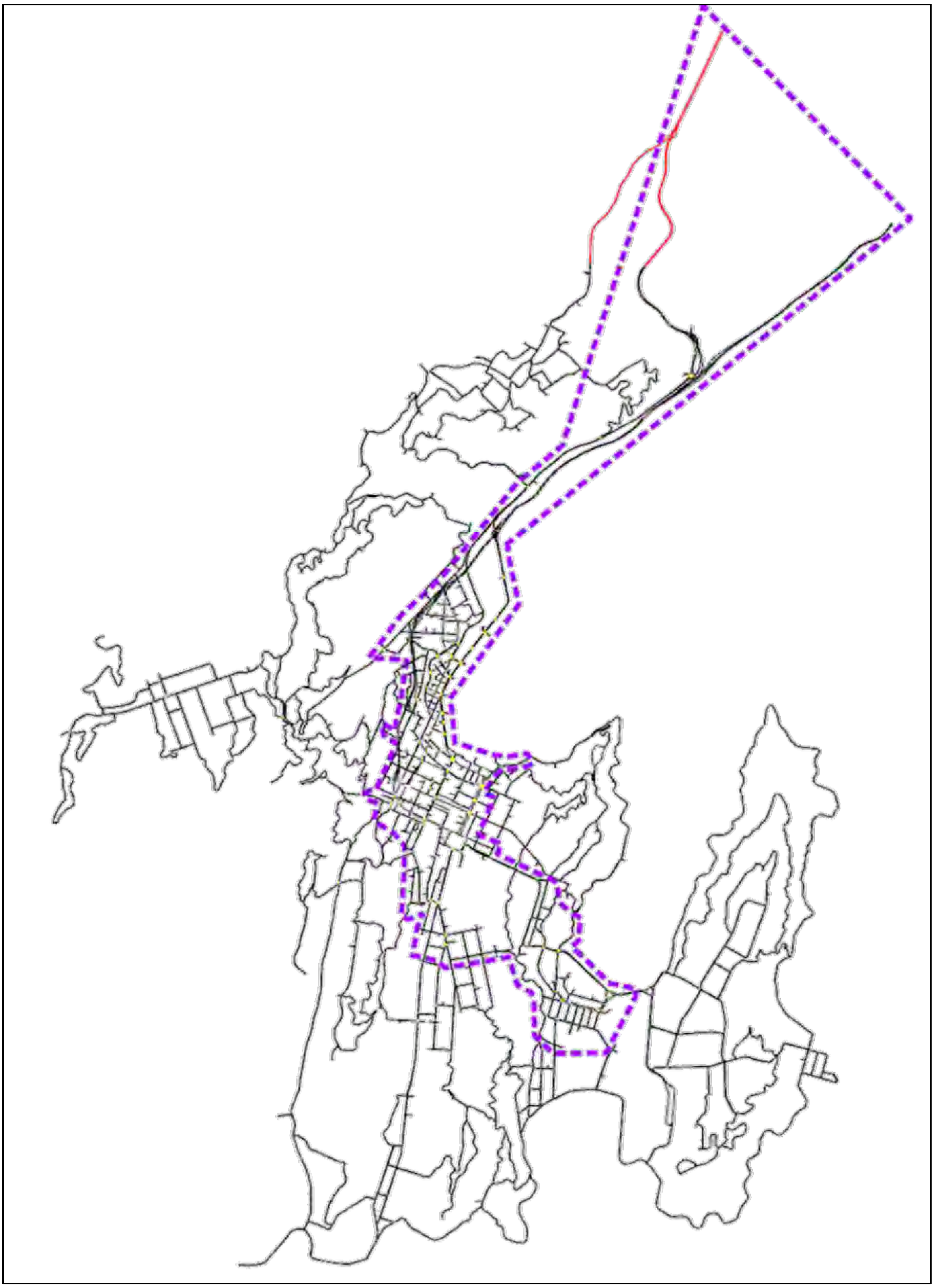


Figure 2-2: N2A Model Geographical Extent

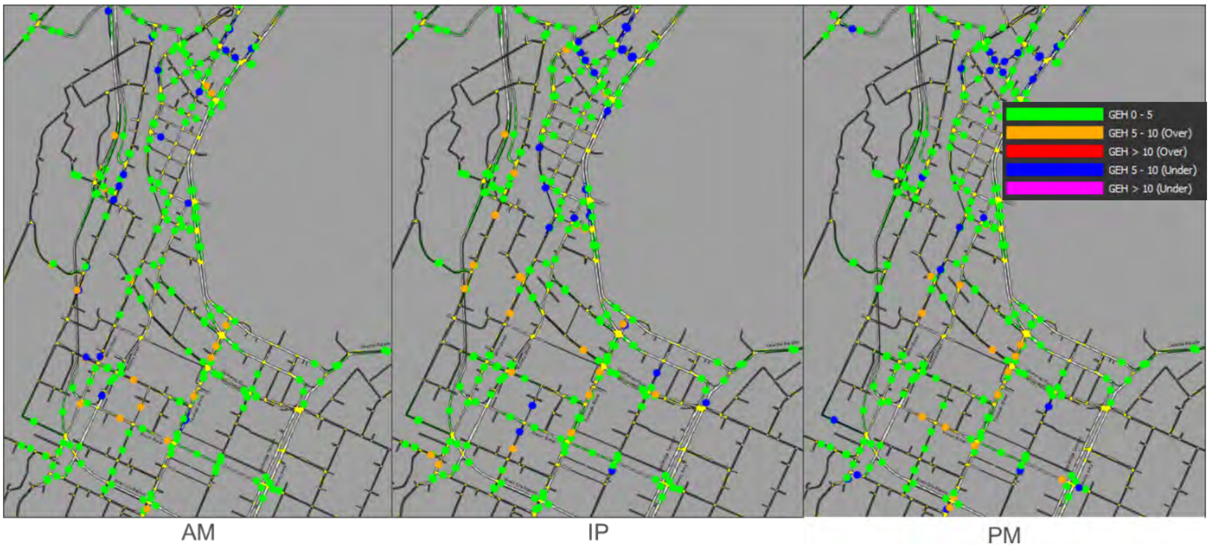


Figure 2-3: GEH calibration in the study area.

The three modelled periods have a good match between the model and observed flow. Some sections such as Taranaki Street, Vivian Street and Courtney Place have higher flows at one of the peak periods when compared to the observed data. Other sections such as The Terrace, Willis Street Northbound and Whitmore Street Westbound show low that are marginally lower than observed. There are no locations where the GEH is calculated to be more than 10 (unacceptable).

2.6 N2A Model Limitations

The number of heavy commercial vehicle (HCV) trips in the central city is low. Furthermore, HCV flows are highly variable with demands changing day to day and month to month. This means that only a small amount of data is available for calibrating HCV movements and that it is extremely challenging to precisely calibrate the model to observed HCV flows. This is a common limitation of models. Therefore, any analysis of HCV outputs in isolation from the overall traffic pattern should be treated with caution.

Models that simulate the movement of individual vehicles are sensitive to size of the sample. Therefore, the smaller the number of vehicles that make the journey, the more chance that forecast travel times for that journey are not representative. This means that the forecast travel times for some bus routes may not be representative. Partly for this reason, the changes to bus travel times and travel time reliability were forecast using a standalone model developed specifically for the project.

Compact and congested urban networks are very sensitive to operational issues such as queueing, weaving and signals operations. This means that the results can be heavily influenced by approach adopted by the modeller. This issue is particularly acute when using the hybrid layer of the model (which is better suited to forecasts needed for informing detailed design). All tests described in this report were undertaken using the meso layer. Nonetheless, manual adjustments were made to some traffic signal timings to optimise the network. Care was taken to ensure a consistent approach was adopted and visual checks undertaken to ensure there were no anomalies in the way that the network was optimised that could skew the forecasts.

2.7 SIDRA Modelling

Discrete, uncalibrated, Sidra models were used to explore possible staging and phasing arrangements for key intersections on the Golden Mile where demands and permitted movements were changed as a result of the project. Sidra models were also used to explore changes to intersections further from the Golden Mile where there was expected to be a need to mitigate traffic re-routing effects resulting from the project.

Proposed changes to signal controlled intersections were provided to WAU as an input to their network model tests using AIMSUN. WAU made further adjustments to the signal timings to further optimise the operation of the traffic network.

3 Do Minimum Assumptions

Future year traffic demands used within the N2A model are derived from the Wellington Transport Strategy Model (WTSM) – a four stage model that includes trip generation (how many trips), trip distribution (origins and destinations), mode choice (form of transport) and trip assignment (which routes or services). The N2A model is able to simulate the traffic effects of road layout changes with more resolution than is possible with the WTSM.

Four alternative future demand scenarios are available within WTSM. The future scenarios are different combinations of land-use behavioural / response scenarios.

Land Use Futures

- A medium growth scenario, which forecasts growth in regional population of 70,000 between 2013 and 2036 with around 40,000 of this growth in Wellington City.
- A higher growth, redistributed scenario that assume higher growth across the region (115,000 additional inhabitants in 2036 compared to 2013) with greater intensification of growth in Wellington City, in part stimulated by infrastructure investment.

Behavioural Futures

The two behavioural scenarios: “trend” or “balanced” future are summarised below.

	Trend Future	Balanced Future
Behavioural assumptions	Continuation of recent trend growth with reference to commuter trips to Wellington CBD in AM peak – all future growth in peak hour trips to Wellington CBD assigned to active modes or PT.	A more balanced future with small increases in peak period car demand but more significant increases in PT and active mode trips to the CBD.
Response to new modes	Higher level of modal shift, using adjusted modal parameters to capture the likely response to a step change in public transport.	Standard level of model shift, using modal parameters as developed for previous work and based upon best practice.

In combination, the land-use and behavioural are used to create four scenarios which can be used to inform option tests:

1. Medium land use growth, trend future – main scenario used for assessment
2. Medium land use growth, balanced future
3. High growth-redistributed land use, trend future
4. High growth-redistributed land use, balanced future

All results described in this report relate to a 2026 forecast year based on **medium land use growth, trend future** as summarised in Table 2, below.

Table 1: Do minimum assumptions

Medium Land use growth	• Medium growth, which forecasts growth in regional population of 70,000 between 2013 and 2036 with around 40,000 of this growth in Wellington City
Trend Future	• continuation of recent trend growth with reference to commuter trips to Wellington CBD in AM peak - all future growth in peak hour trips to Wellington CBD assigned to active modes or PT. • higher level of modal shift, using adjusted modal parameters to capture the likely response to a step change in public transport.

Monitoring by Wellington City Council shows that the number of people crossing the CBD cordon increased between 2000 and 2017[1]. During the same period, the number of motor vehicle occupants crossing the cordon has maintained a largely downward trend. In contrast:

- the number of PT passengers (particularly rail in the last few years) has maintained a largely upward trend;
- persons crossing the cordon on foot or bike have increased, with cyclist numbers having almost doubled (from a relatively low base);

In summary, the number of people travelling to central Wellington is increasing in peak periods, but the increase is accommodated by non-car forms of transport. This is because the central city traffic network operates at or close to capacity at peak times. The network has very limited capacity to accommodate additional demand.

The global COVID-19 pandemic has affected travel patterns with some people working from home for part of the week and a corresponding reduction in public transport demand. There has not however been evidence of a sustained reduction in central city traffic demand. Indeed, monitoring shows that traffic demand recovered more quickly than public transport demand.

4 Option Tests

Many options for reconfiguring the Golden Mile have been considered during the development of the recommended option. Three shortlist options were subject to stakeholder and community engagement. These options were:

- Option 1 – Reduce Traffic: largely retains existing mix of transport mode users and existing access arrangements
- Option 2 – Bus Emphasis: removes private motor vehicles from the Golden Mile, but generally retains the existing road cross sections
- Option 3 – Bus + Pedestrian Emphasis: Removes private motor vehicles from the Golden Mile and increases public realm space for pedestrians by increasing footway width in Lambton Quay and Courtenay Place.

In terms of traffic restrictions, there is no difference between shortlist options 2 and 3. From a traffic modelling perspective they are the same option.

[1] LGWM Data Report, 28th August 2017

The recommended option is an evolution of Option 3 where traffic is restricted from accessing the length of the Golden Mile but continues to be permitted to travel north-south along Tory Street and across Courtenay Place.

4.1 Relationship between Short List Options and Traffic Options Reported

This report presents the forecast effects of 3 different traffic option tests:

- **Do Minimum**: Medium land used growth, trend future (existing traffic movements retained).
- **GM Option 2**: Closure of the entire Golden Mile to general traffic.
- **GM Option 2 Refined** - Closure of the entire Golden Mile to general traffic while allowing traffic to travel north-south along Tory Street and across Courtenay Place.

Table 1 shows how the traffic option labels, used in this report, correspond with the Options that have been considered during the development of the recommended option.

Table 2: Relationship between Short List options and Traffic Model Option

Project Option	Traffic Model Option (in this report)
Shortlist Option 1	Option 1
Shortlist Option 2	Option 2
Shortlist Option 3	Option 2
Recommended Option	Option 2 Refined

5 Variable Demand Forecasting

Traffic assignment models use a fixed demand matrix. In real terms a fixed demand matrix would mean that motorists would continue to travel to exactly the same destinations regardless of any traffic restrictions. The only behaviour response possible to simulate in the model is a change in the route that motorists would follow.

In reality, a broader range of behavioural response is expected. The ways in which people would change, their travel behaviour is expected to include:

- changing their destination (i.e. park in a different location) – parking locations are not the destination of motorists' journeys. Most trips involve walking to the final destination. The introduction of traffic restrictions may cause some motorists to change where they park.
- changing the time of day when they drive.
- changing the route they choose to reach their destination.
- changing the way in which they travel (e.g. travel by bus, by bicycle, on foot or using an e-scooter) – the changes to the Golden Mile will change the relative attractiveness for some (but not all) journeys making travel by car less appealing compared with other modes.

This means that the use of a fixed matrix demand model, when forecasting the effects of traffic restrictions, will present the worst case.

5.1 Matrix Adjustment Approach

To better understand the impacts of the project, out of model variable demand calculations were undertaken to more realistically estimate the effect of the project. In summary the approach adopted was as follows:

- **<u>Step 1</u>** - Run the N2A model with a fixed travel demand matrix and with changes in road capacity. Extract modelled demands and travel times for all origin-destination (OD) pairs in the model.
- **<u>Step 2</u>** - Use an elasticity model to calculate changes in traffic demand in response to modelled changes in travel times at an origin-destination pair level. This step was implemented in a spreadsheet.
- **<u>Step 3</u>** - Input updated traffic demands into the N2A model and re-calculate modelled traffic flows and travel times.

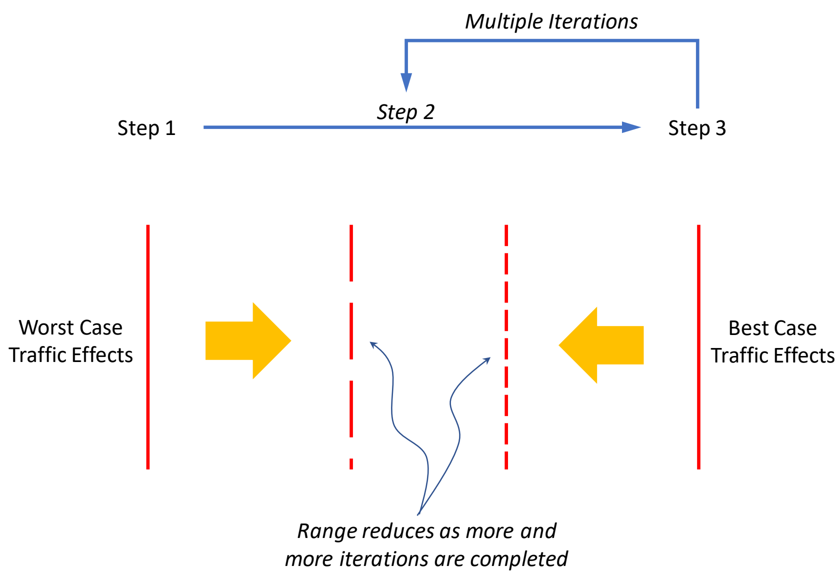
Step 1 will provide the worst-case traffic effects scenario where all motorists continue to drive regardless of the changes. Forecasts developed using the outputs from step 1 are likely to over-estimate traffic delays.

The elasticity model (Step 2) was used to forecast the change in traffic demand resulting from the reduction in traffic capacity and subsequent increase in travel times. The relationship between change in travel time and traffic demand is based on a number of empirical studies (for details see Appendix A) demonstrating that changes to road capacity result in proportionate changes in traffic volumes. Increasing road capacity results in increased traffic volumes. Reducing road capacity results in reduced traffic volumes. While the relationships used in the model were based on international research from various countries, there is local evidence from Wellington that shows the same behavioural response would be observed here. Traffic monitoring during the recent closure of Wallace Street in Mount Cook to enable water supply network renewals showed that traffic volumes changed by a larger amount than average travel times, implying that some people chose to avoid driving on this route in order to avoid even relatively small average delays.

Step 3, in which the N2A model is run with adjusted traffic demands derived from the elasticity model will provide a best-case traffic effects scenario. It is implicit within forecasts derived using Step 3 that a number of motorists change their behaviour providing relief to the traffic network. Forecasts developed using these outputs are likely to underestimate traffic delays. An advantage of this approach is that the elasticity model uses Aimsun outputs to identify origin-destinations pairs that are directly or indirectly affected by the GM changes instead of relying on arbitrary assumptions on which trips are most likely to disappear.

Neither output represents the 'most likely' outcome. In reality the answer sits between these two bookends. Experience shows that traffic demand continually adjusts to match the available capacity. This means that in reality it is most likely that the traffic capacity "freed up" by the change in behaviour from some motorists will be taken up as other, perhaps different, motorists choose to drive.

Ideally, a fourth step would be implemented where iterative re-runs of steps 2 and 3 were applied. We would expect forecasts to converge and the difference between the worst- and best-case traffic effects forecasts reducing.



The results in this report relate to the worst case (Step 1) and the best case (Step 3). Outputs from step 3 are thought to over-state traffic volume reductions and under-estimate traffic delays.

The most likely outcome is expected to lie roughly between these upper and lower bounds. Appendix A is a file note documenting the theory and empirical evidence on which the elasticity model was based. The following section highlights the main differences in travel times resulting from the Golden Mile proposals as forecast using the fixed matrix (Step 1) and the adjusted traffic demand matrix (Step 3).

5.2 Increase in Travel Time to Destination Zones

An easy way of observing the impact of using variable demand matrices instead of fixed is by comparing the network traffic access effects of the Golden Mile project for both traffic demand forecasts. Figure 5-1 is a comparison of the numbers of zones where the difference between option and do minimum total travel time to that zone (from all other zones). There are 336 zones in the model. The figure shows the numbers of zones where the increase is:

- between 5% an 10%; or
- more than 10%

"GM Option 2" represents the results from Step 1 using the fixed matrix and "GM Option 2 (Elastic)" the results from Step 3 using the adjusted matrix.

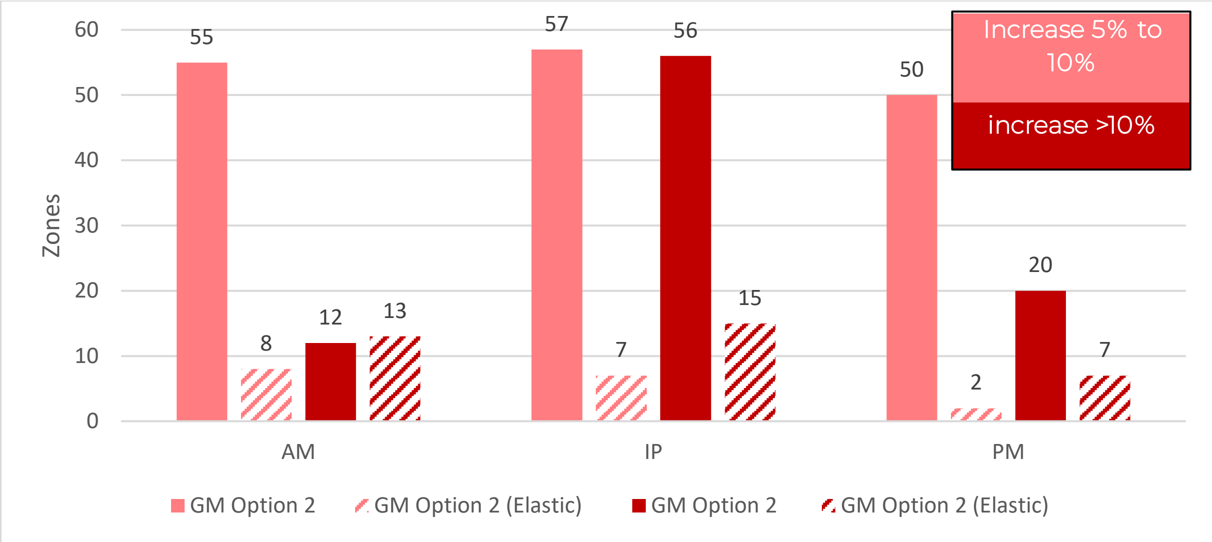


Figure 5-1: Number of destinations with significant increase in travel time.

The comparison shows that the reduced traffic demand forecast in Step 2 leads to a reduction in the traffic impact expected to result from the proposed changes to the Golden Mile. For instance, there are 55 destinations with increased travel time (5 to 10 percent) in the fixed demand, but only 8 destinations in the variable matrix. A similar pattern is observed for all the other cases.

Figure 5-2 shows the location of the destination zones described in Figure 5-1 for the AM peak period only. The pink and red colours correspond with the key used in Figure 5-1. Zones coloured blue are where Step 2 forecasts the total travel time will be shorter than for the Do minimum. A similar pattern is observed for the IP and PM peak periods (See appendix B).

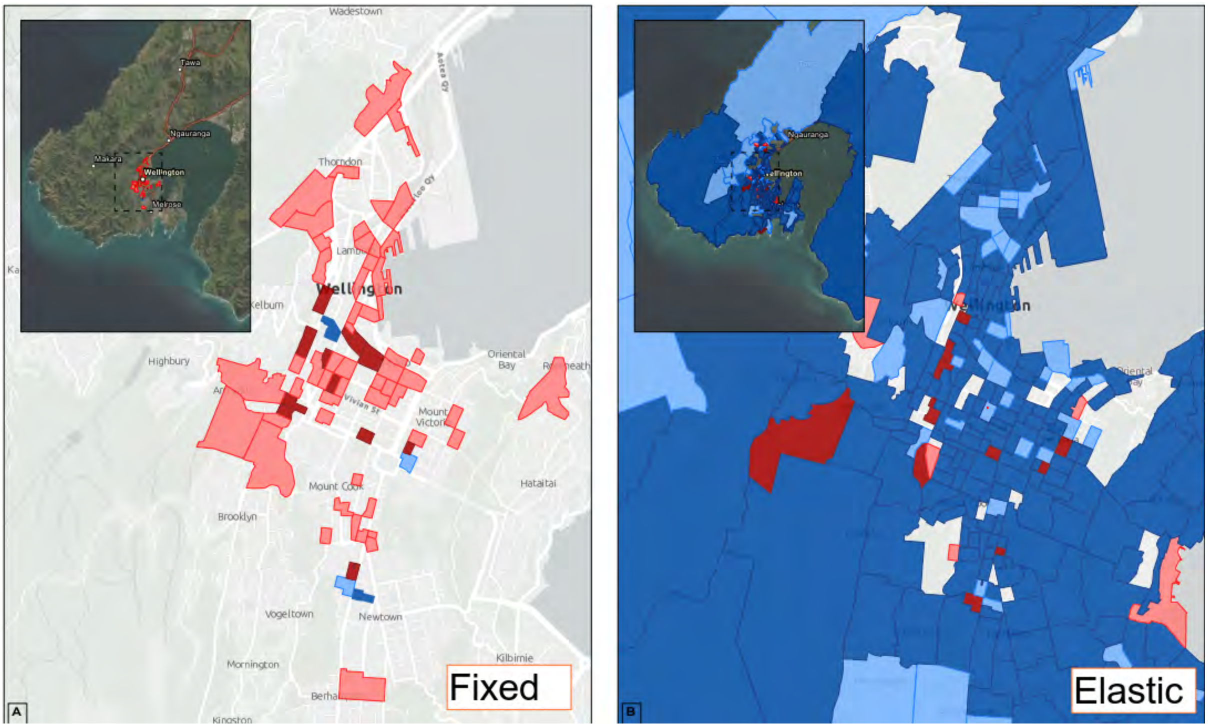


Figure 5-2: Destinations with significant increase in travel time (AM period)

In overall, it is important to consider a variable demand matrix as they are more likely to reflect the true transport network changes when a project is implemented. These statistics also show that if traffic demand reduces, the people that still continue to drive is expected to have less impacts from the reduced traffic capacity.

5.3 Assumed Elastic Response Traffic Volumes to changes in Travel Times

Based on literature review (refer see Appendix A), a 'best guess' elasticity of traffic volumes with respect to travel times of **-0.7** has been used. This is based on:

1. Graham and Glaister's (2004) recommended long-run elasticity of VKT with respect to travel time (-0.74)

2. The midpoint of Wallis's (2004) 'typical range' for the elasticity of traffic volumes with respect to in-vehicle time (-0.6 to -0.8).

Application of this elasticity relationship found that for Option 2 the network-wide traffic volumes are estimated to fall by between 1.3% and 2.2%, corresponding to a 2.0% increase in average travel times.

This approach is considered to be appropriate given timeframes for this modelling and the consensus in the international literature. Future modelling could be improved by developing a local elasticity estimate based on analysis of WTSM outputs following the approach outlined by de Jong and Gunn (2001).

6 Network Traffic Effects

This section compares the network statistics for the options tests completed using the N2A model. Following sections explore localised changes in flows and travel times that motorists may expect to experience while travelling.

To enable comparison, model outputs are shown for:

- the Do Minimum
- Option 2 – with the fixed matrix
- Option 2 – with the adjusted matrix
- Option 2 (Refined) – with the adjusted matrix

As explained in Section 4.1, Option 2 Refined represents the recommended option where traffic is restricted from accessing the length of the Golden Mile but continues to be permitted to travel north-south along Tory Street and across Courtenay Place. Results for the following metrics are presented:

- Traffic Density (veh/km)
- Mean delay time (sec/km)
- Traffic flow (veh/hr)
- Mean Queues (veh)
- Mean travel time (sec/km)

6.1 Network Density

Traffic density can be used as a proxy for traffic congestion within the network. Traffic density is defined as the number of vehicles occupying a unit length of roadway. The more vehicles within a kilometre of road, the higher the density and hence the greater the congestion.

Figure 6-1 shows network densities for all three peak periods: morning (blue), Interpeak (red) and afternoon (yellow).

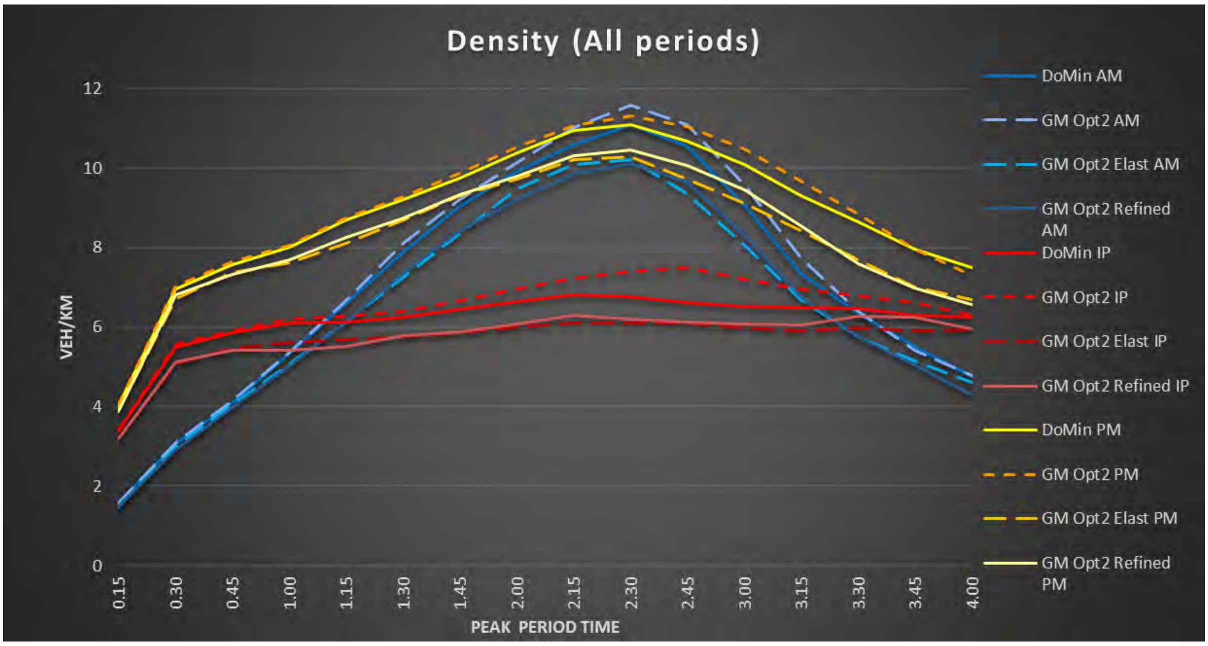


Figure 6-1: Network Density for AM, Inter and PM Peak Periods.

For each time period, the top dashed line represents the results associated with the fixed demand assessment. The bottom dashed line represents the results for the adjusted demands. Tests for the refined option, using the adjusted matrix are also shown for completeness.

Figure 6-1 shows that:

- for the AM and PM peak periods, the increase in traffic density forecast for Option 2 (using the fixed matrix) is minimal
- the increase in inter-peak traffic density forecast for the Option 2 (using the fixed matrix) during the interpeak is proportionally more noticeable but starts from a lower base
- the reduction in traffic demand modelled using the adjusted matrix has more effect on traffic density than the rerouting effects alone
- in terms of traffic density there is little difference between Option 2 and Option 2 (Refined)

In summary, the changes to the Golden Mile are not expected to have a material effect on traffic density at a network level. The behavioural change resulting from the project is likely to have more impact on congestion than the re-routing alone should motorists continue to travel in the way they currently do.

6.2 Network Queues

Mean network queues for all options are shown in Figure 6-2. Queues, measured in vehicles, represent the mean queue lengths across the entire modelled network at any one time. Both tests undertaken with the adjusted matrix (Option 2 and Option 2 – refined) show less queuing than for the Do minimum option or tests of Option 2 undertaken using the fixed matrix. As would be expected, the AM and PM periods show much higher queuing than the interpeak period.

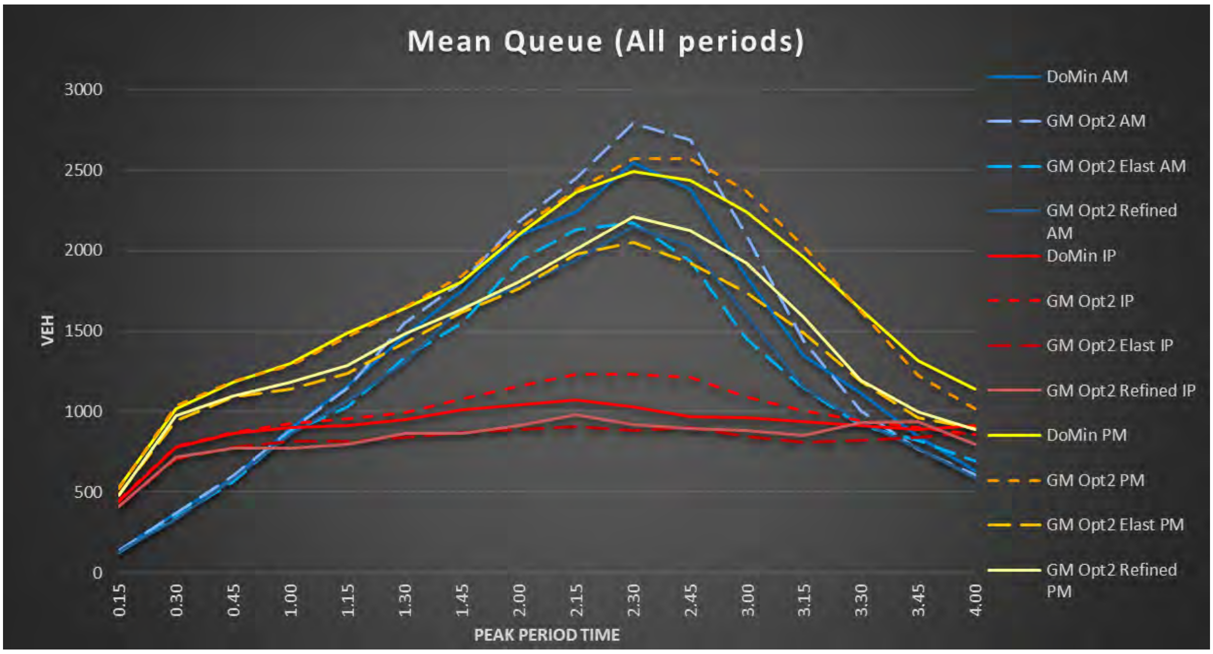


Figure 6-2: Mean Queue network for AM, Inter and PM Peak Periods.

The pattern observed is similar to that for other metrics:

- the changes to the Golden Mile are expected to increase mean queues, particularly at the peak of the peaks.

- the increase in queuing is less significant during the interpeak that compared with peak periods
- demand has a larger effect on the mean queue forecasts than the proposed changes to the traffic network

6.3 Network Delay Time

Mean network delay times are compared for all three modelled periods in Figure 6-3. The same overall pattern is observed with the upper bound delay represented by the Option 2 fixed matrix tests and the lower bound delay represented by the Option 2 adjusted matrix tests. Both the delays for the Do Minimum and the Option 2 Refined sit within these two bounds.

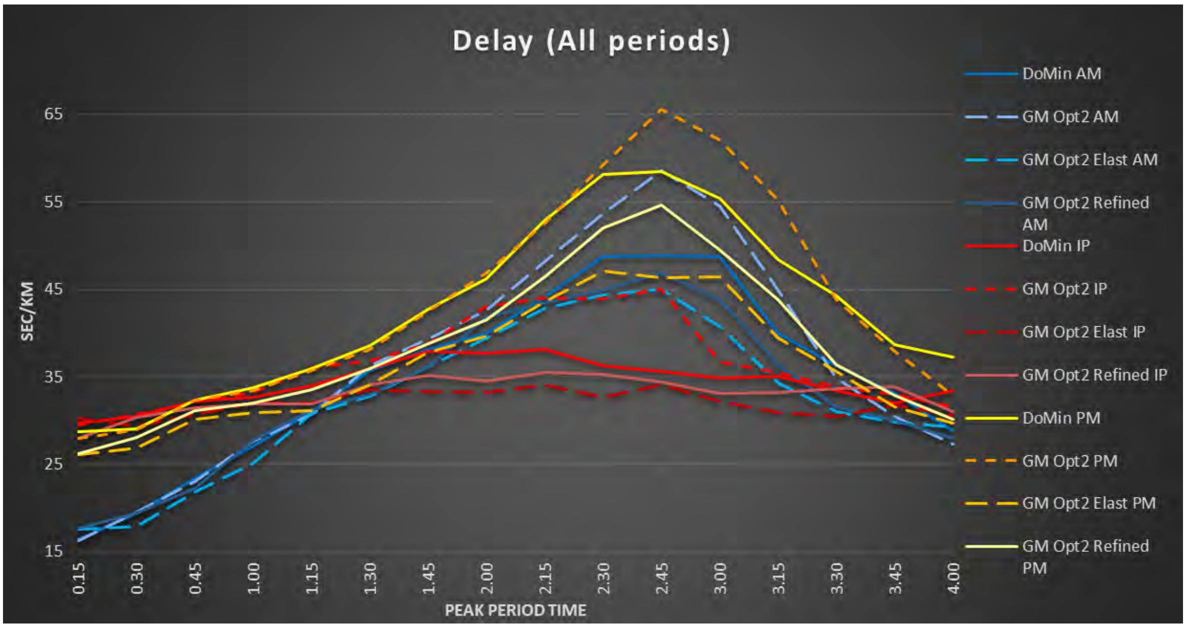


Figure 6-3: Network Delay for AM, Inter and PM Peak Periods.

Figure 6-3. shows that:

- there is little difference in delay for any options in the pre-peak hour for each period (shoulder preceding the two-hour peak).
- network delays forecast for the do minimum sit approximately half way between the upper and lower bounds associated with the Option 2 tested with fixed and adjusted matrix
- a greater increase in network delay is expected to result from the proposed changes to the Golden Mile in the AM and PM peaks than in the interpeak.
- the reduction in traffic capacity associated the project has less effect on network delays in the inter-peak because the network is less congested at this time of day.
- Option 2 (refined) is forecast to result in more network delay, in all three periods, than Option 2 when both are tested with the adjusted matrix

the PM peak is most sensitive to network changes and changes to traffic demand, largely because it already experiences greater and more sustained delays than at other times of the day.

6.4 Network Travel Time

Mean network travel times (sec/km) are compared in Figure 6-4. Option 2 (elasticity) shows the least network travel time for all periods – a reduction from the do minimum. Option 2 (fixed) displays the highest travel time – greater than the Do Minimum. Using the fixed matrix, the tests for Option 2 for both the AM and the PM peaks, indicate that network travel times will grow at the same rate as the Do Minimum but the reduction in capacity leads to higher network travel times in the peak hour that are sustained for longer.

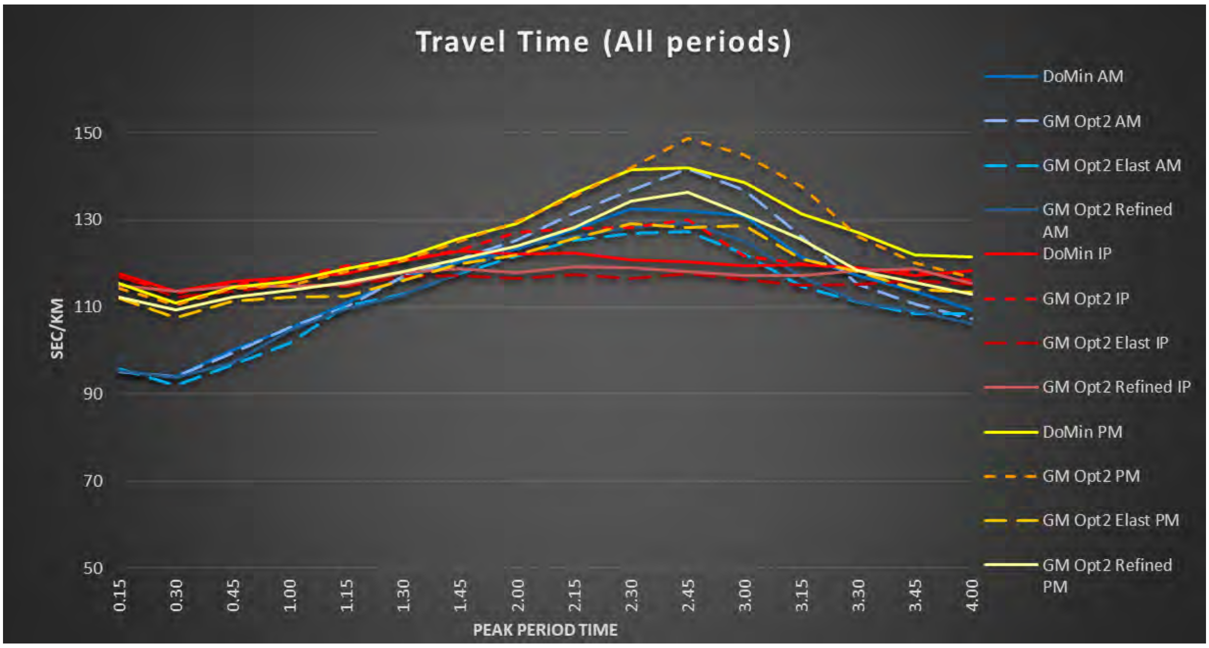


Figure 6-4: Network travel time for all options.

6.5 Network Flows

Figure 6-5 compares the network flow (vehicles per hour) across each modelled period. The figure shows that the biggest influence on network flow is the traffic demand, not the proposed changes to the Golden Mile.

The figure shows that network flow increases when demand for some trips to the central city is reduced (elasticity). It also shows that when the fixed matrix is used (no adjustment to demand), there is negligible difference in flow between the Do Minimum and Option 2.

This negligible difference in flow is intuitively correct given the current use of streets within the Golden Mile. While Lambton Quay and Courtenay Place are extremely important for the movement of people on foot or in buses, their traffic function is largely access. They carry relatively low volumes of traffic. Motorists driving in these streets tend to be reaching the end of their journey. Traffic restrictions will therefore have a relatively small effect on the operation of the network in comparison to any changes to arterial or principal roads within the central city.

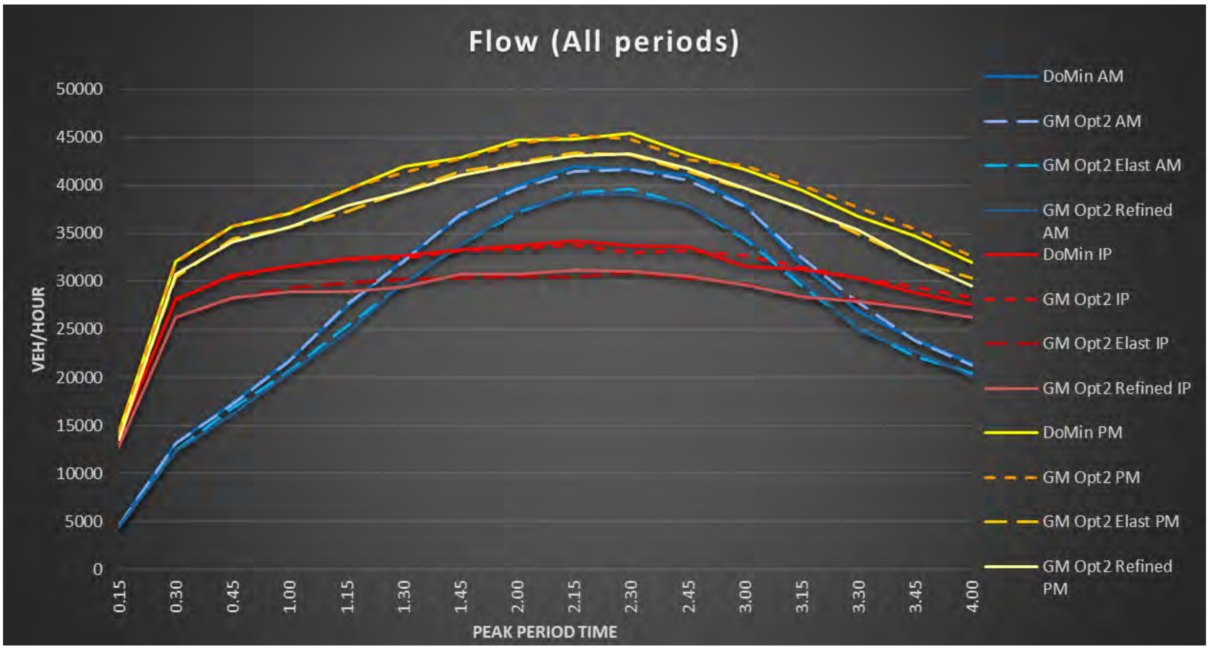


Figure 6-5: Network Flow for AM, Inter and PM Peak Periods

6.6 Summary – Network Effects

Assessment of the network statistics indicates that the proposed changes to the Golden Mile will not have a material impact on the overall operation of central city traffic network. The reduction in traffic capacity does create small increases in queuing, network delay and travel time. Overall there is negligible change to the network traffic flow.

The next section describes localised traffic effects. It explains where additional delay and congestion is expected to be realised as well as communicate which journeys by car may be affected.

7 Traffic Effects – Local Effects

This section compares the traffic forecasts to identify the roads or intersections where localised traffic effects are expected to be noticeable. Options are assessed against similar metrics but presented with more focus on spatial distribution or location of effects. Options are assessed against the following metrics:

- Traffic flow (veh/hr)
- Traffic density (veh/km)
- Level of Service
- Travel time (min)

7.1 Changes in Traffic Flow across Screen lines

Screen lines are imaginary lines that bisect multiple roads of the network. They provide a means for comparing traffic flows several roads for a given time period. Four screen lines have been drawn within the network to compare the forecast traffic flow at several locations (all vehicle types). The screen lines are shown below in Figure 7-1.

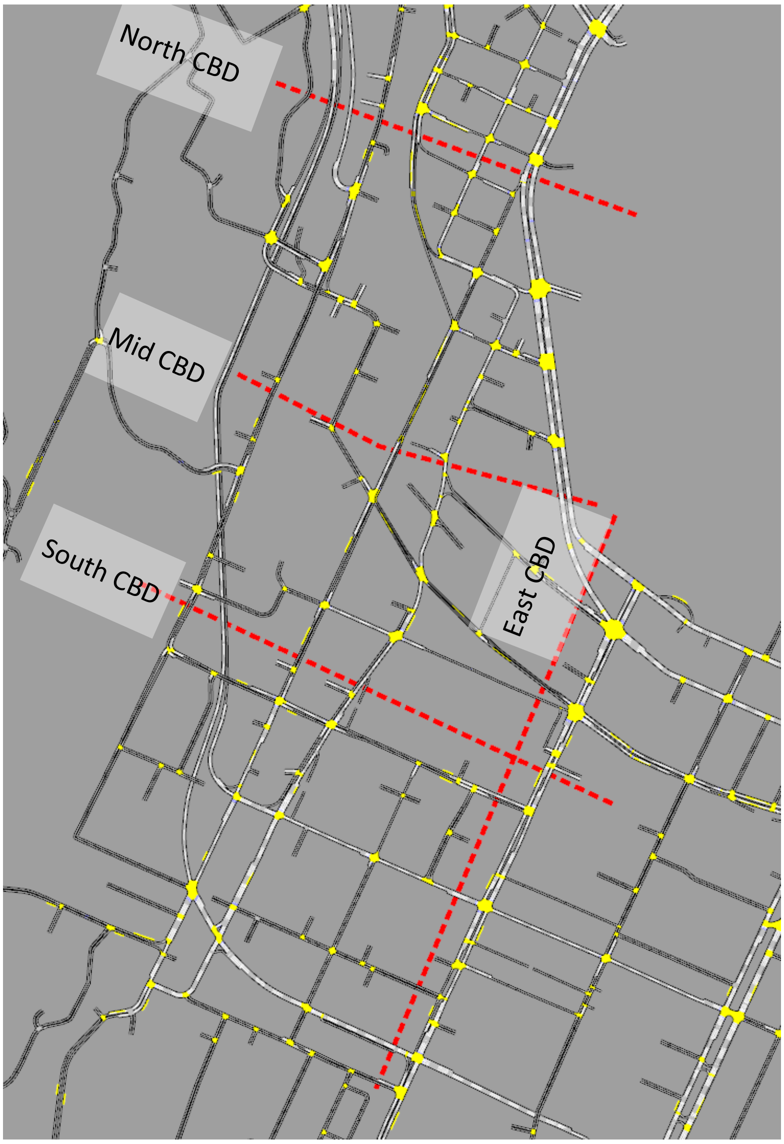


Figure 7-1: Screen lines for traffic flow comparison

Traffic flows are presented for the one-hour "peak of the peak" as listed below. These are the times when traffic flow is greatest and when the re-routing effects will be more noticeable.

- Morning Peak from 7.30 to 8.30am.
- Inter Peak from 12 to 1pm.
- Evening Peak from 4.30 to 5.30pm.

In this section, only the results for the fixed matrix tests are presented: Do Minimum and Option 2. The results shown make no allowance for changes in driver behaviour. This means that the rerouting effects presented should generally be seen as worst case. In reality, it is expected that some motorists would also change their behaviour in other ways such as changing where they park, when they travel or how they travel.

Table 5 is a summary showing locations on the screen lines where traffic flow is forecast to increase significantly (where flow difference is more than 100v.p.h and more than 10%). Appendix C is a complete comparison of traffic flows at all screen line locations. It includes locations where minor increases are forecast and where traffic flow is expected to reduce.

Table 3: Significant flow increase within the Study Area.

Street	Period	Dir.	Traffic Flow (Vehicle/hour)			Percentage Increase
			Do Min	GM Option 2 (Fixed)	Flow Increase	
Featherston Street	AM	SB	880	1,100	220	25%
Ghuznee Street	AM	EB	620	820	200	32%
Taranaki Street	AM	NB	1,280	1,480	200	16%
Arthur Street	IP	WB	1,540	1,780	240	16%
Featherston Street	IP	SB	500	680	180	36%
Terrace	IP	SB	600	720	120	20%
Terrace (Mid CBD)	IP	SB	400	540	140	35%
SH1	IP	NB	1,540	1,720	180	12%
Terrace Off-ramp	IP	SB	480	680	200	42%
Boulcott	IP	NB	400	560	160	40%
Ghuznee Street	IP	EB	820	980	160	20%
Taranaki Street	IP	NB	1,320	1,580	260	20%
Taranaki Street	IP	SB	720	980	260	36%
Waterloo Quay	IP	SB	1,520	1,680	160	11%
Featherston Street	PM	SB	600	920	320	53%
Taranaki Street	PM	NB	1,120	1,360	240	21%

The significance of increased traffic flow is affected by the capacity of the road (e.g. adding 200 vehicles to a single lane would usually have more noticeable effects than adding the same number of vehicles to a higher capacity 2-lane road). It's also affected by the amount of traffic already using each part of the road network. On some streets that operate at or close to saturation at peak times, there is limited ability to accommodate additional traffic flow and traffic will naturally find alternative routes.

Figure 7-3 below shows those locations identified in Table 5.

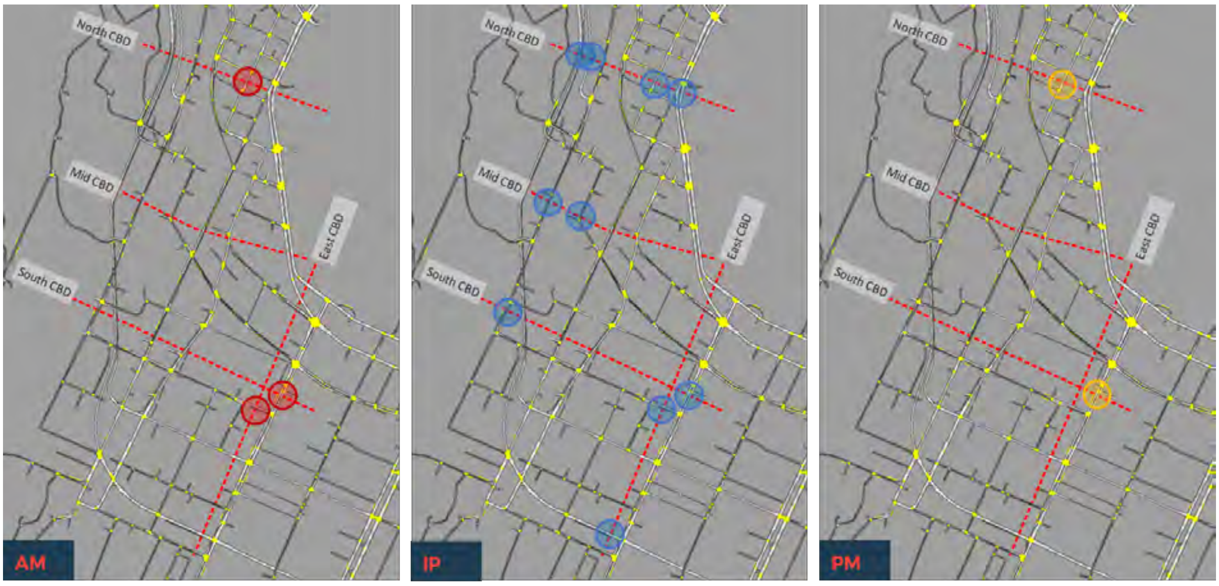


Figure 7-2: Locations with significant increase in traffic flow from GM Option 2 (Fixed)

Overall there were more screen line locations where significant increase in absolute and proportional increases were forecast during the interpeak period than in either of the peak periods. This is partly because outside of the peak, there is less traffic demand and hence more opportunity for the network to accommodate re-routed traffic.

The following sections provide a commentary on the traffic increases in the specific streets.

7.1.1 Featherston Street

Featherston Street is a principal route in the city's road hierarchy. It provides two one-way southbound traffic lanes providing an alternative to the quays as a route from the northern and western suburbs to the central city. Traffic flows are forecast to increase throughout the day. Increases of up to:

- 220 more vehicles in the AM peak hour
- 180 more vehicles in the interpeak; and
- 320 more vehicles in the PM peak.

Currently Featherston Street carries higher traffic flow in the morning peak than at other times of the day. This corresponds with weekday tidal demands to the central city in the mornings and home in the evenings. The increases in traffic flow are of a similar order to the current flow for each direction on Lambton Quay. It is expected that some of the motorists that currently drive southbound on Lambton Quay will divert onto Featherston Street.

Side roads crossing Featherston Street to connect Lambton Quay and Customhouse Quay are one-way creating a circulatory system. The closure of side road intersections on Lambton Quay will mean that more traffic will use Featherston Street instead of driving round the block using Lambton Quay. It is likely however that some motorists travelling to destinations on Lambton Quay will choose more accessible parking places and walk to their final destination.

If there is no change in travel behaviour the increased traffic flow will increase traffic density and congestion (see section 7.2).

7.1.2 Ghuznee Street

Ghuznee Street eastbound towards Taranaki Street shows a flow increase of 200 and 160 vehicles / hour in the morning peak and interpeak respectively. A small increase in eastbound traffic flows in the PM peak (40v.p.h) highlights that the road is already operating at capacity at that time.

The screen line crosses Ghuznee Street immediately west of Taranaki Street at a two-lane approach to the stop line.

Ghuznee Street currently experiences eastbound traffic flows that are two to four times greater than the westbound direction. It is used by motorists entering the city from the Terrace Off-ramp and driving to southern parts of the central city.

The increase in eastbound traffic flow on Ghuznee Street is created by the traffic restrictions to Willis Street northbound. Currently people driving from Brooklyn, Aro Valley, Highbury and Kelburn may drive to destinations in the northern parts of the central city via Willis Street. The proposed traffic restrictions mean that they must instead use Taranaki Street, Jervois and Waterloo Quays to access these parts of the central city. For people driving from these suburbs, Vivian, Buckle/Arthur and Ghuznee Streets will provide the required connections to Taranaki Street. Dixon Street is one-way westbound.

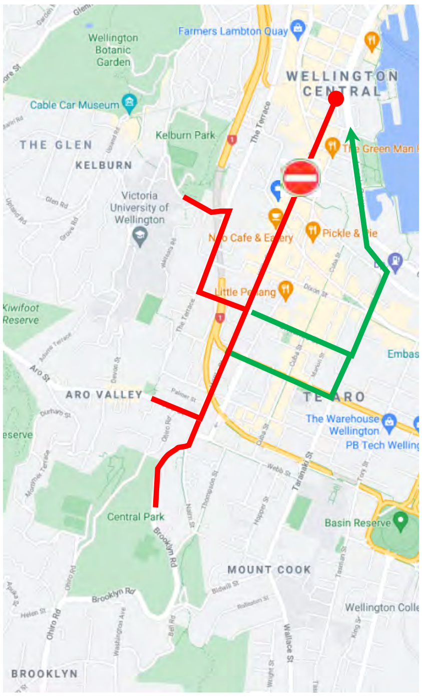


Figure 7-3: Alternative Routes to Willis Street Northbound

The increased traffic flows will create localised congestion on Ghuznee Street. The changes to the traffic patterns will affect the operation of its intersections with:

- Willis Street,
- Victoria Street and
- Taranaki Street

Minor adjustments to the signal timings at these intersections can help to ameliorate, but will not eliminate, the localised traffic impact.

7.1.3 Taranaki Street

Taranaki Street north of its intersection with Ghuznee Street shows an increase in northbound traffic flow of 200 – 260 vehicles per hour in each modelled period. This corresponds with the re-routing described in section 7.1.2, above.

7.1.4 SH1 Terrace Off-Ramp and Boulcott Street

Table 5 shows increases in traffic flow close to The Terrace. The increases signal a redistribution of traffic to SH1. Currently it is as fast / faster to drive to southern parts of the central city via the waterfront route. Changes to the Boulcott / Willis / Manners Street intersection, proposed as part of the project, man that delays on the Boulcott Street approach may be much reduced. This change is enough to make this way of driving to the central city more attractive than the Waterfront.

The increase in flow forecast on the SH1 off-ramp and Boulcott Street is despite the proposed changes which would mean that people will no longer be able to drive from Boulcott Street to Wakefield Street via Mercer Street.

The influence of the Boulcott / Willis / Manners Street intersection is a good example of the sensitivity to the traffic operating plan and the traffic signal timings that are applied within the city. For instance, if the increased traffic flows on Boulcott Street were undesirable, the traffic signal timings could be changed to avoid the increase traffic flow.

7.2 Changes in Traffic Density

Hourly traffic density plots have been generated using the N2A model for the options tested. Traffic density can be used as a proxy for congestion Figure 7-4 to Figure 7-6 show the traffic density in different parts of the network in each modelled period. Streets shown in green have low density (0 to 20 veh/km) with red signifying very high density (more than 120 veh/km). Each figure shows the density forecast for:

- the Do Minimum
- Option 2 – with the fixed matrix
- Option 2 – with the adjusted matrix
- Option 2 (Refined) – with the adjusted matrix

Figure 7-4 shows the expected density of the network for the AM peak. Option 2 (fixed matrix) represents the worst-case traffic density. Tests completed with the adjusted matrix accommodate less traffic demand.

To aid interpretation, annotations have been added to Figure 7-4 to highlight locations where a large increase in traffic density is expected. Locations highlighted include:

- Ghuznee Street – eastbound
- Willis Street – southbound approach to Ghuznee Street
- Taranaki Street - northbound
- Wakefield Street – westbound close to its intersections with Tory, Blair and Allan Streets

The forecast for Option 2 (fixed matrix) also indicates a discernible increase in traffic density on Featherston Street southbound. This does not appear to be as significant as the increase on Ghuznee Street.

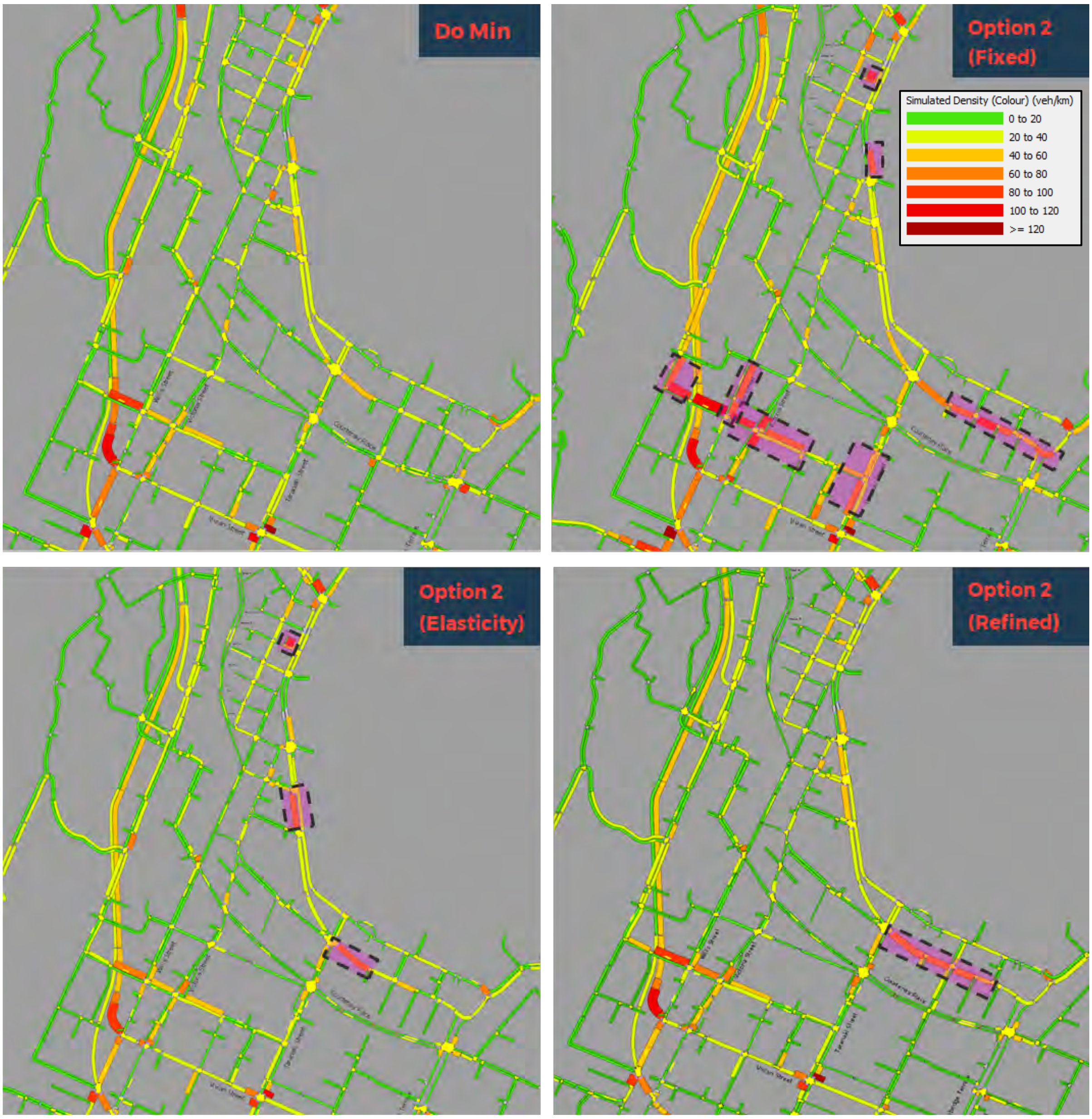


Figure 7-4: AM Network Density (8.00 am to 9.00 am)

Figure 7-5 shows the interpeak density plots. The Golden Mile project option is expected to generate less traffic density interpeak than in the peak periods. Locations where density is expected to increase are again:

- Featherston Street; and
- Ghuznee Street

The rest of the network is forecast to operate with relatively low traffic low-densities.

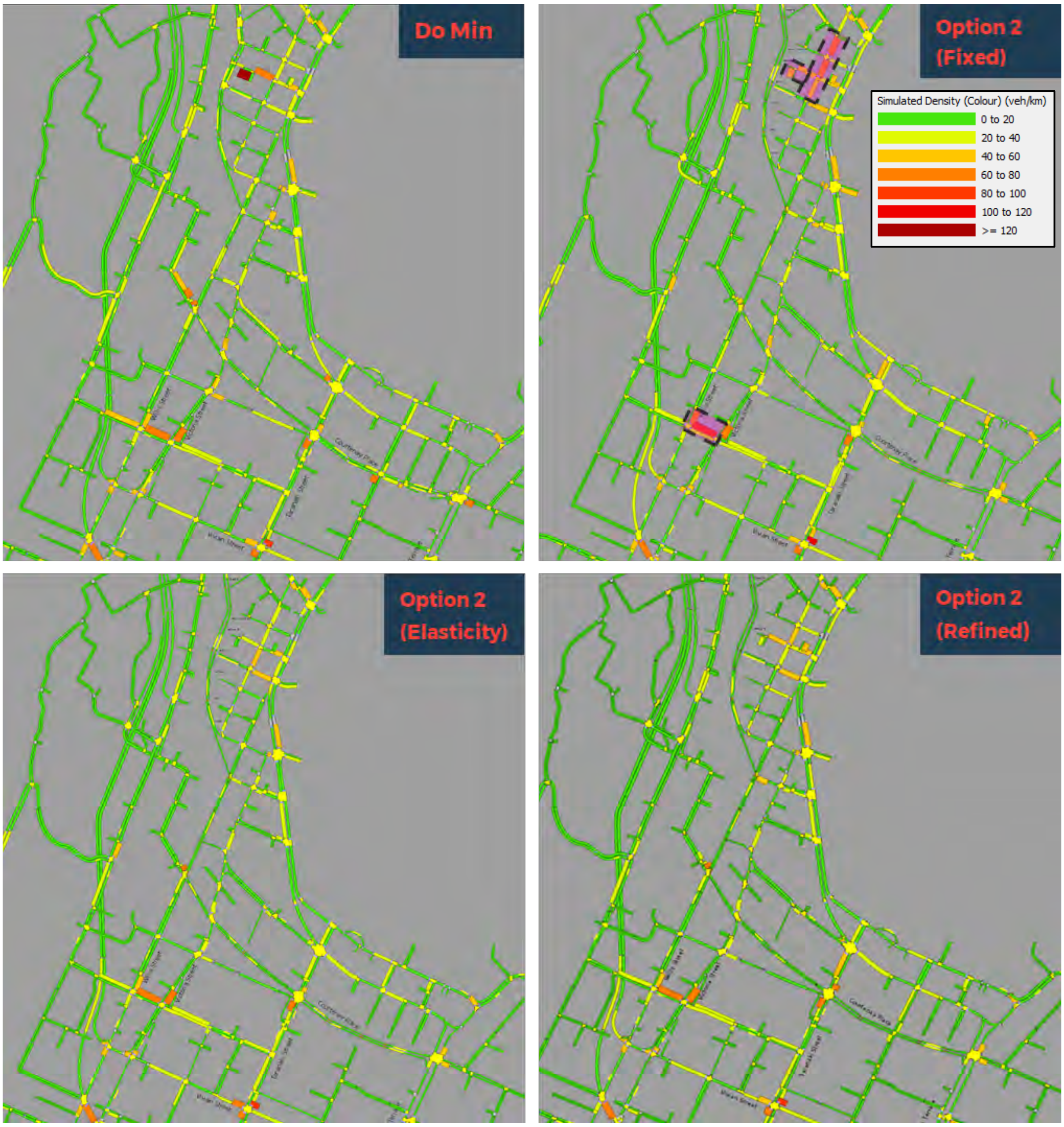


Figure 7-5: IP Network Density (12.00 pm to 1.00 pm)

Figure 7-6 shows the expected density of the network for the PM peak hour. This peak period is already congested in some sections. The Fixed option shows sections of Wakefield Street, Taranaki Street, Ghuznee Street and Cuba Street with higher congestion. In contrast, the elasticity option only shows the Wakefield section to be more congested.

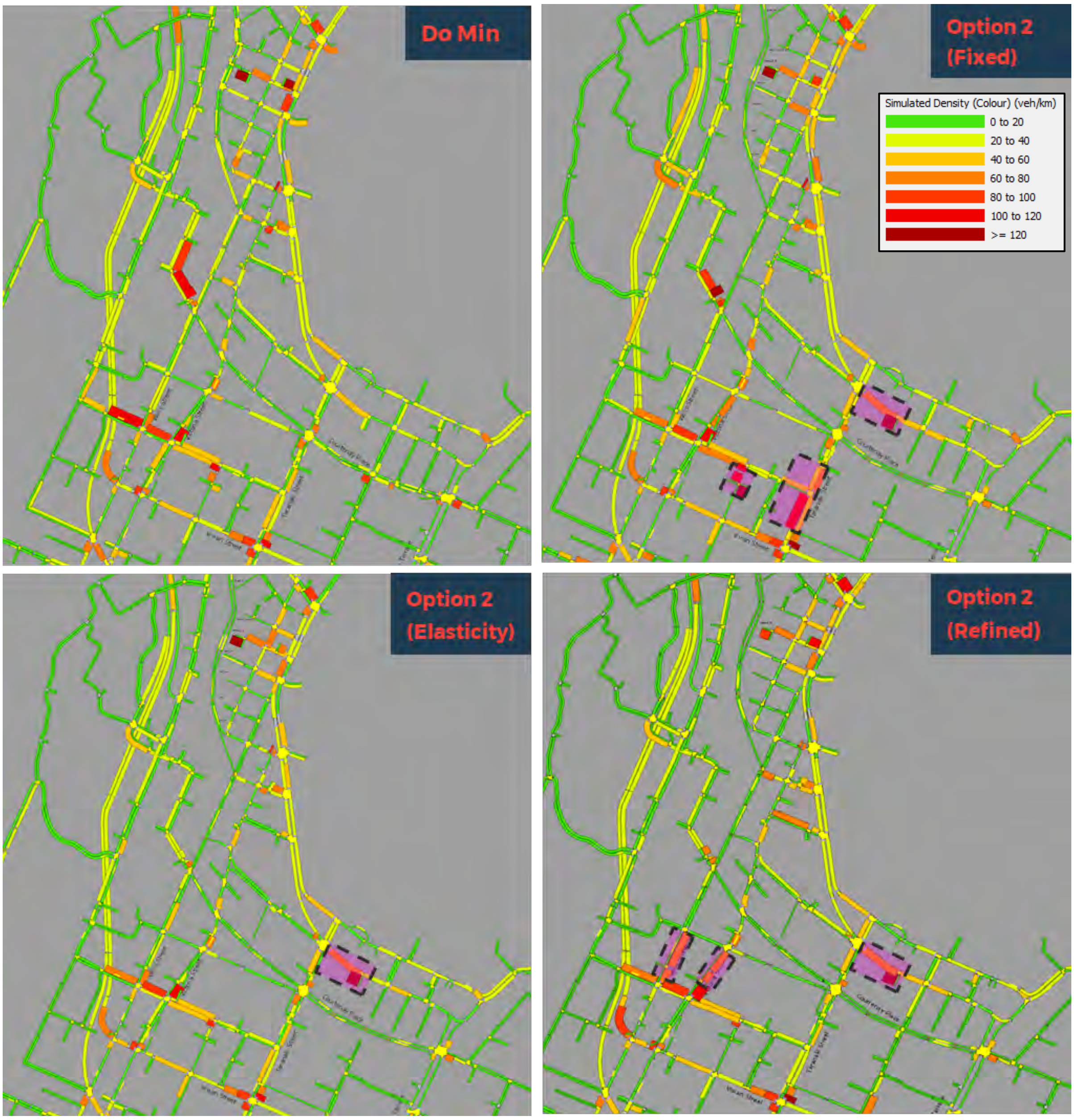


Figure 7-6: PM Network Density (5.00 pm to 6.00 pm)

Figure 7-6 shows that for “Option 2 (Refined) – with the adjusted matrix” additional density is expected on the Willis and Victoria Street southbound approaches to Ghuznee Street. This additional density is caused by changes to the signal phasing at the Victoria / Ghuznee Street intersection which were introduced in an attempt to mitigate the traffic effects on expected on Ghuznee Street. The model results demonstrate that this proposed mitigation requires further development.

As might be expected, the locations where traffic density is expected to increase correspond with the additional traffic flow associated with rerouting to navigate the proposed traffic restrictions on the Golden Mile

7.3 Changes in Level of Service

In a compact central city location, the capacity and performance of the traffic network is more influenced by intersections than by link capacity (the roads between the intersections). This section highlights intersections where a significant change in the level of service (LOS) is expected. The level of service for the approaches of each intersection near the Golden Mile have calculated for the following time periods:

- Morning Peak from 7.30 to 8.30am.
- Inter Peak from 12 to 1pm.
- Evening Peak from 4.30 to 5.30pm.

Level of Service is a metric used to describe attributes such as average delay, queue length, degree of saturation. The LOS presented in this section are based on mean delay. Table 6 shows the delay (in seconds) associated with each LOS classification. “d” corresponds to the turn mean delay in seconds (for all vehicle types).

There are six classifications from LOS A (best operating conditions) to LOS F (worst conditions), LOS D or better is generally considered acceptable. The function of the road also affects the acceptability of approach delays. For example, a poor level of service may be acceptable for a minor access road or for a street that is intended predominantly for use by pedestrians.

Table 4: Level of Service classification

Level of Service	Traffic Signals	Priority Control
A	d ≤ 10	d ≤ 10
B	10 < d ≤ 20	10 < d ≤ 15
C	20 < d ≤ 35	15 < d ≤ 25
D	35 < d ≤ 55	25 < d ≤ 35
E	55 < d ≤ 80	35 < d ≤ 50
F	80 < d	50 < d

Table 7 shows the mean delay and level of service for specific approaches where a large change in LOS is forecast. As would be expected, the reduced demand included in the adjusted matrix, generally minimises the localised decline in LOS associated with traffic rerouting. Table 7 does not show intersection approaches that already displayed unacceptable LOS for the Do Minimum option where this is forecast to continue. A complete comparison of LOS is included as Appendix D.

It may be possible to reduce the delay at some of these locations through further refinement during any future detailed design. It will not be possible to eliminate delay entirely. Future refinement efforts should focus on minimising traffic delay for state highway, arterial and principal traffic routes without eroding the travel time or safety benefits for people travelling by bus or on foot. Poor level of service at other more minor intersection approaches may be acceptable.

Table 5: Mean Turn Delays at Intersections with significant change in the LOS

Intersection	Approaching From	Period	Mean Turn Delays 'd' (Seconds)			
			Do Min	GM Option 2 (Fixed)	GM Option 2 (Elasticity)	GM Option 2 (Refined)
Hunter St / Jervois Quay	TSB Car Park Entrance	IP	58	115.1	76.3	66.8
Lambton Quay / Whitmore / Bowen	Lambton Quay South	AM	28.3	38.4	39.9	67.4
Willis St / SH1	Abel Smith St	IP	42.3	57.2	46.2	95.6
Victoria / Ghuznee St	Victoria St North	AM	43.3	69.0	45.0	55.6
		IP	39.9	62.0	49.6	56.6
		PM	50.9	57.4	46.3	67.4
	Ghuznee St East	AM	35.2	77.2	47.0	56.9
		IP	45.3	89.3	47.5	89.7
		PM	51.1	53.7	44.5	59.3
Taranaki / Wakefield St	Taranaki St North	IP	39.5	59.9	46.1	32.4
	Wakefield St East	IP	26.2	60.0	49.4	36.4
		PM	36.8	60.0	53.1	73.0
	Taranaki St South	AM	15.8	58.1	42.5	36.9
		PM	33.2	70.0	48.9	47.7
Featherston / Brandon St	Brandon St East	PM	52.7	64.0	47.3	44.9
Customhouse Quay / Waterloo / Whitmore St	Lady Elizabeth Lane (north)	IP	48.8	46.6	57.3	47.8

Minor approaches included in Table 7 where additional delay may be accepted include the:

- approach to Jervois Quay / Hunter Street intersection from the TSB Car park
- Abel Smith Street approach to SH1
- Brandon Street approach to Featherston Street
- Lady Elizabeth Lane (north) approach to Customhouse Quay

Some of the four intersections use vehicle detection such that the green phase is only called when vehicles are detected. This method of operation is not simulated within the N2A model which means that the delays for these approaches is likely to be overestimated.

Delays at the Victoria / Ghuznee and Taranaki / Wakefield Street intersections are associated with the re-routing to avoid the Willis Street northbound traffic restriction. Option 2 (Refined) included changes to both intersections intended to minimise additional delays associated with the traffic rerouting. Table 7 indicates that the revisions in Option 2 (Revised) to the Taranaki / Wakefield Street intersection do have the potential to minimise additional delay. The revisions changes in Option 2 (Revised) to the Victoria / Ghuznee Street intersections have not been successful and should be removed or reworked during any future detailed design phase.

Any future design effort will need to address and ideally avoid any additional delay on the Lambton Quay approach to Whitmore Street. In future, the main vehicles that will use this approach to the intersection will be buses that have travelled along the Golden Mile.

7.4 Change in Travel Time

This section summarises the effect of the Golden Mile proposal on travel time for motorised traffic using nine selected routes.

Four of the routes are consistent with those used to assess overall network performance and during calibration of the N2A model. These routes were also used to inform the assessment of the Let's Get Wellington Moving Recommended Package of Improvements.

Five other routes were selected to demonstrate the effect of the proposed Willis Street Traffic restrictions. As described in earlier sections of this report, car journeys to the central city from the nearby suburbs of Brooklyn, Aro Valley, Highbury and Kelburn are expected to be particularly affected by the proposed traffic restrictions.

The travel time presented for these routes corresponds to the 2-hours peaks. More detail is provided in Appendix E.

7.4.1 Routes 1, 2, 5 and 8

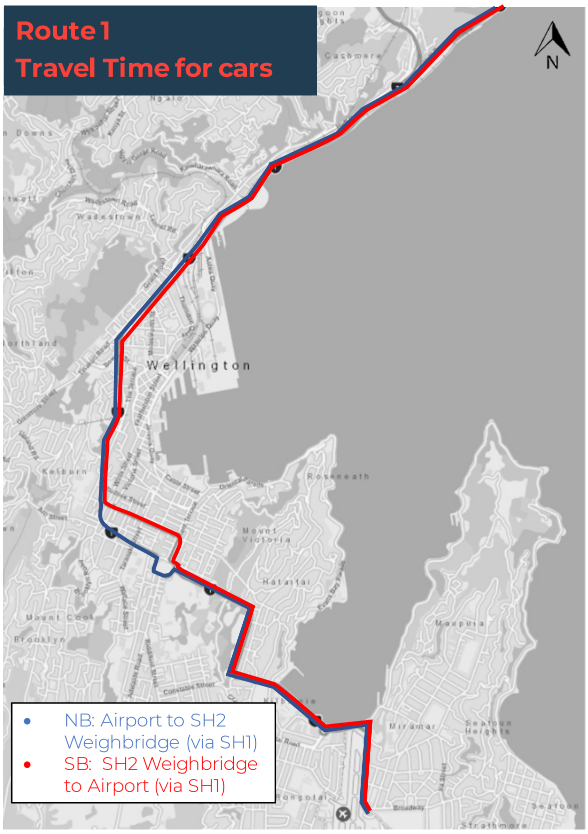
Travel times calculated within the N2A model were extracted for the following routes.

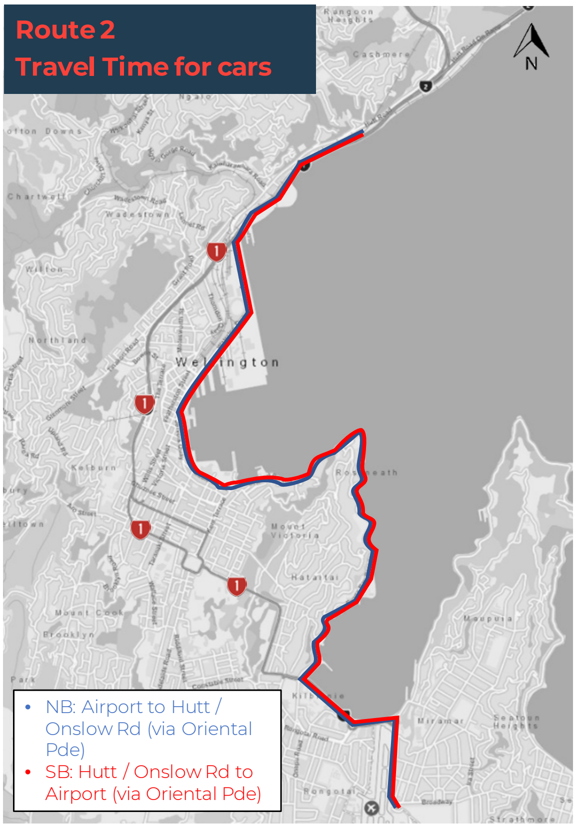
- Route 1 - Airport to SH2 Weighbridge and vice versa (via SH1) - both directions
- Route 2 - Airport to Hutt / Onslow Rd and vice versa (via Oriental Parade) - both directions
- Route 5 - The Terrace (Abel Smith Rd to Bowen St and vice versa) - both directions
- Route 8 - Aotea Quay Off-Ramp to Aro St (via Victoria St) – southbound only

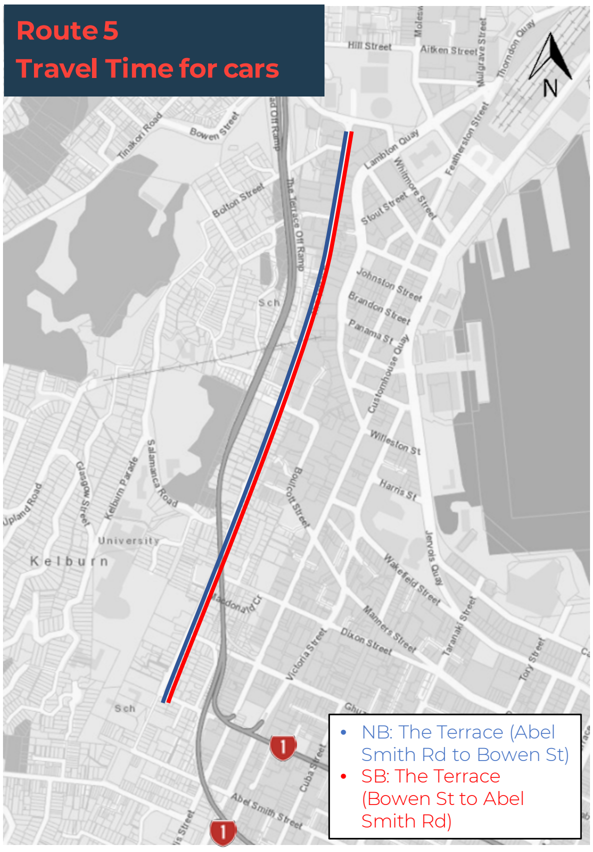
The routes are shown in the figure overleaf. The travel time forecast for each route are shown in Table 6 as well as the difference from the Do Minimum. Travel time forecasts are presented for the proposed Golden Mile improvements both using the fixed demand matrix and adjusted matrix. In many cases the travel times forecast using the adjusted traffic matrix result in lower travel times than for the do minimum.

Table 6 shows that for:

- **Route 1** – except northbound in the morning peak period the changes to travel times are negligible. Northbound travel times on SH1 between the Airport and SH2 could increase in the morning peak period by could increase by up to 1 minute and 46 seconds.
- **Route 2** – northbound travel times between the Airport and SH2 via Oriental Parade and the Waterfront are expected to increase in every modelled period. This is as a result form the additional traffic flow expected along the waterfront as a result of the Lambton Quay traffic restrictions. For a scenario where motorists continue with current travel patterns, travel times for this route are forecast to increase by just over two minutes in the morning peak period and by just under a minute in both the interpeak and evening peak periods.
- **Route 5** – the difference in travel time for The Terrace is forecast to be negligible for both directions in each modelled period. The largest change forecast is 20 seconds northbound in the morning peak period.
- **Route 8** – small increases in southbound travel time are forecast for every period. The largest increase of just over a minute is forecast for the interpeak period.


Route 1
Travel Time for cars
NB: Airport to SH2 Weighbridge (via SH1)
SB: SH2 Weighbridge to Airport (via SH1)
Wellington
N


Route 2
Travel Time for cars
NB: Airport to Hutt / Onslow Rd (via Oriental Pde)
SB: Hutt / Onslow Rd to Airport (via Oriental Pde)
Wellington
N


Route 5
Travel Time for cars
NB: The Terrace (Abel Smith Rd to Bowen St)
SB: The Terrace (Bowen St to Abel Smith Rd)
Kelburn
N


Route 8
Travel Time for cars
SB: Aotea Quay Off-Ramp to Aro St (via Victoria St)
Kelburn

Table 6: Forecast Travel times for Routes 1, 2, 5 and 8 By Direction

Time Period	Direction	Scenario	Travel time (Minutes)				Percentage Difference			
			Route 1	Route 2	Route 5	Route 8	Route 1	Route 2	Route 5	Route 8
Morning Peak	Northbound	Do Min	20.37	22.63	4.83					
		GM Option 2	22.15	24.88	4.88		8.7%	9.9%	1.0%	
		GM Option 2 (Elasticity)	19.81	21.96	4.83		-2.7%	-3.0%	0.0%	
		GM Option 2 (Refined)	20.29	22.68	4.84		-0.4%	0.2%	0.2%	
	Southbound	Do Min	22.12	21.25	4.56	12.20				
		GM Option 2	21.41	21.59	4.90	12.98	-3.2%	1.6%	7.5%	6.4%
		GM Option 2 (Elasticity)	20.95	20.76	4.60	11.83	-5.3%	-2.3%	0.9%	-3.0%
		GM Option 2 (Refined)	21.37	20.82	4.57	12.31	-3.4%	-2.0%	0.2%	0.9%
Inter Peak	Northbound	Do Min	17.89	21.35	4.85					
		GM Option 2	17.92	22.26	4.87		0.2%	4.3%	0.4%	
		GM Option 2 (Elasticity)	17.81	21.42	4.85		-0.4%	0.3%	0.0%	
		GM Option 2 (Refined)	17.78	21.49	4.78		-0.6%	0.7%	-1.4%	
	Southbound	Do Min	17.81	20.26	4.13	11.36				
		GM Option 2	17.82	20.41	4.23	12.63	0.1%	0.7%	2.4%	11.2%
		GM Option 2 (Elasticity)	17.78	19.99	4.26	11.15	-0.2%	-1.3%	3.1%	-1.8%
		GM Option 2 (Refined)	17.66	20.06	4.24	11.45	-0.8%	-1.0%	2.7%	0.8%
Evening Peak	Northbound	Do Min	21.45	21.89	5.06					
		GM Option 2	21.80	22.78	5.17		1.6%	4.1%	2.2%	
		GM Option 2 (Elasticity)	20.18	22.20	5.02		-5.9%	1.4%	-0.8%	
		GM Option 2 (Refined)	20.66	22.43	5.10		-3.7%	2.5%	0.8%	
	Southbound	Do Min	20.00	20.83	4.39	12.42				
		GM Option 2	20.08	21.39	4.23	13.05	0.4%	2.7%	-3.6%	5.1%
		GM Option 2 (Elasticity)	19.48	20.89	4.21	11.44	-2.6%	0.3%	-4.1%	-7.9%
		GM Option 2 (Refined)	20.08	20.80	4.13	11.85	0.4%	-0.1%	-5.9%	-4.6%

The forecasts for scenarios where traffic demand is reduced show less increase and even travel time reductions in some instances. Section 5 explained that further iterations of the variable demand forecasting methodology would see traffic forecasts converge. It is anticipated that this would lead to forecast travel time increases (and decreases) smaller in magnitude) than presented in Table 6.

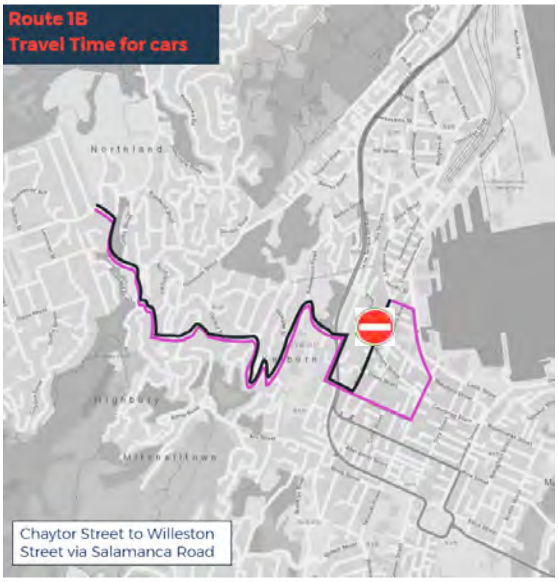
7.4.2 Routes 1A, 1B, 1C, 2 and 3 - Additional Routes

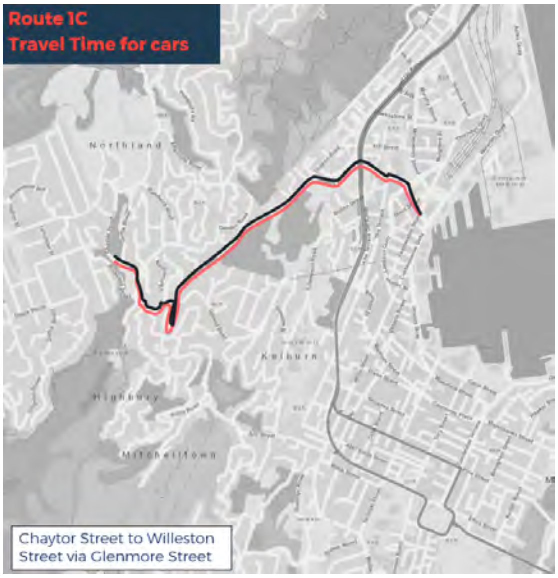
Travel time outputs from the N2A model were extracted for additional routes that were thought could be particularly affected by the proposed changes to the Golden Mile. The routes for which travel times were extracted for one direction only are listed below. Further detail is provided in Appendix E.

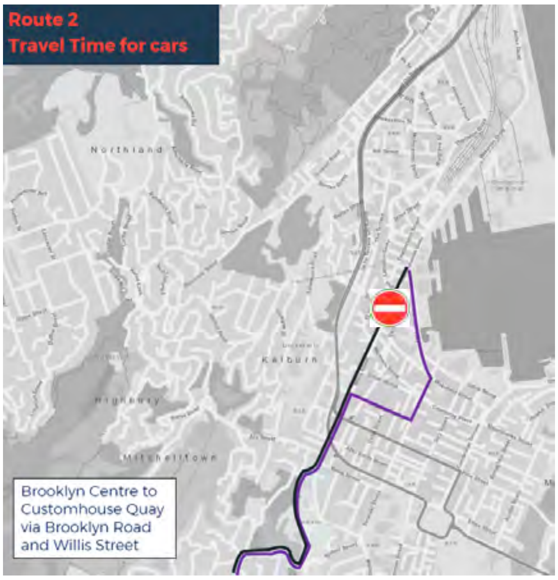
- Route 1A - Chaytor Street to Willeston Street via Aro Valley
- Route 1B - Chaytor Street to Willeston Street via Salamanca Road
- Route 1C - Chaytor Street to Willeston Street via Glenmore Street
- Route 2 - Brooklyn Centre to Customhouse Quay via Brooklyn Road and Willis Street
- Route 3 - SH1 (Motorway Exit) to Willeston Street via Murphy and Featherston Street

The routes are shown in the figure overleaf. Table 7 shows the travel time for each peak period peak, along with the percentage change from the Do Minimum.


Route 1A
Travel Time for cars
Northland
Kelburn
Highbury
Mitchelltown
Chaytor Street to Willeston Street via Aro Valley


Route 1B
Travel Time for cars
Northland
Highbury
Mitchelltown
Chaytor Street to Willeston Street via Salamanca Road


Route 1C
Travel Time for cars
Northland
Kelburn
Highbury
Mitchelltown
Chaytor Street to Willeston Street via Glenmore Street


Route 2
Travel Time for cars
Northland
Kelburn
Highbury
Mitchelltown
Brooklyn Centre to Customhouse Quay via Brooklyn Road and Willis Street


Route 3
Travel Time for cars
Northland
Kelburn
Highbury
Mitchelltown
SH1 (Motorway Exit) to Willeston Street via Murphy and Featherston Street

Table 7: Forecast Travel times for Routes 1A, 1B, 1C, 2 and 3

Peak	Scenario	Travel times (Minutes) Route 1A	Route 1B	Route 1C	Route 2	Route 3	Percentage Difference Route 1A	Route 1B	Route 1C	Route 2	Route 3
Morning Peak	Do Min	11.24	9.82	11.13	9.91	6.47					
	Opt2	16.21	14.01	12.24	12.3	6.91	49.7%	41.9%	11.1%	23.9%	4.4%
	Opt2Elast	14.16	12.49	11.57	11.03	6.65	29.2%	26.7%	4.4%	11.2%	1.8%
	Opt2Ref	14.6	13.57	11.46	11.38	6.71	33.6%	37.5%	3.3%	14.7%	2.4%
Inter Peak	Do Min	10.69	9.83	11.55	9.29	6.48					
	Opt2	13.49	12.48	12.86	10.54	8.13	28.0%	26.5%	13.1%	12.5%	16.5%
	Opt2Elast	12.99	11.98	11.33	9.86	6.53	23.0%	21.5%	-2.2%	5.7%	0.5%
	Opt2Ref	13.83	12.99	11.71	10.24	6.87	31.4%	31.6%	1.6%	9.5%	3.9%
Evening Peak	Do Min	11.39	11.33	11.47	10.44	6.69					
	Opt2	15.66	14.87	13.61	12.7	8.59	42.7%	35.4%	21.4%	22.6%	19.0%
	Opt2Elast	13.92	13.3	11.42	10.95	6.48	25.3%	19.7%	-0.5%	5.1%	-2.1%
	Opt2Ref	16.33	15.45	11.14	11.38	5.87	49.4%	41.2%	-3.3%	9.4%	-8.2%

The outputs from the N2A model suggest that motorised journeys that are diverted via Ghuznee and Taranaki Streets (Routes 1A and1B) could see travel times increase by up to four or five minutes during the morning an evening peak periods. Increases of between two and three minutes could be expected during the interpeak. For journeys to the central city from the nearby suburbs of Aro Valley, Highbury and Kelburn these represent an increase in travel time of almost 50% at peak times. These increases are partly caused by the increased travel distance but largely because of additional congestion expected on Ghuznee Street and Taranaki Street.

Motorised journeys to the central city from Brooklyn (Route 2) are also expected to see an increase in travel times. A smaller increase is forecast for journeys from Brooklyn because they:

- have priority at the Willis Street intersection with Aro Street; and
- approach Ghuznee Street from the Willis Street (south) approach which has more green time than the Ghuznee Street (west) approach

The small (~1 minute) increases in car travel times for journeys between Karori / Northland and the central city are likely to be associated with higher traffic flows as motorists avoid driving via Aro Valley or Kelburn.

Travel time increases of up to two minutes are expected on Featherston Street southbound in the interpeak and evening peak periods. A much smaller increase is forecast for the morning peak period which is already congested.

7.4.3 Summary - Travel Time Routes

This section has shown that the travel times for journeys on the main traffic routes across the city could increase by a one to two minutes if motorists continue to travel in the way they do currently. Increases in the morning peak hour are expected to increase more than at other times of the day, particularly four journeys from north to south.

This section has also shown that there are other journeys from suburbs close to the central city that will experience more significant increase in travel times. Travel times for journeys to the central city from the nearby suburbs of Brooklyn, Aro Valley, Highbury and Kelburn could increase by up to 50%.

It is expected that the changes to the transport system will cause some people to change where they park, when or how they travel. This change in the use of the transport system would reduce traffic demand and minimise the increase in travel times. The travel times resulting from implementation of the Golden Mile project are likely to sit between the extremes reported in Table 6 and Table 7

7.5 Summary - Localised Traffic Effects

Chapter 6 demonstrated that the changes proposed as part of the Golden Mile project are small and will not have a material impact on the overall operation of central city traffic network.

This chapter has reported the traffic effects for scenario where motorists travel behavior does not respond to the changes to the Golden Mile. This is an unrealistic worst-case scenario. This chapter has also reported a scenario where traffic demand reduces as some motorists

- change where they choose to park;
- change the time of day when they drive;
- change the route they choose to reach their destination; or
- change the way in which they travel.

This scenario with adjusted demand is overly optimistic. The forecasts presented in this report should be treated as "bookends" for the forecast. Reality is expected to sit somewhere between the two extremes.

This chapter has highlighted the parts of the traffic network that will experience increased pressure as a result of the traffic restrictions which are part of the Golden Mile project. These are:

- Featherston Street;
- Ghuznee Street; and
- Taranaki Street – intersection with Ghuznee and intersection with Wakefield

These streets and intersections are affected by traffic rerouting to travel around the Willis Street traffic restrictions. Minor changes the to the traffic signal timings at these intersections will help to minimize but will not avoid increased congestion and additional travel time for journeys to the central city from the nearby suburbs of Brooklyn, Aro Valley, Highbury and Kelburn.

Appendix A Adjusting AIMSUM Demand Matrices in Response to Road Capacity Changes

Appendix B Increase Travel Time by Destination

Appendix C Traffic Flows Across Screen Lines

Appendix D Level of Service Comparison

Appendix E Travel time

A

Adjusting AIMSUM Demand Matrices in Response to Road Capacity Changes

Adjusting Aimsun demand matrices in response to road capacity changes

Peter Nunns (WCC), 17 February 2021

The problem

Aimsun is a traffic model that was developed in 2016 for the Ngauranga to Airport corridor study. The model simulates traffic flows on the road network within Wellington City at a more detailed level than the Wellington Transport Strategy Model (WTSM), which is a multi-modal (car and public transport) model that covers the entire Wellington region. See Beca (2019) for an overview of the Aimsun model.

Aimsun incorporates a more detailed zone system and a more detailed representation of the road network, and as a result is preferred for analysis of small-scale changes to the road network. However, the model is limited in other respects – in particular, the fact that traffic demands (ie the number of vehicles travelling between model zones within each modelled time period) are a fixed input to the model.

This limits Aimsun's ability to accurately predict the impact of changes to road capacity on traffic volumes. Aimsun will account for users' choice of alternative routes (eg shifting to another parallel corridor in response to a road closure), but does not capture the following choices:

- Choice of driving or taking PT, walking, or cycling modes
- Not travelling or substituting online shopping or virtual meetings
- Chaining trips together rather than making multiple separate trips
- Changing choice of destination or home location.

Aimsun will therefore over-estimate the traffic disbenefits of temporary or permanent reductions in road capacity because it under-estimates the resulting reductions in traffic volumes.

This issue was identified during model development (see TN06 in Beca, 2019). The proposed approach for addressing it relies upon feedback between Aimsun and WTSM. This has proven difficult to implement in practice due to the need to repeatedly re-run both models.

As a result, a faster and more easily implemented approach to adjust for changes in traffic demands is required.

Evidence on induced and disappearing traffic

A large number of empirical studies demonstrate that changes to road capacity result in proportionate changes in traffic volumes. Increasing road capacity results in increased traffic volumes due to the behavioural responses described above, while reducing road capacity results in reduced traffic volumes.

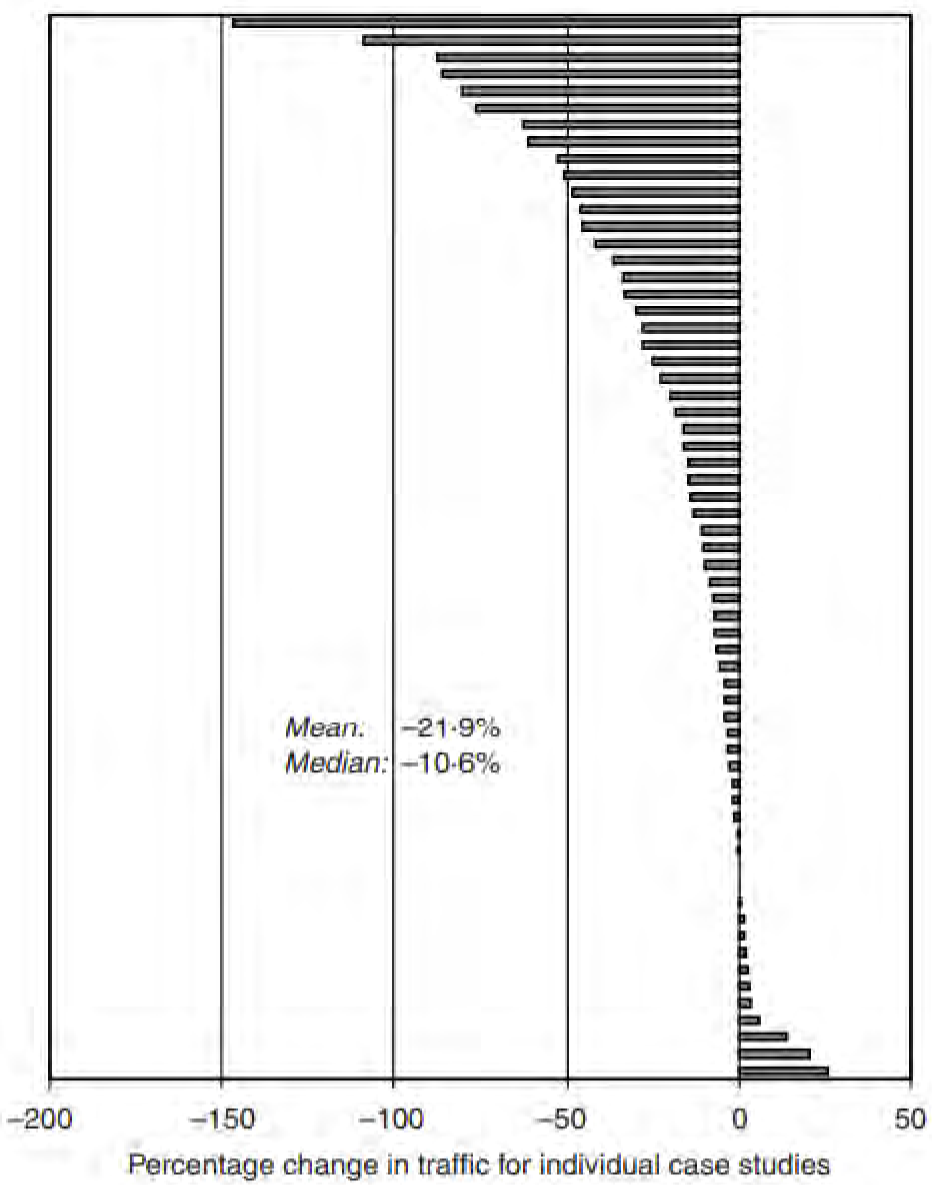
Litman (2020) describes the sources and consequences of induced traffic and summarises previous empirical research on the topic. Some key studies include:

- Handy and Boarnet (2014) review US studies on the impact of highway capacity expansion on VKT and conclude that the long-run elasticity of VKT with respect to capacity falls into the range of 0.6 to 1.0, meaning that a 10% increase in capacity will lead to a 6% to 10% increase in traffic.

- Duranton and Turner (2011) find that vehicle kilometres (VKT) travelled in US cities increase proportionately to road lane kilometres. Increased VKT results from increased driving by current residents, reduced public transport mode share, increased commercial traffic, and faster population growth.
- Hymel (2019) finds that highway capacity expansions in US cities generate an ‘exactly proportional’ increase in vehicle travel, with traffic speeds returning to pre-expansion levels within five years.

In addition to the evidence on induced traffic, there is also evidence that traffic ‘disappears’ in response to reductions in road capacity. Cairns, Atkins, and Goodwin (2002) provide a comprehensive review of over 70 case studies from eleven countries. The following diagram summarises the range of impacts across case studies. In 82% of cases, traffic volumes reduced, sometimes by a large amount. The mean traffic reduction was equal to 22% of total traffic volumes on the affected road and parallel corridors, while the median reduction was 11%.

Figure 1: Distribution of changes in traffic levels after road capacity reductions (Cairns, Atkins, and Goodwin, 2002)



Wellington City has recently experienced several street closures for water and wastewater pipe work on Wallace St and Willis St. While these closures are temporary, they provide a valuable opportunity to study how traffic volumes and speeds respond to reductions in traffic capacity in the local context.

As the Wallace St closure was planned in advance, traffic monitoring data before and during the closure is available to understand the impacts. This evidence can be compared with Aimsun modelling conducted prior to the closure.

A brief statistical analysis of this data is presented at the end of this document, taking into account the impact of holidays and Covid lockdowns. The key findings from that analysis are as follows:

- Average daily traffic volumes crossing a screenline that includes Wallace St, Wright St (the diversion route), Tasman St, and Adelaide Rd dropped by between 1.7% and 2.0% during the closure
- Wallace St traffic volumes largely shifted to Wright St, with smaller shifts to Tasman St and no net increase on Adelaide Rd
- There is some evidence of minor peak spreading on Adelaide Rd, which may have helped to accommodate some of the added volume
- Average traffic speeds did not decline significantly on any corridor, and in fact increased on Wright St due to temporary changes to road layout and on-street parking
- Because the Wright St diversion adds around 200m to the Wallace St route, average travel times for all vehicles travelling between the Adelaide / John / Riddiford intersection and the edge of the city centre increased by around 0.7%.

Lastly, the above results suggest that traffic volumes are likely to be responsive to changes in travel times. Traffic volumes changed by a larger amount than average travel times, implying that some people chose to avoid driving on this route in order to avoid even relatively small average delays. This is consistent with the international literature on travel demand elasticities, discussed below, and suggests that it is appropriate to expect that some traffic will 'disappear', ie shift to other modes, destinations, time periods, etc, in response to road capacity reductions in the Wellington context.

Proposed approach to modelling changes in traffic volumes in Aimsun

The proposed approach to modelling changes in traffic volumes in response to road capacity changes is as follows:

- Step 1: Run Aimsun with a fixed travel demand matrix and with changes in road capacity. Extract modelled demands and travel times for all origin-destination (OD) pairs in the model.
- Step 2: Use an elasticity model to calculate changes in traffic volumes in response to modelled changes in travel times at an OD pair level. This step can be implemented in a spreadsheet.
- Step 3: Input updated traffic volumes into Aimsun and calculate modelled travel times that account for both reductions in road capacity and reductions in traffic volumes.
- Step 4 (not implemented here due to time limitations): Iteratively re-run steps 2 and 3 until the overall model system converges.

The following diagram shows how this approach works using a simplified supply and demand diagram. A road capacity reduction is modelled as an upward shift in the cost of driving to a given area, meaning that traffic speeds are expected to be slower for a given volume of traffic. Demand for driving is shown as a downward-sloping curve, indicating that fewer people are expected to drive between a given origin and destination if travel times are longer.

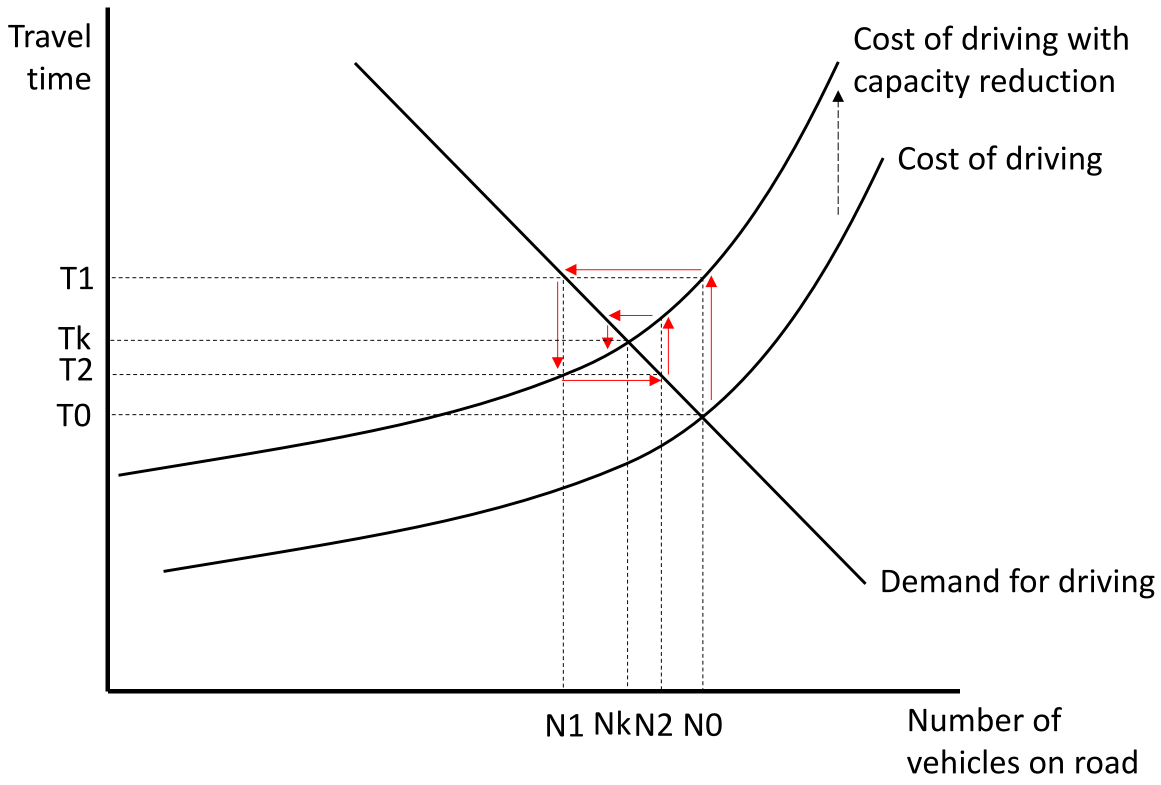
The first step in the modelling approach is to use Aimsun to estimate changes in vehicular travel times between all origin-destination pairs in the model based on a fixed volume of traffic. This results in point (N0, T1) in the diagram.

The second step entails using an elasticity model to estimate how much traffic volumes would be expected to reduce on each origin-destination pairs as a result of the reduction in traffic speeds. This results in point (N1, T1) on the diagram.

The third step involves re-running Aimsun with new origin-destination demands and reduced traffic capacity. This results in point (N1, T2) on the diagram.

As this diagram suggests, outputs from the first step are likely to over-estimate traffic delays while outputs from the third step are likely to over-state traffic volume reductions and under-estimate traffic delays. Further iterations of Aimsun modelling and elasticity modelling (shown as the spiralling red arrows) will therefore converge towards the most likely outcome, which is point (Nk, Tk).[1]

Figure 2: Basic idea of modelling approach



[1] Assuming that traffic speeds universally reduce with increased traffic volumes and that the demand curve is downward sloping, this modelling approach should converge to a unique equilibrium. However, 'noise' in the traffic model will lead to minor variations between model runs and hence perfect convergence may not be achieved. If iterating the modelling approach, it would be necessarily to define a standard for what constitutes adequate convergence between steps.

Advantages of this approach

There are three key advantages of this approach.

- It is straightforward to implement relative to the procedure proposed by Beca (2019), reducing timeframe risk due to the need to integrate inputs and outputs between Aimsun and WTSM
- It is technically defensible as it relies upon empirical evidence on travel demand elasticities, summarised below. In the future, Wellington-specific travel demand elasticities can be estimated using WTSM model outputs to ensure consistency across the model suite.
- It does not rely upon arbitrary assumptions about which trips are most likely to disappear – the elasticity model uses Aimsun outputs to identify origin-destination pairs that are directly or indirectly affected and enables different trips to experience different levels of impacts.

Implementation of elasticity model

To implement Step 2, undertake the following calculation for all origin-destination pairs in the Aimsun model. This approach should be applied separately for each modelled time period to allow impacts to vary by time of day.

Equation 1: Elasticity formula for adjusting traffic volumes

$$V_{ij}^{option} = V_{ij}^{domin} * \left(\frac{T_{ij}^{option}}{T_{ij}^{domin}}\right)^{E}$$

Where V_{ij}^{option} is traffic volume between origin i and destination j in the option scenario; V_{ij}^{domin} is traffic volume in the do-minimum scenario; T_{ij}^{option} is average travel time between origin i and destination j in the option scenario (from Aimsun); T_{ij}^{domin} is average travel time in the do-minimum scenario; and E is the elasticity of traffic volume with respect to travel time.

Initial investigation found that, when applied to Aimsun outputs for a project option that closed one city centre corridor to general traffic, this approach resulted in increased traffic volumes on some origin-destination pairs outside of the city centre. Aimsun predicts reduced travel times for some non-city centre-based trips. This is likely to be an artefact of minor signal optimisation and operational tweaks occurring during model calibration.

When this method is applied to projects that reduce road capacity, traffic volumes should therefore be held constant on all OD pairs where average travel times are predicted to decrease, rather than increased.

Expected outcome of fully iterating the model

Time constraints meant that it was not possible to run the model system to convergence. This is because running the Aimsun model and checking outputs requires a reasonable amount of manual input.

Outputs from steps 1 and 3 therefore provide upper and lower bounds on traffic disbenefits from road capacity reductions. Neither output represents the 'most likely' outcome, and hence neither can be used for reporting central estimates of benefits.

The most likely outcome is expected to lie roughly halfway between these upper and lower bounds.

This is because, for small changes in traffic capacity, we can assume an approximately linear relationship between changes in traffic volumes and changes in travel times. Similarly, the demand curve is expected to be approximately linear over small segments. As a result, the point of convergence, shown by point (Nk, Tk) in Figure 2, will lie halfway between point (N0, T1) and point (N1, T2).[2]

Suggested elasticity of traffic volumes with respect to travel times

The key model parameter is the elasticity of traffic volumes with respect to travel times. A review of the international empirical literature is used to identify a recommended value.

Graham and Glaister (2004) review the international literature on road traffic demand elasticities, including elasticities with respect to fuel prices, incomes, and travel time. The following table summarises their key findings. They recommend elasticities of car demand with respect to travel time drawn from an earlier review of the European literature by de Jong and Gunn (2001).

They find that the average long-run elasticity of car trips with respect to travel time (-0.29) is lower than the short-run elasticity (-0.60). However, the average long-run elasticity of car VKT with respect to travel time (-0.74) is higher than the short-run elasticity (-0.20). This reflects the fact that people substitute towards shorter trips in the long run.

Table 1: Summary of road traffic demand elasticity estimates (Graham and Glaister, 2004)

	Short/long run	Elasticity	Comments
Fuel demand with respect to fuel price	SR	−0.25	mean (n = 377)
	LR	−0.77	mean (n = 213)
Fuel demand with respect to income	SR	0.47	mean (n = 333)
	LR	0.93	mean (n = 150)
Traffic (car-km) with respect to fuel price	SR	−0.15	Graham and Glaister (2002a)
	LR	−0.31	Graham and Glaister (2002a)
Traffic (car trips) with respect to fuel price	SR	−0.16	de Jong and Gunn (2001)
	LR	−0.19	de Jong and Gunn (2001)
Traffic (car-km) with respect to car time	SR	−0.20	de Jong and Gunn (2001)
	LR	−0.74	de Jong and Gunn (2001)
Traffic (car trips) with respect to car time	SR	−0.60	de Jong and Gunn (2001)
	LR	−0.29	de Jong and Gunn (2001)
Traffic (car-km) with respect to income	SR	0.30	Hanly *et al.* (2002)
Traffic (car-km) with respect to income	LR	0.73	Hanly *et al.* (2002)
Freight traffic with respect to price	N.A.	−1.07	mean (n = 143)
Car ownership with respect to cost	SR	−0.20	mean (n = 7)
	LR	−0.90	mean (n = 8)
Car ownership with respect to income	SR	0.28	mean (n = 5)
	LR	0.74	mean (n = 5)

[2] It is straightforward to verify this geometrically.

Wallis (2004) reviews evidence on demand elasticities for public transport and car travel and provides recommendations for best estimate values in the New Zealand context. The following table summarises his key findings, which are generally similar to the above values.

Wallis (2004) recommends a 'typical range' of long-run elasticity of vehicle traffic with respect to in-vehicle travel time of -0.60 to -0.80, and a 'best estimate' of -0.60 for the New Zealand market. This range is based on 17 international studies, including five from Australia. In addition, he suggests that only around 20% of the reduction in traffic volumes will be diverted to public transport, with the remainder reflecting changes in destinations, trip chaining, and reductions in trip generation (eg due to substitution of online shopping or virtual meetings).

Table 2: Private transport direct elasticity values (Wallis, 2004)

Variable	Short run		Long run	
	Best Estimate	Typical Range	Best Estimate	Typical Range
Fuel prices	–0.15	–0.10 to –0.20	–0.25	–0.20 to –0.30
In-vehicle time	–0.30	–0.15 to –0.50	–0.60	–0.60 to –0.80
Parking charges [(1)]	–0.30	–0.10 to –0.60	N/A	N/A
Toll charges	–0.15	–0.05 to –0.40	N/A	N/A

N/A not available
(1) Relates to CBD commuter travel

Based on the above literature reviews, a 'best guess' elasticity of traffic volumes with respect to travel times of **-0.7** is suggested. This is based on:

1. Graham and Glaister's (2004) recommended long-run elasticity of VKT with respect to travel time (-0.74)
2. The midpoint of Wallis's (2004) 'typical range' for the elasticity of traffic volumes with respect to in-vehicle time (-0.6 to -0.8).

This approach is considered to be appropriate given timeframes for this modelling and the consensus in the international literature. However, future modelling could be improved by developing a local elasticity estimate based on analysis of WTSM outputs, following the approach outlined by de Jong and Gunn (2001).

Calculating traffic benefits / disbenefits using model outputs

After completing Steps 1-3 in the proposed model process, traffic benefits/disbenefits should be calculated at an origin-destination pair level with a rule of half adjustment for changes in demand.

This approach differs from the standard method used to calculate traffic benefits/disbenefits using Aimsun outputs, which is to simply sum up total travel times across all origin-destination pairs or road links and compare differences between option and do-minimum scenarios.

The following formula should be used to calculate traffic benefits / disbenefits at an origin-destination pair level.

Equation 2: Calculation of traffic benefits / disbenefits using model outputs

$$Benefits_{ij} = \left(V_{ij}^{option} + V_{ij}^{domin}\right) * \left(T_{ij}^{domin} - \overline{T_{ij}^{option}}\right) * 0.5 * VOT$$

Where V_{ij}^{option} is traffic volume between origin i and destination j in the option scenario (calculated in Step 2 of the process); V_{ij}^{domin} is traffic volume in the do-minimum scenario; $\overline{T_{ij}^{option}}$ is average travel time between origin i and destination j in the option scenario (re-calculated in Step 3 in Aimsun); T_{ij}^{domin} is average travel time in the do-minimum scenario (calculated in Step 1); and VOT is the value of travel time for private vehicles.

As modelled traffic volumes will decrease, it will also be necessary to consider additional categories of benefits, including:

- Greenhouse gas emission reductions and reduced particulate emissions
- Mode shift to public transport and active modes – Wallis (2004) suggests that around 20% of reduced traffic may switch to public transport.

Test implementation

Steps 1 and 2 in the proposed methodology described above have been implemented for two Golden Mile options: GMOpt1, which results in minor traffic capacity reductions and turning restrictions, and GMOpt2, which closes the entire Golden Mile to general traffic. Step 3 has not yet been completed as it is necessary to review outputs from Step 2 before proceeding further.

Model outputs for OD pairs were re-analysed in a spreadsheet and summarised to sectors for reporting. The sector system is described at the end of this document.

An analysis of modelled travel time changes for GMOpt2, as calculated in Step 1, shows that modelled disbenefits are concentrated in a small number of OD pairs:

- A single OD pair accounts for over 10% of total travel time disbenefits
- 22 OD pairs (out of a total of more than 110,000 OD pairs corresponding to trips between more than 300 zones) account for over 27% of total travel time disbenefits
- 376 OD pairs account for over 76% of total disbenefits
- Over 10,000 model zones (around 9% of all zones) are estimated to experience net travel time benefits.

The following 'rug charts' show modelled changes in AM peak traffic volumes between model sectors, based on Step 2 calculations. An elasticity of -0.7 is used, and zones that experience increases in volumes (due to modelled reductions in travel time from Step 1) are not adjusted. Green shading indicates increased traffic volumes, and red shading indicates reduced traffic volumes, corresponding to areas that see traffic benefits/disbenefits in Step 1.

Table 3 shows modelled changes, including any increased traffic volumes estimated due to reduced travel times. This table shows that, under GMOpt2, there are modelled benefits for trips from sector 4 (Mt Victoria / Roseneath / Hataitai) to several nearby sectors (3 – Mt Cook; 5 – Miramar / Seatoun / Strathmore; 6 – Airport; 7 – Kilbirnie; 8 – Island Bay; 9 – Newtown / Berhampore). These trips have origins and destinations outside the city centre and hence are unlikely to interact directly with the Golden Mile. This is likely to be an artefact of signal and network optimisation tweaks undertaken during the modelling process.

There are also large modelled traffic reductions for some origins and destinations that pass through the city centre, such as trips from sector 7 (Kilbirnie) to sector 12 (Karori) or trips from sector 3 (Mt Cook) to sector 2 (Port) in GMOpt2.

Table 4 adjusts for the above issue by setting traffic volumes equal to do-minimum volumes in all OD pairs that experience reduced travel times. This results in larger overall decreases in traffic volumes, as modelled increases in flows on some OD pairs are cancelled out.

Table 3: Modelled changes in traffic volumes between Aimsun model sectors (including increases)

GMOpt1

O\D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	-1%	1%	1%	2%	2%	2%	2%	0%	1%	0%	1%	0%	2%	0%	1%	2%
2	2%	0%	-1%	2%	-2%	#DIV/0!	-2%	1%	-2%	-3%	1%	-1%	0%	-1%	-1%	1%
3	-3%	-3%	0%	-2%	-1%	1%	-1%	-2%	-3%	-2%	-4%	1%	0%	-1%	-3%	-2%
4	6%	10%	12%	0%	4%	5%	16%	5%	11%	4%	-1%	2%	6%	3%	2%	1%
5	3%	3%	2%	2%	-1%	-2%	-4%	-1%	-1%	1%	0%	0%	-2%	1%	2%	3%
6	6%	#DIV/0!	2%	1%	-2%	#DIV/0!	-2%	0%	-4%	2%	10%	1%	11%	4%	7%	6%
7	3%	2%	2%	2%	-1%	-1%	0%	0%	0%	5%	0%	-1%	-5%	-3%	-2%	-2%
8	1%	2%	0%	-2%	-1%	-2%	0%	0%	1%	1%	0%	1%	3%	1%	2%	1%
9	1%	1%	1%	-6%	-4%	-5%	-5%	1%	0%	4%	-9%	0%	8%	-2%	1%	0%
10	1%	1%	4%	6%	-2%	-4%	1%	0%	1%	1%	1%	0%	-1%	0%	2%	0%
11	-1%	-2%	-1%	0%	0%	-2%	5%	0%	-1%	0%	0%	0%	0%	1%	-1%	0%
12	-1%	1%	0%	-1%	-1%	-1%	5%	0%	0%	1%	1%	2%	1%	1%	1%	1%
13	0%	1%	0%	0%	-1%	4%	-1%	3%	-2%	-2%	1%	1%	1%	0%	0%	2%
14	1%	-2%	-1%	-1%	1%	2%	3%	-2%	-1%	1%	1%	1%	3%	1%	0%	1%
15	-6%	-8%	-3%	-3%	-2%	-2%	-3%	-2%	-2%	-2%	-6%	-4%	-1%	-3%	#DIV/0!	-6%
16	8%	7%	9%	7%	5%	4%	12%	5%	6%	7%	6%	6%	5%	13%	10%	#DIV/0!

GMOpt2

O\D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	-4%	-2%	-2%	1%	1%	1%	1%	-1%	-1%	-3%	-1%	-2%	-1%	-1%	0%	1%
2	1%	0%	-2%	3%	1%	#DIV/0!	-1%	3%	-4%	-5%	-2%	1%	-3%	-2%	0%	0%
3	-5%	-8%	-2%	1%	1%	-1%	0%	0%	-2%	0%	-1%	-1%	-4%	-1%	-3%	-3%
4	0%	0%	7%	1%	5%	6%	15%	4%	11%	0%	-2%	-3%	1%	1%	-1%	-1%
5	0%	-1%	0%	1%	0%	0%	-1%	-1%	-1%	0%	-1%	0%	-3%	-1%	-2%	-1%
6	0%	#DIV/0!	-3%	-1%	0%	#DIV/0!	1%	-1%	0%	-2%	0%	-2%	5%	0%	-1%	-2%
7	-3%	-3%	-1%	3%	0%	0%	0%	0%	-1%	2%	-1%	-7%	1%	-3%	-2%	-2%
8	-4%	-3%	1%	0%	0%	0%	0%	0%	1%	1%	-2%	-1%	5%	-1%	-2%	-3%
9	-2%	-4%	4%	1%	1%	1%	-2%	1%	3%	4%	-2%	0%	2%	-1%	-1%	0%
10	-3%	-2%	-1%	0%	-1%	-2%	1%	0%	1%	0%	0%	0%	0%	-2%	-2%	-5%
11	-2%	-3%	-3%	-2%	-2%	-2%	0%	-2%	-2%	-3%	1%	-1%	-1%	0%	0%	0%
12	-2%	-2%	-4%	-2%	-3%	-3%	-3%	-3%	-3%	-3%	0%	3%	0%	0%	0%	0%
13	-3%	-2%	-3%	-2%	0%	5%	-3%	-4%	-4%	-3%	1%	1%	0%	-1%	0%	-2%
14	-2%	-3%	-3%	-1%	-1%	0%	-1%	-4%	-3%	-2%	1%	1%	2%	1%	0%	0%
15	0%	-1%	0%	1%	0%	0%	-1%	0%	-1%	0%	1%	1%	1%	0%	#DIV/0!	-2%
16	-2%	-3%	-3%	1%	-1%	0%	-2%	-1%	-3%	-3%	-1%	-1%	-2%	-1%	-2%	#DIV/0!

Table 4: Modelled changes in traffic volumes between Aimsun model sectors (excluding increases)

GMOpt1

O\D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	-5%	-3%	-3%	-3%	-1%	-1%	-3%	-2%	-3%	-4%	-2%	-2%	-1%	-1%	-1%	0%
2	-3%	0%	-3%	-4%	-3%	#DIV/0!	-5%	-1%	-3%	-6%	-1%	-2%	-4%	-3%	-1%	0%
3	-5%	-4%	-4%	-5%	-4%	-1%	-3%	-3%	-6%	-5%	-6%	-2%	-3%	-3%	-4%	-3%
4	-2%	-1%	-2%	-2%	-1%	-1%	-1%	-3%	-3%	-2%	-3%	-2%	-1%	-1%	-1%	0%
5	-1%	0%	-1%	-2%	-1%	-2%	-4%	-2%	-2%	-1%	-2%	-2%	-3%	-1%	-1%	0%
6	-1%	#DIV/0!	-3%	-3%	-3%	#DIV/0!	-2%	0%	-5%	-1%	-3%	-1%	0%	0%	0%	0%
7	-2%	-1%	-1%	-2%	-2%	-1%	-1%	-1%	-2%	-1%	-3%	-3%	-5%	-3%	-2%	-2%
8	-1%	-1%	-1%	-2%	-1%	-2%	-1%	-1%	-3%	-2%	-2%	-1%	0%	-3%	-1%	-1%
9	-3%	-2%	-3%	-7%	-5%	-6%	-6%	-1%	-6%	-1%	-10%	-3%	-1%	-3%	-1%	-2%
10	-4%	-2%	-2%	-2%	-4%	-4%	-1%	-1%	-4%	-1%	-2%	-2%	-2%	-3%	-1%	-2%
11	-2%	-2%	-3%	-2%	-2%	-3%	-2%	-2%	-2%	-2%	-1%	-1%	0%	-1%	-1%	-1%
12	-1%	-1%	-2%	-3%	-1%	-1%	-2%	-1%	-1%	-1%	-1%	0%	0%	-1%	0%	0%
13	-3%	-1%	-2%	-3%	-4%	-2%	-4%	-1%	-3%	-3%	0%	0%	0%	-1%	0%	0%
14	-2%	-3%	-2%	-3%	-2%	0%	-2%	-2%	-2%	-2%	-1%	-1%	0%	-1%	0%	0%
15	-6%	-8%	-3%	-4%	-2%	-2%	-3%	-3%	-2%	-2%	-6%	-4%	-1%	-3%	#DIV/0!	-6%
16	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	#DIV/0!

GMOpt2

O\D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	-8%	-5%	-5%	-4%	-1%	-2%	-3%	-2%	-4%	-5%	-3%	-3%	-3%	-2%	-1%	-1%
2	-4%	0%	-5%	-4%	-1%	#DIV/0!	-2%	-1%	-4%	-5%	-3%	-2%	-4%	-3%	-1%	0%
3	-7%	-8%	-5%	-3%	-2%	-2%	-2%	-2%	-4%	-2%	-3%	-2%	-5%	-3%	-3%	-3%
4	-4%	-6%	-2%	-1%	0%	0%	-1%	-1%	-2%	-5%	-3%	-5%	-2%	-2%	-2%	-1%
5	-2%	-2%	-1%	-2%	0%	0%	-1%	-1%	-2%	-2%	-3%	-2%	-5%	-2%	-2%	-1%
6	-2%	#DIV/0!	-4%	-4%	0%	#DIV/0!	0%	-1%	-1%	-2%	-5%	-3%	0%	-2%	-1%	-2%
7	-5%	-3%	-3%	-1%	-1%	0%	-1%	-1%	-2%	-1%	-3%	-8%	0%	-3%	-2%	-3%
8	-4%	-5%	-1%	-1%	0%	0%	0%	0%	-1%	-1%	-3%	-2%	0%	-4%	-2%	-3%
9	-5%	-5%	-2%	-1%	-1%	0%	-3%	-1%	-3%	-1%	-4%	-2%	-1%	-2%	-1%	-1%
10	-6%	-4%	-3%	-3%	-2%	-2%	-1%	-1%	-2%	-1%	-1%	-2%	0%	-3%	-3%	-5%
11	-4%	-4%	-4%	-4%	-4%	-3%	-2%	-4%	-3%	-3%	-1%	-1%	-1%	-1%	-1%	-1%
12	-3%	-2%	-5%	-4%	-3%	-4%	-4%	-4%	-4%	-3%	-1%	0%	-1%	-1%	0%	0%
13	-5%	-2%	-4%	-4%	-2%	-1%	-4%	-4%	-5%	-3%	-1%	0%	0%	-1%	-1%	-2%
14	-3%	-4%	-4%	-3%	-2%	-2%	-3%	-4%	-4%	-4%	-1%	-1%	0%	-1%	0%	-1%
15	-1%	-1%	-1%	-1%	0%	0%	-2%	-1%	-1%	-1%	-1%	0%	0%	0%	#DIV/0!	-2%
16	-3%	-3%	-3%	-1%	-2%	0%	-2%	-2%	-4%	-3%	-2%	-1%	-2%	-2%	-2%	#DIV/0!

Table 5 summarises network-wide changes in average travel times and traffic volumes. The third column shows changes in total traffic volumes including zones that experience increased demands.

The fourth column shows changes in total traffic volumes excluding zones that experience increased demands. The final column calculates the implied aggregate elasticity of traffic volumes with respect to travel time as a check on model consistency. Under GMOpt2, network-wide traffic volumes are estimated to fall by between 1.3% and 2.2%, responding to a 2.0% increase in average travel times.

As a sense check, note that Wellington City has a total of around 1200 lane-kilometres of urban road. The Golden Mile is 2.1 kilometres in length and provides a total of around 7 lane-kilometres for general traffic, ie around 0.6% of the total urban road network. GMOpt2 would result in a 0.6% reduction in lane-kilometres available for general traffic, which is on the same order of magnitude as the modelled reduction in traffic volumes, albeit smaller. This suggests a stronger relationship between road capacity and traffic volumes than Duranton and Turner (2011) and Hymel (2019) find in US cities, but a stronger relationship is to be expected in a heavily trafficked city centre context.

Table 5: Summary of changes in AM peak travel times and traffic volumes (elasticity = -0.7)

Key changes by scenario	Change in avg travel time (all OD pairs)	Modelled change in trips, including increases (as in Table 3)	Modelled change in trips, excluding increases (as in Table 4)	Implied aggregate elasticity of traffic volumes with respect to time
GMOpt1	-0.7%	0.5%	-1.8%	-0.69
GMOpt2	2.0%	-1.3%	-2.2%	-0.65

Finally, Table 6 sensitivity tests a lower elasticity of -0.3, which is similar to the short-run elasticity estimates in Graham and Glaister (2004) and Wallis (2004). As predicted, a lower elasticity halves the modelled reduction in traffic volumes.

Table 6: Summary of changes in AM peak travel times and traffic volumes (elasticity = -0.3)

Key changes by scenario	Change in avg travel time (all OD pairs)	Modelled change in trips, including increases (as in Table 3)	Modelled change in trips, excluding increases (as in Table 4)	Implied aggregate elasticity of traffic volumes with respect to time
GMOpt1	-0.7%	0.1%	-0.8%	-0.20
GMOpt2	2.0%	-0.6%	-1.0%	-0.30

Proposed next steps

Timeframes for completing this analysis and finalising Golden Mile economics are short. As a result, the following approach is proposed for reviewing and implementing this approach:

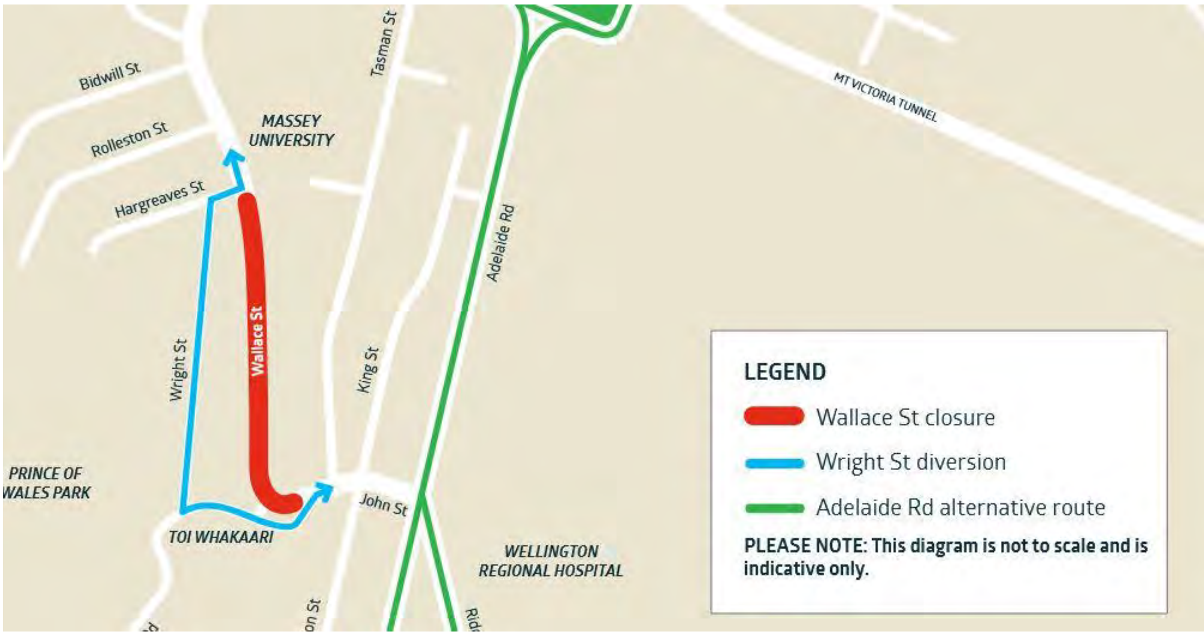
1. Rapid internal review by Golden Mile project team and Wellington Analytics Unit staff, focusing on feasibility to implement proposed approach and validity of proposed elasticity parameter.
2. Technical review by LGWM technical director and key partner TAG members, focusing on the same issues described above
3. Implement Step 3 of methodology in Aimsun and complete transport economics.

Analysis of Wallace St closure

Between 5 January 2020 and mid-2020 Wallace St, one of the main arterial roads between Wellington's southern suburbs and the city centre, was closed for the installation of a new water main. The following diagram shows the road closure and alternative routes on Adelaide Rd and Wright St.

The alternative route on Wright St is a residential street rather than an arterial road. Some changes were made to road layout, eg by reducing on-street parking, to increase its capacity to serve additional traffic volumes.

Figure 3: Wallace St closure



Before the Wallace St closure, traffic modelling was undertaken to understand impacts on the network. This modelling was conducted in Aimsun, which assumes fixed overall traffic demands but simulates route choice. It focused on impacts during the AM peak period.

As shown in the following table, modelling predicted that re-routed traffic would be distributed between Wright St (48% of total re-routed trips), Tasman St (20%), Adelaide Rd (13%), and other routes such as Mt Vic Tunnel (19%). The report suggests that "the Wallace Street closure will have minimal impact on the overall network", but does observe that volume to capacity ratios will increase on Adelaide Rd and other parts of the network, implying declining traffic speeds on this corridor.

Table 7: Aimsum modelling of AM peak traffic volume impacts of Wallace St closure

Location	DM	Scen1	Abs Diff	% Diff
Wallace Street	1,150	0	-1,150	-100%
Tasman Street	250	500	250	100%
Wright Street	50	600	550	1,100%
Adelaide Road	1,750	1,900	150	9%
Totals	**3,200**	**3,000**	**-200**	

Daily traffic counts were carried out at key sites in the area from early December to early March. Work on the project stopped during the Level 4 lockdown starting on 25 March and ending 27 April.

Approach to analysis

The following diagram shows the traffic counting sites operated by the project and indicates the sites included in three separate screenlines. Screenline A is the primary screenline, while the others are used as sensitivity tests.[3]

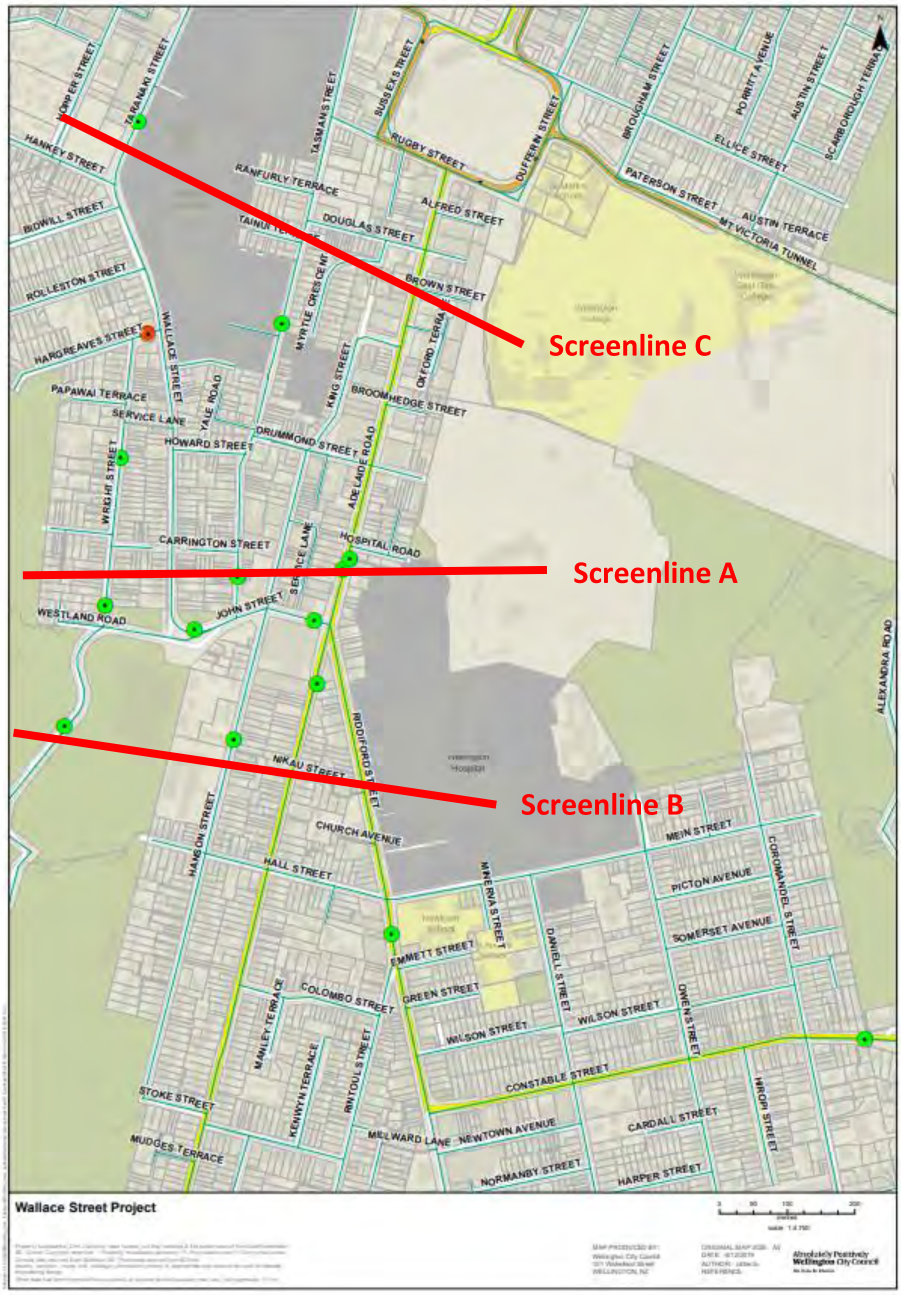
Traffic volumes during the traffic counting period were affected by both summer school holidays and the Covid restrictions starting in March 2020. As a result, the comparison focuses on the following time periods:

- Before Wallace St closure: Second week of December 2019 (week started 8 December 2019).
- After Wallace St closure: Second and third weeks of February 2020 (weeks started 9 February and 16 February 2020). Data for these two weeks was averaged.

A brief analysis of other traffic count data suggests that overall traffic volumes are roughly comparable between these periods. A more sophisticated analysis could formally take seasonality into account by estimating seasonal adjustment factors using data from other traffic count sites.

[3] Screenline A sites are: Adelaide Rd between John St and Hospital Rd; John St between Tasman St and Wallace St; Tasman St between Tainui Tce and Coombe St; and Wright St between Salisbury Tce and Hutchison Rd. Screenline B sites are: Adelaide Rd between John St and Nikau St; Hanson St between John St and Hall St; Hutchison Rd between Wright St and Finnimore Tce; and Riddiford St between Mein St and Emmett St. Screenline C sites are: Adelaide Rd between John St and Hospital Rd; Taranaki St near Hankey St; and Tasman St between Tainui Tce and Coombe St.

Figure 4: Screenline locations



Changes in 7-day average daily traffic volumes

Table 8 summarises changes in average daily traffic volumes across the three screenlines defined above. Average daily traffic reduced by between 1.7% and 2.0% on this route.

Table 8: Changes in 7-day ADT during the Wallace St closure, by screenline

Location	Before Wallace St closure			After Wallace St closure			Percent change
	Inbound ADT	Outbound ADT	Total	Inbound ADT	Outbound ADT	Total	
Screenline A	22,058	22,377	44,435	23,334	20,218	43,551	**-2.0%**
Screenline B	19,237	18,073	37,310	18,923	17,727	36,650	**-1.8%**
Screenline C	21,118	21,478	42,596	20,352	21,500	41,852	**-1.7%**

Table 9 summarises changes in average daily traffic volumes across the four streets included in Screenline A. This shows that:

- Volumes on Adelaide Rd remained the same
- Reductions in traffic on Wallace St (-15,000 trips) were balanced out by diversion to Wright St (+13,000 trips) and, to a lesser extent, Tasman St (+1,000 trips).

This suggests that changes to increase capacity on Wright St played a significant role in accommodating similar traffic volumes. Note that these results contrast with AM peak Aimsum modelling summarised above, which suggested increased volumes on Adelaide Rd.

Table 9: Changes in 7-day ADT across Screenline A, by street

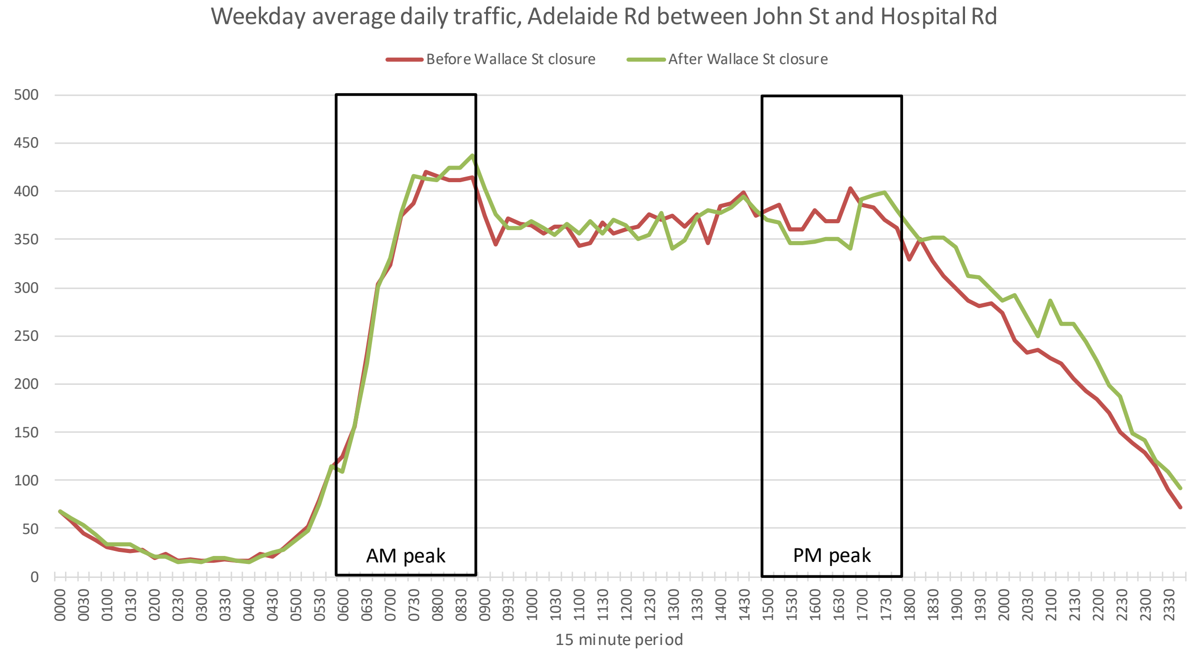
Location	Before Wallace St closure			After Wallace St closure			Change
	Inbound ADT	Outbound ADT	Total	Inbound ADT	Outbound ADT	Total	
Adelaide Rd	13,002	9,511	22,513	12,626	9,940	22,566	53
Wallace St	6,554	9,261	15,815	13	622	634	-15,181
Tasman St	1,968	3,082	5,050	2,474	3,670	6,144	1094
Wright St	534	523	1,057	8,222	5,986	14,208	13,151
Total	**22,058**	**22,377**	**44,435**	**23,334**	**20,218**	**43,551**	**-884**

Time period changes

Figure 5 summarises average weekday traffic volumes in 15 minute intervals before and after the Wallace St closure.[4] This chart suggests that there may have been a modest degree of peak spreading, focused on the end of the AM peak period and a shift from the PM peak period into the evening period. This is in turn likely to have assisted in mitigating traffic delays.

[4] In this case, 'after' data is only based on the week started 9 February 2020, which had slightly higher traffic volumes than the following week.

Figure 5: Traffic volumes on Adelaide Rd by time of day



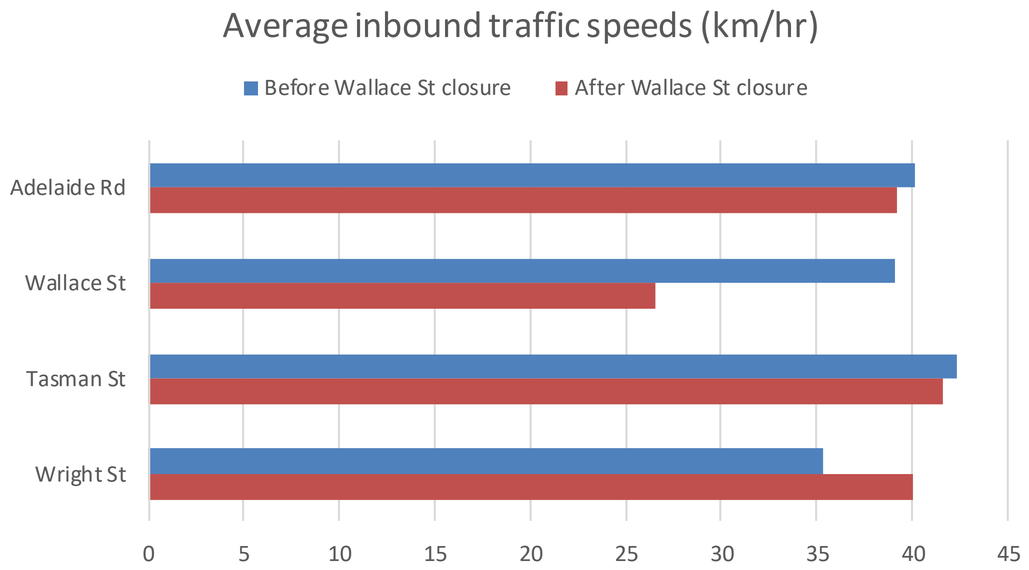
Changes in traffic speeds

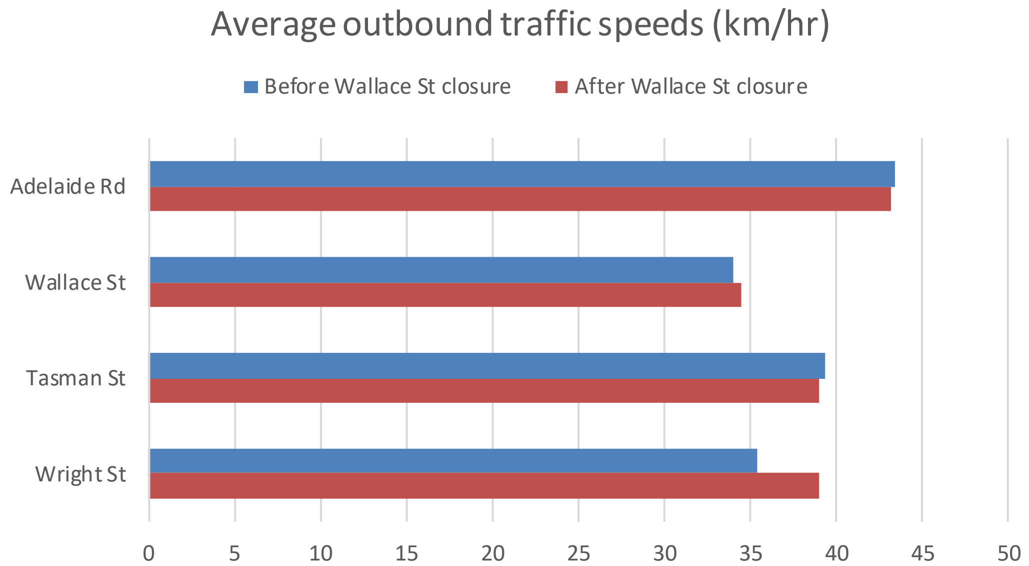
Figure 6 shows changes in average traffic speeds on the four streets comprising Screenline A. Data for Wallace St (based on the John St counting site) is not relevant as there were very few cars using this street. This analysis shows that average traffic speeds did not appreciably reduce on any of the three alternative corridors:

- Average speeds on Adelaide Rd and Tasman St reduced by an insignificant amount – less than 1 km/hr in both the inbound and outbound directions.
- Average speeds on Wright St increased by around 4 km/hr due to changes to road layout and on-street parking.

In short, the Wallace St closure appears to have been accommodated without any significant increase in vehicle delay. This contrasts, somewhat, with Aimsum model plots that show rising volume to capacity ratios on Adelaide Rd north of John St and hence imply falling traffic speeds.

Figure 6: Changes in average traffic speeds across Screenline A





However, the Wright St diversion is slightly longer than Wallace St – it adds roughly 200 metres to the journey from the Adelaide/John/Riddiford intersection to the Taranaki/Karo intersection – and as a result this change has increased average travel times on these routes.

The following table calculates changes in total travel times on all four corridors, in both directions. Distances are calculated from the Adelaide/John/Riddiford intersection and the edge of the city centre (defined as Karo Drive and the top edge of the Basin). Calculations do not account for the impact of signals, as signal timing does not vary significantly during the project period.

Average travel times on this corridor are estimated to increase by 0.7% as a result of the Wallace St closure.

Table 10: Changes in average travel times from Adelaide/John/Riddiford intersection to edge of the city centre

Location	Distance (km)	Before Wallace St closure	After Wallace St closure	Percent change

Adelaide Rd	1.09	1.57	1.60	
Wallace St	1.29	2.14	NA	
Tasman St	1.10	1.63	1.65	
Wright St	1.48	2.51	2.24	
Weighted average travel time		**1.81**	**1.82**	**0.7%**

Elasticity of traffic volumes with respect to travel times

The above calculations can be used to estimate a local elasticity of traffic volumes with respect to travel times. The following caveats and cautions apply to this estimate:

- First, it is assumed that the Wallace St closure (a temporary 'supply shock') is the only factor affecting volumes during this time, and that there are no other major factors changing travel demands
- Second, the above calculations are based on a relatively small amount of data and hence may include statistical 'noise' that makes it difficult to accurately estimate an elasticity
- Third, analysis of travel time impacts is partial, excluding the impact of signals and not accounting for travel times on other parts of people's routes. This will create a downward bias in the estimated elasticity.
- Fourth, analysis of traffic volume changes does not include some wider network routing options such as Brooklyn Rd or the Mt Vic Tunnel. This will create an upward bias in the estimated elasticity.

With those caveats in mind, the following table calculates an implied elasticity of traffic volumes with respect to average travel times. The estimated value is large – in the range of -2.5 to -2.8. This is significantly higher than the values reported in literature reviews by Graham and Glaister (2004) and Wallis (2004).

While this finding should not be relied upon for modelling, it suggests that traffic volumes on routes to the city centre are likely to be responsive to changes in travel times in the local Wellington context.

Table 11: Implied elasticity of traffic volumes with respect to average travel times

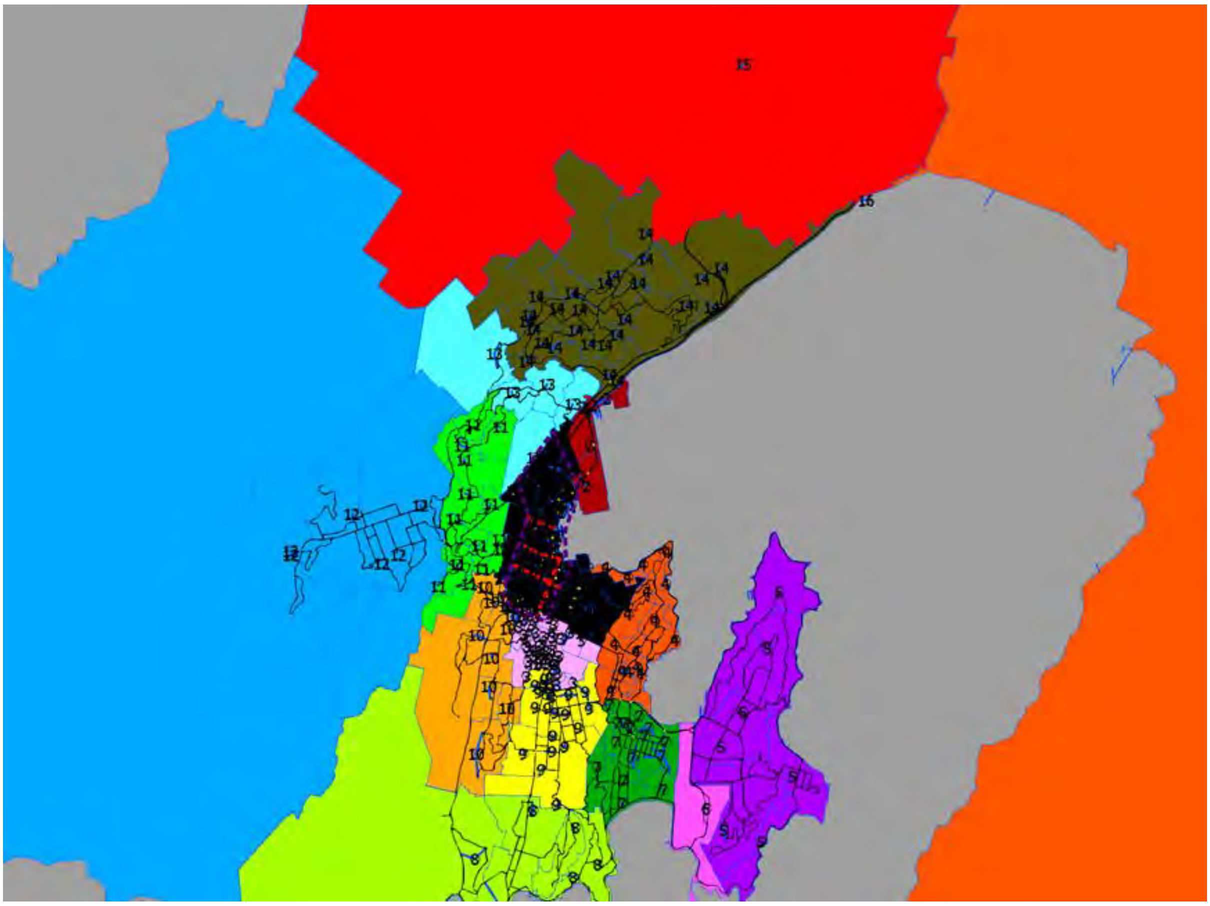
Outcome	Value	Source
Change in traffic volumes across screenlines	-1.7% to -2.0%	Table 8
Change in travel times from Adelaide / John / Riddiford intersection to edge of city centre	0.7%	Table 10
Estimated elasticity	-2.5 to -2.8	Calculated by dividing change in traffic volumes by change in travel times

Aimsun sectors

The sectors used are:

1. CBD
2. Port Area
3. Mount Cook
4. Mt Victoria / Roseneath / Hataitai
5. Miramar / Seatoun / Strathmore
6. Airport
7. Kilbirnie
8. Island Bay
9. Newtown / Berhampore
10. Brooklyn
11. Kelburn
12. Karori
13. Wadestown / Crofton Downs
14. Ngaio / Khandallah
15. SH1 External
16. SH2 External

Figure 7: Aimsun sectors



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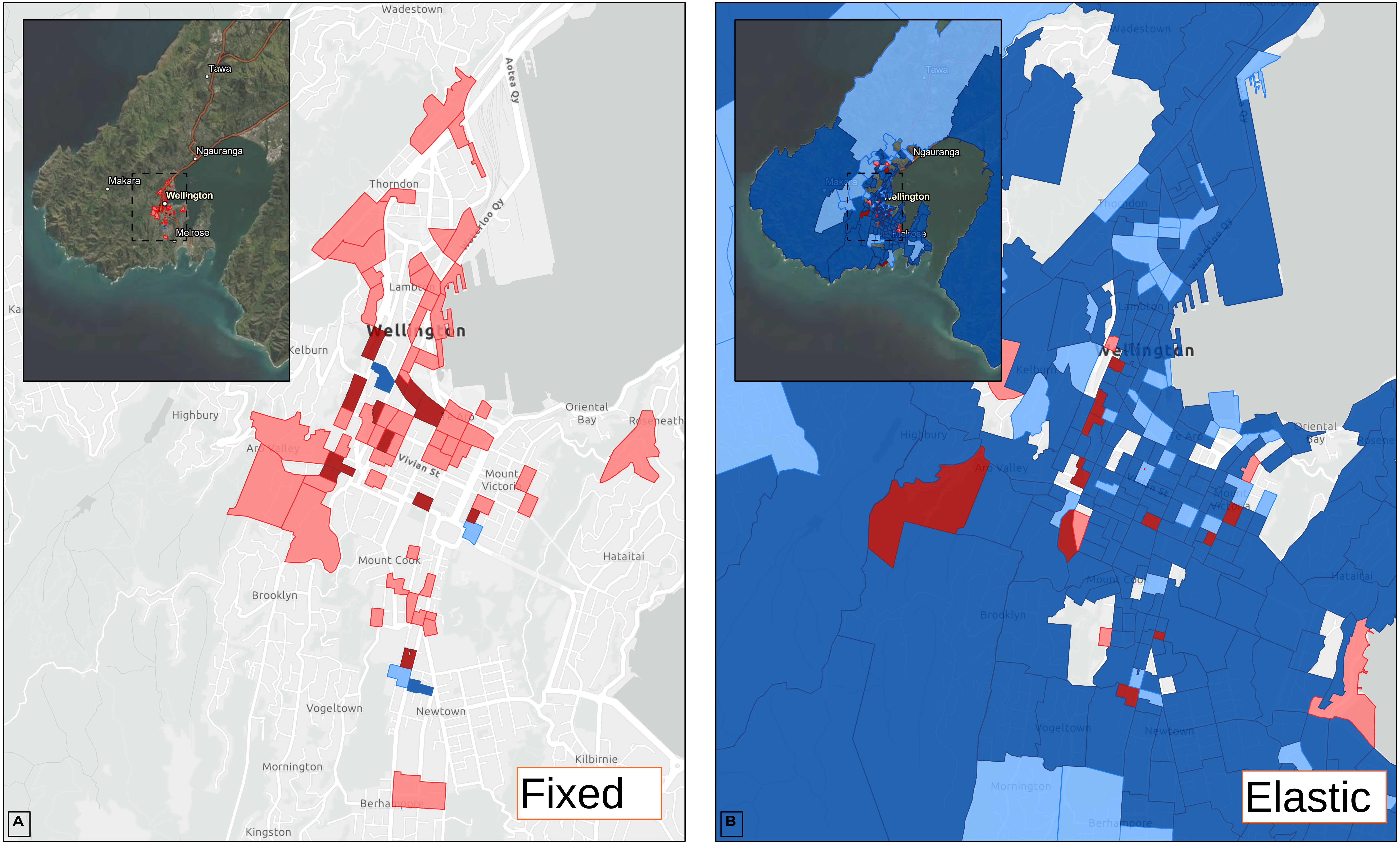
B

Increase Travel Time by Destination



Prepared by:

wsp

Golden Mile Changes in Travel Time

Morning Traffic

A: No Change to Demand

B: Elasticity

Legend:

Change in Total Travel Time

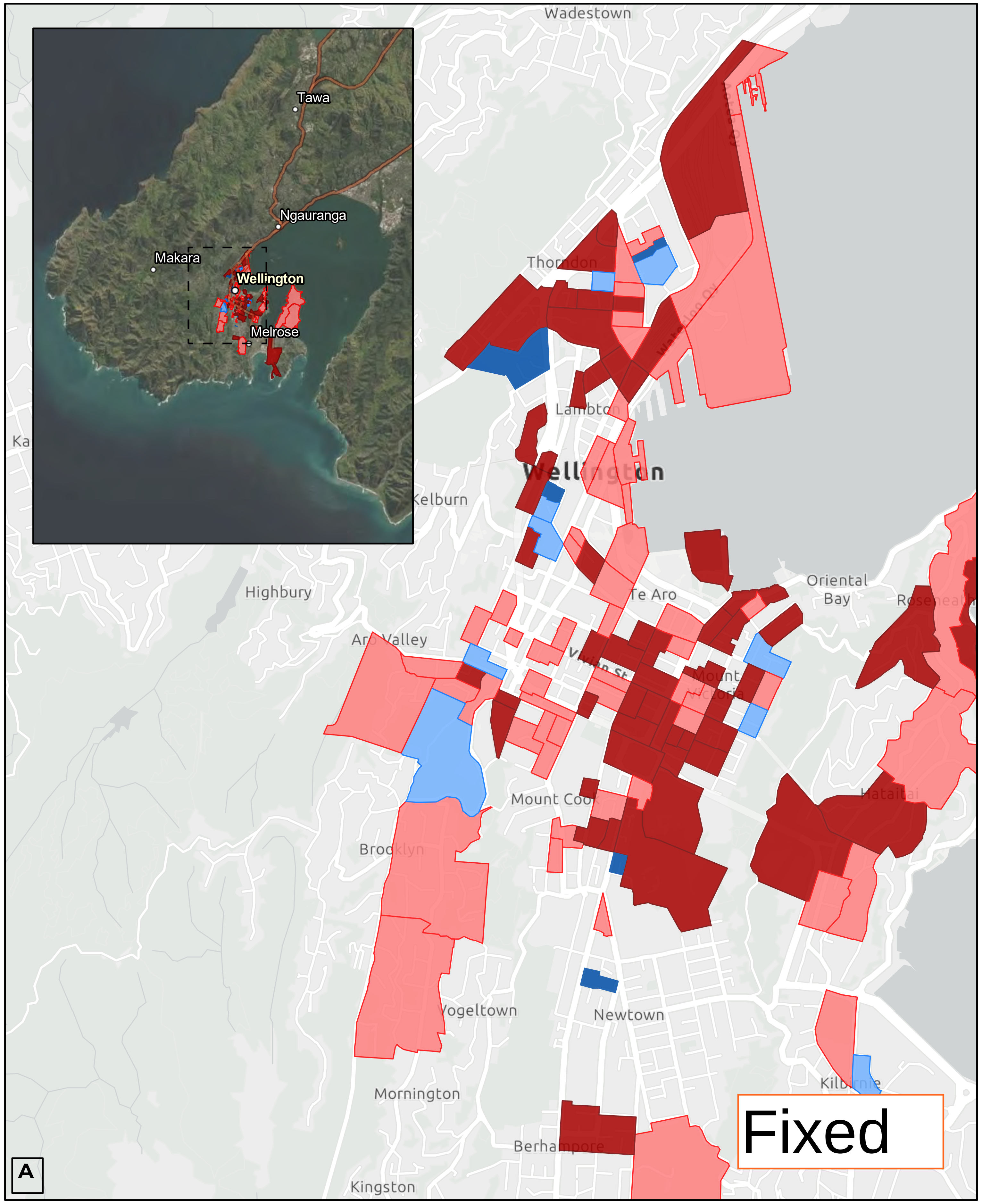
- More than -10%
- Between -5% and -10%
- Between 5% and 10%
- More than 10%

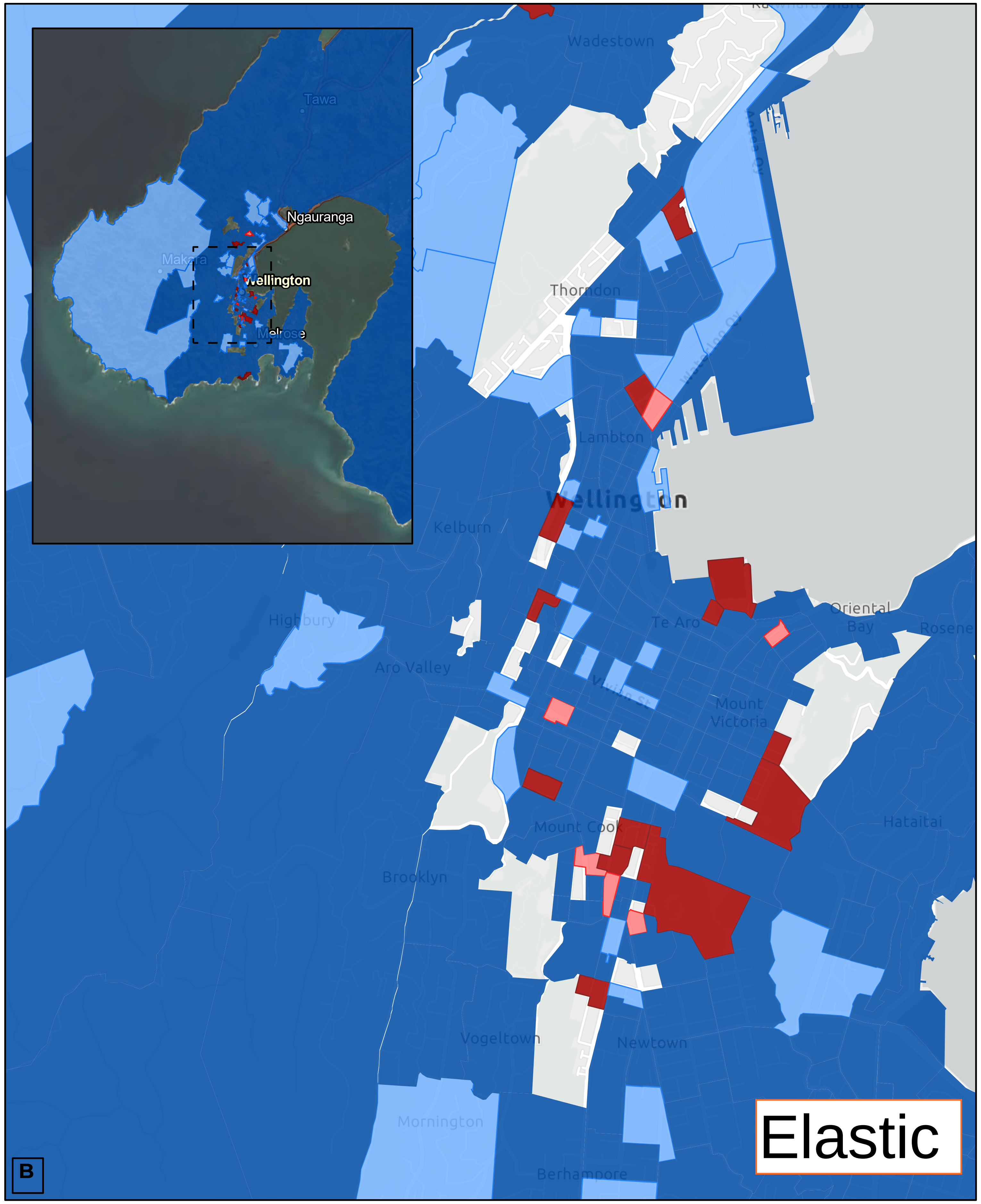
0 0.5 1 Km

N

Date: 18/06/2021

Client: Let's Get Wellington Moving





Prepared by:

Golden Mile Changes in Travel Time

Inter-Peak Traffic

A: No Change to Demand

B: Elasticity

Legend:

Change in Total Travel Time

- More than -10%
- Between -5% and -10%
- Between 5% and 10%
- More than 10%

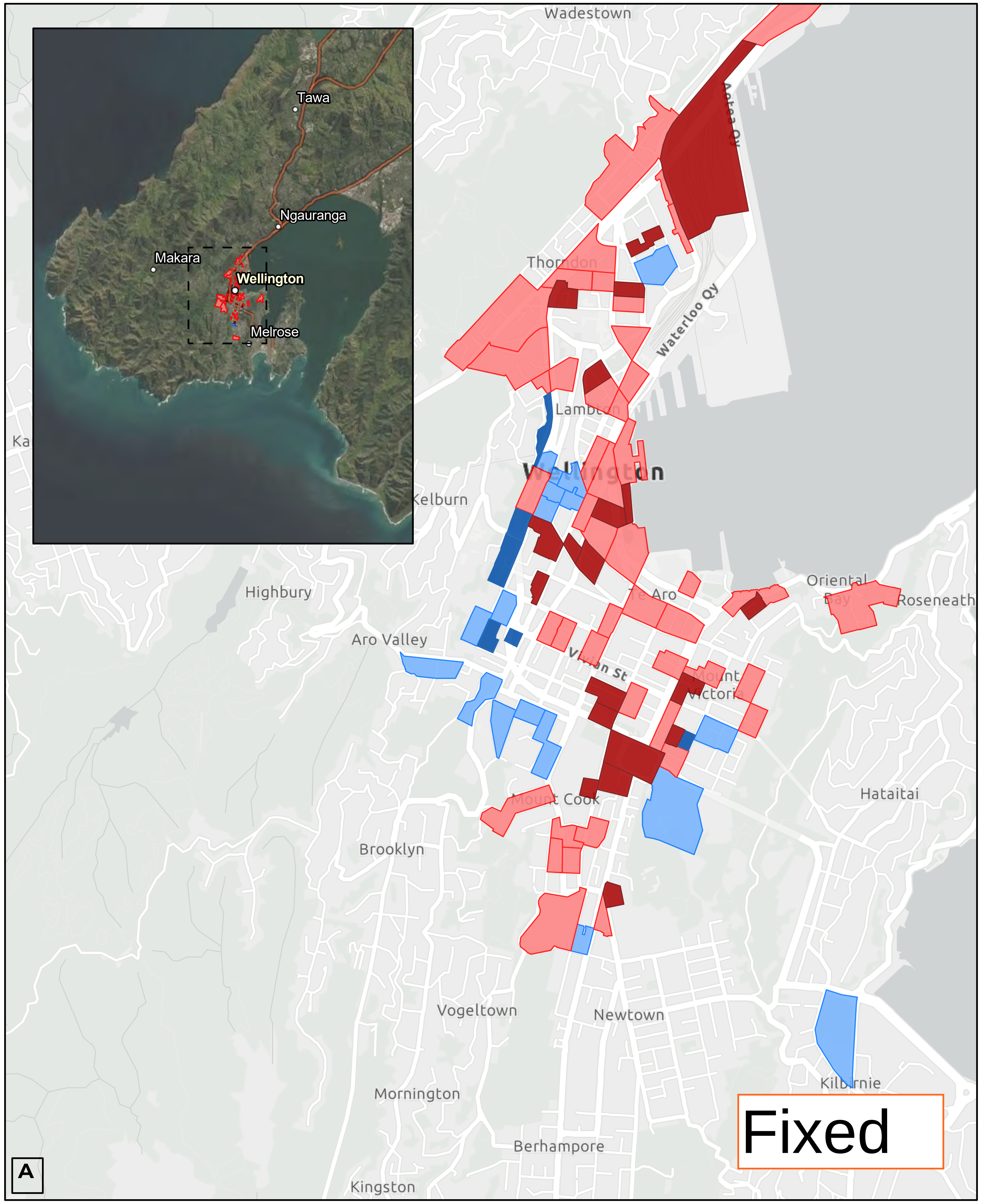
0 0.5 1

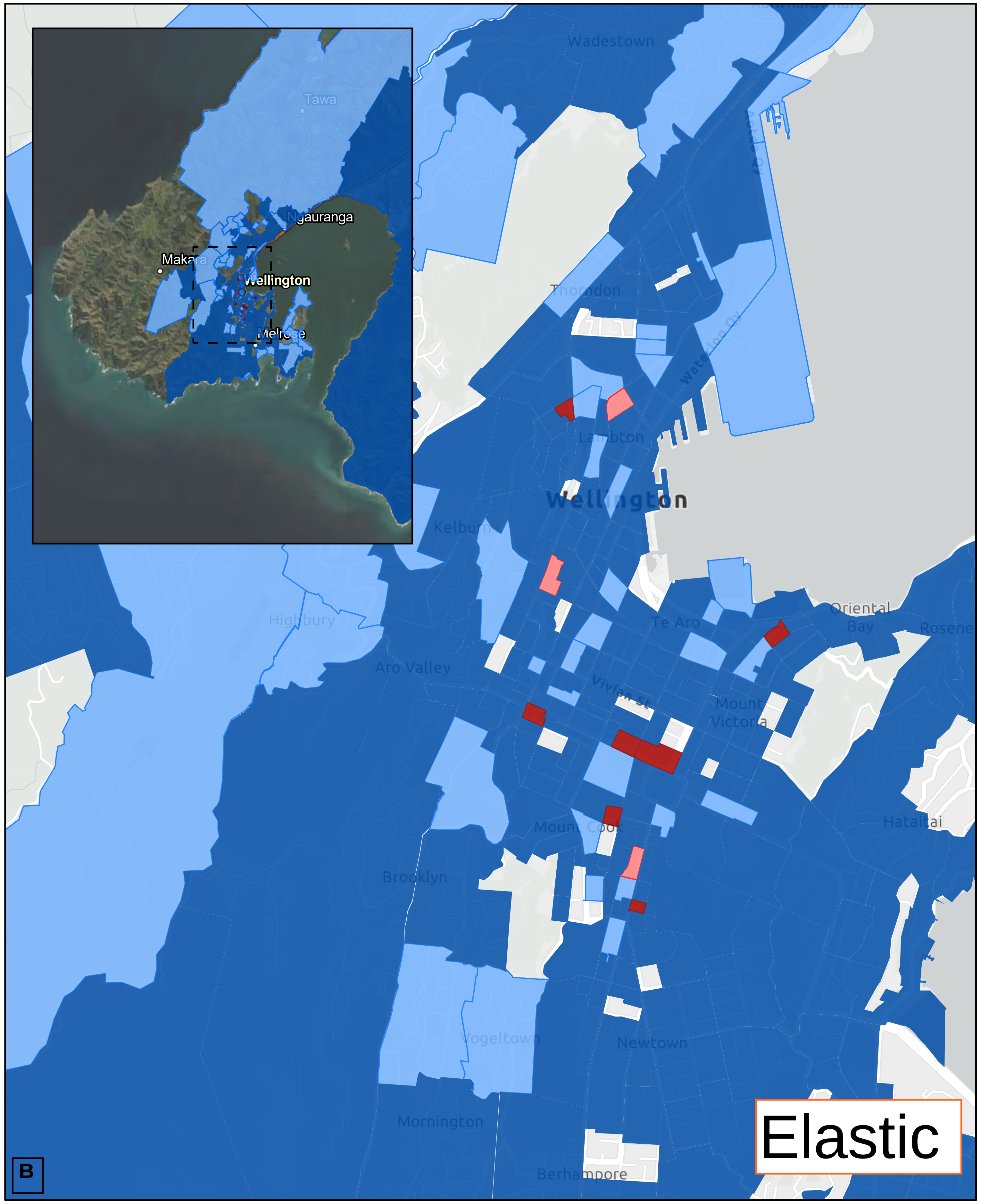
Km

N

Date: 18/06/2021

Client:





Prepared by: WSP

Golden Mile Changes in Travel Time

Afternoon Traffic

A: No Change to Demand

B: Elasticity

Legend:

Change in Total Travel Time

- More than -10%
- Between -5% and -10%
- Between 5% and 10%
- More than 10%

0 0.5 1
Km

N

Date: 18/06/2021

Client: Let's Get Wellington Moving

C

Traffic Flows Across Screen Lines

Vehicle	0	All Veh	REFINED
Rounding Factor	20		

Check Flag Criteria	
Flow Diff	100
% Diff	10%

AM	2110506 12304	23288912	24496490	24496573

Screenline	Section	Direction	Flow				Flow Difference			Percentage Difference			Check Flag		
			DoMin AM	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined
North CBD	Clifton Street	NB	160	200	140	140	40	-20	-20	25%	-13%	-13%	0	0	0
		SB	60	100	60	60	40	0	0	67%	0%	0%	0	0	0
	SH1 Clifton On Ramp	NB	660	680	680	640	20	20	-20	3%	3%	-3%	0	0	0
	SH1	NB	2,040	2,120	2,000	1,960	80	-40	-80	4%	-2%	-4%	0	0	0
		SB	1,340	1,400	1,280	1,360	60	-60	20	4%	-4%	1%	0	0	0
	Terrace Off Ramp	SB	1,920	1,880	1,780	1,740	-40	-140	-180	-2%	-7%	-9%	0	0	0
	Terrace	NB	840	860	780	780	20	-60	-60	2%	-7%	-7%	0	0	0
		SB	340	300	320	320	-40	-20	-20	-12%	-6%	-6%	0	0	0
	Lambton Quay	NB	220	60	60	60	-160	-160	-160	-73%	-73%	-73%	1	1	1
		SB	260	60	60	60	-200	-200	-200	-77%	-77%	-77%	1	1	1
	Featherston	SB	880	1,100	1,060	1,080	220	180	200	25%	20%	23%	1	1	1
	Waterloo Quay	NB	1,880	1,820	1,680	1,740	-60	-200	-140	-3%	-11%	-7%	0	1	0
		SB	2,320	2,320	2,100	2,200	0	-220	-120	0%	-9%	-5%	0	0	0
	Total	**NB**	**5,800**	**5,740**	**5,340**	**5,320**	**-60**	**-460**	**-480**	**-1%**	**-8%**	**-8%**			
		SB	**7,120**	**7,160**	**6,660**	**6,820**	**40**	**-460**	**-300**	**1%**	**-6%**	**-4%**			

Screenline	Section	Direction	Flow				Flow Difference			Percentage Difference			Check Flag		
			DoMin AM	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined
Mid CBD	Terrace	NB	800	760	800	760	-40	0	-40	-5%	0%	-5%	0	0	0
		SB	680	760	800	700	80	120	20	12%	18%	3%	0	1	0
	Boulcott	NB	320	400	340	340	80	20	20	25%	6%	6%	0	0	0
		SB	660	500	480	500	-160	-180	-160	-24%	-27%	-24%	1	1	1
	Willis Street	NB	560	60	60	60	-500	-500	-500	-89%	-89%	-89%	1	1	1
		SB	60	60	60	60	0	0	0	0%	0%	0%	0	0	0
	Victoria Street	SB	860	720	740	620	-140	-120	-240	-16%	-14%	-28%	1	1	1
	Jervois Quay	NB	2,320	2,360	2,160	2,160	40	-160	-160	2%	-7%	-7%	0	0	0
		SB	2,300	2,260	2,100	2,080	-40	-200	-220	-2%	-9%	-10%	0	0	0
	Total	**NB**	**4,000**	**3,580**	**3,360**	**3,320**	**-420**	**-640**	**-680**	**-11%**	**-16%**	**-17%**			
		SB	**4,560**	**4,300**	**4,180**	**3,960**	**-260**	**-380**	**-600**	**-6%**	**-8%**	**-13%**			

Screenline	Section	Direction	Flow				Flow Difference			Percentage Difference			Check Flag		
			DoMin AM	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined
South CBD	Terrace	NB	760	740	700	760	-20	-60	0	-3%	-8%	0%	0	0	0
		SB	780	840	900	800	60	120	20	8%	15%	3%	0	1	0
	Willis Street	NB	340	260	280	260	-80	-60	-80	-24%	-18%	-24%	0	0	0
		SB	340	400	320	320	60	-20	-20	18%	-6%	-6%	0	0	0
	Victoria	NB	80	40	40	40	-40	-40	-40	-50%	-50%	-50%	0	0	0
		SB	400	400	440	360	0	40	-40	0%	10%	-10%	0	0	0
	Taranaki Street	NB	1,280	1,480	1,340	1,280	200	60	0	16%	5%	0%	1	0	0
		SB	800	900	780	700	100	-20	-100	13%	-3%	-13%	0	0	0
	Total	**NB**	**2,460**	**2,520**	**2,360**	**2,340**	**60**	**-100**	**-120**	**2%**	**-4%**	**-5%**			
		SB	**2,320**	**2,540**	**2,440**	**2,180**	**220**	**120**	**-140**	**9%**	**5%**	**-6%**			

Screenline	Section	Direction	Flow				Flow Difference			Percentage Difference			Check Flag		
			DoMin AM	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined	GM Opt2 AM	GM Opt2 Elast AM	GM Opt2 Refined
East CBD	Cable Street	EB	2,280	2,260	2,080	2,080	-20	-200	-200	-1%	-9%	-9%	0	0	0
	Jervois Quay	WB	2,320	2,360	2,160	2,160	40	-160	-160	2%	-7%	-7%	0	0	0
	Manners Street	EB	40	40	40	40	0	0	0	0%	0%	0%	0	0	0
		WB	60	40	60	40	-20	0	-20	-33%	0%	-33%	0	0	0
	Dixon Street	WB	380	380	320	260	0	-60	-120	0%	-16%	-32%	0	0	1
	Ghuznee Street	EB	620	820	740	680	200	120	60	32%	19%	10%	1	1	0
		WB	280	260	240	220	-20	-40	-60	-7%	-14%	-21%	0	0	0
	Vivian Street	EB	2,160	2,200	2,060	2,100	40	-100	-60	2%	-5%	-3%	0	0	0
	Abel Smith Street	EB	140	160	120	100	20	-20	-40	14%	-14%	-29%	0	0	0
		WB	100	120	100	100	20	0	0	20%	0%	0%	0	0	0
	Arthur Street	WB	2,040	2,000	2,040	2,040	-40	0	0	-2%	0%	0%	0	0	0
	Total	**EB**	**5,240**	**5,480**	**5,040**	**5,000**	**240**	**-200**	**-240**	**5%**	**-4%**	**-5%**			
		WB	**5,180**	**5,160**	**4,920**	**4,820**	**-20**	**-260**	**-360**	**0%**	**-5%**	**-7%**			

IP	2110509 2354797	23288904	24496485	24496578

Screenline	Section	Direction	Flow				Flow Difference			Percentage Difference			Check Flag		
			DoMin IP	GM Opt2 IP	GM Opt2 Elast IP	GM Opt2 Refined	GM Opt2 IP	GM Opt2 Elast IP	GM Opt2 Refined	GM Opt2 IP	GM Opt2 Elast IP	GM Opt2 Refined	GM Opt2 IP	GM Opt2 Elast IP	GM Opt2 Refined
North CBD	Clifton Street	NB	60	100	60	60	40	0	0	67%	0%	0%	0	0	0
		SB	140	140	80	60	0	-60	-80	0%	-43%	-57%	0	0	0
	SH1 Clifton On Ramp	NB	660	760	740	660	100	80	0	15%	12%	0%	0	0	0
	SH1	NB	1,540	1,720	1,500	1,560	180	-40	20	12%	-3%	1%	1	0	0
		SB	1,040	980	1,140	1,160	-60	100	120	-6%	10%	12%	0	0	1
	Terrace Off Ramp	SB	480	680	540	520	200	60	40	42%	13%	8%	1	0	0
	Terrace	NB	440	520	400	460	80	-40	20	18%	-9%	5%	0	0	0
		SB	360	360	320	340	0	-40	-20	0%	-11%	-6%	0	0	0
	Lambton Quay	NB	240	40	40	40	-200	-200	-200	-83%	-83%	-83%	1	1	1
		SB	240	40	40	40	-200	-200	-200	-83%	-83%	-83%	1	1	1
	Featherston	SB	500	680	760	740	180	260	240	36%	52%	48%	1	1	1
	Waterloo Quay	NB	1,600	1,480	1,400	1,400	-120	-200	-200	-8%	-13%	-13%	0	1	1
		SB	1,520	1,680	1,300	1,440	160	-220	-80	11%	-14%	-5%	1	1	0
	Total	**NB**	**4,540**	**4,620**	**4,140**	**4,180**	**80**	**-400**	**-480**	**2%**	**-9%**	**-8%**			
		SB	**4,280**	**4,560**	**4,180**	**4,300**	**280**	**-100**	**-300**	**7%**	**-2%**	**0%**			

Screenline	Section	Direction	Flow				Flow Difference			Percentage Difference			Check Flag		
			DoMin IP	GM Opt2 IP	GM Opt2 Elast IP	GM Opt2 Refined	GM Opt2 IP	GM Opt2 Elast IP	GM Opt2 Refined	GM Opt2 IP	GM Opt2 Elast IP	GM Opt2 Refined	GM Opt2 IP	GM Opt2 Elast IP	GM Opt2 Refined
Mid CBD	Terrace	NB	720	680	620	660	-40	-100	-60	-6%	-14%	-8%	0	0	0
		SB	400	540	420	420	140	20	20	35%	5%	5%	1	0	0
	Boulcott	NB	400	560	560	420	160	160	20	40%	40%	5%	1	1	0
		SB	440	320	300	320	-120	-140	-120	-27%	-32%	-27%	1	1	1
	Willis Street	NB	580	40	40	40	-540	-540	-540	-93%	-93%	-93%	1	1	1
		SB	40	40	40	40	0	0	0	0%	0%	0%	0	0	0
	Victoria Street	SB	920	660	760	720	-260	-160	-200	-28%	-17%	-22%	1	1	1
	Jervois Quay	NB	1,620	1,500	1,360	1,320	-120	-260	-300	-7%	-16%	-19%	0	1	1
		SB	1,540	1,660	1,240	1,420	120	-300	-120	8%	-19%	-8%	0	1	0
	Total	**NB**	**3,320**	**2,780**	**2,580**	**2,440**	**-540**	**-740**	**-680**	**-16%**	**-22%**	**-27%**			
		SB	**3,340**	**3,220**	**2,760**	**2,920**	**-120**	**-580**	**-600**	**-4%**	**-17%**	**-13%**			

Screenline	Section	Direction	Flow				Flow Difference			Percentage Difference			Check Flag		
			DoMin IP	GM Opt2 IP	M Opt2 Elast I	Opt2 Refine	GM Opt2 IP	GM Opt2 El	GM Opt2 Re	GM Opt2 IP	GM Opt2 El	GM Opt2 Re	GM Opt2 IP	GM Opt2 Elast IP	GM Opt2 Refi
South CBD	Terrace	NB	580	640	500	540	60	-80	-40	10%	-14%	-7%	0	0	0
		SB	600	720	580	580	120	-20	-20	20%	-3%	-3%	1	0	0
	Willis Street	NB	240	240	200	160	0	-40	-80	0%	-17%	-33%	0	0	0
		SB	220	280	320	300	60	100	80	27%	45%	36%	0	0	0
	Victoria	NB	80	20	20	20	-60	-60	-60	-75%	-75%	-75%	0	0	0
		SB	560	600	560	520	40	0	-40	7%	0%	-7%	0	0	0
	Taranaki Street	NB	1,320	1,580	1,460	1,140	260	140	-180	20%	11%	-14%	1	1	1
		SB	720	980	680	580	260	-40	-140	36%	-6%	-19%	1	0	1
	Total	**NB**	**2,220**	**2,480**	**2,180**	**1,860**	**260**	**-40**	**-120**	**12%**	**-2%**	**-16%**			
		SB	**2,100**	**2,580**	**2,140**	**1,980**	**480**	**40**	**-140**	**23%**	**2%**	**-6%**			

Screenline	Section	Direction	Flow				Flow Difference			Percentage Difference			Check Flag		
			DoMin IP	GM Opt2 IP	M Opt2 Elast I	Opt2 Refine	GM Opt2 IP	GM Opt2 El	GM Opt2 Re	GM Opt2 IP	GM Opt2 El	GM Opt2 Re	GM Opt2 IP	GM Opt2 Elast IP	GM Opt2 Refi
East CBD	Cable Street	EB	1,540	1,660	1,240	1,420	120	-300	-120	8%	-19%	-8%	0	1	0
	Jervois Quay	WB	1,620	1,500	1,360	1,340	-120	-260	-280	-7%	-16%	-17%	0	1	1
	Manners Street	EB	20	20	20	20	0	0	0	0%	0%	0%	0	0	0
		WB	60	40	40	40	-20	-20	-20	-33%	-33%	-33%	0	0	0
	Dixon Street	WB	440	440	460	320	0	20	-120	0%	5%	-27%	0	0	1
	Ghuznee Street	EB	820	980	940	780	160	120	-40	20%	15%	-5%	1	1	0
		WB	220	280	200	180	60	-20	-40	27%	-9%	-18%	0	0	0
	Vivian Street	EB	1,520	1,480	1,460	1,540	-40	-60	20	-3%	-4%	1%	0	0	0
	Abel Smith Street	EB	140	100	80	100	-40	-60	-40	-29%	-43%	-29%	0	0	0
		WB	60	140	40	60	80	-20	0	133%	-33%	0%	0	0	0
	Arthur Street	WB	1,540	1,780	1,580	1,600	240	40	60	16%	3%	4%	1	0	0
	Total	**EB**	**4,040**	**4,240**	**3,740**	**3,860**	**200**	**-300**	**-240**	**5%**	**-7%**	**-4%**			
		WB	**3,940**	**4,180**	**3,680**	**3,540**	**240**	**-260**	**-360**	**6%**	**-7%**	**-10%**			

			2110512			
PM			12306	23288920	24496495	24496583

Screenline	Section	Direction	Flow				Flow Difference			Percentage Difference			Check Flag		
			DoMin PM	GM Opt2 PM	Opt2 Elast F	Opt2 Refined	GM Opt2 PI	GM Opt2 El	GM Opt2 Re	GM Opt2 PI	GM Opt2 El	GM Opt2 Re	GM Opt2 PM	GM Opt2 Elast PM	GM Opt2 Refi
North CBD	Clifton Street	NB	100	140	100	120	40	0	20	40%	0%	20%	0	0	0
		SB	240	200	200	200	-40	-40	-40	-17%	-17%	-17%	0	0	0
	SH1 Clifton On Ramp	NB	1,560	1,680	1,500	1,540	120	-60	-20	8%	-4%	-1%	0	0	0
	SH1	NB	2,260	2,300	2,280	2,280	40	20	20	2%	1%	1%	0	0	0
		SB	1,560	1,580	1,560	1,580	20	0	20	1%	0%	1%	0	0	0
	Terrace Off Ramp	SB	840	820	780	780	-20	-60	-60	-2%	-7%	-7%	0	0	0
	Terrace	NB	440	440	440	440	0	0	0	0%	0%	0%	0	0	0
		SB	540	480	500	500	-60	-40	-40	-11%	-7%	-7%	0	0	0
	Lambton Quay	NB	360	80	80	80	-280	-280	-280	-78%	-78%	-78%	1	1	1
		SB	260	60	60	60	-200	-200	-200	-77%	-77%	-77%	1	1	1
	Featherston	SB	600	920	960	1,080	320	360	480	53%	60%	80%	1	1	1
	Waterloo Quay	NB	2,240	2,220	2,200	2,220	-20	-40	-20	-1%	-2%	-1%	0	0	0
		SB	2,060	2,120	1,900	1,920	60	-160	-140	3%	-8%	-7%	0	0	0
	Total	**NB**	**6,960**	**6,860**	**6,600**	**6,680**	**-100**	**-360**	**-480**	**-1%**	**-5%**	**-4%**			
		SB	**6,100**	**6,180**	**5,960**	**6,120**	**80**	**-140**	**-300**	**1%**	**-2%**	**0%**			

Screenline	Section	Direction	Flow				Flow Difference			Percentage Difference			Check Flag		
			DoMin PM	GM Opt2 PM	Opt2 Elast F	Opt2 Refined	GM Opt2 PI	GM Opt2 El	GM Opt2 Re	GM Opt2 PI	GM Opt2 El	GM Opt2 Re	GM Opt2 PM	GM Opt2 Elast PM	GM Opt2 Refi
Mid CBD	Terrace	NB	660	740	620	660	80	-40	0	12%	-6%	0%	0	0	0
		SB	720	740	640	680	20	-80	-40	3%	-11%	-6%	0	0	0
	Boulcott	NB	700	780	700	700	80	0	0	11%	0%	0%	0	0	0
		SB	400	280	360	280	-120	-40	-120	-30%	-10%	-30%	1	0	1
	Willis Street	NB	480	80	80	80	-400	-400	-400	-83%	-83%	-83%	1	1	1
		SB	60	60	60	60	0	0	0	0%	0%	0%	0	0	0
	Victoria Street	SB	1,060	1,040	920	1,020	-20	-140	-40	-2%	-13%	-4%	0	1	0
	Jervois Quay	NB	2,200	2,140	2,060	2,000	-60	-140	-200	-3%	-6%	-9%	0	0	0
		SB	5,900	6,100	5,400	5,550	200	-500	-350	3%	-8%	-6%	0	0	0
	Total	**NB**	**4,040**	**3,740**	**3,460**	**3,440**	**-300**	**-580**	**-680**	**-7%**	**-14%**	**-15%**			
		SB	**8,140**	**8,220**	**7,380**	**7,590**	**80**	**-760**	**-600**	**1%**	**-9%**	**-7%**			

Screenline	Section	Direction	Flow				Flow Difference			Percentage Difference			Check Flag		
			DoMin PM	GM Opt2 PM	Opt2 Elast F	Opt2 Refined	GM Opt2 PI	GM Opt2 El	GM Opt2 Re	GM Opt2 PI	GM Opt2 El	GM Opt2 Re	GM Opt2 PM	GM Opt2 Elast PM	GM Opt2 Refi
South CBD	Terrace	NB	700	740	640	620	40	-60	-80	6%	-9%	-11%	0	0	0
		SB	680	640	640	620	-40	-40	-60	-6%	-6%	-9%	0	0	0
	Willis Street	NB	220	140	180	140	-80	-40	-80	-36%	-18%	-36%	0	0	0
		SB	460	500	420	360	40	-40	-100	9%	-9%	-22%	0	0	0
	Victoria	NB	40	0	20	20	-40	-20	-20	-100%	-50%	-50%	0	0	0
		SB	740	740	700	660	0	-40	-80	0%	-5%	-11%	0	0	0
	Taranaki Street	NB	1,120	1,360	1,220	1,080	240	100	-40	21%	9%	-4%	1	0	0
		SB	1,000	1,040	940	860	40	-60	-140	4%	-6%	-14%	0	0	1
	Total	**NB**	**2,080**	**2,240**	**2,060**	**1,860**	**160**	**-20**	**-120**	**8%**	**-1%**	**-11%**			
		SB	**2,880**	**2,920**	**2,700**	**2,500**	**40**	**-180**	**-140**	**1%**	**-6%**	**-13%**			

Screenline	Section	Direction	Flow				Flow Difference			Percentage Difference			Check Flag		
			DoMin PM	GM Opt2 PM	Opt2 Elast F	Opt2 Refined	GM Opt2 PI	GM Opt2 El	GM Opt2 Re	GM Opt2 PI	GM Opt2 El	GM Opt2 Re	GM Opt2 PM	GM Opt2 Elast PM	GM Opt2 Refi
East CBD	Cable Street	EB	2,340	2,420	2,140	2,220	80	-200	-120	3%	-9%	-5%	0	0	0
	Jervois Quay	WB	2,200	2,160	2,060	2,000	-40	-140	-200	-2%	-6%	-9%	0	0	0
	Manners Street	EB	60	60	60	60	0	0	0	0%	0%	0%	0	0	0
		WB	100	60	60	60	-40	-40	-40	-40%	-40%	-40%	0	0	0
	Dixon Street	WB	520	520	400	320	0	-120	-200	0%	-23%	-38%	0	1	1
	Ghuznee Street	EB	920	960	960	880	40	40	-40	4%	4%	-4%	0	0	0
		WB	340	380	300	260	40	-40	-80	12%	-12%	-24%	0	0	0
	Vivian Street	EB	1,740	1,760	1,740	1,780	20	0	40	1%	0%	2%	0	0	0
	Abel Smith Street	EB	200	220	160	160	20	-40	-40	10%	-20%	-20%	0	0	0
		WB	100	140	120	100	40	20	0	40%	20%	0%	0	0	0
	Arthur Street	WB	2,020	1,900	1,900	1,940	-120	-120	-80	-6%	-6%	-4%	0	0	0
	Total	**EB**	**5,260**	**5,420**	**5,060**	**5,100**	**160**	**-200**	**-240**	**3%**	**-4%**	**-3%**			
		WB	**5,280**	**5,160**	**4,840**	**4,680**	**-120**	**-440**	**-360**	**-2%**	**-8%**	**-11%**			

D Level of Service Comparison

Veh Type	0 All Vehicles

AM Peak (1 Hour)	0730-0830
Inter Peak (1 Hour)	1200-1300
PM Peak (1 Hour)	1630-1730

Level of Service	Signals	Roundabouts	Sign Control
A	d ≤ 10	d ≤ 10	d ≤ 10
B	10 < d ≤ 20	10 < d ≤ 20	10 < d ≤ 15
C	20 < d ≤ 35	20 < d ≤ 35	15 < d ≤ 25
D	35 < d ≤ 55	35 < d ≤ 50	25 < d ≤ 35
E	55 < d ≤ 80	50 < d ≤ 70	35 < d ≤ 50
F	80 < d	70 < d	50 < d

Turn Mean Delays

Intersection	Type	Node_ID	Approach	Section_ID	Movement	Turn_ID	12304 DoMin AM		2354797 DoMin IP		12306 DoMin PM		23288912 GM Opt2 AM		23288904 GM Opt2 IP		23288920 GM Opt2 PM		24496490 GM Opt2 Elast AM		24496485 GM Opt2 Elast IP		24496495 GM Opt2 Elast PM		24496573 GM Opt2 Ref AM		24496578 GM Opt2 Ref IP		24496583 GM Opt2 Ref PM	
Willis / Ghuznee	Signalised	27311	Willis North	25693	Left Turn	29823	22.3	C	49.7	D	33.0	C	43.1	D	52.5	D	33.8	C	27.8	C	36.9	D	31.4	C	37.1	D	46.0	D	54.7	D
	Signalised		Ghuznee East	22794	Through	29824	11.8	B	23.7	C	19.2	B	19.8	B	28.0	C	18.7	B	22.9	C	20.8	C	16.0	B	17.2	B	20.5	C	22.4	C
	Signalised		Willis South	22621	Left Turn	29819	25.5	C	24.9	C	29.6	C	30.2	C	26.7	C	29.1	C	29.3	C	24.9	C	27.7	C	30.8	C	23.6	C	28.1	C
	Signalised		Ghuznee West	23331	Left Turn	29817	45.7	D	19.7	B	62.8	E	41.7	D	24.1	C	67.3	E	33.8	C	23.0	C	56.8	E	29.5	C	25.9	C	38.1	D
Hunter Street / Jervois Quay	Signalised	27053	Jervois North	24243	Left Turn	2389864	14.4	B	16.1	B	14.3	B	14.9	B	18.2	B	14.8	B	13.9	B	15.6	B	13.7	B	15.4	B	15.1	B	13.5	B
	Signalised		TSB Entrance	4632	Left Turn	2389723	69.1	E	58.0	E	46.4	D	68.6	E	115.1	F	48.2	D	49.7	D	76.3	E	52.5	D	62.6	E	66.8	E	54.9	D
	Signalised		Jervois South	23923	Through	29331	14.6	B	8.7	A	10.4	B	13.1	B	9.4	A	10.9	B	16.3	B	8.7	A	10.4	B	18.4	B	8.3	A	10.4	B
	Signalised		Hunter Street	23072	Left Turn	29330	43.4	D	32.4	C	31.5	C	45.9	D	32.6	C	31.1	C	45.6	D	30.9	C	29.8	C	38.9	D	31.3	C	28.2	C
Featherston / Whitmore Street	Signalised	26983	Featherston North	24024	Left Turn	31006	19.6	B	11.7	B	22.8	C	24.3	C	26.7	C	19.1	B	20.2	C	13.2	B	18.1	B	23.6	C	13.4	B	12.7	B
	Signalised		Whitmore South	23006	Left Turn	31003	13.6	B	15.8	B	20.1	C	13.3	B	20.6	C	20.6	C	14.1	B	19.9	B	19.5	B	13.6	B	19.0	B	19.1	B
	Signalised		Whitmore North	23629	Through	31004	33.7	C	28.9	C	30.4	C	53.0	D	37.0	D	36.9	D	39.5	D	27.5	C	30.0	C	45.4	D	29.2	C	35.4	D
Lambton Quay / Whitmore Street	Signalised	27078	Lambton North	23102	Left Turn	29952	30.4	C	22.7	C	21.5	C	27.7	C	22.5	C	23.3	C	29.8	C	21.4	C	24.5	C	28.4	C	23.5	C	27.4	C
	Signalised		Whitmore South	23627	Left Turn	29961	17.1	B	30.7	C	20.9	C	19.2	B	25.5	C	17.8	B	20.0	B	25.8	C	17.9	B	20.4	C	24.3	C	17.7	B
	Signalised		Lambton South	23501	Left Turn	29964	28.3	C	22.1	C	26.5	C	38.4	D	23.4	C	39.0	D	39.9	D	28.7	C	34.8	C	67.4	E	20.2	C	49.1	D
	Signalised		Whitmore North	23175	Slip (LT)	29497	17.1	B	21.0	C	17.4	B	15.1	B	15.9	B	18.3	B	16.8	B	16.9	B	17.5	B	16.0	B	16.6	B	17.2	B
Courtenay / Kent / Cambridge	Signalised	26822	Kent (North)	23660	Left Turn	28871	19.2	B	19.3	B	14.0	B	20.679	C	22.62	C	19.312	B	21.698	C	24.44	C	19.88	B	0	A	0	A	0	A
	Signalised		Majoribanks	24217	Left Turn	28879	37.0	D	39.7	D	45.6	D	26.915	C	32.95	C	43.135	D	27.765	C	36.37	D	40.68	D	41.69	D	51.564	D	51.66	D
	Signalised		Cambridge (South)	785	Slip (LT)	833	1.9	A	0.1	A	3.0	A	11.759	B	9.735	A	13.047	B	12.412	B	9.608	A	11.21	B	12.88	B	9.9556	A	13.51	B
	Signalised		Courtenay	23880	Slip (LT)	837	27.7	C	20.7	C	26.0	C	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A
Taranaki / Courtenay	Signalised	27465	Taranaki North	23874	Left Turn	30145	14.3	B	17.3	B	17.1	B	12.982	B	10.38	B	20.254	C	15.698	B	14.06	B	12	B	0	A	0	A	0	A
	Signalised		Courtenay East	22855	Left Turn	30153	19.5	B	18.0	B	26.9	C	35.452	D	40.19	D	24.798	C	39.339	D	34.41	C	24.24	C	0	A	0	A	0	A
	Signalised		Taranaki South	23841	Left Dixon	30148	17.4	B	18.1	B	22.8	C	10.659	B	15.84	B	16.687	B	14.601	B	15.37	B	15.58	B	0	A	0	A	0	A
	Signalised		Manners West	26528	Left Turn	10132	17.3	B	30.7	C	47.1	D	19.664	B	27.79	C	25.745	C	19.043	B	29.63	C	24.64	C	0	A	0	A	0	A
Taranaki / Ghuznee	Signalised	27688	Taranaki North	26306	Through	30684	6.4	A	11.9	B	25.6	C	6.9	A	14.7	B	22.0	C	6.3	A	10.9	B	20.5	C	8.5	A	11.7	B	21.2	C
	Signalised		Taranaki South	23011	Left Turn	30681	22.5	C	23.4	C	36.1	D	22.8	C	25.4	C	46.2	D	21.2	C	24.9	C	35.8	D	19.6	B	22.1	C	32.4	C
	Signalised		Ghuznee	24235	Left Turn	30680	12.4	B	15.5	B	14.0	B	13.3	B	15.6	B	14.0	B	12.1	B	16.7	B	14.2	B	13.6	B	16.0	B	14.5	B
Willis / Buckle Street	Signalised	27068	Willis South	23569	Left Turn	29357	26.6	C	28.2	C	27.6	C	28.2	C	26.2	C	30.9	C	27.9	C	24.7	C	28.2	C	26.5	C	27.9	C	26.8	C
	Signalised		SH1	23125	Through Left	29354	20.4	C	22.5	C	16.0	B	19.6	B	22.4	C	15.8	B	20.9	C	23.7	C	14.3	B	20.5	C	24.4	C	14.4	B
	Signalised		Abel Smith	24377	Left	29359	89.1	F	42.3	D	92.5	F	101.5	F	57.2	E	59.4	E	90.5	F	46.2	D	67.0	E	90.9	F	95.6	F	71.4	E
Willis / Vivian Street	Signalised	26562	Willis South	23090	Through	31026	15.3	B	18.2	B	16.0	B	16.2	B	19.5	B	18.4	B	15.4	B	18.9	B	15.6	B	14.5	B	18.7	B	19.3	B
	Signalised		Vivian	22620	Left	33706	11.1	B	7.9	A	6.9	A	10.8	B	7.8	A	6.3	A	10.5	B	7.6	A	6.7	A	11.1	B	7.5	A	6.8	A
Boulcott / Willis Street (DM)	Signalised	26609	Boulcott	24196	Left	28515	14.1	B	19.5	B	15.3	B	12.534	B	12.94	B	15.787	B	12.904	B	13.43	B	9.383	A	14.56	B	15.41	B	15.29	B
	Signalised		Willis North (Bus Only)	24033	Left	28513	3.3	A	5.7	A	0.8	A	1.7921	A	3.436	A	5.432	A	2.8438	A	4.096	A	6.967	A	9.806	A	5.1797	A	7.436	A
	Signalised		Manners	23396	Through	8774	32.0	C	47.7	D	37.0	D	35.299	D	33.4	C	27.875	C	33.176	C	34.43	C	27.21	C	49.52	D	55.517	E	54.94	D
	Signalised		Willis South	23357	Left	28522	15.8	B	21.1	C	14.0	B	15.795	B	12.7	B	17.69	B	13.991	B	13.68	B	12.55	B	20.74	C	22.768	C	13.73	B
Willis / Mercer Street (DM)	Signalised	27779	Willis North	25004	Left	9183	13.7	B	19.0	B	13.4	B	7.1254	A	6.282	A	4.4413	A	9.1768	A	6.899	A	5.401	A	8.231	A	6.2274	A	5.774	A
	Signalised		Willis South	22655	Through	31089	11.1	B	9.9	A	19.3	B	7.4459	A	6.008	A	6.4154	A	7.3475	A	4.872	A	5.341	A	21.5	C	23.771	C	23.2	C
Willis / Williston Street (DM)	Signalised	26658	Willis North	23288	Through	29754	11.9	B	34.9	C	20.0	B	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A
	Signalised		Williston	22699	Through	29751	34.5	C	16.4	B	26.0	C	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A
	Signalised		Willis South	26119	Left	29755	17.2	B	24.7	C	32.5	C	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A
Willis / Williston Street (Opt)	Signalised	26658	Willis North	21966991	Through	23289087	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A
	Signalised		Williston	22699	Through	21966994	34.5	C	16.4	B	26.0	C	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A
	Signalised		Willis South	21966988	Left	21966992	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A

Customhouse Quay / Jervois Quay	Sign Control	33712	Customhouse Quay	23963	Through	33713	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A
	Sign Control		Jervois Quay	24242	Through	33714	0.8	A	1.2	A	5.2	A	0.8	A	11.1	B	6.4	A	0.6	A	0.5	A	8.5	A	0.7	A	0.7	A	1.0	A
Victoria / Mercer Street	Signalised	26660	Victoria	22701	Through	28882	13.4	B	16.6	B	14.8	B	13.3	B	16.0	B	15.4	B	13.3	B	16.9	B	14.2	B	13.0	B	16.6	B	14.8	B
	Signalised		Mercer	24073	Through	28883	30.9	C	22.2	C	39.4	D	17.4	B	17.2	B	30.1	C	22.4	C	24.7	C	28.0	C	19.4	B	18.8	B	30.8	C
Victoria / Ghuznee	Signalised	26760	Victoria North	24185	Left	28772	43.3	D	39.9	D	50.9	D	69.0	E	62.0	E	57.4	E	45.0	D	49.6	D	46.3	D	55.6	E	56.6	E	67.4	E
	Signalised		Ghuznee East	22795	Left	28770	35.2	D	45.3	D	51.1	D	77.2	E	89.3	F	53.7	D	47.0	D	47.5	D	44.5	D	56.9	E	89.7	F	59.3	E
	Signalised		Victoria South	232243	Left	28777	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A
	Signalised		Ghuznee West	23360	Left	28779	13.8	B	31.6	C	30.6	C	22.1	C	32.2	C	33.9	C	17.4	B	29.6	C	29.8	C	22.5	C	30.6	C	42.6	D
Taranaki / Wakefield	Signalised	26833	Taranaki North	23875	Through	30748	31.2	C	39.5	D	34.5	C	22.0	C	59.9	E	32.0	C	23.7	C	46.1	D	26.0	C	37.3	D	32.4	C	35.7	D
	Signalised		Wakefield East	22851	Left	30741	29.0	C	26.2	C	36.8	D	39.3	D	60.0	E	60.0	E	31.7	C	49.4	D	53.1	D	49.8	D	36.4	D	73.0	E
	Signalised		Taranaki South	23548	Left	30746	15.8	B	22.4	C	33.2	C	58.1	E	38.6	D	70.0	E	42.5	D	29.0	C	48.9	D	36.9	D	42.1	D	47.7	D
	Signalised		Wakefield West	23878	Left	30752	33.1	C	40.3	D	28.8	C	33.0	C	42.8	D	30.9	C	31.5	C	41.0	D	33.2	C	36.2	D	40.5	D	31.2	C
Taranaki / Vivian	Signalised	26986	Taranaki North	24211	Left	29203	34.0	C	23.3	C	19.4	B	33.0	C	24.3	C	19.8	B	33.0	C	25.5	C	19.8	B	32.6	C	25.3	C	20.1	C
	Signalised		Taranaki South	24251	Through	29206	23.8	C	19.8	B	27.1	C	26.2	C	18.1	B	23.2	C	26.8	C	18.2	B	26.1	C	24.5	C	19.1	B	25.3	C
	Signalised		Vivian	24231	Left	29201	8.7	A	16.8	B	16.1	B	9.1	A	14.5	B	15.1	B	8.7	A	16.2	B	15.7	B	9.3	A	16.8	B	15.0	B
Featherston / Warring Taylor	Signalised	26601	Featherston North	23952	Through	28502	10.1	B	23.1	C	21.5	C	10.0	B	40.0	D	16.6	B	9.4	A	14.3	B	8.6	A	9.7	A	20.9	C	10.0	A
	Signalised		Warring Taylor East	23093	Left	28500	30.1	C	31.3	C	62.9	E	25.6	C	73.5	E	64.3	E	27.3	C	31.9	C	71.0	E	33.0	C	41.4	D	71.9	E
Featherston / Johnston	Signalised	26603	Featherston North	22650	Left	29567	7.5	A	26.2	C	37.4	D	9.4	A	39.0	D	17.1	B	9.0	A	13.8	B	13.4	B	9.8	A	24.3	C	14.7	B
	Signalised		Johnston West	23098	Through	29569	21.3	C	58.0	E	68.4	E	21.6	C	70.4	E	49.6	D	20.9	C	32.0	C	50.5	D	21.1	C	36.7	D	51.6	D
Featherston / Brandon	Signalised	27202	Featherston North	23221	Through	30872	4.0	A	4.3	A	3.3	A	4.6	A	17.9	B	4.1	A	4.3	A	18.0	B	3.8	A	4.1	A	16.9	B	4.7	A
	Signalised		Brandon East	24059	Left	30874	28.4	C	61.0	E	52.7	D	39.1	D	49.1	D	64.0	E	29.0	C	41.1	D	47.3	D	42.5	D	46.0	D	44.9	D
Featherston / Panama	Signalised	27581	Featherston North	23946	Left	30415	9.8	A	2.6	A	3.7	A	9.9	A	7.9	A	2.6	A	10.3	B	7.7	A	2.6	A	10.1	B	7.7	A	3.2	A
	Signalised		Panama West	23815	Through	30413	35.6	D	23.6	C	27.4	C	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A
Hunter / Customhouse	Signalised	27167	Hunter West	23184	Left	29684	7.8	A	12.8	B	19.6	B	6.2	A	4.9	A	4.8	A	6.1	A	4.9	A	2.7	A	5.7	A	5.0	A	2.4	A
	Signalised		Customhouse North	23206	Left	29686	16.7	B	14.9	B	14.4	B	18.5	B	22.5	C	50.6	D	29.1	C	24.0	C	18.4	B	43.2	D	25.8	C	21.6	C
	Signalised		Customhouse South	23322	Through	29689	26.5	C	25.0	C	25.7	C	5.2	A	22.4	C	10.3	B	4.8	A	11.5	B	10.3	B	25.8	C	24.1	C	24.5	C
Customhouse / Waterloo / Whitmore	Signalised	26981	Waterloo (North)	23767	Left	6393	12.3	B	15.1	B	10.4	B	13.4	B	17.0	B	11.9	B	11.7	B	14.0	B	8.0	A	12.3	B	15.4	B	14.5	B
	Signalised		Lady Elizabeth Lane (East - Loader)	6209	Left	6394	84.8	F	48.8	D	583.2	F	84.8	F	46.6	D	583.2	F	115.8	F	57.3	E	78.9	E	88.6	F	47.8	D	125.5	F
	Signalised		Customhouse (South)	23007	Left	29189	16.9	B	9.7	A	13.2	B	17.6	B	10.7	B	13.9	B	18.3	B	8.8	A	14.2	B	18.9	B	9.5	A	14.3	B
	Signalised		Whitmore (West)	24025	Left	29193	26.4	C	26.8	C	29.3	C	27.7	C	27.8	C	29.9	C	25.2	C	30.5	C	32.6	C	27.8	C	30.8	C	34.7	C
Mercer / Victoria	Signalised	26660	Victoria (North)	22701	Through	28882	13.4	B	16.6	B	14.8	B	13.3	B	16.0	B	15.4	B	13.3	B	16.9	B	14.2	B	13.0	B	16.6	B	14.8	B
	Signalised		Mercer (West)	24073	Right	28883	30.9	C	22.2	C	39.4	D	17.4	B	17.2	B	30.1	C	22.4	C	24.7	C	28.0	C	19.4	B	18.8	B	30.8	C
Courtenay / Tory	Signalised	26831	Tory (North)	22849	Left	28894	21.7	C	18.8	B	50.1	D	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A
	Signalised		Courtenay (East)	23857	Left	28898	16.8	B	16.7	B	20.8	C	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A
	Signalised		Tory (South)	23014	Left	28902	21.3	C	20.9	C	29.0	C	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A
	Signalised		Courtenay (West)	24965	Left	28903	15.7	B	13.3	B	16.7	B	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A	0.0	A

E
Travel Time

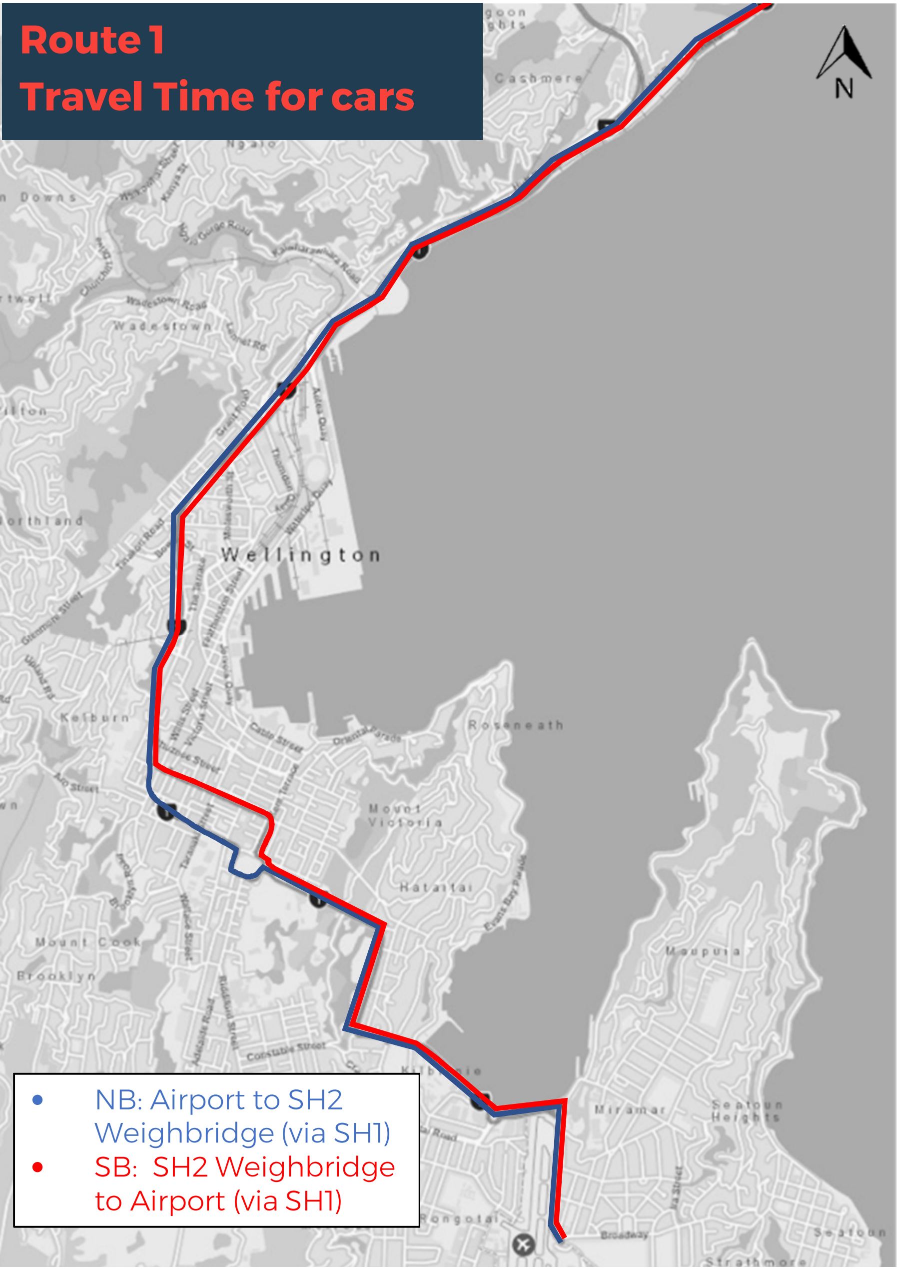
Golden Mile Travel time comparison

- Travel time (in minutes) for different typical journeys (cars only)
- Three different peak periods
- Considering the following options
    - **Do Minimum**
    - **GM Option 2** - Closure of the entire Golden Mile to general traffic (no changes in traffic demand).
    - **GM Option 2 (Elasticity)** - Closure of the entire Golden Mile to general traffic (Changes in traffic demand from implementing the project itself).
    - **GM Option 2 Refined (Elasticity)** - Closure of the entire Golden Mile to general traffic while allowing traffic to travel north-south along Tory Street and across Courtenay Place (incl. Changes in traffic demand from implementing the project itself).

Golden Mile Travel time comparison

Time Period	Direction	Scenario	Travel time (Minutes)				Percentage Difference			
			Route 1	Route 2	Route 5	Route 8	Route 1	Route 2	Route 5	Route 8
Morning Peak	Northbound	Do Min	20.37	22.63	4.83					
		GM Option 2	22.15	24.88	4.88		8.7%	9.9%	1.0%	
		GM Option 2 (Elasticity)	19.81	21.96	4.83		-2.7%	-3.0%	0.0%	
		GM Option 2 (Refined)	20.29	22.68	4.84		-0.4%	0.2%	0.2%	
	Southbound	Do Min	22.12	21.25	4.56	12.20				
		GM Option 2	21.41	21.59	4.90	12.98	-3.2%	1.6%	7.5%	6.4%
		GM Option 2 (Elasticity)	20.95	20.76	4.60	11.83	-5.3%	-2.3%	0.9%	-3.0%
		GM Option 2 (Refined)	21.37	20.82	4.57	12.31	-3.4%	-2.0%	0.2%	0.9%
Inter Peak	Northbound	Do Min	17.89	21.35	4.85					
		GM Option 2	17.92	22.26	4.87		0.2%	4.3%	0.4%	
		GM Option 2 (Elasticity)	17.81	21.42	4.85		-0.4%	0.3%	0.0%	
		GM Option 2 (Refined)	17.78	21.49	4.78		-0.6%	0.7%	-1.4%	
	Southbound	Do Min	17.81	20.26	4.13	11.36				
		GM Option 2	17.82	20.41	4.23	12.63	0.1%	0.7%	2.4%	11.2%
		GM Option 2 (Elasticity)	17.78	19.99	4.26	11.15	-0.2%	-1.3%	3.1%	-1.8%
		GM Option 2 (Refined)	17.66	20.06	4.24	11.45	-0.8%	-1.0%	2.7%	0.8%
Evening Peak	Northbound	Do Min	21.45	21.89	5.06					
		GM Option 2	21.80	22.78	5.17		1.6%	4.1%	2.2%	
		GM Option 2 (Elasticity)	20.18	22.20	5.02		-5.9%	1.4%	-0.8%	
		GM Option 2 (Refined)	20.66	22.43	5.10		-3.7%	2.5%	0.8%	
	Southbound	Do Min	20.00	20.83	4.39	12.42				
		GM Option 2	20.08	21.39	4.23	13.05	0.4%	2.7%	-3.6%	5.1%
		GM Option 2 (Elasticity)	19.48	20.89	4.21	11.44	-2.6%	0.3%	-4.1%	-7.9%
		GM Option 2 (Refined)	20.08	20.80	4.13	11.85	0.4%	-0.1%	-5.9%	-4.6%

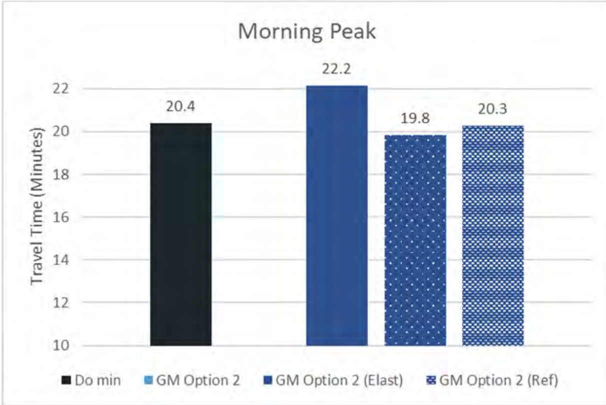
Route 1
Travel Time for cars

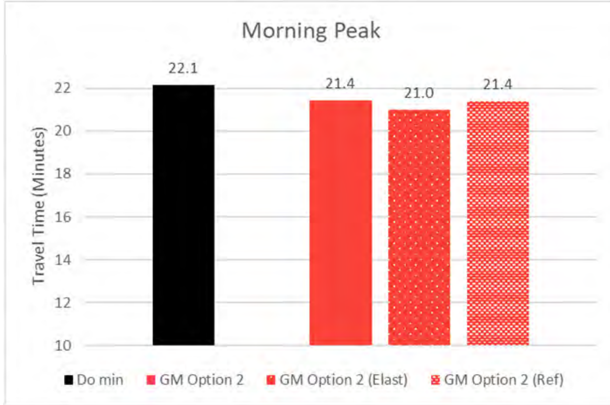


Northbound

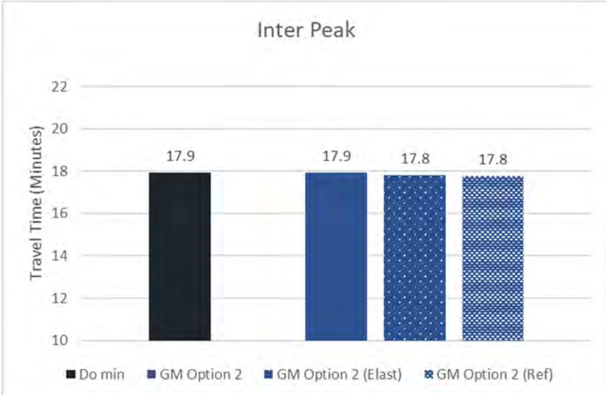
Southbound

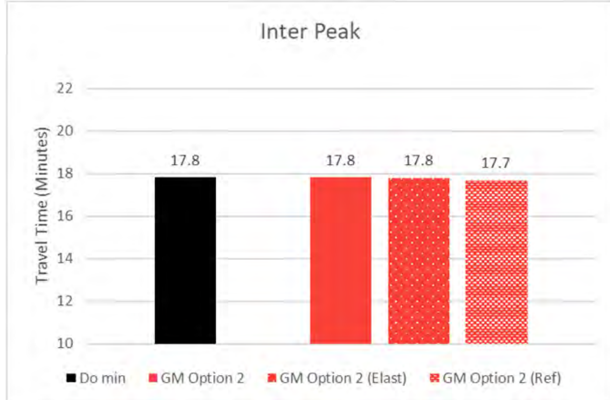
7am – 9 am



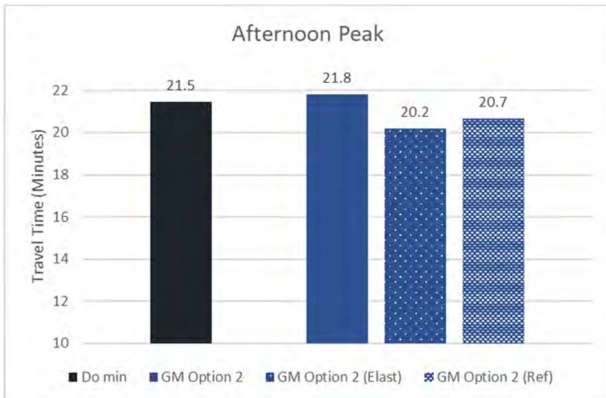


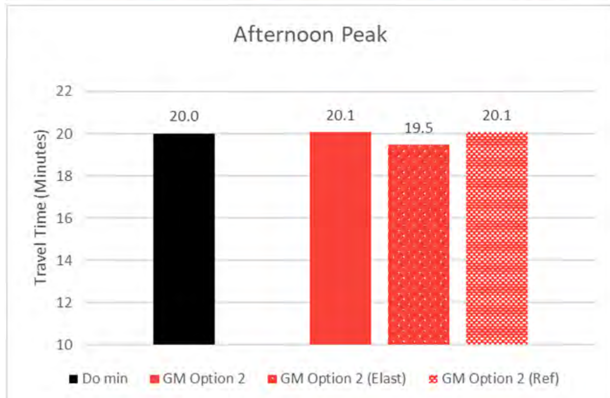
11am – 1pm



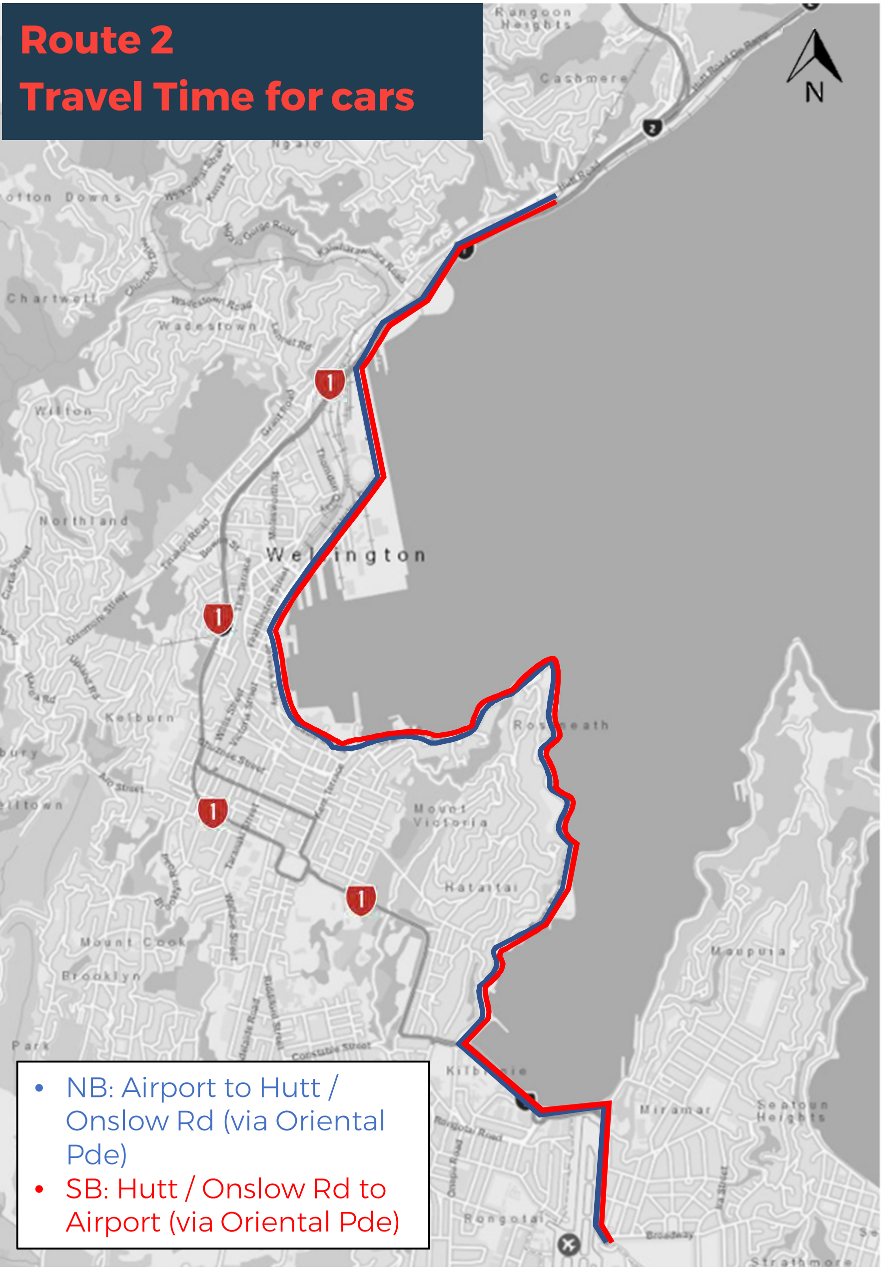


4 pm – 6pm





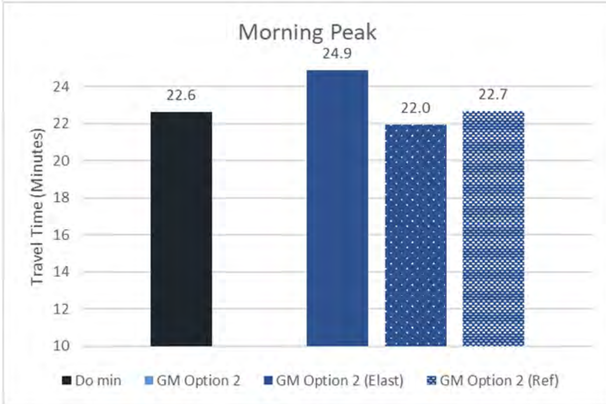
Route 2
Travel Time for cars

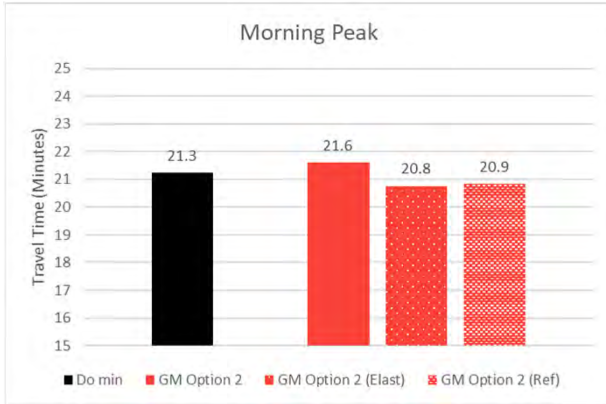


Northbound

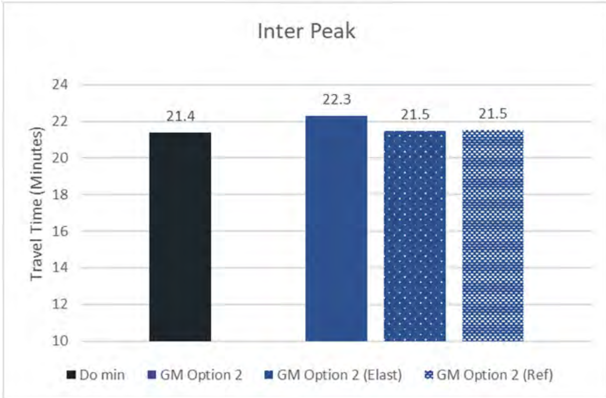
Southbound

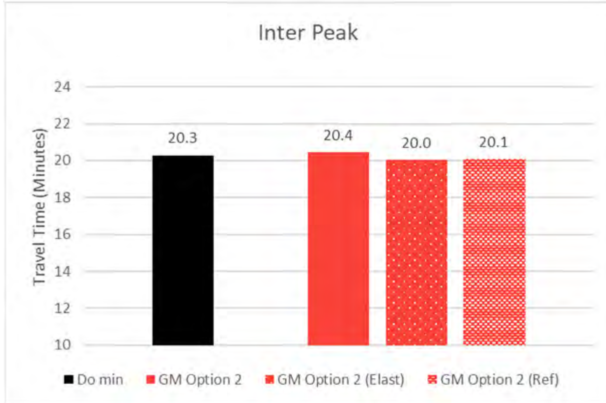
7am – 9 am



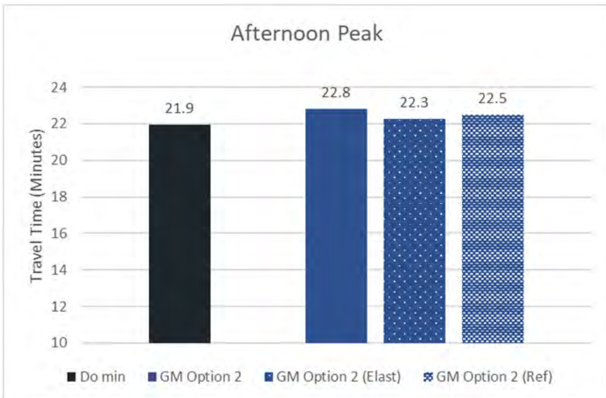


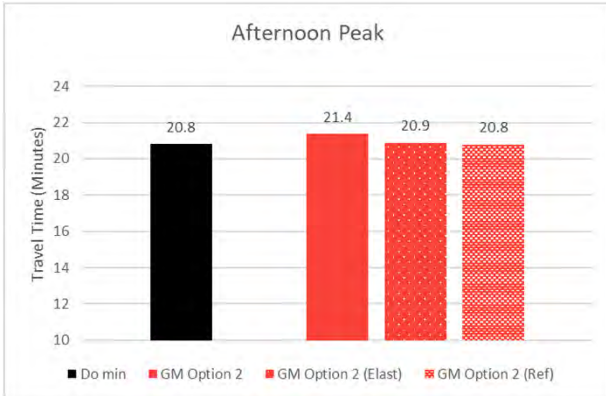
11am – 1pm





4 pm – 6pm

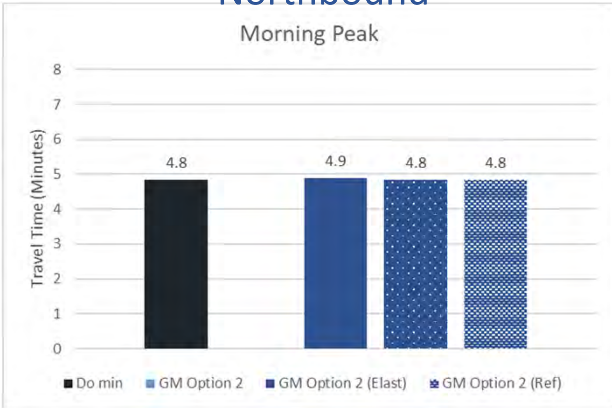




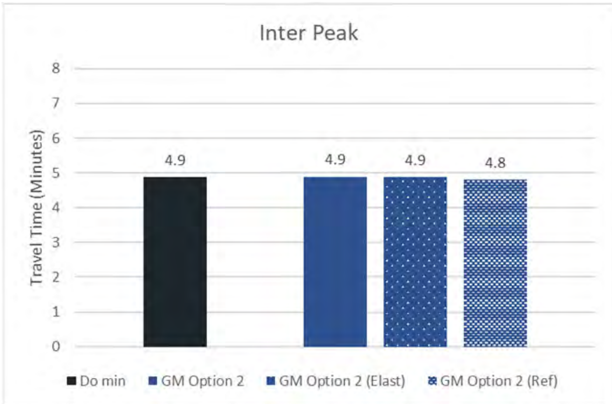
Route 5
Travel Time for cars

Northbound

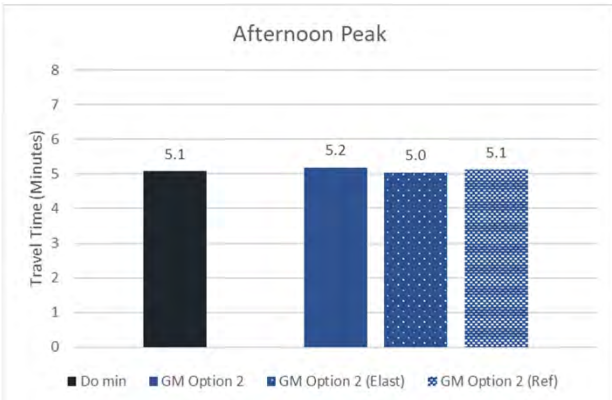
7am – 9 am



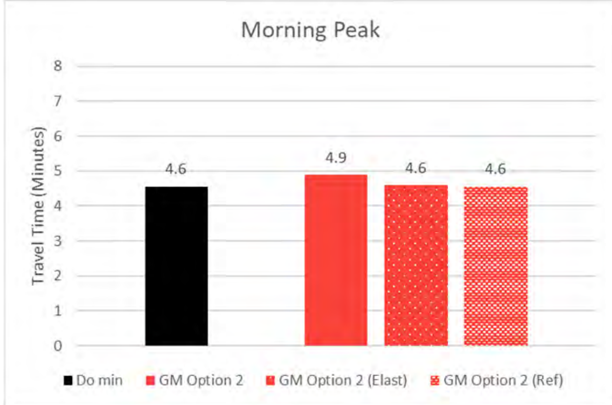
11am – 1pm

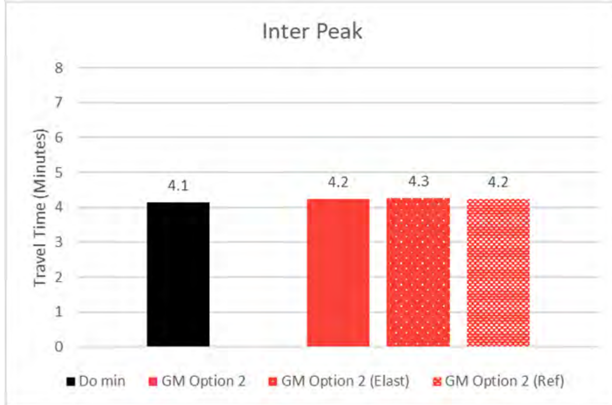


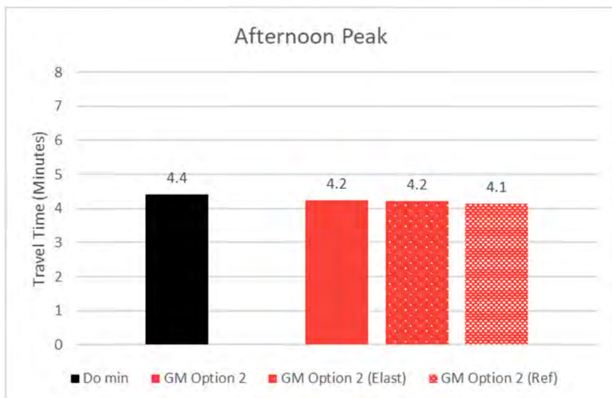
4 pm – 6pm



Southbound



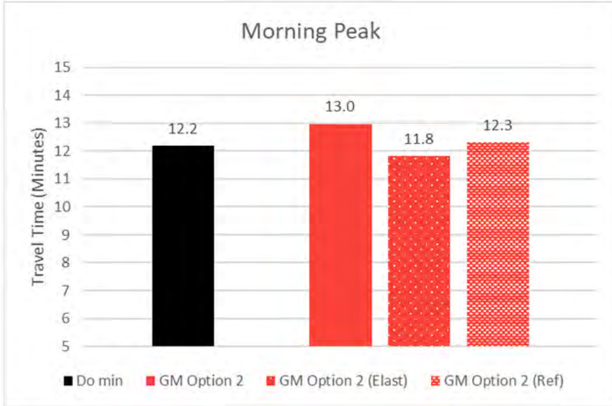




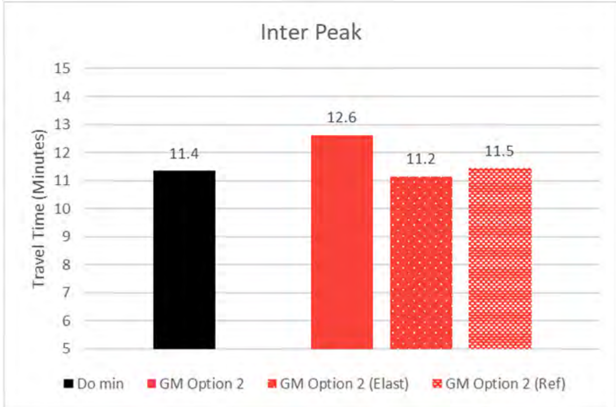
Route 8
Travel Time for cars

Southbound

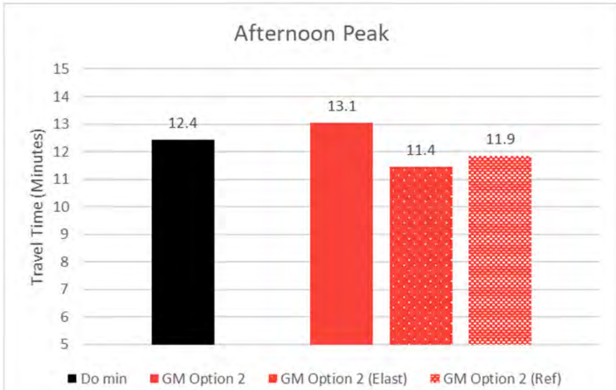
7am – 9 am



11am – 1pm



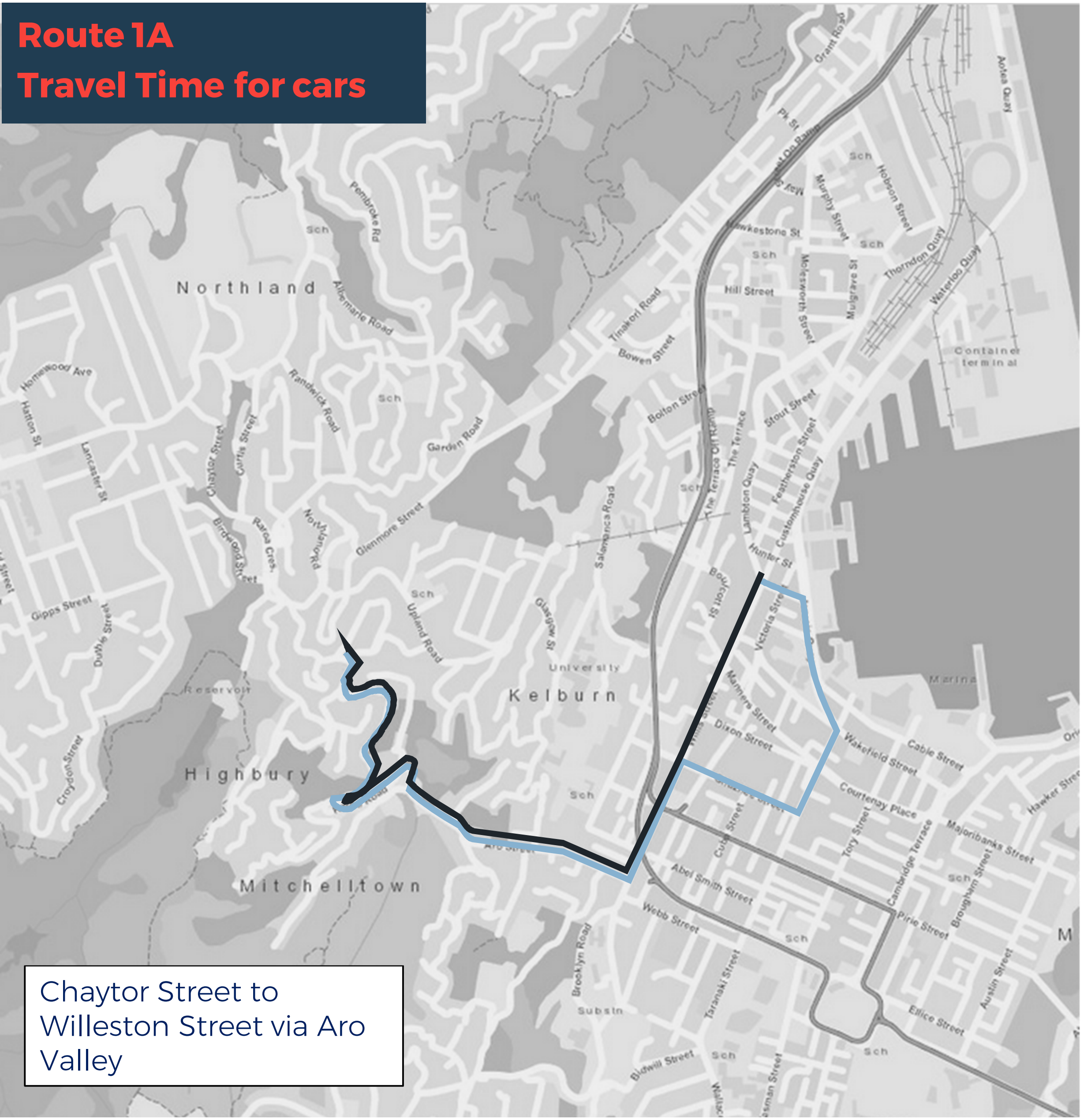
4 pm – 6pm



Golden Mile Travel time comparison 2

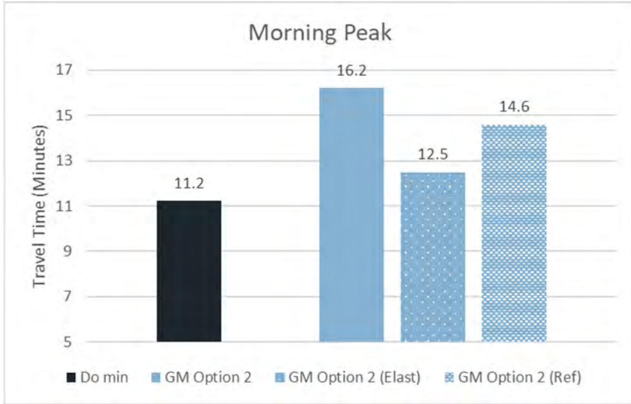
Peak	Scenario	Travel times (Minutes)					Percentage Difference				
		Route 1A	Route 1B	Route 1C	Route 2	Route 3	Route 1A	Route 1B	Route 1C	Route 2	Route 3
Morning Peak	Do Min	11.24	9.82	11.13	9.91	6.47					
	Opt 2	16.21	14.01	12.24	12.3	6.91	49.7%	41.9%	11.1%	23.9%	4.4%
	Opt2 Elast	14.16	12.49	11.57	11.03	6.65	29.2%	26.7%	4.4%	11.2%	1.8%
	Opt2 Ref	14.6	13.57	11.46	11.38	6.71	33.6%	37.5%	3.3%	14.7%	2.4%
Inter Peak	Do Min	10.69	9.83	11.55	9.29	6.48					
	Opt 2	13.49	12.48	12.86	10.54	8.13	28.0%	26.5%	13.1%	12.5%	16.5%
	Opt2 Elast	12.99	11.98	11.33	9.86	6.53	23.0%	21.5%	-2.2%	5.7%	0.5%
	Opt2 Ref	13.83	12.99	11.71	10.24	6.87	31.4%	31.6%	1.6%	9.5%	3.9%
Evening Peak	Do Min	11.39	11.33	11.47	10.44	6.69					
	Opt 2	15.66	14.87	13.61	12.7	8.59	42.7%	35.4%	21.4%	22.6%	19.0%
	Opt2 Elast	13.92	13.3	11.42	10.95	6.48	25.3%	19.7%	-0.5%	5.1%	-2.1%
	Opt2 Ref	16.33	15.45	11.14	11.38	5.87	49.4%	41.2%	-3.3%	9.4%	-8.2%

Route 1A
Travel Time for cars

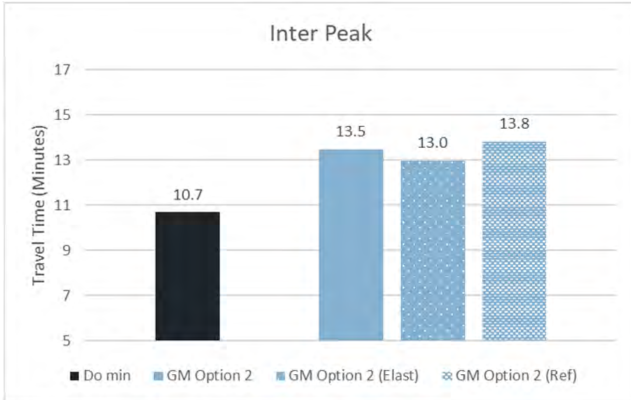


Chaytor Street to Willeston Street via Aro Valley

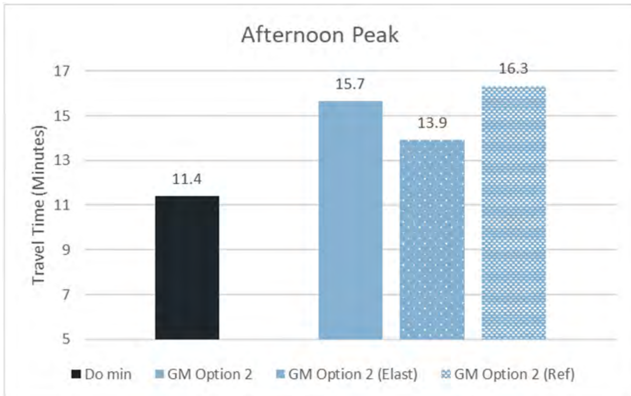
7am – 9 am



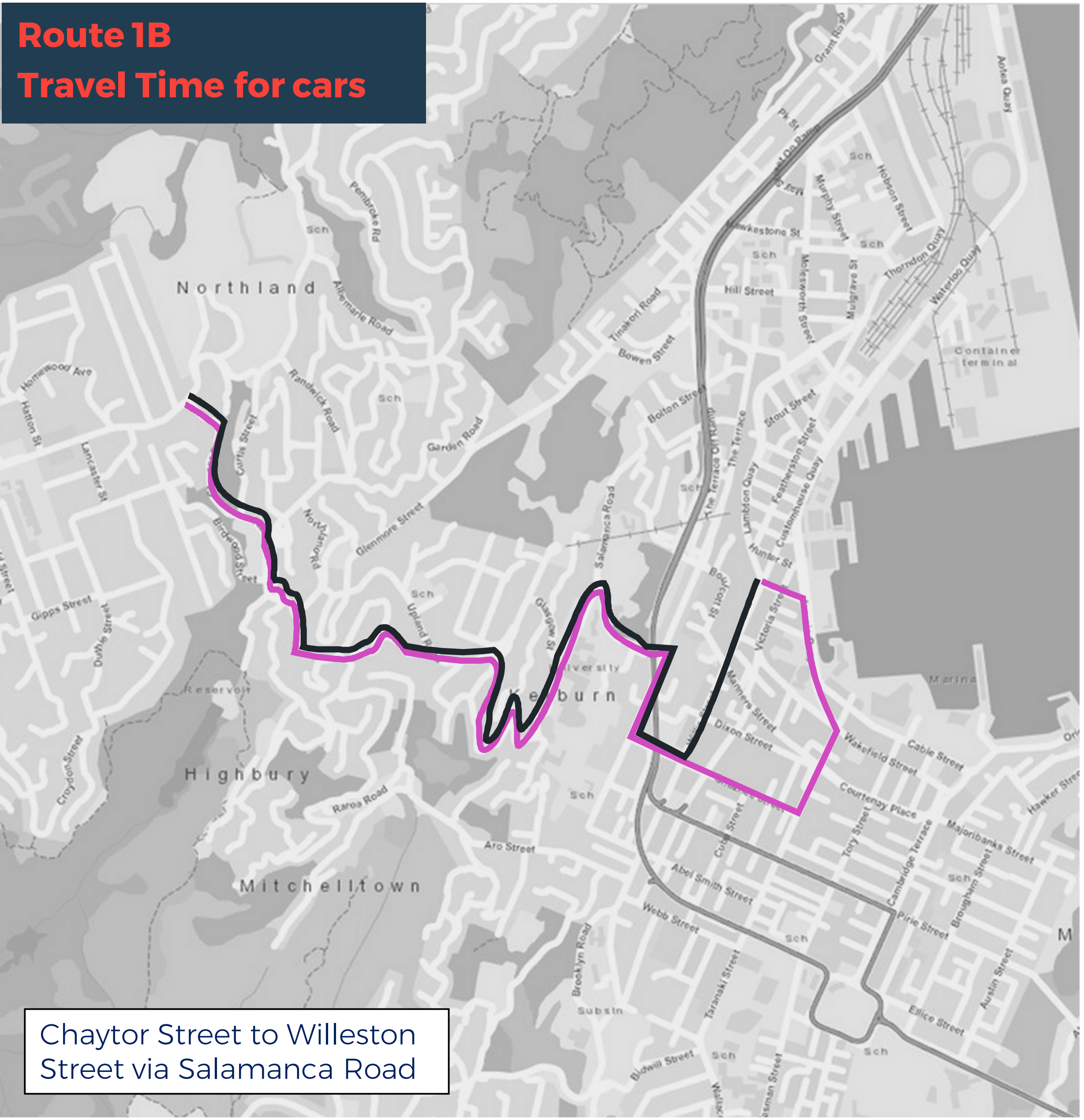
11am – 1pm



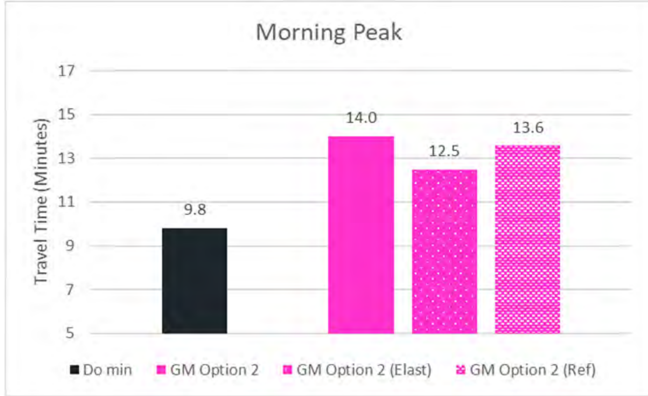
4 pm – 6pm



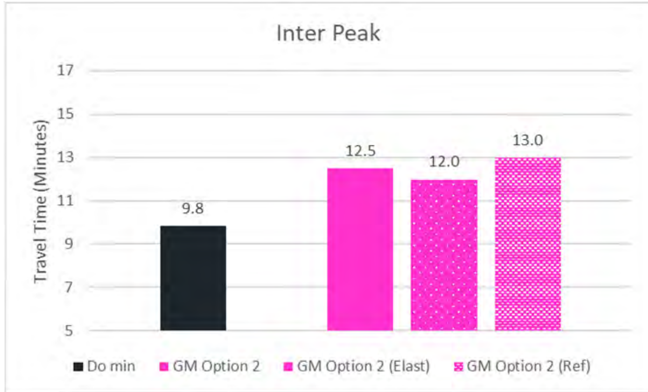
Route 1B
Travel Time for cars



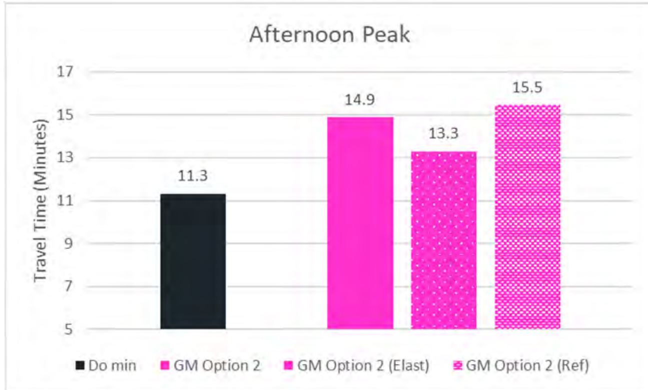
7am – 9 am



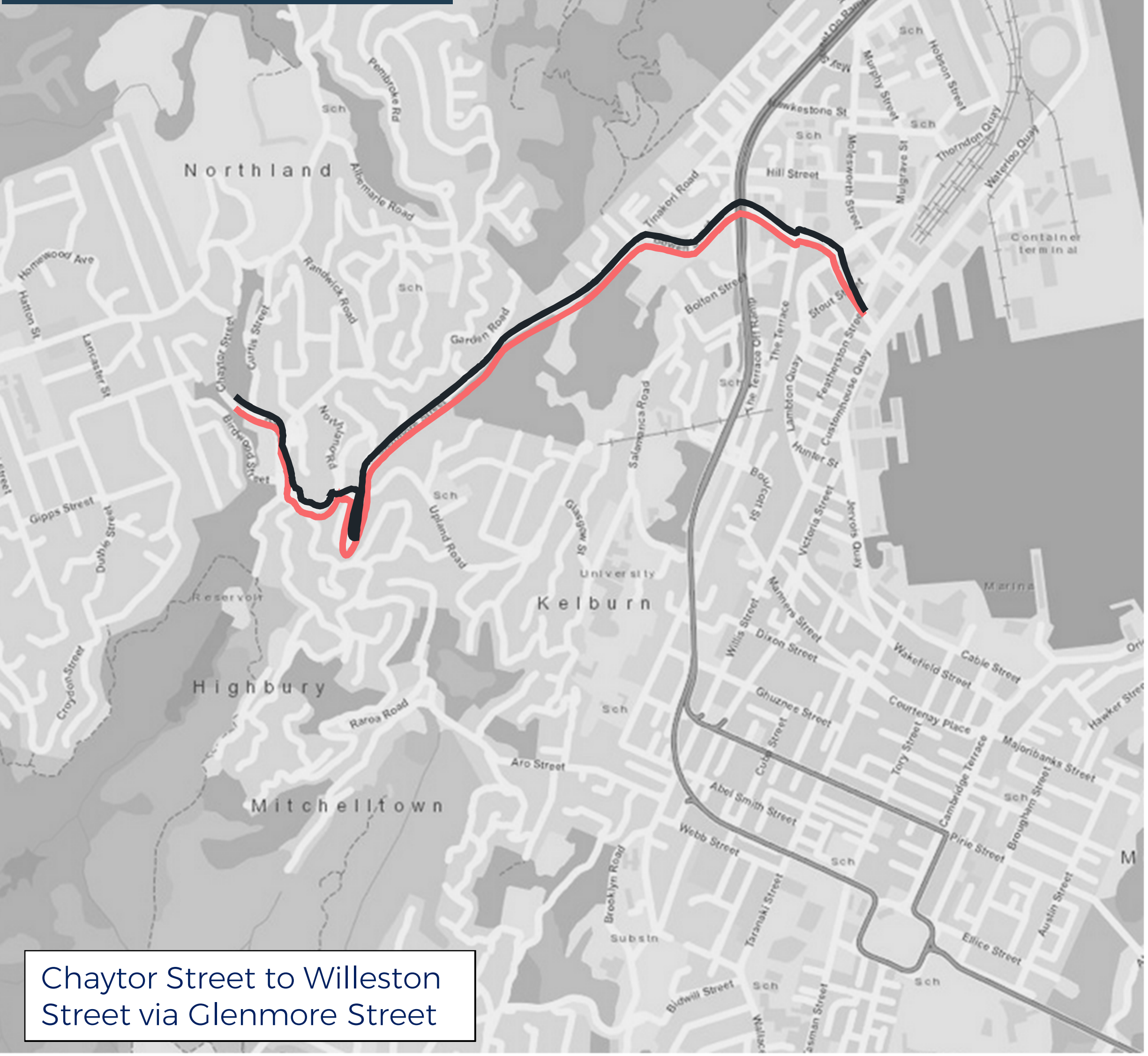
11am – 1pm



4 pm – 6pm

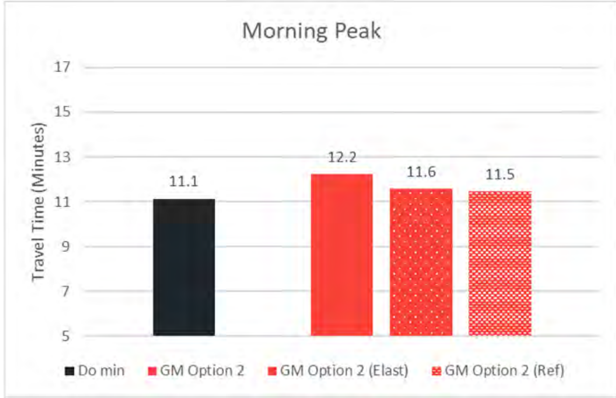


Route 1C
Travel Time for cars

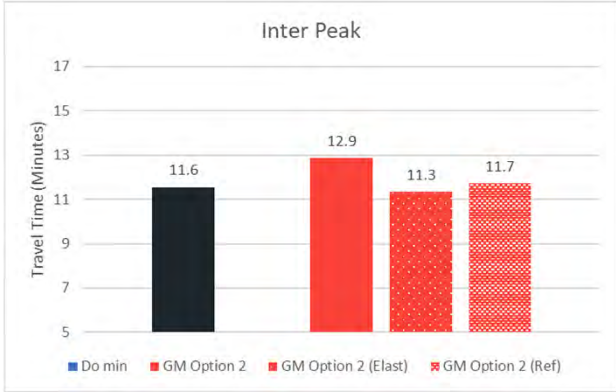


Chaytor Street to Willeston Street via Glenmore Street

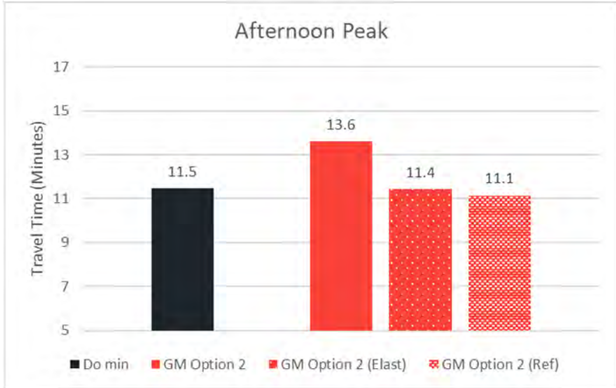
7am – 9 am



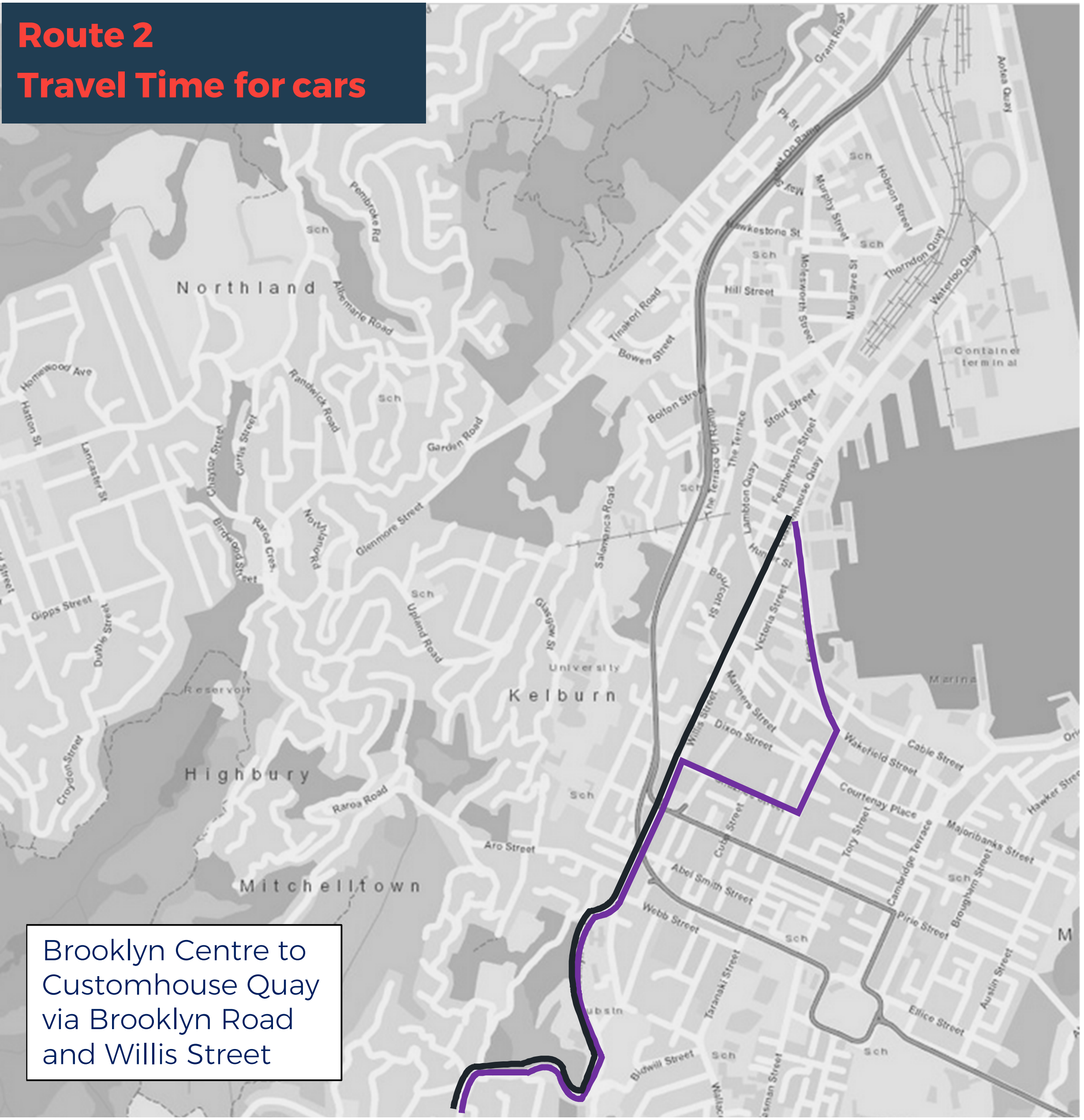
11am – 1pm



4 pm – 6pm

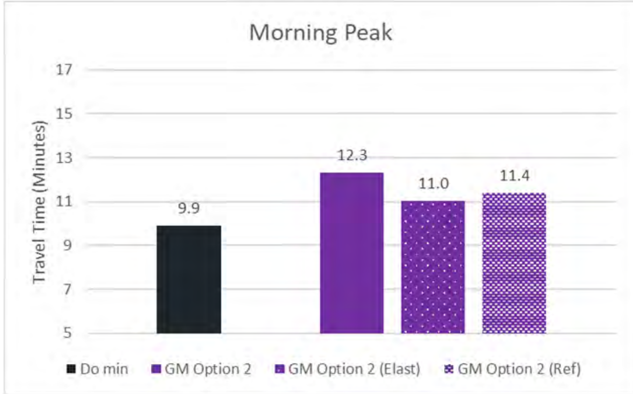


Route 2
Travel Time for cars

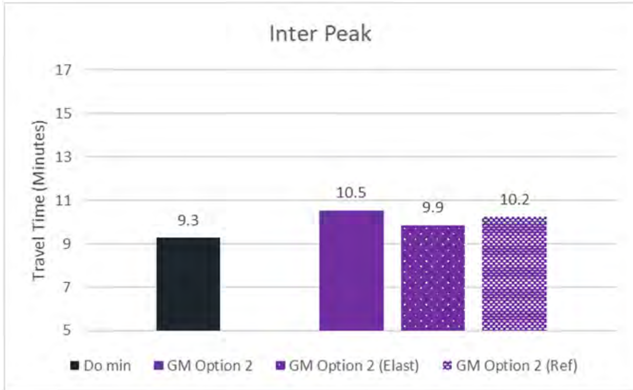


Brooklyn Centre to Customhouse Quay via Brooklyn Road and Willis Street

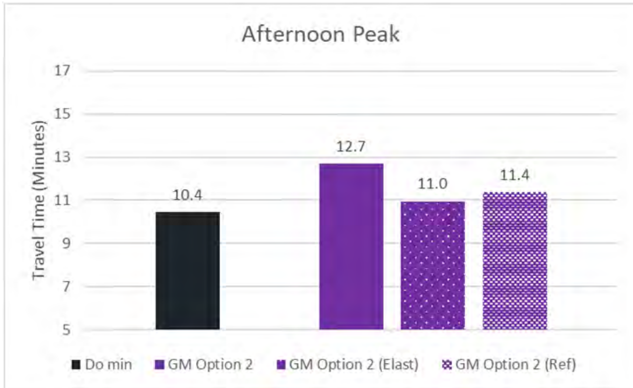
7am – 9 am



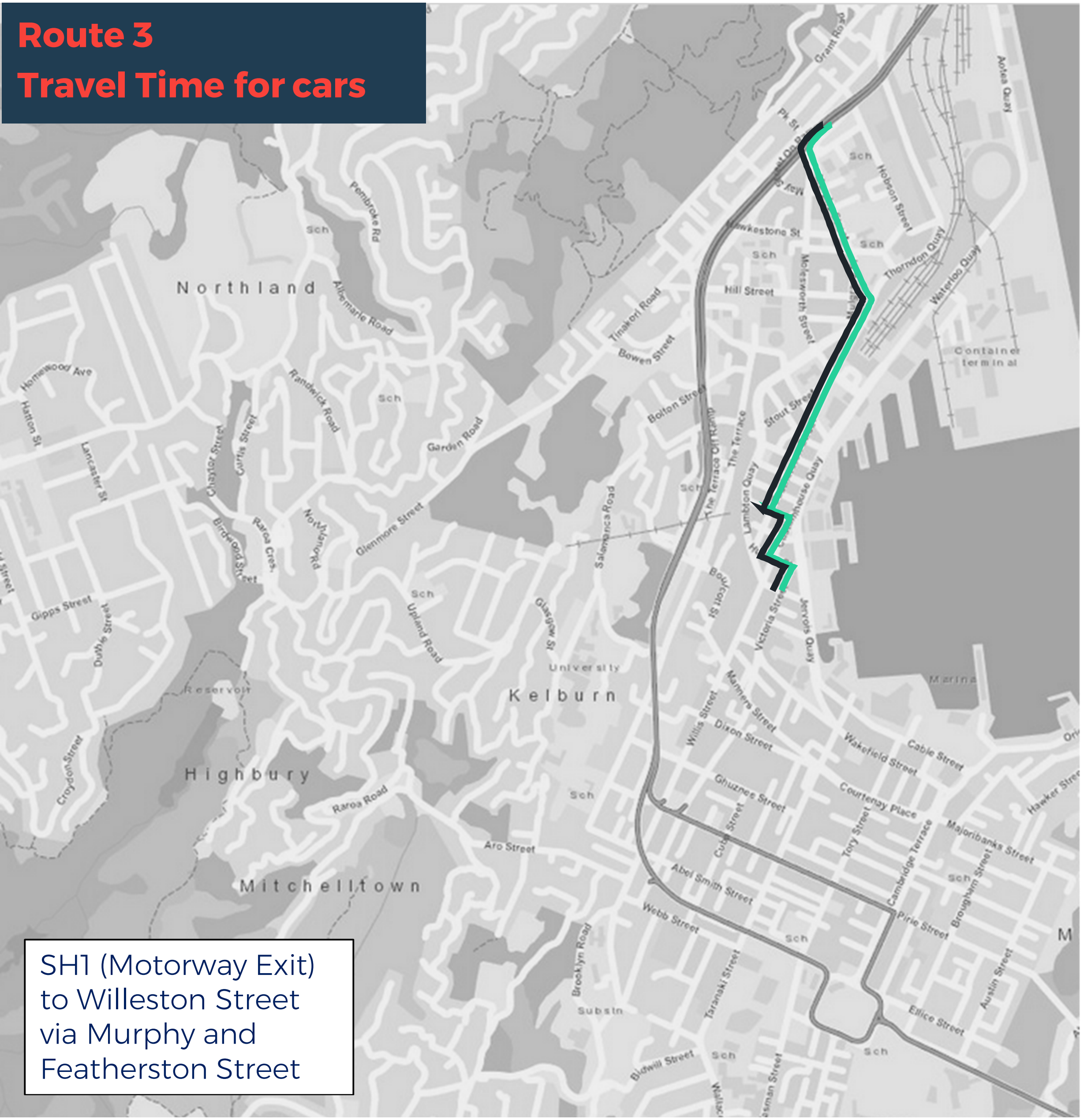
11am – 1pm



4 pm – 6pm

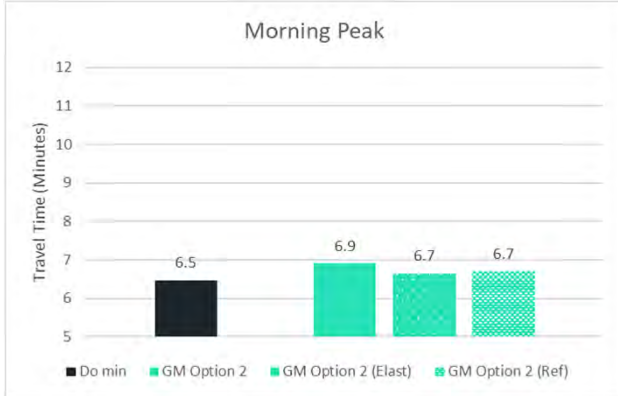


Route 3
Travel Time for cars

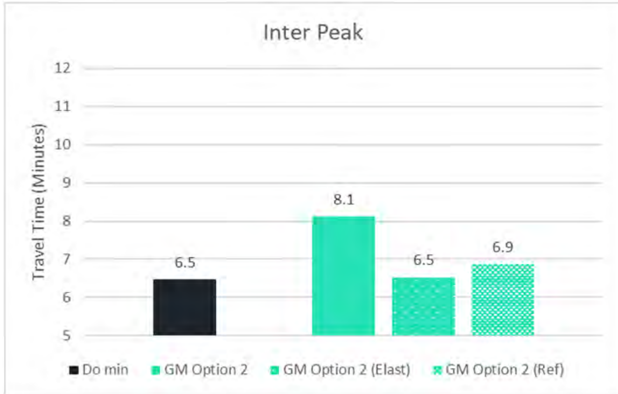


SH1 (Motorway Exit) to Willeston Street via Murphy and Featherston Street

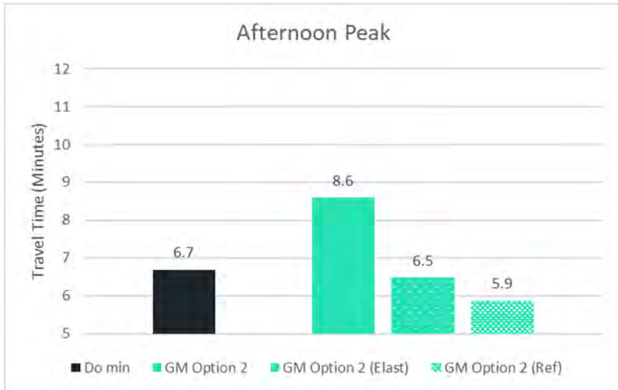
7am – 9 am



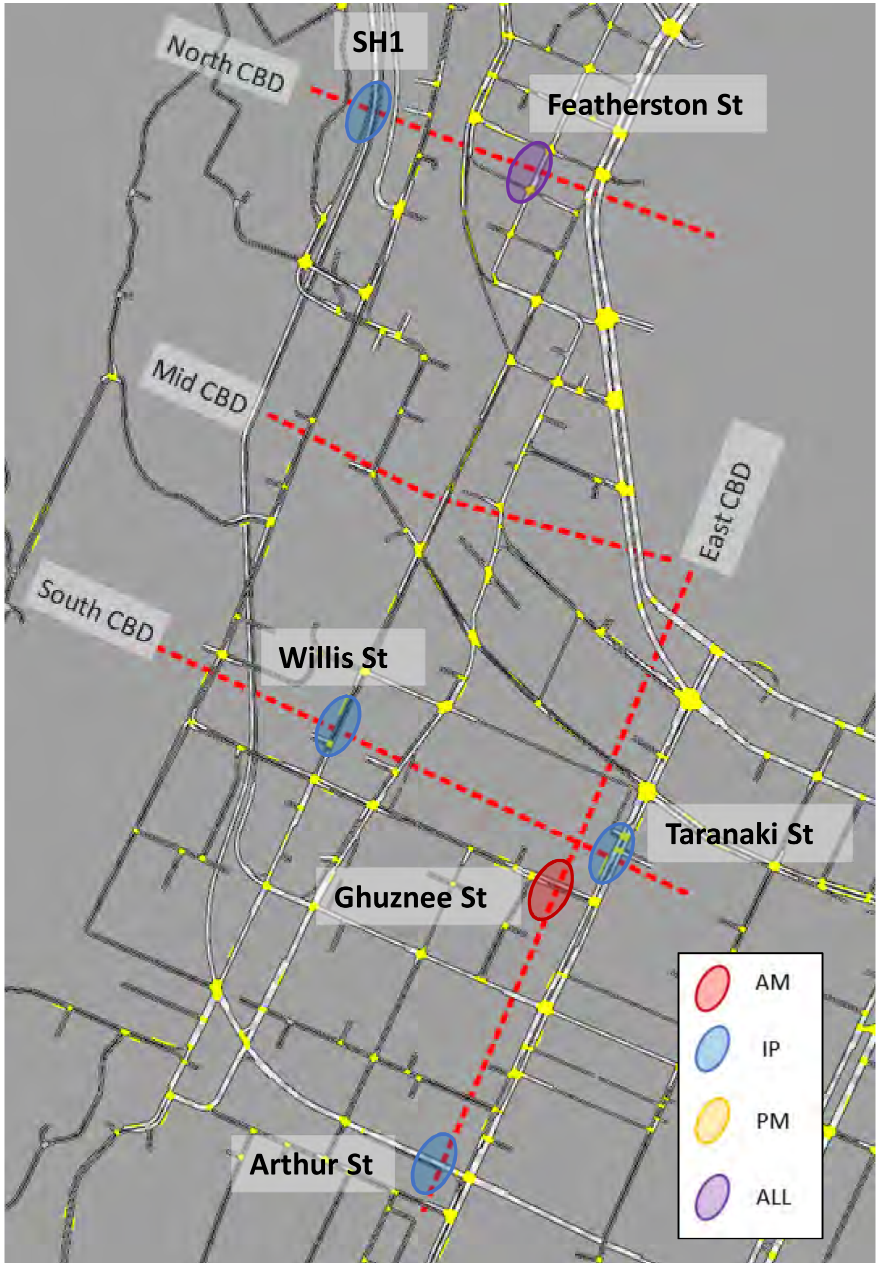
11am – 1pm

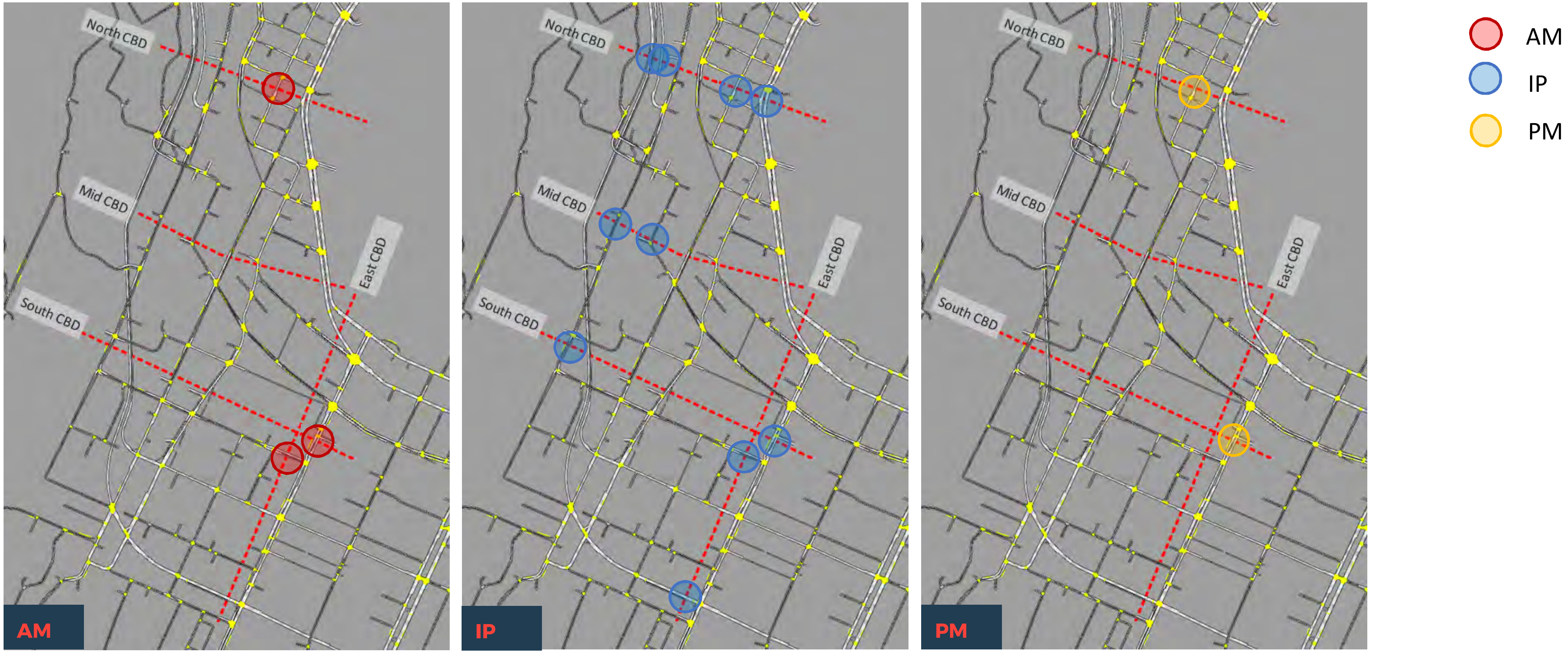


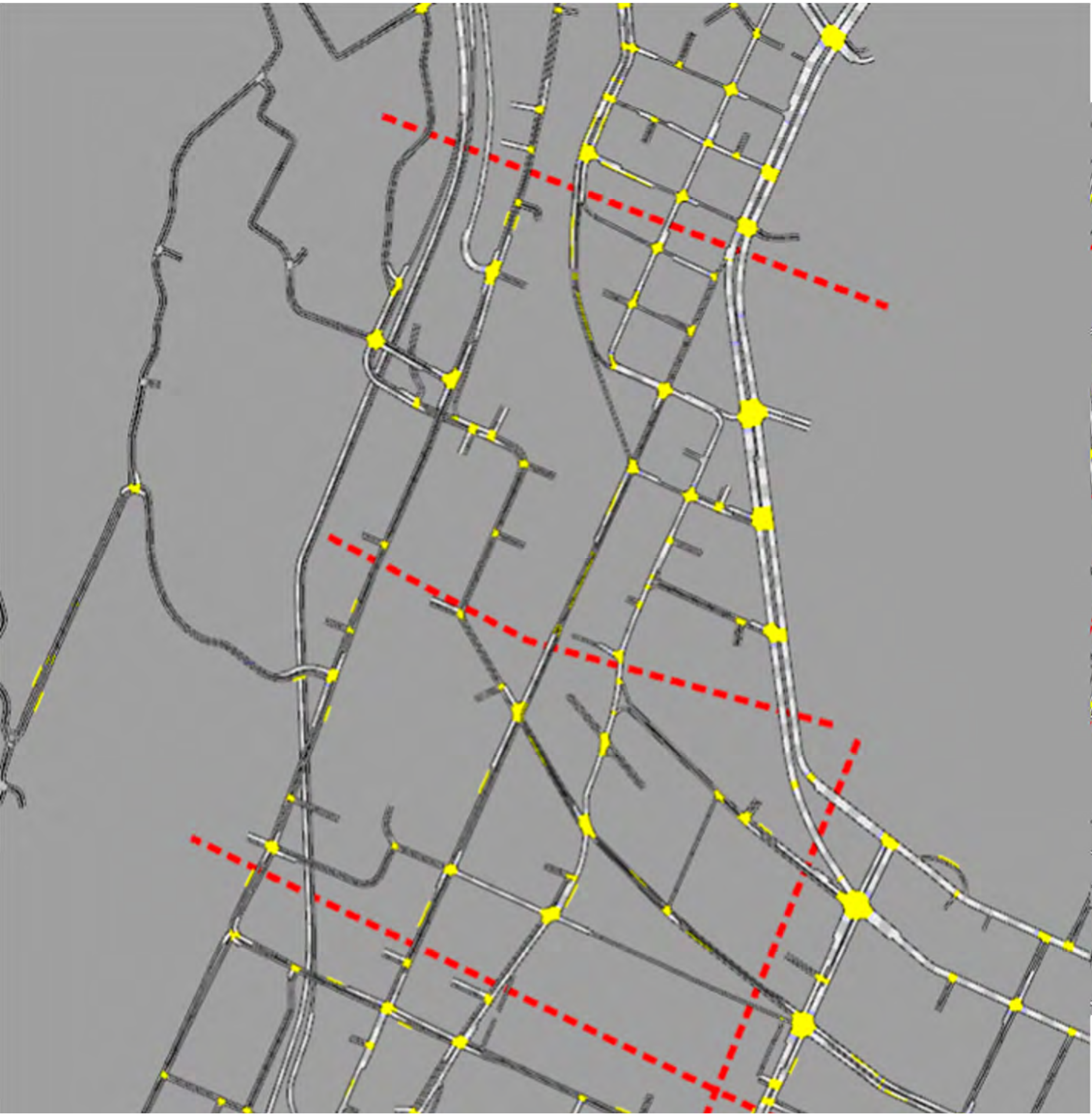
4 pm – 6pm

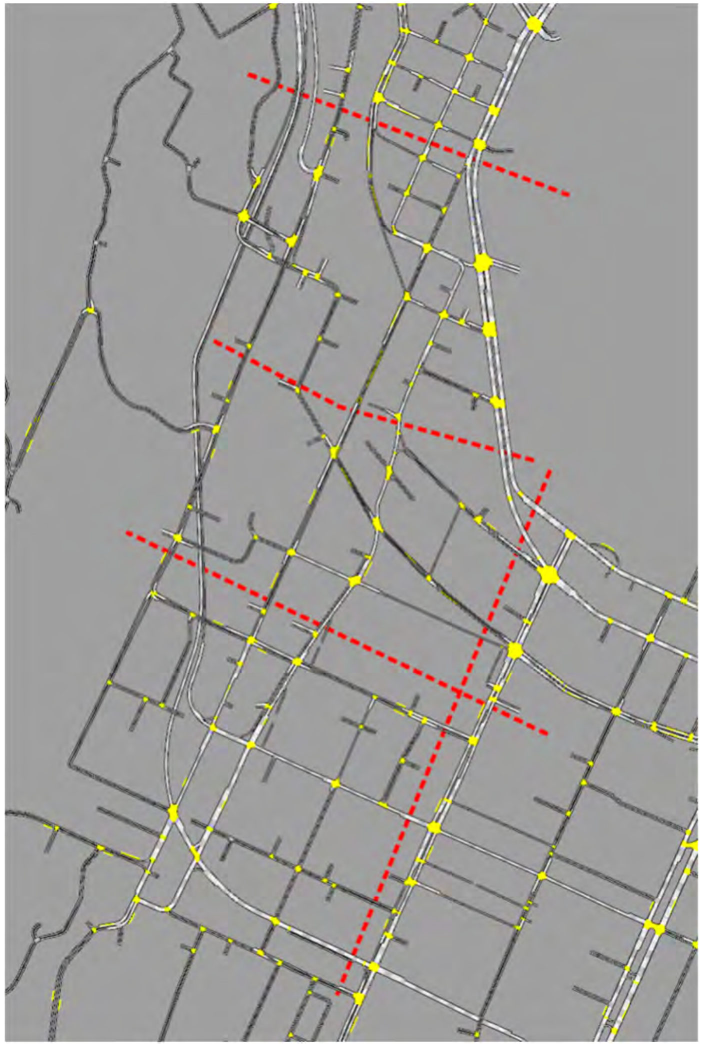



North CBD
Mid CBD
South CBD
East CBD


North CBD
SH1
Featherston St
Mid CBD
East CBD
South CBD
Willis St
Taranaki St
Ghuznee St
Arthur St
AM
IP
PM
ALL

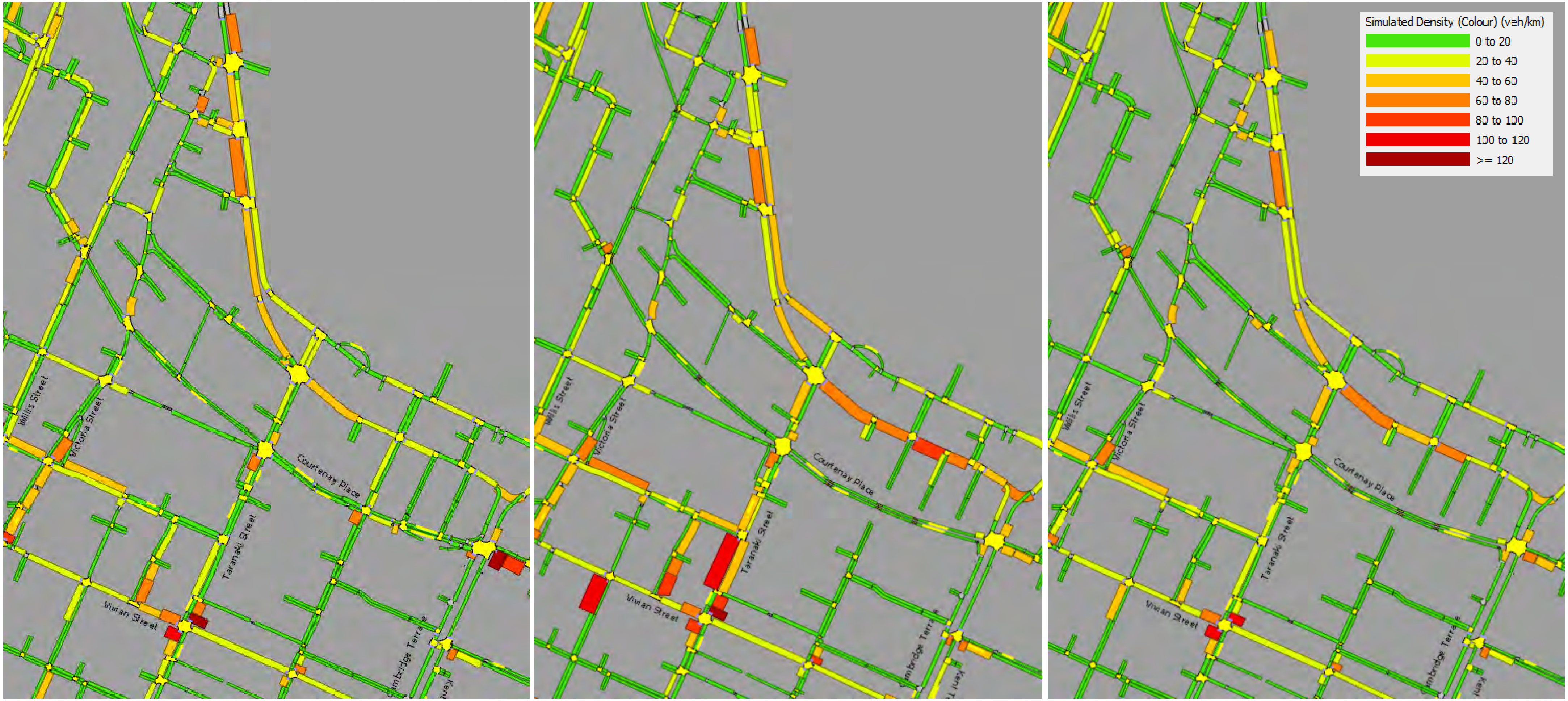

North CBD
Mid CBD
South CBD
East CBD
AM
North CBD
Mid CBD
South CBD
East CBD
IP
North CBD
Mid CBD
South CBD
East CBD
PM
AM
IP
PM





Golden Mile – Courtenay Place/Willis Street Segment AM (8:15AM to 8:30AM)

Do Minimum | Golden Mile Option (DM Matrix) | Golden Mile Option (Elasticity Matrix)



Golden Mile – Lambton Quay Segment

AM (8:15AM to 8:30AM)

Do Minimum

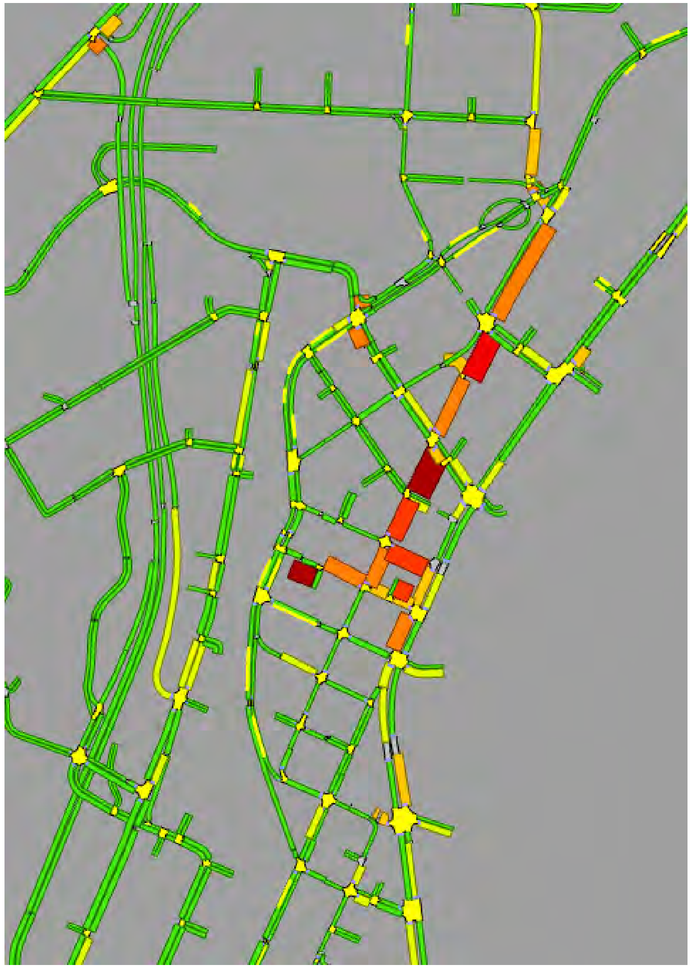
Golden Mile Option (DM Matrix)

Golden Mile Option (Elasticity Matrix)

Golden Mile – Lambton Quay Segment

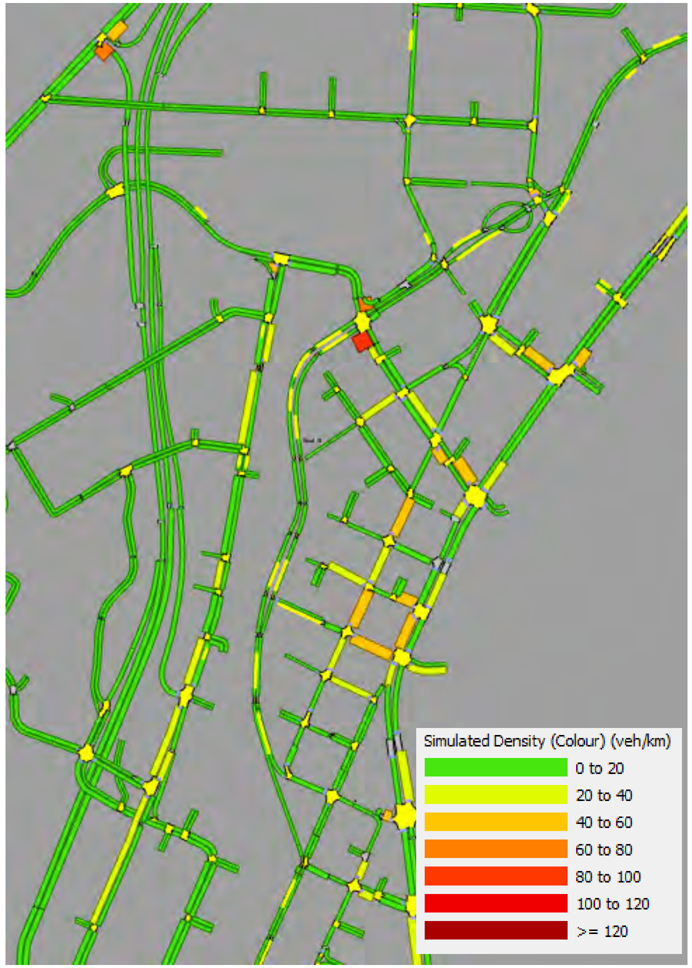
IP (12:30PM to 12:45PM)

Do Minimum



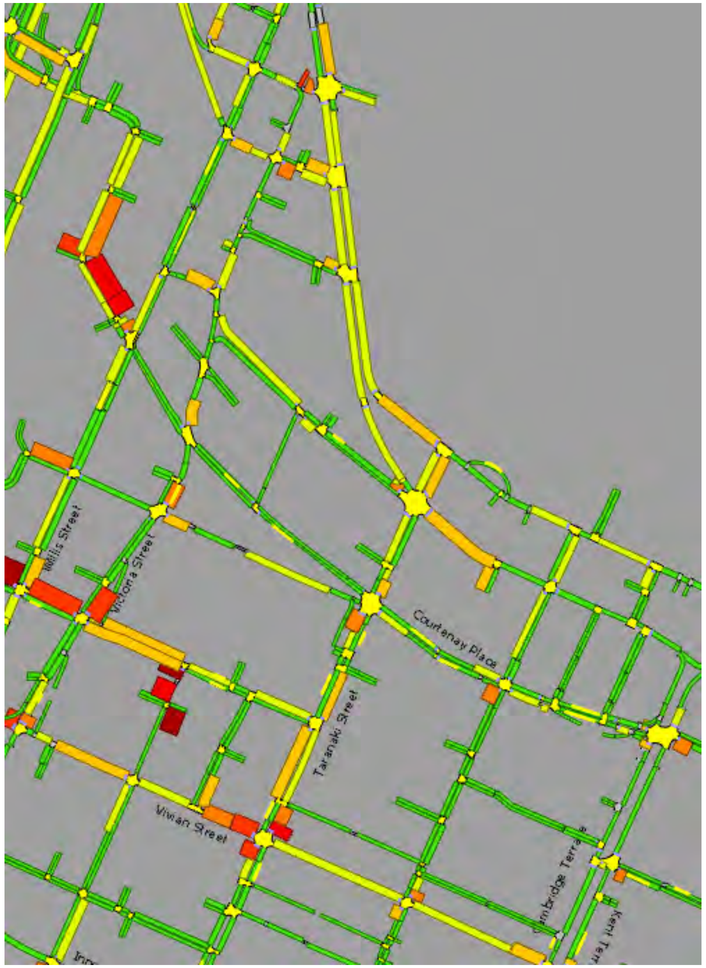
Golden Mile Option (DM Matrix)

Golden Mile Option (Elasticity Matrix)

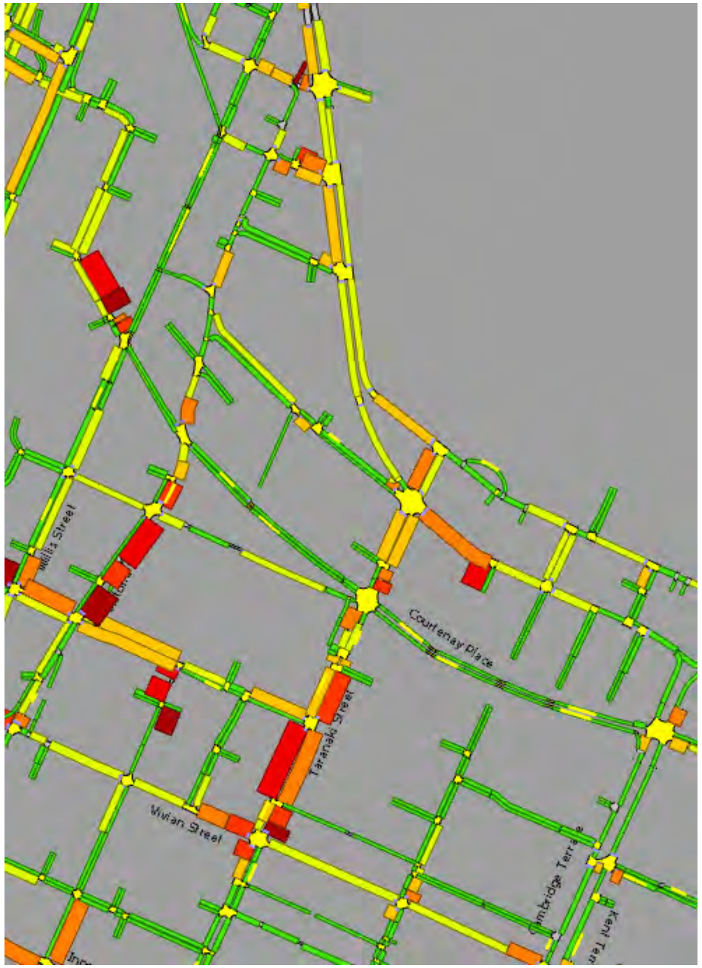


Golden Mile – Courtenay Place/Willis Street Segment PM (5:45PM to 6:00PM)

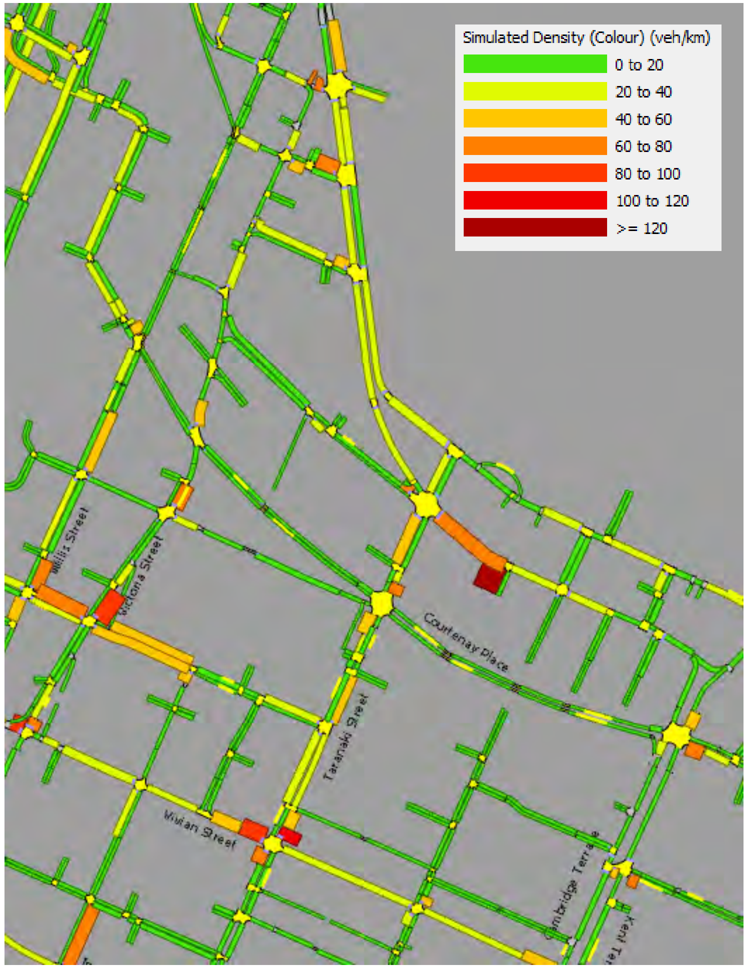
Do Minimum



Golden Mile Option (DM Matrix)



Golden Mile Option (Elasticity Matrix)



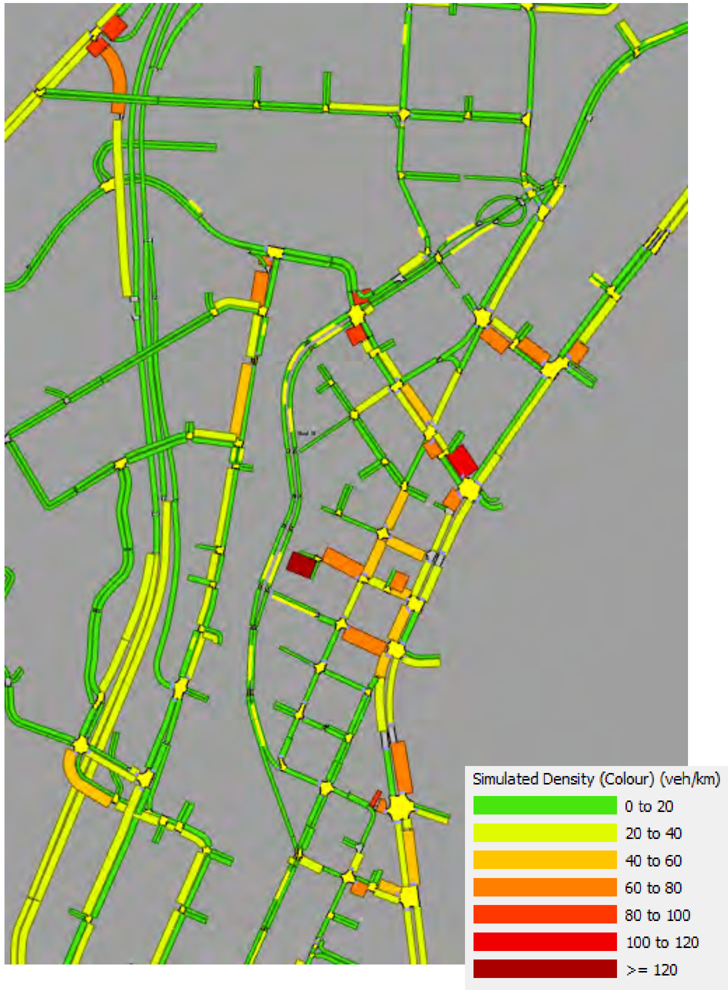
Golden Mile – Lambton Quay Segment

PM (5:30PM to 5:45PM)

Do Minimum

Golden Mile Option (DM Matrix)

Golden Mile Option (Elasticity Matrix)



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