Memorandum

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From	Chris Baker
Office	Auckland Civil
Date	13 Feburary 2017
File	
Subject	Otonga Road / Springfield Road Intersection Traffic Modelling

1. Introduction

Rotorua Lakes Council are proposing to improve pedestrian and cycling facilities at the existing roundabout at the intersection of Springfield Road and Otonga Road. Shared path connections are planned for construction on the southern and eastern approaches to the intersection but at present there are no formal pedestrian or cyclist crossing facilities between the two facilities at this intersection. This memo summarises the results of traffic modelling of the existing intersection and four intersection or pedestrian facility scenarios to assist in evaluating the effects on the operation of the intersection.

1.1. Existing Conditions

Otonga Road is defined as an Urban Collector road by Rotorua Lakes Council and runs roughly north to south, terminating at a cul-de-sac around 850m to the south and at a major roundabout joining State Highway 5, 850m to the north. Springfield Road is an Urban Secondary Arterial road running east to west, which links with State Highway 5 around 550m to the east of the intersection. The number 09 Springfield bus route passes north to south through the intersection, with a stop outside Otonga Primary School.

The intersection is located in an area of primarily residential development with a variety of pedestrian-generating land uses in close proximity to the intersection including:

- A row of shops on the north-western corner of the intersection;
- Otonga Road Primary School 250m to the south;
- Jackson Park and sports fields; and
- Southern Cross Hospital 300m to the north.

The intersection is currently a single lane circulating roundabout with four single lane approaches. Radii of the entries into the roundabout and the centre island are very small, resulting in low deflection and the possibility for vehicles to travel through the intersection at high speed, which is particularly dangerous for active mode users. The existing intersection layout is shown in Figure 1-1.

Figure 1-1 Springfield Road / Otonga Road Intersection

On average, the approach lanes are roughly 3.0m wide, with the northern approach flaring to roughly 7m, enabling two vehicles to store at the stop line. While the lanes themselves are relatively constrained, there is unused space within the intersection (wide exit lanes, traffic islands, parking manoeuvring space) and berms along the roadside that could be used to accommodate additional lanes.

On the northwest corner of the intersection are the Springfield local shops, which include a Superette and takeaway amongst others. There is uncontrolled marked angle parking on the northern side of Springfield Road outside the shops and parallel parking on the southern side of Springfield Road and the western side of Otonga Road.

There is a zebra crossing within 50m of the western approach stop line and within 250m of the southern approach stop line at Otonga Road Primary School. Both crossings have the equipment to operate as a school patrol. We understand the school also operates a number of walking school buses. A shared path is proposed for the western side of the southern approach and the southern side of the eastern approach, with no controlled crossing facility currently provided at the intersection.

1.2. Case for Improvement

Fundamentally, the intersection in its current form has safety issues resulting from high vehicle speeds in combination with large numbers of pedestrians and cyclists. This section examines the reasoning behind upgrading the intersection and identifies specific safety issues and requirements. To support the analysis and decision making, classified turning movement counts were undertaken on Thursday 24th November 2016 for vehicles, cyclists and pedestrians at the intersection and at the zebra crossing on Springfield Road West. The peak hours were identified as 8-9AM and 2:45-3:45PM.

1.2.1. Pedestrian Safety

As part of the traffic surveys, discussed in Section 1.4, the crossing paths and composition of pedestrians using the intersection was captured. This information is summarised in Figure 1-2 and illustrates how crossing behaviour at the intersection changes between peak periods.

The largest crossing demand currently exists on the western approach, likely caused by the shops and primary school on opposite sides of Springfield Road. Sixty pedestrians were observed crossing this leg in the AM peak period, including 31 unaccompanied children. Of note, the majority of the unaccompanied children crossed the western leg at the intersection, rather than at the zebra crossing 25m from the western approach, which was mainly used by adults. In the PM peak period, roughly 26 pedestrians were observed crossing between the parking zones and were likely accessing the row of shops on the northern side. Only one pedestrian was observed crossing at the zebra crossing. Roughly half of the pedestrians counted in the PM peak were unaccompanied children.

On the southern leg, the number of pedestrians observed increased from 4 in the AM peak to 24 in the PM peak. This was the second largest crossing demand at the intersection. Roughly 60% of those crossing on the southern leg in the PM peak did so approximately 30m from the intersection.

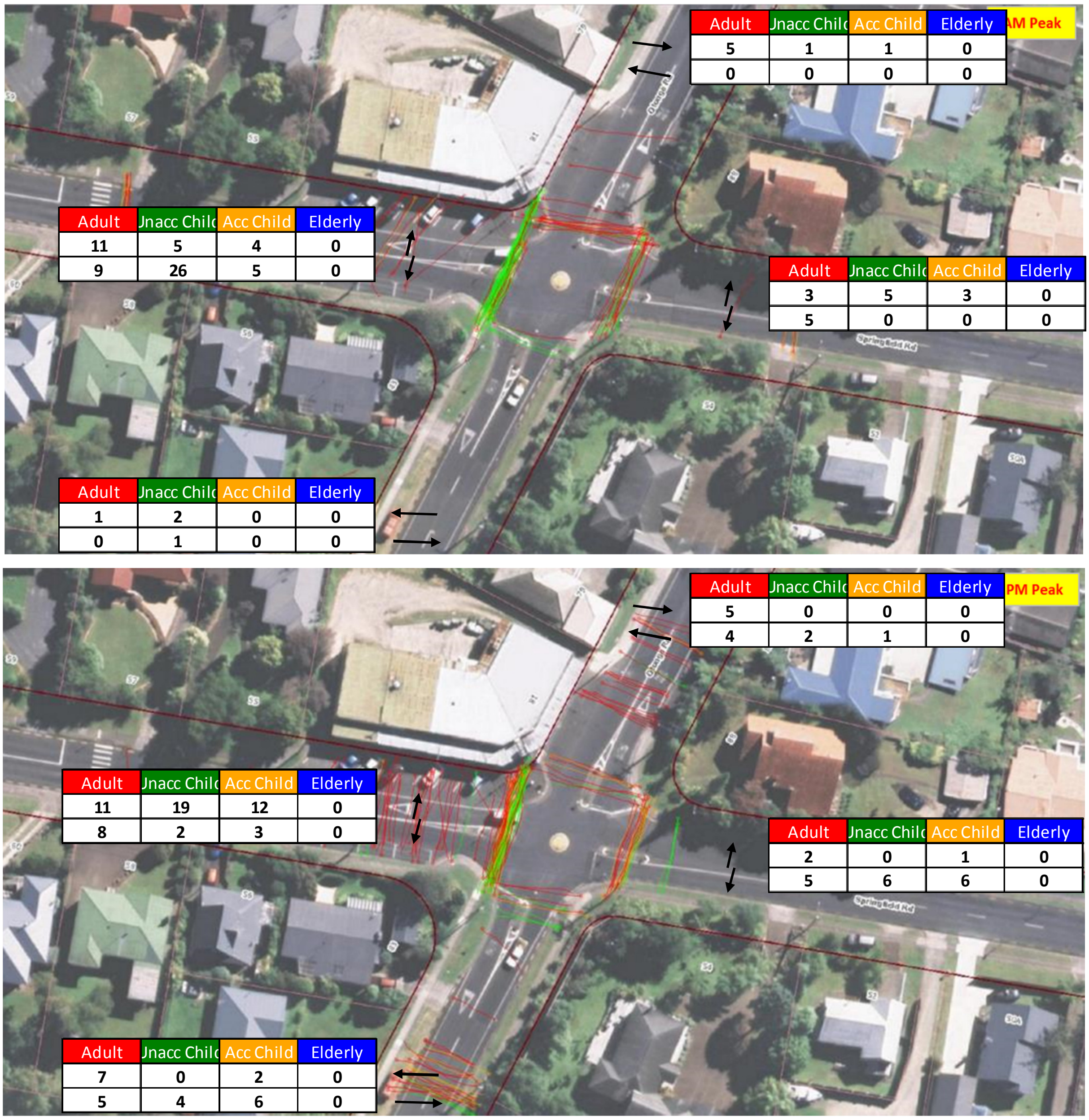


Figure 1-2 Pedestrian Crossing Summary - AM Peak Top, PM Peak Bottom (24th November 2016)

It is understood that the proposal to upgrade the intersection is primarily driven by the proposed shared path on the eastern and southern legs, and a desire to connect the two facilities.

There is a clear demand for crossing at the intersection on the western leg and in particular from unaccompanied children, while demand on other legs is comparatively low. Meanwhile, the existing zebra crossing to the west is underutilised. In addition to accommodating the intersection's major desire lines, an upgraded crossing facility on the western leg would be likely to encourage more pedestrians to cross at this location. With existing pedestrian volumes, signalised crossings on each approach are likely to be excessive and would unnecessarily delay traffic.

The southern approach has the largest vehicle demand throughout the day (617vph in the AM peak); on average, there are 5.8s between vehicles arriving. Assuming a walking speed of 1.4m/s, pedestrians will take roughly 10s to cross the approach and will therefore struggle to find sufficient gaps in the traffic. With an appropriate median refuge, pedestrians would be able to cross each lane in 5s while vehicles would arrive, on average, every 8.8s. This assumes that vehicles are travelling at constant speed, not accounting for vehicles slowing on the approach to the intersection and the potential for drivers to give way to pedestrians.

It should be noted that the existing pedestrian facilities at the intersection are ageing and below standard. There are no provisions for visually impaired users while the crossings and ramps are narrow and some are cracked.

1.2.2. Cyclist Safety

Cyclists' use of the intersection was also captured in the November surveys; a summary of the cyclist count is shown in Table 1-1.

There were 27 cyclists counted in the AM peak and 14 counted in the PM peak. Between 85% and 95% of the cyclists were children, with an even split between those using the footpath and those using the road. The majority of demand was shared between the southern and western approach.

Table 1-1 Cyclist Count at Otonga Road / Springfield Road Intersection (24th November 2016)

		AM			PM		
		Footpath	Road	Total	Footpath	Road	Total
Otonga Rd (North)	**Left**	0	1	1	0	1	1
	Through	2	0	2	2	2	4
	Right	0	0	0	1	1	2
Springfield Rd (East)	**Left**	0	0	0	0	0	0
	Through	0	0	0	0	0	0
	Right	0	0	0	0	0	0
Otonga Rd (South)	**Left**	2	2	4	3	0	3
	Through	3	3	6	1	2	3
	Right	0	2	2	0	0	0
Springfield Rd (West)	**Left**	3	2	5	0	0	0
	Through	1	2	3	0	1	1
	Right	1	3	4	0	0	0
Total		**12**	**15**	**27**	**7**	**7**	**14**

Roundabouts are typically poor for cyclist safety due to higher average vehicle speeds and more conflict points. The existing roundabout has narrow approach lanes but a wide circulating lane, potentially exposing cyclists to dangerous passing by vehicles. Demand for cycling is anticipated to increase with the addition of the proposed shared path. However, the proposal does not include a crossing to connect the eastern and western sides of Otonga Road.

1.3. Scenarios Tested

The scenario modelling was undertaken using SIDRA Intersection 7 software. The scenarios tested are described below.

1) Base (Existing Roundabout) (AM and PM peak periods)

Figure 1-3 shows the geometric parameters used for the base roundabout model of the existing intersection. The performance of each of the options tested was compared to this scenario. The existing roundabout has a diameter of 3.0m, less than the minimum value permitted by the modelling software. Therefore, the minimum permitted value of 4.0m was adopted. This had minimal effect on the results of the modelling.

Approach:	S	E	N	W
Number of Circ Lanes	1	1	1	1
Circulating Width	6.4 m	5.2 m	8.4 m	6.7 m
Island Diameter	4.0 m	4.0 m	4.0 m	4.0 m
Inscribed Diameter	Program	Program	Program	Program
Entry Radius	7.0 m	7.0 m	7.0 m	4.0 m
Entry Angle	26.0 °	25.0 °	24.0 °	12.0 °
Raindrop Design	☐	☐	☐	☐
Circulating Transition Line	☐	☐	☐	☐
Number of Downstream Circ Lanes	Program	Program	Program	Program

Figure 1-3 Base Roundabout Parameters

2) New Roundabout with Larger Radius (AM and PM)

Figure 1-4 shows the geometric parameters used in the model for this scenario, used to represent a concept roundabout design provided by Opus Rotorua for this project. A minimum permitted value of 5.0m was adopted for the circulating width, which is proposed to be 4.5m. The proposed roundabout is limited in size to a maximum diagonal width (including footpath) of 27.5m by existing road boundaries and the shops on the north-western corner.

Approach:	S	E	N	W
Number of Circ Lanes	1	1	1	1
Circulating Width	5.0 m	5.0 m	5.0 m	5.0 m
Island Diameter	7.0 m	7.0 m	7.0 m	7.0 m
Inscribed Diameter	Program	Program	Program	Program
Entry Radius	3.0 m	6.5 m	6.5 m	4.0 m
Entry Angle	30.0 °	30.0 °	30.0 °	20.0 °
Raindrop Design	☐	☐	☐	☐
Circulating Transition Line	☐	☐	☐	☐
Number of Downstream Circ Lanes	Program	Program	Program	Program

Figure 1-4 New Roundabout Scenario Parameters

3) New 1 Lane Approach Traffic Signals (AM and PM)

Signalised intersections with 1 lane approaches are typically inefficient because they require all movements on an approach to be released together or filtered right turns to be used. Both scenarios will usually cause delays as they require multiple signal phases or lead to right turning vehicles blocking the intersection as they wait for a gap in opposing traffic. This arrangement also creates problems with accommodating pedestrians as it is unsafe to allow crossing in conflict with a right turn.

Given the implications of one-lane signalised intersections described above, two one-lane signal phasing scenarios were tested as follows:

a. All movements per approach run at the same time (split phasing)
b. Filter right turns

Figure 1-5 provides an indicative layout for the one lane signals scenario.

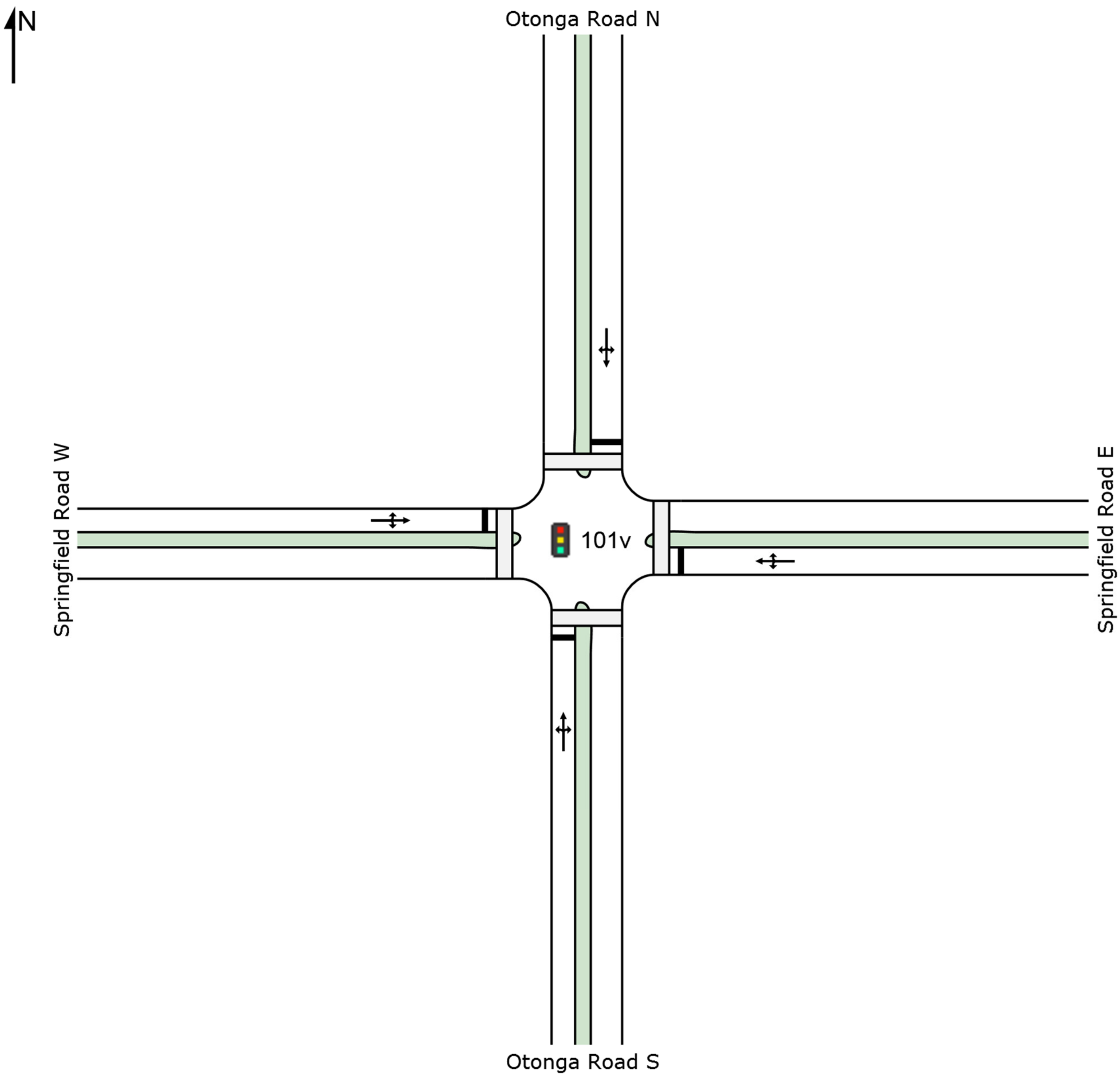


Figure 1-5 One Lane Signals Indicative Layout

For this assessment, all signal scenarios included pedestrian crossings on all approaches. In reality, given the existing demands, crossings would not be necessary on all approaches and the intersection may perform better than reported here.

A) Split Phasing

This scenario refers to signal phasing where all movements on each approach have a green signal concurrently. Pedestrian phases run on the approach to the left of the approach with a green signal, which means that left turning vehicles have to wait for crossing pedestrians to clear the approach. This would require a left turn arrow to be added to the signal head. The phasing is best explained diagrammatically, as shown in Figure 1-6.

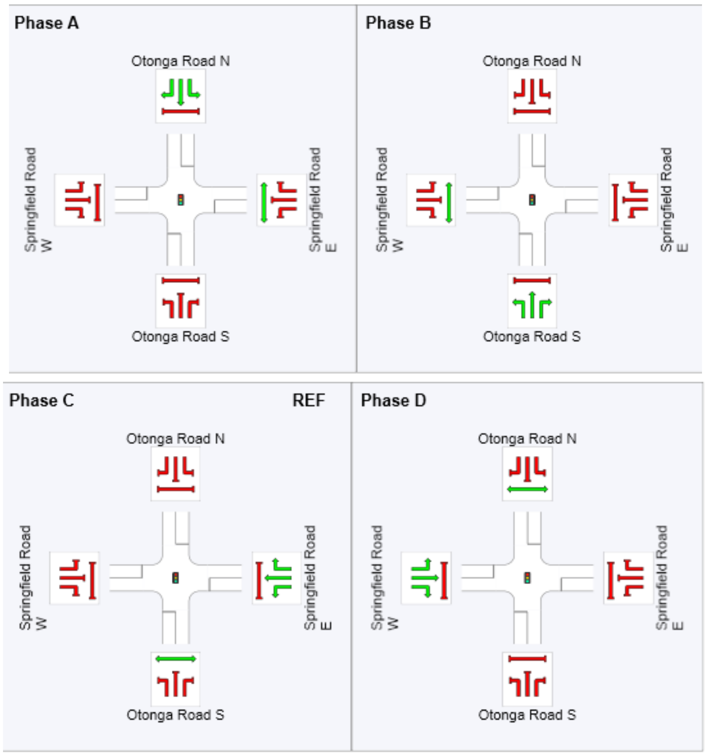


Figure 1-6 Split Phasing

B) Filter Right Turn Phasing

This phasing allows right turning vehicles to filter through gaps in opposing traffic and thus enables phases for 2 approaches to run simultaneously. The option is typically seen at low volume intersections where there are likely to be frequent gaps in the opposing traffic flow. If through volumes are high, right turning vehicles may not have opportunity to clear the intersection and may block through and left turning vehicles for a full phase. A dedicated pedestrian phase would be required as right turns and pedestrians should not run in the same phase for safety reasons. The phasing is shown in Figure 1-7.

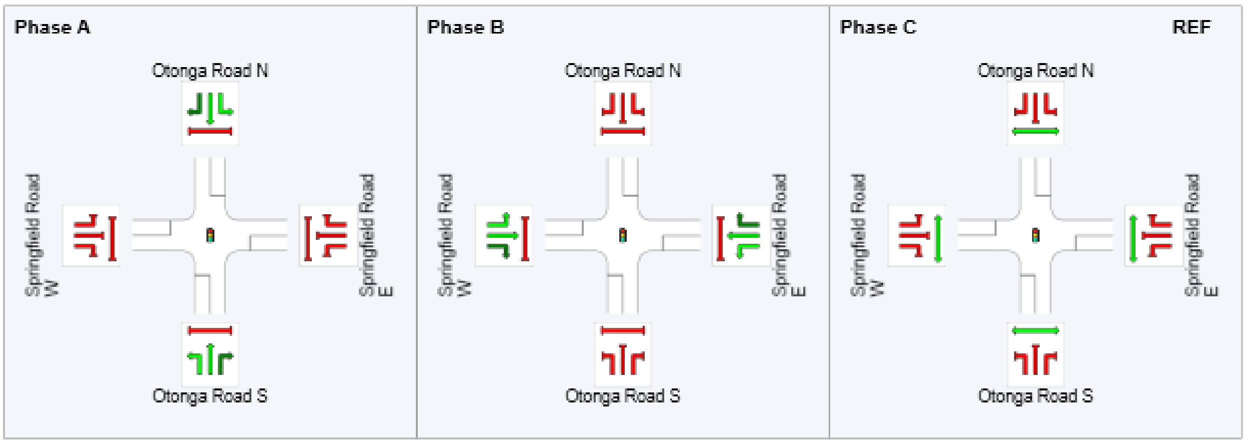


Figure 1-7 Filter Right Turn Phasing

4) New 1 Lane Plus Right Turn Bay Signals (AM and PM)

This scenario was modelled using the same phasing as the one lane filter right turn (Figure 1-7) to allow comparison of the relative benefits. The layout allows space for right turning vehicles to store while allowing through and left turning traffic to pass. An indicative layout for this scenario is shown in Figure 1-8.

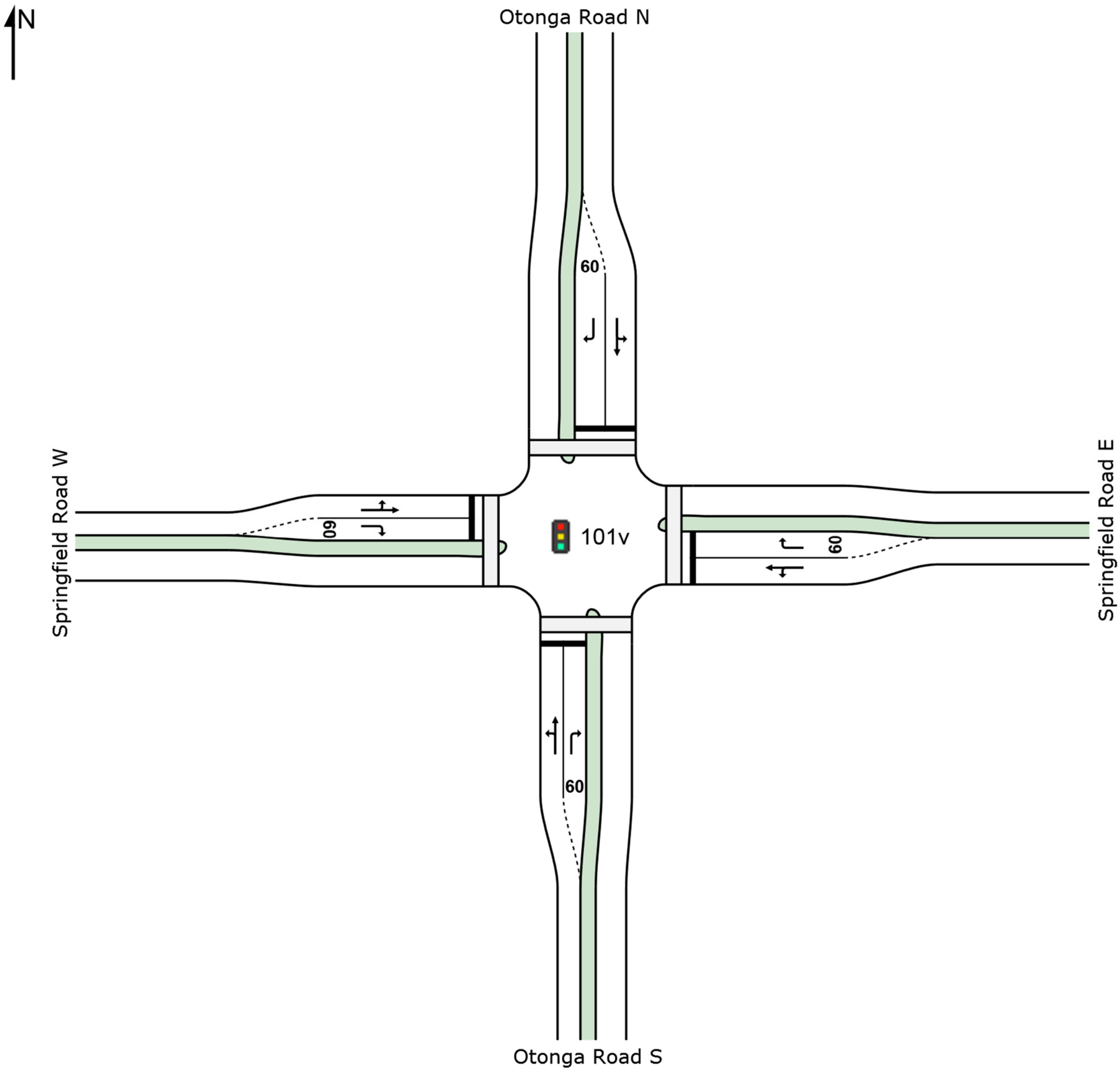


Figure 1-8 One Lane Plus Right Turn Bays Signals Indicative Layout

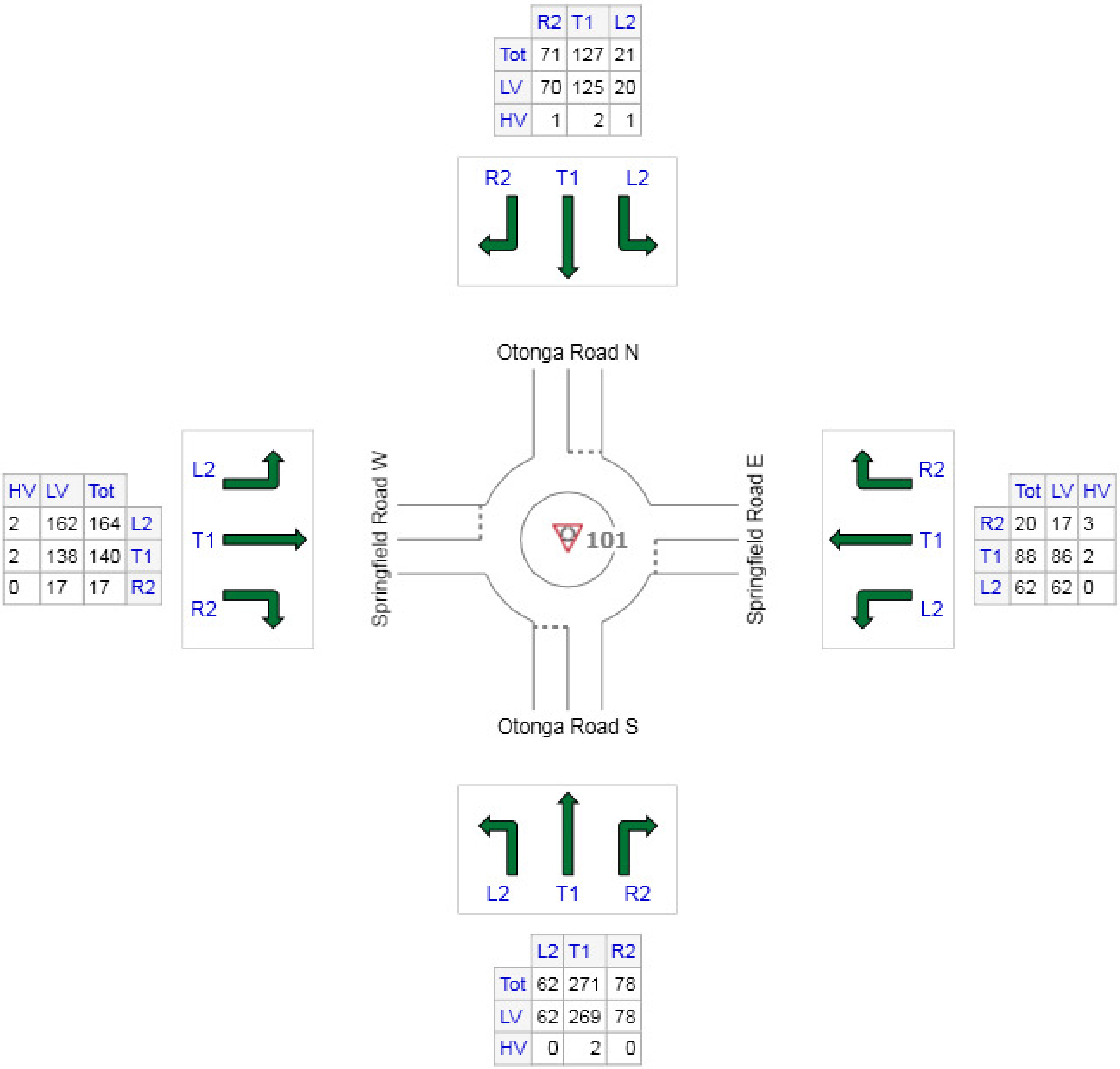
5) Signalised Pedestrian Crossing on the Southern Leg (AM and PM)

This scenario tested the effect of adding a signalised crossing to the southern leg of the existing roundabout. It is assumed that all traffic counted on the southern leg of the intersection during the surveys would pass through the crossing. This scenario was tested as an alternative way of providing a crossing facility without signalising the entire intersection.

1.4. Data Used

Classified turning movement counts were undertaken on Thursday 24th November 2016 for vehicles, cyclists and pedestrians at the intersection and at the zebra crossing on Springfield Road West. Queue lengths were also measured for use in calibrating the SIDRA models. The surveys were undertaken between 07:30 and 09:15 in the morning and 14:30 and 17:15 in the afternoon. The site's AM peak hour was found to be between 08:00 and 09:00 while the PM peak hour was found to be between 14:45 and 15:45.

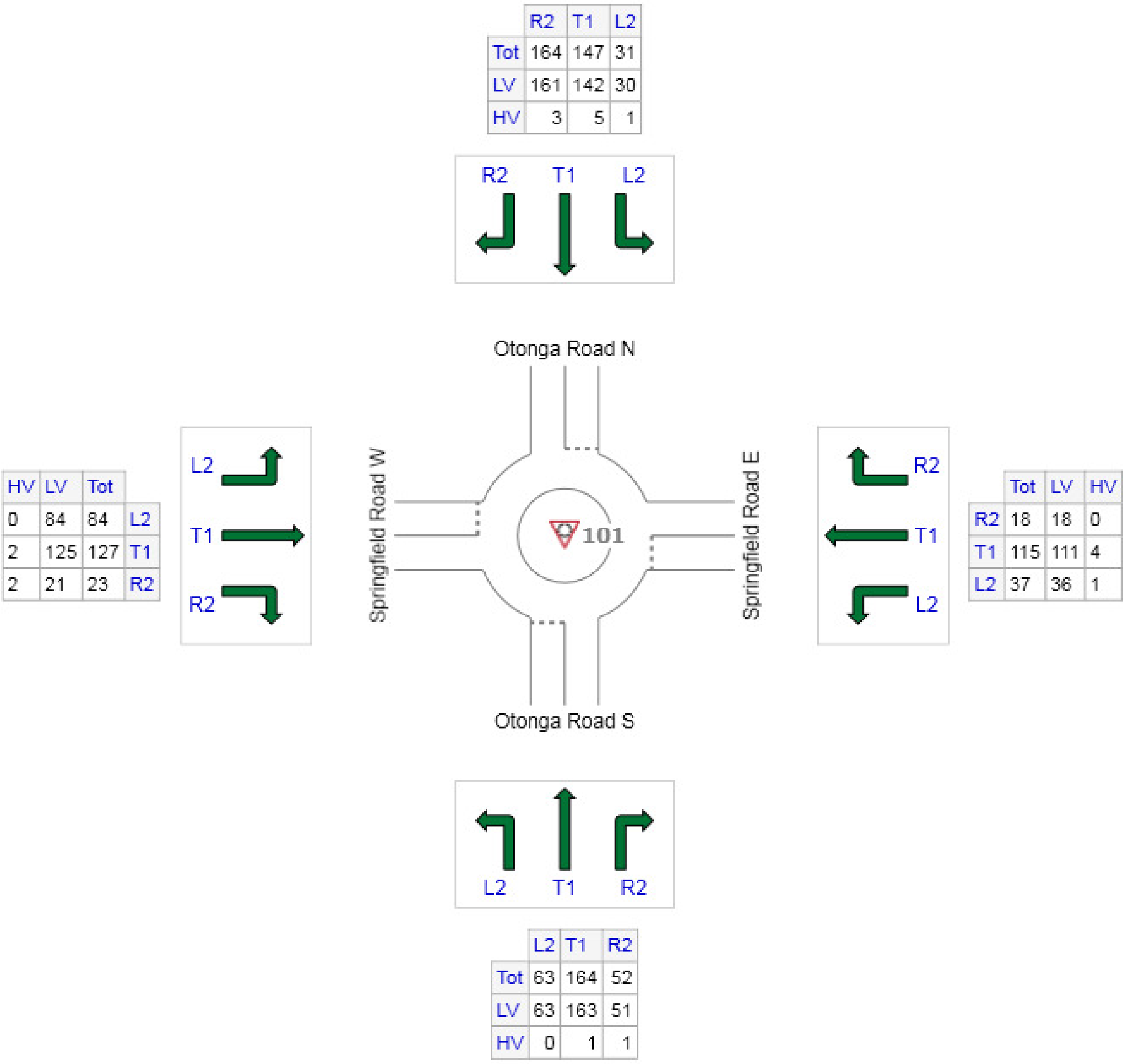
During the AM peak hour, the total traffic volume through the intersection is relatively low (1,121 vehicles per hour). Roughly two thirds of total vehicle demand is from the southern and western approaches, which are also the legs with the highest pedestrian demand. There is a high left turning demand from the western approach (164 vph). Pedestrians crossing the northern leg are at risk of being obscured from the vision of the left turning vehicles by parked vehicles, a kerb buildout and a post box on the corner. Figure 1-9 summarises the observed AM peak hour turning movements.



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Otonga Road S	411	409	2
E: Springfield Road E	170	165	5
N: Otonga Road N	219	215	4
W: Springfield Road W	321	317	4
Total	1121	1106	15

Figure 1-9 AM Peak Hour Traffic Volumes Summary for Otonga Road / Springfield Road Intersection (24th November 2016)

Traffic volumes through the intersection are slightly lower during the PM peak hour than during the AM peak hour. There is a large demand for the right turn from the northern approach, which may affect the operation of the roundabout as two approaches have to give way to this movement. Figure 1-9 summarises the observed PM peak hour volumes.



	All MCs	Light Vehicles (LV)	Heavy Vehicles (HV)
S: Otonga Road S	279	277	2
E: Springfield Road E	170	165	5
N: Otonga Road N	342	333	9
W: Springfield Road W	234	230	4
Total	1025	1005	20

Figure 1-10 PM Peak Hour Traffic Volumes Summary for Otonga Road / Springfield Road Intersection (24th November 2016)

2. Modelling Results

This section provides results for each scenario tested. Results provided here include a Level of Service (LOS) measure, which ranges from A to F. The Level of Service is linked to the amount of delay experienced by vehicles at the intersection in question. Generally, LOS A refers to average delay of less than 10 seconds per vehicle, while LOS F refers to average delay in excess of 80 seconds per vehicle.

2.1. Base Scenario (1) – existing roundabout

From an operational perspective, the roundabout performs well at LOS A with low delays and queue lengths. Modelling cannot give an indication to the performance of pedestrian facilities at the intersection as there are no controlled crossings.

Table 2-1 provides a summary of the modelling for the base scenario. These results should be used as reference for the results from other scenarios. Roundabout geometry is provided in Section 1.3.

Table 2-1 Base Scenario Modelling Results Summary

	AM Peak			PM Peak		
Approach	**95%ile Queue (m)**	**Average Delay (s/veh)**	**Level of Service**	**95%ile Queue (m)**	**Average Delay (s/veh)**	**Level of Service**
Otonga Road South	37	8	A	59	13	B
Springfield Road East	13	8	A	14	9	A
Otonga Road North	11	7	A	20	7	A
Springfield Road West	68	19	B	28	10	A

2.2. New Roundabout with Larger Radius (2)

Only a small change to roundabout geometric parameters is possible given the constrained site and limited amount of road corridor space feasibly available to change the roundabout diameter, circulating width and approach entry angles. The performance of the larger radius roundabout is therefore similar to the base scenario, with a slight reduction in LOS on the southern and western approaches and an increase in delays and queue lengths due to slower entry speeds.

Benefits of altering the geometry of the roundabout, such as safety and pedestrian connectivity, are not provided by the model. However, decreasing the average speed of vehicles using the intersection by changes to entry angles could affect the likelihood and severity of crashes. Changes to the kerb line would also present the opportunity to provide wider pedestrian facilities.

Table 2-2 provides a summary of the modelling for this scenario. The new roundabout geometry is provided in Section 1.3.

Table 2-2 New Roundabout Modelling Results Summary

	AM Peak			PM Peak		
Approach	**95%ile Queue (m)**	**Average Delay (s/veh)**	**Level of Service**	**95%ile Queue (m)**	**Average Delay (s/veh)**	**Level of Service**
Otonga Road South	66	13	B	120	29	C
Springfield Road East	13	7	A	14	9	A
Otonga Road North	12	7	A	22	8	A
Springfield Road West	77	22	C	40	14	B

2.3. New 1 Lane Approach Signals (3)

Modelling results for the two single lane signal phasing options discussed in Section 1.3 are presented here. An indicative layout for the intersection is also provided in Section 1.3.

2.3.1. Split Phasing (3A)

Adopting signals with split phasing and one-lane approaches would cause most approaches to operate at Level of Service F for both AM and PM peak hours. Average delays would be in excess of 1 minute per vehicle and queues would extend up to 295m from the intersection. All performance measures would be significantly worse than the existing roundabout. Due to pedestrians being stopped until their signal phase, pedestrian delay would also increase significantly from the base scenario. Where perceived delay is high, pedestrians may cross against the signals, creating a potential safety issue. Using this phasing would also require left turning vehicles to give way to pedestrians clearing the adjacent crossing, which would block through and right turning traffic.

Modelling results for this option are summarised in Table 2-3.

Table 2-3 New 1 Lane Approach Signals (Split Phasing) Modelling Results Summary

	AM Peak			PM Peak		
Approach	**95%ile Queue (m)**	**Average Delay (s/veh)**	**Level of Service**	**95%ile Queue (m)**	**Average Delay (s/veh)**	**Level of Service**
Otonga Road South	271	75	E	295	81	F
Springfield Road East	121	81	F	107	85	F
Otonga Road North	155	79	E	253	81	F
Springfield Road West	238	82	F	194	90	F

An option was tested with a separate pedestrian-only phase but produced substantially worse results.

2.3.2. *Filter Right Turn Phasing (3B)*

Modelling indicates that signals with filter right turn phasing would produce larger average delays and longer queues than the existing roundabout, but better results than the split phasing option. The drop in level of service from A to D from the existing intersection is likely to be too significant to justify the project. Due to pedestrians being stopped for two phases until a dedicated phase, pedestrian delay would increase significantly from the base scenario. Where perceived delay is too high, pedestrians may cross against the signals, creating a potential safety issue.

Modelling results for this option are summarised in Table 2-4.

Table 2-4 New 1 Lane Approach Signals (Filter Right Turn Phasing) Modelling Results Summary

	AM Peak			PM Peak		
Approach	**95%ile Queue (m)**	**Average Delay (s/veh)**	**Level of Service**	**95%ile Queue (m)**	**Average Delay (s/veh)**	**Level of Service**
Otonga Road South	137	34	C	126	24	C
Springfield Road East	57	34	C	56	38	D
Otonga Road North	80	37	D	167	50	D
Springfield Road West	118	36	D	129	59	E

2.4. New 1 Lane Plus Right Turn Bay Signals (4)

The scenario with an additional lane for right turning vehicles provides similar results to the single lane filter right turn phasing scenario. Average delays and queue lengths are larger than produced by the existing roundabout and the drop in LOS from A to C is larger than recommended. Due to pedestrians being stopped until their signal phase, pedestrian delay would increase significantly from the base scenario. Where perceived delay is too high, pedestrians may cross against the signals, creating an additional safety issue.

An indicative layout for the scenario is provided in Section 1.3. Modelling results for the scenario are summarised in Table 2-5.

Table 2-5 New 1 Lane Plus Right Turn Bay Signals Modelling Results Summary

	AM Peak			PM Peak		
Approach	**95%ile Queue (m)**	**Average Delay (s/veh)**	**Level of Service**	**95%ile Queue (m)**	**Average Delay (s/veh)**	**Level of Service**
Otonga Road South	26	26	C	112	34	C
Springfield Road East	22	22	C	42	33	C
Otonga Road North	25	25	C	57	33	C
Springfield Road West	26	26	C	77	39	D

2.5. Signalised Pedestrian Crossing on the Southern Leg (5)

Modelling for this scenario shows that a separate signalised pedestrian crossing facility on the southern approach would have no significant impact on traffic operations, with LOS A and low average delay. Queueing would not block into the intersection. Modelling results for the scenario are summarised in Table 2-6.

Table 2-6 Signalised Pedestrian Crossing on the Southern Leg Modelling Results Summary

	AM Peak			PM Peak		
Approach	**95%ile Queue (m)**	**Average Delay (s/veh)**	**Level of Service**	**95%ile Queue (m)**	**Average Delay (s/veh)**	**Level of Service**
Northbound	7	2	A	6	3	A
Southbound	3	1	A	3	2	A

3. Conclusions

Based on the modelling results and demand analysis carried out as part of this study, the following conclusions can be made:

- The existing intersection has a relatively low traffic demand and performs well operationally. There is no reason to upgrade the intersection from a capacity or operational perspective.
- Increasing deflection angles and the diameter of the central island would add to average delays, but not significantly. Overall, the intersection would operate similarly to the existing layout due to the potential size of the roundabout being constrained to a similar size as existing.
- Signalising the intersection will, at best, reduce the overall level of service from B to C. Right turn bays would be required to achieve LOS C. Without right turn bays, the intersection level of service would drop to D, which is unlikely to be an acceptable outcome from an operational perspective.
- Given the existing pedestrian crossing demand is relatively low on two of the legs, signalising the entire intersection is an inefficient way of improving pedestrian connectivity as it will unnecessarily delay traffic on all legs and will delay pedestrians.
- A signalised pedestrian crossing on the southern approach would not significantly affect traffic operations while catering to the second largest existing crossing demand at the intersection, which is likely to increase with the completion of the proposed shared path.
- A high pedestrian demand exists across the western leg in both peak hours, in particular from unaccompanied children. The zebra crossing to the west is underutilised in comparison to crossing at the intersection.
- Existing pedestrian crossing facilities in the intersection are substandard and provide no assistance to visually impaired users.
- While there is low existing cyclist demand at the intersection, it is likely to increase with the completion of the proposed shared path. The existing layout of the intersection is less safe than other intersection forms and inconvenient for use by cyclists.

4. Recommendations

It is recommended that the following are adopted, based on current levels of demand:

- Upgrade the intersection by enhancing the existing roundabout, altering kerb lines, splitter islands and the centre island, to increase deflection and reduce average vehicle speeds. This should also include drop kerbs and tactile paving on all legs to the standard described in RTS-14 (NZTA), to accommodate visually impaired pedestrians.
- To cater for future demand and to improve pedestrian and cyclist safety, the pedestrian/cyclist crossing facilities on the southern and western approaches should be upgraded. Further study is required to develop the exact form of the crossing facilities, which depends on the objectives of the crossing itself and its suitability for the potential number of new users generated by the new CyWays shared path on Springfield Road and Otonga School zoning.
- Signalised crossings would suit a high crossing demand and minimise delays for traffic. Operationally, a signalised crossing would not substantially affect traffic operation, but its suitability depends on the overall shared path design, which should include consistent crossing treatments. Zebra crossings on a raised platform would slow traffic and highlight pedestrians but is likely to create additional delay for traffic.