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Appendix E - Golden Mile Economics Assessment Report

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Economic Assessment for Preferred Option

Final Report

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Glossary

Term	Meaning
ADT	Average Daily Traffic count
HCV	Heavy Commercial Vehicle
LGWM	Let's Get Wellington Moving
MBCM	Monetised Benefits and Costs Manual (Waka Kotahi, 2020)
MCA	Multi-Criteria Analysis
MRT	Mass Rapid Transit project, part of Let's Get Wellington Moving programme
SSBC	Single Stage Business Case
VEPM	Vehicle Emissions Prediction Model
WAU	Wellington Analytics Unit
WPTM	Wellington Public Transport Model

Executive Summary

The preferred option of the Golden Mile SSBC includes a suite of interventions that affect all modes of transport. These interventions include the removal of private vehicles from the length of the Golden Mile, a streamlined layout for bus operations including stop locations, pedestrian realm upgrades and the provision of some cycle lanes. Economic impacts for each of these user types have been included except for cyclists where demands are uncertain, and the scale of the benefit is unlikely to be significant when compared to the benefits for other modes. The monetised benefits are:

- Road users: travel time impact, emissions reduction and health benefits from mode shift from cars to public transport
- Public transport users: travel time impact and reliability impact
- Pedestrians: travel time impact (due to closed signalised crossings) and pedestrian realm impact

The costs considered include both construction costs spread over the years ended June 2023 and June 2024 and annual maintenance costs. The following table presents the results of the economic assessment under the default assessment parameters and assumptions, include a 40-year evaluation period and 4% discount rate. The base benefit-cost ratio is 4.6 with a first year rate of return of 0.11 (11%), and a low benefit-cost ratio scenario tested has a benefit-cost ratio of 2.9.

Cost/Benefit	Present value ($m)
Costs	
Construction costs	$80
Maintenance costs	$6
Total costs	**$86**
Benefits	
Car travel time impact	-$20
Emission reduction benefit	$17
Health benefit from mode shift	$48
Public transport travel time impact	$18
Public transport reliability impact	$27
Pedestrian travel time impact	$25
Pedestrian crash reduction benefit	$37
Pedestrian realm benefit	$247
Total benefits	**$399**
Net benefits	$313
Benefit-cost ratio	**4.6**
First year rate of return (FYRR)	0.11

1 Introduction

The purpose of this report is to describe the methodology and results for the economic assessment of the preferred option for the Let's Get Wellington Moving (LGWM) Golden Mile Single Stage Business Case (SSBC). This methodology and assessment have evolved from two previous assessments for this project: *Indicative economic benefits for short list options* (May 2020) and *Economics Assessment of Short List Options for MCA* (January 2021). Throughout these iterations of the assessment, the general methodology has remained consistent while the specific inputs and assumptions have been revised to more recent (and more certain) inputs. This assessment includes a range of sensitivity tests to assist with understanding the implications and sensitivity of the results to some of the inputs.

This economic assessment considers the benefits for private vehicle users, public transport passengers and pedestrians. Benefits for cyclists are not included in this assessment as these benefits are unlikely to be significant relative to the benefits for users of other modes and there is uncertainty around cyclist volumes along the Golden Mile making it difficult to estimate monetised benefits.

2 Options

This report estimates the benefits of costs of the preferred option from the Golden Mile SSBC. The do minimum is intended to represent the current layout of the Golden Mile. In particular:

- Traffic circulation is assumed to be the same as it is currently.
- Public transport (bus) layout and priority is the same as it is currently, with SCATS data informing signal timing assumptions and Snapper data informing dwell time assumptions.
- Pedestrian layout and streetscape are the same as currently.

After the optioneering process, the preferred option was selected to prioritise pedestrians while maintaining provisions for buses to enable them to operate as efficiently as possible. At a high level, the preferred option includes the following improvements:

1. Removes private vehicles from the length of the Golden Mile and closes several side streets that connect to the Golden Mile, providing signalised mid-block crossings at the previous side street access points. Major intersections remain open for through-movements of private vehicles.
2. Provides bus only access along the length of the Golden Mile, with indented bus stops at the two ends of the corridor and buses stopping inline at other stops. The preferred option reduces the number of bus stops along the Golden Mile compared with the current layout.
3. Widens footpaths as much as possible along the corridor, provides dedicated cycle paths and includes public realm upgrades to increase the amenity and 'place' aspect of the Golden Mile.

3 Economic data and inputs

The preferred option for the Golden Mile removes private vehicle capacity, streamlines the bus operations and prioritises pedestrians both through space allocation and amenity improvements. Inputs to the benefit calculations for each mode are outlined in Table 1 and the economic assessment parameters are:

- Evaluation period of 40 years and discount rate of 4%.[1]
- Evaluation year is the year ended June 2022.
- Construction is assumed to begin in the year ended June 2023 and end in the year ended June 2024.
- Benefits will first be realised in the year ended June 2025.
- Benefit values for 2020 are used.[2]
- Other inputs that are specific to each mode are summarised in Table 1 and are detailed further in the methodologies within Section 4.

Table 1 Summary of inputs by mode

Input	Road users	Public transport users	Pedestrians
Base demands	AIMSUN fixed demands	WPTM demands for 2013, scaled up by 25% to reflect 2018 demands	March Monitoring Counts for 2018
Mode shift demands	Elasticity-adjusted demands based on AIMSUN travel time results	Additional demand, diverted from vehicles	Elasticity-adjusted demands based on *Golden Mile Intercept Survey Results*
Growth in demands over time	No growth	1.6% growth per year	1.3% growth per year
Travel times	AIMSUN	PT Runtime Model (see Appendix D)	Intersection delays from SIDRA.
Other benefits	Emissions reduction: vehicle kilometres travelled from AIMSUN	Bus delays/queuing time: from models in *Bus Congestion Research* report	Public realm: interim guidance and preferred option concept plans
Annualisation factors (see Appendix A)	From WAU	From WAU	From Auckland's Heart of the City counters
Value of time	From WAU	From MBCM	From MBCM

[1] These are the default assumptions in the MBCM. The LGWM Mass Rapid Transit (MRT) project is likely to be operational about 10 years after Golden Mile and may reduce some public transport demand for Golden Mile. However, the Golden Mile improvements are included in the do minimum scenario for MRT, so the impacts of MRT should be captured by that business case.

[2] The latest update factors for the MBCM values at the time of writing were for 2020.

4 Costs

Cost estimates for the preferred option have been developed, with details provided in the *SSBC Golden Mile Cost Estimate Report (9 September 2021)*. The costs were finalised and confirmed with LGWM as:

- 50^{th} percentile cost estimate: $84,400,000
- 95^{th} percentile cost estimate: $101,100,000

The construction duration is assumed to occur over 2-years (August 2022 – July 2024), with benefits first being realised in the financial year ending June 2025.

Maintenance costs have been estimated as the *additional* maintenance costs above and beyond what WCC are already committed to with the current infrastructure. This additional annual maintenance cost is estimated at $360,000 per year.

5 Benefits

This section describes the methodology and results of the transport benefits that have been estimated for the preferred option; these are also summarised in Table 2.

Table 2 Summary of benefits estimated

Impact	Description
Road user travel time impact	The road user travel time impact relates to the value of changes in vehicle travel times for car users.
Emissions benefit	The emissions benefit considers the impact of changes to network-wide vehicle kilometres travelled on emissions.
Health benefit from mode shift	The health benefit due to mode shift from cars to public transport is estimated, conservatively assuming that 20% of removed vehicle trips shift to public transport and have an associated 400m walking leg.
Public transport travel time benefits	The public transport travel time benefit estimates the value of travel time savings to public transport users along the Golden Mile.
Public transport reliability benefits	The public transport reliability benefit estimates the value of improved reliability for public transport users along the Golden Mile due largely to signal timing changes and reduced queuing at bus stops.
Pedestrian travel time benefits	Travel time benefits for pedestrians come from removing signalised crossings of side streets *along* the corridor. Impacts of changes to signal timings where all side streets are kept opened is not measured. Signalised crossings (e.g. mid-block crossings) *across* the corridor are not measured due to uncertain demands for crossing across the corridor at signalised crossings.
Pedestrian crash reduction benefit	Removal of traffic and street upgrades are expected to reduce the number of pedestrian crashes on the Golden Mile.
Pedestrian realm benefits	Improvements to the pedestrian environment, such as adding street trees and plantings, also provide benefits to pedestrians and attract more pedestrians than streets without such features.

5.1 Road user impacts

This section outlines the data and assumptions for estimating the road user impacts, the methodology for estimating these impacts and the results for the 'most likely' outcome.

5.1.1 History of AIMSUN modelling

Several rounds of AIMSUN modelling have been completed at various stages of the Golden Mile SSBC.

1. Initial AIMSUN models in mid-2020 modelled three traffic circulation concepts, including the two traffic circulation options in the short list options and applied a 'fixed demand' assumption, so the number of vehicle trips is the same in the options as in the do minimum.
2. In late-2020, these models were revised to reflect the refined short list options and to inform the MCA process, retaining the 'fixed demand' assumption.
3. Also in late-2020, a set of demand-adjusted models were run by applying a demand elasticity approach to the models from round 2. A summary of this approach is included in Appendix B.1 and a full technical note is available on request. This effectively estimated the reduction in vehicle trips between origin-destination pairs where the travel time worsened in the option relative to the do minimum.
4. A final model run was created in mid-2021 to represent the preferred option of improvements, including some minor refinements to the previous models to reflect refinements to the option itself. This traffic circulation model was run with the elasticity-adjusted demands from round 3 of the models.

Accordingly, we now have four model runs that are referred to in relation to this final economic assessment:

1. Do Minimum model: used to compare each of the options against.
2. Emerging Option, fixed demand (from round 2 of the modelling): provides a 'worst case' outcome, in which the Golden Mile interventions are implemented, but no vehicle-users change their travel patterns to respond to the traffic restrictions.
3. Emerging Option, elasticity-adjusted demand (from round 3 of the modelling): provides an 'upper limit' on the improved conditions resulting from the Golden Mile interventions – this model assumes fewer people travel by car because of the traffic restrictions but does not consider that the reduced traffic will improve travel times again and re-induce some of the removed vehicle trips.
4. Preferred Option, elasticity-adjusted demand (from round 4 of the models): considered the 'most likely' outcome as it reflects the preferred option traffic circulation and the travel time results lie between the two Emerging Option models, which was the expected result if the elasticity-adjusted demand approach was iterated.

5.1.2 Data and assumptions

Inputs for the road user impacts include:

- Vehicle demands, travel times and distance travelled from AIMSUN modelling (Preferred Option, elasticity-adjusted demand):
  - The spatial extent of the model covers the city centre.
  - Impacts on private vehicles are included, but on HCVs are excluded as the extent of interventions is limited to streets that do not experience high volumes of HCVs.
  - The four-hour period extracts from AIMSUN are used.
- Emissions factors per kilometre travelled were collected from the Vehicle Emissions Prediction Model (VEPM, v6.2) for light vehicles for the 2018 and 2038 fleet compositions and an average speed of 30km/h. These are summarised in Table 3.
- Value of emissions benefits were collected from the MBCM. These are summarised in Table 3.
- Values of time have been inherited from WAU and updated to 2020 dollars to ensure consistency with other transport projects in Wellington. These are summarised in Table 4.
- Annualisation factors have been inherited from WAU to ensure consistency with other projects in Wellington and are described in Appendix A and summarised in Table 4.

Table 3 Vehicle emissions rates and benefits (source: VEPM v6.2, light vehicle fleet, 30km/h)

Emission type	**Emissions factor (g/km)**		**Emissions benefit (2020$/tonne)**
	2018	**2038**	
CO (carbon monoxide)	2.105	0.253	$4.75
CO_2 (carbon dioxide)	250.2	178.7	$114 in 2018 $178 in 2038
NOx (nitrogen oxides)	0.449	0.132	$18,799
PM10 (brake and tyre)	0.024	0.023	$529,014

Table 4 Value of time and annualisation for different periods (source: WAU)

Period	**Representative model period**	**Model period to annual factor**	**Value of time (2020$/hour)**
AM	AM	250	$19.21
IP	IP	317.5	$19.91
PM	PM	250	$23.11
Offpeak	IP	210	$14.80
Weekend	IP	484.15	$20.04

5.1.3 Travel time impact

The methodology for computing the road user travel time impacts was as follows:

1. For each period: Collect total trips and total vehicle-seconds travelled for each link in the AIMSUN outputs for the relevant 'representative model period' as per Table 4.
    1.1. Compute the 'travel time benefit' (including the rule of half) between the option and do minimum scenarios, using:
    $$B = \frac{1}{2}(n_{DM} + n_{OPT})(t_{DM} - t_{OPT})$$
    where B is the travel time benefit (seconds), n_{DM} is the number of trips in the do minimum scenario, n_{OPT} is the number of trips in the option scenario (noting that the 'rule of half' is applied here), and t_{DM} and t_{OPT} are the average time per trip (seconds) for the do minimum and option scenarios respectively.
    1.2. Convert from vehicle-seconds to vehicle-hours saved.
    1.3. Compute the value of the travel time impacts by applying the values of time from Table 4 to the travel time differences from the previous step.
    1.4. Compute the annual value of the travel time impacts by applying the 'model period to annual' factors from Table 4.
2. Estimate the total annual benefit by summing the benefit for each period.

5.1.4 Emissions impact

The methodology for computing the emissions impact is as follows:

1. Combine the estimated emissions factors (in grams per kilometre travelled) and value of emissions benefits (dollars per tonne of reduced emissions) into an estimate of the emissions benefit per kilometre travelled. This works out to an emissions benefit of $0.0497 per kilometre reduced in 2018 and $0.0465 per kilometre reduced in 2038.
2. Apply the aggregate emissions benefit per kilometre travelled to the change in total modelled kilometres travelled for each period in the option compared to the do minimum.
3. Apply the 'model period to annual' factor from Table 4 and sum across all periods to estimate the total annual emissions benefit.

5.1.5 Health benefit from mode shift

The methodology for computing the health benefit from mode shift from driving to active modes is as follows:

1. Collect the modelled number of car trips in the Do Minimum model and in the elasticity-adjusted models and compute the difference in the number of trips per model period.
2. Apply the 'model period to annual' factor from Table 4 and sum across the AM, IP and PM periods to estimate the total change in annual trips. Note: we are note capturing any health benefit from mode shift in the offpeak or weekend periods, due to uncertainties around the appropriate diversion rates in these periods.
3. Estimate the number of trips that would have shifted to public transport, as 20% of the removed car trips (MBCM, Table 86).
4. For each additional public transport trip, assume an average distance walked of 400m to calculate the total additional distance walked.
5. Apply the health benefit of $4.58 per additional kilometre walked (MBCM Table 6, plus update factors to 2020 value) to the estimated additional distance walked in step 4.

5.1.6 Quantified road user impacts

The travel time impacts from the AIMSUN models are shown in Table 5.

Table 5 AIMSUN results for vehicle travel times

Model period	Total time travelled (hours)	
	Do Minimum	Preferred Option
AM	5,840	5,227
IP	5,263	4,650
PM	7,434	6,731

The AIMSUN outputs of total vehicle kilometres travelled in the study area are included in Table 6.

Table 6 AIMSUN results for vehicle kilometres travelled

Model period	Total kilometres travelled	
	Do Minimum	Preferred Option
AM	147,201	133,535
IP	132,212	117,986
PM	179,372	166,590
Annual	215,395,700	194,391,790

The annualisation and emissions results derived from those vehicle kilometres are included in Table 7 and Table 8.

Table 7 Representative 2018 vehicle emissions impacts

Emissions type	Change in vehicle kilometres travelled	Emissions rate (g/km)	Reduced emissions (tonnes)	2020 $/tonne	Benefit
CO (carbon monoxide)	21,003,910	2.105	44.2	$4.75	$210
NOx (nitrogen oxides)		0.449	9.4	$18,799	$177,289
PM10 (brake & tyre)		0.024	0.5	$529,014	$266,673
CO2 (carbon dioxide)		250.2	5,255.2	$114	$599,090

Table 8 2038 vehicle emissions impacts

Emissions type	Change in vehicle kilometres travelled	Emissions rate (g/km)	Reduced emissions (tonnes)	2020 $/tonne	Benefit
CO (carbon monoxide)	21,003,910	0.253	5.31	$4.75	$25
NOx (nitrogen oxides)		0.132	2.77	$18,799	$52,121
PM10 (brake & tyre)		0.023	0.483	$529,014	$255,561
CO2 (carbon dioxide)		178.7	3,753	$178	$668,105

The AIMSUN model estimates a reduction in annual car trips during the day on weekdays (ie excluding offpeak and weekends) of 7.4 million trips, of which 1.5 million trips are assumed to shift to public transport. This equates to nearly 600,000 additional kilometres walked per year.

5.1.7 Monetised road user impacts

Table 7 shows the estimated results of the road user impacts based on the AIMSUN model of the preferred option with the elasticity-adjusted demands (from round 4 of the models). This is considered the 'most likely' model, which is supported by the results that the travel time impact lies between the two extremes previously estimated with the

Emerging Option model runs. The directionality of these two benefits (ie one being positive and one negative) is because the travel time impact is based on *average travel times*, whereas the emissions impact is estimated from *vehicle kilometres;* in the preferred option model run, the average travel times increased while the total vehicle kilometres travelled declined.

Table 9 Results of road user impacts

Benefit type	Annual impact (2018)	Annual impact (2038)	Present value impact
Road user travel time	-$1,104,553	-$1,104,553	-$19,548,806
Emissions	$1,043,262	$975,812	$17,229,811
Health benefit from mode shift (cars to PT)	$2,693,115	$2,693,115	$47,663,802

5.2 Public transport benefits

MRCagney's public transport runtime model (see Appendix D) is used to estimate bus travel times along each section of the Golden Mile to inform the public transport user benefits. The corridor definition in the latest model has been refined to reflect the latest preferred option corridor layout.

5.2.1 Data and assumptions

The primary data inputs and assumptions for the public transport benefit assessment are recorded below:

- Public transport demands:
    - WPTM model plots were reviewed to estimate the approximate public transport demand along each section of the Golden Mile. Following advice from WAU, the estimated demands were scaled up by 25% to adjust from 2013 modelled outputs to 2018 patronage estimates.
    - Additional public transport demand from trips diverted from cars was also estimated as up to 500 additional passengers per two-hour period on each stretch of the Golden Mile, based on the derivation in Appendix B.2. The resulting demand estimates from this and the previous step are shown in Table 8.
    - Growth in public transport demand to the city centre is estimated to average 1.6% per year from 2016 levels (from 28,000 in 2016 to 37,000 in 2036) as recorded in the *Golden Mile - Do Minimum Scenario Description.* Therefore, the base (2018) benefit estimate is estimated to grow at 1.6% per year throughout the evaluation period for the present value calculations.
- Public transport travel times: MRCagney has a (Monte Carlo) public transport runtime model that was originally developed to estimate indicative travel times for proposed rapid transit corridors and was requested for this assessment. It is a physics-based model that estimates the travel time for independent buses, with consideration of distance travelled, acceleration and deceleration, intersection locations and signal timings, and bus stop locations and dwell times. More detail on this model is provided in Appendix D.
- Value of time: $16.44 per hour. This is based on:
    - MBCM base value of time for each trip purpose (MBCM Table 15): $23.85 work, $7.80 commute, $6.90 other

  - MBCM share of trips by each purpose for 'urban' weekday trips (MBCM Table A42): 20% work, 20% commute, 60% other
  - MBCM uplift factor for value of time: 1.57
  - Formula: $(\$23.85 * 20\% + \$7.80 * 20\% + \$6.90 * 60\%) * 1.57 = \$16.44$
- Annualisation factors have been inherited from WAU to ensure consistency with other projects in Wellington and are described in Appendix A.2.

Table 10 Public transport demands (2018 estimated demands for two-hour periods)

Segment	AM	IP	PM
North/westbound			
Courtenay Place	4,786	1,431	1,515
Manners Street	5,286	1,744	2,558
Willis Street	4,955	1,622	2,842
Lambton Quay	3,205	1,309	3,592
South/eastbound			
Lambton Quay	5,411	1,744	2,933
Willis Street	4,786	1,619	3,683
Manners Street	3,205	1,122	3,467
Courtenay Place	1,580	872	2,967

5.2.2 Travel time benefit

The total public transport travel time benefit was estimated from the model results using the formulas described next.

$$T_{s,p} = \frac{1}{2}(n_{DM,s,p} + n_{OPT,s,p})(t_{DM,s,p} - t_{OPT,s,p})$$

where $T_{s,p}$ is the travel time benefit (seconds) for Golden Mile segment s and period p, $n_{DM,s,p}$ and $n_{OPT,s,p}$ are the number of trips in the do minimum and option scenario (ie including the trips diverted from private vehicle) for segment s and period p, and $t_{DM,s,p}$ and $t_{OPT,s,p}$ are the average time per trip (seconds) for segment s and period p for the do minimum and option scenarios respectively.

Then, the annual travel time savings benefit in each option is estimated using:

$$B = v \sum_{s,p} a_p T_{s,p},$$

where B is the annual benefit value; a_p is the annualisation factor for period p; v is the average value of time; the sum is over all segments (Lambton Quay, Willis Street, Manners Street, Courtenay Place) and periods; $T_{s,p}$ is as defined above.

5.2.3 Reliability benefit

The runtime model includes variability in dwell times and in delays at intersections given the signal timings and intersection arrival times. Delays experienced at each point along the corridor are independent in the model, however, in practice, delays along the corridor may be correlated with one another.

The reliability benefit incorporates two components of reliability:

1. Variability in travel times due to signal timings and dwell times, as estimated by the Public Transport Runtime Model.
2. Reduced bus queuing times due to bus stops operating closer to their capacity in the preferred option.

The variability in travel times is estimated from the 50th and 90th percentile travel time estimates from a set of iterations of the public transport runtime model. This approach is developed on the basis that passengers in general should always allow for public transport travel times to be at least as slow as the 50th percentile travel time. However, in most cases, people need to allow for around the 90th percentile travel times to avoid being late too often. The 90th percentile value assumes people are 'willing' to be late 10% of the time (or once in every ten trips). The reliability benefit is estimated by the following formulas:

$$V_{s,p,o} = P90_{s,p,o} - P50_{s,p,o},$$

where $V_{s,p,o}$ is the variability in travel time for segment s, period p in option o; and $\mathrm{P90}_{s,p,o}$ (and $\mathrm{P50}_{s,p,o}$) are the 90th (and 50th) percentile travel time estimates for segment s, period p in option o.

Bus queuing time delays have been derived from work through the Golden Mile SSBC project on understanding the capacity of bus stops. Analysis of the estimated bus stop capacities and what it means for stops to be 'over capacity' are included in the report *Bus Congestion Research, Golden Mile SSBC (MRCagney, July 2021)*. For both the do minimum and preferred option, the bus stop capacity was estimated using the Transit Capacity Quality of Service Manual's formula for bus stop capacity. A formulation from Alonso et al. (2013) to estimate bus queuing time given the bus stop capacity and actual number of buses was also applied for both the do minimum and the option. We estimate the potential scale of this benefit by applying the same formulation as in Section 4.2.2 where the travel time saving per person is assumed to be the average of the reduced bus queuing delays for each section of the Golden Mile. We only estimate this benefit for the AM and PM peak periods during which the Golden Mile services many more buses per hour than the interpeak or offpeak periods.

This travel time variability is then valued according to:

$$B = v \sum_{s,p} a_p \frac{1}{2}\left(n_{DM,s,p} + n_{OPT,s,p}\right)\left(\left(V_{s,p,DM} - V_{s,p,o}\right) + \Delta T_{queue}\right)$$

where B is the annual benefit value; a_p is the annualisation factor for period p; $n_{DM,s,p}$ and $n_{OPT,s,p}$ are the demands as defined in Section 4.2.2; v is the average value of time; the sum is over all segments (Lambton Quay, Willis Street, Manners Street, Courtenay Place) and periods; $V_{s,p,o}$ is as defined above, and $V_{s,p,DM}$ is the variability in travel time for segment s, period p in the do minimum; and ΔT_{queue} is the change in bus queuing delays in the option compared to the do minimum, as described in the previous paragraph.

5.2.4 Quantified public transport impacts

Figure 1 shows the 'all-day' travel time estimates for buses along the Golden Mile that have resulted from the runtime model. These have been used to estimate the public transport travel time benefits for the short list options. Table 9 shows the median to upper limit of travel time that is expected based on the runtime model.

The estimated change in bus queuing time for each section of the Golden Mile ranges from 12 seconds of additional delay to 55 seconds of reduced delay per person depending on the street section, direction and period of assessment, as shown in Figure 2.

Table 11 Range of median to upper limit travel times in the AM and PM peaks (minutes (range in brackets))

Option	Period	Northbound	Southbound
Case for change	*AM*	*15.5 – 17.5 (2.0)*	*13.5 – 15.5 (2.0)*
Case for change	*PM*	*17.0 – 19.5 (2.5)*	*15.5 – 17.5 (2.0)*
Do minimum	AM	13.1 – 15.1 (2.0)	12.0 – 14.0 (2.0)
Do minimum	PM	13.9 – 16.1 (2.2)	13.0 – 15.1 (2.1)
Preferred option	AM	12.1 – 14.0 (1.9)	12.0 – 13.8 (1.8)
Preferred option	PM	13.2 – 15.1 (1.9)	12.8 – 14.9 (2.1)

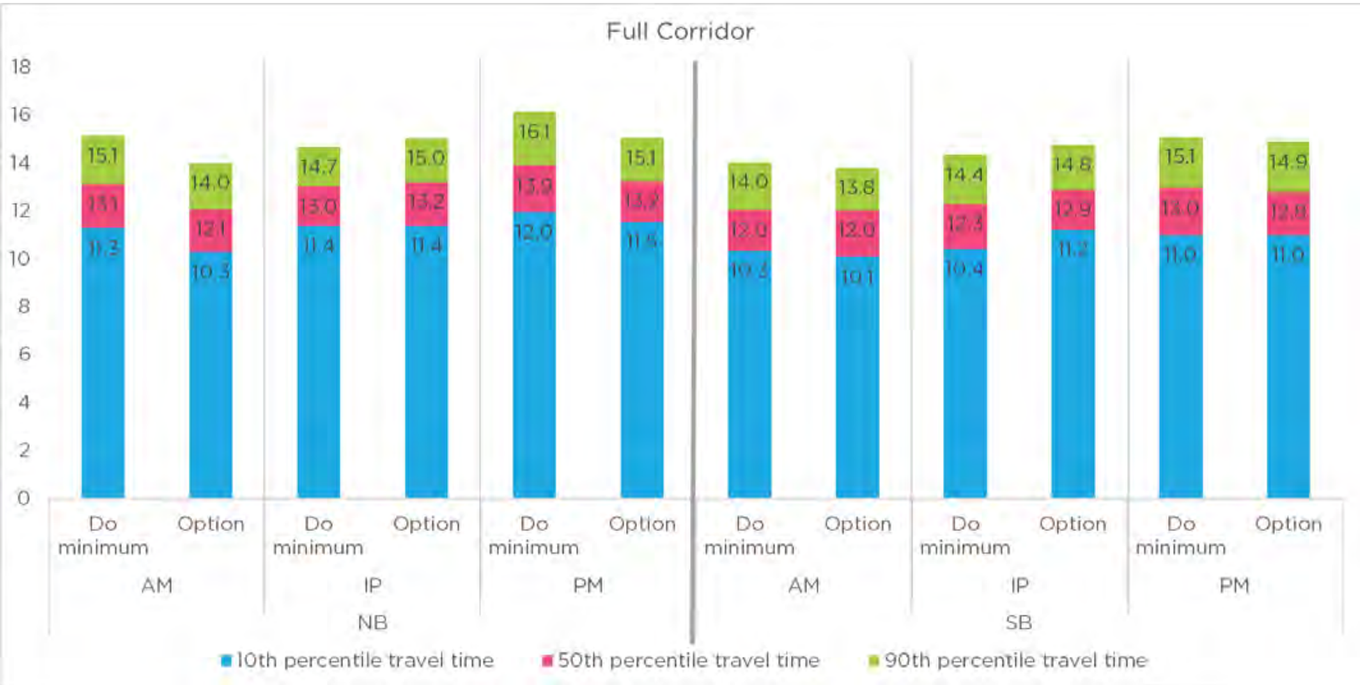

Figure 1 Public transport travel time estimates along Golden Mile

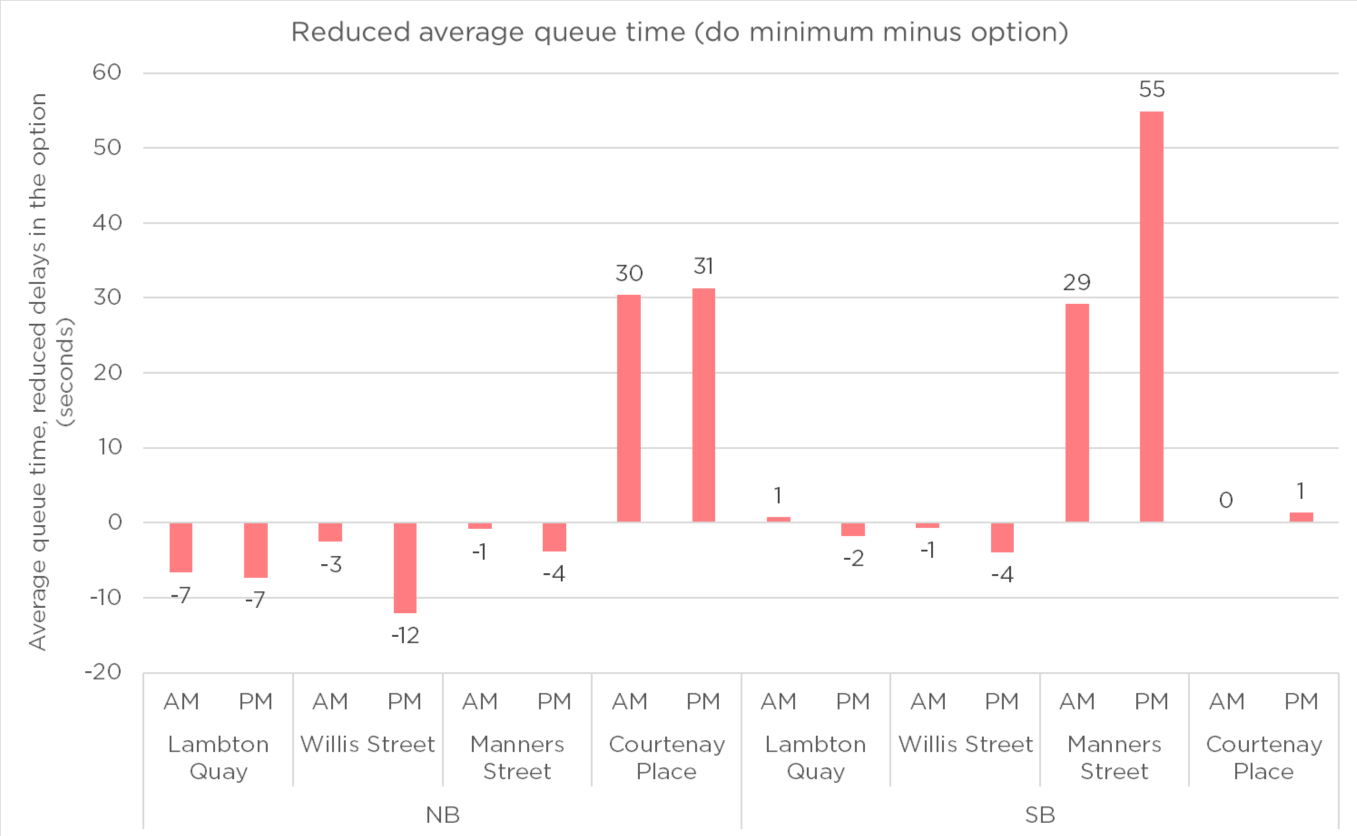

Figure 2 Reduced average bus queue times (positive numbers represent less delayed time)

5.2.5 Monetised public transport impacts

The estimated public transport benefits (from travel time savings and reliability improvements) are included in Table 10. The public transport queuing time benefit is included to provide an indication of the scale of benefit that may be expected, although the estimated bus queuing time inputs have low certainty due to a lack of calibration to the Golden Mile specifically.

Table 12 Results of public transport impacts

Benefit type	Annual impact (2018)	Annual impact (2038)	Present value impact
Public transport travel time	$750,059	$990,078	$17,666,877
Public transport reliability	$1,150,080	$1,150,080	$27,088,973

5.3 Pedestrian benefits

The preferred option includes improvements to the pedestrian environment along the Golden Mile including removing most traffic from the Golden Mile, closing side street access points to cars, widening footpaths and improving the general amenity of the streetscape. Benefits related to these improvements are described in this section.

5.3.1 Data

- Demands:
  - Pedestrian demands are collected from March Monitoring Counts for 2018. The decision to use this data source is recorded in Appendix C.1. Counts up to 2020 are available, however the 2018 data is preferred because this aligns with the public transport demand data and the 2020 counts were affected by COVID-19 alert levels.
  - We add to this base estimate an assumed uplift in pedestrian demand of 3.3% due to the amenity improvements plus the increased number of public transport trips that have diverted from car trips (because the first/last legs of these trips are walking). The rationale for these additional pedestrian demands is outlined in Appendix B.3.
  - Growth in demand for pedestrians entering the city centre is assumed in the *Do Minimum Scenario Definition* to average 1.3% per year; this is assumed to be appropriate for the Golden Mile as well.
- Signal timing assumptions: SIDRA intersection models provided with signal timings and verified with WAU. The length of the green phase for pedestrian crossings is assumed to be 12 seconds.[3]
- Value of pedestrian realm improvements (willingness to pay): from Waka Kotahi's Interim Guidance on *Impact on Urban Amenity in Pedestrian Environments* (Waka Kotahi, March 2020).
- Value of time: $16.44 per hour, as derived in Section 4.2.1.
- Annualisation factor: 287, as derived in Appendix A.3.

5.3.2 Travel time benefit: closing side street crossings

The short list options include closures of some side roads which currently have signalised pedestrian crossings across them. Those crossings introduce a delay for pedestrians travelling *along* the corridor[4]. The benefit of removing or reducing that delay can be measured using conventional transport benefit methods.

To estimate the current average delay per person using these signalised crossings, the assumed signal cycle times and pedestrian green phases have been collected. The cycle time assumption and results of this analysis are included in Table 11. The average delay per intersection is estimated according to:

$$Delay = P(stop) * T(stop) = \frac{C-G}{C} * \frac{C-G}{2} = \frac{(C-G)^2}{2C},$$

where $Delay$ is the average pedestrian delay at the intersection; $P(stop) = (C-G)/C$ is the probability of arriving at the intersection during a red signal and therefore having to stop; $T(stop) = (C-G)/2$ is the average wait time for a pedestrian that arrives at some point during a red phase; C is the intersection cycle time; G is the green time for the pedestrian phase.

The number of pedestrians affected be each side street closure is assumed to be equal to the number of pedestrians at the nearest March Monitoring Counts location. These assumptions and results are recorded in Table 11. The benefit from reduced delays is calculated by:

$$B = v \sum_{s,p} a_p \frac{1}{2}(n_{DM} + n_{OPT})(Delay)$$

[3] This is consistent with assumptions made in the *Active Mode Visualisation Tool* used for other projects, and is recommended in: *Pedestrian planning and design guide*, NZ Transport Agency, Wellington, ISBN 978-0-478-35228-3, Oct. 2009, pp. 15.13.

[4] Delays associated with moving *across* the corridor (Golden Mile) itself are not estimated, in part due to limited data on how many pedestrians cross the road and in part due to uncertainties around how many pedestrians are willing to cross where there are no signals.

where B is the benefit related to side street closures; a_p is the annualisation factor for period p; v is the average value of time; the sum is over all segments and periods; n_{DM} and n_{OPT} are the pedestrian demands in the do minimum and in the option (including the elasticity uplift); and $Delay$ is the intersection delay experienced in the do minimum (the delay in the option is zero, hence its exclusion from this formula).

5.3.3 Pedestrian crash reduction benefit

Removal of private vehicle traffic along the Golden Mile will provide safety benefits to pedestrians in the form of crash reduction benefits. The methodology for calculating these benefits is:

1. Collect crash data for pedestrian crashes (including skateboard and 'wheeled pedestrian' users) in the Golden Mile area (as shown in Figure 4) for the last ten years (2011 to 2020).
2. Scale up the reported crashes to total crashes using the under-reported crash rate factors from Table A26 in the MBCM.
3. Estimate the equivalent number of crashes after the improvements. We assume the improvements would lead to a 70% reduction in the number of pedestrian crashes along the Golden Mile after the improvements which include removal of private vehicles – this is near the upper limit of crash reduction factors for pedestrians in Waka Kotahi's *Crash Estimation Compendium* (2018).
4. Estimate the total cost of crashes in the do minimum and in the option using the values of crashes from Tables A28-A31 in the MBCM and the appropriate update factor.
5. Calculate the reduction in the total cost of crashes in the option compared with the do minimum as the benefit value.

The benefit value is not assumed to grow over time as the other pedestrian benefits are. The results of the crash reduction analysis are included in Section 4.3.5

5.3.4 Pedestrian realm benefit

Pedestrians are often willing to walk out of their way to travel through a more amenable environment; this additional willingness enables the benefit of pedestrian realm improvements to be valued. The process for valuing such improvements is described in Waka Kotahi's *Impact on Urban Amenity in Pedestrian Environments* (March 2020) technical paper. The Golden Mile short list options include several features which can be valued through this interim guidance. These include:

- Seating: people are willing to walk 1% further if there is seating available.
- Street trees or plantings: people are willing to walk up to 20% further for a route that includes trees or plantings on or adjacent to the footpath. This is separated into two components, with a willingness to pay of 11% for street trees and 9% for 'plantings' (eg human-scale planter boxes).[5]
- Adjacent traffic volume reduction: people are willing to walk 5% further per 1000 fewer vehicles (AADT) on the route.
- Widened footpaths in crowded conditions: people are willing to walk 14% further per extra metre of footpath width (capped at 56% further), to walk on a wider footpath if that means the footpath is no longer 'crowded'. Although there is anecdotal evidence of footpath crowding, there is uncertainty around existing data making it difficult to quantify the extent of crowding. Therefore, this benefit has not been monetised in this economic assessment; however, more information is included in Appendix E.

[5] This proportional split is based on the ratio from a report intended to support the Interim Guidance: *Draft Valuing Improved Pedestrian Facilities: Stated Choice Survey Design and Analysis* (Nunns and Dodge, March 2020).

As noted in the bullet points above, the interim guidance provides willingness-to-pay values, as a ratio of walking time; this is the additional proportion of time people are willing to walk for a route that offers a more amenable environment. The total pedestrian realm benefit is then estimated by:

$$Benefits = v * \frac{1}{2}(n_{DM} + n_{OPT}) * WTP_o * T,$$

where v is the average value of time; n_{DM} and n_{OPT} is the average demand (number of pedestrians) using the facility in the do minimum and in the option; WTP_o is the additional willingness to pay ratio in the option relative to the do minimum (this is the sum of the individual willingness to pay ratios for each additional street feature in the option); and T is the time spent walking along the facility being improved, which is assumed to be an average of five minutes (around 375 metres or approximately three street blocks) per person. The appropriate WTP values depend on the level of interventions; this is defined in Section 4.3.5.

The pedestrian demands and the scale of interventions differ at different parts of the Golden Mile; we have therefore separated the Golden Mile into six sections with differing pedestrian demand profiles and/or interventions, as shown in Figure 3.

Figure 3 Street sections for pedestrian realm benefit estimates

The benefit estimation is applied using the following process for each street section and side of the street:

1. Estimate the interpeak pedestrian demand at any given point by computing the average pedestrian demand across the March Monitoring Count locations within the street section.
2. Estimate the daily pedestrian volumes using the interpeak-to-daily factors derived in Appendix C.2.
3. Describe the conditions and characteristics of the current (do minimum) pedestrian environment.
4. Describe the conditions and characteristics of the proposed pedestrian environment.
5. Calculate the increased willingness to pay given the proposed improvements to the pedestrian environment.
6. Annualise and monetise the benefit given the willingness to pay for the proposed improvements.

Table 13 outlines the assumed quality or scale of improvements (out of 100%) in the do minimum and assumptions around the opportunity to improve each of the amenities in the preferred option. This informs the willingness to pay calculations, especially when the option *improves* the amenity without necessarily increasing it from non-existent to 'world class'.

5.3.5 Quantified pedestrian impacts

A summary of the demands and travel time savings from key side street closures are included in Table 11, the crash reduction benefit results are shown in Figure 4 and Table 12 and a summary of the improved pedestrian environment is provided in Table 13.

Table 13 Travel time impacts of side street closures on pedestrians

Side street	Count location	Side of street	Interpeak demand	Estimated daily demand	Average delay (seconds)	Total daily delay (hours)
Stout St	Btn Waring Taylor and Johnston	East	2,307	8,537	13.5	32
Brandon St	Btn Brandon and Panama	East	3,433	12,703	21.6	76
Mercer St	Nth of Mercer	East	4,165	19,576	24.0	131

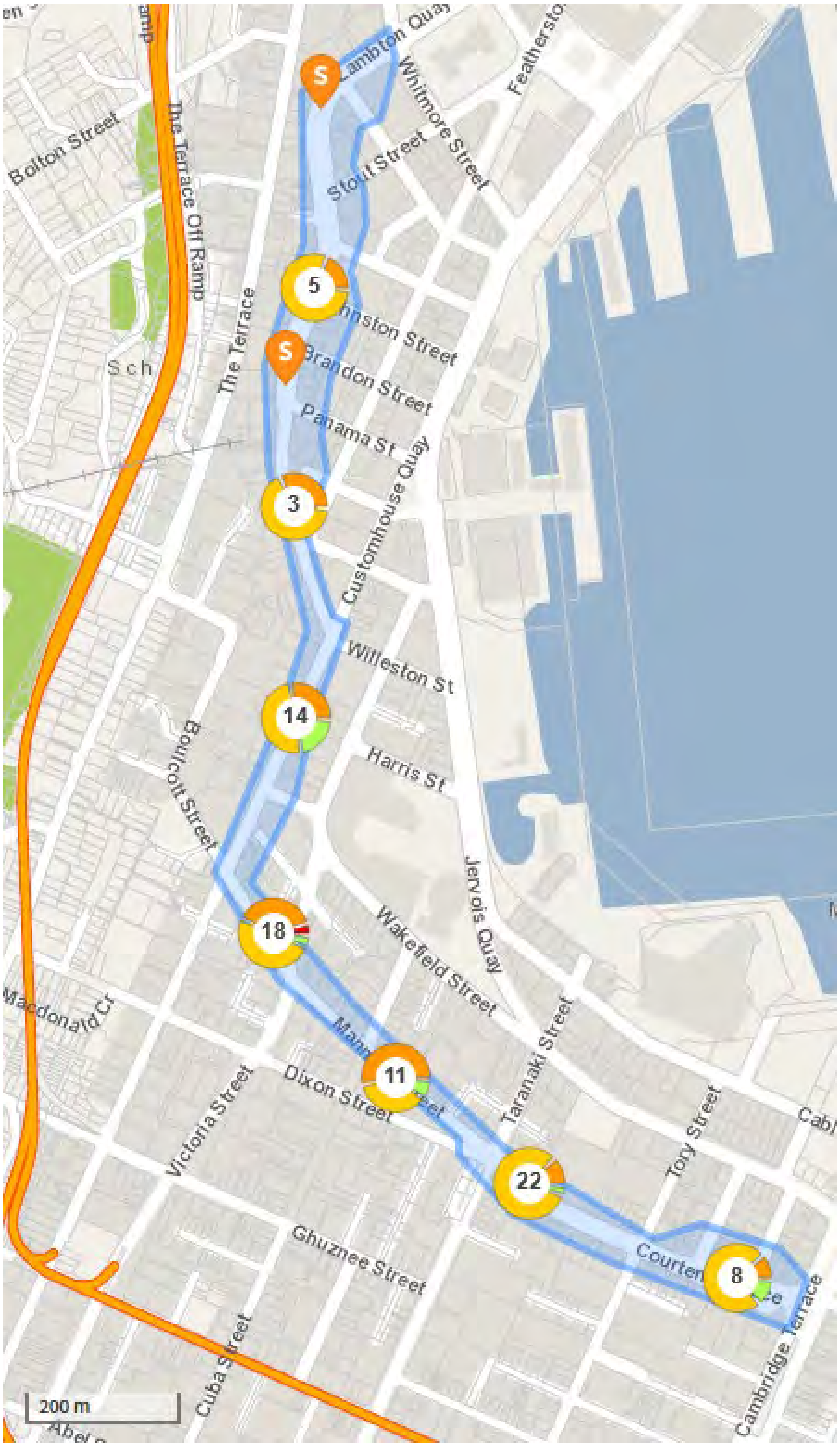

Figure 4 Pedestrian crash area for the Golden Mile

Table 14 Summary of crash analysis and crash reduction benefit

Crash severity	Estimated total crashes (2011-2020)	Estimated reduced crashes (10 years)	Cost per crash (2020$)	Do Minimum, annual cost of crashes	Option, annual cost of crashes	Annual benefit of crash reduction
Fatal	1	0.3	$4,674,000	$467,400	$140,220	$327,180
Serious	37.5	11.25	$495,900	$1,859,625	$557,888	$1,301,738
Minor	225	67.5	$27,360	$615,600	$184,680	$430,920
Non-injury	31.5	9.45	$1,710	$5,387	$1,616	$3,771
Total	**295**	**88.5**		**$2,948,012**	**$884,403**	**$2,063,608**

Table 15 Assumed quality/extent of pedestrian realm improvements

Feature	Option	Lambton Quay (north of Grey Street)	Lambton Quay (south of Grey Street)	Willis Street	Manners Street	Courtenay Place (north of Tory Street)	Courtenay Place (south of Tory Street)
Street trees	DM	Lots of trees but mostly in the median (80%)	Scattered trees (25%)	Tree coverage along about half the section (50%)	Street trees throughout most of the section (100%)	Mostly only in the median (50%)	Pretty good tree coverage (100%)
	Option	100%	25%	80% on the East, 50% on the West	100%	70%	100%

Feature	Option	Lambton Quay (north of Grey Street)	Lambton Quay (south of Grey Street)	Willis Street	Manners Street	Courtenay Place (north of Tory Street)	Courtenay Place (south of Tory Street)
Plantings	DM	Limited to the median (and Midland Park) (10%)	No plantings (0%)	No plantings (0%)	Plantings only really at the eastern end (25%)	Only at the eastern end (10%)	Few plantings (only at the Kent-Cambridge end) (25%)
	Option	60%	0%	25%	25%	60%	70%
Seating	DM	Mostly only at bus stops (50%)	A few seating options (80%)	Seating for half the section on the east side of the street (100%)	Several seating opportunities (80%)	Heaps at the western end but very few elsewhere (50%)	Pretty good at the eastern end but very few at the western end (50%)
	Option	100%	80%	100%	80%	100%	100%
Do minimum traffic volume, ADT (do minimum from MobileRoad[6])	DM	7,500	3,900	6,400	2,250	16,800	8,900
	Option	1,100 (estimated number of buses per day)					
'Willingness to pay' ratios for improvements		East: 0.39 West: 0.39	East: 0.14 West: 0.14	East: 0.32 West: 0.29	North: 0.06 South: 0.06	North: 0.86 South: 0.68	North: 0.43 South: 0.43
Representative 2018 daily demands		East: 6,255 West: 9,804	East: 5,660 West: 17,529	East: 11,770 West: 14,401	North: 3,580 South: 1,957	North: 5,136 South: 4,973	North: 6,074 South: 5,915

[6] https://mobileroad.org/

5.3.6 Monetised pedestrian impacts

The core estimated pedestrian benefits (from travel time savings and urban realm improvements) are included in Table 14.

Table 16 Results of public transport impacts

Benefit type	Annual impact (2018)	Annual impact (2038)	Present value impact
Pedestrian travel time benefit at signals	$1,127,153	$1,420,213	$25,311,423
Pedestrian crash reduction benefit	$2,063,608	$2,063,608	$36,522,540
Pedestrian realm benefit	$10,989,087	$13,846,250	$246,771,573

The proportion of each benefit attributable to the improvements on each street section depends on the scale of improvements for that section and the pedestrian demands. The split of the pedestrian travel time and pedestrian realm benefits[7] across each street section are approximately:

- 43% of the benefit is on Lambton Quay
- 29% of the benefit is on Willis Street
- 1% of the benefit is on Manners Street
- 26% of the benefit is on Courtenay Place

5.4 Non-monetised benefits

5.4.1 Benefits to cyclists

The Golden Mile proposal includes improvements to the cycling facilities along the Golden Mile by providing a dedicated cycle path along most of Lambton Quay and Courtenay Place. Benefits for cyclists are not monetised or quantified here due to uncertainties of the current and projected demands along the Golden Mile, especially given the city centre context with other nearby projects also significantly altering the cycling network of the city centre.

We note that cycling into Wellington's city centre is increasing significantly, with the number of people cycling into the city centre in the peak hour growing approximately threefold from 2000 to 2019. Cycling is also growing relative to walking, with around 15-20% of cordon counts of active modes being cyclists in recent years, compared to just 6-7% 15-20 years ago. However, as the Golden Mile is a much more significant link for pedestrians and public transport than for cyclists, we focus our economic assessment on those modes.

We expect that the magnitude of benefits from cyclist improvements would not be significant relative to the benefits for users of the other mode and would therefore not change the economic case for this SSBC. The benefits are still likely to be meaningful, particularly with the network effects of the cycling improvements anticipated by the City Streets project.

[7] The pedestrian crash reduction benefit has not been separated by street segment.

5.4.2 Footpath widening benefits

Footpath widening benefits are particularly relevant where footpaths are crowded with pedestrians relative to the effective footpath width available for movement. This is applicable at various locations along the Golden Mile, particularly around bus stop waiting areas, where crowds of people waiting for buses occupy the footpath space. This benefit can be valued within the interim guidance for pedestrian realm improvements; however, it has not been included within this assessment due to the complexity of estimating the inputs required. Nevertheless, this would be expected to provide a meaningful additional benefit to the Golden Mile improvements.

5.4.3 Public realm benefits

In addition to the *pedestrian* realm benefits we have estimated here, there is another set of *public* realm benefits that would accrue to people that spend time on the Golden Mile. This would include people who socialise along the Golden Mile, people who spend time in the public realm such as using seating or greenery, and people who visit retail stores or cafés that spill into the space outside their stores. These users are expected to experience an additional benefit from the Golden Mile improvements that have not been captured here because they are not *transport* benefits, and this SSBC focuses on transport considerations.

5.4.4 Operational improvements to bus travel times

Any benefits to bus travel times from signal coordination or optimisation opportunities have not been assessed at the SSBC stage and are therefore not captured within this economic assessment. It is expected that opportunities to capitalise on signal optimisation will be considered in the design phase.

5.4.5 Change in spend at retail stores

There has been significant interest and work throughout the Golden Mile SSBC in understanding and estimating the impact of the improvements on retailers and business along the Golden Mile. That work and the conclusions are available in separate reports from this. The estimated change in spend at retail stores is not considered within this economic assessment, because it is an *economic transfer*, ie if there was an increase in spending, this would be a *benefit* to retailers at a *cost* to the purchasers, so the net social effect is zero. Economic transfers are not relevant in social cost-benefit analyses; therefore, these impacts are not considered within this report.

6 Economic assessment

The results of the economic assessment with the default assumptions and parameters in included in Table 15. It is important to note that this does not capture a range of non-monetised benefits, such as:

- Benefits to cyclists
- Footpath widening benefits
- Public realm benefits

Furthermore, some of these benefits are estimated conservatively, such as the health benefit from mode shift, which assumes only 20% of removed car trips shift to public transport, and only in the AM, IP and PM periods. This is conservative because of uncertainty around what the most likely mode shift would be in the off-peak and weekend periods.

The biggest benefit within this economic assessment is the pedestrian realm benefit, making up 59% of the benefits for the preferred option. The benefit-cost ratio of the project is 4.6, with a first-year rate of return of 0.11 (11%).

Table 17 Base economic assessment of the preferred option

Cost/Benefit	Present value ($m)
Costs	
Construction costs	$80
Maintenance costs	$6
Total costs	**$86**
Benefits	
Car travel time impact	-$20
Emission reduction benefit	$17
Health benefit from mode shift	$48
Public transport travel time impact	$18
Public transport reliability impact	$27
Pedestrian travel time impact	$25
Pedestrian crash reduction benefit	$37
Pedestrian realm benefit	$247
Total benefits	**$399**
Net benefits	$313
Benefit-cost ratio	4.6
First-year rate of return (FYRR)	0.11

6.1 Sensitivity tests

Table 16 presents a range of independent sensitivity tests (ie each test varies just one assumption compared to the base economic assumptions and parameters). If we consider a much shorter evaluation period, we see that the economic benefits for the Golden Mile programme in the period before MRT is expected to be implemented is $156m and the benefit-cost ratio is 1.9, suggesting that even if the Golden Mile improvements were to be superseded by the MRT project, this would be an economically sound project. For all other sensitivity tests, the benefits range from $182m to $475m with the benefit-cost ratio ranging from 2.1 to 5.4.

These results suggest that although the benefit-cost ratio is sensitive to some input assumptions, the economics of this project are robust, and it is likely to be an economically efficient investment. Other than the evaluation period and discount rates, the most sensitive input is the pedestrian realm benefit, which still returns an efficient benefit-cost ratio when it is tested in extreme scenarios.

Table 18 Independent sensitivity tests

Sensitivity	Benefit ($m)	Cost ($m)	Benefit-cost ratio
Base assumptions	*$399*	*$86*	*4.6*
Evaluation period of 13 years (ie 10 years of benefits)	$156	$82	1.9
Discount rate of 6%	$291	$82	3.5
Discount rate of 3%	$475	$88	5.4
95^{th} percentile cost estimate	$399	$102	3.9
Construction delayed by two years	$364	$79	4.6
Low shadow price of carbon	$393	$86	4.6
Exclude bus queuing time benefit	$387	$86	4.5
Exclude pedestrian uplift elasticity	$395	$86	4.6
Health benefit from mode shift: include offpeak and weekends	$443	$86	5.2
Pedestrian realm benefit: reduce benefits by 20%	$349	$86	4.1
Pedestrian realm benefit: exclude benefit of reduced traffic	$182	$86	2.1
Pedestrian realm benefit: only include the benefit of reduced traffic	$368	$86	4.3

Although this Golden Mile project should be included in the base case for the MRT project, the 13-year sensitivity test was included to provide clarity on the proportion of benefits expected in the first ten years of the Golden Mile project: around 40% of the present value benefits across the whole evaluation period are expected to relate to the first ten years after implementation.

We also run one 'low' scenario, that includes several sensitivity tests within one run:

- Low benefit-cost ratio scenario:
  - Discount rate of 6%
  - 95th percentile cost estimate
  - Construction delayed by two years
  - Exclude pedestrian uplift elasticity
  - Reduce pedestrian realm benefits by 20%
  - Benefit = $224; Cost = $87; Benefit-cost ratio = 2.6

Appendix A Annualisation factors

MRCagney has led the economic assessments for the Golden Mile Single Stage Business Case (SSBC) including an initial *Indicative Economic Assessment (May 2020)* during the early short list assessment phase and an *Economic Assessment of Short List Options for MCA (December 2020)*. In these previous analyses, benefits have not been included for full weekdays (ie they excluded off-peak times) or for weekends. These periods were excluded due to a lack of data to estimate how benefits should be scaled for those periods.

For the previous high-level economic assessments, the level of detail was appropriate for the purposes of the assessments: to identify any critical concerns and to compare options. For the *Preferred Option Economic Assessment*, it would be preferable to include the benefits for off-peak and weekend periods. This memorandum outlines the proposed annualisation factors to enable this.

The source of demand data and projections differs for each mode; therefore, the annualisation factors for each mode will differ and are defined independently.

A.1 Annualisation factors for road users

Road user impacts for private vehicles draw on demands from Aimsun modelling across the city centre. The Aimsun model outputs demands and travel times by link for four-hour model periods (AM, IP and PM). Annualisation factors have previously been inherited from the Wellington Analytics Unit (WAU) to ensure consistent assumptions with other projects.

The Aimsun model includes the following periods: AM (6am-10am), IP (10am-2pm), PM (3pm-7pm).

Previous methodology

The previous methodology simply applied WAUs annual factors to the AM, IP and PM four-hour periods, without attempting to first scale to daily demand estimates that included the off-peak periods. This equated to the following factors: 245 for AM (6am-10am), 311.15 for IP (10am-3pm) and 245 for PM (3pm-7pm).

Proposed methodology

We propose to use the same methodology as previously for the AM, IP and PM periods, plus apply the WAU daily and annual factors for off-peak and weekend trips, which each inflate the IP model output as follows: IP*210 to represent annual off-peak impacts and IP*484.15 to represent annual weekend impacts. We also use the latest assumptions provided by WAU which apply the assumption of 250 working days per year, instead of 245.

The resulting road user annualisation factors from model outputs to annual are: 250*AM + 250*PM + 1011.65*IP.

A.2 Annualisation factors for public transport users

Public transport benefits draw from base case (2018) demands provided by WAU from the Wellington Public Transport Model (WPTM) and a demand growth assumption of 1.6% per year as per the *Golden Mile – Do Minimum Scenario Description*. The demands provided represent two-hour model periods for each of AM, IP and PM, totalling six hours across the day.

Previous methodology

The previous methodology annualised the model demands simply by multiplying by 245 (as per WAUs annualisation assumptions for the number of working days per year).

Proposed methodology

We propose to update the annualisation factors to represent a full weekday plus weekend days using the annualisation factors previously provided by WAU. The factors are 350 for AM, 396 for PM and 1272 for IP (to scale to interpeak plus off-peak weekday and weekend combined).

A.3 Developing annualisation factors for pedestrians

Pedestrian benefits draw from historical pedestrian demands that have either been observed or modelled based on observed counts. There has been lots of uncertainty around the most accurate source of data for pedestrian demands, with the conclusion to rely on the March Monitoring Counts outlined in Appendix C.1. Without relitigating that work, we summarise below the data and annualisation approaches used previously and the proposed methodology for the upcoming *Preferred Option Economic Assessment*.

Previous methodology (Indicative Economics)

The first economic assessment, the Indicative Economics, simply used the estimated number of pedestrians on each street section as reported in the *Case for Change (June 2019)*, which represented a nine-hour day. This was annualised with a factor of 245 to consider the number of working days per year.

Previous methodology (Short List Economic Assessment)

The Short List Economic Assessment used pedestrian demands as collected from the *Active Modes Visualisation Tool*,[8] which has since been identified as having some discrepancies with the March Monitoring counts and may therefore have underestimated pedestrian demands. This source of data covered a nine-hour period of a weekday and was annualised with a factor of 245, thus excluding off-peak and weekend pedestrian benefits.

Proposed methodology for pedestrian annualisation

As described in Appendix C.1, the March Monitoring Counts will be used as the 'source of truth' for pedestrian demand estimates in the Preferred Option Economic Assessment. These counts represent only a two-hour midday period. The two-hour interpeak counts are factored up to daily counts using the approach defined in Appendix C.2. These daily counts are then factored up to annual using Auckland's Heart of the City automated pedestrian counter data which has hourly counts for several years.[9] Across 19 pedestrian counting sites in Auckland in 2019, the average daily-to-annual factor is 287, ranging across sites from 258 to 320.[10] We therefore recommend an annualisation factor of 287 is applied to pedestrian counts on the Golden Mile.

[8] The Active Modes Visualisation Tool was developed for the Wellington CBD as part of the Ngauranga to Airport project in 2017, and has been made available for use by other projects since then.

[9] https://www.hotcity.co.nz/city-centre/results-and-statistics/pedestrian-counts

[10] City Centre Walking Demand and Project Benefit Estimate v1 (Peter Nunns, June 2020)

Appendix B Elasticity adjusted demands

The Golden Mile project includes some significant changes to the street environment of the Golden Mile which is likely to influence the preferred mode and/or routing that individuals take through the city centre.

B.1 Road user elasticity approach

This section provides an overview of the elasticity approach applied to the AIMSUN model results. A full methodology is provided in the memo *Adjusting Aimsun demand matrices in response to road capacity changes* (Nunns – Wellington City Council, February 2021).

AIMSUN will estimate route selection and travel times on a modelled road network for a given number of vehicles but will not model, for example:

- Mode choice
- Reduced/removed trips, eg due to substituting to online shopping or virtual meetings
- Trip chaining rather than making multiple separate trips

One option for addressing this would be to iteratively run both the AIMSUN model (to model vehicle travel times) and WTSM (to model mode shift reactions); however, this approach can be difficult to implement in practice due to the need to repeatedly rerun both models. The approach for modelling changes in traffic volumes in response to road capacity changes was previously proposed and approved and was ultimately implemented as outlined in Table 17.

Table 19 Road user elasticity approach and model runs

Step	Model 'name'
1. Run the do minimum model in AIMSUN	Do Minimum
2. Run the emerging preferred option layout in AIMSUN with the do minimum demands	Emerging Option, fixed demand
3. Apply an elasticity model to the changes in travel times between the above to models, to calculate the estimated changes in traffic volumes (methodology described further below)	Elasticity-adjusted demands
4. Run the emerging preferred option layout in AIMSUN with the elasticity-adjusted demands	Emerging Option, elasticity-adjusted demands
5. Run the refined preferred option layout in AIMSUN with the elasticity-adjusted demands	Preferred Option, elasticity-adjusted demands

As outlined in the detailed elasticity memo *Adjusting Aimsun demand matrices in response to road capacity changes* (Nunns – Wellington City Council, February 2021), the elasticity of traffic volumes with respect to travel times is assumed to be -0.7 based on a range of international literature including work Graham and Glaister (2004) and Wallis (2004). Analysis of the elasticity model found that even though the modelled option closed one city centre corridor to general traffic, the elasticity model resulted in increased traffic volumes on some origin-destination pairs outside of the city centre. This is likely to be a result of operational tweaks and signal optimisation during the AIMSUN model calibration, rather than actual impacts of the Golden Mile project. Because of this discrepancy, when we apply the elasticity approach, traffic volumes are held constant on all origin-destination pairs where average travel times are predicted to decrease.

Key outcomes from the elasticity-adjusted demands for the four-hour model periods are shown in Table 18. We assume the reduced vehicle trips are spread evenly across the four hours.

Table 20 Elasticity-adjusted vehicle trips in each (four-hour) time period

Period	Do minimum vehicle trips	Preferred option vehicle trips	Change in vehicle trips
AM	112,159	103,941	-8,218
IP	119,411	109,535	-9,876
PM	152,138	143,472	-8,666

B.2 Diversion rate from road user to public transport

Of the assumed reduction in network-wide traffic volumes, some of these trips will shift to other modes and some of them may not happen at all. Diversion rates to active modes have not been considered in this assessment as previous vehicle trips to the Golden Mile area would have ended as pedestrian trips to reach the final destinations, so those users would already have been counted as pedestrians for the Golden Mile project extent.

Section 4.4 of the MBCM provides guidance in step 2e for estimating the diversion rates from cars to public transport under different conditions. Table 86 of the MBCM indicates that if the reduction in vehicle trips is a response to increases in travel times, approximately 20% of the reduced car trips would shift to public transport and that this would be higher where there is a higher level or quality of public transport. Table 19 outlines the reduction in vehicle trips for the two-hour periods considered for public transport, and the associated number of trips diverted to public transport (as 20% of the removed vehicle trips).

Table 21 Vehicle trips diverted to public transport

Period	Change in vehicle trips (two-hour periods)	Number of trips diverted to public transport
AM	-4,109	822
IP	-4,938	988
PM	-4,333	867

Most buses in Wellington travel along the Golden Mile. With lack of more detailed data, we assume that of the vehicle trips diverted to public transport:

- 50% travel southbound, entering the Golden Mile from Lambton Quay
  - On average, all these users travel the full length of Lambton Quay plus Willis Street
  - On average, half of these users also travel the full length of Manners Street plus Courtenay Place
- 50% travel northbound, entering the Golden Mile from Courtenay Place
  - On average, all these users travel the full length of Courtenay Place plus Manners Street
  - On average, half of these users also travel the full length of Willis Street plus Lambton Quay

For clarity, these assumptions are visualised in Figure 5.

Figure 5 Assumed distribution of trips diverted from cars to public transport

B.3 Pedestrian elasticity approach

Pedestrian realm improvements encourage people to make trips by foot and can induce new trips entirely. This response can be seen in projects such as the Fort Street Precinct upgrade in Auckland, which saw a 50% increase in pedestrians during peak hours. The *Golden Mile Intercept Survey Results* (December 2020) found that 45.6% of respondents would visit the Golden Mile more frequently after improvements than their current behaviour. Assuming each of those respondents would make one additional visit every two weeks on average, on any given day we would expect to see an increase in pedestrian demands along the Golden Mile of 3.3%.

We assume that every additional public transport trip (as derived in Appendix B.2) includes a related walking trip, so every public transport trip that has been diverted from car is also added to the pedestrian demands, based on the distribution profile from Appendix B.2. These additional pedestrians are assumed to be split evenly across each side of the street.

Appendix C Source of pedestrian demands

Throughout this project, various sources of pedestrian demands were available, however, there were significant discrepancies between the different data sources.

The preferred source of pedestrian demands is the annual March Monitoring Counts, as agreed with Wellington City Council via a memorandum dated 19 May 2021. The full memorandum is available upon request, with some excerpts provided as Appendix C.1.

The March Monitoring Counts only cover a two-hour period each day (12pm-2pm) so the selection of this data source requires some scaling of these demands to estimate daily pedestrian counts. The approach for this is included as Appendix C.2.

Finally, the additional data collected in a pedestrian count survey of Courtenay Place is summarised in Appendix C.3.

C.1 Recommendation for pedestrian demands

The purpose of this memorandum is to recommend what data source should be used for the estimated pedestrian demands along the Golden Mile for the Golden Mile Single Stage Business Case (SSBC) economic assessment. For consistency, the same demand estimates should be used across the business case if possible.

C.1.1 Background

As reported in The Case for Change, the Golden Mile has some of the highest pedestrian volumes in New Zealand and must serve as a place that is pleasant, safe and attractive for people. Over 20,000 people walk on the Golden Mile each day, yet they face less than ideal conditions including relatively narrow footpaths and delays at traffic signals.

The Golden Mile SSBC proposes a suite of street upgrades impacting pedestrians, public transport and private vehicles. To compare the options and choose an option that benefits as many people as possible, we need to understand how many people are using the streets in and around the Golden Mile by each transport mode.

Several sources of pedestrian demand estimates have been provided at different stages in the SSBC, some of which are significantly different from others. This led to questioning as to which source of pedestrian demand estimates should be relied on as the most appropriate estimates. The available sources of demand estimates are:

- **Golden Mile Improvements: Problem Definition and Case for Change** (June 2019).
  The Case for Change reports the estimated pedestrian demands on each side of the street, for each street section, for the period 6am-7pm on weekdays. The raw data used for this assessment was a combination of March Monitoring Counts and Intersection Counts. The main missing input (across all data sources) is evening and night-time pedestrian volumes, particularly for Courtenay Place.
- **March Monitoring Counts** (annual, Stantec).
  The annual March Monitoring counts of pedestrians include both sides of the street at 11 locations along the Golden Mile over the midday peak (12:00pm-2:00pm) over one week in March. These counts are conducted manually (i.e. with observers standing on the street counting people) and have been conducted annually since 2000.
- **Active Mode Visualisation Tool** (developed by Beca).
  A second source for pedestrian demand estimates is the Active Mode Visualisation Tool that Beca created for the Ngauranga to Airport Transport Model development. This model covers the AM peak (7:30am-8:30am), interpeak (11:30am-12:30pm) and PM peak (4:30pm-5:30pm) and factors these peak

demands up to nine-hourly totals. The nine-hourly totals represent the hours of 6:30am-9:30am, 11:00am-2:00pm and 3:30pm-6:30pm. The one-hour demands were factored up to three-hour demands using a factor of three for central areas, such as the Golden Mile. The model does not estimate 24-hour demands because no count data was available to validate such estimates.

The base year (2016) estimates are based on interpolation and extrapolation from observed data.[11] The model interpolates/extrapolates by either averaging the observed pedestrian demands on the adjacent links, or simply inheriting the closest pedestrian demand.

Limitations of the model noted within technical reports provided include that over the week of data collection in 2016, total interpeak volumes ranged from 1,200 people to 3,800 people and that the tool estimates somewhere in between this range of volumes.

- **Intersection Turning Counts** (provided by Wellington Analytics Unit).
  Intersection counts of pedestrians from 2016 have been provided for some intersections along the Golden Mile. These provide the total number of pedestrians that crossed each leg of each intersection. This helps to provide a benchmark to compare the other counts against. It does not provide information about the number of people that arrived at intersections and turned with the footpath rather than crossing, so is not suitable to inform the total pedestrian demands.

  This data is available in 15-minute periods for 6:30am-9:30am, 11:00am-2:00pm and 3:30pm-6:30pm. The counts have been aggregated to one-hour periods and the demands collated for the busiest hour within each longer period of data collection. The busiest interpeak hour varies by intersection but is after 12:00pm for all data provided, which is later than the 'peak hour' assumed in the Active Modes Visualisation Tool.

C.1.2 Recommended data source for pedestrian demands

It is recommended that the March Monitoring Counts are used as the 'source of truth' for pedestrian demand estimates as they have been collected annually since 2000 and the trends over the last 20 years have been reasonably consistent as shown in Figure 6, so there is confidence in the scale of demands represented. The estimated midday peak hour demands are provided on the next page, along with the trends of pedestrian counts over time, showing that these trends are consistent.

[11] We understand the Beca model relies on observed data from the annual March Monitoring counts conducted by Stantec.

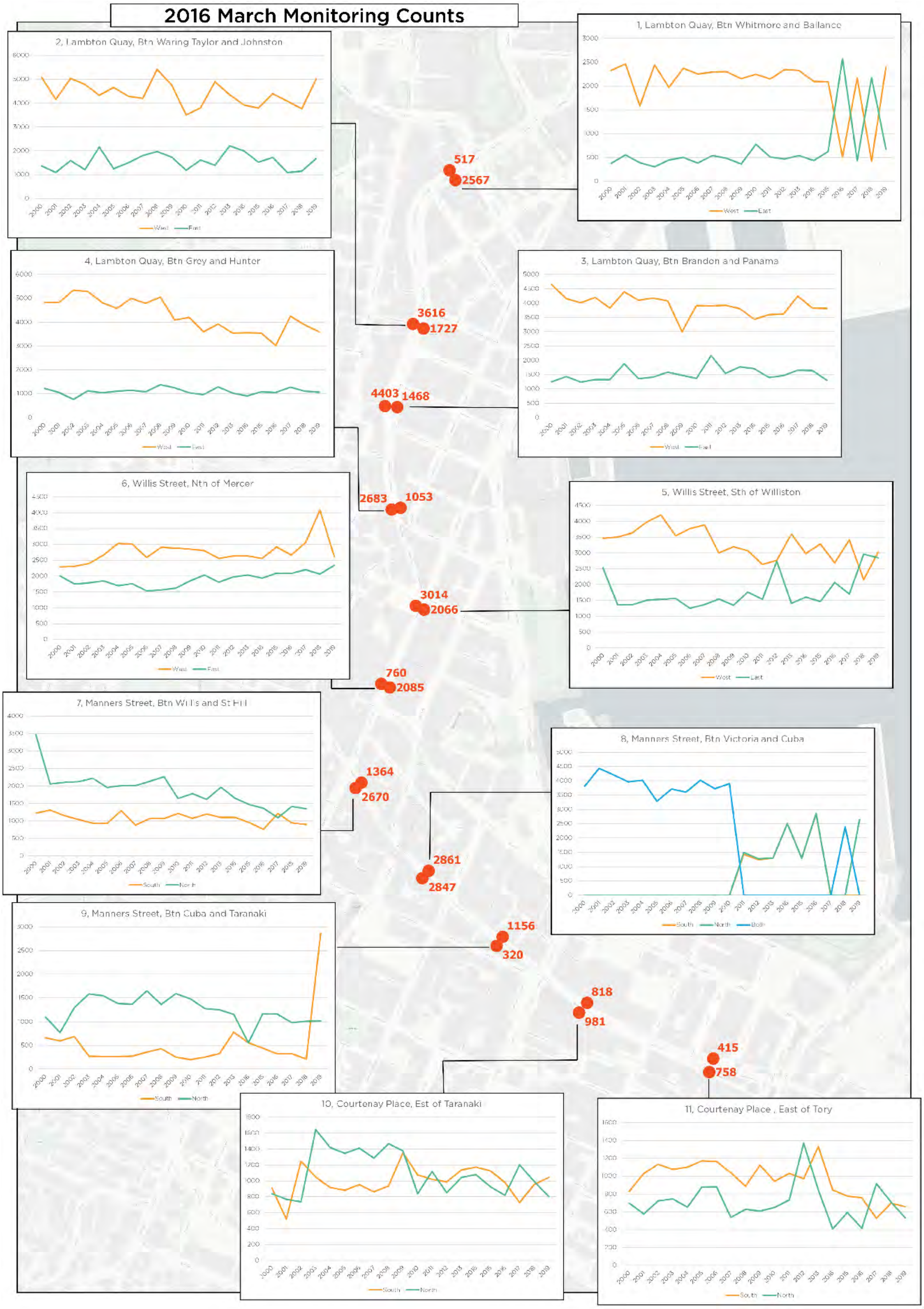

Figure 6 Peak hour March Monitoring Count locations and historical counts

The advantage of using the March Monitoring Counts is that there is data available over a long period of time which is useful for benchmarking and for confidence in the estimated demands as they have remained relatively consistent over time. However, the disadvantage of this data source is that the counts are only available for the period of 12pm-2pm; therefore, we need to understand how we can factor these demands to other periods and the total daily pedestrians. This is described next.

C.2 Scaling interpeak pedestrian counts to daily

As described in Appendix C.1, pedestrian demands for this economic assessment are collected from the annual March Monitoring Counts, which cover a two-hour period (12-2pm) on weekdays. There is a need to scale these interpeak pedestrian counts to daily.

For most sections of the Golden Mile (all sections north of Tory Street), we draw from data in the *Active Modes Visualisation Tool*. Although the individual values in that tool had discrepancies, we consider the trends of demand in that tool across different periods to be reasonable. From this tool, we have collected the ratio of the two-hour interpeak demands to the nine-hour ADT estimates. These results are shown in Table 20.

Table 22 Two-hour interpeak to daily pedestrian factor

Street	Two-hour interpeak[12] (mean)	ADT[13] (mean)	Interpeak-to-daily factor
Courtenay Place (south of Tory)	See Appendix C.3.3 for the derivation of this factor		7.1
Courtenay Place (north of Tory)	870	3,926	4.5
Manners Street	1,017	4,065	4.0
Willis Street	1,660	7,825	4.7
Lambton Quay (south of Grey)	1,551	7,090	4.6
Lambton Quay (north of Grey)	1,750	6,398	3.7

We recommend the interpeak-to-daily factors in Table 20 are applied to the March Monitoring Counts to estimate the total daily pedestrian trips along the Golden Mile. We note that the average equivalent interpeak-to-daily (where 'daily' is a nine-hour ADT) ratio for Auckland sites is 7.6.[14] This is higher than the ratios in Table 20, suggesting that the Golden Mile has a busier lunch peak relative to the rest of the day than Auckland.

[12] Although the *Active Modes Visualisation Tool* only outputs a one-hour interpeak, it assumes the three interpeak hours are equivalent, so we have scaled this accordingly from the on-hour output.

[13] For Courtenay Place (south of Tory) the ADT is for the full day; for other streets it is a nine-hour ADT.

[14] From the memorandum *City Centre Walking Demand and Project Benefit Estimate v1 (Peter Nunns, June 2020)*

C.3 Courtenay Place pedestrian count summary

C.3.1 Background

Traffic Engineering and Management Ltd. (TEAM) conducted a pedestrian count survey for Let's Get Wellington Moving to support the economic assessment of the proposed changes to the Golden Mile in Wellington, New Zealand.

The survey was conducted on both sides – the north side and south side – of Courtenay Place between Allen Street and Blair Street and counted pedestrians heading in both directions – eastbound and westbound. The locations of the survey counts are shown in Figure 7. TEAM used three cameras to conduct the survey. It should be noted that pedestrians were counted if walking along the pedestrian island for the bus stop and these counts have been included in the south side totals.

Figure 7 Locations of pedestrian counts

While the survey was scoped for seven days, the actual survey was undertaken on nine days capturing both weekdays and weekends between 21st June and 5th July 2021. On the 24th of June, Wellington was placed into COVID-19 Level 2 restrictions which restricted gathering sizes and working conditions. Hence, while four days of counts took place before/mostly before restrictions began, the remaining five days of surveys took place immediately following the removal of the Covid-19 Level 2 restrictions.

The proposed count times were for 6am to 12am (midnight) on each of the days. Actual durations of the counts for each day are shown in Table 21, highlighting the variation in counting times across the nine days and a general trend of continuous 24-hour counts. Covid-19 restrictions evidently affected the 24th of June. It is unclear why the count times on 1st July and 5th July are begin later and finish earlier than anticipated.

Table 23 Count dates, days, and times

Date	Day	Count start time	Count end time
21 June 2021	Monday	0:00	24:00
22 June 2021	Tuesday	0:00	24:00
23 June 2021	Wednesday	0:00	24:00
24 June 2021 (Wellington moved to COVID-19 Alert Level 2)	Thursday	0:00	19:00
01 July 2021	Thursday	8:30	24:00
02 July 2021	Friday	0:00	24:00
03 July 2021	Saturday	0:00	24:00
04 July 2021	Sunday	0:00	24:00
05 July 2021	Monday	0:00	19:30

C.3.2 Pedestrian counts

The result of the pedestrian counts for all days except 24th June are shown in Figure 8. Key observations from these counts are:

- Monday to Thursday have very similar demand profiles.
- Friday has higher demands from midday onwards than the other weekdays, with a big spike in pedestrians in the evenings, which declines by 4am on Saturday.
- From midday onwards, Saturday sees more pedestrians than Friday, with a midday (lunchtime) peak, evening (dinnertime) peak and late ('clubbing') peak. This also declines by around 4am on Sunday.
- Other than the early morning demands from Saturday, Sunday sees a similar peak of pedestrian demands to Monday-Thursday, although there is no morning peak, a high lunchtime peak and a slightly lower evening (dinnertime) peak.

The higher pedestrian volumes expected during the night on Friday, Saturday and Sunday are due to the number of bars, restaurants, and clubs near the counting location.

Figure 8 Pedestrian counts from the survey

In total, no significant pedestrian volume difference was recorded between the north side and south side, nor between eastbound and westbound movements as shown in Table 22.

Table 24 Difference in pedestrian movement types

Movement	Pedestrian count	Difference
Westbound movement	64,651	4%
Eastbound movement	61,869	
North side of street	64,868	5%
South side of street	61,652	

In general, the pedestrian counts conducted on Courtney Place between Allen Street and Blair Street between the 21st June and the 5th July 2021 provide useful information on the movements of pedestrians across the day.

C.3.3 Interpeak-to-daily factor

One of the key reasons for collecting this pedestrian count data was to understand the pedestrian volumes on Courtenay Place in the evenings, to estimate how to scale interpeak pedestrian volumes to represent the total pedestrian volume across the entire day.

Table 25 Interpeak and daily demand for each survey day

Day	Interpeak demand	Daily demand	Percent of daily trips in interpeak	Interpeak to daily factor
Monday 21-Jun-21	1,347	8,368	16%	6.2
Tuesday 22-Jun-21	1,703	11,591	15%	6.8
Wednesday 23-Jun-21	1,538	10,411	15%	6.8
Thursday 1-Jul-21[15]	*1,675*	*10,576*	*16%*	*6.3*
Friday 2-Jul-21	1,892	16,974	11%	9.0
Saturday 3-Jul-21	2,424	27,208	9%	11.2
Sunday 4-Jul-21	2,505	26,197	10%	10.5

As shown in Table 23, the interpeak pedestrian volumes on weekdays makes up around 15% of total pedestrian volumes for that day, equivalent to an interpeak-to-daily factor of around 6.8. On Friday, Saturday and Sunday, the interpeak volumes are only 9-11% of the daily volumes, equivalent to a factor of 9.0-11.2.

The March Monitoring Counts being used are for 12-2pm on weekdays, so we estimate the average daily-to-interpeak factor across the Monday to Friday survey days: average of 1,631 in the interpeak, 11,584 all day, equivalent to an interpeak-to-daily factor of 7.1. Therefore, we recommend an interpeak-to-daily factor for Courtenay Place (south of Tory Street) of 7.1.

We note that this factor may underestimate the number of evening pedestrians across the year as this factor is based on the pedestrian count survey that was conducted in winter (albeit on fine weather days in winter). The interpeak-to-daily factors for the other sections are outlined in Appendix C.2.

[15] Data collection on Thursday 1 July only began at 08:30am, so the total daily demand is underestimated.

Appendix D Public transport runtime model

This appendix describes the public transport runtime model methodology and inputs. Key inputs required are a description/mathematical definition of the corridor (which we developed based on concept plans), dwell time data (as outlined in Appendix D.1) and signal timing data (as outlined in Appendix D.2).

D.1 Public transport dwell times

Existing (2019) dwell times at stops along the Golden Mile were estimated by WAU using analysis of Snapper data. We reviewed this data and fitted an exponentially modified Gaussian distribution to the dwell times for each stop within each time period being modelled (AM, IP, PM).[16] Examples of some of the fitted distributions are included as Figure 9 and Figure 10, and the full set of distributions are available upon request.

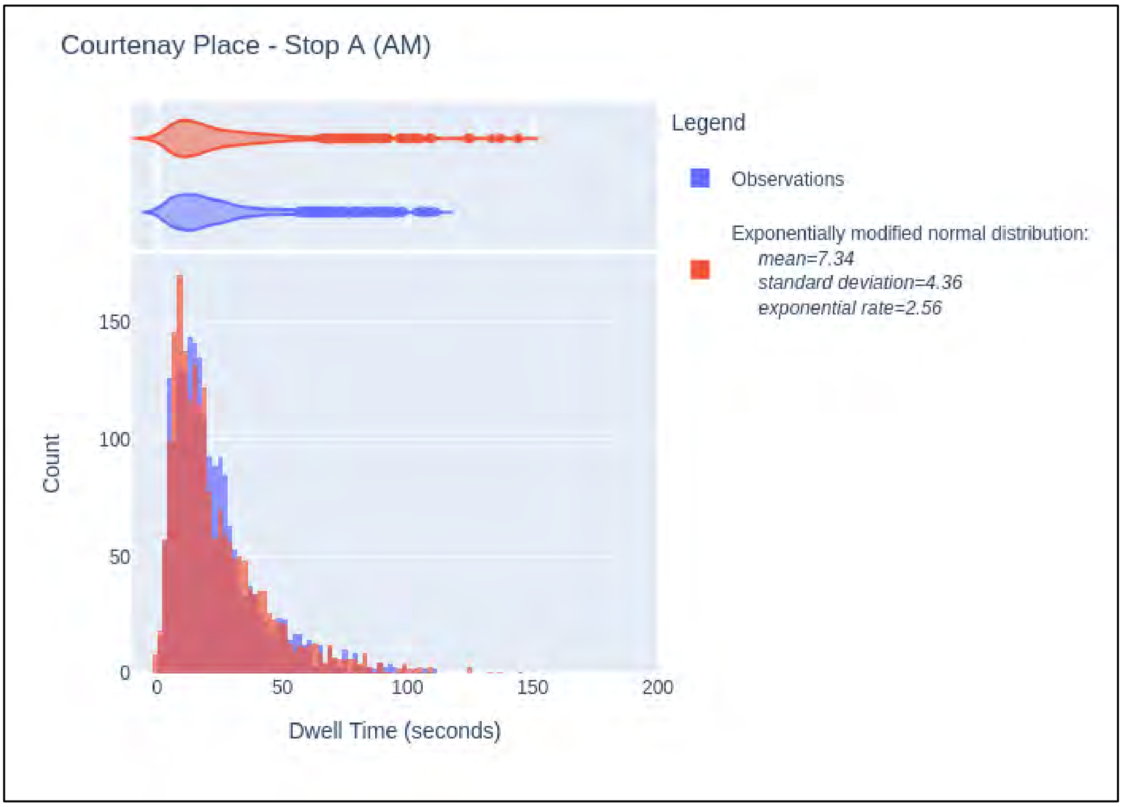

Figure 9 Observed and modelled dwell times for Courtenay Place – Stop A in the AM peak

[16] The model was fitted using this Python library: https://docs.scipy.org/doc/scipy/reference/generated/scipy.stats.exponnorm.html

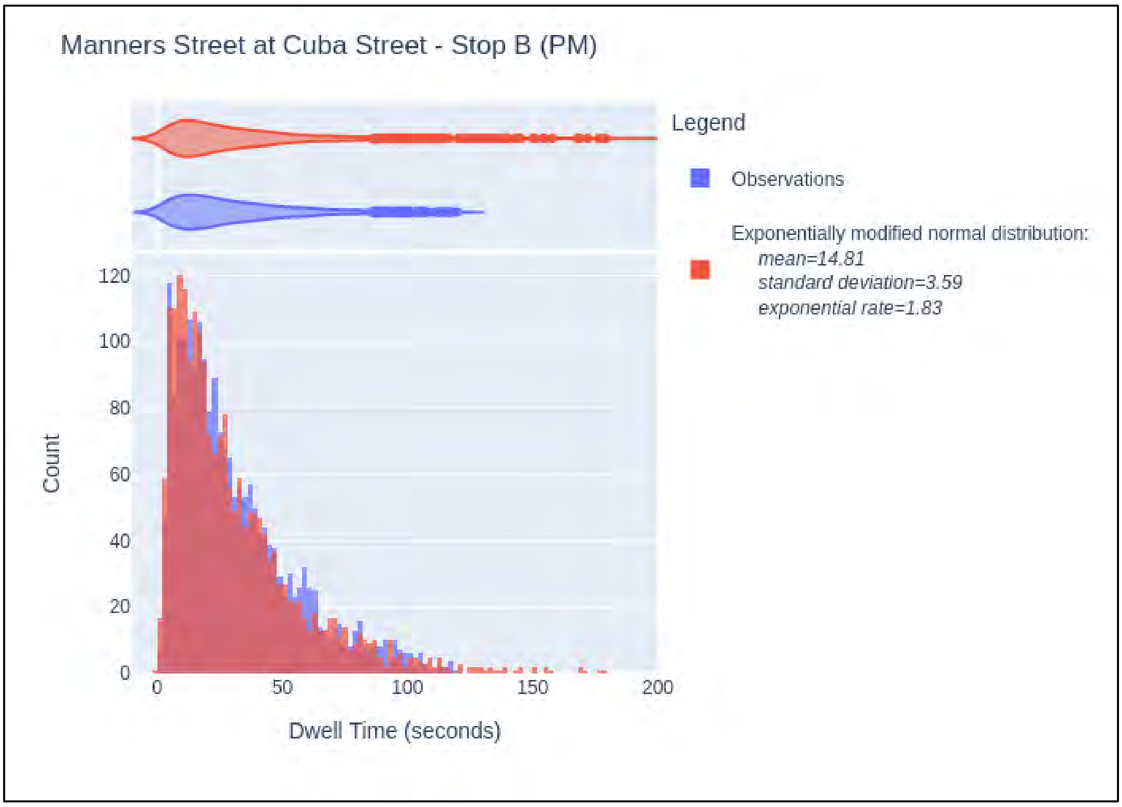

Figure 10 Observed and modelled dwell times for Manners Street at Cuba Street – Stop B in the PM peak

For the proposed stop locations, we created a mapping of the current stops to the future stops as outlined in Table 24. We then created a representative dwell time dataset using the following methodology:

1. For each bus route, *b*, in the existing dataset:

   1.1. Collect the dwell times for bus route *b* at each existing stop location.

   1.2. Recalculate what the dwell times would have been under the proposed stop configuration, given the reallocation of dwell times provided in Table 24.

Table 26 Mapping of how current dwell times are distributed to future assumed dwell times

Direction	Proposed stop	Current stops, with % of dwell time attributed to future stop	
Northbound	Courtenay Place	Courtenay Place – Stop A Courtenay Place at St James Theatre	100% 50%
	Manners Street at Cuba Street	Courtenay Place at St James Theatre Manners Street at Cuba Street – Stop A Manners Street at Willis Street	50% 100% 50%
	Willis Street at Grand Arcade	Manners Street at Willis Street Willis Street at Grand Arcade	50% 100%
	Lambton Quay at Cable Car Lane	Lambton Quay at Cable Car Lane Lambton Central - Stop A	100% 75%
	Lambton Quay North	Lambton Central - Stop A Lambton Quay North - Stop B	25% 100%

Direction	Proposed stop	Current stops, with % of dwell time attributed to future stop	
Southbound	Lambton Quay North	Lambton Quay North - Stop D	100%
	Lambton Central	Lambton Central – Stop B Lambton Quay at Hunter Street	100% 60%
	Willis Street at Mercer Street	Lambton Quay at Hunter Street Willis Street at Willbank Court	40% 100%
	Manners Street at Cuba Street	Manners Street at Cuba Street - Stop B Courtenay Place at Courtenay Central	100% 50%
	Courtenay Place	Courtenay Place at Courtenay Central Courtenay Place - Stop C	50% 100%

From this representative dataset, we again fit exponentially distributed Gaussian distributions to each stop location and time period to develop dwell time models for the proposed Golden Mile layout. Examples of the manipulated data and regression models (for the same stops and time periods as the do minimum) are shown in Figure 11 and Figure 12.[17] Note that the mean dwell times in the proposed stops are longer than in the do minimum; this is because there are fewer stops that are serving the same total dwell time.

Table 25 shows the mean dwell times for each stop based on the existing dataset and for each proposed stop location based on the representative dataset used for future dwell time estimates. Note that the total dwell time across the corridor is the same for the current layout and the proposed layout in each period.

[17] A full set of these charts for each stop is available upon request.

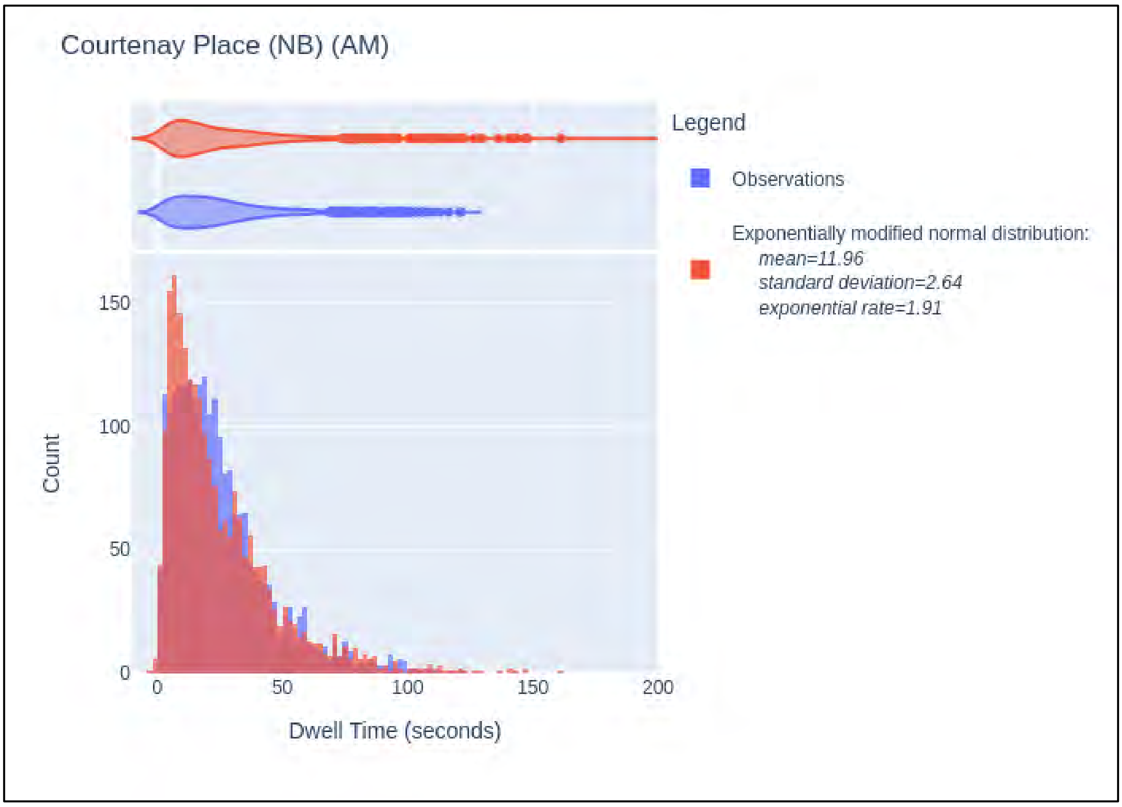

Figure 11 Modified dwell time data and modelled dwell times for Courtenay Place (northbound) in the AM peak

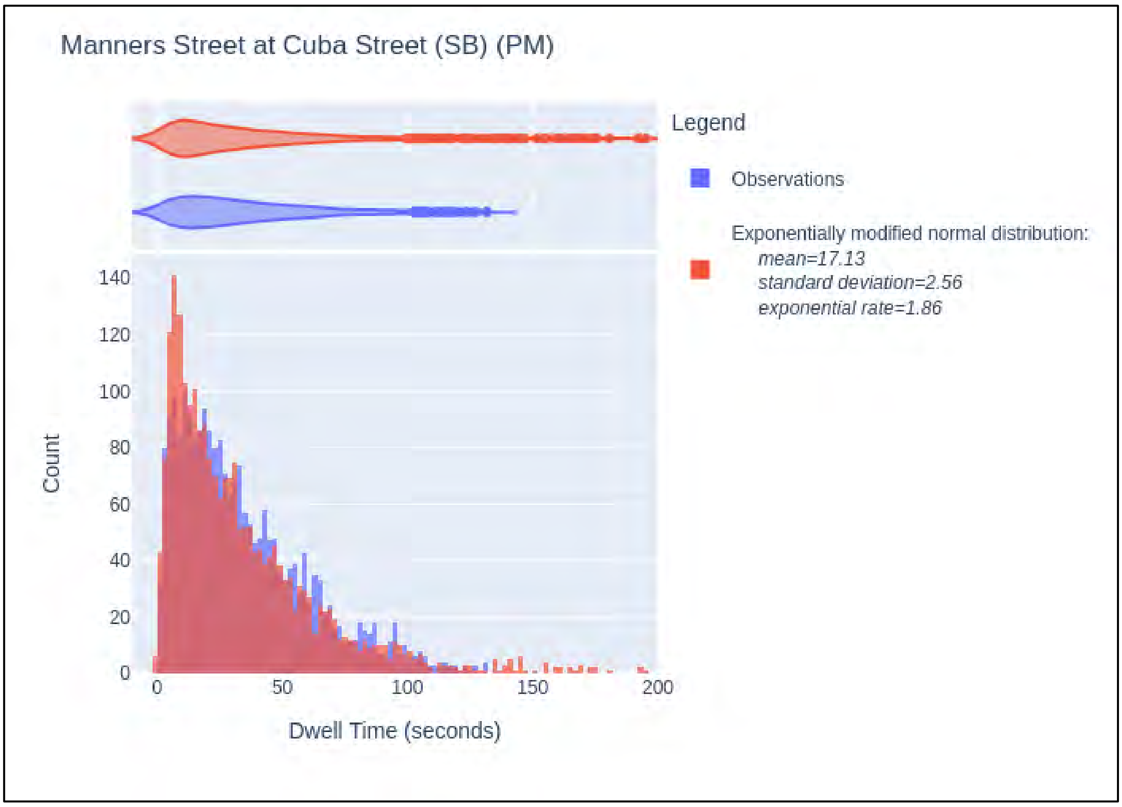

Figure 12 Modified dwell time data and modelled dwell times for Manners Street at Cuba Street (southbound) in the PM peak

Table 27 Mean dwell time assumptions from estimated and from representative proposed dwell times

Current stop	Proposed stop	Direction	Do minimum mean dwell time			Option mean dwell time		
			AM (7am-9am)	IP (12pm-2pm)	PM (4pm-6pm)	AM (7am-9am)	IP (12pm-2pm)	PM (4pm-6pm)
Courtenay Place - Stop A	Courtenay Place	NB	23.1	22.3	20.5	29.7	29.2	27.8
Courtenay Place at St James Theatre		NB	13.1	13.8	14.6			
Manners Street at Cuba Street - Stop A	Manners Street at Cuba Street	NB	17.9	23.4	24.5	32.6	38.8	44.4
Manners Street at Willis Street		NB	16.2	17.1	25.2			
Willis Street at Grand Arcade	Willis Street at Grand Arcade	NB	19.8	17.9	35.5	27.9	26.4	48.1
Lambton Quay at Cable Car Lane	Lambton Quay at Cable Car Lane	NB	21.3	14.9	27.1	35.8	27.5	43.5
Lambton Central - Stop A		NB	19.3	16.8	21.9			
Lambton Quay North - Stop B	Lambton Quay North	NB	12.8	12.7	19.7	17.6	16.9	25.2
Lambton Quay North - Stop D	Lambton Quay North	SB	19.0	16.8	22.8	19.0	16.8	22.8
Lambton Central - Stop B	Lambton Central	SB	28.0	31.6	36.5	38.3	39.7	49.4
Lambton Quay at Hunter Street		SB	17.1	13.4	21.4			
Willis Street at Willbank Court	Willis Street at Mercer Street	SB	24.0	23.5	35.8	30.8	28.9	44.4
Manners Street at Cuba Street - Stop B	Manners Street at Cuba Street	SB	17.1	25.8	30.8	24.1	32.6	40.0
Courtenay Place at Courtenay Central		SB	14.1	13.5	18.4			
Courtenay Place - Stop C	Courtenay Place	SB	12.9	18.1	20.5	19.9	24.9	29.8

D.2 Signal timings

The runtime model encodes signal timing assumptions to estimate the delays at signals. Such delays are estimated by generating a random arrival time at each intersection relative to its signal timings, and delays being calculated accordingly given the signal phasing.

For the do minimum scenario, SCATS data was provided to inform signal timing assumptions.

For the preferred option, signal timings were 'optimised' using SIDRA and were then incorporated in AIMSUN. These signal timings were generally also inherited for the public transport runtime model, with the exception of some of the midblock crossing timings. Some of the midblock crossing timings were not fully refined as they don't affect vehicle traffic, and the initial signal timings did not allow enough time for buses (10 seconds out of a 40 second cycle time). Therefore, we refined the midblock crossing timings to ensure enough time is provided for pedestrians to cross, while still enabling buses to pass through without major delays.

The following mid-block crossing timings in the preferred option apply to these crossings: Blair Street, Allen Street, St James Theatre, Cuba Street, Mercer Street, Chews Lane, Grey Street, Brandon Street, Midland Park, Stout Street and Masons Lane. The mid-block crossing timing assumptions and derivation are as follows:

- Most mid-block crossings are 6.4-7 metres wide, with the exception of Blair Street at 9.6 metres.
- Assume an average walking speed of 1.4 metres per second, it takes 5 seconds to cross the carriageway.
- For the AM and PM periods:
  - We allow 13 seconds for pedestrians to cross, plus 6 seconds of clearance before the green signal for buses.
  - We then allow a green signal for buses for 20 seconds plus 6 seconds of clearance before the green signal for pedestrians.
  - This makes for a total cycle time of 45 seconds, of which buses get 20 seconds of green phase.
- For the IP period:
  - We allow 19 seconds for pedestrians to cross, plus 6 seconds of clearance before the green signal for buses. This provides more priority for pedestrians in periods when there are more pedestrians and fewer buses.
  - We then allow a green signal for buses for 14 seconds plus 6 seconds of clearance.
  - This makes for a total cycle time of 45 seconds, of which buses get 14 seconds of green phase.

Although the Blair carriageway is wider than the others, this still allows for a much slower than average walking speed of 0.9 metres per second to cross during the green phase, so this signal timing is considered appropriate for that crossing as well.

D.3 Model methodology

MRCagney's public transport runtime model is a Monte Carlo model of the corridor that uses a physics-based approach to estimate the runtime of independent buses travelling along the corridor. This model was originally developed to estimate indicative travel times for proposed rapid transit corridors and does not model interactions between buses and vehicles or other buses. The use of this model was requested for this project, despite the limitations of not modelling interactions, due to timeframes and availability of other models.

The corridor definition within the model includes:

- Road links: stretches of roads segmented by traffic signals, intersections and bus stops. Each road link includes information about the length of the link and the maximum realistic travelling speed for buses.
- Intersections: traffic signals are coded with signal timing assumptions (SCATS data for the do minimum and SIDRA/AIMSUN inputs for the preferred option) for the total cycle time and green time for the relevant bus movement. Intersections are also coded with a maximum speed that buses can travel at through the intersection if they arrive at a green light.
- Bus stops: bus stops are coded with variable dwell times based on the dwell time regression models fitted with the methodology described in Appendix D.1.

The model computes travel time for each 'element' outlined above, incorporating the following considerations:

- Acceleration and deceleration from bus stops or intersections (or road links with a different maximum speed) at a rate of 1.2m/s^2. [18]
- Travelling at the maximum reasonable speed between the acceleration and deceleration phases.
- Stopping at bus stops for a dwell time based on the dwell time profiles for each stop, as described in Appendix D.1.
- Delays at intersections based on random arrival times and assumptions of signal timings.

Key limitations of this public transport runtime model are:

- Delays from bus interactions congestion are not modelled, as the runtime estimates are based on a single bus's journey through the corridor and is not a simulation model of buses arriving and interacting with/affecting other buses. Some work has been done to estimate the bus queuing time at stops due to them being over-capacity in the do minimum and in the preferred option; this is described in Appendix D.4.
- Congestion effects from general traffic is not modelled. It could be approximated by adjusting acceleration/deceleration rates and/or top speeds, although this has not been done.
- Impacts of private vehicles parking or accessing loading zones is not included. It could be approximated by including 'dummy' stations or intersections to reflect the likely conditions or effects of such conflicts, but this has not been done.

D.4 Modelling effects of bus queuing

As MRCagney's public transport runtime model does not estimate the impacts of bus-on-bus congestion, some work was done to investigate the ability to quantify such impacts.[19] Through this work, a model was found that used the bus stop capacity formulation of the Transit Capacity Quality of Service Manual and the actual number of buses using each stop to estimate the bus queuing time at stops, due to being unable to reach the designated stopping bays. The proposed model was only calibrated on stops with a ratio of bus volumes to bus stop capacity of up to 1.4 and when this ratio increased further (as it does on the Golden Mile) the estimated bus queuing times increase exponentially at an unreasonable rate. Therefore, we suggested that the bus queuing times should be capped at the values that would apply at the ratio of 1.4. The estimated bus queuing times for the do minimum and the preferred option are shown in Figure 13 and Figure 14.

[18] 1.2m/s^2 is a reasonable assumption for acceleration/deceleration of buses when local data is not available (Transit Capacity and Quality of Service Manual—2nd Edition, page 4-46)

[19] Bus Congestion Research, Golden Mile SSBC (MRCagney, 1 July 2021)

These savings can be quantified and monetised in the same way as travel time savings as described in Section 4.2.2. When estimating the bus queuing time experienced per person along each section of the Golden Mile, we have to make some assumptions, because not all people on each section will experience the total bus delays at all stops. Therefore, we assume that on average, each person on each section of the Golden Mile will experience a delay equal to the average of the estimated bus queuing time across all bus stops along that street section.

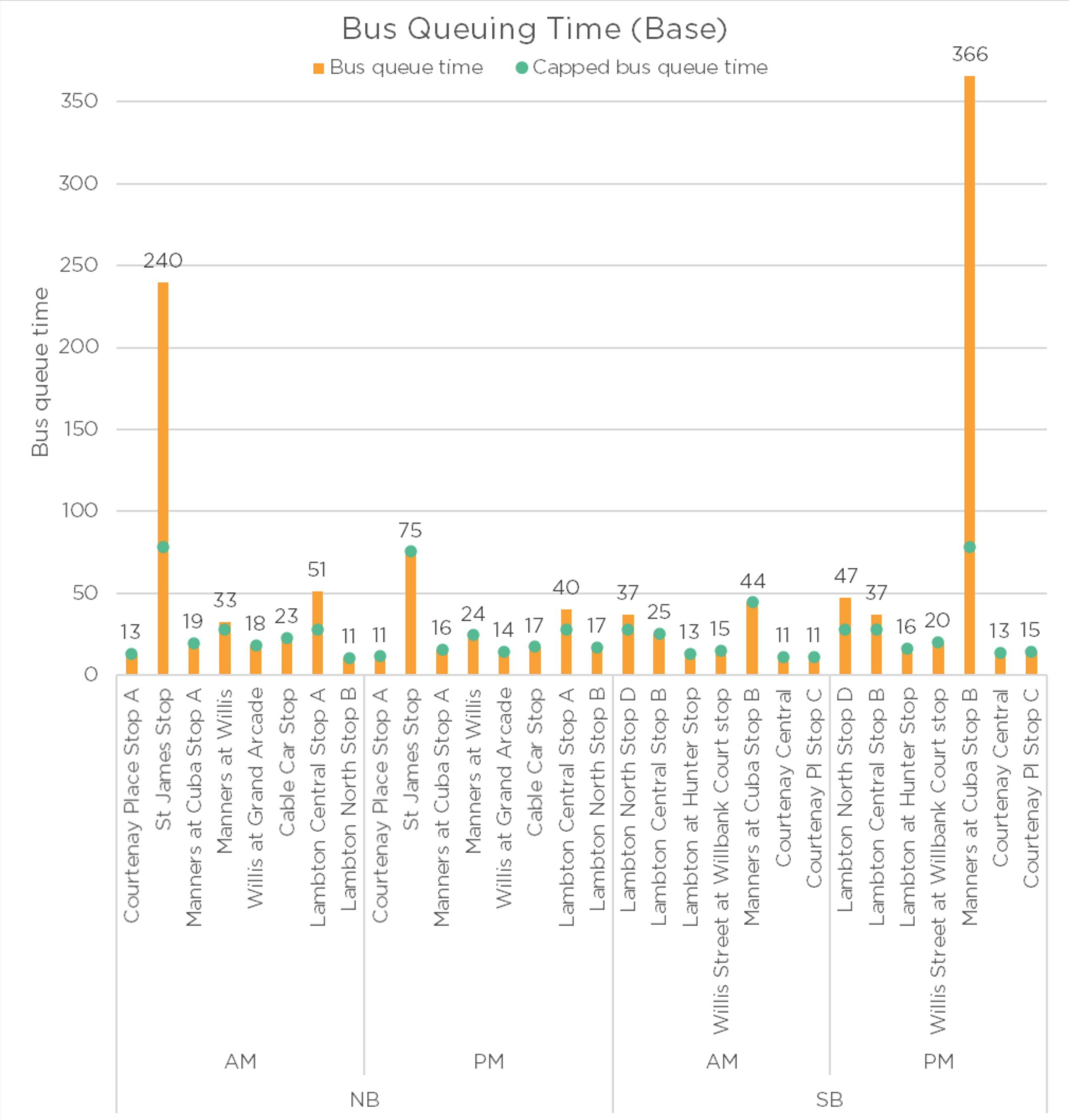

Figure 13 Estimated bus queuing times in the do minimum

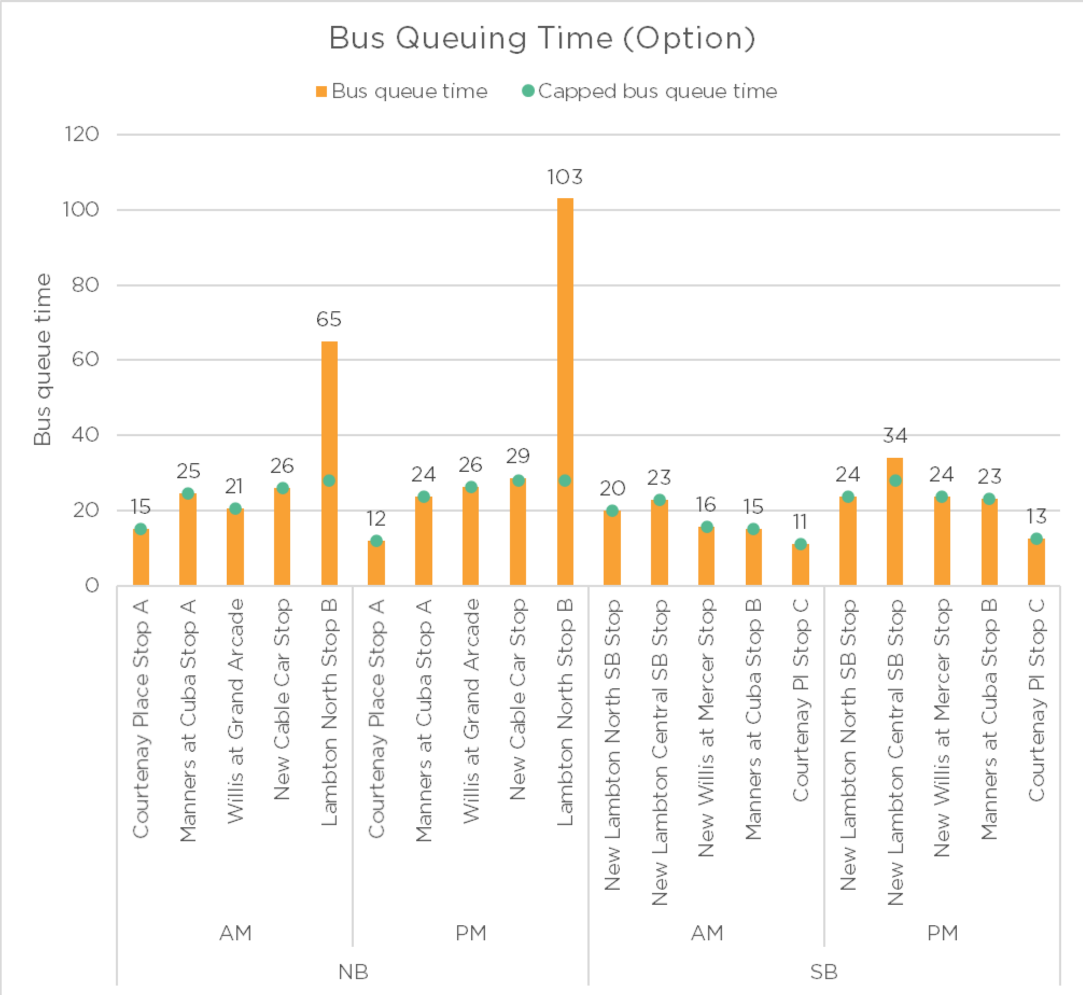

Figure 14 Estimated bus queuing times in the option

Appendix E Footpath widening benefits

The interim guidance, *Impact on Urban Amenity in Pedestrian Environments* (March 2020), includes a benefit for widening of crowded footpaths. Wider footpaths provide significant value to pedestrians in areas with high pedestrian volumes, such as along the Golden Mile. The current average available footpath width along the Golden Mile ranges from 3-5 metres. However, the presence of 'street clutter' (such as rubbish bins, seats, bus stop waiting areas, etc.) and edge zones at building frontages and kerbsides reduce the width available to pedestrians, in many places by 1-1.5 metres.

The interim guidance proposes a threshold of 33 people per minute per metre of footpath width to consider a footpath as crowded, based on international literature. This value may not be the best threshold in a New Zealand context but gives some indication of the scales of pedestrian demands that could be considered crowded. This threshold is important because the benefit of footpath widening is dependent on how crowded the footpath feels to the pedestrians using it.

Along the Golden Mile, if we consider the busiest interpeak hour pedestrian count for each section, we get the results shown in Table 26. Even without considering the effect of the footpath width, the busiest count site we have only gets to 24.6 pedestrians per minute in the busiest interpeak hour. If we were to calculate the peak hour pedestrians per minute per metre of footpath widths, these numbers would be even smaller, and would not be close to the indicative threshold for crowding of 33 people per minute per metre.

Although the quantitative evidence is unclear as to the extent and scale of footpath crowding, there is clear anecdotal evidence of this along the corridor, particularly when there are huge crowds waiting at bus stops or where there is lots of street furniture reducing the effective width of the footpath. The preferred option for the Golden Mile increases the footpath widths along most of the Golden Mile which will have associated benefits although these are not quantified here. Previous work (in the Economic Assessment of Short List Options for MCA, January 2021) estimated that annual benefits from pedestrian widening could be as great as $600,000-$750,000 with present value benefits potentially reaching $17m.

Table 28 Maximum interpeak hour pedestrians per section

Section	Side of street	Maximum peak hour pedestrians	Peak hour pedestrians per minute	Approximate current footpath width (Case for Change)	Proposed footpath width (Concept Plans)
Lambton Quay (north of Grey Street)	East	1,265	10.5	3.2m	4.2-9m
	West	1,999	16.7	3.3m	4.7-7m
Lambton Quay (south of Grey Street)	East	571	4.8	3.2m	4m
	West	2,027	16.9	3.3m	6m
Willis Street	East	1,591	13.3	3.9m	4-5.5m
	West	2,954	24.6	3.4m	4.8-6.5m
Manners Street	North	765	6.4	4.1m	3-4.5m
	South	490	4.1	5.1m	2.2-6.2m
Courtenay Place (north of Tory Street)	North	524	4.4	3m	8.5m
	South	483	4.0	3m	5m
Courtenay Place (south of Tory Street)	North	374	3.1	3m	7.6-17m
	South	394	3.3	3m	4-5.5m

Appendix F History of economic assessments for the Golden Mile SSBC

This section provides an overview of the evolution of the stages of economic assessments for the Golden Mile SSBC and the key changes in inputs and assumptions in each iteration of the assessment. There have been three stages of economics within this SSBC: *Indicative economic benefits for short list options* (May 2020), *Economics Assessment of Short List Options for MCA* (January 2021), and this economic assessment of the preferred option. More details on the assumptions and methodologies for each of these assessments are available from the full reports for each of them.

F.1 Indicative economic benefits for short list options

This was done as an indicative assessment to gain an early understanding of the potential scale of benefits and/or disbenefits of the short list options. Key assumptions that were made in this assessment include:

- Discount rate of 6% was applied as it was based on the previous Economic Evaluation Manual guidance.
- Benefits were assumed to begin in the year ended June 2022.
- 2019 benefit values were used.
- Annualisation factors excluded off-peak periods on weekdays and weekends.
- Demands for each mode were collected from:
    - Vehicles: AIMSUN model, fixed demands
    - Public transport and pedestrians: Case for Change summaries
- Growth rates for demands were assumed to be:
    - Vehicles: 0.36% per year
    - Public transport: 1.8% per year
    - Pedestrians: 1.1% per year
- Scale of benefits:
    - Vehicles: AIMSUN results
    - Public transport: MRCagney's Public Transport Runtime Model with no variability in dwell times
    - Pedestrians: assume full scale of improvements to pedestrian realm based on interim guidance

F.2 Economics assessment of short list options for MCA

This economic assessment was to conduct a 'fit for purpose' assessment of each of the options for the MCA: it was required to provide a relative comparison between the short list options and was appropriate to exclude certain benefits or refine inputs that would affect the ultimate benefit-cost ratio if they would not affect the relative assessment of each of the options. Key assumptions that were made in this assessment include:

- Discount rate of 4%, updated to the new requirements of the MBCM.
- 2019 benefit values were used.
- Annualisation factors excluded off-peak periods on weekdays and weekends.
- Demands for each mode were collected from:

- Vehicles: AIMSUN model, fixed and elasticity-adjusted demands
- Public transport: WPTM model results
- Pedestrians: Active Modes Visualisation Tool

- Growth rates for demands were assumed to be:
  - Vehicles: no growth
  - Public transport: 1.6% per year as defined in the Do Minimum Scenario Description
  - Pedestrians: 1.3% per year as defined in the Do Minimum Scenario Description
- Scale of benefits:
  - Vehicles: AIMSUN results, only travel time impacts included
  - Public transport: MRCagney's Public Transport Runtime Model with no variability in dwell times
  - Pedestrians: assume full scale of improvements to pedestrian realm based on interim guidance

F.3 Preferred option economics

Key parameters and inputs that have changed in this round of the economic assessment include:

- Updated to 2020 benefit values.
- Annualisation factors updated to include off-peak and weekend periods.
- Pedestrian demands updated to draw from the March Monitoring Counts rather than the Active Modes Visualisation Tool.
- Added demand uplifts for:
  - Public transport demands increased due to diversion of car trips to public transport.
  - Pedestrian trips increased due to the above public transport trips including a 'first/last-mile' connection via walking, and an uplift elasticity assumed due to the realm improvements.
- Summary of other changes to the pedestrian benefit:
  - Demands revised as above (using March Monitoring Counts instead of the ADT from Active Modes Visualisation Tool); this resulted in a much lower 'total distance walked' estimate (about half of the previous estimate).
  - Added in benefits of additional signage and wayfinding, and of removal of 'adjacent' traffic on the Golden Mile. The average additional willingness to pay from these features is 0.17 (people would walk 17% further for these improvements alone).
  - Refined the other benefits to estimate the 'scale' of improvement of each element, rather than assuming they all improve from 'non-existent' to 'perfect'.
  - Added in factoring to include off-peak and weekend estimates.
- Scale of benefits:
  - Vehicles: added the emissions benefit
  - Public transport: added variable dwell times to the Public Transport Runtime Model and added a bus queuing time benefit for sensitivity testing.
  - Pedestrians: estimated a baseline and future 'proportion of full improvements', to scale the pedestrian realm improvements to the expected level of improvement on the ground.

Appendix G References

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