

Appendix B14 Technical Note 38: SH6 Frankton East Corridor Operation and Future Performance

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Technical Note #38

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SH6 Frankton East Corridor Operation & Future Performance

Executive Summary

This note sets out the results of an assessment of the suitable form of intersections required along the SH6 Frankton-Ladies Mile Highway section of the network, from SH6/SH6A to Shotover Bridge.

This technical note provides a detailed assessment of the operation of the SH6 Eastern Corridor under two different design layout concepts:

- signalised roundabouts at SH6/Hawthorne Drive and SH6/Grant Road, and conventional signalised intersections elsewhere
- conventional signalised intersections across the corridor

The signalised roundabout arrangements require less land take along the corridor, as the roundabouts are generally more efficient than conventional intersections. In terms of impact, the conventional intersections arrangements require the following additional widening requirements to provide a similar level of performance to the roundabout option:

- SH6/Hawthorne Drive
 - Extra approach lane on Hawthorne Drive
 - Extra approach lane on SH6 East, and exit lane of SH6 West
 - Extra short right turn lane on SH6 East
 - Extra short left turn lane on SH6 West
- SH6/Grant Road, SH6/Hansen Road and SH6/Joe O'Connell Drive
 - Extra westbound approach lane on SH6 East, and exit lane of SH6 West

The assessment has indicated the following:

- The two layout options have a similar level of traffic capacity at all intersections, and are both compatible with the preferred intersection layout at the key SH6/SH6A intersection
- Bus and general traffic travel times, and individual intersection performance is similar in both options – providing a compatible level of capacity and performance to the proposed upgrades to adjacent parts of the road network
- At-grade pedestrian provision and pedestrian delay is generally better in the conventional intersection layouts, although in this option there are still some locations where crossings cannot be provided (east side of SH6/Hawthorne Drive) or need to be staggered (at SH6/Hansen Road and SH6/Joe O'Connell). At SH6/Grant Road, a grade-separated solution (underpass or bridge) would need to be provided across SH6 in the roundabout option
- The signalised roundabout arrangements allow U-turn movements to continue to be accommodated which is a useful feature in the network particularly as land use is built-up along the corridor (with an associated increase in kerbside activity)

A separate multi criteria assessment of the two options has also been undertaken. This evaluation also shows little overall difference between the two options in terms of bus and general traffic travel times and overall network performance. The roundabout option scores higher for the need for less land-take along the corridor, alignment with the Frankton masterplan, and road safety. The conventional arrangement scores higher for pedestrian provision and supporting future land use development.

In summary, both Options provide a high level of benefits over the existing intersection form, with the decision being a choice between the relative importance of the various trade-offs in costs and benefits, and the consideration of other scheme objectives.

Introduction

This note sets out the results of an assessment of the suitable form of intersections required along the SH6 Frankton-Ladies Mile Highway section of the network, from SH6/SH6A to Shotover Bridge. This is a key transport link within the Regional road network, providing the main route to/from the north and east to both Frankton and Queenstown.

The existing link provides a number of access points to local land use (see Figure 1):

- Joe O'Connell Drive (south side), access to Queenstown Events Centre
- Hansen Road (north side), access to City Impact Church and Lake Johnson
- Grant Road (south side), access to Five Mile and Queenstown Central mixed-use developments and Frankton Flats zoning
- Hawthorne Drive (south side), access to Queenstown Central mixed-use development, other large retail, warehouse units (on Hawthorne Drive and Glenda Drive) and Shotover Park zoning, and the Hawthorne Drive link through to Remarkables Park Town Centre (and the area south of the airport runway)
- Hardware Lane (south side), access to Glenda Drive (from westbound SH6 only)

In addition, a fourth arm at the SH6/Hawthorne Drive intersection is planned to access the Quail Rise residential area (existing and future), as an extension to Ferry Hill Drive

Land use intensification is expected on both sides of SH6, but particularly on the north side which is currently principally made up of single rural residential or commercial properties. This will have the effect of urbanising the corridor, and therefore increasing vehicular and pedestrian movements both along and across the corridor.

Consequently, the optimum arrangement for the corridor is focussed on achieving a good level of operation for all modes, and particularly public transport and active modes. It should be noted that a (separately reported) Multi-Criteria Assessment (MCA) has also been undertaken on upgrade options, so as to ensure that the options are evaluated against the wider project objectives, implementability and an assessment of effects criteria.

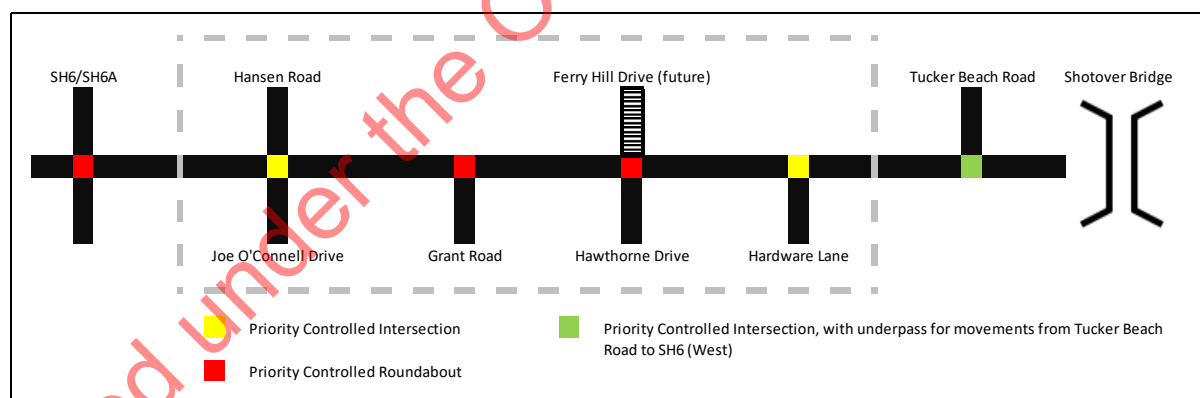


Figure 1: Schematic of the Intersection Form on the Existing Link

Background

Previously, analysis of the SH6/Joe O'Connell/Hansen Road intersection was undertaken for the previous SH6 Grant Road to Kawarau Falls Bridge ("GR2KFB") Single Stage Business Case in 2018. This indicated that signalising the intersection was required so as to improve road safety and access/egress to and from the two side road links. A roundabout upgrade was discarded at that time due to the additional land requirements and the lack of ability to provide segregated or protected (at-grade) pedestrian and cyclist crossing facilities.

A refresh of this work in line with the extension of the QTC DBC and F2Q SSBC project into Frankton was undertaken in 2019, with the scope extended out to the section of SH6 Frankton-Ladies Mile Highway through to the SH6/Tucker Beach Road intersection (just to the west of Shotover Bridge).

This note provides analysis of the short-listed concepts and layouts considered at each of these intersections – each intersection is looked at in isolation, but within the context of the operation of the whole section.

The SH6 Frankton east corridor performs an important movement function for Frankton, Queenstown and the wider regional State Highway network, and as such is classified as a Regional State Highway under the One Network Road Classification system, and so restricting this movement function will have a detrimental effect on the local and regional economy.

REGIONAL



Demand for suitable development land in and around Queenstown has seen the recent District Plan review and current Spatial Plan exercise rezone the land north of SH6 as Business Mixed Use, Medium and High Density Residential that will result in the increasing vehicular and pedestrian movements both along and across the corridor.

Shortlisted Corridor Options

In essence, two main options have been considered along the corridor:

- OPTION 1:
 - Signalise the existing roundabout at Grant Road
 - Signalise the existing roundabout at and Hawthorne Drive
 - Signalise the existing intersection as a T-intersection at Joe O'Connell Drive
 - Re-align Hansen Road and create a new signalised T-intersection between Joe O'Connell Drive and Grant Road
- OPTION 2:
 - Convert the existing roundabout at Grant Road to conventional signalised T-intersection
 - Convert the existing roundabout at Hawthorne Drive to conventional signalised X-intersection
 - Signalise the existing intersection as a T-intersection at Joe O'Connell Drive
 - Re-align Hansen Road and create a new signalised T-intersection between Joe O'Connell Drive and Grant Road

In addition to, and due to the characteristics of each of the two options, there are further variations possible for the provision of pedestrian crossing facilities at each location, both sub-grade and at-grade (or combinations of both).

There are various advantages and disadvantages of each set of options (which could be mix and matched, both on the corridor and with the alternative options at the SH6/SH6A intersection), in terms of primary traffic impacts (operational performance, pedestrian provision) and secondary effects (land use enhancement, property requirements). This note concentrates on the former (as a technical note on operation), but other impacts are also considered throughout the commentary. As noted above, a (separately reported) Multi-Criteria Assessment (MCA) has also been undertaken on upgrade options, so as to ensure that the options are evaluated against the wider project objectives, implementability and an assessment of effects.

Traffic Modelling

Traffic modelling has been undertaken at all intersections along the corridor, with equivalent assumptions used for both options outside of the immediate area around the SH6/SH6A Junction. In terms of demand, the "NZUP 2028 Bus Max" option has been used – this sees a significant growth in general traffic trips compared to the (2018) base, with a larger still increase in public transport patronage, related to the wider package of transport network interventions planned as part of the DBC/SSBC work.

Assessments have been carried out in LinSig (a small signalised-network assessment tool) and S-Paramics (a micro-simulation network analysis tool). In terms of process, the LinSig model was used to develop the optimum phasing arrangement and resultant signal timings, with these timings then

entered into the S-Paramics model for fine tuning. However, for the purposes of this note, the LinSig output is reported to show a comparison of likely performance between each option (and variation).

Consequently, output is presented in the sections below for six sets of analytics:

- Ratio of Flow to Capacity (RFC) - LinSig
- Mean Maximum Queue - LinSig
- Intersection delay per movement – LinSig
- Travel times for buses – Paramics
- Travel times for general traffic – Paramics
- Visualisations (general indication of network performance and queue lengths) – Paramics

The results are presented in two sections – firstly individual intersections are shown, which demonstrates the operation of each intersection in an isolated sense (from the LinSig model).

Then follows a separate section on network performance as modelled in Paramics.

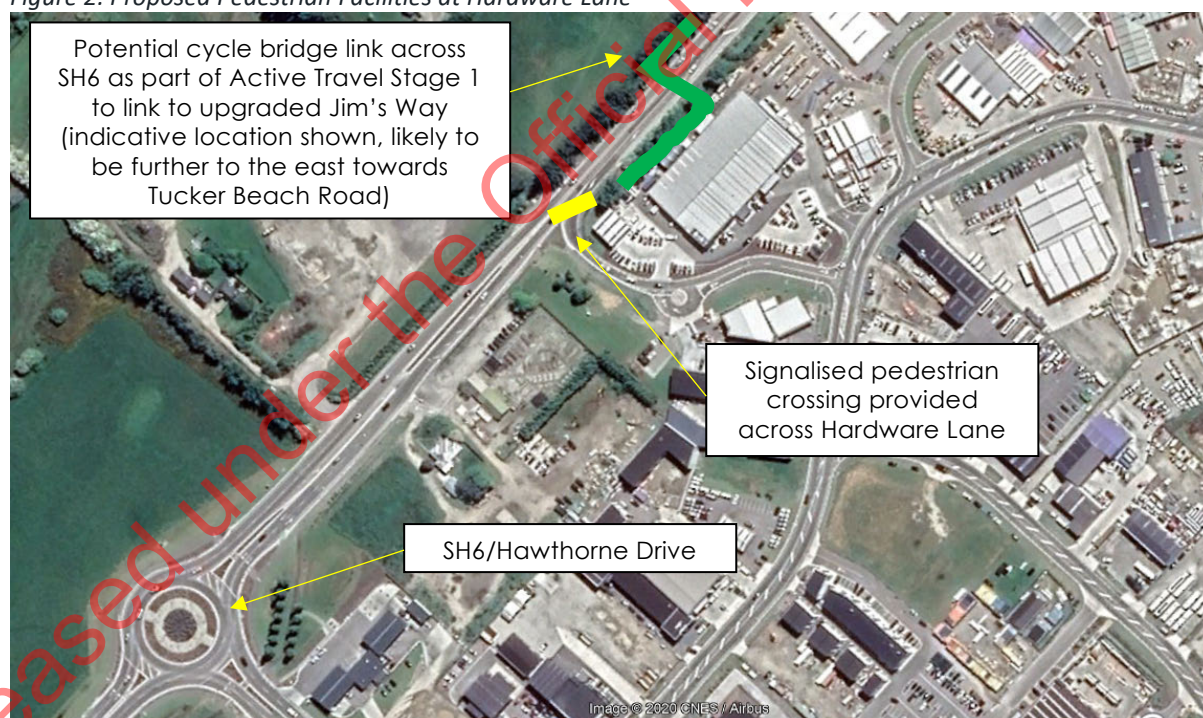
Individual Intersection Results

Hardware Lane

It is not expected that a full intersection will be provided at Hardware Lane. However, in order to enable a safe crossing of Hardware Lane itself, it is proposed that a pedestrian crossing be installed across the left turn movement from westbound SH6 into Hardware Lane. There is not an operational issue in terms of performance of this facility, the critical element is that the layout provides a safe crossing point.

Figure 2 shows an indicative layout of this facility.

Figure 2: Proposed Pedestrian Facilities at Hardware Lane



In terms of crossing SH6 in the vicinity of Hardware Lane, there is currently an uncontrolled pedestrian refuge immediately west of the Hardware Lane intersection, which mainly serves a link to an Eastbound bus stop in the vicinity. A signalised crossing point is not considered possible at this point due to traffic capacity concerns, particularly in the PM peak, when there is very little spare capacity in the eastbound direction.

As part of the Active Travel Stage 1 Design & Construction, a pedestrian/cycle bridge further to the east is being considered, to link from an upgraded track along Jim's Way to the north-east, across to Hardware Lane – which would then link through to the at-grade pedestrian crossing set out in Figure 2.

As will be set out in the next section, it is also difficult to establish crossing provision on the east leg of the Hawthorne Drive intersection – and therefore such a grade-separated solution to the east would provide an alternative route across SH6 in this part of the network.

Hawthorne Drive

At the Hawthorne Drive intersection, three options were considered:

1. Signalising the existing roundabout, with some road widening to provide bus lanes in each direction
2. Convert to a signalised X-intersection, with more road widening to provide bus lanes in each direction
3. Convert to a signalised X-intersection, with less road widening to provide bus lanes in each direction (similar land take to signalised roundabout option)

It is important to note that the Ferry Hill Drive extension (as part of the Quail Rise HIF) is planned to add a fourth (north) arm at this intersection, and in all options, this has been considered to be included.

Signalised Roundabout

A signalised roundabout arrangement was devised with the signalisation of three of the four legs (Ferry Hill Drive leg remains priority controlled, as the volumes are much lower than the other three legs), which is shown in Figure 3.

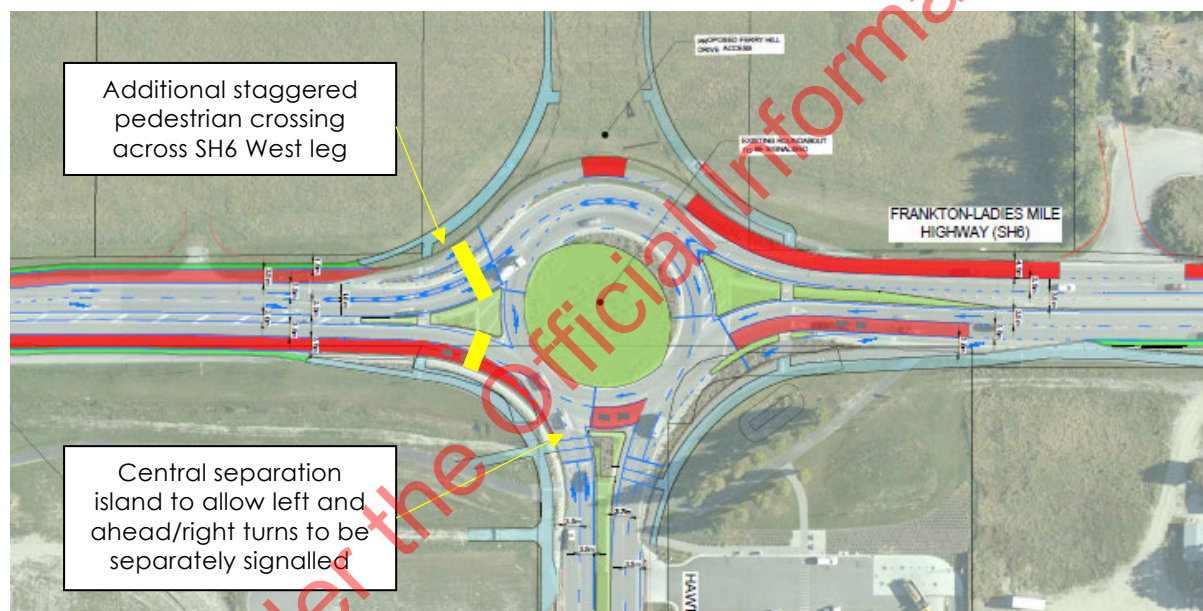


Figure 3: Signalised Roundabout Option at SH6/Hawthorne Drive

The roundabout includes the following features:

- Kerbside bus lanes provided in both directions – in the case of the eastbound direction, the bus lane would terminate at the point of the existing merge (opposite Hardware Lane) on the approach to Shotover Bridge. This means that the existing downstream eastbound merge from two lanes to one lane is retained, but only as a merge between buses and general traffic – each approach only feeds a single stream of traffic into the downstream merge, which is predicted to improve flow through this section of the network (principally in the PM peak)
- Staggered fully protected pedestrian crossings are provided on the south and west arms. Due to operational constraints, a crossing on the east arm is not possible to be incorporated into the operation – and the demand across this side of the intersection will be relatively low (most potential future land use is to the west, except for a limited amount of additional medium-high density housing related to the Quail Rise development to the east). Additionally, it is also difficult to provide a crossing on the north leg, without adding an additional short lane on the eastbound approach, which would need to cross the bus lane near the signal limit line. Consequently, at this time, it is assumed that an uncontrolled crossing would be sufficient across this arm, given the low traffic volumes – the recent upgrade to the Tucker Beach Road intersection has provided a safer route for traffic from this link to SH6 westbound, and therefore Ferry Hill Drive is forecast to carry a relatively low level of access-only traffic

- In terms of operation, for the SH6 East and Hawthorne Drive approaches, passing through a green at the entry limit line would also receive a green at the downstream circulatory limit line, and so vehicle queues on the circulatory lanes at these points would be very low (only traffic moving to/from Ferry Hill Drive would get delayed at the circulatory stop line. For traffic arriving on the SH6 West approach, right turns into Hawthorne Drive would be held at the circulatory stop line, but this has been widened to two lanes to ensure there is sufficient stacking space to accommodate the predicted queue without blocking back to the upstream entry limit line
- It is expected that the signal cycle time will need to be relatively high at the intersection to maintain capacity – and in all three periods, the models assume a 120 second cycle time

The results show that in the AM peak and Interpeak periods, operation is satisfactory. There are relatively high delays to traffic on the Hawthorne Drive approach, but operation is within capacity, and is generally just a function of the high cycle time. Also, high delay is experienced on the right turn movement into Hawthorne Drive, but this is a function of the operation, in that these vehicles wait at the circulatory stop line – so essentially receive delay at two separate parts of the intersection.

In the PM peak, operation of the SH6 West ahead and Hawthorne Drive right turn is just above capacity. However, this is a function of the downstream single lane constraint on the approach to Shotover Bridge – this is being better controlled in this option, by removing the merge (except for a few buses per hour). Providing more capacity at this intersection for these movements (by providing two through and/or right turn lanes for example) would flood the downstream merge, and result in queues back to the intersection, resulting in poorer performance – much as what happens on occasion in the existing situation, but on a more regular basis and for a longer period of time, as the operation of the merge point would struggle to recover to a free-flow condition.

In all three peak periods, bus delay for the through movements along SH6 is low (around 20 seconds) showing the benefits of the bus lanes on the approaches. Any buses approaching on the Hawthorne Drive arm, however, would encounter significant delay in the PM peak period due to the lack of priority on this approach (note, currently no service buses use this route, but it is possible a low frequency service may be introduced in the future).

Consequently, it is concluded that the operation of the signalised roundabout option is satisfactory in terms of vehicular operation.

Table 1 shows the results of the operational assessment of the signalised roundabout option. In this table, and all subsequent tables for these sets of results:

- Dedicated bus lane movements are shown in blue
- RFC values are banded:
 - **Red**: >100% (i.e. above capacity)
 - **Orange**: 80-100% (approaching practical capacity)
- Delay values are banded:
 - LOS F: **Red**
 - LOS E: **Orange**
 - LOS D: **Yellow**
 - LOS A to C: **Green**

The results show that in the AM peak and Interpeak periods, operation is satisfactory. There are relatively high delays to traffic on the Hawthorne Drive approach, but operation is within capacity, and is generally just a function of the high cycle time. Also, high delay is experienced on the right turn movement into Hawthorne Drive, but this is a function of the operation, in that these vehicles wait at the circulatory stop line – so essentially receive delay at two separate parts of the intersection.

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Consequently, it is concluded that the operation of the signalised roundabout option is satisfactory in terms of vehicular operation.

Table 1: SH6/Hawthorne Drive – operational performance (2028) with signalised roundabout

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
SH6 West	Bus Lane + Left	3%	1	13	4%	1	16	6%	1	22
	Ahead	56%	21	13	71%	13	36	100%	49	114
	Right Turn	56%		60	71%		65	100%		119
Ferry Hill Drive	Left	9%	1	6	6%	1	9	11%	1	18
	Ahead			35			29			27
	Right			76			74			77
SH6 East	Left Turn	29%	5	14	20%	3	18	25%	4	20
	Bus Lane	3%	1	14	3%	1	16	3%	1	19
	Ahead	83%	28	37	72%	20	36	65%	15	35
	Right			81			86			102
Hawthorne Drive	Left Turn	61%	7	64	58%	9	51	37%	6	40
	Ahead	77%	15	58	85%	22	58	105%	81	183
	Right			62			64			202
Intersection LOS		C			C			E		

Table 2 shows the predicted pedestrian travel times to traverse the intersection – note as the crossing on the north arm is not signal controlled (but has low conflicting traffic volumes) a nominal 10 second delay per pedestrian has been assumed for journeys that incorporate this movement. In this table, and all subsequent tables for these sets of results:

- Delay values are banded:
 - Delay less 60 seconds
 - Delay less than 2 minutes
 - Delay less than 3 minutes
 - Delay more than 3 minutes

The results show that pedestrian journey times are high, with movements across one leg of the intersection (either the west or south) seeing a delay of around 90-120 seconds (or up to 2 minutes), with journeys across both of these legs increasing to around 200 seconds (over 3 minutes). This is a function of the high cycle time, and staggered nature of the pedestrian provision, and is a definite disadvantage of the option – albeit, pedestrian crossing volumes are likely to be minimal in the short-to-medium term until there is significant levels of development on the north side of SH6 through this section of the network. However, it does indicate that passengers boarding and alighting public

transport services on the north side of SH6 (to access development on the south side) would see considerable delay in crossing SH6 at this location under this option.

Table 2: SH6/Hawthorne Drive – pedestrian delay in seconds (2028) with signalised roundabout

From	To	AM peak	Interpeak	PM Peak
North-East	North-West	10	10	10
	South-East	194	199	202
	South-West	94	100	106
North-West	North-East	10	10	10
	South-East	184	189	192
	South-West	84	90	96
South-West	North-East	131	126	119
	North-West	121	116	109
	South-East	87	97	101
South-East	North-East	224	219	216
	North-West	214	209	206
	South-West	121	111	107

In summary:

- The option has benefits in terms of relatively low additional footprint compared to the existing situation (some widening is required along the north side of SH6), which has a secondary benefit in terms of minimal disruption during construction
- Recently newly constructed infrastructure cost is better utilised as it is not ripped out and replaced early in its life
- The performance of the intersection is satisfactory in terms of capacity, notwithstanding the downstream issue of Shotover Bridge. However, the restriction of single lanes for the movements towards the bridge removes the merging issue that currently causes problems in the network in the PM peak, and also provides bus priority right up to this point – so bus delay is minimal
- Pedestrian delay is high, and protected facilities can only be provided on the west and south approaches, albeit this is where crossing demand is likely to be highest
- Although dwell times are long at grade pedestrian crossing, they provide more priority, mobility, and personal safety (CPTED) when compared to grade separated options
- Signalised pedestrian crossing supports future land use development north of the corridor and along the corridor
- Maintaining four lanes mid-block supports the Frankton Masterplan concept of the 'Urban arterial' when future land use development is realised to the north and south of the state highway

Signalised Intersection – With Widening

A signalised intersection arrangement was devised (to incorporate the addition of the fourth Ferry Hill Drive leg, which is shown in Figure 4. It is important to note that there is an intended imbalance in through lane provision on SH6 at this intersection (and elsewhere on the corridor) - two eastbound ahead lanes are required, with only a single eastbound through lane. This is due to the high right turn volumes into Hawthorne Drive (and Grant Road) conflicting with the westbound through traffic, but which can run in parallel with the eastbound through,

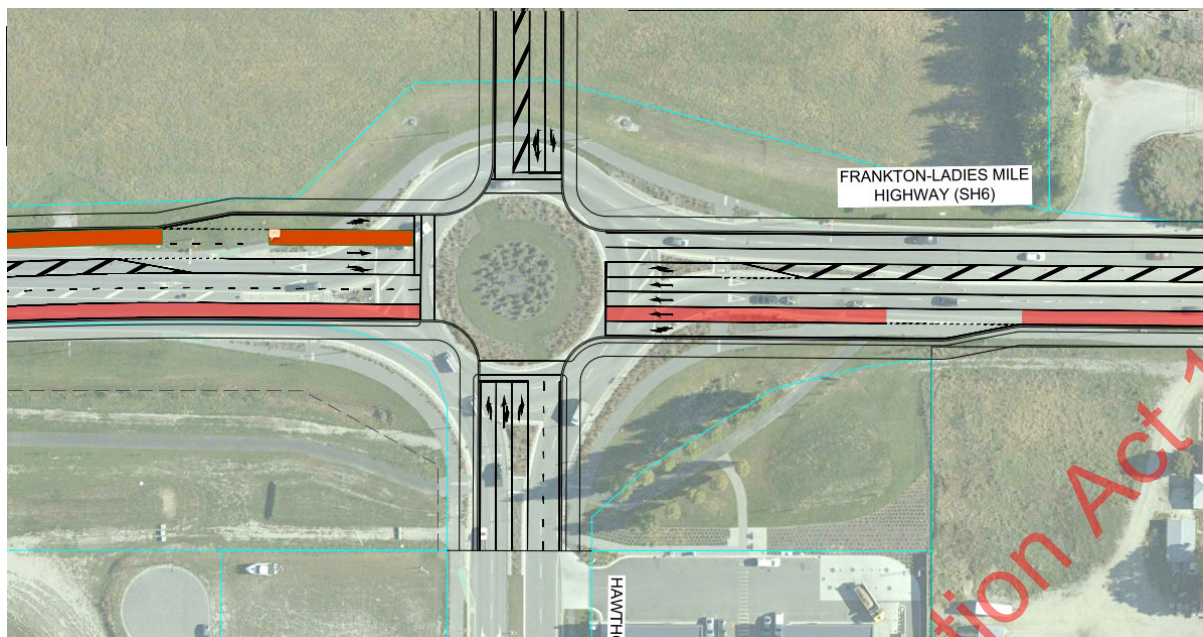


Figure 4: Signalised Intersection Option at SH6/Hawthorne Drive

The signalised intersection includes the following features:

- Kerbside bus lanes provided in both directions – in the case of the eastbound direction, the bus lane terminates at the limit line, but essentially a virtual bus lane operates on the exit from the intersection, with the buses merging back into a single stream of traffic at the merge point
- Fully protected straight (one stage) pedestrian crossings are provided on the south, north and west arms. Due to operational constraints, a crossing on the east arm is not possible to be incorporated into the operation – and the demand across this side of the intersection will be relatively low (most potential future land use is to the west)
- A number of additional lanes are required at the intersection to establish sufficient capacity to accommodate the demand – this also results in these additional lanes being required through the rest of the Eastern corridor (Hardware Lane to SH6/SH6A intersection):
 - Additional westbound traffic lane on SH6 (compared to roundabout option)
 - Additional approach lane on Hawthorne Drive, to enable two right-turn lanes at the intersection. This means that the existing downstream eastbound merge from two lanes to one lane is retained, but only as a merge between general traffic turning from Hawthorne Drive (as above the single eastbound ahead traffic lane on the approach to the intersection allows eastbound buses to merge more easily) – the operation is such that these two lanes of right turn vehicles are able to merge at the downstream pinch point and clear the intersection prior to the eastbound ahead vehicle phase at the SH6/Hawthorne Drive intersection, so that buses do not join the end of a queue of vehicles waiting to merge. However, this operation does result in a poorer operation at the merge point compared to the signalised roundabout option
 - Additional localised widening (and re-alignment) on the SH6 East, SH6 West and Ferry Hill Drive approaches so as to provide additional left and/or right turn lanes
- In terms of operation, a 5-phase operation is proposed as shown in Figure 5, with all vehicular moves allowed (except U-turns).
- It is expected that the signal cycle time will need to be relatively high at the intersection to maintain capacity – and in all three periods, the models assume a 120 second cycle time. The models assume all pedestrian crossing movements are called in every cycle – should pedestrian calls be less frequent, this would have negligible impact on the operation of the intersection, as the pedestrian crosswalks all operate by holding back non-critical traffic movements (the left turns from the west, east and south) – in any case, it is expected that as development occurs on the north side of SH6, pedestrian crossing demand will increase

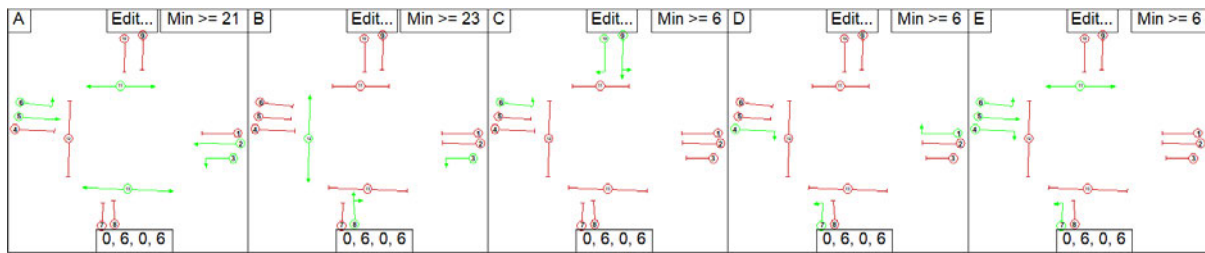


Figure 5: SH6/Hawthorne Drive - Signalised Intersection Phase Arrangement

Table 3 shows the results of the operational assessment of the signalised intersection option.

Table 3: SH6/Hawthorne Drive – operational performance (2028) with signalised intersection

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
SH6 West	Left	3%	1	12	5%	1	15	8%	1	16
	Bus Lane	3%	1	7	3%	1	13	3%	1	12
	Ahead	54%	7	15	70%	11	26	89%	18	94
	Right Turn	67%		56	64%		60	89%		68
Ferry Hill Drive	Left + Ahead	21%	1	77	8%	1	71	28%	1	77
	Right Turn	33%	1	81	22%	1	77	14%	1	75
SH6 East	Left Turn	45%	8	28	29%	4	29	32%	5	27
	Bus Lane	3%	1	25	3%	1	32	3%	1	29
	Ahead	85%	19	39	77%	12	44	61%	9	36
	Right	2%	1	71	1%	1	71	1%	1	71
Hawthorne Drive	Left Turn	69%	7	70	77%	10	67	73%	8	69
	Ahead	64%	8	57	71%	11	54	101%	55	139
	Right Turn			65			65			216
Intersection LOS		D			D			E		

The results show that in the AM peak and Interpeak periods, operation is satisfactory. There are relatively high delays to traffic on the Hawthorne Drive, Ferry Hill Drive and right turn movements from SH6, but operation is within capacity, and is generally just a function of the high cycle time.

In the PM peak, operation of the Hawthorne Drive right turn is just above capacity. This is a function of the downstream single lane constraint on the approach to Shotover Bridge – traffic from Hawthorne Drive is turning from two lanes, and therefore must merge at Hardware Lane back to the single lane. Therefore, traffic is held back on this right turn at the intersection to ensure that the queue from the merge does not stretch back to the intersection (and impact on other movements). The RFC predicted for this movement is very similar to the signalised roundabout option, albeit the through eastbound movements is improved (89% versus 100%).

In all three peak periods, bus delay for the through movements along SH6 is low (less than 30 seconds) showing the benefits of the bus lanes on the approaches. As for the signalised roundabout option, any buses approaching on the Hawthorne Drive arm would encounter significant delay in the PM peak period due to the lack of priority on this approach (note, currently no bus services use

this route, but it is possible a low frequency service may be introduced in the future) – and in this option there is less scope to introduce a bus lane on this approach, as widening is already needed to provide the additional right turn lane.

Consequently, it is concluded that the operation of the signalised intersection option is satisfactory in terms of vehicular operation – but additional land take along the corridor and implementation cost would be required compared to the signalised roundabout option, to achieve a similar level of operation. In terms of the future built form context this widening of the corridor does not align particularly well with the 'urban arterial' concept in the Frankton Masterplan. A widening to 6-7 lanes in this option undermines the ability to have meaningful relationships between buildings across the street and the ability to frame the street with strong built form edges.

Table 4 shows the predicted pedestrian travel times to circumvent the intersection.

Table 4: SH6/Hawthorne Drive – pedestrian delay in seconds (2028) with signalised intersection

From	To	AM peak	Interpeak	PM Peak
North-East	North-West	56	56	56
	South-East	140	146	142
	South-West	104	98	98
North-West	North-East	56	56	56
	South-East	92	104	100
	South-West	56	56	56
South-West	North-East	80	86	86
	North-West	56	56	56
	South-East	56	56	56
South-East	North-East	111	105	109
	North-West	87	75	79
	South-West	56	56	56

The results show that pedestrian journey times are relatively high, but significantly lower than those experienced in the signalised roundabout option – this shows a clear benefit of this option, due to the full (non-staggered) nature of the crossings.

In summary:

- The option has benefits in terms of pedestrian delay over the signalised roundabout option, albeit pedestrian volumes are likely to be modest at this location
- The performance of the intersection is satisfactory in terms of capacity, notwithstanding the downstream issue of Shotover Bridge. However, the restriction of the eastbound single lane for the movement towards the bridge reduces the merging issue that currently causes problems in the network in the PM peak, which is important in terms of maintaining good bus journey times along eastbound SH6. However, there is a risk that providing two right turn lanes from Hawthorne Drive will still result in some occasions of queues blocking back from the downstream merge point to the intersection
- The option has dis-benefits in terms of requiring more significant road widening, particularly on the SH6 West, SH6 East and Hawthorne Drive approaches, removal of newly constructed assets and construction cost
- At grade pedestrian crossing provides more priority, mobility, and personal safety (CPTED) when compared to grade separated options

- Signalised pedestrian crossing supports future landuse development north of the corridor and along the corridor.
- The provision of 6-7 lanes widens the carriageway such that it performs weakly against the aspiration of the Frankton Masterplan 'Urban arterial' concept.

Signalised Intersection – Without Widening

Initially, an alternative arrangement was also considered for a conventional signalised intersection which did not require any additional lanes to be provided on SH6 or Hawthorne Drive – that is, for a single traffic lane and single bus lane to be provided in each direction on SH6, similar to the signalised roundabout option. Whilst this option has advantages in terms of reducing pedestrian crossing distances, providing a strong future urban aesthetic and minimising land requirements, this alternative was eliminated at an early stage due to the poor operational performance.

Table 5 shows the results of the operational assessment of this signalised intersection option.

Table 5: SH6/Hawthorne Drive – operational performance (2028) with reduced-size signalised intersection

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
SH6 West	Left	4%	1	10	6%	1	18	8%	1	17
	Bus Lane	3%	1	7	3%	1	5	3%	1	5
	Ahead	55%	7	20	75%	13	32	94%	22	44
	Right Turn	61%		60	77%		66	94%		80
Ferry Hill Drive	Left + Ahead	21%	1	75	8%	1	74	26%	1	82
	Right Turn	33%	1	81	22%	1	77	14%	1	75
SH6 East	Left Turn	45%	8	28	26%	4	25	31%	5	25
	Bus Lane	3%	1	24	3%	1	25	3%	1	29
	Ahead	120%	123	382	116%	80	327	94%	16	75
	Right	2%	1	70	1%	1	70	1%	1	70
Hawthorne Drive	Left Turn	69%	7	70	101%	18	171	80%	9	81
	Ahead	122%	61	418	118%	77	368	179%	256	951
	Right Turn			420			371			956
Intersection LOS		F			F			F		

The results show that in all three periods, operation is very poor, particularly for the Hawthorne Drive and SH6 East approaches. This demonstrates that the provision of the minimum number of lanes at the intersection in order to reduce pedestrian crossing times and limit land requirements is not a feasible option in terms of performance.

Signalised Intersection Variations

A number of variations were considered to the signalised intersection layout, mainly to improve operational efficiency and pedestrian provision:

- Additional full pedestrian crossing on east side of the intersection – models showed RFC for critical movements of over 120% in the Interpeak and 160% in the PM peak period. Although, at least in the short-medium term, it is unlikely that this crossing would be demanded every cycle, the significant detrimental impact in providing this crossing is considered a fatal flaw

- Additional staggered pedestrian crossing on east side of the intersection – models showed RFC for critical movements of over 120% in the AM and PM peak periods. Again, it is unlikely that this crossing would be demanded every cycle, but there would still be a significant detrimental impact if this crossing were called even 10 times an hour (33% hit rate). In addition, as the other three legs have full crossings, there would be an inconsistency in provision which may cause confusion. Therefore, this has also been considered to be fatally flawed
- Initially an additional eastbound through lane was considered as part of the signalised intersection design. However, this comes at significant additional cost (land take and construction), and as shown for the PM peak results above, the constraint is the pinch point towards the Shotover Bridge – and therefore the additional lane would just serve as extra stacking space for the queue. In addition, the previous two options have attempted to remove (or partially remove) the merging issues by better controlling the throughput towards the merge point – which would be eroded by providing two eastbound lanes (as in the existing situation). Therefore, this option has also been discarded

Therefore, the signalised roundabout and signalised intersection options (as described in the sections above) are considered appropriate for further consideration.

Summary

The analysis of the SH6/Hawthorne Drive has shown that:

- Operational performance is similar between the two options
- Pedestrian provision is better in the conventional arrangement, which allows full straight crossings to be provided on three of the four arms of the intersection
- Land take – higher in conventional arrangement, which requires more widening on all four approaches, as well as additional widening along the corridor to provide an additional westbound lane

The choice of preferred option therefore comes down to the respective aims and objectives of the overall programme – as a balance between additional widening (and cost) of the conventional option against the improved pedestrian provision and land use opportunities that this option would bring.

Grant Road

At the Grant Road intersection, two options were considered

1. Signalising the existing roundabout, with some minor road widening to provide bus lanes in each direction
2. Convert to a signalised X-intersection, with more road widening to provide bus lanes in each direction

Signalised Roundabout

A signalised roundabout arrangement was devised with the signalisation of all three legs, which is shown in Figure 6.

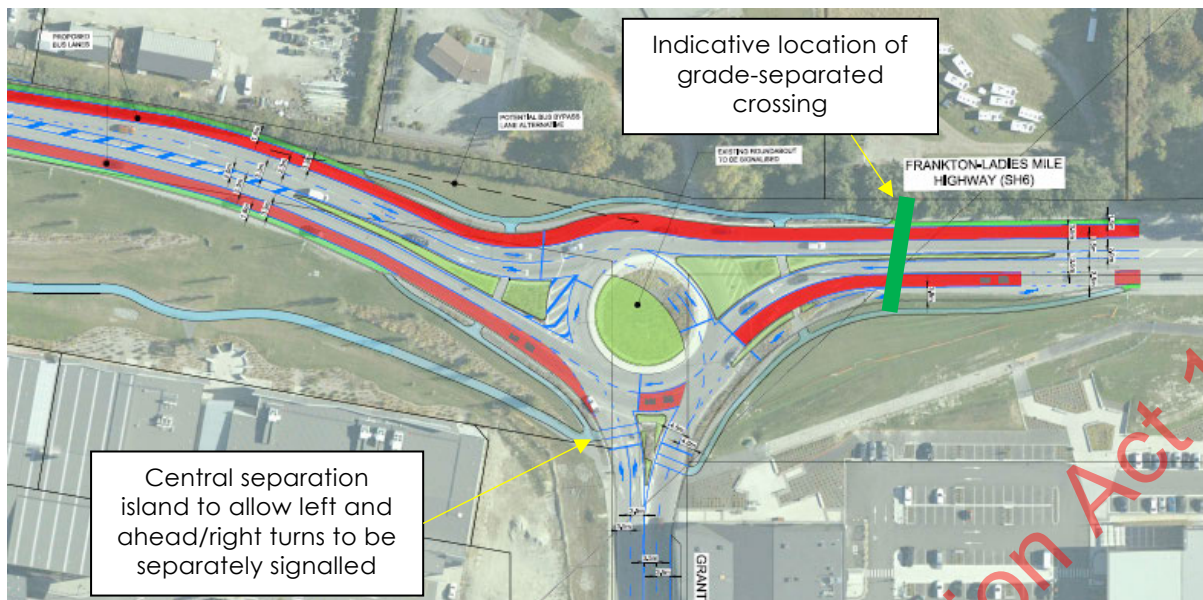


Figure 6: Signalised Roundabout Option at SH6/Grant Road

The roundabout includes the following features:

- Kerbside bus lanes provided in both directions – in the case of the eastbound direction, the bus lane provides a continuous lane through the roundabout
- A staggered fully protected pedestrian crossing is provided on the south arm. Due to operational constraints, crossings on the west and east arms are not possible to be incorporated into the operation – therefore a grade-separated crossing is proposed at this site, likely to be on the east side of the intersection. Although an underpass has been previously identified as the preferred solution, an overpass (pedestrian/cycle bridge) is another alternative, although this is likely to require additional ramp length (compared to the underpass, due the height clearance required for oversized vehicles)
- In terms of operation, for the SH6 East and Grant Road approaches, passing through a green at the entry limit line would also receive a green at the downstream circulatory limit line, and so vehicle queues on the circulatory lanes at these points would be very low (only U-turns would get delayed at the circulatory stop line). For traffic arriving on the SH6 West approach, right turns into Grant Road would be held at the circulatory stop line, but this has been widened to two lanes to ensure there is sufficient stacking space to accommodate the predicted queue without blocking back to the upstream entry limit line
- Due to the small size of the roundabout, and the limited stacking space to hold right turn vehicles at the circulatory stop line, the signal cycle time will need to be relatively low at the intersection to maintain capacity – and in all three periods, the models assume a 60 second cycle time (note this double-cycles within the wider network 120 second cycle time, so co-ordination is maintained)

The results show operation is satisfactory in all three peak periods. Although the SH6 westbound ahead and Grant Road left turn movements are approaching capacity in all three periods, downstream capacity (at both SH6/Joe O'Connell Drive and SH6/SH6A intersections) is less than is provided at this intersection, so any additional capacity would be underutilised.

Table 6 shows the results of the operational assessment of the signalised roundabout option.

The results show operation is satisfactory in all three peak periods. Although the SH6 westbound ahead and Grant Road left turn movements are approaching capacity in all three periods, downstream capacity (at both SH6/Joe O'Connell Drive and SH6/SH6A intersections) is less than is provided at this intersection, so any additional capacity would be underutilised.

Table 6: SH6/Grant Road – operational performance (2028) with signalised roundabout

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)

SH6 West	Bus Lane	2%	1	3	2%	1	4	2%	1	5
	Ahead	61%	8	6	71%	16	9	76%	16	14
	Right Turn	61%		27	71%		29	76%		23
SH6 East	Left Turn	17%	2	16	29%	3	21	48%	4	34
	Bus Lane	2%	1	6	2%	1	11	2%	1	16
	Ahead	85%	28	33	94%	26	54	84%	19	42
Grant Road	Left Turn	76%	6	43	88%	12	40	88%	13	36
	Right Turn	12%	1	36	33%	2	34	59%	5	35
Intersection LOS		B			C			C		

Levels of Service are also good, with most movements experiencing a LOS C or better – principally due to the low cycle time proposed. In all three peak periods, bus delay for the through movements along SH6 is low (less 20 seconds) showing the benefits of the bus lanes on the approaches.

Consequently, it is concluded that the operation of the signalised roundabout option is satisfactory in terms of vehicular operation.

Table 7 shows the predicted pedestrian travel times to traverse the crossing on the south leg of the intersection.

Table 7: SH6/Grant Road – pedestrian delay in seconds (2028) with signalised roundabout

From	To	AM peak	Interpeak	PM Peak
South-West	South-East	59	59	59
South-East	South-West	25	25	25

The results show that pedestrian journey times are low, even with the staggered arrangement – this is due to the low cycle time which pedestrians do not have to wait long before the next pedestrian phase can be called.

The disadvantage of this arrangement is that no at-grade facilities can be provided across SH6 at this intersection, but, as above, it is intended that an underpass is provided in the vicinity to enable pedestrians to cross the highway either to access future development on the north side of SH6 and/or access bus stops.

In summary:

- The option has benefits in terms of relatively low additional footprint compared to the existing situation (some widening is required along the north-west side of SH6), which has a secondary benefit in terms of minimal disruption during construction
- Recently newly constructed infrastructure cost is better utilised as it is not ripped out and replaced early in its life
- The performance of the intersection is satisfactory in terms of capacity, and the low cycle time results in low levels of both pedestrian and vehicular delay at the intersection. Bus priority lanes are also provided right up to the signal limit lines on both SH6 approaches, and therefore bus delay is minimal
- At-grade protected pedestrian facilities can only be provided across the south approach, albeit this is where the highest demand is likely to be in the short term.
- An underpass (or overpass) would need to be provided to serve pedestrian and cycle movements across SH6 providing access to future landuse to the north of the corridor and access to east bound bus stops
- The pedestrian access across SH6 does not provide as much priority, mobility, and personal safety (CPTED) in comparison to other crossing locations along the corridor

Signalised Intersection

A signalised intersection arrangement was devised, which is shown in Figure 7.

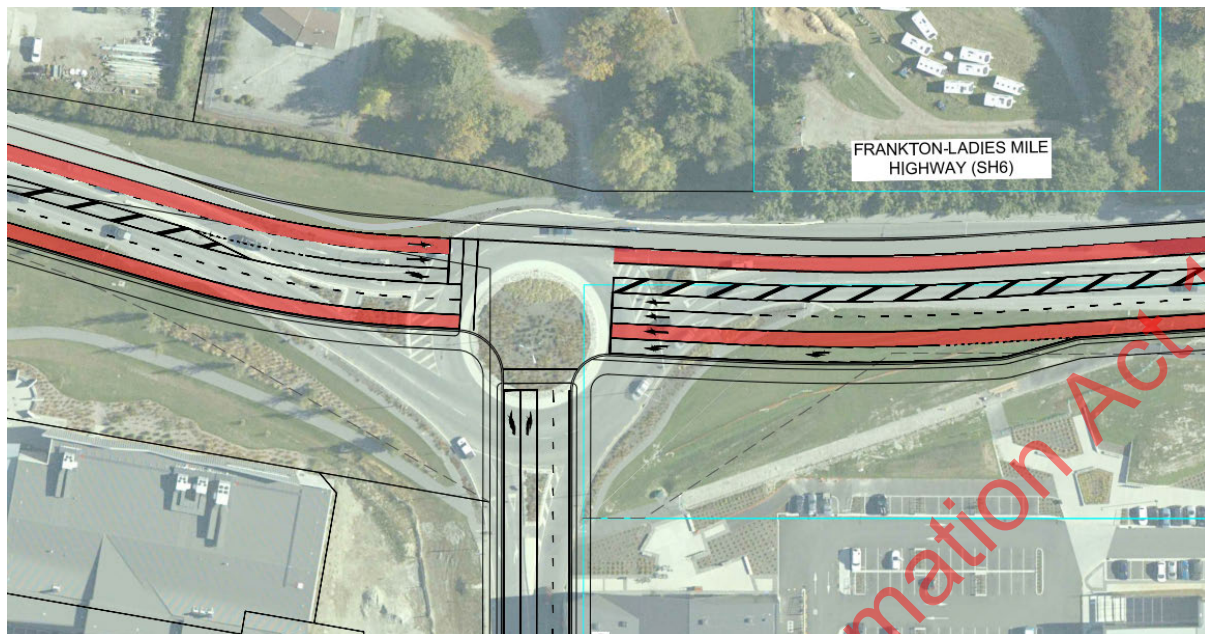


Figure 7: Signalised Intersection Option at SH6/Grant Road

The signalised intersection includes the following features:

- Kerbside bus lanes provided in both directions
- Fully protected straight (one stage) pedestrian crossings are provided on the south and west arms. Due to operational constraints, a crossing on the east arm is not possible to be incorporated into the operation – see midblock crossing options in the next section
- A number of additional lanes are required at the intersection to establish sufficient capacity to accommodate the demand – this also results in these additional lanes being required through the rest of the Eastern corridor (Hardware Lane to SH6/SH6A intersection):
 - Additional westbound traffic lane on SH6 (compared to roundabout option)
 - Additional localised widening (and re-alignment) on the SH6 East, SH6 West and Grant Road approaches so as to provide additional left and/or right turn lanes
- In terms of operation, a simple 3-phase operation is proposed as shown in Figure 7, with all vehicular moves allowed (except U-turns). Signal groups 7 and 8 (the pedestrian crossings) are fully protected for the full period of walk and clearance time (left turns late start)
- It is expected that the signal cycle time will need to be relatively high at the intersection to maintain capacity, and co-ordination with adjacent sites – and in all three periods, the models assume a 120 second cycle time. The models assume all pedestrian crossing movements are called in every cycle – should pedestrian calls be less frequent, this would have negligible impact on the operation of the intersection, as the pedestrian crossings all operate by holding back non-critical traffic movements (the left turns from the east and south)

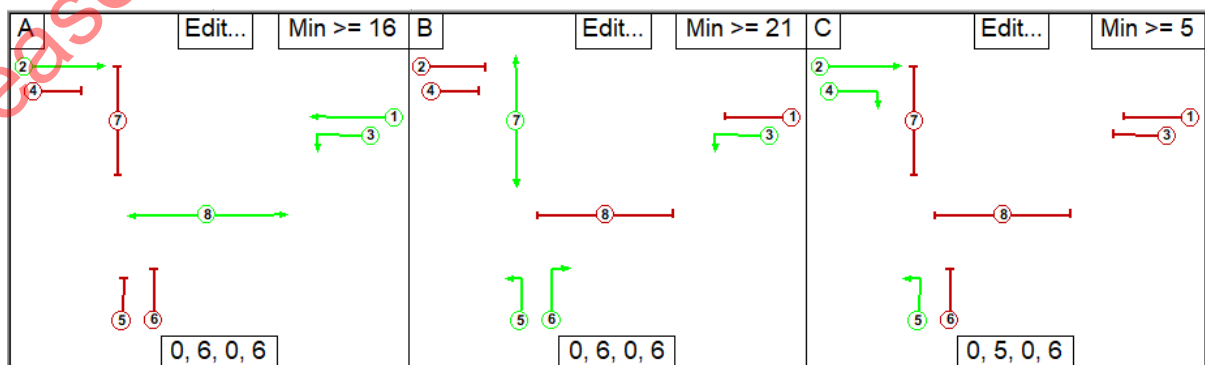


Figure 8: SH6/Grant Road - Signalised Intersection Phase Arrangement

Table 8 shows the results of the operational assessment of the signalised intersection option.

Table 8: SH6/Grant Road – operational performance (2028) with signalised intersection

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
SH6 West	Bus Lane	2%	1	9	2%	1	9	2%	1	8
	Ahead	75%	19	19	82%	16	13	70%	20	12
	Right Turn	75%		36	82%		30	70%		19
SH6 East	Left Turn	16%	3	14	23%	4	19	28%	5	28
	Bus Lane	2%	1	15	2%	1	27	2%	1	49
	Ahead	63%	13	13	78%	24	26	72%	24	30
Grant Road	Left Turn	60%	9	48	85%	20	51	87%	23	48
	Right Turn	9%	1	47	36%	4	51	81%	11	70
Intersection LOS		C			C			C		

The results show operation is satisfactory in all three peak periods, with a limited amount of spare capacity available in all three periods. Theoretically, this suggest that a lower cycle time could be utilised – but this would then result in poor co-ordination with adjacent sites, and is therefore not recommended.

Levels of Service are also good, with most movements experiencing a LOS C or better. One point to note, however, is that due to the high cycle time, the queues on the Grant Road arm are predicted to stretch back to the Grant Road/Central Street intersection. Additional green time could be re-allocated to this approach (from SH6 movements) but this is unlikely to make a significant difference – the queue length is a function of the number of vehicles per cycle rather than congestion.

Consequently, it is concluded that the operation of the signalised intersection option is satisfactory in terms of vehicular operation, but with some issues in terms of queue lengths.

Table 9 shows the predicted pedestrian travel times to transverse the intersection.

Table 9: SH6/Grant Road – pedestrian delay in seconds (2028) with signalised intersection

From	To	AM peak	Interpeak	PM Peak
North	South-East	96	108	123
	South-West	56	56	56
South-West	North	56	56	56
	South-East	56	56	56
South-East	North	93	81	65
	South-West	56	56	56

The results show that pedestrian journey times are relatively low across all movements, with the diagonal move predicted to have a delay of up to around 2 minutes in all periods.

In summary:

- The option has benefits in terms of pedestrian provision over the signalised roundabout option, as at-grade crossings are provided across two legs

- At grade pedestrian crossing provides more priority, mobility, and personal safety (CPTED) when compared to grade separated options
- Signalised pedestrian crossing supports future landuse development north of the corridor and along the corridor
- The performance of the intersection is satisfactory in terms of capacity, but there is a concern that the short distance between this intersection and Grant Road/Central Street will result in queues blocking back in the northbound direction
- The option has dis-benefits in terms of requiring more significant road widening, particularly on the SH6 West and SH6 East approaches
- Provision of 6-7 lanes widens the carriageway such that it performs weakly against the aspiration of the Frankton Masterplan 'Urban arterial' concept.

Signalised Intersection Variations

A number of variations were considered to the signalised intersection layout, mainly to improve operational efficiency and pedestrian provision:

- Additional full pedestrian crossing on east side of the intersection – models showed RFC for critical movements of around 95% in the Interpeak and PM peak period. Although, at least in the short-medium term, it is unlikely that this crossing would be demanded every cycle, the detrimental impact in providing this crossing is considered a risk to the operation of both this intersection, and results in unsettled co-ordination with adjacent sites, which could result in variable queues being experienced in the network. In addition, the pedestrian delay in: Table 9 showed that the levels were relatively low. Consequently, it is recommended that a pedestrian crossing is not provided on this arm.
- For the same reasons of inconsistency as for SH6/Hawthorne Drive, it is also not recommended that a staggered crossing be considered across this leg either
- Initially an additional eastbound through lane was considered as part of the signalised intersection design. However, this comes at significant additional cost (land take and construction), and as shown for the PM peak results above, the downstream constraint is the pinch point towards the Shotover Bridge – and therefore the additional lane would just serve as extra stacking space for the queue. It also maintains the existing eastbound merge issue just downstream of SH6/Hawthorne Drive. Therefore, this option has also been discarded.

Therefore, the signalised roundabout and signalised intersection options (as described in the sections above) are considered appropriate for further consideration.

Summary

The analysis of the SH6/Grant Road has shown that:

- Operational performance is similar between the two options
- Pedestrian provision is better in the conventional arrangement, which allows full straight crossings to be provided on two of the three arms of the intersection. Crossing of SH6 in the roundabout option would require a grade-separated solution.
- Land take – higher in conventional arrangement, which requires additional widening along the corridor to provide an additional westbound lane

The choice of preferred option therefore comes down to the respective aims and objectives of the overall programme – as a balance between additional widening (and cost) of the conventional option against the improved pedestrian provision and land use opportunities that this option would bring.

Midblock Crossing

It is anticipated that land use intensification will occur on the north side of SH6 within the Eastern corridor, together with further development on the south side. Consequently, in addition to a range of crossing alternatives at the intersections of SH6/Grant Road and SH6/Hawthorne Drive, there will likely be a future desire to cross SH6 between the two intersections, which are spaced around 400m apart. Consequently, we have investigated the operational performance of both full or staggered at-grade crossing types at a midpoint between the two intersections, assuming either signalised roundabouts or signalised intersections at either end of the section. The six options are therefore:

- Signalised Roundabouts at either end; Staggered crossing at Midblock
 - Single cycling at 120 seconds

- Double cycling at 60 seconds
- Signalised Roundabouts at either end; Full crossing at Midblock
 - Single cycling at 120 seconds
- Signalised Intersections at either end; Staggered crossing at Midblock
 - Single cycling at 120 seconds
 - Double cycling at 60 seconds
- Signalised Intersections at either end; Full crossing at Midblock
 - Single cycling at 120 seconds

The staggered crossing arrangement provides additional flexibility in operation between single and double cycling within the expected master cycle time of 120 seconds. In the short-medium term, when pedestrian demand is likely to be modest, it is unlikely that the staggered double-cycled facility would be demanded every cycle (i.e. every 60 seconds) – so the results should be interpreted in this context, and that a double cycling regime could be introduced in low traffic conditions, and then double cycled if the network become under stress.

Table 10 shows the results of the assessment in terms of vehicular operation, and Table 11 sets out the predicted pedestrian delay for each scenario.

The results show that all six scenarios operate satisfactorily in terms of vehicular capacity, albeit with eastbound traffic in the PM peak and westbound traffic in the AM peak approaching capacity in a number of scenarios.

However, on balance, for both intersection options (signalised roundabouts and signalised intersections at either end of the section), the full crossing type offers the lowest pedestrian delays, whilst maintaining a reasonable of operation for traffic. Consequently, it is recommended that the **full crossing layout** be taken forward, irrespective of the eventual intersection layout preference along the wider corridor.

Table 10: SH6/Midblock Crossing – operational performance (2028)

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
Roundabout; Stagger; Single Cyc	Eastbound	45%	2	3	56%	5	4	63%	11	6
	Westbound	73%	14	10	64%	10	8	52%	1	3
Roundabout; Stagger; Double Cyc	Eastbound	57%	9	5	71%	18	8	80%	18	13
	Westbound	92%	24	27	79%	19	18	66%	15	15
Roundabout; Full; Single Cyc	Eastbound	50%	7	9	62%	15	9	70%	13	10
	Westbound	80%	9	9	69%	10	10	57%	9	5
Signalised; Stagger; Single Cyc	Eastbound	46%	1	2	56%	2	3	65%	16	6
	Westbound	37%	1	2	32%	1	2	27%	1	2
Signalised; Stagger; Double Cyc	Eastbound	59%	2	4	71%	10	10	90%	13	19
	Westbound	49%	10	8	42%	13	8	35%	2	3
Signalised; Full; Single Cyc	Eastbound	51%	4	4	62%	5	5	73%	15	11
	Westbound	43%	2	3	36%	2	2	32%	2	2

Table 11: SH6/Midblock Crossing – pedestrian delay (in seconds)

Approach	Pedestrian Movement	AM peak	Interpeak	PM Peak
Roundabout; Stagger; Single Cyc	Southbound	114	98	121
	Northbound	93	110	87
Roundabout; Stagger; Double Cyc	Southbound	61	62	37
	Northbound	28	28	49
Roundabout; Full; Single Cyc	Southbound	56	56	56
	Northbound	56	56	56
Signalised; Stagger; Single Cyc	Southbound	65	57	141
	Northbound	140	148	63
Signalised; Stagger; Double Cyc	Southbound	30	34	53
	Northbound	63	50	31
Signalised; Full; Single Cyc	Southbound	56	56	56
	Northbound	56	56	56

Joe O'Connell Drive and Hansen Road

Potential improvements at the SH6/Joe O'Connell/Hansen Road intersection were previously investigated as part of the Grant Road to Kawarau Falls Bridge (GR2KFB) SSBC project in 2017-18. As part of the analysis within that earlier project, a number of options were discarded:

- Retain as existing – there are current difficulties in egressing the Joe O'Connell Drive leg, particularly for the right turn movement. This leads to vehicles either turning left and U-turning at the existing SH6/SH6A roundabout, or forcing their way out across SH6 and/or accepting very low gaps in the main through traffic. Given the forecast growth in traffic levels, it was therefore concluded that the existing layout was not fit for purpose
- Convert to 4-arm signalised intersection – due to the angled alignment of the Hansen Road arm, the Joe O'Connell Drive and Hansen Road approaches would need to be assigned to separate signal phases (they cannot operate simultaneously for safety reasons). This resulted in very poor operation of the intersection, especially in the future when development is expected on the north side of SH6. Re-alignment of the north arm to join SH6 on a perpendicular orientation has not been considered at this location, due to land ownership issues and other practicalities. Therefore this option was also discarded

As a result of the above, and in discussion with the land owner on the north-west side of the intersection (No.1 Hansen Road between Frankton Cemetery and Hansen Road), a staged approach to the improvement was developed:

1. In the short term, signalise the SH6/Joe O'Connell intersection, with Hansen Road remaining as a priority-controlled arm but limited to left in, left out movements only – roundabouts at the SH6/SH6A and SH6/Grant Road intersections would allow U-turns for traffic to access Hansen Road
2. In the longer term, the Hansen Road leg would be closed, and re-aligned to join SH6 approximately 150m to the east. In this situation, the SH6/Joe O'Connell Drive and SH6/Hansen Road would both operate as a combination of T-intersections

Therefore, to be consistent with the options at the SH6/Grant Road and SH6/Hawthorne Drive intersections, there are two options that have been investigated in terms of these signalised T-intersections:

1. Minor widening to provide bus lanes in each direction, plus a single traffic lane in each direction – this would be consistent with the signalised roundabout options at SH6/Grant Road and SH6/Hawthorne Drive
2. More significant road widening to provide bus lanes in each direction, plus a single lane in the eastbound direction and two traffic lanes in the westbound direction – this would be consistent with the conventional signalised intersection options at SH6/Grant Road and SH6/Hawthorne Drive. This would also provide access to newly rezoned Business Mixed Use land on the north side of SH6

T-intersections to be consistent with adjacent Signalised Roundabout at SH6/Grant Road

A signalised T-intersection arrangement was devised with the signalisation of all three legs, which is shown in Figure 9. A similar arrangement for SH6/Hansen Road is shown in Figure 10.

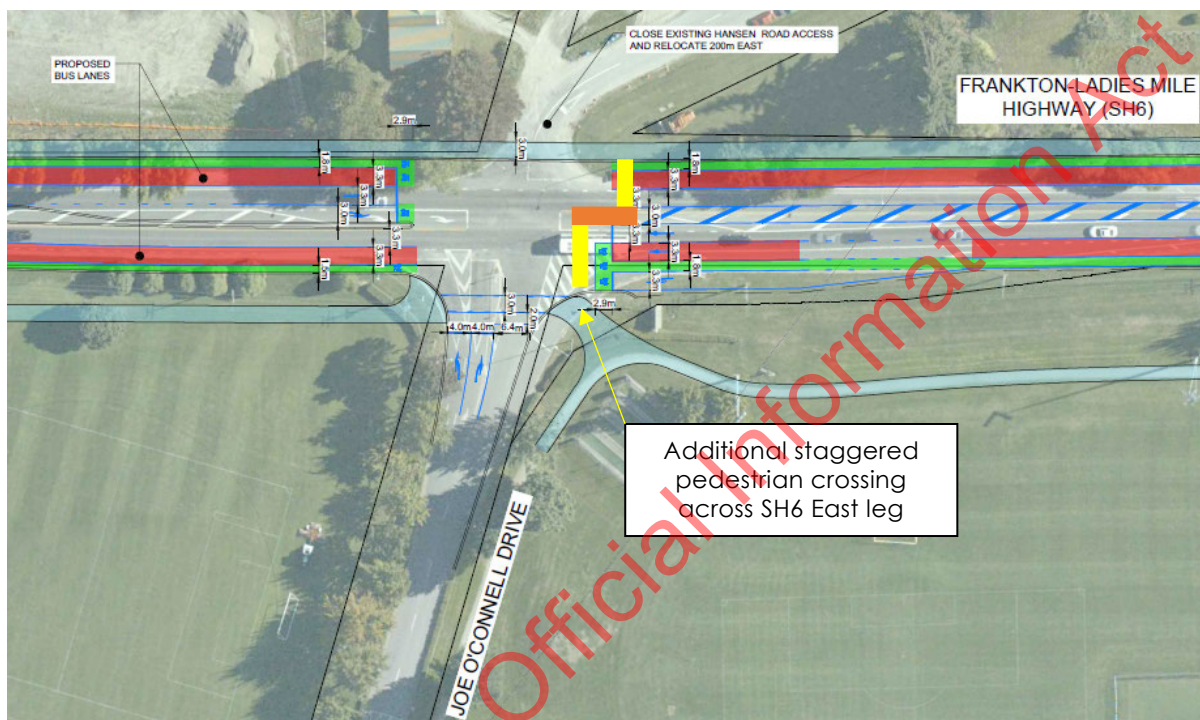


Figure 9: Signalised T-intersection Option at SH6/Joe O'Connell Drive

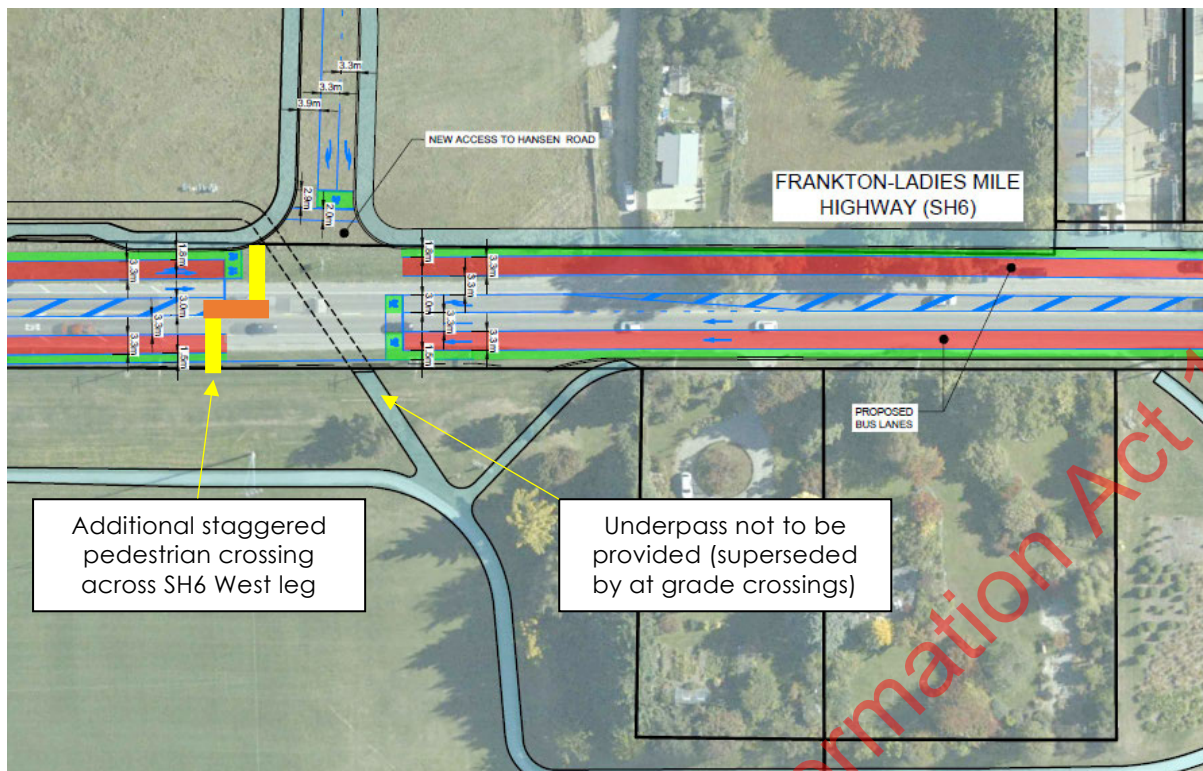


Figure 10: Signalised T-intersection Option at SH6/Hansen Road

The arrangement at both intersections includes the following features:

- Kerbside bus lanes provided in both directions
- Direct pedestrian crossings are provided across the side road at both intersections, fully protected for the wait and clearance times
- Although not shown in Figure 9 and Figure 10, a staggered fully-protected pedestrian crossing is provided on the east arm of the SH6/Joe O'Connell Drive intersection, and on the west arm of the SH6/Hansen Road intersection. The location of these crossings would be in the shadow of the adjacent right turn lanes (at both sites) and therefore would require little extra widening to accommodate physically
 - It was considered not possible to incorporate crossings on the opposing arm into the operation, due to the additional widening that would be required to provide the central island of the stagger. Similarly, a direct crossing on SH6 (either west or east) could not be incorporated, due to the significant increase in lost time that would be attributed to traffic movements along SH6
 - An alternative to the staggered pedestrian crossing (shown in Figure 9 and Figure 10) are pedestrian underpasses. These are considered later in the analysis as an alternative.
 - All staggered crossings would also be fully protected for the wait and clearance periods
- Figure 11 shows the proposed phase arrangement at SH6/Joe O'Connell Drive. Phases E and B allow the pedestrian crossing across Joe O'Connell Drive to be called twice per cycle to minimise pedestrian delay on this key pedestrian and cycle movement along the corridor. This operation is similar to the one provided to protect cycle movements along the SH1 cycleway in central Dunedin. Figure 12 shows the proposed phase arrangement at SH6/Hansen Road – pedestrian movements along the north side on SH6 are likely to be significantly less than on the south side (even with future development on the north side) and so a more conventional arrangement is proposed

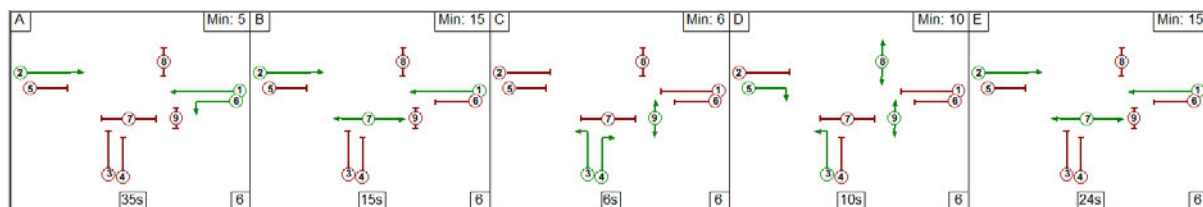


Figure 11: Proposed Phase Arrangement at SH6/Joe O'Connell Drive

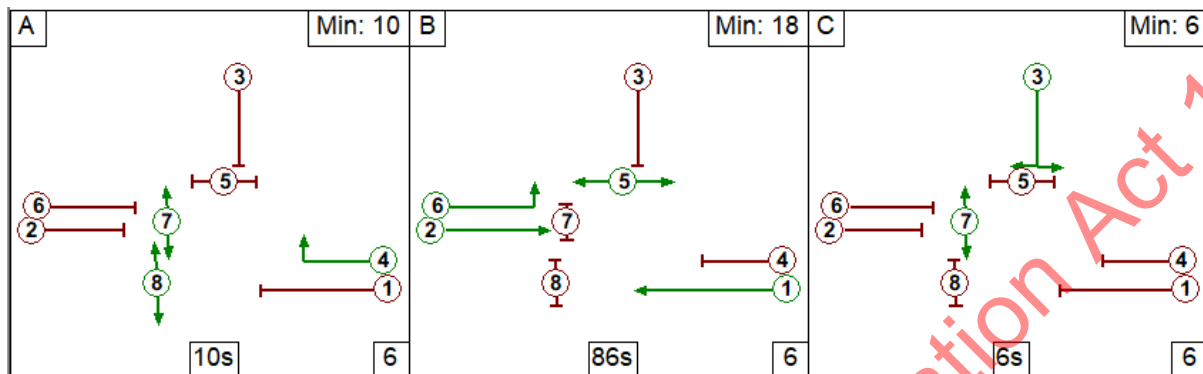


Figure 12: Proposed Phase Arrangement at SH6/Hansen Road

Table 12 shows the results of the operational assessment of the two T-intersections consistent with the signalised roundabout option at SH6/Grant Road.

The results show at capacity operation in all three peak periods. Although the SH6 westbound ahead movements are approaching capacity in all three periods, downstream capacity (at the SH6/SH6A intersection) is no more than is provided at this intersection, so any additional capacity would be underutilised.

Levels of Service are generally good, with most movements experiencing a LOS C or better – principally due to majority of traffic moving through the intersections on SH6 receiving the bulk of the green time allocation. In all three peak periods, bus delay for the through movements along SH6 is minimal (less 15 seconds) showing the benefits of the bus lanes on the approaches.

Consequently, it is concluded that the operation of this intersection option is satisfactory in terms of vehicular operation.

Table 12: SH6/Joe O'Connell and SH6/Hansen Road – operational performance (2028) with signalised roundabout at SH6/Grant Road

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
SH6/Joe O'Connell Drive										
SH6 West	Bus Lane	2%	1	6	2%	1	6	2%	1	6
	Ahead	79%	25	16	94%	44	31	85%	30	19
	Right Turn			57			73			62
SH6 East	Left Turn	17%	2	38	13%	1	27	19%	2	29
	Bus Lane	2%	1	6	2%	1	5	2%	1	15
	Ahead	88%	11	15	95%	19	25	89%	8	14
	Left Turn	30%	3	48	56%	4	52	45%	4	51

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
Joe O'Connell Drive	Right Turn			61			65			63
		B			C			C		
SH6/Hansen Road										
SH6 West	Left Turn	3%	1	5	3%	1	6	1%	1	6
	Bus Lane	2%	1	3	2%	1	5	2%	1	5
	Ahead	75%	10	6	92%	12	18	79%	7	10
Hansen Road	All moves	39%	2	83	31%	1	80	35%	1	82
SH6 East	Bus Lane	2%	1	5	2%	1	2	2%	1	7
	Ahead	93%	40	28	102%	74	76	95%	44	36
	Right Turn			77			124			84
Intersection LOS		B			D			C		

The results show that pedestrian journey times are relatively high for any diagonal movements (that must cross all three stages of the crossing at each intersection), but that pedestrian delay is generally lower for movements across a single leg of the intersection. At the SH6/Joe O'Connell Drive intersection, the dual appearance of the crossing over the side road limits average pedestrian delay to below 30 seconds in all periods. Note, the delay times are the same for each period at both sites, as the side road and right turn phases generally run for a minimum length every cycle, and therefore delay is very consistent.

Table 13 shows the predicted pedestrian travel times to traverse the crossings at both intersections.

The results show that pedestrian journey times are relatively high for any diagonal movements (that must cross all three stages of the crossing at each intersection), but that pedestrian delay is generally lower for movements across a single leg of the intersection. At the SH6/Joe O'Connell Drive intersection, the dual appearance of the crossing over the side road limits average pedestrian delay to below 30 seconds in all periods. Note, the delay times are the same for each period at both sites, as the side road and right turn phases generally run for a minimum length every cycle, and therefore delay is very consistent.

Table 13: SH6/Joe O'Connell and SH6/Hansen Road – pedestrian delay in seconds (2028) with signalised roundabout at SH6/Grant Road

From	To	AM peak	Interpeak	PM Peak
SH6/Joe O'Connell Drive				
North-East	South-East	152	152	152
	South-West	165	165	165
South-East	North-East	60	60	60
	South-West	26	26	26

From	To	AM peak	Interpeak	PM Peak
South-West	North-East	63	63	63
	South-East	26	26	26
SH6/Hansen Road				
North-West	North-East	56	56	56
	South-West	60	60	60
North-East	North-West	56	56	56
	South-West	135	135	135
South-West	North-West	152	152	152
	North-East	166	166	166

An additional test has been run, with the staggered pedestrian crossings over SH6 removed, with the assumption that underpasses would be provided as an alternative. In this arrangement, phase D at SH6/Joe O'Connell Drive (Figure 11) can operate the eastbound ahead movement, and phase A at SH6/Hansen Road (Figure 12) can operate the westbound ahead movement. Whilst this provides more capacity for these movements, in both cases this action pushes traffic into the internal section between the two intersections. As the downstream ahead movements do not receive any additional green time (or very minimal, related to a marginal saving in lost time from not running pedestrian clearance periods), then the actual improvement in performance is only around 2-3%. Consequently, there is not a significant benefit in efficiency from not providing the crossing facilities across SH6 – any benefits of an underpass will be driven by the potential saving in pedestrian delay (and road safety benefits).

In summary:

- The option has benefits in terms of relatively low additional footprint compared to the existing situation (some widening is required along SH6 to provide bus lanes), which has a secondary benefit in terms of minimal disruption during construction
- The performance of the intersection is satisfactory in terms of capacity, and in line with the level of capacity provided at adjacent intersections. Bus priority lanes are also provided right up to the signal limit lines on both SH6 approaches, and therefore bus delay is minimal
- At-grade staggered protected pedestrian facilities can be provided at both intersections, albeit the pedestrian delay is significant due to the staggered nature of the crossing.
- At grade pedestrian crossing provides more priority, mobility, and personal safety (CPTED) when compared to grade separated options
- Signalised pedestrian crossing supports future landuse development north of the corridor and along the corridor.

T-intersections to be consistent with adjacent Signalised Intersection at SH6/Grant Road

The arrangement of the intersections in this option is as the previous option **except for an additional westbound through traffic lane at both intersections**. The phase arrangements are also the same as those shown in Figure 11 and Figure 12, as is the pedestrian provision.

Table 14 shows the results of the operational assessment of the two T-intersections consistent with the signalised roundabout option at SH6/Grant Road

Table 14: SH6/Joe O'Connell and SH6/Hansen Road – operational performance (2028) with signalised intersection at SH6/Grant Road

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
SH6/Joe O'Connell Drive										
SH6 West	Bus Lane	2%	1	6	2%	1	6	2%	1	6
	Ahead	79%	25	16	94%	458	33	85%	30	20
	Right Turn			58			73			62
SH6 East	Left Turn	11%	1	13	12%	1	13	16%	2	25
	Bus Lane	2%	1	3	2%	1	3	2%	1	15
	Ahead	44%	12	7	51%	18	5	45%	30	17
Joe O'Connell Drive	Left Turn	29%	3	48	57%	4	54	44%	4	51
	Right Turn			61			67			63
		B			C			C		
SH6/Hansen Road										
SH6 West	Left Turn	3%	1	13	4%	1	13	2%	1	15
	Bus Lane	2%	1	6	2%	1	6	2%	1	6
	Ahead	75%	16	14	93%	20	25	80%	16	17
Hansen Road	All moves	35%	2	79	28%	1	76	31%	1	77
SH6 East	Bus Lane	2%	1	2	2%	1	2	2%	1	5
	Ahead	45%	5	4	53%	16	6	50%	30	11
	Right Turn			58			61			59
Intersection LOS		B			B			B		

The results show at capacity operation in all three peak periods. The impact of adding the additional westbound traffic lane has significantly improved performance in this westbound direction. However, the additional pedestrian crossing distance resultant from the increase in the number of lanes has resulted in poorer operation of the eastbound direction, pushing this up to a predicted RFC of 96% in the Interpeak period.

Consequently, it is concluded that the intersection operation in the layout consistent with conventional signalised intersections provided at SH6/Grant Road and SH6/Hawthorne Drive is marginally better than that provided in the signalised roundabout layout – but the critical link performance is transferred from the westbound direction to the eastbound direction.

Alternative layouts for this arrangement have also been considered, mainly to improve operational efficiency and pedestrian provision:

- If the staggered pedestrian crossing over SH6 is moved to the west side of the intersection, this would provide an improvement to the operation of the critical eastbound movement of around 15% (i.e. Interpeak drops from an RFC of 95% in Table 14, to an RFC of 81%). This would however

require further widening of around 3-4m to provide a central refuge on the west side of the intersection – this is equivalent to providing an additional westbound lane (in terms of land requirements), which would be more effective at improving the efficiency of the intersection operation. Consequently, this additional variation has been discarded

- Full pedestrian crossing on east and/or west side of the intersection could be provided if two general traffic lanes were provided (plus the bus lanes) in each direction. As above, this is more effective than adding a pedestrian island, but has a significantly higher land requirement than the signalised roundabout option, especially when the operation of the network is constrained at adjacent intersections. Consequently, it is also considered that this option is not pursued unless the provision of at-grade single stage pedestrian crossing facilities is a critical requirement
- As for the signalised roundabout compatible arrangement, an underpass is an alternative (or additional) option for providing pedestrian crossing facilities across SH6 – albeit with little operational performance gain by removing the at-grade facilities

In summary:

- The performance of the intersection is satisfactory in terms of capacity, and in line with the level of capacity provided at adjacent intersections. Bus priority lanes are also provided right up to the signal limit lines on both SH6 approaches, and therefore bus delay is minimal
- The option has a higher additional footprint compared to the signalised roundabout compatible
- At-grade staggered protected pedestrian facilities can be provided at both intersections, albeit the pedestrian delay is significant due to the staggered nature of the crossing. An underpass could be provided as an alternative (or additional option) to better serve pedestrian and cycle movements across SH6

Summary

The analysis of the SH6/Joe O'Connell Drive and SH6/Hansen Road intersections has shown that:

- In the short term, before the Hansen Road intersection is implemented, the existing Hansen Road link would be incorporated as a priority controlled "Left-in, Left-out" only within the SH6/Joe O'Connell Drive intersection – this arrangement is better suited to the roundabout option at SH6/Grant Road, which would allow U-turns for access
- The format of both intersections would be similar in both options, except for the additional westbound through lane, which is required in the conventional intersection arrangement (at the Grant Road and Hawthorne Drive intersections to the east)
- Pedestrian provision is provided as a staggered facility across SH6 – a full crossing arrangement was not possible without further widening at the intersection (to 1 bus lane and 2 traffic lanes in each direction, plus turn lanes)
- Land take – higher in conventional arrangement (for consistency with the intersections to the east), with additional widening along the corridor to provide an additional westbound lane

Therefore, the preferred format of the intersection is selected, and the actual design is dependent on the choice of intersection format at the other sites to the east.

Network Performance

The following results have been obtained from the Paramics model, with the SH6/SH6A modelled as the emerging conventional intersection option – although the form of this intersection has minimal impact on the operation of the Eastern corridor.

Travel Times for Buses

Table 15 sets out the bus travel times (in minutes) for four sections of directional movements that pass through the corridor (in each of the two options) for each of the three modelled peak hour periods (0800-0900; 1200-1300; 1700-1800). Green cells represent where the travel time in the roundabout option is quicker.

Table 15: Travel Time Results for PT (journey time in minutes) (2028)

From	To	AM Peak			Interpeak			PM Peak		
		Oabout	Conv	Diff	Oabout	Conv	Diff	Oabout	Conv	Diff
Stalker Road	Hawthorne Drive	0.9	0.9	0.0	0.9	0.9	0.0	0.9	0.9	0.0
Hawthorne Drive	Grant Road	1.7	1.9	0.2	1.7	2.0	0.3	1.7	1.6	-0.1
Grant Road	Joe O'Connell	1.2	0.9	-0.3	1.4	1.8	0.3	1.2	1.7	0.5
Joe O'Connell	SH6/SH6A	2.3	2.4	0.1	2.2	2.5	0.3	2.2	2.7	0.5
Westbound Total		6.1	6.1	0.0	6.3	7.2	0.9	6.1	6.9	0.9
SH6/SH6A	Joe O'Connell	1.9	2.5	0.6	1.8	2.4	0.5	2.0	2.2	0.2
Joe O'Connell	Grant Road	1.9	2.0	-0.1	2.0	2.1	0.1	2.0	1.6	-0.3
Grant Road	Hawthorne Drive	1.5	1.4	-0.1	1.5	1.5	0.0	1.5	1.5	0.0
Hawthorne Drive	Stalker Road	0.9	0.9	0.0	0.9	0.9	0.0	0.9	0.9	0.0
Eastbound Total		6.3	6.8	0.5	6.2	6.8	0.6	6.3	6.2	-0.1

Several conclusions can be drawn from Table 15:

- In the AM period, both options provide similar travel times
- In the Interpeak period, the roundabout generally provides around a benefit of a minute in terms of travel times. This is primarily due to the difference in signal offsets along the corridor in the two options. As the offsets are currently optimised to minimise queues between each intersection, this can lead to a differential in how these optimised offsets affect buses – given that buses can stop at intermediate bus stops for a variable dwell time, it is often difficult to set an offset that optimises the arrangement for buses as well as general traffic. However, in both options, the bus delays are generally low due to:
 - The provision of bus lanes for the majority of the corridor in both directions
 - Most bus services are generally operating on the main west-east through route along the corridor which receives the highest portion of green time at each intersection, and therefore the residual bus delay is relatively low
- In the PM peak, a similar travel time saving of around 1 minute is predicted in the westbound direction in the roundabout option. Again, this is likely to be coincidental to signal offsets rather than a fundamental advantage of the option to provide better bus travel times

In summary, there are relatively minor bus travel time differences between the two options, and these are likely to be down to specific signal offsets used in the two models, rather than a fundamental advantage of one option over the other.

Travel Times for General Traffic

Table 16 sets out the general traffic travel times (in minutes) for four sections of directional movements that pass through the corridor (in each of the two options) for each of the three modelled peak hour periods (0800-0900; 1200-1300; 1700-1800). Green cells represent where the travel time in the roundabout option is quicker.

Table 16: Travel Time Results for General Traffic (journey time in minutes) (2028)

From	To	AM Peak			Interpeak			PM Peak		
		Oabout	Conv	Diff	Oabout	Conv	Diff	Oabout	Conv	Diff
Stalker Road	Hawthorne Drive	0.9	0.9	0.0	0.9	0.9	0.0	0.9	1.0	0.0
Hawthorne Drive	Grant Road	1.5	1.4	-0.1	1.5	1.5	0.0	1.5	1.4	-0.1
Grant Road	Joe O'Connell	0.9	0.5	-0.4	1.4	0.6	-0.8	1.0	0.6	-0.4
Joe O'Connell	SH6/SH6A	1.6	1.6	0.0	2.5	3.7	1.1	1.6	1.7	0.0
Westbound Total		4.9	4.4	-0.5	6.3	6.7	0.4	5.1	4.7	-0.4
SH6/SH6A	Joe O'Connell	1.9	1.8	-0.1	2.1	1.9	-0.2	2.1	1.8	-0.3
Joe O'Connell	Grant Road	0.8	0.6	-0.2	0.8	0.6	-0.3	1.4	0.8	-0.6
Grant Road	Hawthorne Drive	0.9	1.0	0.1	0.9	1.0	0.1	1.0	1.2	0.2
Hawthorne Drive	Stalker Road	0.9	0.9	0.0	0.9	0.9	0.0	1.0	1.0	0.0
Eastbound Total		4.6	4.3	-0.3	4.8	4.5	-0.3	5.4	4.7	-0.7

Several conclusions can be drawn from Table 16:

- In all periods (except Interpeak westbound), the conventional intersection option provides a modest benefit in terms of travel times
- In the westbound direction this can be explained by the additional through westbound lane in this option, which provides some resilience into journey times in this direction
- In the eastbound direction, the main source of additional delay in the roundabout option is on the approach to the Grant Road roundabout. As this roundabout operates double-cycled within the network cycle time, some eastbound traffic will inevitably be delayed at this roundabout – albeit the LOS is still good for this approach. In the conventional option, as the right turn out of Grant Road is relatively light, the eastbound through movement receives a higher proportion of the green time allocation (compared to the roundabout option), and

therefore a “green wave” can be established between the long eastbound through movement green time at the Joe O’Connell Drive, Hansen Road and Grant Road intersections

In summary, there are relatively minor general traffic travel time differences between the two options, and most are likely to be down to specific signal offsets used in the two models, rather than a fundamental advantage of one option over the other.

As noted above, the signal offsets employed in the model can be adjusted, which would enable the balance between travel times for buses against general traffic to be fine-tuned. However, as the majority of green time is provided for the through movements along SH6 in both options, the level of delay along this section of the corridor is relatively low.

Network Control

An important consideration in efficient operation of the corridor is ensuring that all intersections are compatible – ideally that they are all suited to operate at a similar cycle time (or multiple of the network cycle time) to maximise co-ordination between adjacent signalised intersections.

The modelling work has generally assumed that a maximum cycle time of 120 seconds would be in operation – whilst there is no fixed limit on a usable cycle time, it is generally accepted that a 120 second cycle is the upper boundary, so as to not result in excessive wait time for pedestrian movements (on inter-urban or rural strategic routes, cycle times can be higher as pedestrian movements are usually negligible or absent). Ideally a cycle time below 90 seconds should be used on urban corridors where high pedestrian volumes are present – although it should be noted that this is constrained and influenced by the specific elements of the network and is not always possible – for example, the Stanley Street/Shotover Street intersection in Queenstown Town Centre operates with a cycle time of 120 seconds for the majority of the day, when a lower cycle time would be desirable in the context of the location.

Therefore, for this network a 120 second cycle time has been used in the models – it is likely that this would be required for capacity reasons, and at least in the short-term pedestrian crossing volumes will be low to moderate.

Table 17 shows the assumed cycle times at each location within the network.

Table 17: Proposed Network Operation Cycle Times

Intersection	Recommended Cycle Time (seconds)	
	Signalised Roundabout Layout	Signalised Intersection Layout
SH6/Hawthorne Drive	120	120
SH6 Midblock	120	60/120
SH6/Grant Road	60	120
SH6/Hansen Road	120	120
SH6/Joe O’Connell Drive	120	120
SH6/SH6A	60	120

For both network options (signalised roundabouts or signalised intersections), the cycle times are compatible. The signalised roundabouts options generally allow/require a lower cycle time to operate effectively, which can benefit in terms of minimising pedestrian wait times (although this is generally couple with staggered crossing arrangements, rather than full crossings).

The conclusion is that a “pick and mix” options is possible, as cycle times are compatible across both network options.

A further point to note in terms of the operation of the wider network, is the proposed (or potential) removal of existing roundabouts at SH6/Lucas Place, SH6/SH6A, SH6/Grant Road and SH6/Hawthorne Drive. This limits the opportunities for vehicles to reverse directions, particularly buses, coaches and taxis which are more likely to have non-linear routes.

Whilst the existing SH6/Grant Road and SH6/Hawthorne Drive roundabouts see negligible U-turn movements at present, this could potentially increase with growth in kerbside activity at the PT hub

to the west – by either private coach services, taxis or kiss and ride activity. Therefore, particularly in combination with the removal of the ability to U-turn at the SH6/SH6A, there will need to be an increasing reliance on local streets to provide a means for traffic to carry out existing U-turn manoeuvres if the roundabouts are converted to conventional signalised intersections.

Conclusions and Summary

This technical note has detailed an assessment of the operation of the SH6 Eastern Corridor under two different design layout concepts:

- signalised roundabouts at SH6/Hawthorne Drive and SH6/Grant Road, and conventional signalised intersections elsewhere
- conventional signalised intersections across the corridor

The assessment has indicated the following:

- The two layout options have a similar level of traffic capacity at all intersections, and are both compatible with the preferred intersection layout at the key SH6/SH6A intersection
- Bus and general traffic travel times are relatively similar in both options, with the fine-tuning of signal offsets between intersections likely to allow an adjustment of the balance of priority to buses versus general traffic – subject to the offsets being sufficiently optimised for general traffic to minimise queues lengths on each section
- At-grade pedestrian provision and pedestrian delay is generally better in the conventional intersection layouts, although in this option there are still some locations where crossings cannot be provided (east side of SH6/Hawthorne Drive) or need to be staggered (at SH6/Hansen Road and SH6/Joe O'Connell). However, it is still to be determined whether underpass crossings are better provided at some locations, which would reduce the advantages of the conventional arrangement (over the signalised roundabouts)
- The signalised roundabout arrangements require less land take along the corridor, as the roundabouts are more efficient than conventional intersections. In terms of impact, the conventional intersections arrangements require:
 - SH6/Hawthorne Drive
 - Extra approach lane on Hawthorne Drive
 - Extra approach lane on SH6 East, and exit lane of SH6 West
 - Extra short right turn lane on SH6 East
 - Extra short left turn lane on SH6 West
 - SH6/Grant Road, SH6/Hansen Road and SH6/Joe O'Connell Drive
 - Extra approach lane on SH6 East, and exit lane of SH6 West
- The signalised roundabout arrangements allow U-turn movements to continue to be accommodated which is a useful feature in the network particularly as land use is built-up along the corridor (with an associated increase in kerbside activity)

A separate multi criteria assessment of the two options has also been undertaken. This evaluation also shows little overall difference between the two options in terms of bus and general traffic travel times and overall network performance. The roundabout option scores higher for the need for less land-take along the corridor, alignment with the Frankton masterplan, and road safety. The conventional arrangement scores higher for pedestrian provision and supporting future land use development.

In summary, both Options provide a high level of benefits over the existing intersection form, with the decision being a choice between the relative importance of the various trade-offs in costs and benefits, and the consideration of other scheme objectives.

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Released under the Official Information Act 1982

NZTA Contract 2018235 – Arterial Stage 1 Pedestrian Permeability Assessment

Technical Note #32

31 July 2020

1. Introduction

The introduction of the Arterial Stage 1 (Melbourne Street – Henry Street), is shown in *Figure 1*. The removal of east – west traffic to the new arterial will enhance the amenity and operation of Stanley Street, particularly for pedestrians and public transport. However, due to topography, related engineering design and safety constraints, it was identified that pedestrian movement across the Arterial Stage 1 may be compromised in locations. This technical note summarises these constraints, the expected impact, and proposed mitigation measures.



Figure 1 Arterial Stage 1 Design

1.1 Option Assessment

The business case project team members (design manager, traffic engineer, urban designer and transport planner) met to consider and assess pedestrian permeability across the Arterial Stage 1.

2. Design Considerations

A key element of the Queenstown Town Centre Detailed Business Case (DBC) design approach is to give effect to the Queenstown Town Centre Masterplan, including the prioritisation of pedestrian movement in the town centre. Other elements include strengthening the civic axis connection between the residential developments on Queenstown Hill, Project Manawa development site and Queenstown Lakefront. The Arterial Stage 1 enables significant pedestrian improvements, including providing widened footpaths and enhanced urban realm. This will be supported by reducing, and the eventual removal of, through traffic in Stanley Street, (public transport only, between Ballarat and Shotover Streets).

The arterial design process has included a focus on design compliance with the Safe System objective to eliminate death and serious injuries for all road users, and in particular, vulnerable road users such as pedestrians and cyclists. The Safe System approach is based around minimising the user's exposure to, the likelihood of and/or crash severity. The new link may affect previous movement desire lines i.e. Ballarat or Beetham Streets. Minimising the risk to pedestrians crossing the arterial is a fundamental design consideration in the project.

2.1 Henry - Gorge Intersection

The Henry Street/Gorge Road/Shotover intersection shown in *Figure 2*, will be upgraded to a signalised T-intersection with pedestrian phases on each leg of the intersection. This will improve pedestrian permeability and safety at this location.



Figure 2 Proposed design of Henry Street/Gorge Street Intersection

Pedestrians will be incentivised to use this crossing opposed to informal crossing options, as it allows users to cross safely. This is expected to be the preferable option when crossing the arterial road in this vicinity.

2.2 Henry - Malaghan Intersection

The introduction of the arterial will result in the closure of the Henry/Malaghan Street intersection to vehicular traffic. Steps will be provided to aid pedestrian movement between Henry and Malaghan Streets and are shown in *Figure 3*.

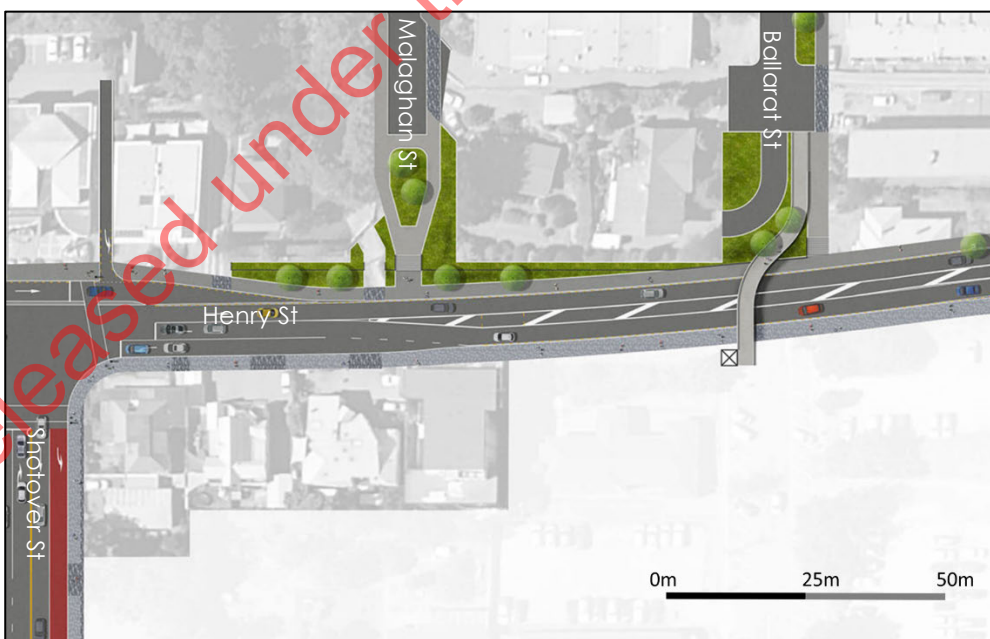


Figure 3 Proposed design of Henry Street/Malaghan Street Intersection

With the Henry-Malaghan intersection being within 70m of the signalised crossing at Henry/Gorge Road, it is expected that pedestrian movement will be along the footpath to the safe crossing location and not impact overall desire lines. It would be unsafe to provide an at-grade crossing facility directly at this location due to the expected continuous flow of vehicles due to:

- Merging traffic lanes in the eastbound direction (north side of the road).
- A straight through lane from Gorge Road which will only be stopped when the pedestrian phase is activated at the signals.
- Two westbound lanes including the need for queuing space on the approach to the signals which would also obstruct sightlines.

2.3 Henry – Ballarat Intersection

Ballarat Street is currently a key access route from Queenstown Hill to the town centre due to its comparatively gentler gradient and the signalised crossing facility at Stanley Street. The introduction of the arterial could sever this link so at-grade, over and under-pass options have been considered. The proposed design is illustrated in Figure 4.



Figure 4 Proposed design of Henry Street/Ballarat Street Intersection showing overpass

As a result of Project Manawa, Ballarat Street between Henry and Stanley Streets will be closed. While initial site plans have shown pedestrian access through the site will be maintained, the final site layout has yet to be confirmed.

At-Grade Crossing

A signalised, at grade crossing would be consistent with the Queenstown masterplan objectives and maintain the current desire line. The intersection of Ballarat and Henry Streets however is also where the new link from Melbourne Street would connect. Due to the significant change in elevation between the Melbourne/Beetham and Ballarat/Henry intersections, the road gradient along this section would poses significant safety and/or operational risks for both pedestrian and vehicle movements:

- The cross-fall on the road would make pedestrian movements uncomfortable and pose difficulties for those with mobility impairments or using wheeled assistance e.g., wheelchairs or push chairs, as they would have gradient induced tendency to travel down the road rather than across it.
- Westbound vehicles would have impaired sight lines due to the crest of the road which would not meet safe stopping distance requirements.
- The ability of vehicles travelling downhill to stop at a crossing would be compromised by the steep gradient, particularly in poor road conditions e.g., slippery road conditions due to ice or grit.

- The ability of vehicles travelling uphill starting from a complete stop may also be compromised, particularly in poor conditions.
- Heavy vehicles would experience severe limitations on an uphill gradient, and there are visibility issues as the crossing would be over the crest of the downhill gradient

As such, this option would not be recommended as it would not provide a safe crossing facility for pedestrians.

Underpass

An underpass could be introduced and would run from Ballarat Street (north) with an exit out onto the footpath on the south side of the arterial, or if feasible, into the Project Manawa site.

An underpass is unlikely to be suitable as:

- It does not realise the desired pedestrian priority objectives.:
- Pedestrians feel vulnerable in situations where they perceive or experience obstructed sightlines and spaces where they may feel trapped. Underpasses are generally not recommended from a CPTED¹ perspective.
- Constraints regarding the land required for the access and egress points and ensuring steps and ramp requirements met acceptable standards i.e., gradients not exceeding 8%, may be significant considering the adjacent land users and topography.

Providing an underpass, while technically feasible, is not desirable from a pedestrian perspective nor recommended by the project team.

Overbridge

Similar to the underpass, an overbridge could be installed on the approach from Ballarat Street (north), crossing the arterial before landing on the footpath or being incorporated into the Project Manawa development.

Any design would need to meet minimum clearance compliant with the Heavy Haulage Association's *Road Design Specifications for Over-Dimension Loads* which is likely to exceed 6.5m. If the overbridge was to land on the footpath, it may require an elevator or extensive ramping to manage maximum ramp gradients. Alternatively, if the overbridge landing was integrated into the Manawa development, it may be possible to incorporate such requirements into the development.

Providing an overbridge is consistent with the outcome of the Queenstown Town Centre Masterplan and would address pedestrian safety issues along this key desire line. The project team recommends this option for implementation.

2.4 Melbourne – Beetham Intersection

Similar to the Henry/Malaghan Street intersection, the introduction of the arterial will result in the closure of Beetham Street to vehicular traffic (shown in *Figure 5*), with pedestrian steps provided to aid movement to and from the new arterial from both the north and south side of the road.

While Beetham Street provides a pedestrian link between Hallenstein, Melbourne and Stanley Streets, its desirability as a key pedestrian corridor is compromised by the reduced level of service provided due to the steep gradient, the provision of only one, narrow, footpath on east side of the road and the poor crossing provision at Melbourne St.

¹ Crime Prevention Through Environmental Design



Figure 5 Proposed design of Melbourne Street/Beetham Street Intersection

With the introduction of the arterial, the provision of a signalised at-grade crossing facility would be unsafe as it would occur on the crest of the new road and have restricted sightlines. Due to steep gradients (upto 12%) this would create an operationally challenging environment for vehicles stopping and starting, particularly in adverse conditions such as in wet/icy surfaces. Without signals, pedestrian safety would be compromised due to their movements being unprotected along with the reduced visibility as result of the changing gradient.

The area is topologically constrained for pedestrians (shown in Figure 6) and gradients for the arterial will be undesirable for pedestrians.



Figure 6 Street view of gradients for arterial link

The proposed street layout including the arterial is a grid, resulting in pedestrians travelling similar distances to get to their destination. The closest crossing option for pedestrians from Melbourne and Ballarat Streets is the Sydney Street signalised intersection or the proposed pedestrian overpass at Henry/Ballarat intersection.

An underpass could be considered in this location but is not recommended for similar reasons to Ballarat street which are:

- It does not realise the desired pedestrian priority objectives.
- Pedestrians may feel vulnerable in situations where they perceive or experience obstructed sight lines and spaces where they may feel trapped. Underpasses are generally not recommended from a CPTED perspective.

- Constraints regarding the land required for the access and egress points and ensuring steps and ramp requirements met acceptable standards i.e., gradients not exceeding 8%, may be significant considering the adjacent land users and topography.

Providing an underpass, while technically feasible, but is not desirable from a pedestrian perspective.

Due to the safety and operational constraints, there is no safe crossing proposed at Beetham and pedestrian movement is directed toward the Ballarat Street Civic Axis as a key connection over the arterial.

2.5 Melbourne – Sydney Intersection

The Melbourne/Sydney Street intersection shown in *Figure 7*, will be upgraded to a signalised four-way intersection with appropriate pedestrian phasing. This will improve pedestrian permeability and safety at this location.



Figure 7 Proposed design of Melbourne Street/Sydney Street Intersection

2.6 Melbourne – Frankton Intersection

Similar to the Melbourne/Sydney Street intersection, the Melbourne/Frankton Street intersection shown in *Figure 8*, will be upgraded to a signalised intersection with pedestrian phases. This will improve pedestrian safety and permeability at this location through the provision of a safe pedestrian priority crossing.

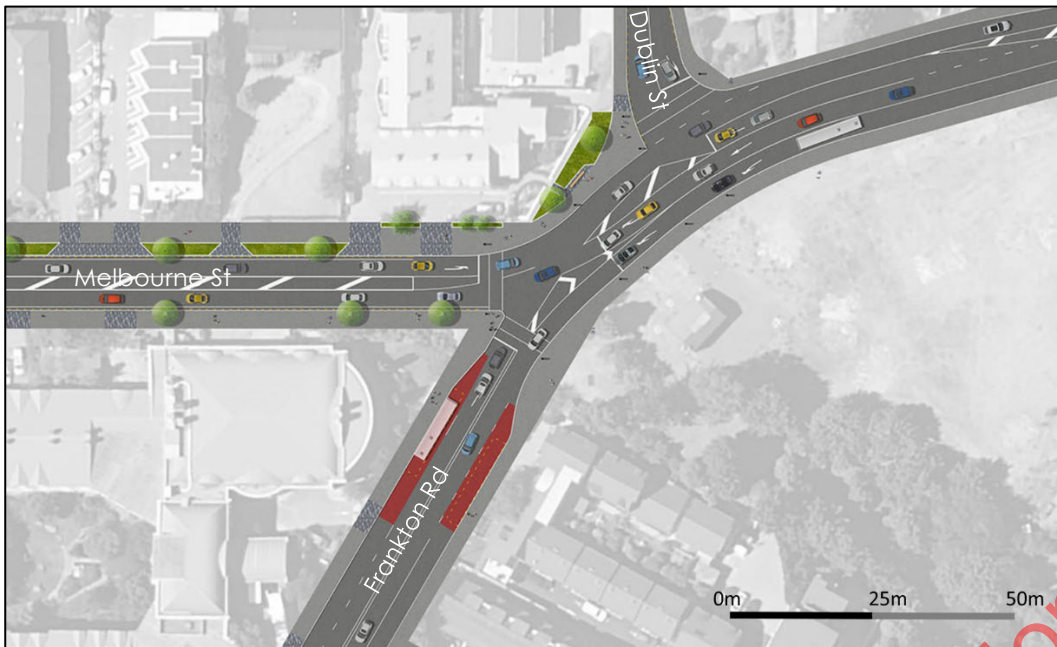


Figure 8 Proposed design of Melbourne Street/Frankton Road Intersection

2.7 Pedestrian Permeability

Pedestrians moving between the town centre and Queenstown Hill will be required to use crossing facilities at either Gorge/Henry, Ballarat or Sydney Streets. Beetham and Malaghan Streets would provide access to the new arterial, however due to safety reasons will not be able to cross directly at these locations. Due to the relatively steep gradients on these streets, it is considered that these will be of secondary importance compared to Ballarat or Sydney Streets.



Figure 9 Pedestrian permeability map of routes to the town centre

Figure 9 shows that overall permeability will be maintained with only limited impacts on existing desire lines if the proposed pedestrian overbridge is introduced from Ballarat Street into the Project Manawa Development.

3. Summary

While no pedestrian movements have been precluded with the current design of the new arterial road, i.e., no median barrier will be installed, consideration has gone into ensuring that the key movements are protected where possible. The introduction of signalised crossing facilities at Henry/Gorge and Melbourne/Sydney, as well as the recommended overbridge at Ballarat Street will enable key existing and future desire lines to be maintained and enhanced.

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