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NZTA Contract 2018235 - F2Q SSBC & QTC DBC

Technical Note # 42

3 May 2020

SH6A (Frankton Road) Bus Signal and Virtual Priority

Introduction

This note sets out the modelling of the SH6A corridor (Frankton Road), under a number of scenarios:

- 2028 Do Minimum
- 2028 Managed Demand
- 2028 Virtual Priority (Managed Demand + Signal Priority)
- 2028 Virtual Priority Eastbound only (Managed Demand + Signal Priority)
- 2028 Full Bus Priority Lanes

Scenarios

Table 1 provides a summary of the various assumptions used in the modelling tests, with a summary explanation of the key elements of each test described below.

2028 Do Minimum

This scenario assumes that a number of signalised intersections along SH6A are implemented (for road safety and access benefits, rather than for bus priority). This provides the most likely scenario for a Do Minimum, with minimal network management of the corridor (in terms of the wider network control of general traffic volumes). This provides a baseline of travel times, for both general traffic and PT services, from which to compare against the potential improvement options.

Further details of the general operation of the proposed signalled intersections along the corridor is provided in the next section.

2028 Managed Demand

This scenario aims to control traffic volumes along SH6A to a level at which both general traffic and PT services can be provided with a reasonable level of service (and travel time) **along the corridor itself**.

This is done in the westbound direction through the use of network control and management on the State Highway network within Frankton (and in the longer term and/or if required, further afield on Ladies Mile to the east, and south of the Kawarau Falls Bridge to the south). This strategy assumes that significant lengths of bus lane are provided on the approaches to the SH6/SH6A roundabout (which itself is upgraded and includes signal control) so that buses can bypass any queues of general traffic that are held due to the capacity of SH6A being unable to accommodate the demand – in effect, the improved SH6/SH6A intersection acts as a gateway to Frankton Road, with traffic volumes released into SH6A at around a 80-85% volume to capacity ratio. This ensures that the corridor can accommodate actual volumes, and that queues are generally residual at each intersection (i.e. queues clear during a single signal cycle, or green period).

In the eastbound direction, this strategy is more difficult to implement, as traffic volumes are added to the eastbound SH6A at numerous points along the length of Frankton Road (from Queenstown Hill residential areas). The majority joins within, or just to the east of the town centre (predominantly from Stanley Street and Dublin Street), but additional traffic joins at other intermediate intersections (e.g. Hensman Road, Goldfield Heights) such that peak volumes are generally recorded around the SH6A/Marina Drive/Sugar Lane intersection. As such, unlike in the westbound direction, a single traffic gating point is not available – and therefore demand is more difficult to manage in the eastbound direction. This issue is discussed later in the technical note.

This scenario also introduces some short sections of physical bus lane along SH6A (as per Table 1), although these are minimal due to cost implications, property (and social) impacts and/or topographical constraints.

Table 1 Modelling assumptions

	2028 Do Min	2028 Managed	2028 Virtual Priority	2028 Full Priority
SH6A Corridor Intersections				
SH6A/McBride	"Option B" (signalised intersection)			
SH6A/Marina	Fully protected crosswalks (signalised intersection)	EBRT ban, staggered crossing on west side, fully protected crosswalks (signalised intersection)		
SH6A/New Marina/Perkins	Signalised crossing provided	New south leg, fully protected crosswalks on south and east (signalised intersection)		
SH6A/Battery Hill	Signalised crossing provided			
SH6A/Goldfields	Fully protected crosswalks on west (staggered) and north (signalised intersection)			
SH6A/Larch Hill	Signalised crossing provided			
SH6A/Hensman	Fully protected crosswalks on west (staggered) and north (signalised intersection)			
SH6A/Oaks Club	Signalised crossing provided			
SH6A/Dublin	Hallenstein St optimisation (without Arterials is worst case so assume that with Arterials would be less good for full priority)			
Frankton				
SH6/SH6A	As existing	Guavabout		
SH6 Kawarau Road	NB bus lane from Lucas Place to Frankton Hub			
SH6 Frankton-Ladies Mile Hwy	EB and WB bus lanes from SH6/SH6A to Hardware Lane (where two lanes currently, kerbside lane is re-allocated as bus lane)			
QTC				
General	With Arterial version, as this maximises the throughput EB out of QTC in the PM peak			
SH6A Corridor Bus Lanes				
SH6/SH6A to Yewlett	WB kerbside lane reallocated as bus lane	EB kerbside lane reallocated as bus lane; WB reduced to single lane		Widened to provide bus lanes in both directions (only broken for short LT allowances); SH6/SH6A to Yewlett WB kerbside lane reallocated as bus lane
Yewlett to Marina	None	None		
Marina to Perkins		WB and EB bus lanes provided through widening		
Perkins to Middleton		None		
Middleton to Battery Hill		None		
Battery Hill to Goldfields		None		
Goldfields to Larch Hill		EB bus lane provided through widening		
Larch Hill to Hensman		None		
Hensman to Suburb		None		
Suburb to Ballarat	WB bus lane through to Stanley, with sensitivity testing length of Suburb bus lane, i.e. does it need to start earlier than Suburb St. WB buses diverted to Coronation Drive, short WB bus lane at western end of Coronation Drive			
Bus stops	All offline	Online in bus lane sections, otherwise offline		All online
Demand (all use same demand set)				
SH6A WB	100% (controlled by how much can pass through SH6/SH6A roundabout)	~85% (managed at Guavabout to hold demand to east/south)		100% (controlled by how much can pass through guavabout)
SH6A EB	100%			

2028 Virtual Priority

This scenario includes the managed demand philosophy of the previous scenario, but also introduces bus signal priority. This is provided via a number of methods:

- Phase extension (1) - If a bus is approaching an intersection towards the end of the main eastbound/westbound phase (and the bus stop is on the exit side of the intersection), then the phase is extended to clear the bus through the intersection (within a maximum limit of around a 10 second journey time)
- Phase extension (2) – If a bus is at a bus stop on the approach side (will generally be close to the limit line) towards the end of the main eastbound/westbound phase, then the phase should be extended to allow bus to leave the stop and pass through the intersection
- Bus phase – If bus is at an approach side bus stop during red for the westbound/eastbound signal phase (or within an approach bus lane that terminates on the exit side of the intersection), then a special bus "B" aspect/phase is inserted before the main westbound/eastbound phase to allow the bus an early start (typically, a 5 second green)
- Early phase termination (phase recall) – If a bus is in an exit side inset bus stop during the westbound/eastbound phase, apply early termination of the westbound/eastbound phase (subject to a, say, 50 second minimum) so that buses can re-join traffic stream. If a downstream bus lane exists, then this priority is not applicable

In addition to the above:

- The above activations are applied for both signalised intersections and crossings
- The fixed 100-120 second network cycle time will be retained, with re-balancing of green time between subsequent westbound/eastbound phases. In this way, a "base" level of offset optimisation can be achieved without activating any signal priority (i.e. the buses where possible arrive at each intersection during the normal eastbound/westbound green phase, thus receiving a form of virtual priority)

2028 Virtual Priority (Eastbound only)

This scenario applies bus signal priority in the eastbound direction only, with managed demand applied westbound. This scenario was tested due to two additional constraints in the eastbound direction for bus priority:

- As noted above, managing traffic demand is more difficult in the eastbound direction. Therefore, bus priority is more critical in this direction
- Due to most intersections being three-arm, with the side road on the north (hill) side of the intersection, the eastbound through movement generally receives less green time per cycle than the westbound through movement, due to the need to run protected westbound right turn phases. Therefore, bus signal priority is more effective in this direction

2028 Full Priority

The final scenario assumes that physical bus lanes are provided for the full length of Frankton Road (Dublin Street to SH6/SH6A) so as to segregate buses from general traffic. This is a high cost scenario, but is tested to show the best possible operation of the corridor for buses – for general traffic, there is still a need to apply demand management as the single lane capacity of the corridor is similar to the above scenarios.

Signalised Intersection Operation

The following sections set out the proposed operation and layout of each signalised intersection under all scenarios, except for the Full Priority option. This scenario would have additional eastbound and westbound kerbside bus lanes throughout the corridor, albeit the general operation of the intersection would be similar to the other scenarios. The principal objectives of the intersection signalisation are to:

- Improve access/egress to/from side roads, to improve road safety
- Provide formal controlled pedestrian crossing facilities along the corridor, to improve pedestrian and cycle connectivity and safety
- Provide a means of providing pro-active control in the operation of the corridor
- Provide a means of providing bus signal priority

It should be noted that the preliminary/schematic layouts shown below are still in development and are therefore subject to change – but the overall strategy is unlikely to change significantly.

Marina Drive/Sugar Lane

The principal changes in operation at the intersection are shown in Figure 1 and the list below:

- Signalised
- Removal of eastbound right turn – to be provided at new intersection to the west (see next intersection)
- Fully protected pedestrian crossings provided on north, south and west crosswalks. The staggered nature of the west crosswalk allows more flexibility in terms of operation (with and without pedestrian crossing demand), and reduces pedestrian crossing clearance times
- Bus lanes provided in each direction, to the west of the intersection
- Bus stops provided on the exit side of the intersection on Frankton Road in both directions

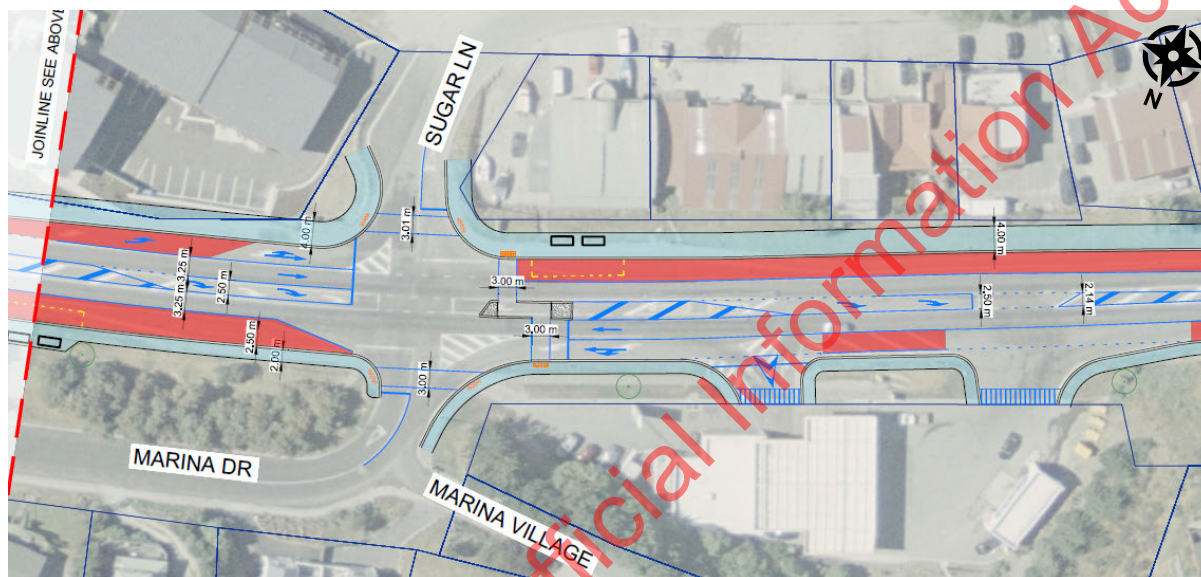


Figure 1: Proposed schematic layout of Frankton Road/Marina Drive

In terms of bus signal priority, as the bus stops are on the exit side of the intersection in both directions, signal priority is proposed to be afforded in two methods:

- Phase extension - If a bus is approaching the intersection towards the end of the main eastbound/westbound phase, then the phase is extended to clear the bus (within a maximum limit of around a 10 second journey time)
- Early phase termination (phase recall) – If a bus is in the exit side inset bus stop during the westbound/eastbound phase, apply early termination of the westbound/eastbound phase (subject to a, say, 50 second minimum) so that buses can re-join traffic stream – this is applied in the eastbound direction only, as a westbound bus lane provides protection in this direction

New Marina Access and Perkins Road

The principal changes in operation at the intersection are shown in Figure 2 and the list below:

- Signalised at new Marina access intersection
- Right turn out of new access is not allowed, as traffic can egress at existing intersection
- Fully protected pedestrian crossings provided on south and east crosswalks
- Bus lanes provided on the approach in each direction,
- Bus stops provided on the approach side of the intersection on Frankton Road in both directions

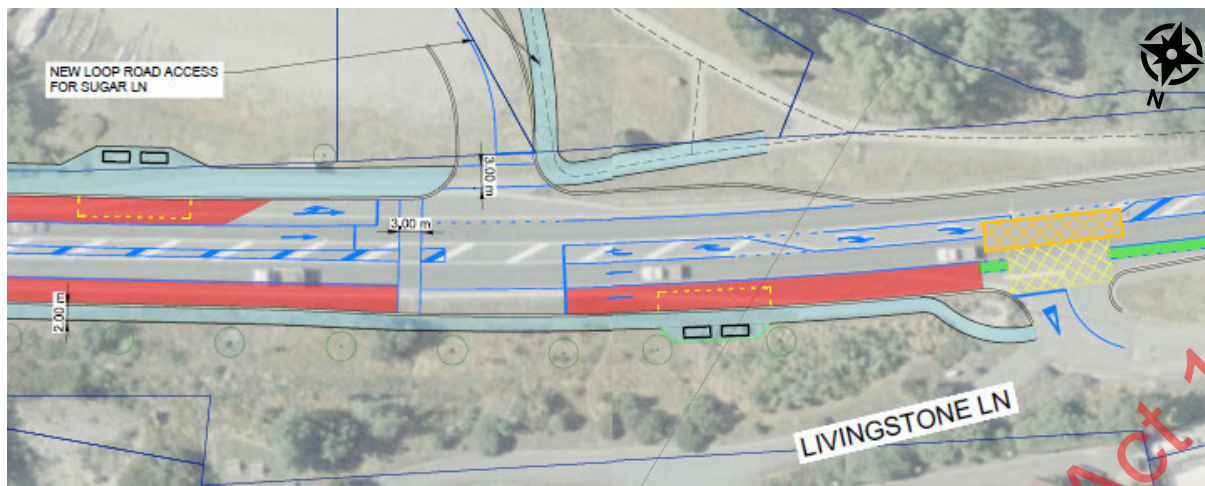


Figure 2: Proposed schematic layout of Frankton Road/Perkins Road

In terms of bus signal priority, as the bus stops are on the approach side of the intersection in both directions, signal priority is proposed to be afforded in two methods:

- Phase extension – If a bus is at a bus stop on the approach side (will generally be close to the limit line) towards the end of the main eastbound/westbound phase, then the phase should be extended to allow bus to leave the stop
- Bus phase – If bus is at the westbound bus stop during red for the westbound/eastbound signal phase, then a special bus “B” aspect/phase is inserted before the main westbound/eastbound phase to allow the bus an early start (typically, a 5 second green). This is applied in the westbound direction only, as an eastbound bus lane provides protection in this direction

In addition, the addition of a signal intersection at this location would also create gaps in the Frankton Road traffic stream, to enable vehicles to enter/egress Perkins Road more safely.

Battery Hill (Potters Hill Drive)

The principal changes in operation at the intersection are shown in Figure 3 and the list below:

- Fully protected signalised pedestrian crossing provided on the east side of the intersection
- Bus stops provided on the exit side of the intersection on Frankton Road in both directions

In terms of bus signal priority, as the bus stops are on the west side of the crossing, signal priority is proposed to be afforded in three methods:

- Phase extension - If a westbound bus is approaching the crossing towards the end of the main eastbound/westbound phase, then the phase is extended to clear the bus (within a maximum limit of around a 10 second journey time) – i.e. the pedestrian crossing phase is delayed
- Early phase termination (phase recall) – If a westbound bus is in the exit side bus stop during the westbound/eastbound phase, apply a call for the pedestrian crossing phase so that buses can re-join traffic stream – this is applied in the westbound direction only
- Bus phase – If bus is at the eastbound bus stop during the pedestrian phase, then a special bus “B” aspect/phase is inserted before the main westbound/eastbound phase to allow the bus an early start (typically, a 5 second green). This is applied in the eastbound direction only

In addition, should excessive queues be experienced on the Potters Hill Drive side road (due to high traffic volumes on Frankton Road), then a dummy pedestrian call could be placed for the crossing phase so as to create a break in traffic in Frankton Road, and allow vehicles to egress the side road more safely.

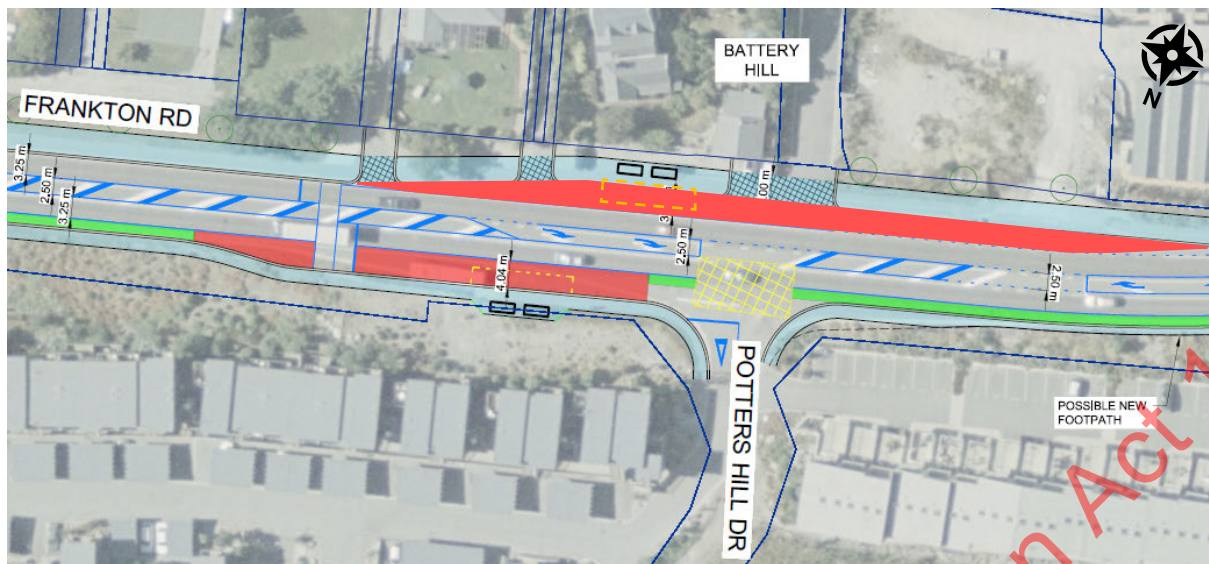


Figure 3: Proposed schematic layout of Frankton Road/Potters Hill Drive

Goldfield Heights

The principal changes in operation at the intersection are shown in Figure 4 and the list below:

- Signalised
- Fully protected pedestrian crossings provided on north and west crosswalks. The staggered nature of the west crosswalk allows more flexibility in terms of operation (with and without pedestrian crossing demand), and reduces pedestrian crossing clearance times
- Bus stops provided on the exit side of the intersection on Frankton Road in both directions

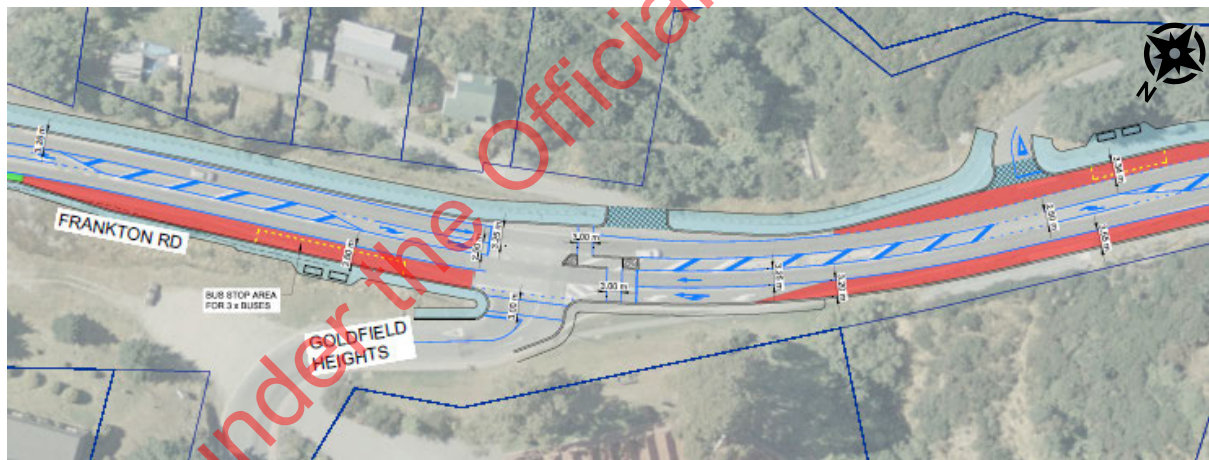


Figure 4: Proposed schematic layout of Frankton Road/Goldfield Heights

In terms of bus signal priority, as the bus stops are on the exit side of the intersection in both directions, signal priority is proposed to be afforded in two methods:

- Phase extension - If a bus is approaching an intersection towards the end of the main eastbound/westbound phase, then the phase is extended to clear the bus (within a maximum limit of around a 10 second journey time)
- Early phase termination (phase recall) – If a bus is in the exit side inset bus stop during the westbound/eastbound phase, apply early termination of the westbound/eastbound phase (subject to a, say, 50 second minimum) so that buses can re-join the traffic stream

Larch Hill Place

The principal changes in operation at the intersection are shown in Figure 5 and the list below:

- Fully protected signalised pedestrian crossing provided on the east side of the intersection
- Eastbound bus stops provided on the exit side of the intersection on Frankton Road (no westbound stop in the vicinity)

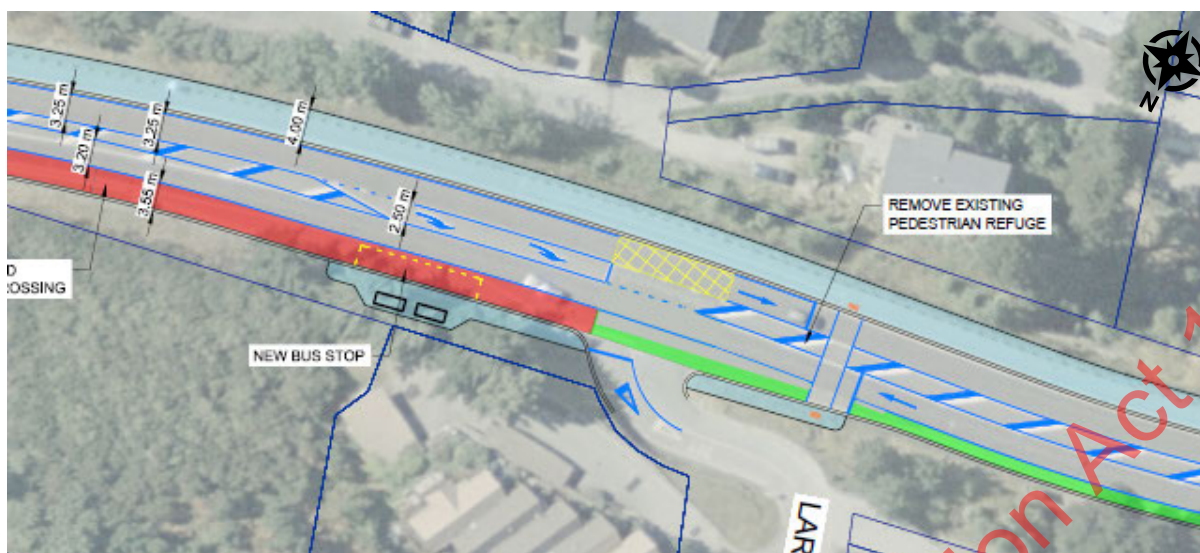


Figure 5: Proposed schematic layout of Frankton Road/Larch Hill Place

In terms of bus signal priority, signal priority is proposed to be afforded in two methods:

- Phase extension - If a westbound bus is approaching the intersection towards the end of the main eastbound/westbound phase, then the phase is extended to clear the bus (within a maximum limit of around a 10 second journey time) – i.e. the pedestrian crossing phase is delayed
- Bus phase – If bus is at the eastbound bus stop during the pedestrian phase, then a special bus "B" aspect/phase is inserted before the main westbound/eastbound phase to allow the bus an early start (typically, a 5 second green)

In addition, should excessive queues be experienced on the Larch Hill Place side road (due to high traffic volumes on Frankton Road), then a dummy pedestrian call could be placed for the crossing phase so as to create a break in traffic in Frankton Road, and allow vehicles to egress the side road more safely.

Hensman Road

The principal changes in operation at the intersection are shown in Figure 6 and the list below:

- Signalised
- Fully protected pedestrian crossings provided on north and west crosswalks. The staggered nature of the west crosswalk allows more flexibility in terms of operation (with and without pedestrian crossing demand), and reduces pedestrian crossing clearance times
- Bus stops provided on the exit side of the intersection on Frankton Road in the eastbound direction, and on the approach in the westbound direction

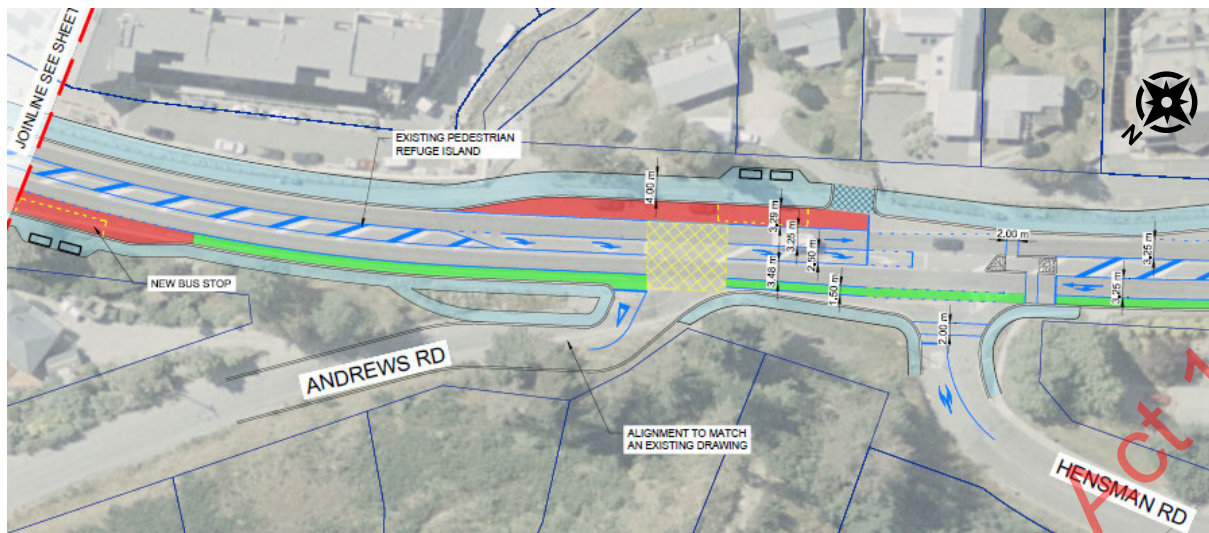


Figure 6: Proposed schematic layout of Frankton Road/Hensman Road

In terms of bus signal priority, signal priority is proposed to be afforded in three methods:

- Phase extension - If an eastbound bus is approaching the intersection towards the end of the main eastbound/westbound phase, then the phase is extended to clear the bus (within a maximum limit of around a 10 second journey time). If a westbound bus has dwelled at the stop towards the end of the main eastbound/westbound phase for a pre-set duration, then the phase is extended to clear the bus (within a maximum limit of around 10 seconds)
- Early phase termination (phase recall) – If an eastbound bus is in the exit side inset bus stop during the westbound/eastbound phase, apply early termination of the westbound/eastbound phase (subject to a, say, 50 second minimum) so that eastbound buses can re-join traffic stream
- Bus phase – If bus is at the westbound bus stop during red for the westbound/eastbound signal phase, then a special bus “B” aspect/phase is inserted before the main westbound/eastbound phase to allow the bus an early start (typically, a 5 second green)

In addition, the addition of a signal intersection at this location would also create gaps in the Frankton Road traffic stream, to enable vehicles to enter/egress Andrews Road more safely.

Oaks Club

The principal changes in operation at the intersection are shown in Figure 7 and the list below:

- Fully protected signalised pedestrian crossing provided in the vicinity of bus stops visitor accommodation to prevent need for pedestrians to cross SH6A on blind corner
- Bus stops provided on the exit side of the intersection on Frankton Road in the westbound direction, and on the approach in the eastbound direction

In terms of bus signal priority, as the bus stops are on the exit side of the crossing in both directions signal priority is proposed to be afforded in two methods:

- Phase extension - If a westbound bus is approaching the crossing towards the end of the traffic phase, then the phase is extended to clear the bus (within a maximum limit of around a 10 second journey time). If an eastbound bus has dwelled at the stop towards the end of the main traffic phase for a pre-set duration, then the phase is extended to clear the bus (within a maximum limit of around 10 seconds) if a pedestrian call has been demanded
- If a westbound bus is in the exit side bus stop during the traffic phase, apply a call for the pedestrian crossing phase so that buses can re-join traffic stream – this is applied in the westbound direction only

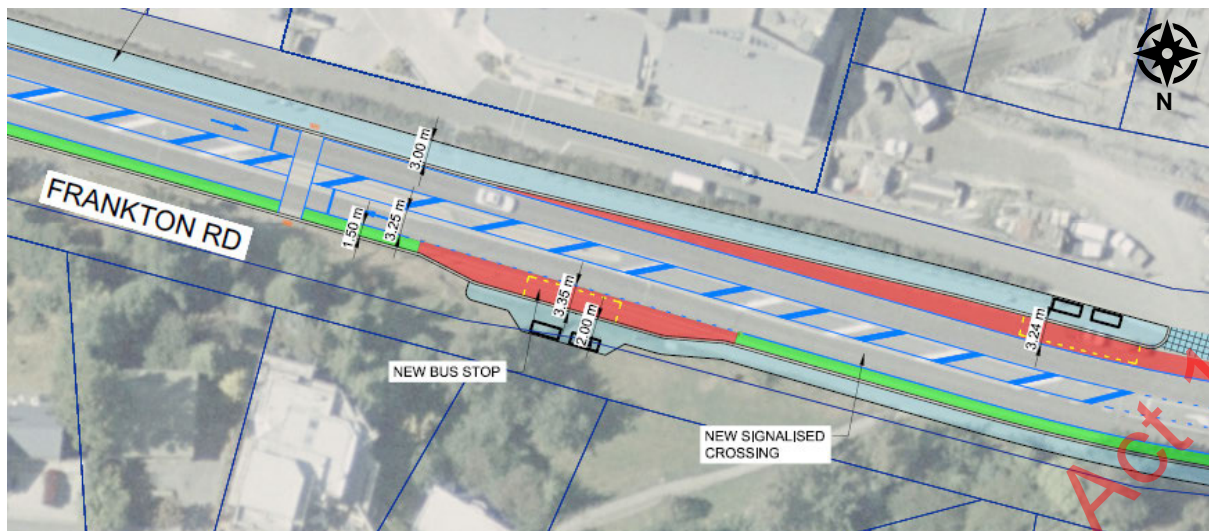


Figure 7: Proposed schematic layout of Frankton Road/Oaks Club Bus Stops

Results

Table 2 show the results output from the Paramics model for each scenario, in the **AM peak** period (0800-0900).

Table 2: **AM Peak** travel times on Frankton Road (in seconds)

Direction	Vehicle Type	Do-Min	Managed	Virtual	Virtual (EB only)	Full Priority
Westbound	General	461	439	457	427	436
	Bus	706	718	740	711	660
Eastbound	General	413	418	444	418	424
	Bus	893	881	908	861	738

A number of trends can be seen:

- General traffic travel times are significantly lower than for public transport movements – this is generally due to the number of stops on the route, with the assumption that all buses stop for 20 seconds at all stops on route. In practice, some stops may be skipped, and therefore bus travel times would reduce accordingly
- General traffic travel times are fairly stable across all scenarios, demonstrating that the differences between the scenarios have little impact on general traffic times within the corridor
- In both directions, the Managed scenario has no measurable impact on bus travel time compared to the Do Minimum, due to the lower level of traffic in the AM peak period
- In the Virtual scenario, travel times are poorer than in the Do-Min – this is likely to be due to several reasons:
 - Conflicting calls for opposing priority strategies in the two directions, resulting in the additional delay being experienced by some buses
 - This is likely to be exacerbated by the high frequency of bus calls (20 per hour per direction), which causes the signal control to be in a permanent state of flux and unable to react optimally to each priority call
 - The limited signal plan logic within the Paramics model being unable to fully represent the required signal priority (i.e. less effective than that which could be used in practice)
- In the Virtual Eastbound-only scenario, bus travel times are moderately improved in the eastbound direction, with no discernible reduction for westbound services. This demonstrates worth in providing signal priority in the direction in which traffic generally receives less green time per cycle (due to opposing right turns into side roads onto Queenstown Hill) – and in the direction where managing traffic volumes is more difficult

- Full priority provides the greatest travel time savings as would be expected. However, the savings (around 45 seconds westbound; 150 seconds eastbound) are relatively modest for the infrastructure works required. It is interesting to note that it is also in the eastbound direction where travel times savings are more significant (due to the reasons in the previous bullet) – and suggests that any physical bus lane sections that can be accommodated relatively cost-effectively in the other scenarios should be concentrated in the eastbound direction

Table 3 show the results output from the Paramics model for each scenario, in the **PM peak** period (1700-1800).

Table 3: **PM Peak** travel times on Frankton Road (in seconds)

Direction	Vehicle Type	Do-Min	Managed	Virtual	Virtual (EB only)	Full Priority
Westbound	General	574	452	465	462	466
	Bus	767	689	811	699	617
Eastbound	General	444	422	461	461	442
	Bus	928	870	889	846	695

A number of trends can be seen:

- General traffic travel times are significantly lower than for public transport movements as per the AM peak period results
- General traffic travel times are fairly stable across all scenarios, except for in the Do-Min scenario for the westbound direction – this shows that managing the westbound demand at the east end of the corridor results in significant on-corridor travel time savings. It should be noted that westbound volumes are generally higher in the Winter PM peak period (due to traffic heading back from the ski fields) than those tested here, and it is expected that the Do Min would be worse in this period
- In both directions, the Managed scenario provides modest bus travel time savings compared to the Do Minimum, due to the controlling of traffic volumes, especially in the westbound direction
- As for the results in the AM peak period, in the Virtual scenario, travel times are poorer than in the Managed scenario, for the same reasons of conflicting signal priority requests and limitations in the modelling software
- In the Virtual Eastbound-only scenario, bus travel times are further improved in the eastbound direction (from the Managed scenario), with no discernible reduction for westbound services. As for the AM peak period, this demonstrates worth in providing signal priority in the direction which traffic generally receives less green time per cycle (due to opposing right turns into side roads onto Queenstown Hill) – and in the direction where managing traffic volumes is more difficult
- Full priority provides the greatest travel time savings as would be expected. The savings compared to the Do-Min (around 150 seconds westbound; 230 seconds eastbound) are more significant than in the AM peak period, due to the higher levels of traffic (and therefore potential congestion) on the corridor in the PM peak period. However, as greater savings are also predicted for the Managed and Virtual priority scenarios (than in the AM peak period), the travel time savings compared to these scenarios are still modest for the infrastructure works required
- Compared to the Full priority scenario:
 - In the westbound direction, the Virtual Eastbound only scenario achieves 45% of the travel time savings over the Do Minimum travel time
 - In the eastbound direction, the Virtual Eastbound only scenario achieves 35% of the travel time savings over the Do Minimum travel time

It is expected that due to the limitations of the signal plan logic within the Paramics model being unable to fully represent the required signal priority, the travel time savings achieved above (against a full priority situation) are likely to be conservative – i.e. the signal plans in practice would be more adaptive, and be able to achieve greater travel time savings

Conclusions and Recommendations

The modelling work has investigated the predicted relative bus and general traffic travel times on Frankton Road, between a Do-Min scenario, and a range of Managed/Virtual Priority and Full Priority scenarios at 2028 predicted demand levels. Given the restriction on overall capacity both on the corridor, within the Queenstown Town Centre and in the wider network, the results are also analogous to all later future years (as additional growth in general traffic demand cannot be served).

Key conclusions of the work are as below:

- Managing demand levels on SH6A Frankton Road has benefit in terms of improving bus (and general traffic) travel times, and reliability, along the corridor. For reliability across the network, this is reliant on physical bus priority measures (i.e. bus lanes) being provided within Frankton so as to ensure buses can bypass any general traffic queues to access the corridor from the eastern end
- Applying Bus Signal Priority across the corridor results in some issues in terms of travel time savings effectiveness – due to the combination of conflicting signal priority by direction, and the relatively high frequency of services (and therefore priority calls). Although the Paramics priority signal coding has some significant limitations in applying what could be achieved on the corridor in practice, it is considered that allowing all buses to call priority routines at all signal sites would result in poor operation of the corridor
- Applying Bus Signal Priority only in the critical eastbound direction provides additional travel time benefits to the Managed scenario – this is due to less priority calls per intersection per hour, and less conflicting requests (although still possible for bunching services in the high frequency scenario). In this scenario, as westbound traffic receives a large proportion of the green time per cycle, there is little detrimental impact on westbound bus services
- The Full Priority scenario provides the greatest travel time benefits as would be expected, but savings are relatively moderate, and come with a significant infrastructure cost (as well as other issues such as consenting, buildability, property and social impacts, etc)

Consequently, it is recommended that a Managed plus Signal Priority concept is taken forward as the preferred option, but with bus priority, both physical and signal related, concentrated in the eastbound direction only (except in lower bus frequency periods, when signal priority could be operational in both directions). In practice, it would also be possible to prioritise the activation of bus priority by time of day and direction – and potentially to incorporate into a system that differentiated between on-time and late-running services (against the schedule) to provide a suitable level of priority.

However, this strategy does require the layout of the corridor (for public transport) to be designed to maximise the efficiency of bus movements. Where possible this should include:

- Bus stop positions close to signalised intersections where possible, to maximise the use of signal priority strategy to reduce delay for buses entering and exiting the stops
- Bus stops to have "free-flow egress" from stops where possible (especially when not close to signalised intersections), which could include bus lanes downstream of the stop, half-inset bus stop layouts or acceleration lanes out of the stop to re-join the traffic stream
- Any physical bus lanes that can be economically justified to be provided in the eastbound direction, particularly towards the eastern end of the corridor where traffic demands are forecast to be highest (between SH6/SH6A and Goldfield Heights)

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**Appendix B9 Technical Note 11: Queenstown Traffic Demand
Management Programme**

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Technical Note #11

18 September 2019

Summary: Queenstown TDM programme

Queenstown is one of New Zealand's fastest growing regions - rapid growth has boosted the region's economy but a high reliance on the car for travel has resulted in traffic congestion and parking problems that are negatively impacting the region's economic productivity, liveability and the visitor experience. Historically, investment in transport by government has been guided by the number of residents in a town or region rather than the total population. In Queenstown's case, this has resulted in an under investment in transport and infrastructure to support sustainable and efficient transport.

Given the location and geography, providing more infrastructure for cars is challenging and expensive. It also does not align with aspirations to reduce carbon emissions from transport, improve access to sustainable modes and increase wellbeing outcomes from the transport system. According to the public transport modelling being undertaken to support the business cases, a significant alternative mode share is required for peak periods (PM, in particular) by 2028 (40%) and 2048 (60%) for the transport network to continue to provide adequate levels of service to Queenstown residents and visitors. While a new bus service (November 2017), changes in parking charges and a network of off-road cycle trails have increased the uptake of sustainable modes in recent years, more focus is needed to achieve a mode shift away from cars. The current (2018) alternative mode share is in the range of 4-5%. The Wakatipu Basin Future PT Model predicts a significant increase in public transport mode share of 30% by 2028 and 42% by 2048 which still leaves a gap.

A Travel Demand Management (TDM) programme for the Wakatipu Basin area (pending approval) has been developed as part of the TDM business case to close this gap between predicted PT usage and total trip demand. The recommended programme has been developed by: understanding other transport projects being planned or underway; considering the local context; conducting structured interviews with stakeholders to understand their transport experiences and gauge the appetite for a transport management association (TMA)¹; and drawing on best practice and lessons learnt from overseas and national case studies. The delivery of the programme will rely on being able to secure funding, develop partnerships and fostering coordination between government agencies, as well as ongoing stakeholder engagement and collaboration to ensure that the public has ownership and 'buy-in' to the plan.

The recommended TDM programme for Queenstown has **four key areas** of focus:



¹ A Transport Management Association (TMA) is a not-for-profit organisation that represent an area's businesses and residents, with local government support. TMA's are member-controlled and take on roles ranging from advocacy and promotion of sustainable transport, through to running services such as vanpooling, shuttles or parking brokerage (OIC&KMC 2015).

1. **Policy** – Implementing policy changes takes time and requires public support, the list that this document recommends sets the agenda for the changes that are needed to achieve mode shift at scale. New policy or changes will be needed to support: car share; to require travel plans for large employers, key trip generators and new developments; to introduce charges for parking in areas that are presently free or cheap (where sustainable and more efficient transport choices are available); park and ride study; and initiatives that encourage a visitor mode shift like travel plans for popular destinations and a self-drive permit system. Road pricing may also be considered in the long term.
2. **Travel planning and behaviour change initiatives** – This section lists items that are usually led by local government in New Zealand. Its focus is on programmes that benefit residents and the recommended measures include: enhancing the school travel plan programme; providing cycle and scooter training for adults and children; supporting the development of residential travel plans and encouraging travel behaviour change efforts through an award scheme and gamification.
3. **Wayfinding improvements** – With so many visitors each year, Queenstown needs to make it easy for people to find their way around. People use both physical signs and digital platforms to navigate. Physical wayfinding needs should be comprehensively identified by way of an audit and there is a need for a systematic, easy to use Wayfinding Game Plan. Digital and physical systems should map 'smooth walking/wheeling routes' that are accessible to wheelchair users or the best route for someone wheeling a pram or luggage.
4. **Transport Management Association** – A TMA will be pivotal to the success of a TDM programme in Queenstown; it was a common feature of the international resort-based towns that were studied. Interviews with businesses, residents' associations and other key stakeholders indicated a strong appetite to get involved in solving Queenstown's transport problems and for a TMA to lead and coordinate effort.

See Appendix A for the recommended programme.

If implemented, the TDM programme will help ease pressure on the Frankton to Queenstown section and the Queenstown Town Centre.

The majority of the trips from Frankton to Queenstown cater for through traffic (70%). SH6A between Frankton and Queenstown town centre is expected to exceed its theoretical capacity of 28,500 vehicles per day as early as 2020 (based on the traffic monitoring numbers and observed growth rates). This is based on average vehicles per day however, peak hour volumes already exceed this capacity with an increasing number of days throughout the year when this happens.

The key focus for this section therefore is to shift people to more efficient and sustainable modes of transport before they reach Frankton. Many of the TDM initiatives (along with improvements in public transport and walking cycling infrastructure) recommended in the programme will help create this shift specifically:

- Marketing of Queenstown as a car-free destination and changing the way tourists travel in and around Queenstown
- Coordination and collaboration with the tourism sector
- Workplace travel plans for major employers like Queenstown Airport, NZ Ski, Real Journeys, Council, and other tourism and hospitality employers
- Improving information on travel by alternative modes for tourists at the airport
- Better wayfinding for those using alternative modes
- School and community travel plans
- Incentives for alternative modes
- Coordinating with the business community to identify collaboration opportunities e.g. NZ Ski staff transport
- Behaviour change campaigns
- Park and rides

- Cycle/scooter training
- Freight management
- Services like luggage logistics
- Better spatial planning
- Charging for parking
- Dynamic ridesharing/carpooling
- Mobility co-operatives in the outlying areas. A co-op may encourage people to sell or transfer their existing transport assets for shared use, or club together to buy new ones.
- Requirement for new developments to provide infrastructure that supports and encourages use of sustainable transport

The Queenstown Town Centre has limited capacity to cater for additional traffic. The kerbside is under pressure from tourist buses, public buses, taxis and rideshare services like Uber. Previous parking analysis demonstrates that the town centre parking is close to or already at capacity and congestion is exacerbated from people searching for parking spaces. A Parking Strategy was released in 2018 to address this issue. There is no evidence at this stage to confirm the impact of the measures implemented as part of the strategy, but anecdotal evidence suggests improvement.

The Future PT Model indicates a significant increase in pedestrians in QTC in the future (as a result of increased use of public transport) and less space for cars as streets reprioritised for pedestrians and cyclists, especially in the historic core. TDM along with infrastructure improvements can help create a shift away from car driving in and around the town centre through initiatives such as:

- Travel planning (workplaces, schools and communities)
- Incentives for alternative modes
- Reduced car parking
- District plan parking rules ie maximum parking requirements
- Increased parking pricing
- End of trip facilities for cycling
- Shared modes (e.g. shared bikes, e-bikes and e-scooters)
- A requirement for travel plans for events
- Improved information and wayfinding
- Coordination and collaboration with the tourism sector
- Freight management
- Dynamic ridesharing/carpooling
- Bike share/E-bike share offering to connect key destinations and hotels

The above travel demand management initiatives will enable more efficient use of the available infrastructure, reduce car dependence, lower transport-related emissions and improve access to safe and sustainable transport choices in the town centre and for the Frankton to Queenstown section.

The next steps to progress the implementation of the TDM programme for Queenstown are to:

- Gain approval from the Wakatipu Way to Go Partners
- Secure funding for the programme
- Gain ownership for each of the recommended initiatives
- Establish an interim working group for the TMA.

Appendix A:

TDM programme for Queenstown

WBS #	TDM Programme	Quick win	Year 1	Year 2	Year 3	Organisation(s) responsible for delivery	Could be delivered by the TMA when established
1	Policy						
1.1	Region-wide strategies						
1.1.1	Develop a sustainable transport vision for Queenstown		☒			QLDC	
1.1.2	Car-free tourism		☒	☒	☒	MBIE, DQ, QLDC, NZTA	
1.1.3	Mobility co-ops for outlying areas e.g. Arrowtown, Lake Hayes (research and blueprint)		☒			QLDC, NZTA	
1.1.4	Car-share policy		☒			QLDC	
1.2	Park and ride study		☒			QLDC	
1.3	Require travel plans for new developments, large employers and significant trip generators			☒		QLDC	
1.4	Require new developments to provide infrastructure that supports and encourages use of sustainable transport (new developments, outlying areas that generate trips into Queenstown)			☒	☒	QLDC	
1.5	Require travel plans for events as part of consent/ traffic impact assessments			☒	☒	QLDC	
1.6	Charging for parking that is currently free or cheap			☒		QLDC	
1.7	Freight management plan			☒		QLDC	
1.8	TDM for emergencies (eg weather, crashes, natural disasters)			☒		QLDC, ORC, NZTA, Civil Defence	✓
1.9	Car-free town centre and residential areas			☒	☒	QLDC	
1.10	Promote Queenstown as a Sustainable Tourism Destination (as options become available)		☒			DQ	
1.11	Airport Access Study and travel plan		☒			Queenstown Airport, QLDC	
1.12	Understand current levels of service for walking and cycling		☒	☒		QLDC	
1.13	Considering wider trips						
1.13.1	Advocate for travel plans for tourist destinations eg Routeburn Track, Milford Sound, Arrowtown, Wanaka, ski resorts, the Gondola		☒			QLDC, ORC, NZTA	
1.13.2	Self-drive Permit Study (to protect sensitive areas)		☒			MBIE, NZTA, MoT	
2	Travel planning and behaviour change initiatives						
2.1	Continue and enhance the school travel plan programme		☒	☒	☒	QLDC, MoE	✓

WBS #	TDM Programme	Quick win	Year 1	Year 2	Year 3	Organisation(s) responsible for delivery	Could be delivered by the TMA when established
2.2	Cycle/scooter training (adults and children)		☐	☐	☐	QLDC, Police	✓
2.3	Community travel plans (eg Lake Hayes, Shotover, Jacks Point)		☐	☐		QLDC, ORC	✓
2.4	Awards/ rating scheme (eg cycle/scooter-friendly employer or destination, link in with existing reward schemes or rewards for mode-shift/ car free journeys)					QLDC	✓
2.5	Gamifying mode shift within travel plans (to encourage mode shift for residents and tourists)					QLDC, TMA	✓
3	Wayfinding improvements (digital and physical)						
3.1	Wayfinding and Information Provision Audit and Design Guide (including wayfinding for public transport, key destinations, facilities, routes, parking)					QLDC with TMA input, NZTA	
3.2	Smooth walking/wheeling routes & CCS disability action links	✓				QLDC and TMA	✓
4	Transport Management Association (TMA)						
4.1	Set up						
4.1.1	Establish itself (mission, values, brand, set up Incorporated society, confirm board of directors)					TMA	?
4.1.2	Write Business Plan and Funding Plan					TMA	?
4.1.3	Agree membership fees & recruit members					TMA	?
4.1.4	Establish potential revenue sources (Parking brokerage and event management plans)					TMA	?
4.1.5	Recruit staff to run the TMA and its activities; includes office rent and annual insurance cost					TMA	?
4.2	Action plan						
4.2.1	Develop Communication Plan (document co-ordination, communication channels, stakeholder matrix etc)					TMA	?
4.2.2	Develop website and promotional material about the TMA itself to raise the profile of the TMA and communicate to people what it's going to do					TMA	?
4.2.3	Fund raising (depending on the level of funding secured from the NZ Transport Agency)					TMA	?
4.2.4	Co-ordinate submissions on on-going projects, policies and strategies					TMA	?
4.3	Set up programmes						
4.3.1	Guaranteed ride home scheme	✓				TMA	?
4.3.2	Luggage logistics action plan	✓				TMA	?
4.3.3	Journey Planning App/ Travel amalgamator	✓				TMA	?
4.3.4	Set up bike share/E-bike share connecting key destinations and hotels					QLDC, TMA	?

WBS #	TDM Programme	Quick win	Year 1	Year 2	Year 3	Organisation(s) responsible for delivery	Could be delivered by the TMA when established
4.3.5	Dynamic ridesharing/carpooling	✓				TMA	?
4.3.6	Mobility Lab (based on Arlington, Virginia, USA)					TMA	
4.3.7	Identify sustainable transport workforce deficits and establish programmes to run the sustainable transport sector eg bicycle technician, e-bike and e-scooter servicing, sustainable transport ambassador programmes, cycle skills training, bus driver workforce planning and development					TMA	?
4.4	Documenting the data gaps						
4.4.1	Work with partners and confirm what information the businesses/ member organisations are willing to share; identify what data should be collected					TMA	?
4.4.2	Create an inventory of existing bus and shuttle services; understand current situation; agree if and how to collaborate; identify potential partnerships; make it happen					TMA	?
4.4.3	Set up events register for Queenstown (for event travel demand management)	✓				TMA	?
4.4.4	Data inventory and gap analysis (establish what data is available and where there are gaps in the data)					TMA	?
4.4.5	Understand and establish a register of transport jobs in Queenstown (to identify gaps)					TMA	?
4.5	Better information provision						
4.5.1	Collate and communicate transport information on getting around without a car through the TMA website (using tools like the Bus map movie and travel scenarios)	✓				TMA	?
4.5.2	Marketing of car-free holidays (information to support this on the TMA website)					TMA, DQ	?
4.6	Advocacy						
4.6.1	Advocate for/ support enhanced public transport service to the airport					TMA	?
4.6.2	Advocate for changes to bus time tables/ routes to better meet the needs of users	✓				TMA	
4.6.3	Gain commitment from the businesses to develop their own travel plans/ work on travel plan activities together through the TMA					TMA	?
4.6.4	Advocate for/ support high quality branded bus stops (eg iconic bus stops)					TMA	?
4.6.5	Advocate for inclusion of bike technicians and others in the Immigration NZ skills shortage visa category to support sustainable transport	✓				TMA	?

WBS #	TDM Programme	Quick win	Year 1	Year 2	Year 3	Organisation(s) responsible for delivery	Could be delivered by the TMA when established
4.6.6	Gain commitment from the tourism industry in the delivery of the plan (DQ, travel agents, tour providers)					TMA, DQ, MBIE	
4.6.7	Advocate for improved access to bus/ferry ticketing					ORC, TMA	
4.6.8	Advocate for supplier contracts to be reviewed and updated to include metrics to capture quality of service					TMA, ORC	
4.6.9	Advocate for Queenstown to adopt the Sustainable Travel Town vision					TMA	
4.6.10	Advocate for Queenstown to become a Blue Zone					TMA, DHB	

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Appendix B10 Bus Lane Interventions

Released under the Official Information Act 1982

Table 1: SH6A proposed new bus lanes

Location	Upgrade	Purpose
bl1. Towne Place to McBridge Street	Eastbound bus lane	Provide priority for buses on approach to SH6/SH6A intersection, where queues are expected to be significant
bl2. Perkins Road to 90m east of Marina Drive	Eastbound and westbound bus lane	Provide priority through busy Marina intersection and between bus stops at Perkins Road and Marina Drive, utilising flat land and redundant flush median (no side roads) to build bus lanes at minimal cost
bl3. Larch Hill place to Goldfield Heights	Eastbound bus lane	Provide priority through busy Goldfield Heights intersection, utilising redundant flush median (no side roads) to build bus lanes at minimal cost
bl4. East of Suburb Street to Dublin Street	Westbound bus lane	Provide priority for buses on approach to Dublin Street, where queues are expected to be significant
Coronation Drive (town centre)	Westbound bus lane	Provide priority for buses on approach to Stanley Street, where queues are expected to be significant
Beetham Street to east of Sydney Street (town centre)	Eastbound bus lane	Provide priority for buses exiting the town centre, up the gradient on Stanley Street

**Appendix B11 Technical Note 39: SH6 Frankton Southern Corridor
Operation and Future Performance**

Released under the Official Information Act 1982

NZTA Contract 2018235 - F2Q SSBC & QTC DBC

Technical Note #39

28 September 2020

SH6 Frankton Southern Corridor Operation & Future Performance

Executive Summary

This technical note sets out the results of an assessment of the suitable form of intersections required along the SH6 Kawarau Road section of the network, from SH6/SH6A to Kawarau Falls Bridge.

The note provides a detailed assessment of the operation of the SH6 Southern Corridor under the preferred scenario layout concepts, which consist of the following changes:

- SH6/SH6A – signalised intersection
- SH6/Gray Street – signalised intersection, incorporating bus gate and staggered crossing facility across SH6
- SH6/PT hub – signalised intersection (long term)
- SH6/Lucas Place – signalised intersection
- SH6/Humphrey Street – signalised intersection

The assessment has indicated that the operation is satisfactory in terms of vehicular performance, albeit approaching capacity by 2028. The pinch point in the network is a combination of Shotover Bridge, the SH6/SH6A intersection and SH6A Frankton Road – and therefore any additional capacity provided at intersections on the Southern corridor will have little impact on network operation.

However, beyond 2028, this section of the network is predicted to operate beyond the operational capacity, subject to further traffic growth on the corridor – see **Queenstown Business Case Transport Modelling – Future Modelling Option Report (FMOR), 16 Sept 2020**. At this time, any further trip growth would need to be accommodated by public transport, and therefore it is highly likely that additional bus lanes would need to be provided on the northbound approaches to Frankton – the FMOR suggests:

- *"It is recommended that a northbound bus lane on Lucas Place (Riverside Road roundabout to Airport roundabout) is considered for implementation beyond 2028. This would also aid outbound services running from Remarkables Park Town Centre towards the Kawarau Falls Bridge (via the proposed Humphrey Street link)"*
- *"It is recommended that northbound bus priority lanes (and complimentary measures) are considered for implementation south of the Kawarau Falls Bridge beyond 2028. This would include priority lanes to serve the proposed Park and Ride site in the vicinity of Boyd Road."*

Pedestrian and cycle crossing facilities have been improved along the corridor, with fully protected crossings provided at all the new signalised intersections above. Bus lanes in the northbound direction provide reliability of travel times for journeys from Kawarau Falls Bridge to Frankton PT hub and through to the SH6/SH6A intersection.

Although some travel time variability is experienced in the Interpeak and PM peak periods for northbound bus services, this is relatively minor. However, in the longer term it is recommended that the implementation of a northbound bus lane along Lucas Place be considered to provide protection of bus service reliability – subject to a PT Services DBC providing greater detail on future bus routes.

In summary, the preferred scheme provides a high level of benefits over the existing intersection form, in terms of bus travel times and reliability, pedestrian and cycle crossing safety, network management and control, and vehicle operations.

Introduction

This technical note sets out the results of an assessment of the suitable form of intersections required along the SH6 Kawarau Road section of the network, from SH6/SH6A to Kawarau Road Bridge. This is a key transport link within the Regional road network, providing the main route to/from the south to both Frankton and Queenstown.

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

- Gray Street and Ross Street (both west side), access to Frankton Village Shops and 'Old Frankton' (residential area), Frankton Beach and the Frankton Track to Queenstown
- Lucas Place (east side), access to Queenstown International Airport, and Remarkables Park Town Centre and Hawthorne Drive (southern side of Frankton Flats)
- McBride Street (west side), access to 'Old Frankton' (residential area)
- Humphrey Street (east side), access to Lakes District Hospital, Remarkables Park Town Centre and Hawthorne Drive (southern side of Frankton Flats). There is an additional short cul-de-sac of Southberg Avenue to the south of the Humphrey Street intersection. Pedestrian and cycle access to Frankton Beach and the Frankton Track to Queenstown

Although land use intensification is not expected along this part of the SH6 corridor, this section does provide the means of access to the Remarkable Park Town Centre, Queenstown Airport and southern area of Frankton Flats, which is expected to see significant intensification, for both commercial and residential land uses. This means that volumes on the corridor are expected to increase significantly, particularly between these areas, to and from Queenstown Town Centre and further residential development south of Kawarau Falls Bridge. In addition, the corridor runs close to the eastern end of the Frankton Arm of Lake Wakatipu, and there is projected to be an increase in activity around and along the lakefront, which will lead to cross-movements over SH6.

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) was originally undertaken on upgrade options as part of the SH6 Grant Road to Kawarau Falls Bridge SSBC (to ensure that the options are evaluated against the wider project objectives, implementability and an assessment of effects criteria), but this MCA has not yet been updated as part of the Frankton SSBC.

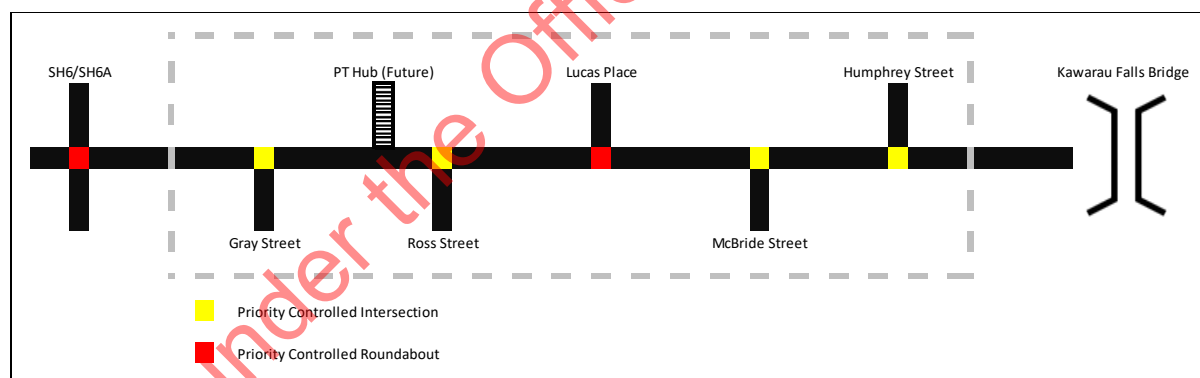


Figure 1: Schematic of the existing Intersection Form on the Existing Link

Background

The scope of the QTC DBC and F2Q SSBC project was extended out to the section of SH6 Kawarau Road through to the Kawarau Falls Bridge as part of the Frankton SSBC.

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 south 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



Corridor Options

In essence, the main design philosophy of the corridor is relatively straightforward, consisting of

- Widening of the road between the SH6/SH6A and Lucas Place intersections to provide two lanes in each direction, to be consistent with intersection treatments at either end
- Minimal widening of the road between the Lucas Place and Humphrey Street intersections, to provide a northbound bus lane
- Providing connected and continuous on road and off cycle facilities and crossings
- Providing connected and continuous footpath and crossing facilities

The main optioneering has been undertaken on the intersection form at each key location:

- SH6/SH6A and Gray Street intersections
- Proposed bus hub access intersections
- SH6/Lucas Place
- SH6/Humphrey Street

Traffic Modelling

Traffic modelling has been undertaken at all key intersections along the corridor. 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). The Paramics results are set out elsewhere within the Queenstown Detailed Business Case stream of work, although a summary of bus travel times is provided here.

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

- Ratio of Flow to Capacity (RFC) - LinSig
- Mean Maximum Queue - LinSig
- Intersection delay per movement – LinSig
- Bus travel times - 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).

Individual Intersection Results

Humphrey Street

A key feature of the wider Business Case is to provide an improved linkage between SH6 Kawarau Road and the southern area of Frankton Flats (Remarkables Park Town Centre and Hawthorne Drive). Therefore, it is proposed that Humphrey Street would be extended through to Lucas Place, so as to both provide a more direct and suitable route into the area, and also reduce traffic on the residential links of Robertson Street and Douglas Street.

The design detail of this link upgrade is provided elsewhere, but the provision of this through link offers the catalyst to upgrade the SH6/Humphrey Street intersection (as well as a new intersection at the connection point with Lucas Place), together with the opportunity to provide pedestrian and cycle crossing facilities across SH6 at this location – this facility then provides a connection across

Consequently, a signalised intersection was chosen as the preferred option to accommodate these requirements – with a variation on the form of pedestrian provision. Figure 2 shows the general arrangement considered. A roundabout was considered in initial optioneering but would be severely constrained by space and topography.

- Widening of the Humphrey Street to provide around 30m of two lane approach
- Northbound bus lane starting from the proposed bus stop, heading north towards (and through) the Lucas Place intersection
- Re-located southbound bus stop on the intersection exit
- Boyes Crescent retained as a pedestrian/cycle only link to the intersection (as existing) – note that the signalised layout of the intersection has been future-proofed to enable a four-arm operation in the future (for improved access to the lakefront to/from the south), although the performance of this intersection has not been assessed at this stage

1. Signalising the existing intersection, with a full all-red period for pedestrians
2. Signalising the existing intersection, with a fully protected pedestrian crossing on the north and east arms only

Requires maximizing the length of the northbound right turn lane

HUBBARD STREET

SOUTHERGATE AVE

CRESCENT

Based on the Official Info

All-red Pedestrian Phase Option

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 a significant impact on the operation of the intersection, as this would allow around 25 seconds of green time to be re-allocated to traffic movements. For optimum road safety, the northbound right turn has been assumed to be fully protected (no filtering), and only operates in phase D.

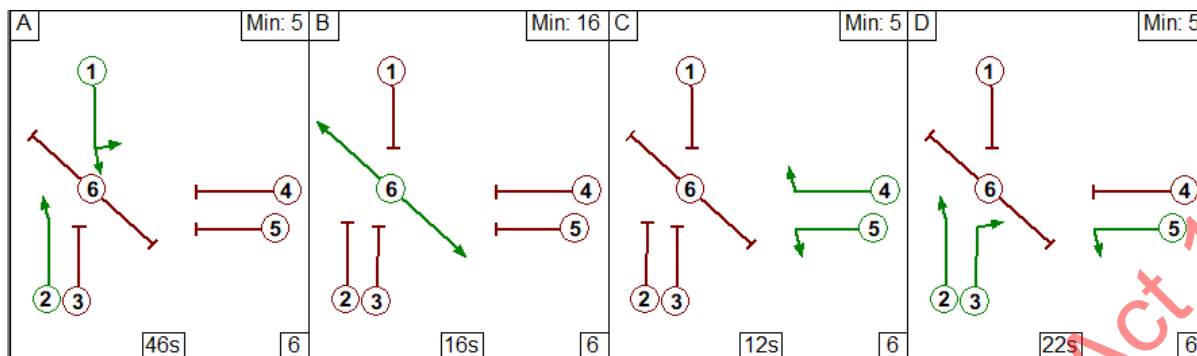


Figure 3: SH6/Humphrey Street - Signalised Intersection Phase Arrangement (Pedestrian all-red)

Table 1 shows the results of the operational assessment of the all-red pedestrian phase 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**

Table 1: SH6/Humphrey Street – operational performance (2028) with all-red pedestrian phase

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
SH6 North	Left Turn	82%	18	52	82%	21	43	82%	20	45
	Ahead			52			44			44
Humphrey Street	Left Turn	79%	6	47	75%	11	49	84%	16	53
	Right Turn	79%		77	82%		98			111
SH6 South	Ahead	54%	13	14	36%	7	11	42%	9	14
	Right Turn	85%	14	66	85%	11	81	81%	10	77
Intersection LOS		D			D			D		

The results show that operation in all three periods is satisfactory, but approaching capacity. In particular, the two right turn movements are operating at LOS F – although, this a function of the high (120 second) cycle time and the (robust) assumption that the pedestrian crossing phase operates in every signal cycle.

Pedestrian Crossings on North and East Arms Option

In terms of operation, a 4-phase operation is proposed as shown in Figure 4, with all vehicular moves allowed (except U-turns).

The signal cycle time has been reduced to 90 seconds, to reflect the increased flexibility in operation that is brought about by removing the all-red pedestrian phase. For optimum road safety, the northbound right turn has been assumed to be fully protected (no filtering), and only operates in phase D.

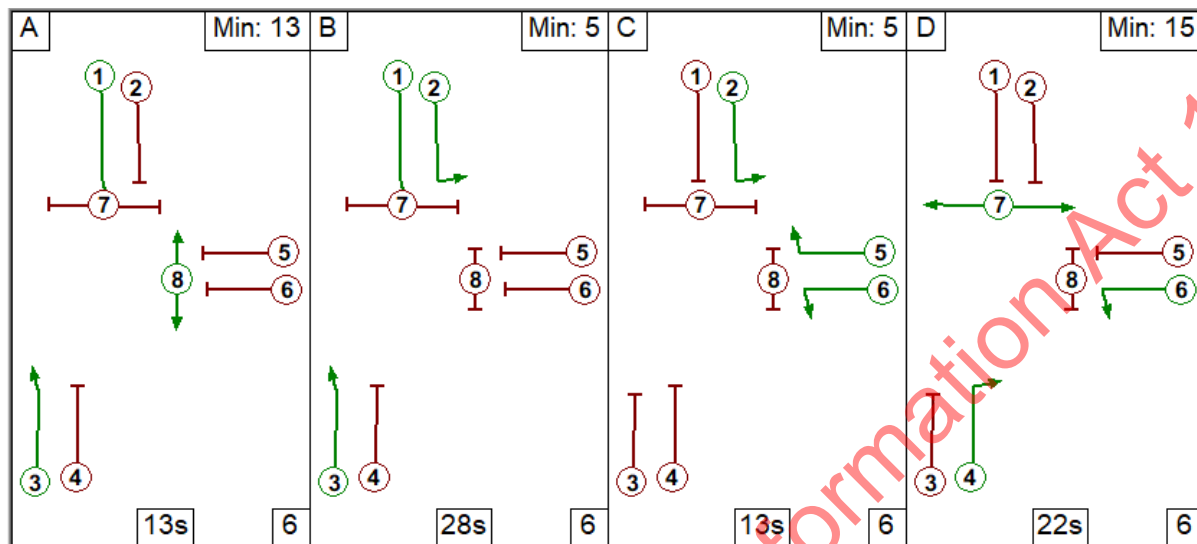


Figure 4: SH6/Humphrey Street - Signalised Intersection Phase Arrangement (Pedestrian Crossing on 2 arms)

Table 2 shows the results of the operational assessment of the all-red pedestrian phase option.

Table 2: SH6/Humphrey Street – operational performance (2028) with two pedestrian crossing movements

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
SH6 North	Left Turn	60%	10	23	69%	13	22	67%	12	20
	Ahead			23			23			23
Humphrey Street	Left Turn	76%	5	36	59%	6	27	69%	10	29
	Right Turn	76%		60	59%		47	69%		63
SH6 South	Ahead	78%	16	30	48%	8	19	54%	9	21
	Right Turn	80%	11	48	66%	7	43	67%	6	46
Intersection LOS		C			C			C		

The results show that operation in all three periods is much improved compared to the option with an all-red pedestrian phase, due to the ability to reduce the cycle time considerably.

However, there are a number of other issues to note in terms of a comparison between the two options:

- As noted previously, at least in the short to medium term, it is likely that pedestrian and cycle crossing movements will be minimal – and therefore the all-red crossing phase in the first options will not be called in all signal cycles
- A crossing on the south side of the intersection is a more direct route for cyclists travelling between the two tracks on either side of the intersection. If this crossing is added to the second option, then the operation would need to revert to an all-red pedestrian phase –

there is little benefit in operating a separate protected crossing phase for this crossing, as it can only run in parallel with non-critical movements (left turn in and right turn out of Humphrey Street)

- As the intersection is around 500m from the next (proposed) signalised intersection to the north at Lucas Place, the requirement to ensure that this intersection operates on the wider network cycle time (likely to be 120 seconds) for co-ordination is less critical. This means that the intersection could operate at a lower cycle time than 120 seconds (with or without pedestrian phase demands) for additional flexibility

In summary, therefore, it is proposed that crossings are provided on all three approaches. This could operate as an all red-pedestrian crossing phase, or with each crosswalk separately protected within specific phases – there is likely to be little difference between operation performance in the two options – and that the intersection operates “isolated” from the rest of the SH6 network, except under certain conditions where it is required to ensure downstream co-ordination or be used within a network wide strategy.

In addition, the introduction of signals at the Humphrey Street intersection is likely to provide an improved level of safety and efficiency for vehicles egressing Southberg Avenue, as gaps in southbound platoons will be created (and the general speed of traffic will be lower than at present as they pass through the adjacent signal intersection).

The SH6/Humphrey St intersection layout has been designed to future proof for a 4th arm to Boyes Crescent is desired in the future to access potential ferry terminal on Frankton Arm.

It should be noted that beyond 2028, this intersection (and downstream sites through to SH6/SH6A) are predicted to operate beyond the operational capacity, subject to further traffic growth on the corridor – see **Queenstown Business Case Transport Modelling – Future Modelling Option Report (FMOR), 16 Sept 2020**. At this time, any further trip growth would need to be accommodated by public transport, and therefore it is highly likely that additional bus lanes would need to be provided on the northbound approaches to Frankton – the **FMOR** suggests:

- *“It is recommended that a northbound bus lane on Lucas Place (Riverside Road roundabout to Airport roundabout) is considered for implementation beyond 2028. This would also aid outbound services running from Remarkables Park Town Centre towards the Kawarau Falls Bridge (via the proposed Humphrey Street link)”*
- *“It is recommended that northbound bus priority lanes (and complimentary measures) are considered for implementation south of the Kawarau Falls Bridge beyond 2028. This would include priority lanes to serve the proposed Park and Ride site in the vicinity of Boyd Road.”*

Lucas Place

The existing roundabout form at SH6/Lucas Place is satisfactory in terms of accommodating the forecast traffic volumes, but has a number of other issues:

- No pedestrian crossing facilities are provided (or can be provided in a protected sense, in the existing form)
- In busier periods, queues of traffic can stretch back from the SH6/SH6A intersection to this intersection (and beyond). This can create road safety issues at the roundabout itself, but also a lack of control over the priority of movements, which can lead to imbalanced queues. In addition, the lack of control in these busier periods is not conducive to maximising any future bus lanes on the northbound approaches

Initial investigations looked into signalling the roundabout, but the small size (20m inscribed diameter) results in practically no stacking space being available, and therefore the operation would be much like a split phased operation (each approach operating in a separate phase) which has limitations on capacity. There are also constraints on land availability in increasing the size of the roundabout.

Consequently, a signalised intersection was chosen as the preferred option to accommodate these requirements – returning the intersection to a similar layout as was in operation (albeit un-signalised) before the roundabout upgrade was implemented. Figure 5 shows the general arrangement considered.

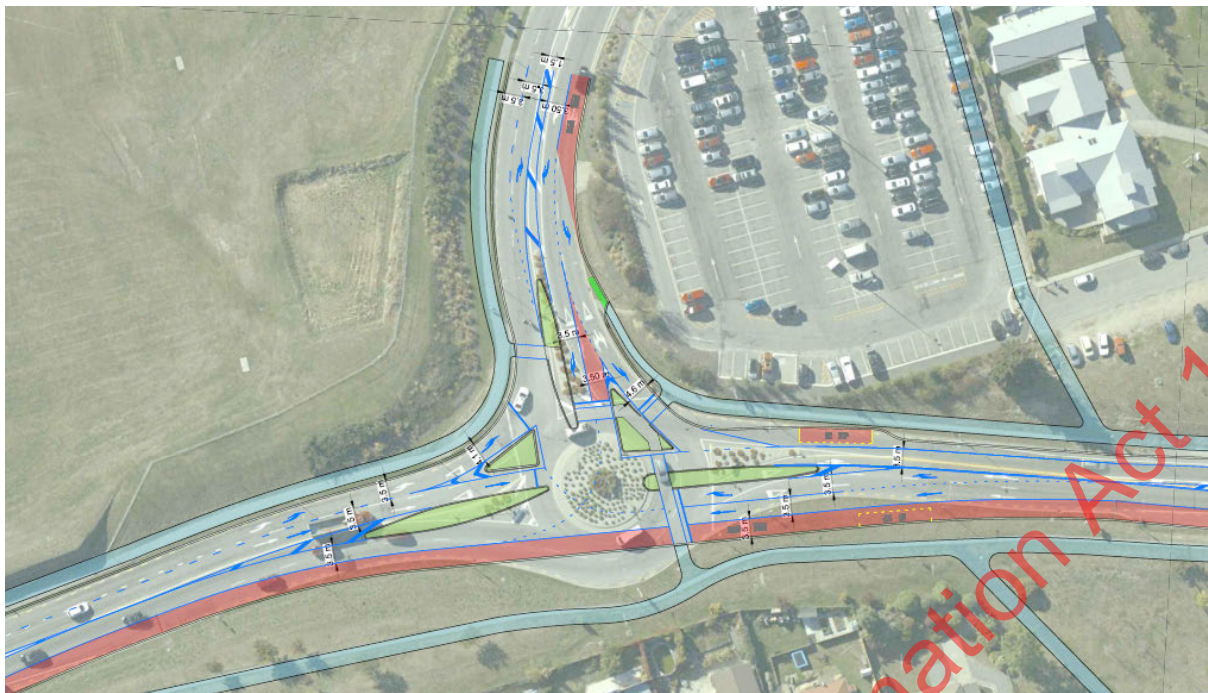


Figure 5: Proposed Signalised Intersection at SH6/Lucas Place

The intersection has the following features:

- Widening of the SH6 south approach to provide an additional bus lane
- New bus stops on the south side of the intersection (both directions)
- Pedestrian crossing facilities provided on the south and east arms of the intersections, with a staggered crossing across the latter (in three stages)

In terms of operation, a 4-phase operation is proposed as shown in Figure 6, 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 minimal impact on the operation of the intersection, as all crossings run in parallel with other non-conflicting vehicular movements. For optimum road safety, the northbound right turn has been assumed to be fully protected (no filtering), and only operates in phase D.

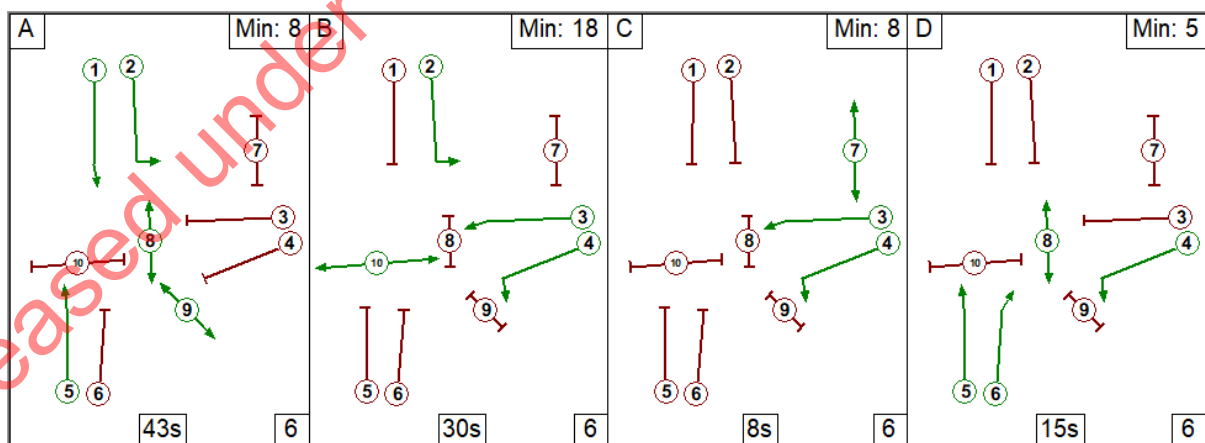


Figure 6: SH6/Lucas Place - Signalised Intersection Phase Arrangement

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

Table 3: SH6/Lucas Place – 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)
SH6 North	Left Turn	40%	7	12	55%	11	10	51%	9	8
	Ahead	74%	15	45	92%	24	69	83%	18	53
Lucas Place	Left Turn	76%	16	28	93%	29	46	85%	23	31
	Right Turn			40			52			37
SH6 South	Bus Lane	2%	1	15	2%	1	25	2%	1	22
	Ahead	74%	19	29	62%	13	33	76%	18	39
	Right Turn	74%		87	69%		96	76%		108
Intersection LOS		C			C			C		

The results show that operation in all three periods is satisfactory, with some space capacity. In particular, the northbound right turn movement is operating at LOS F – although, this a function of the high (120 second) cycle time.

However, there are some other considerations to note in terms of this level of operation:

- A crossing on the north side of the intersection could be provided as part of the operation, although this would result in some detriment to vehicular performance – as only the northbound right turn can operate simultaneously, which is a low volume movement. This is predicted to push operation up to LOS D in the PM peak, and LOS E in the Interpeak, predominantly due to at-capacity operation on the critical right turn movement out of Lucas Place in both these periods. Consequently, due to the low expected pedestrian crossing volumes at this location) it is not considered that this additional crossing point should be incorporated into the design. It should be noted that alternative crossing locations provide for this movement, either across the south side of the proposed intersection, or at the (existing, and retained) pedestrian crossing midblock to the south of the Ross Street intersection, which serves the route to and from Remarkables Park Primary School to Queenstown Events Centre
- The intersection is around 400m from the next (proposed) signalised intersection to the north at the southern end of the bus hub (see next section). Given that the intersection moves the confluence of two movements heading north towards SH6/SH6A, there is a requirement to ensure that this intersection operates on the wider network cycle time (likely to be 120 seconds) for co-ordination and network operational strategy

In summary, therefore, it is proposed that crossings are provided on the south and east approaches within a conventional 3-arm signalised intersection. Bus lanes are provided on two of the three approaches to protect bus travel times – and it is not expected that southbound bus journeys will be significantly delayed by running with general traffic through this section of the network. However, as for the SH6/Humphrey Street section, it is likely that extended northbound bus lanes on Lucas Place will need to be provided beyond 2028 to protect bus travel times.

Frankton PT Hub

Due to constraints within the existing bus hub on the west side of Kawarau Road, the DBC has identified that a larger Frankton PT hub is required to accommodate future growth of local public transport services, regional services, private coach operations, kiss and ride activity and better integration with all active modes.

Figure 7 shows the proposed arrangement of the intersection.

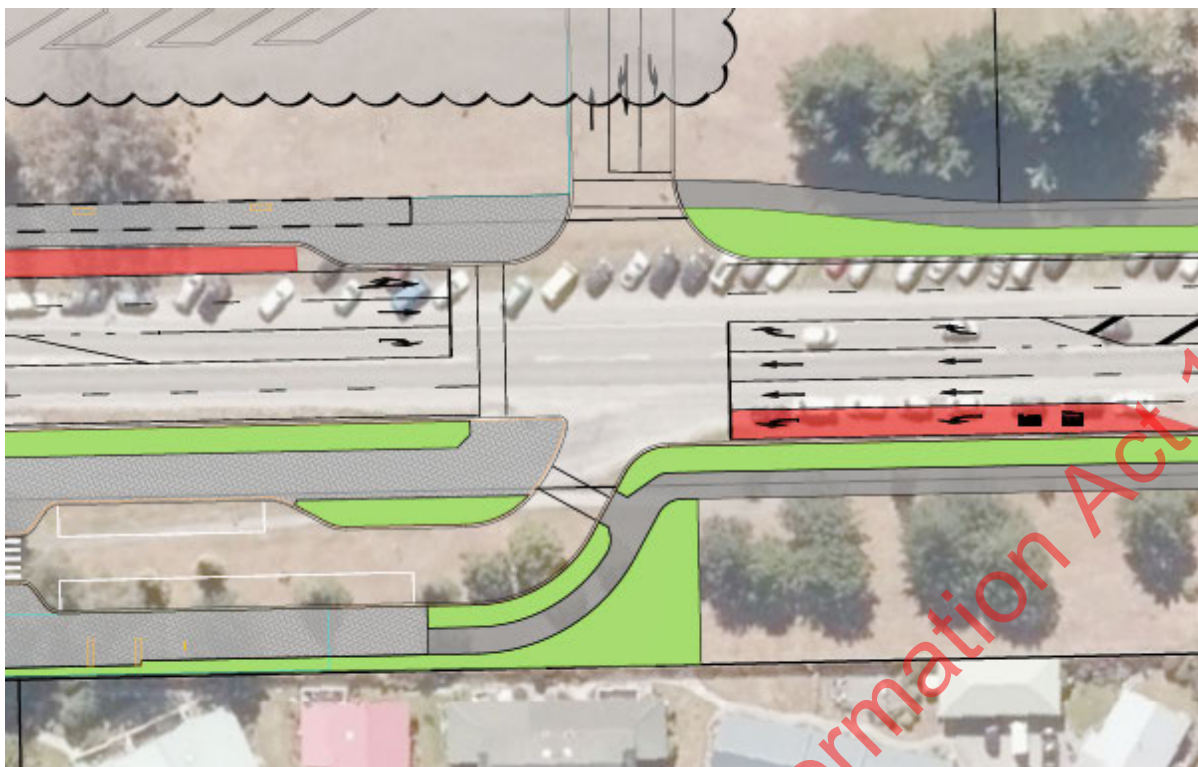


Figure 7: Frankton Bus Hub (long term arrangement)

A two-stage programme for the upgrade has been identified:

1. In the short-medium ("interim") term, an elongated facility will be provided on the west side of SH6, stretching south of the existing PT hub location. This will provide stops for both local PT and private PT service transfers, but with a significantly greater capacity than the existing provision. Stops and associated amenities will also be improved on the east side of SH6, directly opposite the PT hub, with at-grade pedestrian crossings across SH6 provided at both the north and south ends of the hub. Access to the extended PT hub would be provided from a new signalised intersection at the southern end. **In this arrangement the fourth (eastern) leg of the intersection would not be in operation**
2. In the longer term, a new PT hub is to be provided on the east side of SH6, which will be dedicated to local public transport operations. The interim hub (on the west side of SH6) would then revert to operations for Regional and private coach transfers. It is also possible that an Emergency Services hub would also be established on the east side of SH6, adjacent to the new PT hub. It is proposed that both the PT and Emergency Services hub would be accessed from the same intersection introduced within the Interim option, but with the fourth arm added

Operation of SH6/PT Hub – Interim Arrangement

In terms of operation, a 4-phase operation is proposed as shown in Figure 8. The northbound left turn and southbound right turn would only be allowed for authorised vehicles (buses and coaches using the hub, plus taxis should a stand be provided within the hub).

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 a beneficial impact on the operation of the intersection. For optimum road safety, the southbound right turn has been assumed to be fully protected (no filtering), and only operates in phase D. Both pedestrian crossing movements are also fully protected (walk plus clearance time). A crossing has not been provided on the south arm, as the majority of pedestrian movements are likely to be related to the PT hub on the north side – this is consistent with the provision in the longer term arrangement, where both sides of the hub will be on the north side of the intersection.

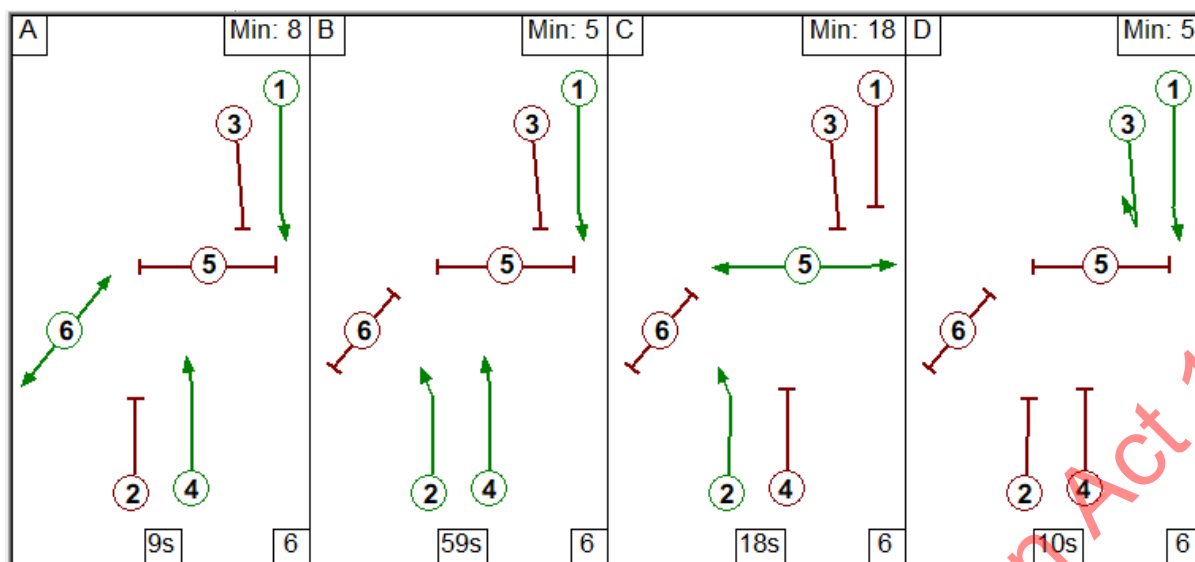


Figure 8: SH6/PT Hub (Interim) - Signalised Intersection Phase Arrangement

Table 4 shows the results of the operational assessment of the signalised intersection option.

Table 4: SH6/PT hub (interim) – 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)
SH6 North	Ahead	40%	2	3	39%	2	3	35%	7	3
	Right Turn	42%	1	61	39%	1	64	36%	1	56
SH6 South	Left Turn	2%	1	10	2%	1	2	2%	1	2
	Ahead	77%	16	18	81%	21	20	90%	31	27
Intersection LOS		B			B			B		

The results show operation is satisfactory in all three peak periods. Although the SH6 southbound right turn movement has a significant delay attributed, phase D could be introduced at more than one point within the signal cycle (i.e. on demand) so as to reduce delay on this movement.

In the PM peak period, although the northbound approach is predicted to operate with a RFC of 90%, the downstream operation at the SH6/SH6A intersection is predicted to be operating with a higher RFC (between 90-100%) so this level of performance at the PT hub intersection is satisfactory.

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

Operation of SH6/PT Hub – Longer Term Arrangement

In terms of operation, a 4-phase operation is proposed as shown in Figure 9. Some restrictions on turns would apply:

- The northbound and southbound left and right turns would only be allowed for authorised vehicles (buses and coaches using either sides of the hub, plus taxis should a stand be provided within the hub)
- The turn out of the PT hub (on the eastern side) would be restricted to left and ahead (into the western side of the hub) – in terms of the latter, this would be the bus through route up to the traffic signals (and bus gate) at Gray Street
- For emergency vehicles, the above ban is problematic. The right turn out of the eastern arm (onto northbound SH6) cannot be allowed as it conflicts with the pedestrian crossing across the north arm. Consequently, as this turn would be required for emergency vehicles, it is

likely that a special phase would be introduced so as to put the intersection to all-red to allow egress for emergency vehicles – this could be coupled with a special emergency lane out of the fourth (eastern) arm, so as to avoid conflicts with buses

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 a beneficial impact on the operation of the intersection. For optimum road safety, the northbound and southbound right turns have been assumed to be fully protected (no filtering), and only operates in phase D. All pedestrian crossing movements are also fully protected (walk plus clearance time). A crossing has not been provided on the south arm, as the majority of pedestrian movements are likely to be related to the two halves of the PT hub on the north side – this is consistent with the provision in the interim arrangement.

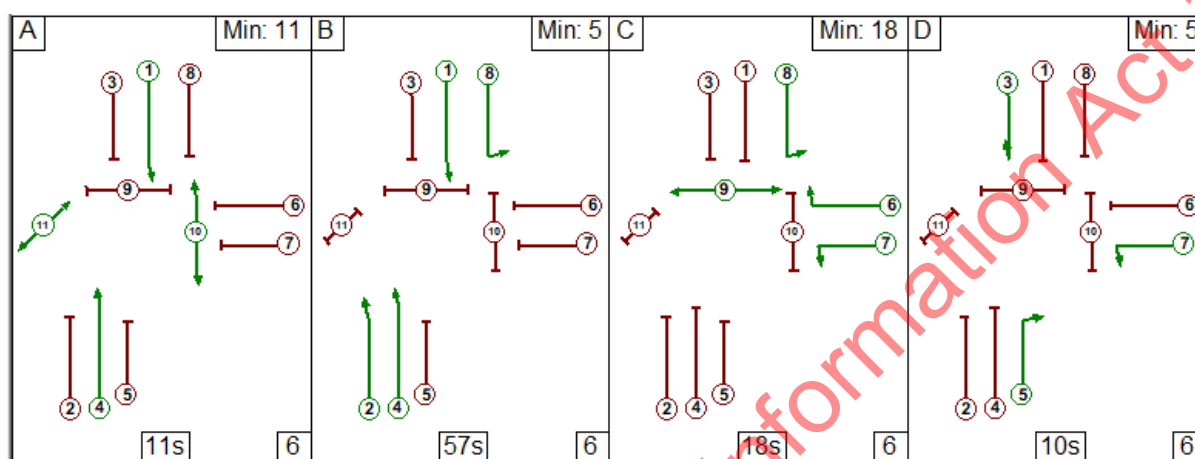


Figure 9: SH6/PT Hub Long-Term - Signalised Intersection Phase Arrangement

The results show operation is satisfactory in all three peak periods, with very similar operation to the Interim arrangement – this is to be expected as all critical movements receive a similar level of green time in both arrangements.

Consequently, it is concluded that the operation of the signalised intersection in the longer-term option is satisfactory in terms of vehicular operation. However, there are a few variations in the egress arrangement for emergency vehicles (should the emergency precinct be established adjacent to the PT bus hub on the east side of SH6) that would need to be further tested and confirmed so as to ensure acceptable intersection operation in this scenario.

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

Table 5: SH6/PT hub (interim) – 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)
SH6 North	Ahead	46%	7	4	52%	7	4	42%	2	3
	Right Turn	1%	1	53	1%	1	53	1%	1	53
PT Hub (East)	Left Turn	23%	2	38	23%	2	38	23%	2	38
	Right Turn			51			51			51
SH6 South	Left Turn	1%	1	18	1%	1	18	1%	1	18
	Ahead	77%	16	18	82%	21	20	90%	31	27
	Right Turn	13%	1	75	13%	1	69	13%	1	71
Intersection LOS		B			B			B		

The results show operation is satisfactory in all three peak periods, with very similar operation to the Interim arrangement – this is to be expected as all critical movements receive a similar level of green time in both arrangements.

Consequently, it is concluded that the operation of the signalised intersection in the longer-term option is satisfactory in terms of vehicular operation. However, there are a few variations in the egress arrangement for emergency vehicles (should the emergency precinct be established adjacent to the PT bus hub on the east side of SH6) that would need to be further tested and confirmed so as to ensure acceptable intersection operation in this scenario.

Gray Street

It is proposed to introduce a major upgrade to the SH6/SH6A intersection, in the form of a large conventional arrangement as shown in Figure 10.

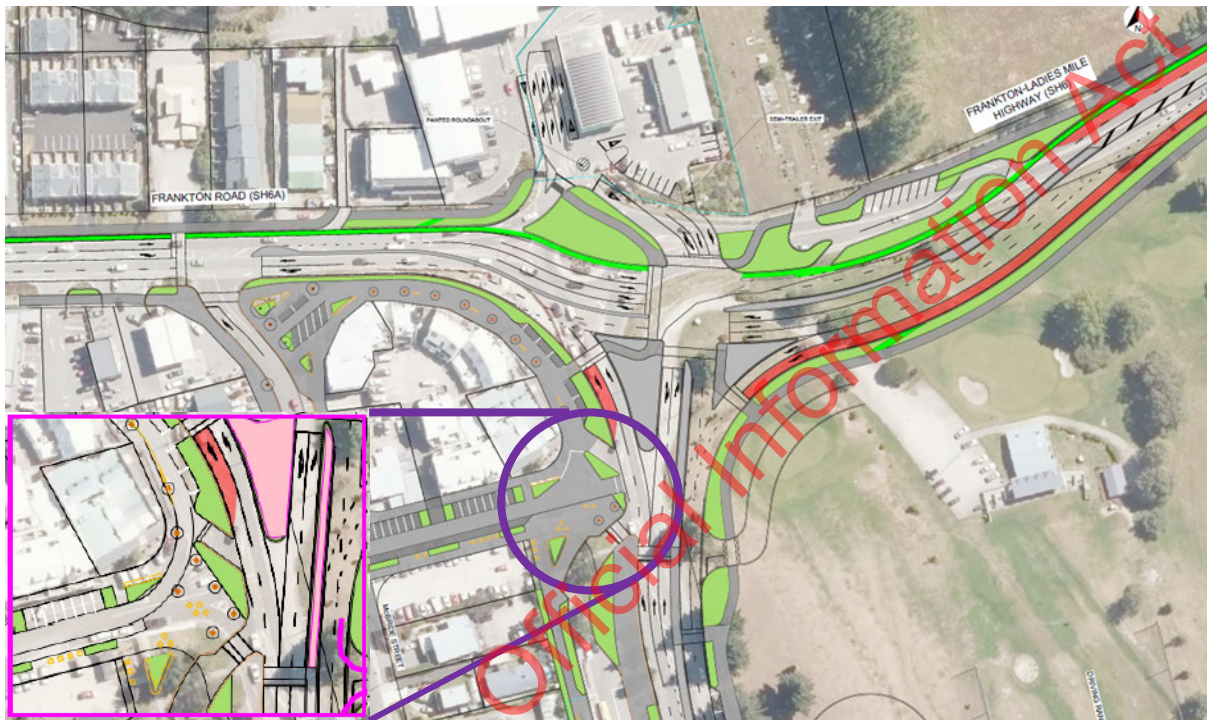


Figure 10: Proposed Upgrade at SH6/SH6A and Gray Street

This results in the following changes to the access arrangements to and from Frankton Village Shops and nearby local streets:

- An egress into Gray Street and the Frankton Village Shopping area is provided from Kawarau Road for northbound movements only. Access from the southbound direction was tested in the modelling, but is not possible due to the short distance between the two intersections. A staggered pedestrian crossing is provided on the south side of the Kawarau Road/Gray Street intersection – again, the closeness of the two intersections meant that the southbound half of the crossing needed to be moved south of Gray Street so as to ensure visibility of the midblock, and allow sufficient vehicle stacking capacity
- Access onto Kawarau Road has been provided from Gray Street, but only as a left turn – again, a right turn was impossible to provide within the constraints of the operation. Whilst this reduces the options for traffic exiting this link (and local shops), alternative egress is possible via Ross Street, for traffic heading south (assuming that this link will remain open to the south with the proposed 'Old Frankton' street closures to prevent rat running, predominantly northbound in the winter PM). **Note, that a further variation is to remove this egress point from Gray Street (as shown in the inset in Figure 10 and re-assign all traffic to Ross Street – this has not been tested in the set of modelling work reported here, but has a positive impact on the operation of the Gray Street intersection – although traffic re-assignment to Yewlett Crescent and Ross Street as the nearest available egress points onto the SH are likely to become more stressed. Figure 10 shows an inset with this alternative "closed" arrangement for Gray Street**
- The signalisation of the SH6A/McBride Street intersection provides safe and direct egress onto SH6A for traffic heading towards Queenstown. Left turn and right turn movements into McBride Street are provided at this location allow vehicles from the east and west

respectively to access the area. This also allows a straight across pedestrian crossing to be provided across SH6A on the east side of the intersection

- Bus lanes are provided on the northbound Kawarau Road approach via a route through the interim PT hub, by installing a bus gate on the approach to the Gray Street intersection
- The staggered crossing at Gray Street across Kawarau Road provides connectivity between the two sides of the road, between Frankton Village Shops and the longer term bus hub location on the east side of SH6 Kawarau Road and Queenstown Events Centre (and other potential future land use on the east side of Kawarau Road)

Operation of SH6/Gray Street

In terms of operation, a 3-phase operation is proposed as shown in Figure 11, for the northbound direction.

The signal cycle time will need to be relatively high at the intersection to maintain co-ordination with the main SH6/SH6A intersection – and in all three periods, the models assume a 120 second cycle time.

Phase A would be rigidly co-ordinated with the operation at the SH6/SH6A intersection, with traffic held back at the Gray Street intersection to minimise queues within the downstream internal section – this would allow buses in signal Phase B or local traffic in signal Phase C to move into this area. Note if the Gray Street egress were not provided, as discussed in the variation above, then the Phase C time would be re-allocated to bus movements in Phase B.

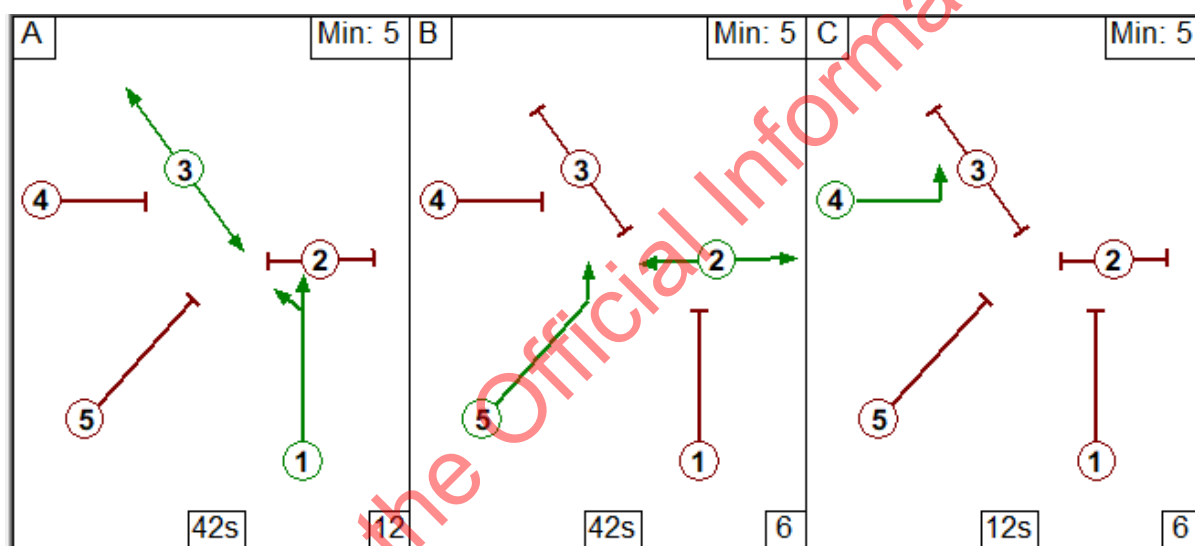


Figure 11: SH6/Gray Street - Signalised Intersection Phase Arrangement

For southbound SH6, a standard midblock crossing operation is proposed, although this will act in tandem with the northbound intersection at Gray Street to provide two halves of the staggered crossing arrangement.

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

The results show operation is at capacity in all three peak periods, for the northbound direction – this is to be expected, as the downstream SH6/SH6A is also operating at capacity, and the Gray Street intersection is acting as the hold point for queues. Queues and delay on southbound SH6 are minimal, which is as a result of the fixed co-ordination between the two intersections resulting in little traffic being stacked in the internal links between the two intersections.

Table 7 below shows a summary of pedestrian delay (in seconds) for movements across Kawarau Road at the Gray Street intersection (i.e. across the staggered crossing facility).

The results show that pedestrian delay is relatively low in both directions, despite the high cycle time of 120 seconds. In effect, the two halves of the crossing are also well coordinated, with most pedestrians not delayed within the centre refuge – this is because the west side of the crossing has a long walk time (around 40-50 seconds) whilst northbound general traffic is held back at the crossing (from entering the short downstream link), and therefore “overlaps” the appearance of the eastern half of the crossing, at both the start and end.

Consequently, it is concluded that the operation of the signalised intersection and associated crossing at Gray Street is satisfactory.

Table 6: SH6/Gray Street – 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)
SH6 North	Ahead	50%	3	4	44%	4	4	43%	3	6
SH6 South	Kerbside Lane	85%	16	50	95%	28	66	100%	37	101
	Offside Lanes	74%	13	42	68%	14	31	72%	13	41
PT Hub	Ahead	9%	2	45	9%	2	43	10%	2	49
Gray Street	Left Turn	25%	1	63	58%	3	81	49%	3	71
Intersection LOS		C			C			D		

Table 7: Pedestrian Delay (in seconds)

Direction	AM peak	Interpeak	PM peak
Gray Street Crossing (of SH6)			
Eastbound	49	47	50
Westbound	52	55	52

Other Intersections

All other intersection within the corridor are retained in their existing form of priority control:

- SH6/Southberg Avenue
- SH6/McBride Street (south)
- SH6/Ross Street

Although traffic volumes on the corridor are predicted to increase significantly towards (and beyond) 2028, the addition of signal control at adjacent intersections provides an opportunity for improved egress and access to and from these other side roads, as more consistent gaps in platoons are created by the signal control.

In addition, the two existing signalised midblock crossings are retained to maintain pedestrian crossing points away from intersections – these are provided approximately 60m south of the Ross Street intersection, and 120m south of the McBride Street intersection. It is anticipated that the crossing close to Ross Street may need to be brought into the network cycle time (or at least linked to the operation of the PT hub intersection) so as to minimise delay for traffic through this section.

Network Performance

The following results have been obtained from the Paramics model, with the SH6/SH6A modelled as the emerging preferred conventional intersection option – although the form of this intersection has minimal impact on the operation of the Southern Corridor. The results shown are for the long-term arrangement, with the PT hub on the east side of SH6 Kawarau Road.

Travel Times for Buses

Table 8 sets out the bus travel times (in minutes) for four sections of directional movements that pass along the corridor for each of the three modelled peak hour periods (0800-0900; 1200-1300; 1700-1800). Journeys through to and from Remarkables Park Town Centre are also shown.

Several conclusions can be drawn from Table 8:

- Bus travel times along SH6 through to/from Kawarau Falls Bridge are relatively consistent between periods
- The largest variation in travel times is for journeys heading out of Remarkables Park Town Centre, towards either the Airport or Kawarau Falls Bridge in the PM peak period. This is due to northbound congestion through to the SH6/SH6A intersection – which leads to some queues stretching back down through to Lucas Place (see Figure 12). As secondary effect of this is that some vehicles try to use Humphrey Street as an alternative to northbound Lucas Place, which then makes this secondary route also busy (affecting the buses heading towards the bridge)

Table 8: Travel Time Results for PT (journey time in minutes) (2028)

Bus travel times in minutes for journeys along the section				
From	To	AM Peak	Interpeak	PM Peak
Northbound				
Kawarau Falls Bridge	PT Hub	5.3	5.5	4.9
Kawarau Falls Bridge	Remarkables Park TC	3.1	3.4	3.2
Remarkables Park TC	Airport	2.6	3.0	3.5
Airport	PT Hub	4.1	3.4	3.5
Southbound				
PT Hub	Kawarau Falls Bridge	4.3	4.0	4.0
PT Hub	Airport	2.0	1.8	1.4
Airport	Remarkables Park TC	1.9	2.1	2.0
Remarkables Park TC	Kawarau Falls Bridge	3.6	3.7	5.0

In terms of the latter, this impact is not considered critical at this stage. However, it is recommended that a northbound bus lane on Lucas Place (between the existing Riverside Road roundabout and the Airport access roundabout) be investigated at some point in the future so as to protect bus travel times from any congestion in this area.

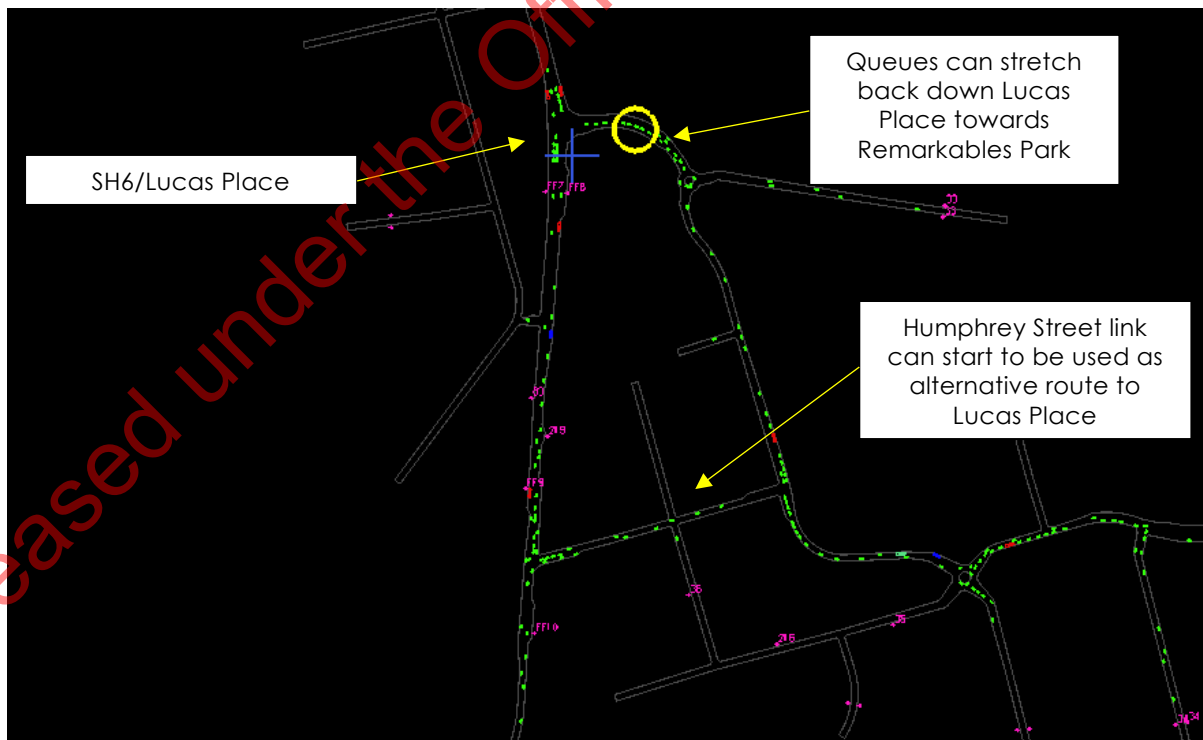


Figure 12: Screenshot at 17:30

In summary, bus travel times on the corridor are generally reliable in both directions, with the northbound bus lane facility providing protection for bus travel time delay on the most congested section within this part of the network.

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 9 shows the assumed cycle times at each location within the network.

Table 9: Proposed Network Operation Cycle Times

Intersection	Type	Recommended Cycle Time (seconds)
SH6/Humphrey Street	Intersection	120 (or could operate at a lower cycle time on isolated control)
SH6/McBride Street	Crossing	Isolated operation
SH6/Lucas Place	Intersection	120
SH6/Ross Street	Crossing	120
SH6/Gray Street	Intersection	120
SH6/SH6A	Intersection	120

Given the increased density of signal controlled intersections on this part of the network (Kawarau Falls Bridge to SH6/SH6A), it is recommended that a Network Operating Plan (NOP) be developed to guide strategic operation of the corridor, and the interdependencies with the operation of the SH6A corridor, and adjoining SH6 section between SH6/SH6A and Shotover Bridge.

Additionally, further consideration will need to be given for the operation of the network post-2028, when it is expected that network management and control of SH6 will need to be extended to the south of Kawarau Falls Bridge. Given the level of residential development to the south of the bridge, the operation of the corridor will need to be optimised to maximise PT share, with the likelihood that northbound bus lanes along SH6 and a dedicated Park and Ride site will be required along this corridor.

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/Lucas Place roundabout sees negligible U-turn movements at present, this could potentially increase with growth in activity at the PT hub to the north – 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.

Conclusions and Summary

This technical note has set out the results of an assessment of the suitable form of intersections required along the SH6 Kawarau Road section of the network, from SH6/SH6A to Kawarau Falls Bridge.

This technical note provides a detailed assessment of the operation of the SH6 Southern Corridor under the preferred scenario layout concepts, which consist of the following changes:

- SH6/SH6A – signalised intersection
- SH6/Gray Street – signalised intersection, incorporating bus gate and staggered crossing facility across SH6
- SH6/PT hub – signalised intersection (long term)
- SH6/Lucas Place – signalised intersection
- SH6/Humphrey Street – signalised intersection

The assessment has indicated that the operation is satisfactory in terms of vehicular performance, albeit approaching capacity by 2028. The pinch point in the network is a combination of Shotover Bridge, the SH6/SH6A intersection and SH6A Frankton Road – and therefore any additional capacity provided at intersections on the Southern Corridor will have little impact on operation.

However, beyond 2028, this section of the network is predicted to operate beyond the capacity, subject to further traffic growth on the corridor – see **Queenstown Business Case Transport Modelling – Future Modelling Option Report (FMOR), 16 Sept 2020**. At this time, any further trip growth would need to be accommodated by public transport, and therefore it is highly likely that additional bus lanes would need to be provided on the northbound approaches to Frankton – the **FMOR** suggests:

- "It is recommended that a northbound bus lane on Lucas Place (Riverside Road roundabout to Airport roundabout) is considered for implementation beyond 2028. This would also aid outbound services running from Remarkables Park Town Centre towards the Kawarau Falls Bridge (via the proposed Humphrey Street link)"
- "It is recommended that northbound bus priority lanes (and complimentary measures) are considered for implementation south of the Kawarau Falls Bridge beyond 2028. This would include priority lanes to serve the proposed Park and Ride site in the vicinity of Boyd Road."

Pedestrian crossing facilities have been improved along the corridor, with fully protected crossing provided at all the new signalised intersections above. Bus lanes in the northbound direction provide reliability of travel times for journeys from Kawarau Falls Bridge to Frankton PT hub and through to the SH6/SH6A intersection.

Although some travel time variability is experienced in the Interpeak and PM peak periods for northbound bus services, this is relatively minor. However, in the longer term it is recommended that the implementation of a northbound bus lane along Lucas Place be considered to provide protection of bus service reliability – subject to a PT Services DBC providing greater detail on future bus routes.

In summary, the preferred scheme provides a high level of benefits over the existing intersection form, in terms of bus travel times and reliability, pedestrian and cycle crossing safety, network management and control, and vehicle operations.

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Technical Note #41

4 November 2020

South West Frankton Intersection Operation & Future Performance

Executive Summary

This technical note sets out the results of an assessment of the possible upgrade to intersections in the south-west corner of Frankton Flats, including:

- The extension of Humphrey Street to Lucas Place ("the Humphrey Street link")
- A new intersection at Humphrey Street/Lucas Place
- Layout modifications at Lucas Place/Hawthorne Drive/Riverside Road

The assessment concludes the following:

- The Humphrey Street link provides relief in terms of lower traffic volumes (and improved road safety) to the two residential roads of Douglas Street and Robertson Street
- At the proposed Lucas Place/Humphrey Street intersection, a signalised T-intersection provides benefits in terms of pedestrian provision (over an alternative roundabout option) with satisfactory operation in all three modelled periods at 2028 demand levels
- At the Lucas Place/Hawthorne Drive/Riverside Road intersection, the assessment has shown that a signalised T-intersection provides benefits in terms of pedestrian provision (over the existing alternative roundabout option) with satisfactory operation in all three modelled periods at 2028 demand levels – this assumed that the Humphrey Street link is implemented, and that a secondary priority controlled T-intersection is formed between Riverside Road and Robertson Street
- The addition of a fourth arm at either of the above intersections has been investigated, and in both cases, operation deteriorates to an at-capacity level with the predicted 2028 demand flows (for either roundabout or signalised intersection arrangements). Although nominal flow volumes are used for the fourth arm (in both cases), the results suggest that limited vehicle access into this arm(s) (for buses, emergency vehicles or a limited amount of authorised vehicles) would likely result in an improved level of performance, and is therefore likely to be a preferred option

It is important to note that beyond 2028, this section of the network is predicted to operate beyond capacity, subject to further traffic growth on the corridor – see **Queenstown Business Case Transport Modelling – Future Modelling Option Report (FMOR), 16 Sept 2020**. At this time, any further trip growth would need to be accommodated by public transport, and therefore it is highly likely that additional bus lanes would need to be provided on the northbound approaches to Frankton – the **FMOR** suggests:

- "It is recommended that a northbound bus lane on Lucas Place (Riverside Road roundabout to Airport roundabout) is considered for implementation beyond 2028. This would also aid outbound services running from Remarkables Park Town Centre towards the Kawarau Falls Bridge (via the proposed Humphrey Street link)"
- "It is recommended that northbound bus priority lanes (and complimentary measures) are considered for implementation south of the Kawarau Falls Bridge beyond 2028. This would include priority lanes to serve the proposed Park and Ride site in the vicinity of Boyd Road."

In terms of a northbound bus lane on Lucas Place, the form of the proposed intersection at Lucas Place/Humphrey Street is fairly agnostic to the operation of the bus lane, although the signal layout does offer the opportunity to incorporate signal priority within the operation to reduce public transport delay. Also, should an additional airport access link be added at either intersection on Lucas Place, it is possible that a through public transport route would be created between Remarkable Park Town Centre and Queenstown Airport, which would make a northbound bus lane on Lucas Place redundant – so there are several interdependencies between the various options.

Introduction

This technical note sets out the results of an assessment of the possible upgrade to intersections in the south-west corner of Frankton Flats, as shown in Figure 1. The scope of this note considers:

- Lucas Place/Hawthorne Drive/Robertson Street/Riverside Road intersection
- Extension of Humphrey Street through to Lucas Place ("the Humphrey Street link")
- Lucas Place/Humphrey Street intersection (proposed)
- Humphrey Street/Douglas Street intersection
- Existing residential roads of Douglas Street and Robertson Street

The technical evaluation of upgrades to the SH6/Humphrey Street intersection (and the whole section of SH6 between the SH6A intersection and Kawarau Falls Bridge) is not included in this note – please see **Technical Note #37 - SH6 Frankton Southern Corridor Operation & Future Performance**.

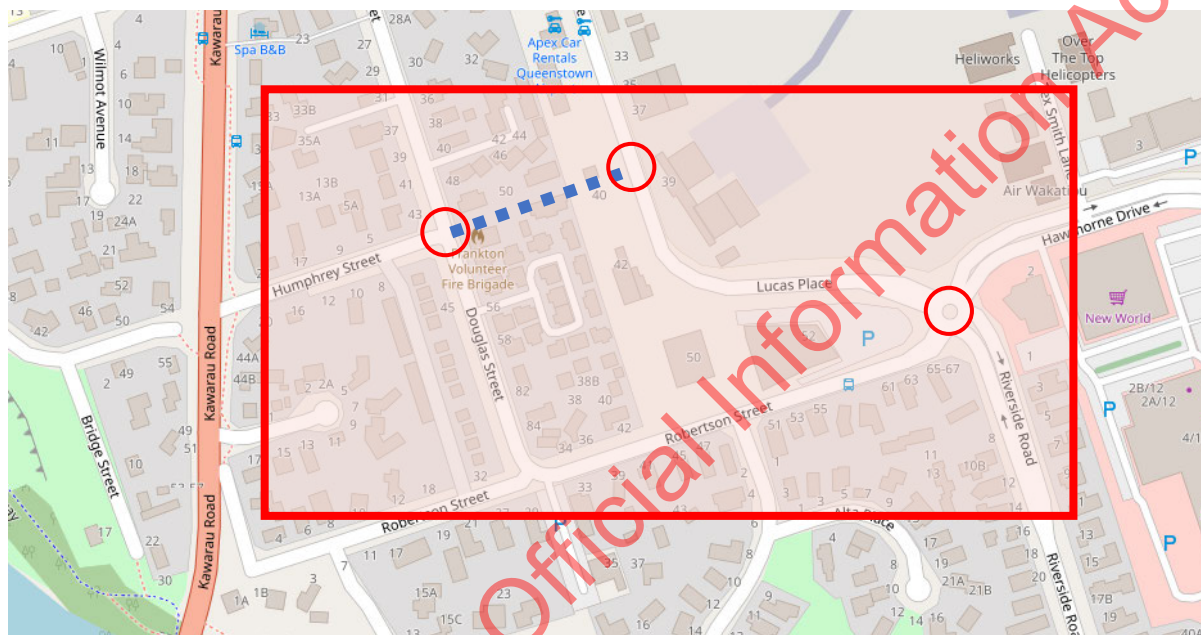


Figure 1: Study Area (Source: OpenStreetMap.org)

The scope of the QTC DBC and F2Q SSBC project was extended out to the section of SH6 Kawarau Road through to the Kawarau Falls Bridge as part of the Frankton SSBC, and the South-West Frankton Flats area.

Although land use intensification is not expected in this part of the network, this section does provide the principal means of access to and from the Remarkables Park Town Centre, Queenstown Airport and southern area of Frankton Flats, via Lucas Place (from the north, east and west), Humphrey Street (from the south), and Hawthorne Drive (from the east). These adjacent areas are expected to see significant intensification, for both commercial and residential land uses. This means that volumes on the roads through the study area are expected to increase significantly, particularly between these areas, to and from Queenstown Town Centre and further residential development south of Kawarau Falls Bridge.

This note provides analysis of the short-listed concepts and layouts considered at each of these intersections and links within the study area.

Traffic Modelling

Traffic modelling has been undertaken at all key intersections and links along the corridor. 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 SIDRA (a small signalised-network assessment tool) and S-Paramics (a micro-simulation network analysis tool). In terms of process, the SIDRA 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 SIDRA

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

- Ratio of Flow to Capacity (RFC) - SIDRA
- Mean Maximum Queue - SIDRA
- Intersection delay per movement – SIDRA
- Traffic volumes - Paramics

Humphrey Street Link

A key feature of the wider Business Case is to provide an improved linkage between SH6 Kwararou Road and the southern area of Frankton Flats (Remarkables Park Town Centre and Hawthorne Drive). Therefore, it is proposed that Humphrey Street would be extended through to Lucas Place, so as to both provide a more direct and suitable route into the area, and also reduce traffic on the residential links of Robertson Street and Douglas Street. Robertson Street also forms part of the cycle route between the riverside trail (along the southern edge of Frankton Flats) and Frankton Beach and the Frankton trail – this route will also benefit from the proposed crossing connection at the SH6/Humphrey Street intersection.

Abley undertook an earlier study into improving access into Frankton from the South-west (2017 Western End Study Modelling), looking at various options but principally focussed on the provision of the Humphrey Street extension. Although monetary benefits were attributed to the scheme, these were relatively low as both the travel time and vehicle operating costs are similar in both with and without scenarios – the result is a relatively simple re-assignment of traffic between two parallel routes. Therefore, the BCR for the scheme is likely to be relatively low (between 0 and 1).

Consequently, the justification of the link extension is not related to poor performance of the existing route between SH6 and Hawthorne Drive (via Douglas Street and Robertson Street) – but the growth in traffic levels that would be experienced on these two residential streets, and the disbenefit in terms of amenity on this route.

Figure 2 shows the 2018 base volumes in the PM peak period (generally the period of highest demand in this areas of the network).



Figure 2: 2018 Base Volumes in PM peak hour (vehicles/hour)

The volumes on Douglas Street and Robertson Street are relatively high given the residential nature of the link. The MobileRoad website shows an AADT estimate of around 4,000-5,000, which is

generally consistent with the 2018 model volumes – again, this is a high AADT for the nature of the link.

It should be noted that Douglas Street is classified as an Arterial road, and Robertson Street as a Collector Road in the QLDC District Plan (the former due to a historic designation as State Highway to link to a potential new bridge across Kawarau River) – again, these classifications are somewhat at odds with the nature and layout of the link.

Figure 3 shows the proposed format of the extended Humphrey Street link, from the intersection with Douglas Street to the intersection with Lucas Place. Note, the latter intersection is shown as a signalised intersection – the form of this intersection is evaluated in a later section of this technical note.

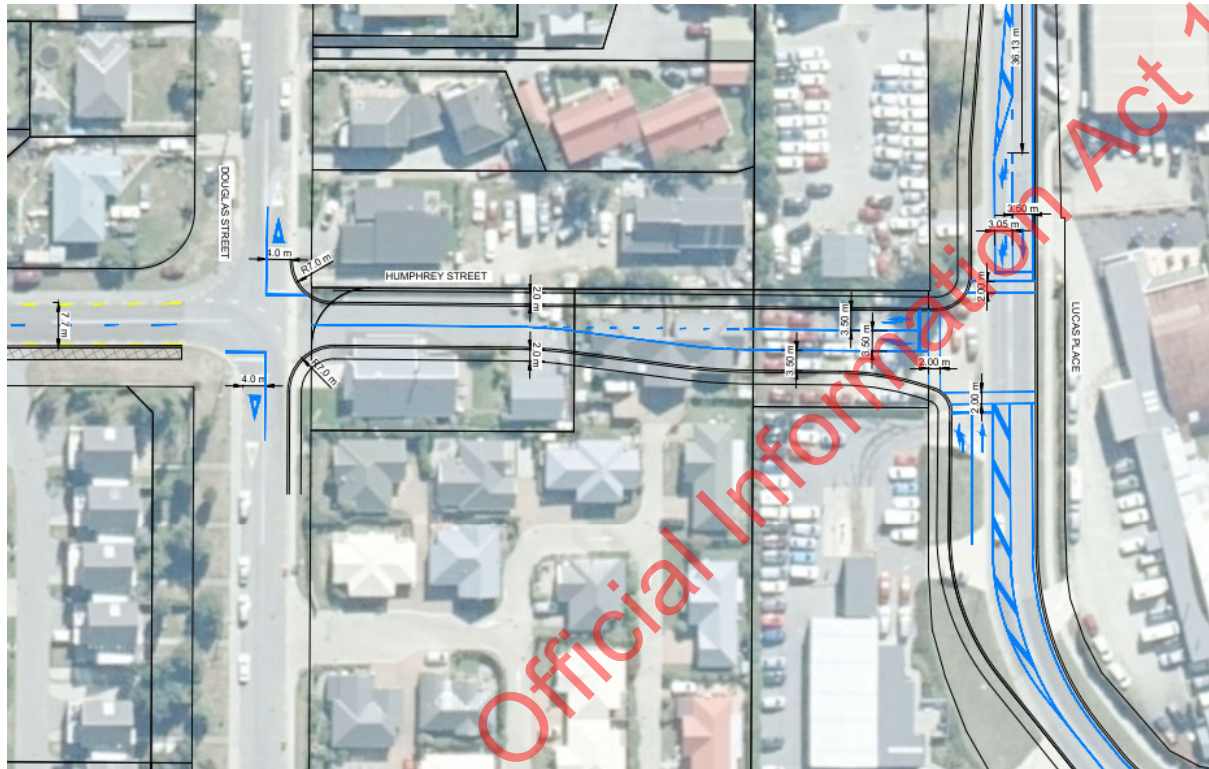


Figure 3: Proposed layout of Humphrey Street link

The form of the Douglas Street/Humphrey Street intersection would migrate to conventional 4-arm priority controlled operation, with Humphrey Street as the major link.

The Paramics model has been used to determine the change in traffic flows in this area of the network from 2018 to 2028, both with and without the Humphrey Street link. Figure 4 shows the predicted 2028 PM peak hour volumes (without Humphrey Street link) and Figure 5 shows the change in traffic volumes from 2018 to 2028 with the existing layout (no link) in the PM peak hour. Note in Figure 5 that there are some links that show zero change in volume – but this is due to a change in node structure in the model rather than an actual result (example central section of Lucas Place).

The plots show that there is predicted to be a significant increase in flow volumes on the Robertson Street and Douglas Street sections due to continued development to the south of Kawarau Falls Bridge and the southern half of Frankton Flats:

- Eastbound – increase from 140v/h to 279v/h (increase of 99%)
- Westbound – increase from 253v/h to 437v/h (increase of 72%)

This suggests that the AADT would increase to somewhere around the 7,000-9,000 level, which is high for a residential street.

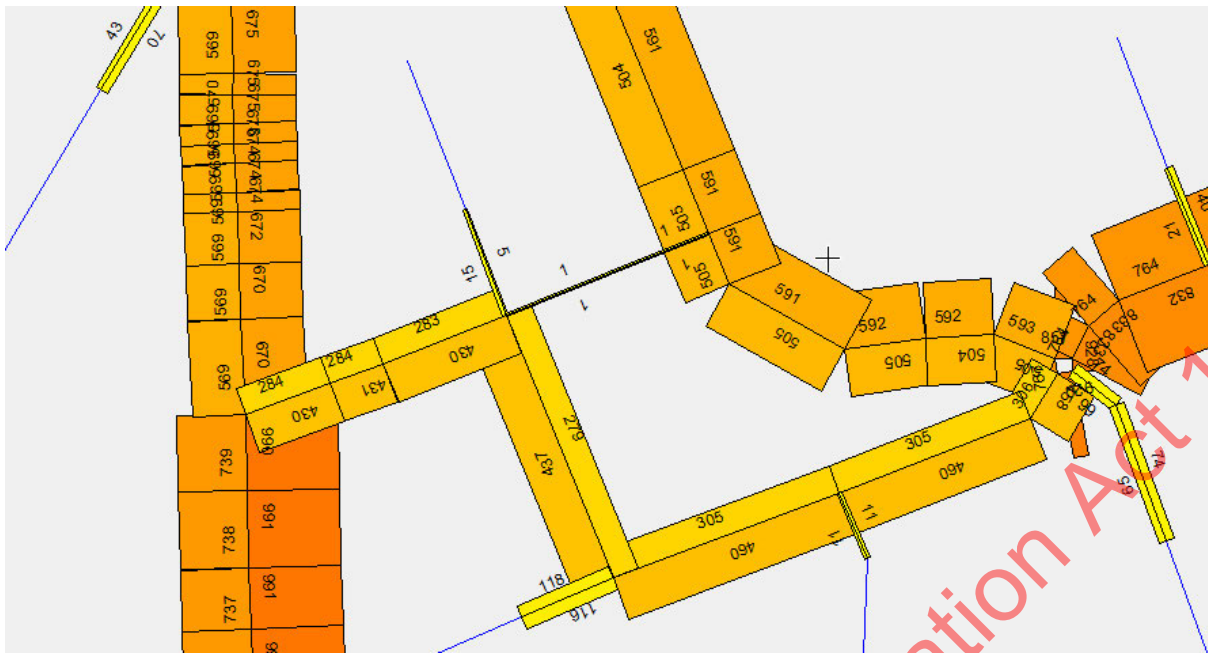


Figure 4: 2028 PM Peak hour volumes, existing network

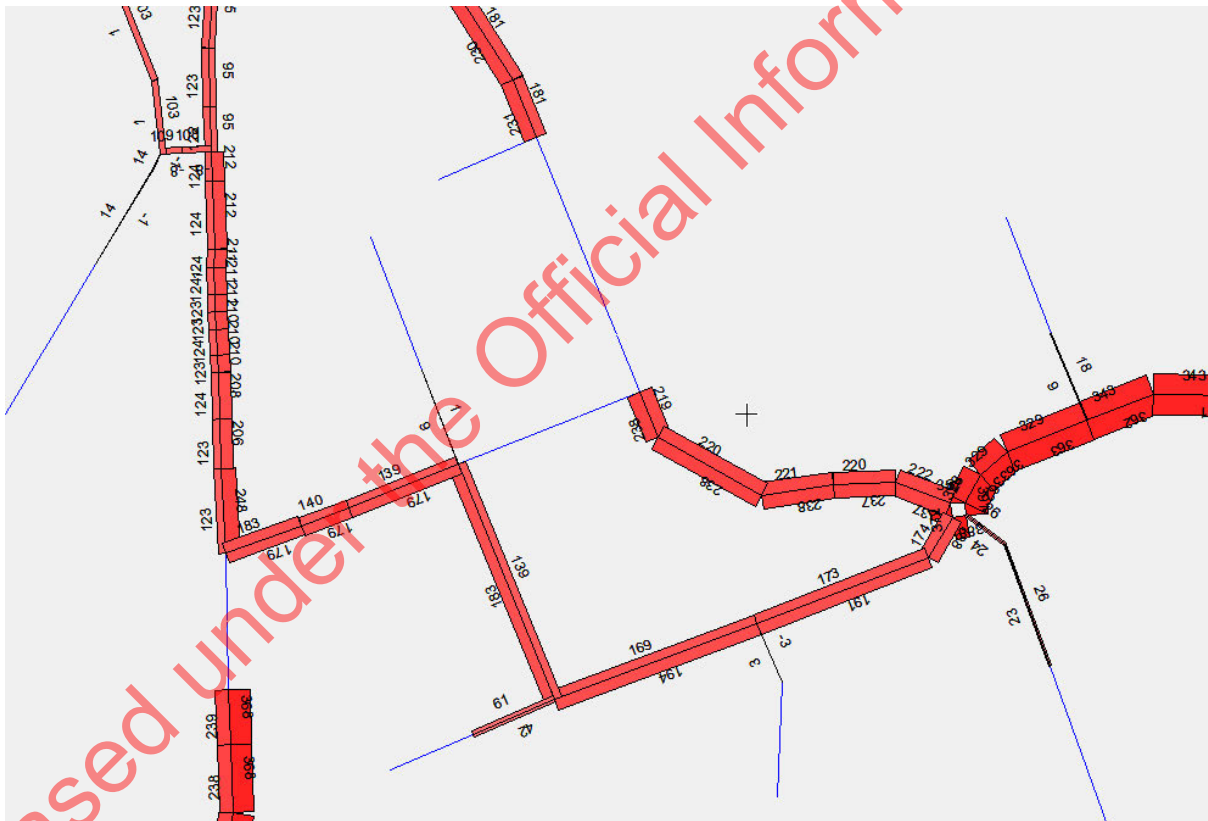


Figure 5: 2018 versus 2028 PM Peak hour volumes, existing network (red = increase, green = decrease)

Figure 6 shows the predicted 2028 PM peak hour volumes, with the Humphrey Street link added and Figure 7 shows the change in traffic volumes in 2028, between the without and with Humphrey Street link scenarios, for the PM peak hour. From these two volume plots it can be concluded that:

- Around 90% of traffic volumes through the area would re-assign onto the Humphrey Street link, with the remaining traffic on Douglas Street and Robertson Street being principally access-only trips. This assumes that some form of traffic calming would be implemented on these two links to encourage use of the new link as the principal through route
- There is also a minor traffic re-assignment onto Lucas Place for trips heading to/from the Airport to/from Kawarau Falls Bridge (and beyond), as this provides a new alternative route to the existing SH6 route

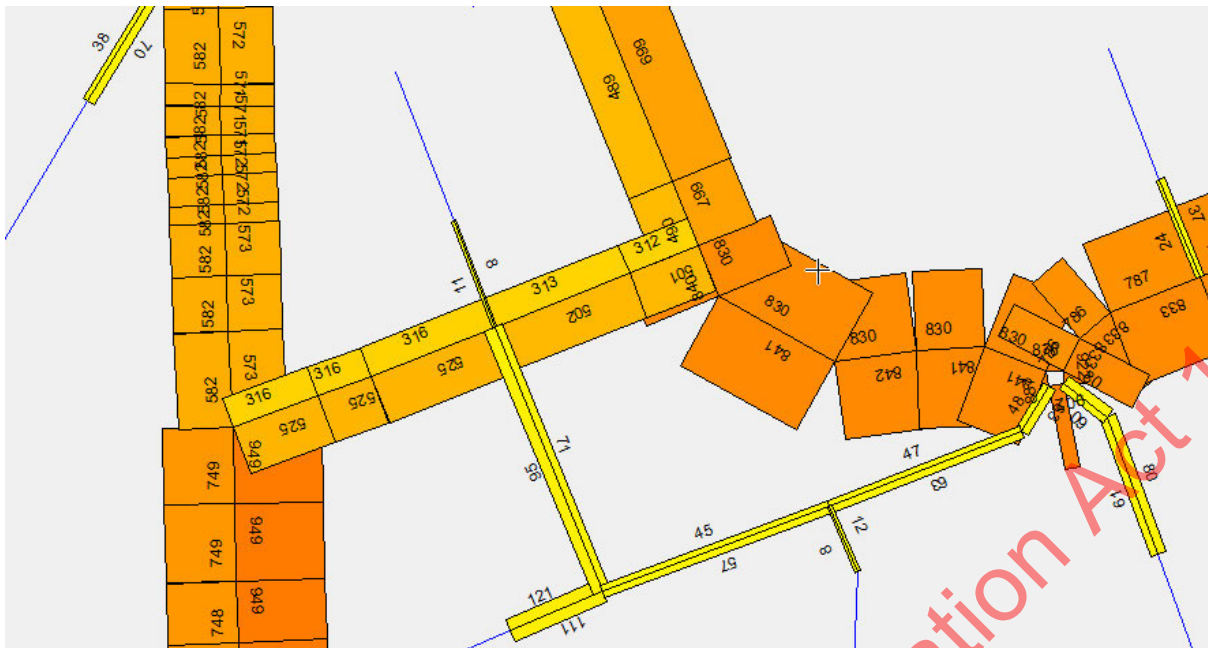


Figure 6: 2028 PM Peak hour volumes, with Humphrey Street link

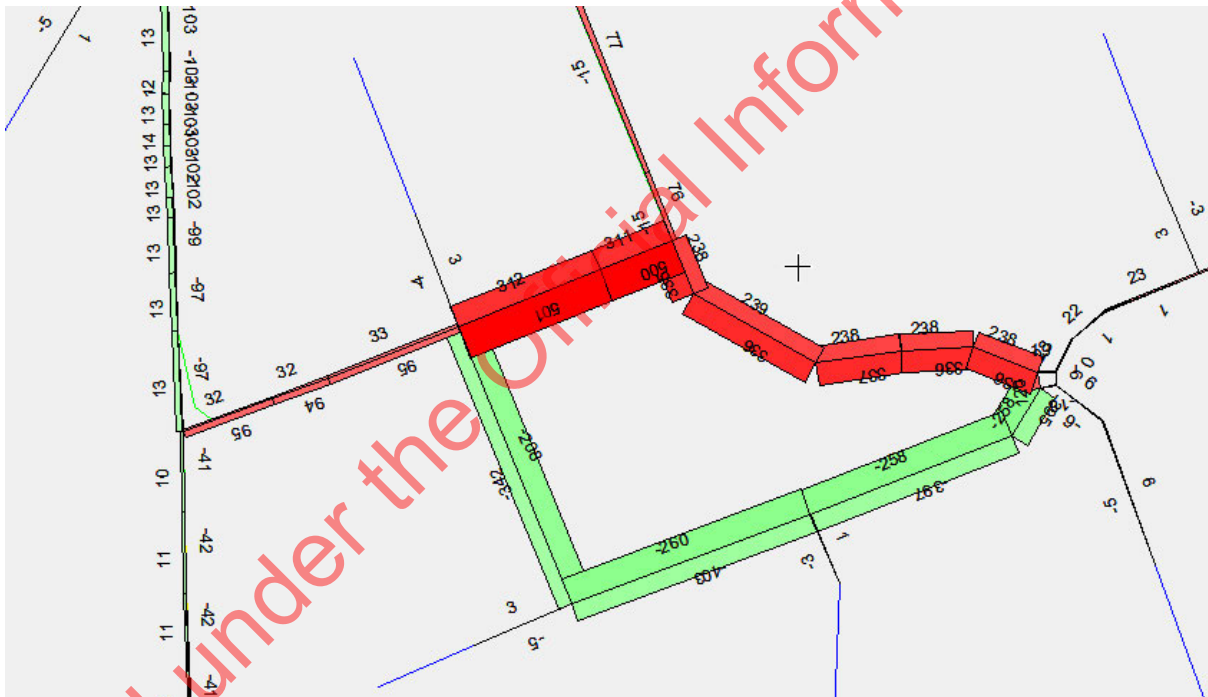


Figure 7: Change in 2028 PM Peak hour volumes, between without and with Humphrey Street link scenarios (red = increase, green = decrease)

In conclusion, the Humphrey Street link provides the opportunity to provide a more direct route between SH6 and Hawthorne Drive, and de-classify Douglas Street and Robertson Street to local streets. It is possible that PT services could continue to use Douglas Street and Robertson Street (rather than the new link) for greater penetration into the residential area to the west of Remarkables Park Town Centre – in which case, the provision of the Humphrey Street link would provide some minor PT benefits due to the decrease in volumes of traffic on this existing route.

Lucas Place/Humphrey Street

At the new Lucas Place/Humphrey Street intersection, a number of options were considered:

- A priority controlled T-intersection
- A signalised T-intersection, as shown in Figure 3, with a couple of signal operation alternatives

- A small 3-arm roundabout

In addition, the possibility of a fourth approach linking directly into the airport was also analysed – this is considered in a later section.

Option 1 - Priority Controlled Intersection

Although this was considered a poor option, as it results in all vehicles on the Humphrey Street arm having to yield to Lucas Place traffic, the option was investigated to show the likely operation. The layout was assumed to be as per Figure 3, but with without signals (i.e. additional short turn lanes on all 3 approaches).

Table 1 shows the results of the operational assessment of the all-red pedestrian phase 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**

Table 1: Lucas Place/Humphrey Street – operational performance (2028) with priority control

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
Lucas Place South	Left Turn	18%	1	5	23%	1	5	34%	2	5
	Ahead	19%	0	0	24%	0	0	18%	0	0
Lucas Place North	Ahead	18%	0	0	31%	0	0	38%	0	0
	Right Turn	16%	1	8	17%	1	10	12%	4	10
Humphrey Street	Left Turn	15%	1	8	15%	1	9	9%	1	7
	Right Turn	127%	77	535	222%	140	2239	255%	152	2840
Intersection LOS		F			F			F		

The results show that operation in all three periods is poor for the right turn out of Humphrey Street, with the intersection unable to accommodate the forecast traffic volumes, with queues forecast to stretch back onto SH6 and have a significant detrimental effect on the wider network. Therefore, this layout option was discarded.

Option 2a – Signalised Intersection with all-red for pedestrians

The layout shown in Figure 3 was investigated, with a 4-phase operation proposed as shown in Figure 8. The signal cycle time was set to a maximum of 120 seconds, although the model has generally optimised operation at a lower value (which brings benefits to both vehicular movement and pedestrians). For optimum road safety, the southbound right turn has been assumed to be fully protected (no filtering), and only operates in phase C – the demand for this volume is low so filtering could be permitted, but this is unlikely to make a significant difference to the overall operation.

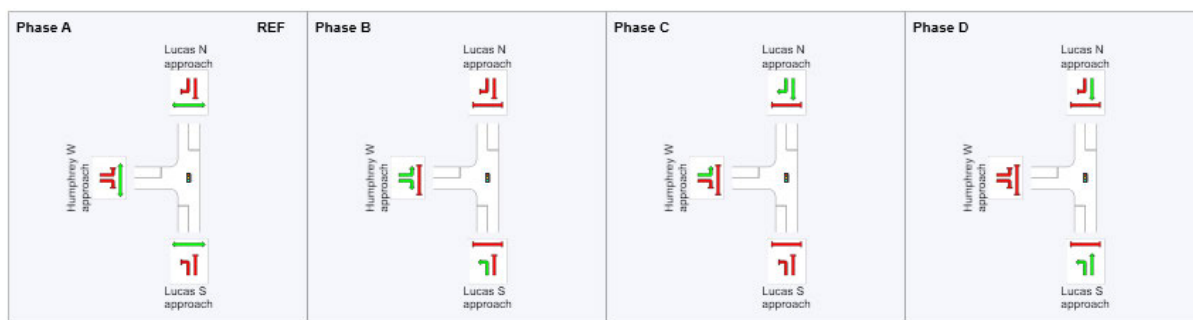


Figure 8: Lucas Place/Humphrey Street - Signalised Intersection Phase Arrangement (Pedestrian Crossing on all 3 arms with all-red pedestrian phase)

Table 2 shows the results of the operational assessment of the all-red pedestrian phase option.

Table 2: Lucas Place/Humphrey Street – operational performance (2028) with signal control (all-red pedestrian phase)

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
Lucas Place South	Left Turn	30%	3	13	37%	5	14	51%	8	14
	Ahead	78%	14	35	79%	17	32	54%	12	27
Lucas Place North	Ahead	48%	9	19	78%	19	22	82%	26	24
	Right Turn	74%	5	48	74%	4	49	42%	3	49
Humphrey Street	Left Turn	18%	3	24	19%	3	28	12%	2	29
	Right Turn	81%	11	44	81%	8	47	76%	9	49
Intersection LOS		C			C			C		
Optimised Cycle Time (s)		80			80			90		

The results show that operation in all three periods at 2028 is satisfactory, with the option to increase the cycle time to accommodate shorter periods of increased demand. Note also, that these tests assume the all-red pedestrian phase is called every cycle. At least in the short to medium term, it is likely that pedestrian (and cycle) crossing movements will be relatively low – and therefore the all-red crossing phase will not be called in all signal cycles.

As a sensitivity, we have increased the traffic volumes by 20%, and the operation of the intersection is still within capacity (RFC of 90% or less on all movements), if the cycle time is increased to 120 seconds, demonstrating some resilience in the operation of the layout.

Option 2b – Signalised Intersection with parallel fully protected pedestrian movements

The same layout shown in Figure 3 was investigated, but with an alternative phase operation proposed where pedestrian movements appear in different phases, and with pedestrian crossings provided on the north and west arms only. Figure 9 shows the intended operation. In essence there is a simple 3-phase operation, but to ensure that the pedestrian crossing operate fully protected, phases A and B have been split into two halves, initially with the conflicting traffic movements held back to fully protect (walk plus clearance times) the pedestrian movements, and then in a second period with the vehicle movements running.

The signal cycle time was set to a maximum of 120 seconds, although the model has generally optimised operation at a lower value (which brings benefits to both vehicular movement and pedestrians). For optimum road safety, the southbound right turn has been assumed to be fully protected (no filtering), and only operates in phase C – the demand for this volume is low so filtering could be permitted, but this is unlikely to make a significant difference to the overall operation.

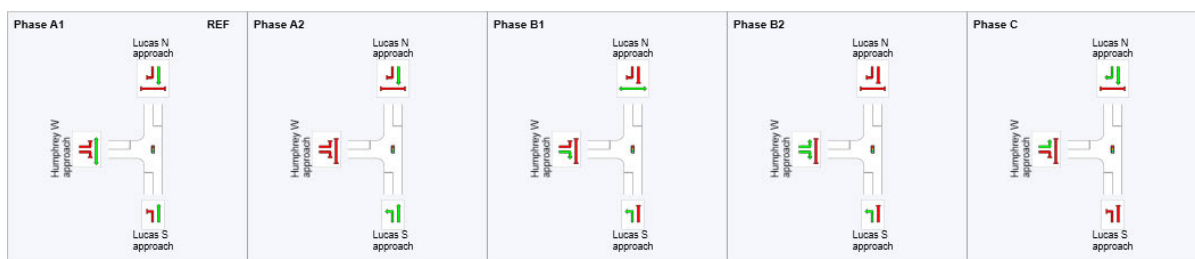


Figure 9: Lucas Place/Humphrey Street - Signalised Intersection Phase Arrangement (Pedestrian Crossing on 2 arms with movements parallel to non-conflicting traffic movements)

Table 3 shows the results of the operational assessment of the parallel pedestrian movement option.

Table 3: Lucas Place/Humphrey Street – operational performance (2028) with signal control (separated pedestrian movements)

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
Lucas Place South	Left Turn	39%	4	20	50%	6	20	76%	10	25
	Ahead	66%	8	19	74%	10	19	57%	7	16
Lucas Place North	Ahead	34%	5	8	56%	9	8	70%	12	9
	Right Turn	54%	3	29	46%	2	29	31%	2	28
Humphrey Street	Left Turn	40%	3	26	45%	2	29	31%	2	28
	Right Turn	62%	6	24	56%	5	25	55%	4	25
Intersection LOS		B			B			B		
Optimised Cycle Time (s)		50			50			50		

The results show that operation in all three periods is excellent with a very low cycle time – it is likely that under actuated control, the cycle time would be slightly higher, but still with a significant level of spare capacity.

As a sensitivity, we have increased the traffic volumes by 20%, and the operation of the intersection is still within capacity (RFC of 70% or less on all movements), with only marginal increase in the cycle time to around 60-70 seconds, demonstrating a good level of resilience in the operation of the layout.

Pedestrian volumes in the area are likely to be low to moderate – there is potential for a greater level of walk trips generated by development to the south-east (on land on the south side of Hawthorne Drive) but areas to the west are likely to remain as low density residential. Consequently, it is recommended that a layout with crossing on all three arms is provided, given that demand for the crossings will be relatively light, and therefore operation will be better than that shown in Table 2.

Option 3 – Small Roundabout

An urban roundabout option was investigated, with a nominal 20m external diameter footprint, and single lane on each approach – this is similar in size to the existing roundabouts on Shotover Street in Queenstown Town Centre.

Table 4 shows the results of the operational assessment of the small urban roundabout option.

The results show that operation in all three periods is satisfactory, with a LOS A due to the free-flowing nature of the operation. However, the RFC level predicted for the Lucas Place North approach is at 80%, which demonstrates that the operation is approaching capacity. As a sensitivity, we have increased the traffic volumes by 20%, and the operation of the Lucas Place

North approach is predicted to deteriorate to an RFC of 103% and delay of over 100 seconds per vehicle (LOS F) – the Interpeak period operation on this approach is also at an RFC of 90%.

Table 4: Lucas Place/Humphrey Street – operational performance (2028) with small urban roundabout

Approach	AM Peak			Interpeak			PM Peak		
	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
Lucas Place South	54%	5	5	65%	8	5	64%	8	4
Lucas Place North	55%	5	8	74%	10	9	80%	14	11
Humphrey Street	52%	4	11	46%	3	12	35%	2	10
Intersection LOS	A			A			A		

Given that any pedestrian crossing provision on any of the approaches will further deteriorate the overall intersection level of performance, the option would appear to be less attractive than the traffic signal options – given that a dual approach and circulatory lane roundabout is unlikely to be feasible (or desirable) in this location.

Fourth Airport Approach

We have also investigated the future incorporation of a fourth east arm into the intersection as a new access into the airport. As it is uncertain as to how the arrangement of the internal road structure would operate under such a scenario, and whether the new access would be for all traffic or restricted to certain vehicle types (buses, emergency vehicles), a nominal additional two-way general traffic volume of 300v/h has been added to use this fourth leg, equally distributed across the three other approaches/exit links.

Given the restriction on lane allocations that are likely at the intersection, we have looked at two options:

- A signalised X-intersection, with an all-red pedestrian crossing phase – the parallel crossing option is unlikely to be possible without having separate (additional) left and right turn lanes on all approaches, which is difficult on some approaches without further land take
- A small 4-arm roundabout – a simple addition of the fourth arm

The signal option would require a 5-phase operation is proposed as shown in Figure 10. The signal cycle time was set to a maximum of 150 seconds.

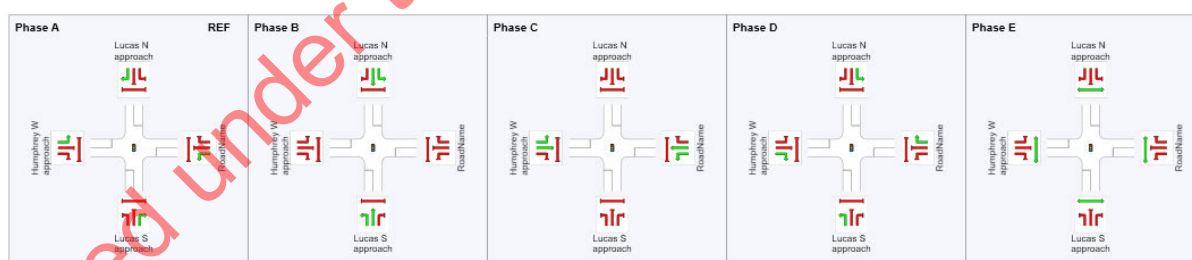


Figure 10: Lucas Place/Humphrey Street – 4-arm Signalised Intersection Phase Arrangement (with all-red pedestrian phase)

Table 5 shows the results of the operational assessment of the all-red pedestrian phase option. The operation shows that the intersection is predicted to operate poorly in all three periods, with LOS F on a number of key movements, even when operating at a high cycle time of 130-150 seconds.

Table 6 shows the results of the operational assessment of the 4-arm roundabout option. The operation shows that the intersection is predicted to operate satisfactorily in the AM peak period, but with the Lucas Place (north) approach operating at capacity in the Interpeak and PM peak hour periods.

Table 5: Lucas Place/Humphrey Street – operational performance (2028) with 4-arm signal control (all-red pedestrian phase)

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
Lucas Place South	Left+Ahead	104%	68	167	105%	92	181	107%	99	201
	Right Turn	44%	4	81	55%	4	84	64%	3	76
Airport	Left+Ahead	57%	6	61	62%	6	62	76%	5	55
	Right Turn	13%	3	53	17%	3	57	20%	3	58
Lucas Place North	Left+Ahead	82%	25	57	100%	67	122	109%	105	236
	Right Turn	97%	10	117	104%	12	181	82%	5	80
Humphrey Street	Left+Ahead	81%	9	61	80%	8	61	82%	6	56
	Right Turn	87%	20	74	89%	16	84	92%	15	85
Intersection LOS		F			F			F		
Optimised Cycle Time (s)		150			150			130		

Table 6: Lucas Place/Humphrey Street – operational performance (2028) with small urban 4-arm roundabout

Approach	AM Peak			Interpeak			PM Peak		
	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
Lucas Place South	68%	8	9	82%	15	12	83%	15	10
Airport	28%	2	11	37%	3	14	42%	3	17
Lucas Place North	72%	9	15	93%	27	31	100%	56	72
Humphrey Street	68%	8	17	64%	6	17	50%	4	12
Intersection LOS	B			B			C		

Overall, the assessment suggests that a roundabout would be a better long-term option, as it allows the fourth arm to be included with a better level of performance. However, this would be to the potential detriment for pedestrians, unless some form of crossing facility were incorporated into the layout. Pedestrian volumes are likely to increase in the future, as further development takes place on plots to the south side of Hawthorne Drive – albeit they are likely to remain at moderate levels given the (relative) lack of high density land use to the west of Lucas Place.

Consequently, it is recommended that a 3-arm traffic signal intersection be installed in the shorter term, to incorporate fully protected pedestrian crossing facilities on all 3 arms.

Lucas Place/Hawthorne Drive/Riverside Road

At the Lucas Place/Hawthorne Drive/Robertson Street/Riverside Road roundabout, it is not expected that future capacity will be an issue at the intersection. However, the layout of the

intersection is not conducive to pedestrian or cycle safety, and therefore options have been considered to improve efficiency and safety for these modes:

- A signalised T-intersection, with Robertson Street re-aligned to join Riverside Road as an additional priority controlled T-intersection
- Retain the existing 4-arm roundabout

It is assumed the Humphrey Street link would be provided in both options, essentially re-assigning traffic from Robertson Street and onto Lucas Place.

In addition, the possibility of a fourth/fifth approach linking directly into the airport on the north side was also analysed – this is considered in a later section.

Option 1 – Existing Roundabout

Table 7 shows the results of the operational assessment of the existing roundabout at 2028.

Table 7: Lucas Place/Hawthorne Drive – operational performance (2028) with existing roundabout

Approach	AM Peak			Interpeak			PM Peak		
	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
Riverside Road	12%	1	7	5%	1	10	8%	1	10
Hawthorne Drive	35%	2	7	57%	5	7	61%	6	7
Lucas Place	36%	3	5	49%	4	6	52%	5	6
Robertson Road	6%	1	7	11%	1	8	10%	1	9
Intersection LOS	A			A			A		

The results show that operation in all three periods is satisfactory – this is largely due to the implementation of the Humphrey Street link, which means that most vehicle conflicts are removed from the roundabout (the majority now move from Hawthorne Drive to Lucas Place and vice versa).

Option 2a – Signalised Intersection with all-red for pedestrians

The conceptual layout shown in Figure 12 was investigated, with a 4-phase operation proposed as shown in Figure 11. The layout assumes that the Lucas Place and Hawthorne Drive approaches are straightened, with the centre of the intersection moved to the north of the existing roundabout. The existing Robertson Street arm is then re-aligned to join Riverside Road at a new priority controlled all moves intersection around 40m south of the main signalised intersection – the operation of this T-intersection has not been assessed as the traffic volumes on all three arms are expected to be light.

The signal cycle time was set to a maximum of 120 seconds, although the model has generally optimised operation at a lower value (which brings benefits to both vehicular movement and pedestrians).

For optimum road safety, the eastbound right turn has been assumed to be fully protected (no filtering), and only operates in phase D – the demand for this volume is low so filtering could be permitted, but this is unlikely to make a significant difference to the overall operation.

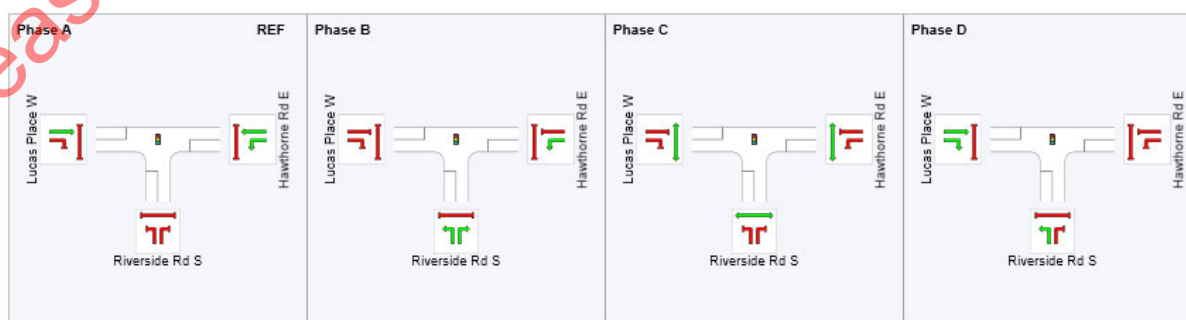


Figure 11: Lucas Place/Hawthorne Drive - Signalised Intersection Phase Arrangement (Pedestrian Crossing on all 3 arms with all-red pedestrian phase)

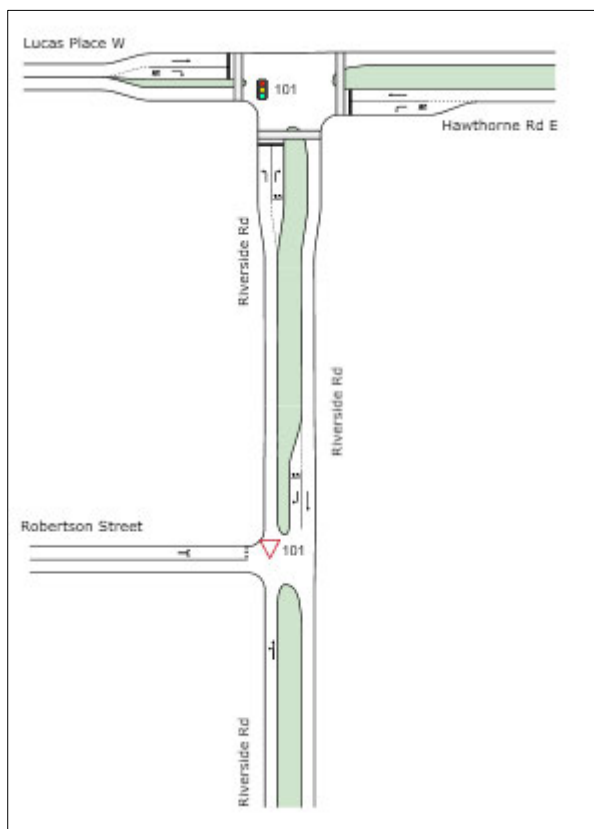


Figure 12: Conceptual signalised layout at Lucas Place/Hawthorne Drive signalised intersection

Table 8 shows the results of the operational assessment of the all-red pedestrian phase option.

Table 8: Lucas Place/Hawthorne Drive – operational performance (2028) with signal control (all-red pedestrian phase)

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
Riverside Road	Left Turn	39%	2	21	16%	1	30	23%	2	33
	Right Turn	39%	2	43	82%	5	63	68%	4	65
Hawthorne Drive	Left Turn	12%	2	17	15%	2	15	15%	4	15
	Ahead	84%	17	34	89%	33	38	88%	35	36
Lucas Place	Ahead	66%	15	14	70%	21	15	75%	25	14
	Right Turn	29%	2	43	84%	5	64	89%	7	72
Intersection LOS		C			C			C		
Optimised Cycle Time (s)		75			100			110		

The results show that operation in all three periods is satisfactory, albeit approaching capacity in all three peak periods. Note, there is the option to increase the cycle time to accommodate shorter periods of increased demand, and that these tests assume the all-red pedestrian phase is called every cycle. At least in the short to medium term, it is likely that pedestrian (and cycle) crossing movements will be relatively low – and therefore the all-red crossing phase will not be called in all signal cycles.

As a sensitivity, we have increased the traffic volumes by 20%, and the operation of the intersection is at capacity (RFC of 100% or less on all movements), if the cycle time is increased to 120 seconds, demonstrating some resilience in the operation of the layout, but with a detriment to pedestrian wait times.

Option 2b – Signalised Intersection with parallel fully protected pedestrian movements

The same layout shown in Figure 12 was investigated, but with an alternative phase operation proposed where pedestrian movements appear in different phases, and with pedestrian crossings provided on the south and east arms only. Figure 13 shows the intended operation – in essence there is a simple 3-phase operation, but to ensure that the pedestrian crossing operates fully protected, phase A has been split into two halves, initially with the conflicting traffic movements held back to fully protect (walk plus clearance times) the pedestrian movements, and then in a second period with the vehicle movements running.

The signal cycle time was set to a maximum of 120 seconds, although the model has generally optimised operation at a lower value (which brings benefits to both vehicular movement and pedestrians). For optimum road safety, the eastbound right turn has been assumed to be fully protected (no filtering), and only operates in phase C – the demand for this volume is low so filtering could be permitted, but this is unlikely to make a significant difference to the overall operation.

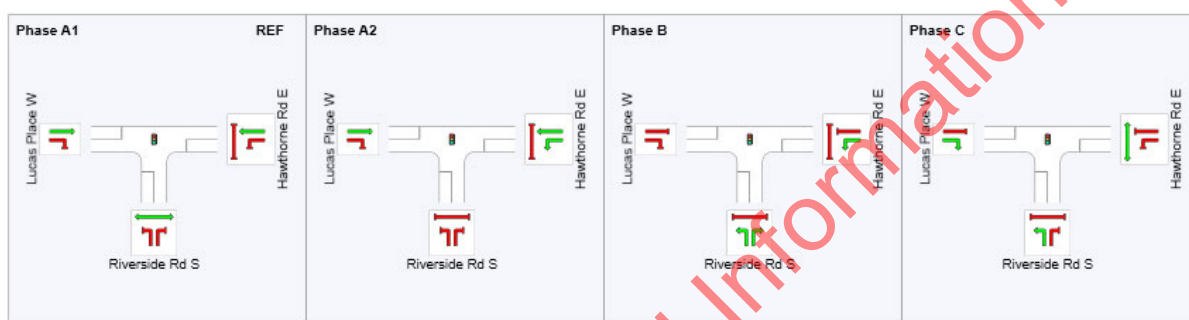


Figure 13: Lucas Place/Hawthorne Drive - Signalised Intersection Phase Arrangement (Pedestrian Crossing on 2 arms with movements parallel to non-conflicting traffic movements)

Table 9 shows the results of the operational assessment of the parallel pedestrian movement option.

Table 9: Lucas Place/Hawthorne Drive – operational performance (2028) with signal control (separated pedestrian movements)

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
Riverside Road	Left Turn	24%	3	25	9%	1	32	9%	2	25
	Right Turn	31%	2	34	66%	4	48	53%	3	49
Hawthorne Drive	Left Turn	28%	2	28	24%	4	25	33%	5	32
	Ahead	67%	11	19	83%	24	24	83%	25	23
Lucas Place	Ahead	84%	17	26	82%	24	23	88%	32	29
	Right Turn	9%	1	24	24%	3	34	32%	4	37
Intersection LOS		C			C			C		
Optimised Cycle Time (s)		60			80			85		

The results show that operation in all three periods is satisfactory with a cycle time lower than the equivalent operation with an all-red pedestrian period.

As a sensitivity, we have increased the traffic volumes by 20%, and the operation of the intersection is still within capacity (RFC of 90% or less on all movements), with an increase in the cycle time to around 100-110 seconds, demonstrating a good level of resilience in the operation of the layout.

Pedestrian volumes in the area are likely to be moderate – there is potential for a greater level of walk trips generated by development to the south-east (on land on the south side of Hawthorne Drive) but areas to the west are likely to remain as low density residential. Most pedestrian movements are expected to be across the Riverside Road arm. Consequently, it is recommended that a layout with crossing on all three arms is preferred, given that demand for the crossings across Lucas Place and Hawthorne Drive will be relatively light, and therefore operation will be better than that shown in Table 8.

Fourth Airport Approach

We have also investigated the future incorporation of a fourth north arm into the intersection as a new access into the airport. As it is uncertain as to how the arrangement of the internal road structure would operate under such a scenario, and whether the new access would be for all traffic or restricted to certain vehicle types (buses, emergency vehicles), a nominal additional two-way general traffic volume of 300v/h has been added to use this fourth leg, equally distributed across the three other approaches/exit links.

We have looked at the single option of a signalised X-intersection, with parallel (separated) pedestrian crossing movements as left turn and right turn pockets are able to be provided to hold back turns from the pedestrian crossings. A revised roundabout option (re-assigning the Robertson Street to a T-intersection as per the arrangement in the previous section, and moving the roundabout north so as to provide sufficient deflection for the west-east movements and add in the north arm) was not considered due to the additional cost, land take and lack of protected pedestrian crossing provision. The signal option would require a 4-phase operation is proposed as shown in Figure 14. The signal cycle time was set to a maximum of 150 seconds.

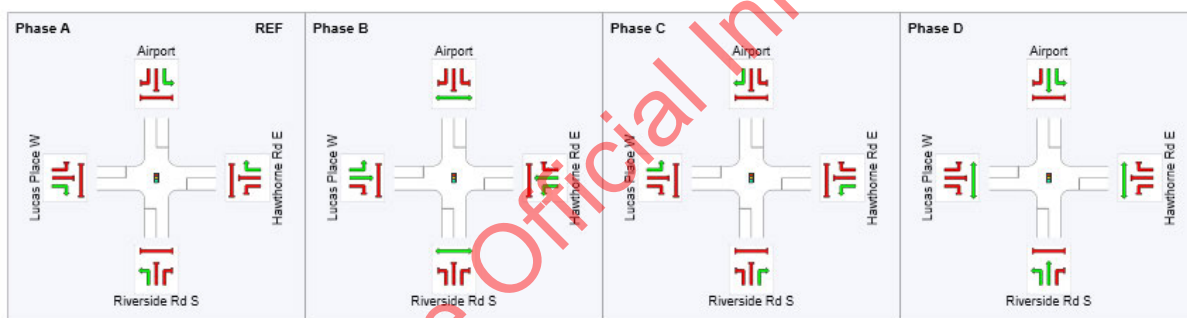


Figure 14: Lucas Place/Humphrey Street – 4-arm Signalised Intersection Phase Arrangement (with separate pedestrian crossing movements)

Table 5 shows the results of the operational assessment of the all-red pedestrian phase option. The operation shows that the intersection is predicted to operate at capacity in all three periods, but with a relatively high cycle time particularly in the Interpeak and PM peak periods. The queue lengths predicted would also result in queues back into the internal roads within Remarkables Park Town Centre, which could result in blocking issues, and a loss of throughput back at the intersection limit lines.

Overall, the assessment suggests that it would be difficult to include a fourth arm at the intersection as queues would extend back into adjacent parking areas under normal operation.

Table 10: Lucas Place/Hawthorne Drive – operational performance (2028) with 4-arm signal control (with separate pedestrian crossing movements)

Approach	Movement	AM Peak			Interpeak			PM Peak		
		RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)	RFC (%)	MMQ (veh)	Delay (s)
Riverside Road	Left+Ahead	88%	5	57	33%	2	67	39%	4	76
	Right Turn	45%	2	49	49%	5	62	38%	5	73
Hawthorne Drive	Left+Ahead	78%	16	29	90%	39	44	92%	40	35
	Right Turn	41%	2	49	49%	3	68	38%	4	76
Airport	Left+Ahead	41%	2	49	49%	3	68	38%	4	76
	Right Turn	41%	2	49	29%	3	61	30%	3	72
Lucas Place	Left+Ahead	89%	25	41	87%	38	38	89%	49	42
	Right Turn	33%	2	48	87%	6	76	85%	9	87
Intersection LOS		D			D			D		
Optimised Cycle Time (s)		85			120			145		

Conclusions and Comment

This technical note sets out the results of an assessment of the possible upgrade to intersections in the south-west corner of Frankton Flats, including:

- The extension of Humphrey Street to Lucas Place ("the Humphrey Street link")
- A new intersection at Humphrey Street/Lucas Place
- Layout modifications at Lucas Place/Hawthorne Drive/Riverside Road

The assessment has concluded the following:

- Humphrey Street link – although this project essentially re-assigns traffic from the local streets of Douglas Street and Robertson Street, onto Humphrey Street, and is thus unlikely to bring significant benefits in terms of operational efficiency, it does provide relief in terms of lower traffic volumes (and improved road safety) to these two residential roads
- At the proposed Lucas Place/Humphrey Street intersection:
 - The assessment has shown that a signalised T-intersection provides benefits in terms of pedestrian provision (over an alternative roundabout option) with satisfactory operation in all three modelled periods at 2028 demand levels
 - The addition of a fourth arm into the intersection results in at-capacity operation at 2028, assuming a nominal 300v/h two-way flow on the new arm. An alternative operation with limited vehicle access into this arm (for buses, emergency vehicles or a limited amount of authorised vehicles) would likely result in an improved level of performance, and is therefore likely to be a preferred option (subject to future demand flows in the network)
- At the Lucas Place/Hawthorne Drive/Riverside Road intersection:
 - The assessment has shown that a signalised T-intersection provides benefits in terms of pedestrian provision (over the existing alternative roundabout option) with satisfactory operation in all three modelled periods at 2028 demand levels – this assumed that the Humphrey Street link is implemented, and that a secondary priority controlled T-intersection is formed between Riverside Road and Robertson Street

- The addition of a fourth arm into the signalised intersection results in at-capacity operation at 2028, assuming a nominal 300v/h two-way flow on the new arm. An alternative operation with limited vehicle access into this arm (for buses, emergency vehicles or a limited amount of authorised vehicles) would likely result in an improved level of performance, and is therefore likely to be a preferred option (subject to future demand flows in the network). This would be as an alternative to providing an additional fourth arm at the Lucas Place/Humphrey Street intersection

It is important to note that beyond 2028, this section of the network is predicted to operate beyond the capacity, subject to further traffic growth on the corridor – see **Queenstown Business Case Transport Modelling – Future Modelling Option Report (FMOR), 16 Sept 2020**. At this time, any further trip growth would need to be accommodated by public transport, and therefore it is highly likely that additional bus lanes would need to be provided on the northbound approaches to Frankton – the **FMOR** suggests:

- “It is recommended that a northbound bus lane on Lucas Place (Riverside Road roundabout to Airport roundabout) is considered for implementation beyond 2028. This would also aid outbound services running from Remarkables Park Town Centre towards the Kawarau Falls Bridge (via the proposed Humphrey Street link)”
- “It is recommended that northbound bus priority lanes (and complimentary measures) are considered for implementation south of the Kawarau Falls Bridge beyond 2028. This would include priority lanes to serve the proposed Park and Ride site in the vicinity of Boyd Road.”

In terms of a northbound bus lane on Lucas Place, the form of the proposed intersection at Lucas Place/Humphrey Street is fairly agnostic to the operation of the bus lane, although the signal layout does offer the opportunity to incorporate signal priority within the operation to reduce public transport delay.

Also, should an additional airport access link be added at either intersection on Lucas Place, it is possible that a through public transport route would be created between Remarkable Park Town Centre and Queenstown Airport, which would make a northbound bus lane on Lucas Place redundant – so there are several interdependencies between the various options. Therefore, the addition of the northbound bus lane on Lucas Place is highly dependent on future bus routes, and so the need and justification for this facility would need to be confirmed by the PT Services DBC.

In summary, the Humphrey Street link provides benefits in terms of reducing/removing through traffic from a less appropriate residential route, particularly given the future growth in traffic levels expected to 2028 and beyond. The proposed intersection improvements at Lucas Place/Humphrey Street and Lucas Place/Hawthorne Drive provide improvements in terms of network control and pedestrian (and cycle) crossing provision and safety.

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Appendix B13 Technical Note 35: SH6/SH6A Operation and Future Performance

Released under the Official Information Act 1982

NZTA Contract 2018235 - F2Q SSBC & QTC DBC

Technical Note #35

13 August 2020

SH6/SH6A Operation & Future Performance

Introduction

This note sets out the results of a re-evaluation exercise regarding the suitable form of intersection required at the SH6/SH6A Junction. This Junction is the key point within the Regional road network, as the meeting point of the SH6 through Frankton (classified as a "Regional" road under the One Network Road Classification as shown in Figure 1), and SH6A the main link into Queenstown Town Centre. Additionally, the existing Frankton PT hub is located immediately south of the Junction on Kawarau Road, which serves as a transfer point for both local and tourist bus services. There is also local activity at the location with Frankton Village Shops on the south-west corner, and Terrace Junction retail and BP service station on the north side.

Consequently, the optimum arrangement of an upgraded Junction at this location 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: One Network Road Classification for SH6

Background

Previously, a signalised roundabout concept (colloquially known as the "Guavabout" option, due to the shape of the central island) was taken forward through the short-list to preferred option MCA process (including stakeholder engagement) for the previous Grant Road to Kawarau Falls Bridge ("GR2KFB") Single Stage Business Case in 2018. It was accepted that the implementation of this arrangement would require land take from the existing Frankton golf course, albeit the existing 9-hole facility could be rearranged and still be operated within the remaining land with the same overall PAR. The GR2KFB work was then put on hold in 2018, in light of uncertainties regarding the size and location of an expanded public transport hub in Frankton, and the parallel undertaking of a PT demand study to better establish future PT infrastructure and service requirements within the wider Wakatipu Basin.

A refresh of this work in line with the extension of the QTC DBC and F2Q SSBC project into Frankton was undertaken in 2019, which indicated that the Guavabout design was still the most appropriate form of intersection.

However, due to concerns expressed (by the Queenstown Lakes District Council and Waka Kotahi representatives) over the extent of the land take required – and other matters such as compatibility with potential future land use in the vicinity of the intersection, and pedestrian/cycle crossing provision – it was agreed that the (previously discarded) conventional signalised intersection options would be re-visited to ensure that the current preferred Guavabout option was still the optimum arrangement, both for the intersection itself, and as a compatible feature within the wider network changes.

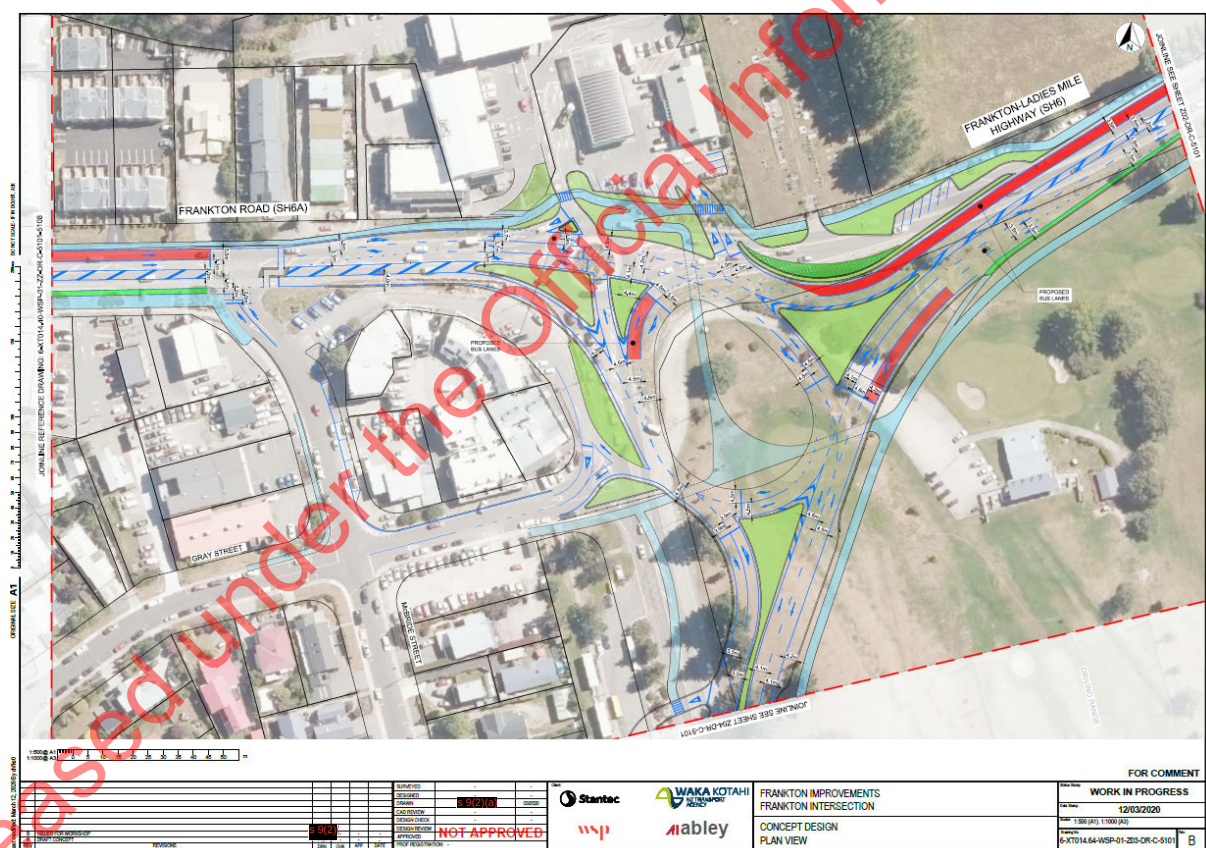
Guavabout Option

A signalised roundabout arrangement was devised with the signalisation of three of the four legs (BP/Terrace Junction leg remains priority controlled), which is shown in Figure 2.

As also shown in Figure 2 an egress from the circulatory has also been provided into Gray Street and the Frankton Village Shops. Access onto the roundabout has not been provided from Gray Street, which therefore reduces the options for traffic exiting this link (and local shops). However, the signalisation of the SH6A/McBride Street intersection (also shown in Figure 2) provides safe and direct egress onto SH6A, with McBride Street currently becoming northbound only at this intersection.

Figure 3 shows the intended operational philosophy and resultant signal timings at each of the three nodes (diagram shows start and end green times, relative to a 60 second cycle time). In short, the signals are set to operate similarly to a split-phased approach, to ensure that any vehicles passing the first approach stop line at green, will also pass through the first circulatory stop line at green. In this way, only the relatively low traffic movements heading to or from the BP/Terrace Junction leg would be held at a circulatory stop line. In addition, the cycle time at the roundabout would be kept low, at around 50-60 seconds (depending on demand) to minimise delay, and optimise the efficiency of the roundabout. The main principle of a signalised roundabout approach is that the "normal" conflict points in a conventional intersection all occur in the centre of the intersection, whereas in the roundabout they are spread out around the circulatory carriageway, which allows two or more normally conflicting movements to operate simultaneously (as their conflict points are essentially moved to different points on the circulatory).

Another feature of the operation of the Guavabout is to maximise the throughput from the SH6A arm, and therefore clear out traffic on this approach where bus lanes are difficult to provide for any extended length. In addition, improved control of the northbound and westbound approaches allows traffic heading towards Queenstown to be gated (so that downstream intersections can accommodate the traffic volumes), with bus lanes providing priority for public transport services to bypass any queues on the approaches to the Guavabout.



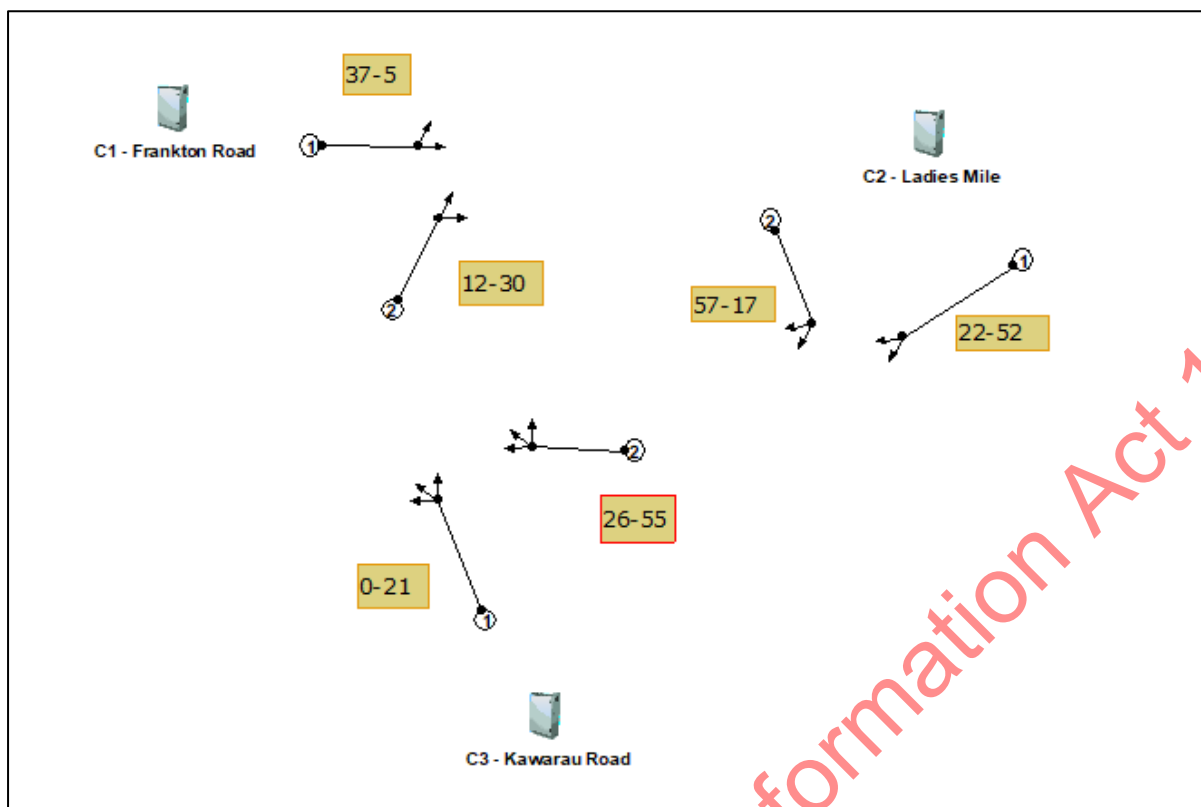


Figure 3: Guavabout Signal Timings (Green Start-Green End seconds as related to a 60 second cycle time) – Interpeak period, but similar for AM and PM peak

In terms of the operation of the Terrace Junction/BP egress, this traffic would be priority controlled. As shown in Figure 3, at the Frankton Road node, it is proposed to introduce longer all-red periods so as to provide short “virtual-green” periods for vehicles to safely exit this north arm, whilst all upstream traffic is held.

Bus lanes would be provided as below:

- SH6 Frankton-Ladies Mile Highway – bus lane provided to first stop line at Guavabout (extended back along SH6 to Hardware Lane). The majority of buses would head towards the bus hub on Kwarau Road, and depending on location of this facility (both in the short and longer term) on either the west or east of Kwarau Road, then the bus lane would be marked in either the kerbside or centre lane. At present, it is not expected that any through (east to west) services would bypass the PT hub on Kwarau Road – however, should this be required, it may be necessary to introduce a bus gate around 30-40m prior to the Guavabout stop line so as to provide buses with a safer movement into the offside (Queenstown-bound) lane. Although not tested, it is likely that the operation of such a facility would be marginally detrimental to public transport services approaching from the east (due to additional delay at the bus gate), and that such a facility would operate with lower delay in the Guavabout option than the Conventional intersection option due to the lower cycle time proposed in the former.
- Kwarau Road – bus lane provided up to proposed staggered crossing around 60-80m south of the Guavabout. The detail of this depends on the interim and ultimate arrangement of the bus hub, but the intention is that buses will be brought to the front of any queues on the northbound section of Kwarau Road and “jump” the queue at this midblock crossing. This northbound bus lane is proposed to stretch back to the SH6/Humphrey Street intersection
- Frankton Road – short bus lane provided to protect new bus stop between Yewlett Crescent and McBride Street, terminating prior to the proposed signals at the SH6A/McBride Street intersection

In terms of pedestrian (and cycle) movements, the original proposal was to grade-separate movements through the centre of the intersection. This is currently being reviewed in line with ensuring compatibility with future land use, but it should be noted that at-grade fully protected crossing facilities can also be provided across the signal stop lines with no impact on operational efficiency. Although such crossing facilities would require pedestrian movements to be undertaken in several stages, the low cycle time operating at the Guavabout results in a low level of wait times for pedestrians.

Table 1 below shows a summary of pedestrian delay (in seconds) for various movements around the Junction in the two scenarios where at-grade facilities are provided in both (in this case, the PM peak, but pedestrian delay is relatively similar across all time periods).

The results show that pedestrian delay in the Guavabout option is significantly lower across almost all movements – this is due to the simplistic nature of the operation, and the lower cycle time. In the conventional arrangement, movements over more than a single arm often require the crossing to be undertaken in several stages, resulting in delay at each hold point around the intersection. It should be noted that, depending on the wider route that a pedestrian is taking, the Guavabout option may result in longer walk distances (and therefore some additional travel time on a link), but these are generally lower than the signal delay savings at the crossing points. In addition, any grade-separated provision would operate with a zero second signal delay on any movements, albeit some extra link travel time (and distance) may be incurred for some movements.

Table 1: Pedestrian Delay (in seconds)

From	To	PM Peak		
		Signals	Guavabout	Difference
North-East	North-West	56	10*	-46
	South-East	120	97	-33
	South-West	176	104	-72
North-West	North-East	56	10*	-46
	South-East	70	87	+17
	South-West	126	95	-31
South-West	North-East	188	111	-77
	North-West	142	101	-41
	South-East	103	101	-2
South-East	North-East	176	104	-72
	North-West	130	94	-36
	South-West	155	83	-72

* In Guavabout option, crossings across the north leg are uncontrolled against low volumes of traffic, so pedestrian delay is expected to be minimal

In terms of wider network operation, as the Guavabout only allocates single lanes to all movements to/from the Frankton Road and Frankton-Ladies Mile Highway approaches, lane number consistency is managed against both the existing and future proposed road network. Therefore, merging of vehicles upon intersection exit (from 2-lane to single lane, say) is not encountered in this arrangement, which removes pinch points from the network, and maintains a more consistent level of vehicle capacity through the network

Conventional Signalised Intersection Option

As an alternative to the Guavabout, an updated conventional signalised intersection arrangement was also devised, the general arrangement of which is shown in Figure 4.

Figure 5 shows the intended operational philosophy and resultant signal timings at the intersection). Modelling has been undertaken at a (maximum) 120 second cycle time – although increasing the cycle time would provide a small improvement in overall capacity, pedestrian wait times are considered to be too long above the 120 seconds used (for an increasingly urban location). Operation at lower cycle times resulted in very poor operation of the intersection (due to lack of capacity) – which could only be overcome by providing additional lanes for most movements, which required further land take at the intersection itself (and required additional lanes being

added throughout the network so as to be consistent with the capacity provided at this intersection).

In order to provide sufficient capacity for traffic, several movements are allocated to 2-lanes which results in a high number of lanes on three of the four approaches. Two additional changes have been included (in the modelling) that differ from Figure 4:

- The left-turn from Frankton Road is added as a short fifth approach lane, with a triangular island provided to separate this movement from the adjacent movement (similar to the Kawarau Road approach). This allows a bit more flexibility in operation, and slightly reduces the pedestrian crossing distance on the west side of the intersection
- The crossing on the east side of the intersection has been removed, so as to improve the operational level (principally for the eastbound ahead movement from Frankton Road) however removal of the crossing doesn't meet current Safe System requirements

For the conventional intersection under the Safe System approach ramps have been included to reduce the speed to 30km/h through the intersection for pedestrian safety. This reduces the capacity of the conventional intersection further, whereas the Guavabou is already operating at this speed due to being a roundabout. The intersection options have been modelled on this basis.

As also shown in Figure 4, an egress into Gray Street and the Frankton shopping area is provided from Kawarau Road for northbound movements only. Access from the southbound direction was tested in the modelling, but is not possible due to the short distance between the two intersections. However, this results in the provision of a direct and straight across pedestrian crossing being able to be provided on the south side of the Kawarau Road/Gray Street intersection.

Access onto Kawarau Road has not been provided from Gray Street which therefore reduces the options for traffic exiting this link (and local shops). However, the signalisation of the SH6A/McBride Street intersection (also shown in Figure 4) provides safe and direct egress onto SH6A. A left turn into McBride Street at this location is provided to allow vehicles from the east to access the area. It is possible that egress from Gray Street could be allowed (as a left turn only, to head towards the main intersection) but this has not been tested in the latest operational assessments – and would make little difference to the overall operation of the network.

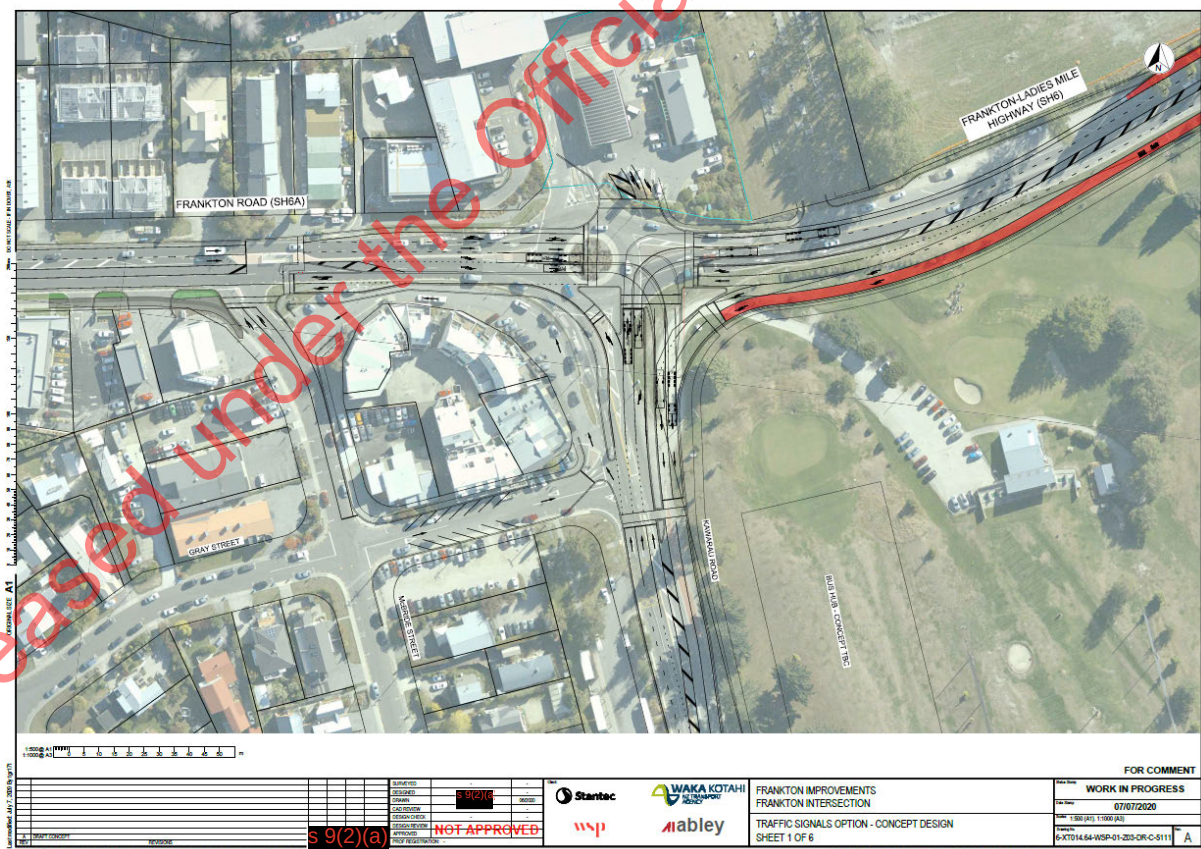


Figure 4: Conventional Signalised Intersection Option

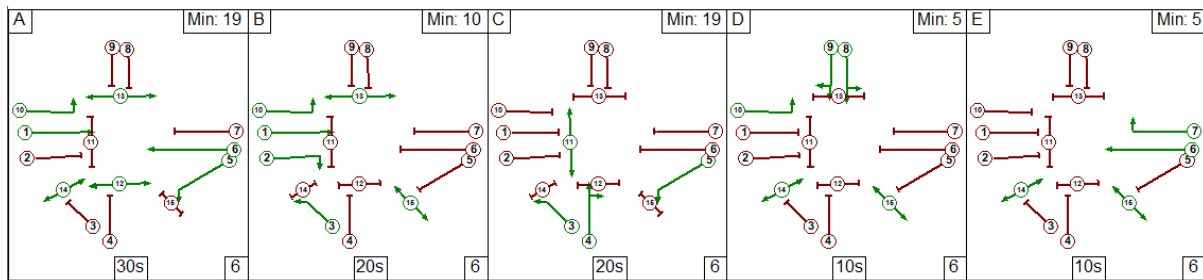


Figure 5: Conventional Signal Intersection Phase Arrangement (green periods are shown in the centre-bottom of each phase, related to a 120 second cycle time) – Interpeak period, but similar for AM and PM peak

Bus lanes would be provided in a similar manner to the Guavabout option (see previous section).

In terms of pedestrian (and cycle) movements, fully-protected at-grade pedestrian crossings are provided across three of the four arms (no crossing provided on the east side as above), albeit some movements require the crossing in 2 or 3 stages, due to the splitter islands provided in the layout. The full crossing at Gray Street across Kawarau Road provides good connectivity between the two sides of the road, between Frankton Village Shops and the potential bus hub location (and other related future land use on the east side of Kawarau Road)

In terms of wider network operation, single lane allocations are provided for movements towards SH6A so as to be consistent with downstream constraints. For movements heading east, double lanes are allocated to movements towards Frankton-Ladies Mile Highway. This therefore requires either:

- A merge to a single lane prior to Joe O'Connell Drive (safety issue)
- Extending the two-lane section through to Grant Road (and beyond) for a consistent 2-lane section (plus extra bus lane) – additional expense, property and land impacts

This issue is expanded upon in the next section. Notwithstanding the above commentary on the likely operational characteristics on the conventional intersection arrangement, Figure 5 shows a summary of remaining issues with the layout of this option.

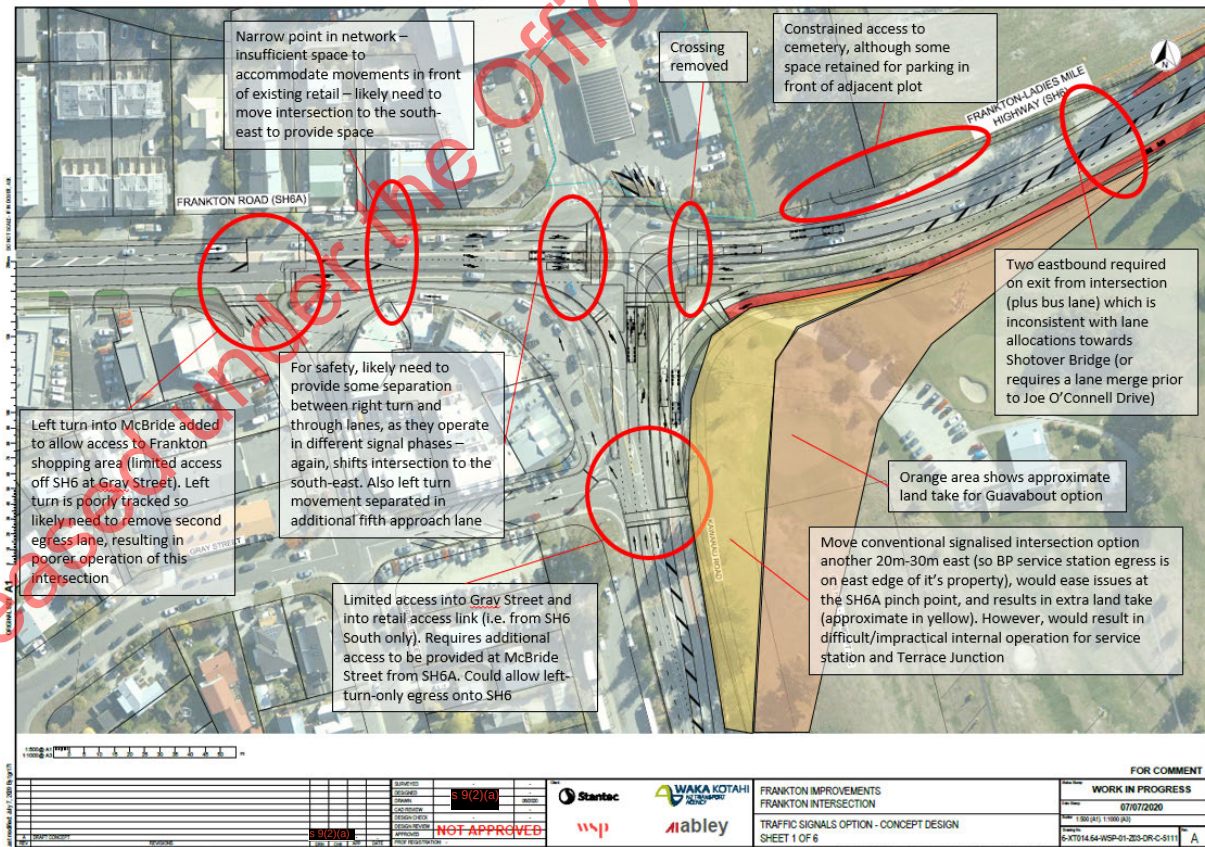


Figure 6: Conventional Signalised Arrangement - Layout Issues

Wider Network Operation

The choice of option for the main SH6/SH6A Junction has some key interdependencies with the adjacent links, and the future operation of the wider network. Whilst this is complex set of interactions, there are three main operational constraints.

SH6A Frankton Road

Due to difficulties in providing physical PT infrastructure along SH6A, and the need to signalise a number of intersections along Frankton Road for road safety and access, the concept is to actively manage the volumes of traffic entering SH6A from the east (i.e. at the SH6/SH6A Junction) so as to ensure a certain level of performance of the corridor, particularly for public transport services. Therefore, the exit from the Junction into SH6A is reduced to a single lane (from an existing two-lane facility, which merges to a single lane before Yewlett Crescent) in both Options, which means that bus lanes on the approaches to the Junction are critical in ensuring buses can bypass any queues of general traffic.

SH6 Kawarau Road

It is intended to provide two general traffic lanes in each direction in the southbound direction, from the Junction to the Lucas Place intersection. In the northbound direction, two general traffic lanes are provided from the bus hub intersection through to the Junction, with a northbound bus lane provided back from the Humphrey Street intersection (just north of Kawarau Falls Bridge) through to the bus hub intersection, and then north up a point approaching the main Junction. In this way, northbound services are protected from any general traffic delays.

SH6 Frankton-Ladies Mile Highway

The key interaction of the Junction is with the eastern leg through to Shotover Bridge. In the current Guavabout proposal, a single general traffic through lane would be provided in each direction along this section, plus an additional bus lane in each direction (and other shorter sections of left turn and right turn lanes). In this way, a consistent lane allocation is provided, which avoids the issue of merging and lane drops at points across the corridor (which is present in the existing situation). In order to provide sufficient capacity and network control along this corridor with a single general traffic lane, the following other intersection upgrades are proposed:

- SH6/Joe O'Connell Drive – converted to 3-arm conventional signalised intersection
- SH6/Hansen Road – access from Hansen Road to SH6 is closed at the above intersection, and a new 3-arm conventional signalised intersection is provided around 100-150m east of the Joe O'Connell Drive intersection (is dependent on land use changes on the north side of SH6 in this vicinity)
- SH6/Grant Road – existing roundabout converted to signalised roundabout operation. Layout is largely as existing, except for some widening to accommodate bus lanes and extra turn lanes
- SH6/Hawthorne Drive – existing roundabout converted to signalised roundabout operation. Layout is largely as existing, except for some widening to accommodate bus lanes and extra turn lanes. Future fourth leg on the north side is accommodated within the layout, to operate as an uncontrolled access to the intersection

Alternative options are possible for the above intersections, in the form of more conventional signalised intersections at Grant Road and Hawthorne Drive. Whilst these can provide better pedestrian crossing provision at the intersections themselves (rather than underpasses across SH6 in the roundabout options), they also require additional widening of the whole corridor to provide an additional through general traffic lane in both directions, due to the comparative lack of capacity at such intersection compared to a signalised roundabout layout. This then leads to safety issues in the eastbound direction of retaining the existing eastbound two-to-one-lane merge towards Shotover Bridge (adjacent to Hardware Lane), with the additional issue of merging the eastbound bus lane into the single traffic lane heading towards the bridge (effectively a three-to-one-lane merge).

Consequently, as the Conventional Signalised Intersection option requires a two-lane eastbound exit from the Junction, it is more difficult for this arrangement to tie into a single eastbound general traffic lane without a merge prior to the Joe O'Connell intersection (or beyond), or a wider carriageway widening programme throughout this section of the corridor to support a longer-term programme of lane use changes and urban development.

The proposed layout and operation of this section of SH6 (SH6/SH6A to Shotover Bridge) is set out in more detail in a separate Technical Note (currently in preparation).

Traffic Modelling

Traffic modelling has been undertaken on both layouts, 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 both 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. Figure 7 shows the extents of the S-Paramics model – this is important, as any queues of vehicles that extend beyond the end of the links within the model are recorded as unreleased vehicles (and in reality, would add to the end of the link). In terms of the Frankton side of the model, the geographical edges of the model are:

- Shotover Bridge
- Kawarau Falls Bridge
- Remarkables Park (Hawthorne Drive/Cherry Blossom Drive)

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

- Ratio of Flow to Capacity (RFC) of the main intersection – LinSig
- Travel times for buses – Paramics
- Travel times for general traffic – Paramics
- Unreleased vehicles (level of traffic unable to join the network at certain points due to congestion) – Paramics
- Visualisations (general indication of network performance and queue lengths) – Paramics

In terms of the Paramics model, each model in each time period has been run 5 times, with the results averaged over these 5 seeds.



Figure 7: Extents of S-Paramics Network

RFC

Table 2 sets out the RFC values for each movement at the main intersection (in each option) for each of the three modelled peak hour periods (0800-0900; 1200-1300; 1700-1800).

Table 2: RFC Assessment output

Approach	Movement	AM Peak		Interpeak		PM Peak	
		Signals	Guava	Signals	Guava	Signals	Guava
Frankton Road	Ahead + Left	49%	78%	65%	99%	58%	85%
	Right Turn	99%	43%	106%	47%	116%	49%
Terrace Junction/BP	All	87%	30%	98%	51%	92%	36%
Frankton-Ladies Mile Hwy	Left Turn	58%	47%	71%	51%	57%	44%
	Ahead	88%	92%	116%	97%	110%	107%
	Right Turn	78%		62%		109%	
Kawarau Road	Left Turn	85%	90%	99%	99%	98%	97%
	Ahead + Right	91%	72%	95%	69%	83%	63%

Several conclusions can be drawn from Table 2:

- More generally, the Interpeak and PM peak periods are more critical in terms of operation. The PM peak is currently (2020) the busiest period in Frankton from observations (and counts data) and this period is still expected to be busier than the existing situation even with a significant increase in PT mode share. In the Interpeak period, higher overall general traffic growth is expected (relative to the traditional commuter peak periods) due to the lower PT share predicted in this period
- In the AM period, both options are predicted to operate satisfactorily, albeit close to capacity on a number of turns
- In the Interpeak period and PM periods, similar trends are predicted:
 - The Frankton Road approach is predicted to operate significantly better in the Guavabout option – this is critical in terms of ensuring buses experience as little delay as possible on SH6A eastbound
 - The Terrace Junction approach is also expected to operate significantly better in the Guavabout option, with a good level of spare capacity. In the conventional option, operation of this approach is at/close to capacity, which suggests queues are likely to stretch back into the BP forecourt (additional green time could be provided, but this would be at the expense of other movements)
 - The Frankton-Ladies Mile Highway approach is predicted to operate significantly better in the Guavabout option in the Interpeak period, with a marginally better operation predicted in the PM period
 - The Kawarau Road approach is predicted to operate with a similar level of operation predicted in both Interpeak and PM peak periods

In summary, overall the south approach has a similar level of service in both options – however, Frankton Road and the local access on the north side of the intersection operate with a much-improved Level of Service in the Guavabout option, in all three modelled periods. Frankton-Ladies Mile Highway also sees significantly better operation in the critical Interpeak period (when total traffic volumes are at the highest).

This finding suggests that the Guavabout option is measurably better at accommodating the forecast traffic volumes, particularly in the most stressed case of the Interpeak period (which can also be used as a proxy for other high percentile demand events such as the peak days in Summer and Winter). The Conventional Intersection option provides a lower level of service to traffic, and therefore is unable to accommodate these critical peak demands – which would result in significant delay to general traffic across the network (as is discussed in the subsequent Paramics results). Additionally, the poorer performance of this option would also result in public transport lanes being

less effective than in the Guavabout option, as queues of general traffic are likely to stretch back beyond the extents of the currently proposed bus lane sections.

Travel Times for Buses

Table 3 sets out the travel times (in minutes) for eight longer-distance directional movements that pass through the intersection (in each option) for each of the three modelled peak hour periods (0800-0900; 1200-1300; 1700-1800). Green cells represent where the travel time in the Guavabout option is quicker.

Table 3: Travel Time Results for PT (journey time in minutes)

From	To	AM Peak			Interpeak			PM Peak		
		Guava	Conv	Diff	Guava	Conv	Diff	Guava	Conv	Diff
QTC PT Hub	Frankton PT Hub	20.5	20.5	0.0	21.9	28.7	6.7	20.3	22.1	1.8
Frankton PT Hub	QTC PT Hub	20.2	20.4	0.2	20.3	22.3	2.0	21.7	22.3	0.7
Kawarau Falls Bridge	Frankton PT Hub	5.2	5.3	0.1	6.2	6.2	0.0	5.1	5.5	0.5
Frankton PT Hub	Kawarau Falls Bridge	4.3	4.4	0.0	4.6	4.0	-0.5	3.5	3.7	0.2
Remarkables Park Town Centre	Frankton PT Hub	6.1	6.7	0.5	5.8	7.2	1.3	8.0	10.5	2.5
Frankton PT Hub	Remarkables Park Town Centre	3.9	4.0	0.0	3.8	4.0	0.3	3.9	5.5	1.6
Frankton PT Hub	Shotover Bridge	7.7	9.5	1.8	7.9	10.1	2.3	8.1	10.4	2.3
Shotover Bridge	Frankton PT Hub	8.2	8.1	-0.1	8.6	20.5	11.9	8.2	8.1	-0.1

Several conclusions can be drawn from Table 3, where green cells represent the travel time in the Guavabout option being quicker:

- In the AM period, both options provide similar travel times
- In the Interpeak period, there are some key differences between the options:
 - The eastbound journey along SH6A is predicted to be over 6 minutes quicker in the Guavabout option, with a similar travel time to the less congested AM peak period. This suggests that significant delay is experienced on the SH6A approach in the conventional intersection option
 - The westbound journey from Shotover Bridge to Frankton hub is predicted to be 12 minutes quicker in the Guavabout option, again with a similar travel time to the less congested AM peak period. This suggests that significant delay is experienced on the Frankton-Ladies Mile approach in the conventional intersection option, with queues extending way beyond the extent of the proposed westbound bus lanes approaching the SH6/SH6A Junction. However, it is noted that the model ends at Shotover Bridge, and therefore the impact of bus lanes further back on Ladies Mile (and potential gating of traffic at a point east of the bridge) is not included here which may close the deficit. However, it is likely that the delays experienced by general traffic would be significant (see later section)
- In the PM periods, although delay improvements are more modest compared to the Interpeak period, almost all journeys have a lower travel time in the Guavabout option, of up to 3 minutes

In summary, there are significant bus travel time differences between the two options, with the Guavabout option providing a better level of service across almost all journeys and time periods. This is particularly key to eastbound bus movements along SH6A where bus priority lanes are much more difficult (physically and cost-wise) – so it is critical that the SH6A approach to the Junction has sufficient capacity to accommodate the forecast total traffic demand, so that buses do not get caught in any subsequent queues.

Travel Times for General Traffic

Table 4 sets out the travel times (in minutes) for eight longer-distance directional movements that pass through the intersection (in each option) for each of the three modelled peak hour periods (0800-0900; 1200-1300; 1700-1800). Green cells represent where the travel time in the Guavabout option is quicker.

Table 4: Travel Time Results for General Traffic (journey time in minutes)

From	To	AM Peak			Interpeak			PM Peak		
		Guava	Conv	Diff	Guava	Conv	Diff	Guava	Conv	Diff
Stanley/Shotover	SH6/SH6A	8.7	8.4	-0.3	10.2	15.2	5.0	8.9	9.4	0.5
SH6/SH6A	Stanley/Shotover	8.9	8.4	-0.5	9.6	9.0	-0.7	9.7	9.8	0.0
Kawarau Falls Bridge	SH6/SH6A	2.9	4.7	1.9	3.4	7.1	3.7	5.6	7.9	2.3
SH6/SH6A	Kawarau Falls Bridge	3.6	3.7	0.0	4.4	4.3	-0.1	3.0	3.2	0.2
Remarkables Park Town Centre	SH6/SH6A	4.2	6.5	2.3	4.7	8.9	4.2	7.9	11.6	3.7
SH6/SH6A	Remarkables Park Town Centre	3.8	3.9	0.1	3.9	3.9	0.0	4.6	5.3	0.8
SH6/SH6A	Shotover Bridge	4.3	4.4	0.1	4.5	4.6	0.1	5.0	4.8	-0.2
Shotover Bridge	SH6/SH6A	5.5	6.2	0.7	10.4	25.7	15.3	7.8	8.8	1.1

Several conclusions can be drawn from Table 4 where green cells represent the travel time in the Guavabout option being quicker:

- In the AM period, both options provide similar travel times, although trips towards SH6/SH6A from the south are around 2 minutes quicker in the Guavabout option
- In the Interpeak period, there are some key differences between the options:
 - The eastbound journey along SH6A is predicted to be over 5 minutes quicker in the Guavabout option, a similar result to the equivalent PT journey. This suggests that significant delay is experienced on the SH6A approach in the conventional intersection option
 - The westbound journey from Shotover Bridge to Frankton hub is predicted to be 15 minutes quicker in the Guavabout option, albeit this journey is also 5 minutes longer in the Guavabout option when comparing to the AM peak (which shows the effectiveness of the bus lanes on this section, as the equivalent bus travel time between periods was almost identical in Table 3). As in the previous section, this shows significant stress in the network on this approach in the Interpeak period under the conventional option
 - Northbound journeys towards SH6/SH6A are also quicker in the Guavabout option
- In the PM periods, although delay improvements are more modest compared to the Interpeak period, almost all journeys have a lower travel time in the Guavabout option, of up to 3 minutes

In summary, there are significant general traffic travel time differences between the two options, with the Guavabout option providing a better level of service across almost all journeys heading towards the SH6/SH6A Junction for all time periods.

Unreleased Vehicles

An analysis of the level of unreleased vehicles in the network gives a good initial indication of where queues are extending to the edge of the model boundary (i.e. back to the start of coded links).

Table 5 shows the results of an analysis of the number of unreleased vehicles (in each option) at the end of the three modelled peak hour periods (0900; 1300; 1800). Green cells represent where the volume of unreleased vehicles in the Guavabout option is less.

Table 5: Levels of Unreleased Vehicles (in vehicles at end of simulated period)

Approach	AM Peak			Interpeak			PM Peak		
	Guava	Conv	Diff	Guava	Conv	Diff	Guava	Conv	Diff
Terrace Junction	0	5	5	0	25	25	0	2	2
McBride	0	0	0	0	2	2	0	17	17
Joe O'Connell	0	1	1	0	37	37	0	19	19
Grant Road	0	0	0	156	391	235	127	223	96
Hawthorne Drive (N)	0	0	0	0	12	12	115	189	74
SH6 East (@Stalker)	0	0	0	0	282	282	0	0	0
Remarkables Park	0	0	0	0	0	0	21	119	98
SH6 South (Kawarau Road)	0	0	0	0	0	0	0	12	12
Total	0	6	6	156	749	593	263	581	318

Several conclusions can be drawn from Table 5:

- In the AM peak, there is very little unreleased traffic, which shows that on the whole all demand can be accommodated in the models
- In the Interpeak, there are significant levels of unreleased vehicles, predominantly on the east approach to the SH6/SH6A Junction – with vehicles queueing off the end of both Grant Road (Frankton Flats internal zone) and SH6 (east) across Shotover Bridge. However, it is noted that levels of unreleased vehicles are **5 times** as high on these two approaches in the Conventional Intersection option, suggesting very poor operation on this section of the network – which aligns with the travel time results presented in the previous two sections.
- In the PM peak, there are also levels of unreleased traffic, albeit lower than in the Interpeak. In addition to queues on the east approach to the SH6/SH6A intersection, there are also some issues in the south of the network – this latter effect is less significant than on the east approach and is caused by queues stretching back to Lucas Place and beyond, which results in some re-assignment of traffic between Lucas Place and Humphrey Street as a northbound route for traffic exiting Remarkables Park and Hawthorne Drive. This in turn results in some unstable operation in this area of the model, as traffic bounces between these two routes – however, the model is generally more stable in the Guavabout option

In summary, the results show that queues of traffic are stretching back into internal and external zones within the Conventional Intersection option to a higher degree than the equivalent Guavabout option.

Visualisations

The following section sets out a few "screen-grabs" of the S-Paramics model of the two options within the critical Interpeak period.

Figure 8 shows a screenshot of the Guavabout Option at 13:00. The yellow circles represent "hotspots" in the model, which are generally where vehicles experience delay – either at intersections or within queues of unreleased vehicles at the start of links. Vehicles are shown as green blocks moving along the grey road links.

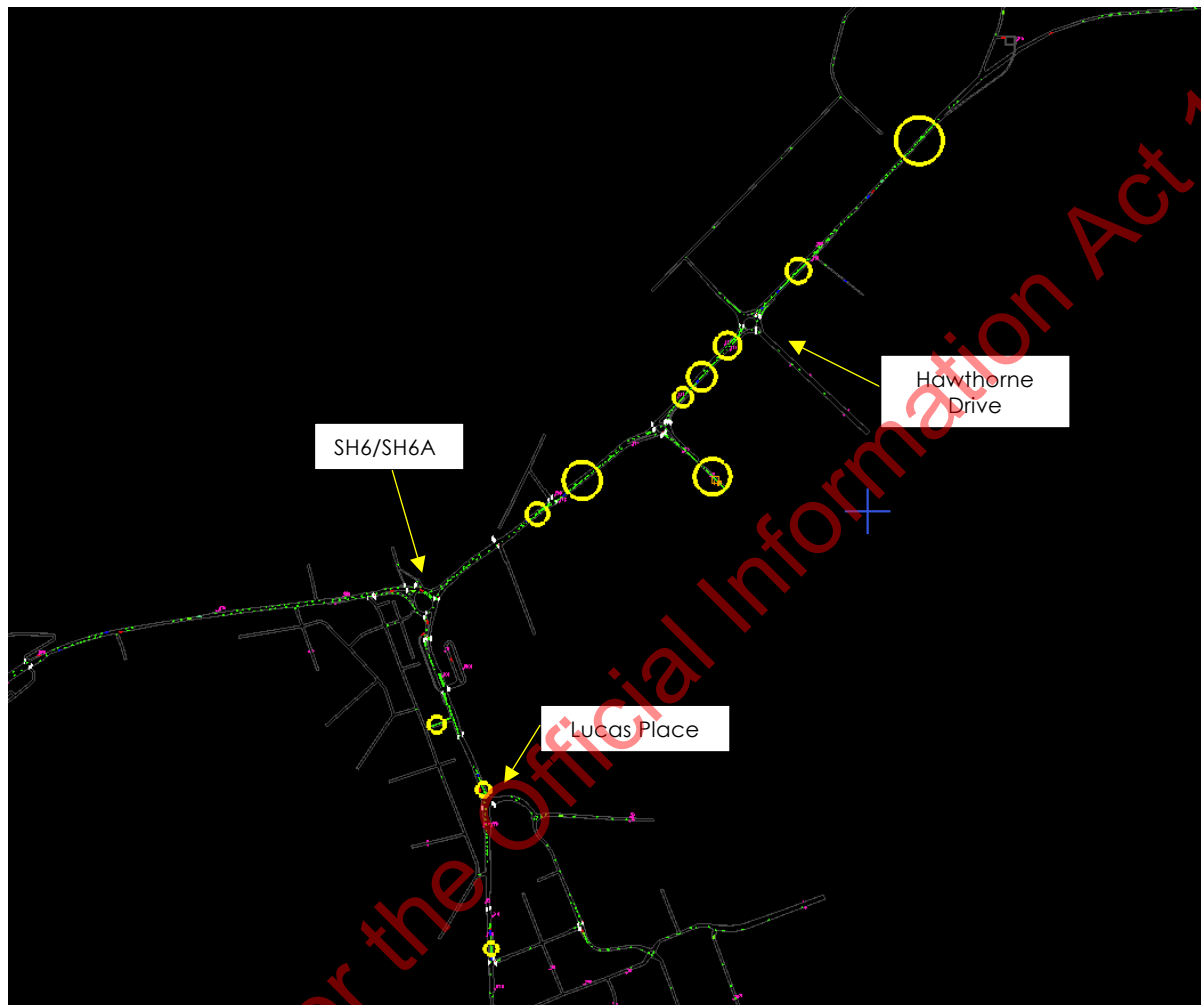


Figure 8: Interpeak operation of Guavabout option (typical at 13:00)

Figure 8 shows that in this critical Interpeak period (in terms of the highest demand set), operation is largely satisfactory except for some queues developing on the east approach (SH6 Frankton-Ladies Mile Highway), with some traffic unreleased on the Grant Road link (as per Table 5).

Figure 9 and Figure 10 shows screenshots of the Conventional Intersection Option at 13:00, west and east of SH6/SH6A respectively.

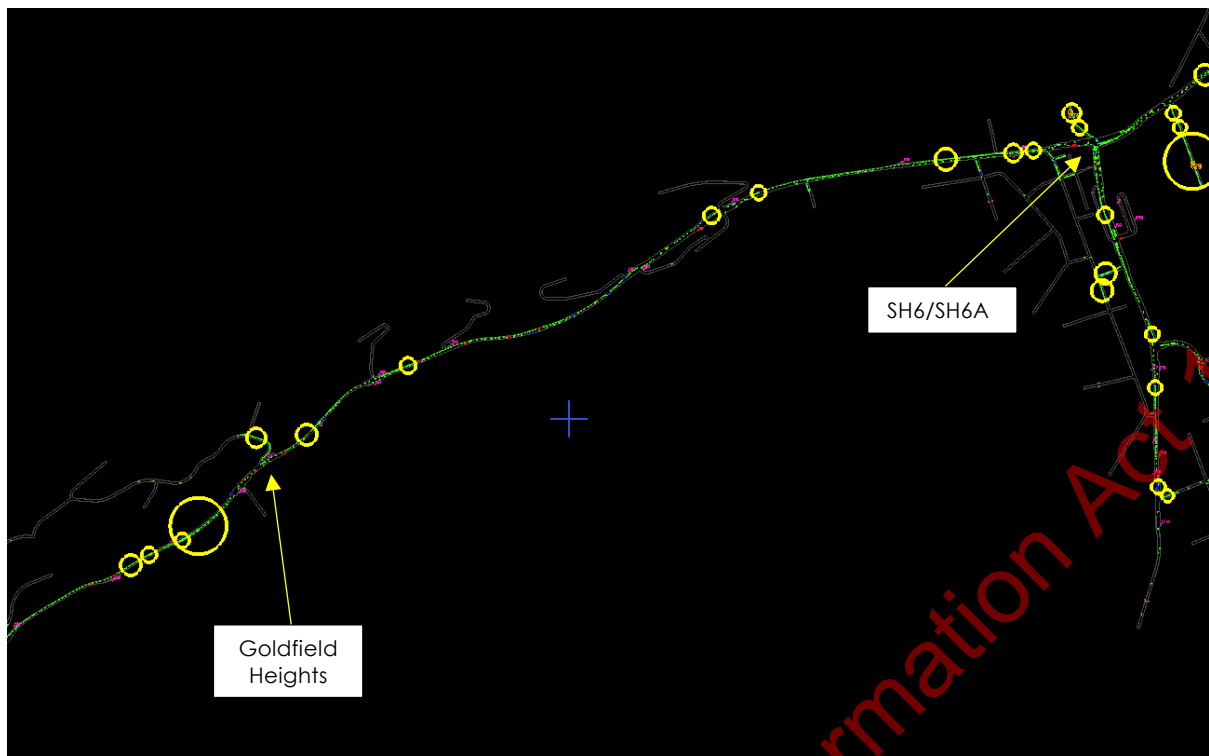


Figure 9: Interpeak operation of Conventional option (typical at 13:00) – west of SH6/SH6A

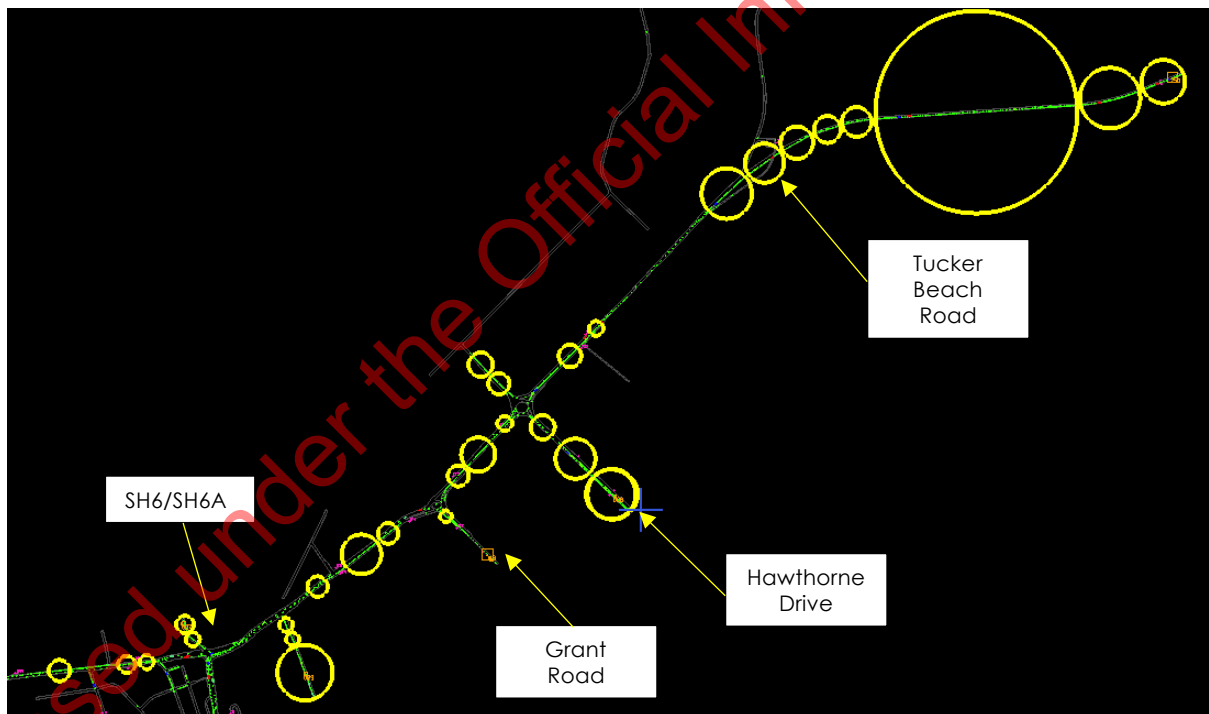


Figure 10: Interpeak operation of Conventional option (typical at 13:00) – east of SH6/SH6A

Figure 9 shows that significant delay is experienced on SH6A eastbound in the Interpeak – and it should be noted that the model ends at 13:00 with the queue lengths still growing (to around Hensman Road), and therefore it is expected that this would continue to beyond 13:30 (at least). This demonstrates why the eastbound travel times in the Conventional Intersection option are significantly greater than the Guavabout option, as set out in Table 3 and Table 4.

Figure 10 shows extended queues to the east of the SH6/SH6A intersection, in the westbound (inbound) direction, both on the external link over Shotover Bridge, and on links serving the internal Frankton Flats area. Again, these visual images align with the analytics shown in Table 3, Table 4 and Table 5.

Conclusions and Summary

This technical note has detailed an assessment of the operation of the SH6/SH6A Junction under two different design layout concepts, a signalised roundabout "Guavabout" and a conventional 4-arm signalised intersection.

The assessment has indicated the following:

- The Guavabout Option has a higher level of traffic capacity than the conventional signalised intersection option, due to more efficient use of green time (and spreading the conflict points out around the circulatory)
- The above results in improved performance for both general traffic and public transport services through the Junction in the Guavabout option, particularly in terms of travel times
- In addition, higher levels of queued traffic are predicted in the Conventional option, particularly on the SH6A, Frankton-Ladies Mile Highway and Terrace Junction legs of the Junction
 - In terms of the Terrace Junction leg, this is likely to affect internal operation of the petrol filling station
 - For SH6A, due to the difficulty in providing full priority lanes along this section of the corridor, it is of critical importance that the eastbound approach to the SH6/SH6A Junction operates satisfactorily to ensure buses do not get caught in any lengthy general traffic queues (which would have a subsequent impact on the likelihood of achieving the target mode shift onto public transport)
 - For Frankton-Ladies Mile Highway, although the westbound approach includes a proposal to provide bus lanes back from Hardware Lane, extensive queues on this approach are still likely to result in some additional bus delay in the Conventional option, as queues extend back beyond Hardware Lane (and also for the potential Frankton Orbital bus route which would be stuck in queues on the approach to SH6)
- Although pedestrian crossing desire lines are better served in the Conventional layout, due to the high cycle time and separation of most crossing movements into two or more stages, pedestrian delay is relatively high in this option – although the Guavabout was originally intended to incorporate grade-separated pedestrian and cycle movements, it can be adapted to provide at-grade facilities, either as a replacement or in addition to grade-separated provision. Such at-grade crossings actually operate significantly better than the Conventional alternative, in terms of delay at the crossing points
- The Guavabout requires more land take from the south-east corner of the site, although due to physical constraints on the SH6A arm in particular, the Conventional arrangement is also likely to require a significant portion of this land.

A separate multi criteria assessment of the two options has also been undertaken. This takes into account a broad range of criteria as agreed with the project stakeholders. We understand that there are some stakeholders who would prefer to see a conventional signalised intersection in this location. The consequences of this would be poorer levels of service for traffic and public transport users, greater land take across the corridor and higher implementation cost. A number of options exist to improve the operation of the signalised intersection, but all of these would come with significant disbenefits:

- Further widening of the SH6 Frankton-Ladies Mile cross section (to ensure compatibility with two lanes eastbound off the main Junction) would improve efficiency for general traffic and public transport but would increase overall cost and land take, reduce pedestrian level of service and reduce the attractiveness of the corridor for development;
- Widening of the SH6A approach to provide a longer dedicated bus lane would allow PT vehicles to bypass the congestion on the western approach to the conventional intersection. However, this would significantly increase overall cost, land take, property impacts and result in significant network disruption during construction;
- Removal of turn movements. For example, access to Terrace Junction/BP could be limited to improve the operation of the intersection. This would be met with significant community and commercial resistance; or
- Reduce land development and constrain growth in traffic across the Wakatipu Basin. Furthermore, harder forms of travel demand management, such as a congestion charge, could be implemented to reduce traffic volumes. There currently isn't the legislation in place to

implement a charge and reducing land development would go against the intent of the Frankton Masterplan and Spatial Plan.

In summary, it is the recommendation of the project team that the Guavabout option is the preferred option for the upgrade of the SH6/SH6A Junction.

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