29 September 2021

Let’s Get Wellington Moving

Golden Mile Bus Stop Capacity Calculations

SHI: Aurecon supported by
Future Group
MRT: Jacobs and GHD JV

Table of Contents

Table of Figures

List of Tables

1 Overview

The Transit Capacity & Quality of Service Manual, Third Edition[1] (TCQSM) contains two methods for estimating the capacity of bus lanes. The first method is generic values based on the type of street and desired level of service for public transport and the second is detailed calculations of the capacity of each stop along the corridor. The TCQSM guidelines state that the generic values may only be used for high level planning purposes and that more precise values should be used for design purposes. Considering this recommendation and the fact that the Golden Mile has a high density of bus stops and signalised intersections which reduces bus lane capacity it is not recommended that generic bus lane capacity values are used for this analysis. Instead detailed calculations at a bus stop by bus stop level have been used to estimate the capacity of the Golden Mile corridor.

This report therefore documents the process that was followed to estimate the capacity of the bus stops along the Golden Mile corridor within the Wellington Central as a way to estimate the capacity of the corridor as a whole. For the purposes of this memo capacity refers to the maximum number of buses that can use a bus stop in an hour at a desired level of operational reliability. As the volume of buses approaches the stop capacity then buses will increasingly experience congestion at the bus stop which increases delay and reduces reliability.

The bus stops which this capacity analysis was undertaken for are shown in Figure 1-2 below which includes all the bus stops along the Golden Mile. These bus stops serve the highest volume of buses in the Wellington Region as most bus services in Wellington City converge on the Golden Mile in order to serve CBD (Figure 1-1).

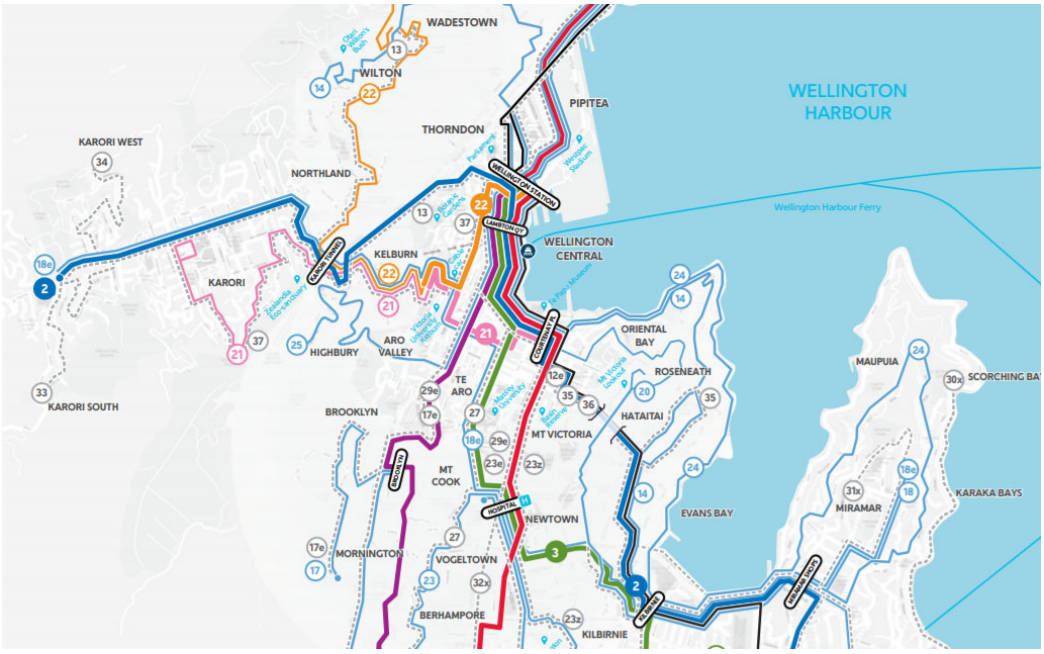


Figure 1 Public transport network map with Wellington City showing high number of bus routes which serve Wellington CBD (Source: Greater Wellington Regional Council)

[1] Transit Cooperative Research Program Report 165, retrieved from http://www.trb.org/Main/Blurbs/169437.aspx

Figure 2 Map showing location of bus stop along the Golden Mile. Southbound bus stops shown in orange and northbound bus stops shown in blue (Image source: Remix)

2 Methodology

The Golden Mile bus stop capacity analysis has followed the process contained in the TCQSM guidelines for a detailed capacity assessment. This process recognises that there are numerous factors which influence the capacity of a bus stop are listed below in no particular order:

- The volume of passengers boarding and alighting;
- The time each passenger takes to board and alight which is influenced by the design of the bus and the payment method;
- The number of loading areas at the bus stop;
- The location of the bus stop in relation to traffic signals;
- For bus stops located at traffic signals, the proportion of green time allocated to bus movements;
- Whether passing lanes are available at the bus stop so that buses can overtake; and
- Whether the adjacent lane is bus only or shared with general traffic.

The TCQSM then proposes a 6-step approach to calculating the bus stop capacity as follows:

1. Define the bus stop type
2. Gather input data
3. Set a design bus stop failure rate
4. Determine dwell time
5. Determine loading area capacity
6. Determine bus stop capacity

The following additional steps were undertaken for the 2060 calculations:

1. Multiply passenger boardings and alightings by the growth rate
2. Estimate future bus volumes along the Golden Mile

3 Step 1 and 2: gathering data (including bus stop type/ features)

The data and assumptions that were used in calculating the bus stop capacity are listed below:

- Passenger boardings and alightings: uses March 2019 ticketing data
- Number of buses at each stop: uses Google Transit Feed data for March 2020
- Payment method: uses the proportion of passengers using cash, Super Gold card and Snapper from March 2019 ticketing data
- Board and alight time for each payment method: used the recommended values per passenger from TCQSM which is 4.5 sec for cash, 2.0 sec for Super Gold card and 2.8 sec for Snapper
- Boarding lost time: used the recommended values from TCQSM
- Door opening and closing time: used the recommended values from TCQSM
- Dwell time variability: used field measurements checked against the standard range contained in TCQSM
- Number of loading areas: measured the length of each bus stop using Wellington City Council GIS viewer and assumed a 12.5m long bus with 0.5m gap between buses
- Green time ratio: used data from Linsig models of the signalised intersections along the Golden Mile[2]
- Adjacent traffic lane volume: used data from Linsig models of the signalised intersections along the Golden Mile
- Patronage growth rate: assumed 1% compounding growth rate based on Wellington Public Transport Model results

4 Step 3: Set the Bus Stop failure rate (level of reliability)

As the number of buses which use a stop per hour increase there is a point at which buses start to queue back from the stop because another bus is occupying the stop. Having buses wait for long periods of time before a bus stop is vacated is undesirable for several reasons; 1) bus journey times increase to the time spent waiting for the bus stop to become available 2) bus service reliability suffers due to the additional delays. However, in central city locations where road space is limited and bus volumes are high there is also a desire to maximise the use of bus stops. Therefore, bus stop capacity is a balance between maximising the use of the stop and minimising the impact of journey times and reliability.

Transit Capacity and Quality of Service Manual recommends a maximum design failure rates of 15% for central city locations which takes into account this trade-off. At a 15% failure rate queues form behind the bus stop for about 10 minutes out of the hour and bus speeds are about 20% lower than when bus volumes are well below capacity. For the purposes of this bus stop capacity assessment a design failure rate of 15% has been used as the upper limit and a design failure rate of 2.5% has been used as the

[2] Golden Mile Bus Priority Improvements at Traffic Signals, for Let's Get Wellington Moving, IZ126200-REP-001, 08 November 2019

desirable limit. A failure rate of 2.5% represent bus operations which are unconstrained by stop capacity. Between a failure rate of 2.5% and 15% buses experience an increasing level of queuing at bus stops with a subsequent decrease in bus speeds and reliability.

5 Step 4: Determine dwell time

The process to calculate the dwell times at a stop involves the following steps 1) calculate the time for customers to board and alight 2) calculate the time when the bus is stationary but customers are not boarding/alighting.

Time for customers to board and alight

First the total boardings and alightings for each stop during the peak hour was taken from Metlink ticketing data. Then the boardings and alightings were divided by the number of buses which use the stop in the peak hour to calculate average boardings/ alightings per bus. Current operational procedures for Wellington buses is that customers board at the front door and can use the driver channel or the Snapper machine channel depending on the payment method used. Boarding channel is a concept that considers that two passengers can board at the same time if one passenger uses cash or Super Gold card (driver channel) and one customer uses Snapper (Snapper machine channel). The number of boardings for each channel was calculated using a ratio 7% cash, 8% Super Gold card and 85% Snapper. The ratio of payment methods was calculated using Metlink ticketing data. A similar process was repeated for alightings with the alightings per bus being split 25% front door and 75% rear door which is a ratio from TCQSM. Next the average boarding time per channel was calculated using a value of 4.5 sec per passenger for cash, 2.0 sec for Super Gold and 2.8 sec for Snapper. The process was repeated to calculate average alight time per customer which uses 2.5 sec per passenger for cash and Super Gold and 3.5 sec for Snapper. The average board and alight time per customer use values from TCQSM. For the boarding channels it was assumed that customers waiting to board the bus would wait until customers on the bus had finished alighting before boarding. Therefore, the alight time at the front door was added to the board time for each channel to get the total time. Because boardings and alightings can occur simultaneously at the front door channels and the rear door only the maximum of the three values was taken. For example, if customers took 20 sec to board/alight at the driver channel, 10 sec to board/alight at the Snapper channel and 5 sec to alight from the rear door then the critical time would be the driver channel.

Time when the bus is stationary but customers are not boarding/alighting

In addition to the time needed for customers to board and alight there is time lost when the bus is stationary at the stop. Customers tend to wait near the head of the stop (where the bus stop sign is) but for bus stops with multiple loading areas the bus may stop further down the road. Because customers do not know which loading area will be used they tend to wait at the head of the stop and walk down to the bus once the bus has stopped which is time lost. For bus stops with one loading area the bus stops close to where the customers are waiting so the walk time is 0 seconds. For each additional loading area the TCQSM guidelines state that 2 seconds should be added to the dwell time to account for the customer walk time. The next source of lost time is the time between when a bus is station and when the doors are open and the time after customers have finished boarding/alighting and the doors are shut. The door opening and closing time used for these calculations is 3 seconds which is the value contained in the TCQSM guidelines.

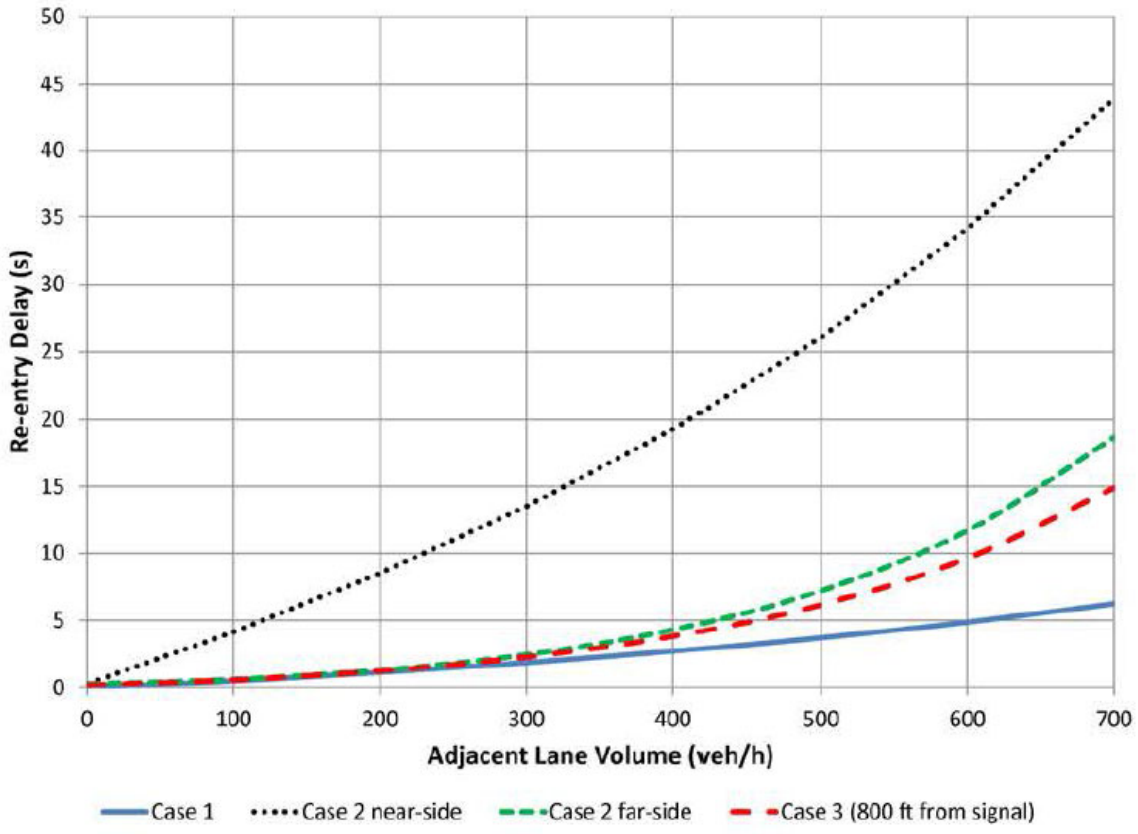
6 Step 5: Define loading area (bus bay) capacity

The loading area capacity is calculated using the stop failure rate, the dwell time at the stop and the characteristics of the bus stop and bus service. The characteristics of the bus stop and bus service which influence the loading area capacity are dwell time variability, green time ratio and clearance time.

In practice the time which a bus dwells at a loading area varies from one trip to the next depending on customer and driver behaviour. To take these variations into account a coefficient of the dwell time variability was used with a zero meaning that all dwell times are the same and a 1.0 meaning that approximately one in three buses have a dwell time twice as large as the average. The TCQSM guidelines states that dwell times typically range for 0.4 to 0.8 based on observations from U.S. cities. Field observations were taken of the dwell times at the Lambton Central (near 171) stop between 4pm and 6pm were the observed dwell time range was 0.8 with this value being used for the calculations.

Green time ratio is the percentage of the total phase time at a signalised intersection which is dedicated to bus movements. A lower green time ratio reduces load area capacity buses buses are more likely to be held up at the intersection. This value only applies for bus stops located near side (before) signalised intersections and not midblock or far side bus stops

Clearance time is the time that it takes the bus to leave the loading area once the passengers have finished boarding/alighting and the doors have been closed. Clearance time has two components 1) is the time for a bus to move out of the loading area 2) is the re-entry delay caused by other traffic movements. A time of 10 seconds was used as the time for a bus to move out of the loading area which is an average value from the TCQSM guidelines. Re-entry is the average time which a bus needs to wait for a gap in the traffic before it can pull out of the bus stop and into the adjacent lane. Re-entry delay does not apply to bus stop which do not have use of an adjacent lane because in this case there is no potential conflict with other traffic. The TCQSM guidelines provides the graph shown on the following page to estimate re-entry delay based on the type of bus stop and the adjacent lane volume. For the Golden Mile capacity assessment the adjacent lane volume was taken from the Linsig model that was used to calculate the green time ratio.



Case 1 is a bus stop located away from the influence of traffic signals, case 2 is a bus stop at a traffic signal and case 3 is a bus stop downstream of a traffic signal.

7 Step 6: Determine overall bus stop capacity

Loading area refers to the individual point at which a bus stops to pickup and drop off passengers. A bus stop may have space for more than one bus and will therefore have multiple loading areas (for example a 26m long bus stop will have room for two buses). To consider bus stops with multiple loading areas the capacity of the loading area is converted in the capacity of the overall bus stop. This calculation has three steps 1) determine the effective number of loading areas 2) determine the traffic signals blockage adjustment factor 3) consider split stops.

Effective number of loading areas

For bus stops which have multiple loading areas a bus that is stationary in the rear loading area may block another bus from using the front loading area. The extent to which is occurs is influenced by the number of loading areas (is a more common occurrence for longer bus stops) and the extent to which buses can manoeuvre around stationary buses. To consider the efficiency of loading area TCQSM contains the following table to convert number of loading areas into number of effective loading areas.

	On-Line Loading Areas				Off-Line Loading Areas	
	Random Arrivals		Platooned Arrivals		All Arrivals	
Loading Area #	Efficiency %	Cumulative # of Effective Loading Areas	Efficiency %	Cumulative # of Effective Loading Areas	Efficiency %	Cumulative # of Effective Loading Areas
1	100	1.00	100	1.00	100	1.00
2	75	1.75	85	1.85	85	1.85
3	70	2.45	80	2.65	75	2.60
4	20	2.65	25	2.90	65	3.25
5	10	2.75	10	3.00	50	3.75

Sources: *TCRP Report 26* (21) and *TCRP Research Results Digest 38* (37).
Notes: On-line values assume that buses do not overtake each other.
Values apply only to linear loading areas; non-linear designs are 100% effective.

Traffic signals blockage adjustment factor

In mixed traffic lane situations (eg buses and cars share the same lane) cars may use up signal green time that would otherwise have been available for bus movements. The reduced green time available to buses in turn reduces bus stop capacity. The impact on bus stop capacity depends on the traffic volumes relative to the lane capacity and the bus stop location relative to the intersection. If other vehicles are not allowed to use the bus facility (eg a busway or exclusive bus lanes) there is no traffic blockage impact and this step is skipped. For bus stops that are located on the far side of the intersection and mid block bus stops located more than 400m from the intersection there is also no traffic blockage impact.

Split stops

In some instances larger bus stops are split into multiple independent sub-stops with bus routes assigned to stop at one of these sub-stops. For example, at Wellington Station there is three stops serving southbound buses (Stop A, B and C) and for Lambton Quay North there is also three stops serving northbound buses. All other bus stops along the Golden Mile are standard bus stops where all bus stops stop at all the stops. Because split stops operate independent of the other sub-stops the total capacity of these stops has been combined for the purposes of the Golden Mile capacity assessment. If

one sub-stop is at capacity then it might be possible to reallocate a bus route to another sub-stop thus balancing the capacity. However, this is not possible with standard stops where all bus stops need to stop. Split stops tend to be used where there is a large area of kerb space available for the bus stop and there is an adjacent lane available to enable buses to pass one another.

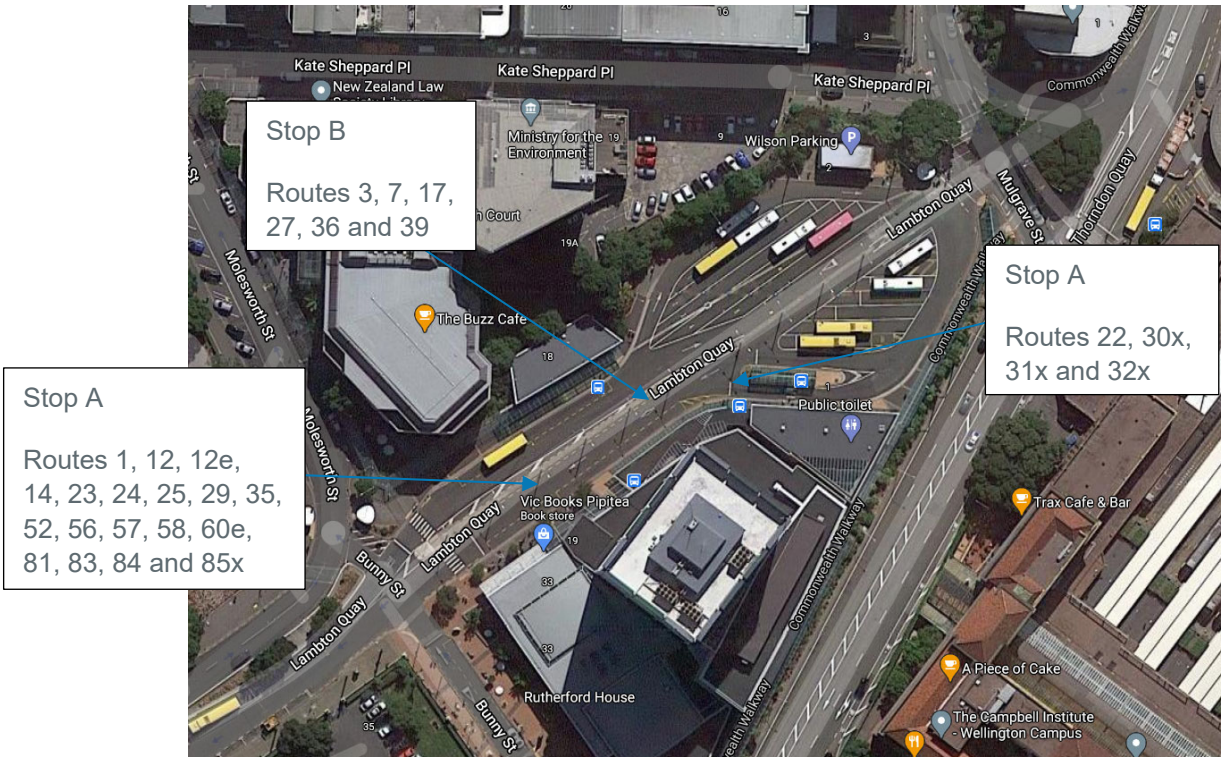


Figure 3 Example of split stop for Wellington Station southbound (Base image: Google Maps)

8 Estimating future year bus volumes and capacity

In order to estimate future capacity along the Golden Mile the number of buses and boarding/ alighting volume were updated using the following process:

Number of buses

- Calculate the peak load for each bus corridor (peak load is boardings at each stop minus alightings);
- Increase the peak load by a 1% per year compounding growth rate until 2060;
- Assign a bus type for each bus corridor. For this analysis it was assumed that double deck buses would be used on all main bus corridors except for Seatoun and Karori which are constrained by tunnels;
- Calculate the planning capacity of each bus type which is the maximum capacity times by 0.85 to account for day to day variability in boardings and alightings;
- Divide the peak load in 2060 by the planning capacity of the bus type for each corridor to calculate the number of buses needed to provide sufficient capacity; and
- Total the bus volume on each corridor to calculate the bus volume along the Golden Mile.

Boarding/ alighting volume

- Increase the boarding and alighting values for each stop by a 1% per year compounding growth rate until 2060.

9 Worked example

Below is a worked example to show the key inputs and results for the Lambton Central (near 171) stop for both 2020 and 2060:

Table 1 Key inputs and results for Lambton Central (near 171) in morning peak

Input/ results	2020 morning peak	2060 morning peak
Boarding/ alighting volumes	445 passengers	663 passengers
Number of buses	69 buses	94 buses
Boardings and alightings per bus	6.4 passengers	7.0 passengers
Payment method	7% cash, 8% Super Gold and 85% Snapper	7% cash, 8% Super Gold and 85% Snapper
Front door vs back door alighting split	25% front door and 75% rear door	25% front door and 75% rear door
Board time per customer	4.5 sec cash, 2.0 sec Super Gold and 2.8 sec Snapper	4.5 sec cash, 2.0 sec Super Gold and 2.8 sec Snapper
Door opening and closing time	3 sec	3 sec
Average dwell time	21 sec	22 sec
Dwell time variability	0.8	0.8
Failure rate for upper limit	0.15	0.15
Failure rate for desirable limit	0.025	0.025
Green time ratio for buses	0.31	0.31
Time for bus to move out of loading area	10 sec	10 sec
Capacity of single bus bay	30 buses per hour	28 buses per hour
Effective number of loading areas	2.45	2.45
Bus stop capacity upper limit	63 buses per hour	61 buses per hour
Bus stop capacity desirable limit	45 buses per hour	43 buses per hour

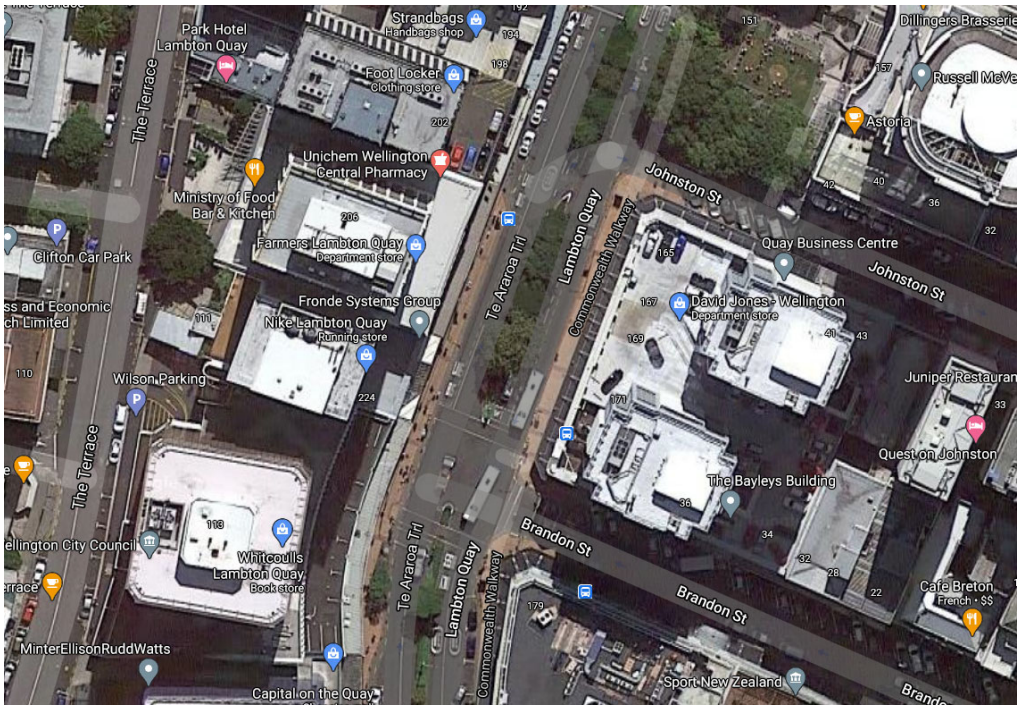


Figure 4 Image showing location and characteristics of Lambton Central (near 171) bus stop

10 Results for 2020

The tables below show the results for the bus stop capacity assessment. Percentages over 100% indicates that the bus stop is over its theoretical capacity, using the predetermined upper limit failure rate.

Table 2 Morning peak Wellington Station to Courtenay Place in 2020

Bus stop name	Wellington Station	Lambton Quay North	Lambton Central (near 171)	Lambton Quay at Hunter Street	Willis Street at Willbank Court	Manners Street at Cuba Street – Stop B	Courtenay Place at Courtenay Central	Courtenay Place – Stop C
Bus stop number	5500, 6000, 6001	5502	5506	5508	5510	5513	5514	5516
Demand volume (buses per hr)	69	69	69	71	69	57	52	52
Bus stop capacity desirable limit (buses per hr)	112	154	45	83	56	33	107	118
Bus stop capacity upper limit (buses per hr)	165	199	63	111	81	47	145	152
Percentage of upper capacity limit utilised	42%	35%	109%	64%	84%	121%	36%	34%

Table 3 Morning peak Courtenay Place to Wellington Station in 2020

Bus stop name	Courtenay Place – Stop A	Courtenay Place at St James Theatre	Manners Street at Cuba Street – Stop A	Manners Street at Willis Street	Willis Street at Grand Arcade	Lambton Quay at Cable Car Lane	Lambton Central – Stop A	Lambton Quay North	Wellington Station – Stop D
Bus stop number	5000	5002	5515	5006	5008	5010	5012	5011, 5014, 5015	5016
Demand volume (buses per hr)	69	68	69	66	81	81	87	87	62
Bus stop capacity desirable limit (buses per hr)	128	76	45	24	51	112	107	231	99
Bus stop capacity upper limit (buses per hr)	166	94	64	35	69	148	141	298	133
Percentage of upper capacity limit utilised	41%	72%	108%	189%	117%	55%	62%	29%	47%

Table 4 Afternoon peak Wellington Station to Courtenay Place in 2020

Bus stop name	Wellington Station	Lambton Quay North	Lambton Central (near 171)	Lambton Quay at Hunter Street	Willis Street at Willbank Court	Manners Street at Cuba Street – Stop B	Courtenay Place at Courtenay Central	Courtenay Place – Stop C
Bus stop number	5500, 6000, 6001	5502	5506	5508	5510	5513	5514	5516
Demand volume (buses per hr)	73	79	80	82	81	67	60	61
Bus stop capacity desirable limit (buses per hr)	216	124	38	79	63	35	122	105
Bus stop capacity upper limit (buses per hr)	286	163	55	106	91	51	163	137
Percentage of capacity utilised	26%	48%	146%	77%	89%	132%	37%	44%

Table 5 Afternoon peak Courtenay Place to Wellington Station in 2020

Bus stop name	Courtenay Place – Stop A	Courtenay Place at St James Theatre	Manners Street at Cuba Street – Stop A	Manners Street at Willis Street	Willis Street at Grand Arcade	Lambton Quay at Cable Car Lane	Lambton Central – Stop A	Lambton Quay North	Wellington Station – Stop D
Bus stop number	5000	5002	5515	5006	5008	5010	5012	5011, 5014, 5015	5016
Demand volume (buses per hr)	57	54	61	63	75	76	92	92	58
Bus stop capacity desirable limit (buses per hr)	199	62	48	22	59	160	149	303	122
Bus stop capacity upper limit (buses per hr)	254	81	70	32	81	209	192	379	162
Percentage of capacity utilised	22%	67%	87%	195%	93%	36%	48%	24%	36%

11 Results for 2060

The tables below show the estimated bus stop capacity in the year 2060. Comparing the results from 2020 to 2060 shows that the bus stop capacity is expected to decrease slightly in future. This is because of the expected increase in boardings and alightings per bus in the future means that buses dwell at the loading area for longer. Longer average dwell times in turn decreases the capacity of the bus stop.

Table 6 Morning peak Wellington Station to Courtenay Place in 2060

Bus stop name	Wellington Station	Lambton Quay North	Lambton Central (near 171)	Lambton Quay at Hunter Street	Willis Street at Willbank Court	Manners Street at Cuba Street – Stop B	Courtenay Place at Courtenay Central	Courtenay Place – Stop C
Bus stop number	5500, 6000, 6001	5502	5506	5508	5510	5513	5514	5516
Estimated demand volume (buses per hr)	94	94	94	94	94	79	60	60
Bus stop capacity desirable limit (buses per hr)	114	148	43	78	54	32	96	110
Bus stop capacity upper limit (buses per hr)	155	192	61	105	78	46	132	143
Percentage of capacity utilised	61%	49%	154%	90%	121%	173%	45%	42%

Table 7 Morning peak Courtenay Place to Wellington Station in 2060

Bus stop name	Courtenay Place – Stop A	Courtenay Place at St James Theatre	Manners Street at Cuba Street – Stop A	Manners Street at Willis Street	Willis Street at Grand Arcade	Lambton Quay at Cable Car Lane	Lambton Central – Stop A	Lambton Quay North	Wellington Station – Stop D
Bus stop number	5000	5002	5515	5006	5008	5010	5012	5011, 5014, 5015	5016
Estimated demand volume (buses per hr)	81	81	81	81	103	103	103	103	73
Bus stop capacity desirable limit (buses per hr)	114	70	40	22	47	103	93	208	84
Bus stop capacity upper limit (buses per hr)	149	89	58	32	65	136	124	270	113
Percentage of capacity utilised	54%	91%	139%	250%	159%	76%	83%	38%	65%

Table 8 Afternoon peak Wellington Station to Courtenay Place in 2060

Bus stop name	Wellington Station	Lambton Quay North	Lambton Central (near 171)	Lambton Quay at Hunter Street	Willis Street at Willbank Court	Manners Street at Cuba Street – Stop B	Courtenay Place at Courtenay Central	Courtenay Place – Stop C
Bus stop number	5500, 6000, 6001	5502	5506	5508	5510	5513	5514	5516
Estimated demand volume (buses per hr)	96	103	103	103	103	85	76	76
Bus stop capacity desirable limit (buses per hr)	198	115	35	72	58	32	115	98
Bus stop capacity upper limit (buses per hr)	263	152	50	97	84	47	155	130
Percentage of capacity utilised	37%	68%	204%	106%	123%	181%	49%	59%

Table 9 Afternoon peak Courtenay Place to Wellington Station in 2060

Bus stop name	Courtenay Place – Stop A	Courtenay Place at St James Theatre	Manners Street at Cuba Street – Stop A	Manners Street at Willis Street	Willis Street at Grand Arcade	Lambton Quay at Cable Car Lane	Lambton Central – Stop A	Lambton Quay North	Wellington Station – Stop D
Bus stop number	5000	5002	5515	5006	5008	5010	5012	5011, 5014, 5015	5016
Estimated demand volume (buses per hr)	68	68	76	76	95	95	115	115	72
Bus stop capacity desirable limit (buses per hr)	185	57	44	20	54	146	137	285	109
Bus stop capacity upper limit (buses per hr)	237	75	65	30	75	192	178	358	145
Percentage of capacity utilised	29%	90%	117%	255%	126%	49%	65%	32%	50%

12 Discussion of results

12.1 2020 results

The 2020 bus stop capacity assessment results provide the following insights:

- The capacity constraints of Golden Mile bus stops are experienced in both the northbound and southbound direction for both the morning and afternoon peaks.
- Manners St at Willis St is the most congested bus stop with an upper capacity limit of 35 buses per hour in the morning peak and 32 in the afternoon peak. This is due to there being no passing lanes on Manners St and the intersection with Willis St being a major intersection which provides buses with a low green time ratio (12% in the morning peak and 11% in the afternoon peak);
- The next most congested bus stop is Manners Street at Cuba Street – Stop B with an upper capacity limit of 47 buses per hour in the morning peak and 51 buses per hour in the afternoon peak;
- The bus stop with the most capacity is Lambton Quay North with an upper capacity limit of 298 buses per hour in the morning peak and 270 buses per hour in the afternoon peak. The high capacity threshold is due to the large number of loading areas (6 across the multiple sub-stops) and there being an adjacent lane available to buses to enable passing manoeuvres.

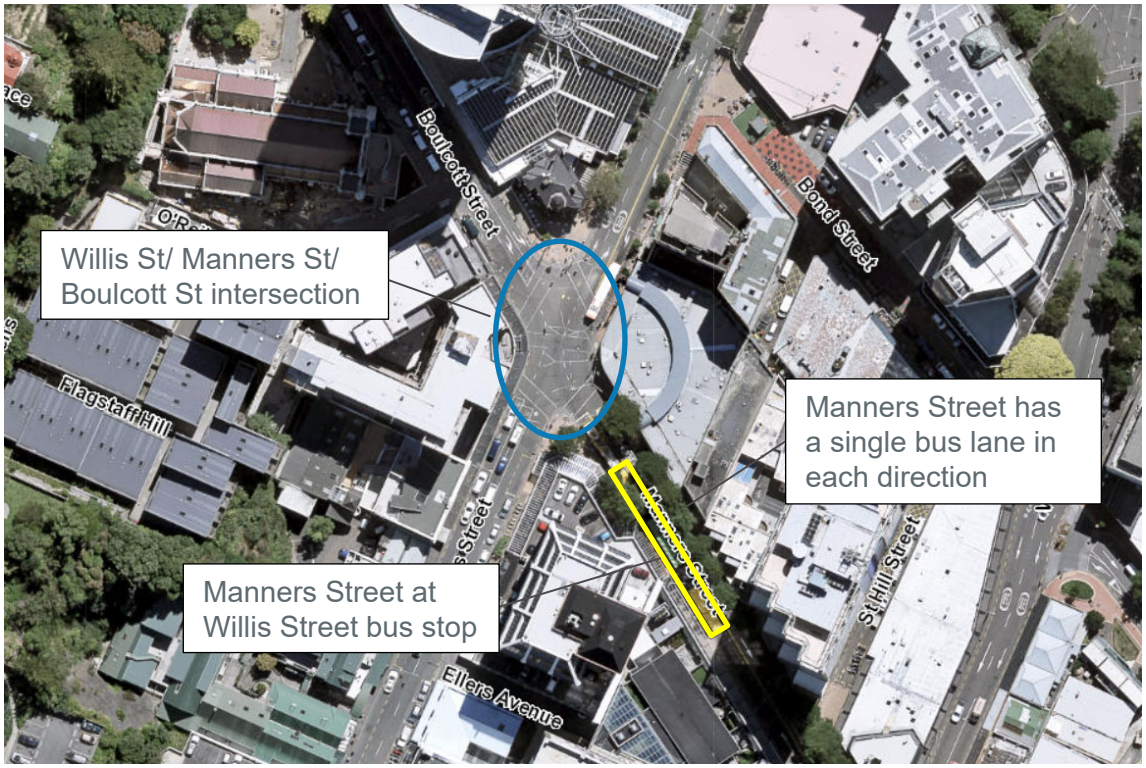


Figure 5 Aerial photo showing location of Manners Street at Willis Street bus stop in relation to intersection (image source: Wellington City GIS Viewer)

12.2 2060 capacity analysis findings

The bus stop capacity assessment results for 2060 indicate the following:

- Bus stops become increasingly over capacity due to the increase in bus volume needed to meet future patronage growth using existing vehicle types; and
- The increase in bus volumes along the Golden Mile without a corresponding increase in bus stop capacity is expected to further increase bus journey times and service unreliability.

12.3 Overall corridor capacity

The volume of buses which can be accommodated on the Golden Mile whilst achieving the desired level of service reliability is dependent on the critical stop along the corridor in each direction. The critical stop refers to the stop or grouping of sub-stops with the lowest capacity. For the Golden Mile, the critical stops are Manners Street at Cuba Street – Stop B in the southbound direction and Manners Street at Willis Street in the northbound direction. Based on the upper capacity limit of the critical stops the capacity of the Golden Mile bus corridor for 2020 and 2060 is shown in the table below. For the 2060 estimates the expected patronage growth increases dwell times at stops which in turn reduces the capacity of stops:

Table 10 Overall capacity of Golden Mile corridor considering critical stop capacity

Direction	Morning peak	Afternoon peak
Wellington Railway Station to Courtenay Place (southbound)	2020: 47 buses/ hr 2060: 46 buses/ hr	2020: 51 buses / hr 2060: 47 buses / hr
Courtenay Place to Wellington Railway Station (northbound)	2020: 35 buses/ hr 2060: 32 buses/ hr	2020: 32 buses/ hr 2060: 30 buses/ hr

The capacity of the Golden Mile based on detailed calculations of the critical stops is significantly lower than the generic capacity values of bus lanes. The generic capacity value for a downtown street at an unstable flow scenario is shown as 81 to 100 buses per lane per hour (Figure 1-6). Whereas the capacity of the critical bus stops from the detail calculations is between 30 to 50 buses per lane per hour. The reason for this difference is that the Golden Mile has multiple bus stops which do not have passing lanes and that are located prior to signalised intersections. Therefore, the detail capacity calculations should be used over the generic capacity values because the detail calculations consider the specific characteristics of the Golden Mile and the desired experience for Wellington public transport customers.

Description	Service Volume bus/lane/h	Average bus/lane/h
ARTERIAL STREETS		
Free flow	25 or less	15
Stable flow, unconstrained	26 to 45	35
Stable flow, interference	46 to 75	60
Stable flow, some platooning	76 to 105	90
Unstable flow, queuing	106 to 135	120
Forced flow, poor operation	over 135*	150*
DOWNTOWN STREETS		
Free flow	20 or less	15
Stable flow, unconstrained	21 to 40	30
Stable flow, interference	41 to 60	50
Stable flow, some platooning	61 to 80	70
Unstable flow, queuing	81 to 100	90
Forced flow, poor operation	over 100*	110*

Figure 6 Generic bus lane capacity values from TCQSM

If the generic capacity value of 100 buses per lane per hour is used as the threshold for the relocation of bus services from the Golden Mile then this is likely to result in further delays for public transport services. This is because 100 buses per lane per hour exceeds the calculated capacity of bus stops along Manners Street, Willis Street and some stops on Lambton Quay (see Tables 1-2 to 1-9). Furthermore, 100 buses per lane per hour is materially higher than the current bus volumes along the Golden Mile (69 southbound and 81 northbound at Willis Street). The Golden Mile is already one of the slowest and least reliable parts of the Wellington bus network with average operating speeds of between 8 to 10 km/hr during peak times. Therefore, to achieve higher public transport operating speeds and reliability the number of buses which use the Golden Mile should be reduced rather than increased.

13 Recommended Capacity Threshold for Let's Get Wellington Moving

The following section discusses the potential thresholds for relocating bus routes from the Golden Mile onto alternative corridor(s) based on the assessment of capacity using both current (2020) and future (2060) demands and bus volumes.

It is understood that the Golden Mile project is proposing to remove the Manners Street at Willis Street bus stop with passengers using the nearby stops of Manners Street at Cuba Street – Stop B or Willis Street at Grand Arcade. The reason for this recommendation is that the Manners Street at Willis Street stop is unpaired (eg there is no bus stop on the opposite side of the road) and the nearest alternative bus stop is 260m, or 3min walk away. This technical note supports the recommendation to consolidate the Manners Street at Willis Street bus stop because it would remove the stop along the Golden Mile with the lowest capacity.

Assuming the consolidation of the Manners Street at Willis Street bus stop the recommended capacity threshold (using the upper limit failure rate as outlined above) is 50 to 60 buses per hour per direction. This recommendation takes account of the capacity limitations of the remaining bus stops on the corridor and seeks to balance public transport operating speeds and reliability whilst making the most use of the Golden Mile corridor.

14 Example of bus volumes versus stop capacity

The following graphs provide a detailed illustration of the bus volumes using the Lambton Central (near 171) stop and the calculated capacity thresholds of the stop.

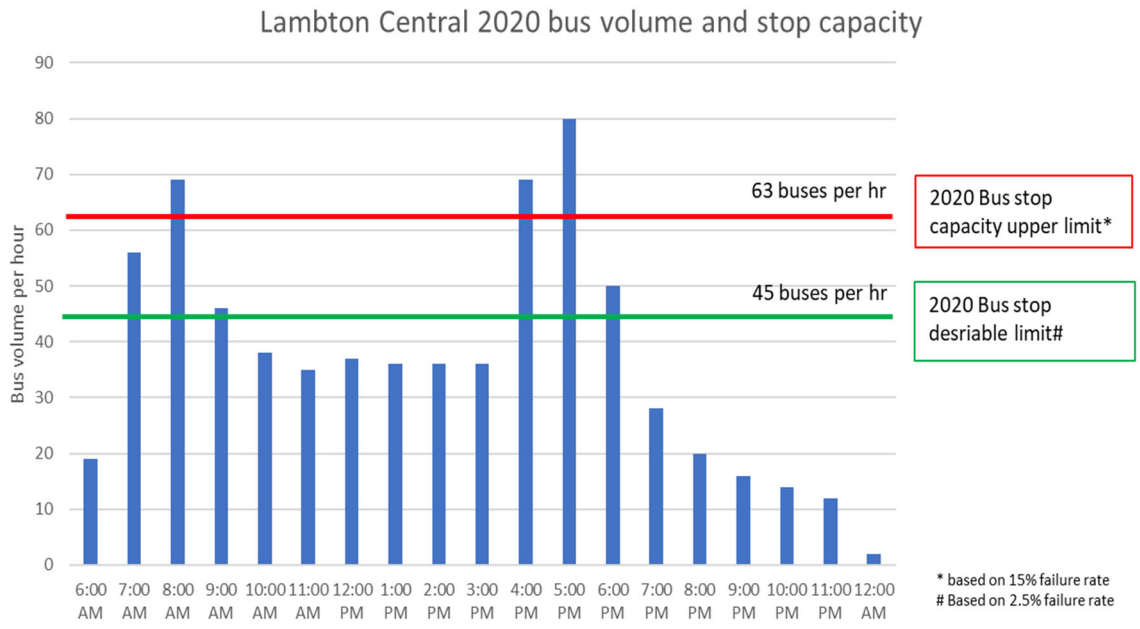


Figure 7 Graph showing 2020 bus volume by time of day with desirable capacity limit as green line and upper capacity limit as red line

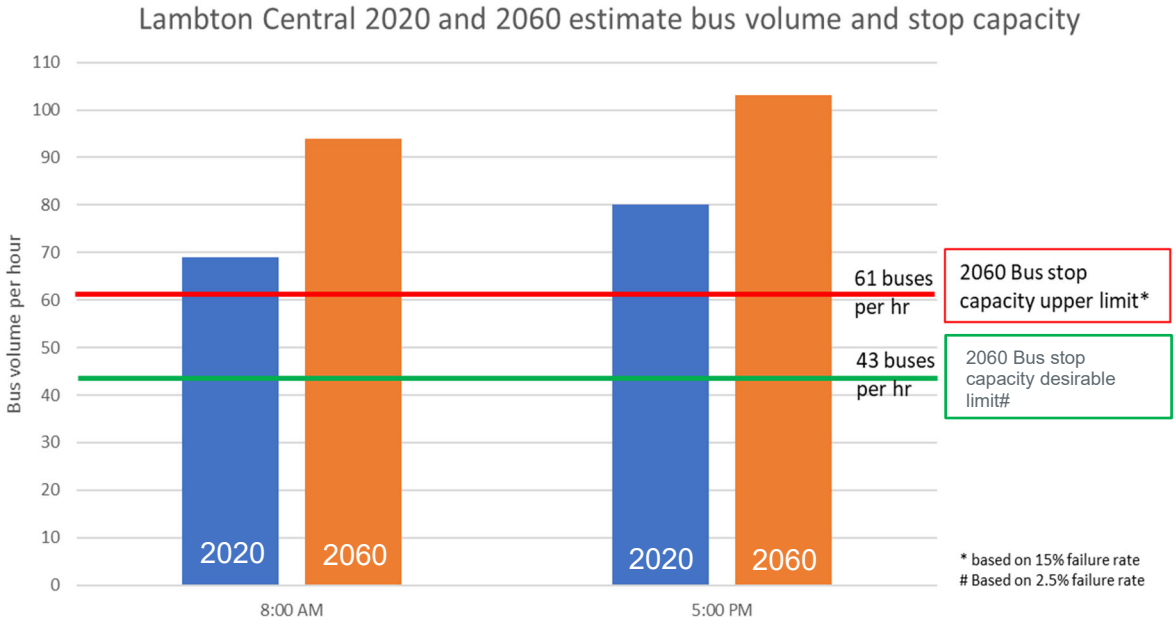


Figure 8 Graph showing estimated 2060 bus volumes in morning and afternoon peak with desirable capacity limit as green line and upper capacity limit as red line. Bus volumes in 2020 also shown for comparison.

15 Caveats and limitations

The Golden Mile bus stop capacity assessment has the following limitations:

- Bus stop capacity is influenced by factors which have a high degree of variability including the number of passengers, the speed at which passengers board/alight and how quickly the bus driver leaves the stop. Therefore, the level of congestion at bus stops will vary from day to day with average values having been used for the capacity calculations;
- Traffic signals are controlled by SCATs system which dynamically shortens or lengthens the phases based on real time traffic conditions. Therefore, the amount of green time that buses receive can vary with average phase lengths being used for the calculations;
- Assumptions around the mix of ticket types (cash/ snapper/ super gold) may change along with time taken to board and alight passenger as front door only boarding has been assumed at this stage; and
- The future year scenarios assume a 1% patronage growth rate informed from previous assumptions established during the Let's Get Wellington Moving Programme Business Case. Future public transport patronage and bus volumes may be higher or lower than the level assumed.