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TDG Ref: 13561.3
4 September 2017

Issued via email: **andrew@merccapital.com.au**

Dear Andrew,

Old Northern Road / Francis Street Intersection
Traffic Signals Warrant Assessment

Thank you for engaging TDG to provide a traffic signals warrant assessment relating to the layout and operation of the existing T-intersection at Old Northern Road and Francis Street in Castle Hill.

1. Background

A Parking and Traffic Study (**PTS**) was prepared by TDG in July 2017, which indicated that traffic signals are currently required at the existing intersection of Old Northern Road and Francis Street in Castle Hill. The assessment concluded that upgrading from an unsignalised intersection to a signalised intersection and the provision of a northbound right turn lane on Old Northern Road would considerably improve the overall operation of the intersection in both existing and future conditions.

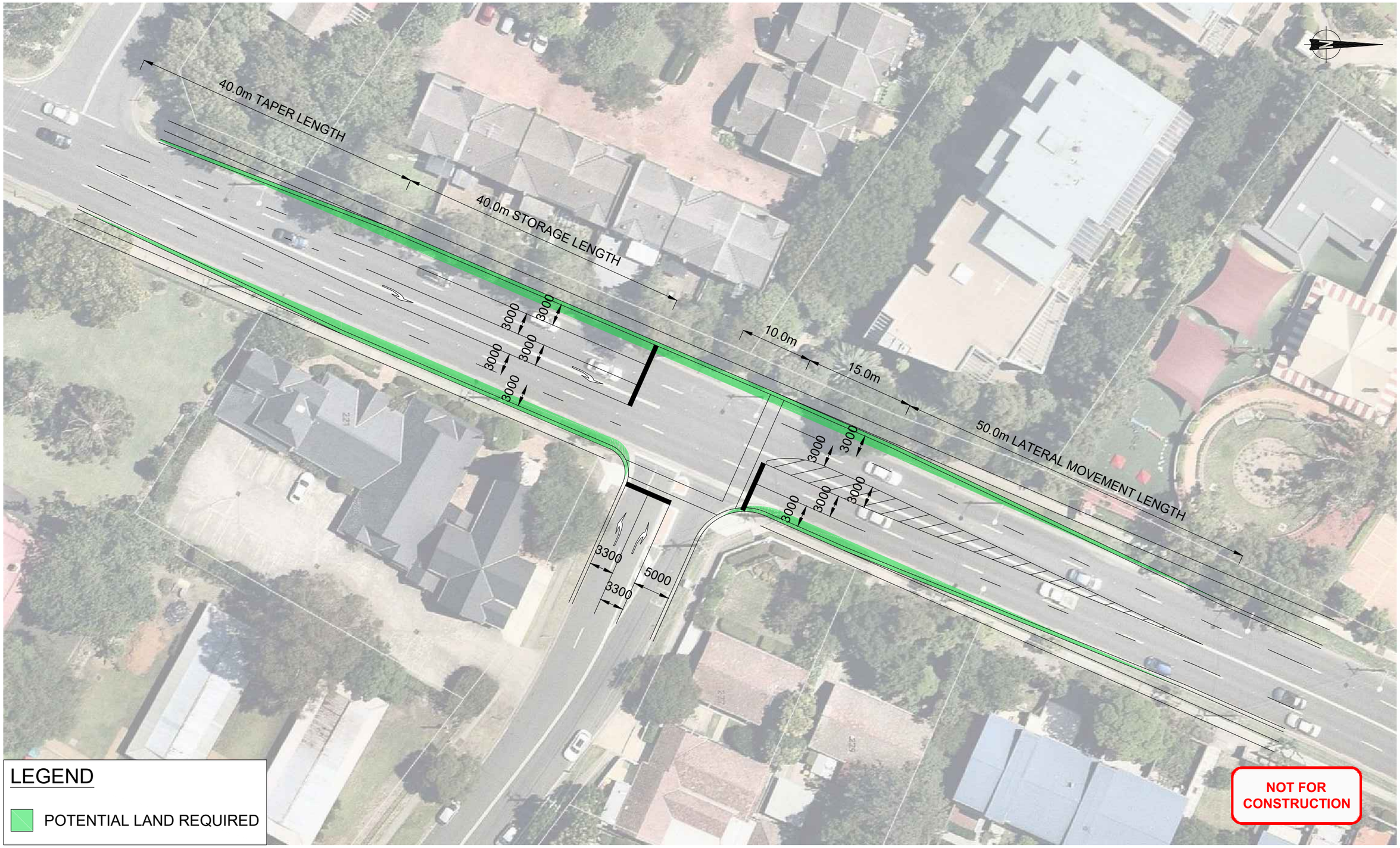
A concept intersection layout plan was prepared for Roads and Maritime Services (**RMS**) in July 2017, which shows a widened Old Northern Road, to cater for the provision of a northbound right turn lane, and signalisation of the intersection.

The PTS was prepared to support a mixed use development on the southern side of Cecil Avenue, with access to Roger Avenue. The PTS identified that the intersection currently operates with a level of service "F" during both morning and afternoon peak periods, and would continue to do so with the proposed development traffic added. It also demonstrated that with signalisation of the intersection, the average delays would reduce significantly and the intersection would operate at level of service "A" for both peak periods.

This Signals Warrant Assessment has been prepared to assess the intersection against the RMS warrants as requested, whilst also considering other aspects of road safety and efficiency.

2. Concept Design

Figure 1 shows the concept layout design of the intersection, including the approximate area of land required to facilitate the design.



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Friday, 23 June 2017

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Old Northern Road / Francis Street

Concept Intersection Layout

DRAWN: TJG
DATE: 23/06/2017
SCALE: 1:500 @ A3
DWG NO:13561-2S1A

TDG

1

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3. Traffic Volumes

A turning movement count survey was undertaken at the intersection in February 2017.

The weekday morning peak hour was found to occur from 8:00am to 9:00am, and the afternoon peak hour was found to occur from 4:30pm to 5:30pm.

A summary of the turning movement counts are displayed below in **Table 1**:

Time Period	Old Northern Road South			Old Northern Road North			Francis Street		
	Through	Right	Total	Through	Left	Total	Left	Right	Total
AM Peak	1,349	113	1,462	1,449	97	1,546	194	3	197
PM Peak	1,379	146	1,525	1,476	55	1,531	86	1	87

Table 1: Peak Hour Turning Volumes at the Old Northern Road / Francis Street Intersection

The proposed development discussed in the PTS is expected to generate traffic that will flow through the Old Northern Road / Francis Street intersection, and the resulting turning volumes are shown below in **Table 2**:

Time Period	Old Northern Road South			Old Northern Road North			Francis Street		
	Through	Right	Total	Through	Left	Total	Left	Right	Total
AM Peak	1,349	158	1,507	1,455	52	1,507	209	100	309
PM Peak	1,379	172	1,551	1,495	62	1,557	91	100	191

Table 2: Expected Future Traffic Volumes at the Old Northern Road / Francis Street Intersection

As the proposed development is expected to generate additional traffic through the intersection, the expected future volumes have been used for the purposes of this assessment.

4. Signal Warrants

The intersection has been assessed against the warrants included in the Roads and Traffic Authority of New South Wales' (now Roads and Maritime Services) "*Traffic Signal Design – Section 2 - Warrants*" (**RTA Warrant Guide**).

The warrants for the installation of traffic signals are included in the RTA Warrant Guide, and are reproduced in **Table 4** below.

The RTA Warrant Guide states that as a guide, a signalised intersection may be considered if *one* of the five following warrants is met. It was anticipated that the subject site would meet warrant (a) or (b) regarding traffic demands and these have been assessed.

The warrants require that volume limits be met during four hours of the day. As described in Section 3 of this assessment, only two peak hours were assessed during the weekday period, and as such there are no future traffic volumes for a four hour period. However, shoulder peak hours adjacent to the peaks are typically only marginally lower than the peak hour, particularly in larger urban areas where peak spreading occurs and the network is often operating at close to its capacity. For this assessment, the adjacent peak hour periods for both the morning and afternoon peaks have been conservatively assessed to be 15 percent lower than the peak hour volumes discussed in Section 3.

The four hourly volumes are displayed below in **Table 3**, and were used in the assessment against warrants (a) and (b).

Time Period	Old Northern Road South			Old Northern Road North			Francis Street		
	Through	Right	Total	Through	Left	Total	Left	Right	Total
AM Peak	1,349	158	1,507	1,455	52	1,507	209	100	309
PM Peak	1,379	172	1,551	1,495	62	1,557	91	100	191
AM Adjacent Peak	1,147	134	1,281	1,237	44	1,281	178	85	263
PM Adjacent Peak	1,172	146	1,318	1,271	53	1,324	77	85	162

Table 3: Peak Hourly and Estimated Adjacent Peak Hourly Volumes at Intersection

Warrants		Actual Situation	Meets Warrants
a) Traffic Demand	For each of four one-hour periods of an average day:		NO.
	i) The major road flow exceeds **600** vehicles per hour (**vph**) in each direction; and	YES. Major road volumes exceed 600 vph in one direction for all four peak hours.	
	ii) The minor road flow exceeds **200** vph in one direction.	NO. The minor road volume exceeds 200 vph in the eastbound direction for the AM peak and AM peak adjacent hours, but not more than 200 vph for either PM hour.	
b) Continuous Traffic	For each of four one-hour periods of an average day:		YES.
	i) The major road flow exceeds **900** vph in each direction; and	YES. Major road volumes exceed 900 vph in one direction for all four peak hours.	
	ii) The minor road flow exceeds **100** vph in one direction; and	YES. Minor road volumes exceed 100 vph in one direction for all four peak hours.	
	iii) The speed of traffic on the major road or limited sight distance from the minor road causes undue delay or hazard to the minor road vehicles; and	YES. Considerable delay and hazard expected.	
	iv) There is no other nearby traffic signal site easily accessible to the minor road vehicles.	YES.	
c) Pedestrian Safety	For each of four one-hour periods of an average day:		Not Assessed.
	i) The pedestrian flow crossing the major road exceeds **150** persons per hour (**pph**); and	Not recorded as part of the traffic volume counts.	
	ii) The major road flow exceeds **600** vph in each direction or, where there is a central median of at least 1.2m wide, **1,000** vph in each direction.	YES. Major road volumes exceed 600 vph in one direction for all four peak hours.	
d) Pedestrian Safety – High Speed Road	For each of four one-hour periods of an average day:		Not Assessed.
	i) The pedestrian flow crossing the major road exceeds **150** pph; and	Not recorded as part of the traffic volume counts.	
	ii) The major flow exceeds **450** vph in each direction or, where there is a central median of at least 1.2m wide, **750** vph in each direction; and	YES. Major road volumes exceed 600 vph in one direction for all four peak hours.	
	iii) The 85th percentile speed on the major road exceeds 75 km/h.	Not assessed. However the posted speed limit is 60 km/h so	

		this warrant is unlikely.	
e) Crashes	For each of four one-hour periods of an average day:		Not Assessed.
	i) The intersection has been the site of an average of three or more reported tow-away or casualty traffic accidents per year over a three year period, where the traffic accidents could have been prevented by traffic signals; and	Not assessed.	
	ii) The traffic flows are at least 80% of the appropriate flow warrants.	YES.	

Table 4: RTA Signal Warrants

The assessment against the warrants indicates that warrant (b), Continuous Traffic, is met but warrant (a), Traffic Demand, is not.

The warrants based on pedestrian safety have not been formally assessed due to the uncertainty regarding pedestrian volumes; however it is evident that the higher risk traffic volumes and speeds targeted by the warrants will be present.

5. Operating Efficiency

The intersection has been modelled using the SIDRA intersection analysis software, for both the existing and future concept scenarios. Both layouts are shown below in **Figure 2** and **Figure 3**.

The signalised intersection was modelled using a standard t-intersection A-B-C phasing, with northbound right filter turns permitted during the A phase. To be conservative, both pedestrian movements were modelled as operating every cycle.

The results of the analyses for both the existing and future concept scenarios are summarised in **Table 5**, with SIDRA output summaries included in **Appendix A**.

The concepts of intersection capacity and level of service (**LoS**), as defined in the guidelines published by the RTA (2002), are discussed in **Appendix B** together with criteria for their assessment. The assessment of the LoS of traffic signals is based on the evaluation of the average delay (seconds per vehicle) of vehicles on all approaches. The assessment of LoS of roundabouts and unsignalised intersections is based on the average delay of the critical movements, i.e. the movement with the highest delay.

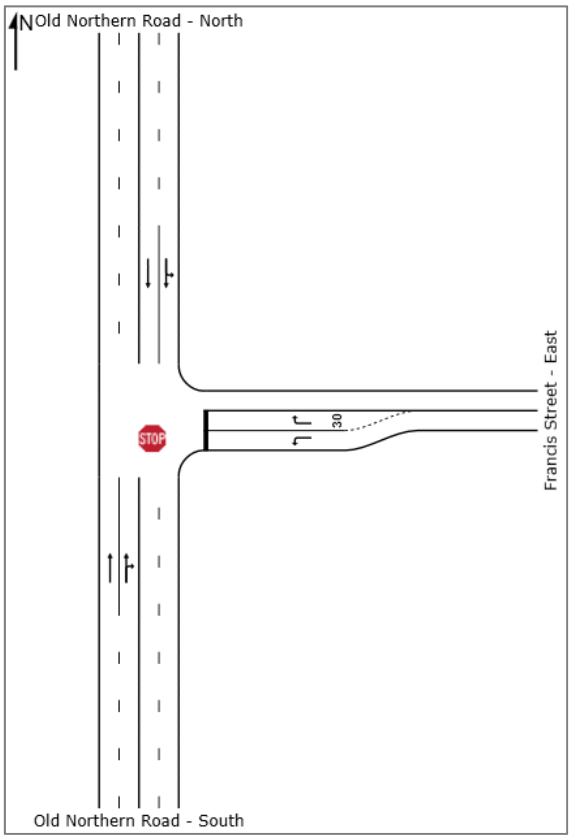

Figure 2: Modelled Existing Layout (Unsignalised)

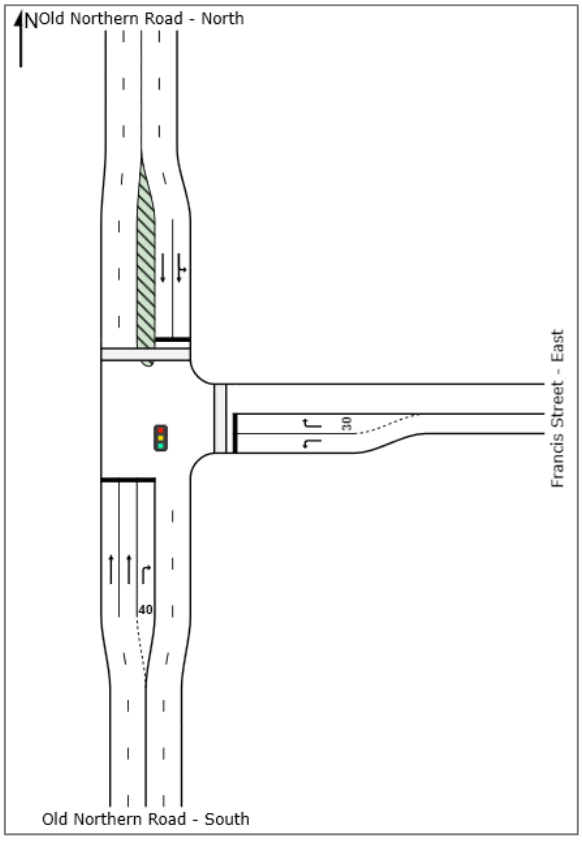

Figure 3: Modelled Future Concept Layout (Signalised)

Intersection Scenario	AM Peak		PM Peak	
	Average Delay (sec/veh)	Level of Service (LoS)	Average Delay (sec/veh)	Level of Service (LoS)
Existing – Unsignalised Intersection (Critical movement - Francis Street right turn)	>70.5	F	>70.5	F
Future – Signalised Intersection (All movements)	10.9	A	13.3	A

Table 5: Existing and Future Concept SIDRA Analysis Results

Under priority control, the intersection is modelled as running at a very poor level of service "F" during both the morning and afternoon peak hours. This can be attributed to the large volumes of through traffic on Old Northern Road restricting the traffic exiting from Francis Street. For the existing intersection, the largest delays (of well over 70.5 seconds per vehicle) are for the right turning vehicles on Francis Street, of which there were 3 vph recorded in the morning peak and 1 vph recorded in the afternoon peak. The next highest critical movement is the northbound right turn movement from Old Northern Road onto Francis Street, with average delays of 75.1 sec / veh in the morning peak and 152.7 sec / veh in the afternoon peak.

The large delay and small volumes undertaking the right turn from Francis Street effectively show from a practical point of view that this movement is no longer possible during peak traffic periods.

The provision of traffic signals would considerably improve the operation of the intersection, improving the intersection operation to a level of service "A" as shown in Table 5, including after the additional development traffic is taken into account.

6. Conclusion

Based on the above assessment, the intersection of Old Northern Road and Francis Street in Castle Hill has been determined to warrant an upgrade to a signalised intersection under the RMS warrants.

This is also supported by the SIDRA modelling which shows an overall significant improvement to the intersection's operating LoS.

Yours sincerely
Traffic Design Group Ltd

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Attached:
Appendix A – SIDRA Movement Summaries
Appendix B – Guidelines for the Evaluation of Intersection Operation

Appendix A

SIDRA Movement Summaries

MOVEMENT SUMMARY

Site: 101 [Old Northern Road / Francis Street - Existing AM]

AM Peak - Existing
Stop (Two-Way)

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Old Northern Road - South											
2	T1	1420	0.0	0.728	0.2	LOS A	0.0	0.0	0.00	0.00	59.6
3	R2	119	0.0	0.848	75.1	LOS F	4.4	30.7	0.98	1.28	25.6
Approach		1539	0.0	0.848	6.0	NA	4.4	30.7	0.08	0.10	54.0
East: Francis Street - East											
4	L2	204	0.0	0.438	16.3	LOS C	2.1	14.5	0.74	1.10	43.7
6	R2	3	0.0	1.000	1608.3	LOS F	2.3	15.8	1.00	1.04	2.2
Approach		207	0.0	1.000	40.6	LOS E	2.3	15.8	0.74	1.10	33.9
North: Old Northern Road - North											
7	L2	102	0.0	0.419	5.6	LOS A	0.0	0.0	0.00	0.08	57.6
8	T1	1525	0.0	0.419	0.1	LOS A	0.0	0.0	0.00	0.03	59.6
Approach		1627	0.0	0.419	0.4	NA	0.0	0.0	0.00	0.04	59.4
All Vehicles		3374	0.0	1.000	5.4	NA	4.4	30.7	0.08	0.13	54.4

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: 101 [Old Northern Road / Francis Street - Existing PM]

PM Peak - Existing
Stop (Two-Way)

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Old Northern Road - South											
2	T1	1452	0.0	0.744	0.2	LOS A	0.0	0.0	0.00	0.00	59.5
3	R2	154	0.0	1.057	152.7	LOS F	12.7	89.0	1.00	1.93	16.5
Approach		1605	0.0	1.057	14.8	NA	12.7	89.0	0.10	0.18	47.6
East: Francis Street - East											
4	L2	91	0.0	0.208	14.6	LOS B	0.7	5.1	0.69	1.01	44.6
6	R2	1	0.0	1.000	4082.5	LOS F	2.1	14.7	1.00	1.02	0.9
Approach		92	0.0	1.000	61.4	LOS F	2.1	14.7	0.69	1.01	28.4
North: Old Northern Road - North											
7	L2	58	0.0	0.414	5.5	LOS A	0.0	0.0	0.00	0.04	57.3
8	T1	1554	0.0	0.414	0.1	LOS A	0.0	0.0	0.00	0.02	59.5
Approach		1612	0.0	0.414	0.3	NA	0.0	0.0	0.00	0.02	59.4
All Vehicles		3308	0.0	1.057	9.0	NA	12.7	89.0	0.07	0.13	51.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: 101v [Old Northern Road / Francis Street - Future AM]

AM Peak - Existing Plus Development
Signals - Fixed Time Isolated Cycle Time = 70 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Old Northern Road - South											
2	T1	1349	0.0	0.473	3.8	LOS A	9.1	63.5	0.43	0.39	56.5
3	R2	158	0.0	0.503	22.7	LOS C	4.6	31.9	0.90	0.82	40.5
Approach		1507	0.0	0.503	5.8	LOS A	9.1	63.5	0.48	0.43	54.2
East: Francis Street - East											
4	L2	209	0.0	0.438	28.6	LOS C	6.1	43.0	0.88	0.79	37.5
6	R2	100	0.0	0.628	41.3	LOS D	3.6	25.4	1.00	0.82	33.2
Approach		309	0.0	0.628	32.7	LOS C	6.1	43.0	0.92	0.80	36.0
North: Old Northern Road - North											
7	L2	52	0.0	0.688	17.0	LOS B	18.2	127.3	0.76	0.70	46.0
8	T1	1455	0.0	0.688	11.4	LOS B	18.3	127.8	0.76	0.69	50.4
Approach		1507	0.0	0.688	11.6	LOS B	18.3	127.8	0.76	0.69	50.2
All Vehicles		3323	0.0	0.688	10.9	LOS B	18.3	127.8	0.65	0.59	50.1

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P2	East Full Crossing	15	10.9	LOS B	0.0	0.0	0.56	0.56
P3	North Full Crossing	15	29.3	LOS C	0.0	0.0	0.91	0.91
All Pedestrians		30	20.1	LOS C			0.74	0.74

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

MOVEMENT SUMMARY

Site: 101v [Old Northern Road / Francis Street - Future PM]

PM Peak - Existing Plus Development
Signals - Fixed Time Isolated Cycle Time = 60 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Old Northern Road - South											
2	T1	1379	0.0	0.513	4.5	LOS A	9.4	66.1	0.50	0.45	55.8
3	R2	172	0.0	0.518	24.0	LOS C	4.5	31.2	0.94	0.81	39.9
Approach		1551	0.0	0.518	6.7	LOS A	9.4	66.1	0.55	0.49	53.5
East: Francis Street - East											
4	L2	91	0.0	0.163	21.5	LOS C	2.0	14.0	0.77	0.73	40.5
6	R2	100	0.0	0.538	34.7	LOS C	3.0	21.3	0.99	0.78	35.3
Approach		191	0.0	0.538	28.4	LOS C	3.0	21.3	0.89	0.76	37.6
North: Old Northern Road - North											
7	L2	62	0.0	0.813	23.3	LOS C	22.1	154.6	0.91	0.91	44.9
8	T1	1495	0.0	0.813	17.9	LOS B	22.2	155.1	0.91	0.91	46.2
Approach		1557	0.0	0.813	18.1	LOS B	22.2	155.1	0.91	0.91	46.1
All Vehicles		3299	0.0	0.813	13.3	LOS B	22.2	155.1	0.74	0.71	48.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Vehicle movement LOS values are based on average delay per movement.
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P2	East Full Crossing	15	12.7	LOS B	0.0	0.0	0.65	0.65
P3	North Full Crossing	15	24.3	LOS C	0.0	0.0	0.90	0.90
All Pedestrians		30	18.5	LOS B			0.78	0.78

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

Appendix B

Guidelines for the Evaluation of Intersection Operation

The RTA has included in the "Guide to Traffic Generating Developments" (Dec 1993, Issue 2) a section on the assessment of intersections. The assessment of the level of service of an intersection is based on the evaluation of the following Measures of Effectiveness:

(a) Average delay (seconds/veh) (all forms of control)

(b) Delay to critical movement (seconds/veh) (all forms of control)

(c) Degree of saturation (traffic signals and roundabouts)

(d) Cycle length (traffic signals)

INTANAL was used to calculate the relevant intersection parameters. INTANAL is a software which allows comparisons between different forms of intersection control and different forms of intersection configurations to be readily evaluated. That is at each intersection the priority control, roundabout and signal control options will be examined to determine the most efficient form of control.

The best indicator of the level of service at an intersection is the average delay experienced by vehicles at that intersection. For traffic signals, the average delay over all movements should be taken. For roundabouts and priority control intersections (with Stop and Give Way signs or operating under the T-junction rule) the critical movement for level of service assessment should be that with the highest average delay.

With traffic signals, delays per approach tend to be equalised, subject to any over-riding requirements of signal co-ordination as well as to variations within individual movements. With roundabouts and priority - control intersections, the critical criterion for assessment is the movement with the highest delay per vehicle. With this type of control the volume balance might be such that some movements suffer high levels of delay while other movements have minimal delay. An overall average delay for the intersection of 25 seconds might not be satisfactory if the average delay on one movement is 60 seconds.

The average delay for level of service E should be no more than 70 seconds. The accepted maximum practical cycle length for traffic signals under saturated conditions is 120 - 140 seconds. Under these conditions 120 seconds is near maximum for two and three phase intersections and 140 seconds near maximum for more complex phase designs. Drivers and pedestrians expect cycle lengths of these magnitudes and their inherent delays in peak hours. A cycle length of 140 seconds for an intersection which is almost saturated has an average vehicle delay of about 70 seconds, although this can vary. If the average vehicle delay is more than 70 seconds, the intersection is assumed to be at Level of Service F.

Table B1 sets out average delays for different levels of service. There is no consistent correlation between definitions of levels of service for road links as defined elsewhere in this section, and the ranges set out in Table G1. In assigning a level of service, the average delay to the motoring public needs to be considered, keeping in mind the location of the intersection. For example, drivers in inner-urban areas of Sydney have a higher tolerance of delay than drivers in country areas. Table B1 provides a recommended baseline for assessment.

Level of Service	Average Delay per Vehicle (seconds/veh)	Traffic Signals, Roundabout	Give Way and Stop Signs
A	less than 14	Good operation	Good operation
B	15 to 28	Good with acceptable delays and spare capacity	Acceptable delays and spare capacity
C	29 - 42	Satisfactory	Satisfactory, but accident study required
D	43 to 56	Operating near capacity	Near capacity and accident study required
E	57 to 70	At capacity; at signals, incidents will cause excessive delays Roundabouts require other control mode	At capacity, required other control mode

Table B1: Level of Service Criteria for Intersections

The figures in Table B1 are intended as a guide only. Any particular assessment should take into account site-specific factors including maximum queue lengths (and their effect on lane blocking), the influence of nearby intersections and the sensitivity of the location to delays. In many situations, a comparison of the current and future average delay provides a better appreciation of the impact of a proposal, and not simply the change in the level of service.

The intersection degree of saturation (DS) can also be used to measure the performance of isolated intersections. At intersections controlled by traffic signals, both queue length and delays increase rapidly as DS approaches 1.0. An upper limit of 0.9 is appropriate. When DS exceeds 0.8 - 0.85, overflow queues start to become a problem. Satisfactory intersection operation is generally achieved with a DS of about 0.7 - 0.8. (Note that these figures are based on isolated signalised intersections with cycle lengths of 120 seconds. In co-ordinated signal systems DS might be actively maximised at key intersections). Although in some situations additional traffic does not alter the level of service, particularly where the level of service is E or F, additional capacity may still be required. This is particularly appropriate for service level F, where small increases in flow can cause disproportionately greater increases in delay. In this situation, it is advisable to consider means of control to maintain the existing level of absolute delay. Suggested criteria for the evaluation of the capacity of signalised intersections based on the Degree of Saturation are summarised in Table B2.

Level Of Service	Optimum Cycle Length (Seconds) (Co)	Volume/Saturation Y	Intersection Degree Of Saturation X
A/B - Very good operation	< 90	< 0.70	< 0.80
C - Satisfactory	90-120	0.70-0.80	0.80-0.85
D - Poor but manageable	120-140	0.80-0.85	0.85-0.90
E/F - Bad, extra capacity required	>140	>0.85	> 0.90

Table B2: Criteria for Evaluating Capacity Of Signalised Intersections*

** Source: Roads & Traffic Authority (2002)*