in association with:
Gennaoui Consulting

Merc Property Pty Ltd

Mixed Residential Development at Cecil Avenue, Castle Hill

Planning Proposal

Parking and Traffic Study

July 2017

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Parking and Traffic Study

Quality Assurance Statement

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1. Introduction

1.1 Background

Merc Property Pty Ltd is submitting a Planning Proposal for a mixed-residential development to be situated between Cecil Avenue and Roger Avenue, Castle Hill as shown in **Figure 1**.

Figure 1: Aerial Image of Proposed Site

The proposed complex will consist of four (4) buildings providing:

- 52,860 m^2 GFA (460 apartments)
- 8,810 m^2 of commercial & retail.

A planning proposal was lodged with the Hills Shire Council. Council has requested that a traffic study be provided which addresses the peak hour directional splits, potential impacts on the nearby intersections, measures to address capacity issues in Cecil Avenue and Roger Avenue.

TDG in association with *Gennaoui Consulting Pty Ltd* has been commissioned to investigate and report on the parking requirements and traffic impact of the proposed development.

1.2 Scope of Report

The report includes the findings and conclusions in respect to the parking requirements and traffic impact of the proposed development on the surrounding road network and nearby intersections.

2. Parking and Access Evaluation

2.1 The Proposal

The Planning Proposal is for the construction of four (4) buildings ranging from 3 to 18 storeys comprising 52,860 m^2 of residential (460 units) as well as about 8,800 m^2 of commercial development as noted in **Table 1**.

Land Use		MAYORAL MINUTE	
		Rate	Space
Residential			
Tenants	460	1.0	460
Visitors		0.2	92
Total Residential Spaces			**552**
Commercial m^2 GFA	8,000	1 per 25m^2 GFA	320
Retail m^2 GFA	810*	1 per 18.5m^2 GLFA	35
Total Commercial	**8,810**		**355**
TOTAL			**907**

Table 1: Proposed Mixed Development

* 80% of GFA = 648 m^2 GLFA

2.2 Parking Requirement

The proposed parking requirement for the proposed development will be based on the latest Council's requirement which stipulates the following parking provisions for residential apartments and commercial developments.

- Residential Apartments:

The proposed development will be located about 650 m from the under-construction railway station at Castle Hill. Consideration should therefore be given to reduce this number of parking spaces by adopting the Mayoral Minutes No 9/ 2016 adopted by Council on at its meeting held on 25 October 2016. The Minute concerns housing mix and diversity within the Sydney Metro Norwest Corridor which included an "*incentivised*" car parking policy rate for developments meeting Council's requirements. This planning proposal meets these requirements for mix and size and therefore car parking has been calculated accordingly as follows:

- Residential
  - 1 space per apartment:
  - 1 visitor spaces per 5 units
- Commercial (office) component
  - 1 space per 25 m^2 GFA
- Retail component
  - 1 space per 18.5m^2 GLFA

Based on these rates, some 552 spaces would be required for the residential component of the development as noted in **Table 1**; in addition the commercial areas would require some 355 spaces. Thus a minimum of 907 spaces would be required.

2.3 Evaluation of Parking Layout

All parking spaces will be designed to comply with Council's DCP and the Australian Standards *AS 2890.1-2004 Parking Facilities Part 1 Off Street car parking".* Spaces for cars with a mobility impaired permit should comply with the AS/NZS 2890.6 - 2009, Parking Facilities Part 6: Off-Street parking for people with disabilities".

A loading area to cater for the proposed commercial component of the development and residential (removals trucks) will also be provided. It will be designed to comply with the Australian Standards *AS 2890.2-2002 Parking facilities - Off-street commercial vehicle facilities.*

Parking will be provided over several levels with all basement levels inter-connected. A detailed assessment of the parking layout and circulation will be provided in conjunction with the Development Application.

To minimise the impact along Cecil Avenue and provide adequate sight distance for vehicles entering and exiting the development, on-street parking adjacent to the development may need to be restricted.

2.4 Vehicular Access to the Site

The main access to the proposed development will be provided from Cecil Avenue; it will be situated near the eastern corner of the site about 125m from Terminus Street. This access will be used by all vehicles associated with the commercial part of the development as well as all visitors to the residential units. It could also be used by tenants accessing residential parking levels.

A secondary access will be provided onto Roger Avenue. This access will be restricted to residents only of the development; it would mostly be used by residents with an origin or destination to the south.

The driveways will be designed to comply with the Australian Standards *AS 2890.1-2004 Parking Facilities Part 1 Off Street car parking.*

3. Assessment of Traffic Conditions

3.1 Approach Roads

Major access route to the proposed development is provided by the by-pass route along Terminus Street and Cecil Avenue which connects to Old Northern Road and Showground Road. The direct access to and from the proposed development will be via Cecil Avenue; Orange Street and Crane Street would also be used.

Cecil Avenue has 10.0m wide carriageways with parking permitted on both sides. East of Terminus Street, Crane Street also has a 10m wide carriageway. Orange Grove has a narrower 9m carriageway.

The route along Terminus Street and the section of Cecil Avenue, between Terminus Street and Old Northern Road have a four-lane divided carriageway with turning lanes at all signalised intersections along this route.

Traffic to and from Cecil Avenue, east of Terminus Street is restricted by a median along the by-pass route to left turning in and out only.

Traffic to and from the south may use Roger Avenue and Francis Street to access Old Northern Road. Francis Street has a 10m carriageway with parking permitted on both sides. Roger Avenue has a narrower carriageway, between 6 and 7 m in width. Francis Street is controlled by a Stop Sign. A pedestrian refuge assists pedestrians crossing Francis Street.

Traffic signals control the intersection of the Cecil Avenue with Old Northern Road, and the intersections of Terminus Street with the access to Council's car park and with Crane Street.

A one lane circulating roundabout is provided at the intersection of Cecil Avenue with Orange Grove.

3.2 Existing Traffic Conditions

3.2.1 Traffic Counts

In order to gauge the traffic conditions in the vicinity to the site, traffic movements were counted at the following intersections:

- Old Northern Road with Cecil Street;
- Terminus Street with Crane Street and Castle Street;
- Cecil Avenue with Orange Grove;
- Cecil Avenue with Terminus Street;
- Francis Street with Roger Avenue; and
- Old Northern Road with Francis Street.

These counts were carried out during the morning (7.00 to 9.00am) and afternoon (between 4:00 and 6:00 pm) peak periods on 8 December 2016 and 2 February 2017.

Overall, traffic volumes peaked between 8.00 and 9.00 am and from 4.30 to 5.30pm during the morning and afternoon respectively. The peak hour volumes at these surveyed intersections are shown in **Figure 2**.

3.2.2 Existing Operation of Major Approach Roads

The existing traffic volumes along Terminus Street, Cecil Avenue, Old Northern Road and Crane Street are summarised in **Table 2** together with their appropriate level of service.

LOCATION	LANES	AM PEAK			PM PEAK		
		East/North	South/West	LoS	East/North	South/West	LoS
Crane St							
East of Terminus St	4U	214	585	A	397	396	A
West of Terminus St	4UC	175	589	A	235	558	A
Cecil Avenue							
East of Orange Grove	4UP	53	147	A	105	60	A
East of Terminus St	4UP	43	141	A	95	82	A
East of Old Northern Rd	4DC	969	1,317	A	1,111	1,571	A
West of Old Northern Rd	4U	384	359	A	407	388	A
Francis Street							
East of Old Northern	4UP	160	197	A	201	87	A
East of Roger Ave	4UP	158	203	A	184	79	A
Old Northern Road							
South of Cecil Ave	4UC	1479	1,424	A	1,517	1,588	B
North of Cecil Ave	4U	817	389	A	862	454	A
South of Francis St	4UC	1462	1,643	B	1,525	1,562	B
Orange Grove							
North of Cecil Ave	4UP	144	128	A	162	64	A
South of Cecil Ave	4UP	162	129	A	187	84	A
Roger Avenue							
North of Francis St	2U	1	3	A	5	3	A
Terminus Street							
North of Cecil Ave	4DC	814	1,237	A	1,018	1,540	A
South of Crane St	4DC	880	1,271	A	1,199	1,342	A
North of Crane St	4DC	946	1,380	A	1,086	1,553	A

Table 2: Existing Carriageway Level of Service

Interrupted Flow Conditions - Table A1 of Appendix A
Uninterrupted Flow Conditions - Table A2 of Appendix A
4DC 4 lanes divided carriageway with clearway (Uninterrupted flow conditions of Appendix C)
4UC 4 lanes undivided carriageway with clearway
4U 4 lanes undivided carriageway with some parking
2U 2 lanes

The concepts of carriageway capacity and Level of Service (LoS) are discussed in **Appendix A** together with criteria for their assessment. The absence of major traffic movements entering/crossing from major developments along Terminus Street, Old Northern Road, south of Cecil Avenue, and Castle Street between Terminus Street and Old Northern Road, means that the service one-way hourly volumes for uninterrupted traffic included in Table A2 of **Appendix A** could be used; all other streets were assessed based on the service one-way hourly volumes for interrupted traffic included in Table A1 of **Appendix A**.

Currently Old Northern Road operates at a good level of service "B" or better. All other roads operate at a very good Level of Service "A".

3.2.3 Operation of Existing Critical Intersection

The concepts of intersection capacity and level of service, 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 level of service of traffic signals is based on the evaluation of the average delay (seconds/vehicle) of vehicles on all approaches. The assessment of the level of service of roundabouts and signed controlled intersections is based on the average delay (seconds/vehicle) of the critical movement.

An analysis of the operation of all four critical intersections in the vicinity of the site was carried out using the SIDRA computer modelling program. The results of this analysis are summarised in **Table 3**.

INTERSECTION	AM		PM	
	Delay sec/v	LoS	Delay sec/v	Los
Traffic Signals				
Old Northern Road with Cecil Avenue	30.8	C	34.3	C
Terminus Street with Crane Street	44.2	D	40.9	C
Roundabout				
Cecil Avenue with Orange Grove	8.8	A	9.0	A
T-Junctions				
Old Northern Road with Francis Street	>70	F	>70	F
Francis Street with Roger Avenue	5.9	A	5.5	A
Cecil Avenue with Terminus Street	11.2	A	12.2	A

Table 3: Existing Operation of Intersections

The intersection of Old Northern Road with Cecil Avenue currently operates at a satisfactory level of service "C" during the morning peak and the afternoon peak hours.

The traffic signals at the intersection of Terminus Street with Crane Street currently operates at an acceptable level of service "D" during the morning peak hour, improving to a satisfactory level of service "C" during the afternoon peak.

The roundabout controlling the intersection of Cecil Avenue with Orange Grove operates at a very good level of service ”A” during the morning and afternoon peak periods.

The right turning movements from Old Northern Road into Francis Street experience very high delays whilst waiting for a gap in the large volume of southbound traffic resulting in a very poor level of service “F”. The banning of the right turning movement into Francis Street is not suggested as it is the only direct access to a very large residential area east of Old Northern Road.

To resolve this existing problem, traffic signals should be installed.

3.3 Traffic Impact of Proposed Development

3.3.1 Trip Generation and Distribution

The following peak hourly trip generations stipulated in the RTA *Guide to Traffic Generating Developments Issue 2.2. October 2002* were adopted to estimate the likely trip generation of the proposed development.

- Residential Component

The RMS Technical Directive 04a (2013) indicates that the average trip generation rates for high density residential buildings near railway stations is an average 0.19 trips/units based on a range of 0.07 to 0.32 trips/units (from 8 high density buildings) during the morning peak hour. During the afternoon peak hour, is 0.15 vehicle trips/units based on a range of 0.06 to 0.41 trips/units.

The 85% rates of 0.28 trips per unit and 0.18 trip/unit have been adopted to estimate the trip generation during the morning and afternoon peak hour respectively of the proposed high density residential buildings.

- Office Component

The following rates published in the RMS Technical Direction TDT 2013/04a were adopted

  - AM Peak: 1.6 trips/100 m^2 GFA
  - PM Peak: 1.2 trips /100m^2 GFA

- Retail Component

The proposed retail will be part of a large residential and office development within 650 m of a railway station. It was therefore considered reasonable to adopt similar generation rates than those estimated for Norwest Marketown at Norwest

  - AM Peak: 4.5 trips/100 m^2 GLFA
  - PM Peak: 9.0 trips /100m^2 GLFA

The proposed development is likely to generate about 285 vph and 240 vph during the morning and afternoon peak hours respectively as noted in **Table 4**.

The main access to the proposed development will be provided from Cecil Avenue; it will be used by all vehicles associated with the commercial part of the development as well as all

visitors to the residential units. The second access onto Roger Avenue will be restricted to residents only. The likely number of trips using each driveway is also included in **Table 4**.

	No. Units	AM Peak		PM PEAK	
		Arr	Dep	Arr	Dep
Residential	460	39	90	54	29
Office	8,000 m^2 GFA	115	13	24	72
Retail	810 m^2 GFA*	23	6	23	35
Total		**177**	**109**	**101**	**136**

Table 4: Trip Generation of Proposed Development

* GLFA = 80% GFA

3.3.2 Trip Distribution

The distribution for approaching and departing traffic included in **Table 5** was derived from the existing traffic counts in the vicinity of the subject site.

APPROACH ROUTES			AM PEAK		PM PEAK	
	Arr	Dep	Arr	Dep	Arr	Dep
Old Northern Road						
S of Francis	24%	17%	42	19	24	23
N of Cecil St	14%	27%	25	29	14	37
Terminus St						
N of Crane St	40%	31%	71	34	40	42
Cecil Avenue						
W of Old Northern Rd	13%	12%	23	13	13	16
W of Orange Grove	3%	3%	5	3	3	4
Crane Street						
W of Terminus	6%	11%	11	12	6	15
Total	**100%**	**100%**	**177**	**110**	**101**	**137**

Table 5: Approach Routes Trips Distribution

3.3.3 Impact on Major Approach Roads

The future traffic volumes along Terminus Street and all major approach roads are summarised in **Table 6**, together with their appropriate level of service. The proposed potential developments would only marginally affect the level of service of most major approach roads to the site which would operate at a Level of Service "B" or better.

Traffic volumes along Roger Avenue would increase during the morning and afternoon peak hours to less than 50 cars. These volumes are well within the environmental (~300 vph) and physical capacity of the road.

LOCATION	LANES	AM PEAK			PM PEAK		
		East/North	South/West	LoS	East/North	South/West	LoS
Crane St							
East of Terminus St	4U	*218*	*622*	*A*	*403*	*435*	*A*
West of Terminus St	4UC	222	593	A	260	558	A
Cecil Avenue							
East of Orange Grove	4UP	*56*	*152*	*A*	*109*	*64*	*A*
East of Terminus St	4UP	*150*	*195*	*A*	*151*	*148*	*A*
East of Old Northern Rd	4DC	969	1371	A	1111	1647	B
West of Old Northern Rd	4U	*388*	*371*	*A*	*413*	*402*	*A*
Francis Street							
East of Old Northern	4UP	*204*	*210*	*A*	*230*	*91*	*A*
East of Roger Ave	4UP	*167*	*207*	*A*	*187*	*87*	*A*
Old Northern Road							
South of Cecil Ave	4UC	1479	1434	A	1517	1611	B
North of Cecil Ave	4U	854	389	A	908	454	A
South of Francis St	4UC	1502	1661	B	1548	1583	B
Orange Grove							
North of Cecil Ave	4UP	*181*	*132*	*A*	*201*	*70*	*A*
South of Cecil Ave	4UP	*202*	*133*	*A*	*202*	*92*	*A*
Roger Avenue							
North of Francis St	2U	*18*	*25*	*A*	*30*	*10*	*A*
Terminus Street							
North of Cecil Ave	4DC	814	1344	A	1018	1596	B
South of Crane St	4DC	880	1378	A	1199	1398	*A*
North of Crane St	4DC	979	1462	A	1125	1591	B

Table 6: Carriageway Level of Service with Proposed Development

Interrupted Flow Conditions -Table C1 of Appendix C
Uninterrupted flow conditions -Table C2 of Appendix C
4DC 4 lanes divided carriageway with clearway (Uninterrupted flow conditions of Appendix C)
4UC 4 lanes undivided carriageway with clearway
4U 4 lanes undivided carriageway with some parking
2U 2 lanes

3.3.4 Impact on Critical Intersections

An analysis of the operation of the surveyed critical intersections with the development in place was also carried out using the SIDRA computer intersection modelling program. The results of this analysis are summarised in **Table 7**.

INTERSECTION	AM		PM	
	Delay sec/v	LoS	Delay sec/v	Los
Traffic Signals				
Old Northern Road with Cecil Avenue	32.0	C	39.7	C
Terminus Street with Crane Street	54.4	D	46.3	D
Roundabout				
Cecil Avenue with Orange Grove	8.9	A	8.6	A
T-Junctions				
Old Northern Road with Francis Street	70	F	>70	F
Francis Street with Roger Avenue	6.2	A	5.6	A
Cecil Avenue with Terminus Street	11.2	A	12.2	A

Table 7: Operation of Intersections with Proposed Development

The intersection of Old Northern Road with Cecil Avenue would continue to operate at a satisfactory level of service "C" during the morning peak and the afternoon peak hours.

The traffic signals at the intersection of Terminus Street with Crane Street would operate at an acceptable level of service "D" during the morning peak and the afternoon peak hours.

The roundabout controlling the intersection of Cecil Avenue with Orange Grove Street would continue to operate at a very good level of service "A" during the morning and afternoon peak periods.

The right turning movement from Old Northern Road into Francis Street would experience slightly higher delays exacerbating an already very poor level of service "F".

As mentioned before, to resolve this existing problem, traffic signals incorporating an exclusive right turn bay should be installed.

4. Summary and Conclusions

Merc Property Pty Ltd is submitting a Planning Proposal for a mixed-residential development to be situated between Cecil Avenue and Roger Avenue, Castle Hill, comprising four (4) buildings including a total of 52,860 m^2 of residential (460 units) and 8,810 m^2 of commercial development

The proposed development will comply with Council's parking requirements. To minimise the impact along Cecil Avenue on-street parking adjacent to the development may need to be restricted. A detailed assessment of the traffic implication of the proposed development will be carried out in conjunction with the preparation of the development application.

Currently Old Northern Road operates at a good level of service "B" or better. All other roads operate at a very good Level of Service "A". The proposed potential developments would only marginally affect the level of service of most major approach roads to the site which would operate at a Level of Service "B" or better.

The signalised intersection of Old Northern Road with Cecil Avenue and the intersection of Terminus Street with Crane Street currently operates at levels of service "C" and "D" respectively. These levels of service will not be unduly affected by the proposed development.

Thus the surrounding road network would easily accommodate the traffic generated by the proposed development, more particularly the intersection of Francis Street with Old northern Road where traffic signals would be required including the provision of an exclusive right turn lane from Old Northern Road.

Preliminary investigation indicates that the intersection upgrade and its cost is a feasible proposition within the scale of development growth envisaged for the town centre and in the Cecil Avenue proposal and taking into account the existing traffic conditions.

It is anticipated that the design and implementation of the intersection upgrade would be made in consultation with RMS and Council at subsequent stages as a normal part of the planning and development process.

TDG

References

Roads and Traffic Authority of NSW (2002) *"Guide to Traffic Generating Developments".* Issue 2.2. October.

Standards Australia (2004). *"AS 2890.1-2004 Parking Facilities Part 1 Off Street car parking."*

Appendix A

Concept of Carriageway Capacity and Level of Service

The capacity of major streets within an urban area can be based on an assessment of their operating Level of Service.

Level of service is defined by Austroads as a "qualitative measure of the effects of a number of features, which include speed and travel time, traffic interruptions, freedom to manoeuvre, safety, driving comfort and convenience, and operating costs. Levels of service are designated from A to F from best (free flow conditions) to worst (forced flow with stop start operation, long queues and delays) as follows:

***LEVELS OF SERVICE**

A - Free flow (almost no delays)
B - Stable flow (slight delays)
C - Stable flow (acceptable delays)
D - Approaching unstable flow (tolerable delays)
E - Unstable flow (congestion; intolerable delays), and
F - Forced flow (jammed)

A service volume, as defined by Austroads, is the maximum number of vehicles that can pass over a given section of roadway in one direction during one hour while operating conditions are maintained at a specified level of service. It is suggested that ideally arterial and sub-arterial roads should not exceed service volumes at level of service C. At this level, whilst most drivers are restricted in their freedom to manoeuvre, operating speeds are still reasonable and acceptable delays experienced. However, in urban situations, arterial and sub-arterial roads operating at Level of Service D are still considered adequate. Traffic Volumes along urban roads with interrupted and uninterrupted flow conditions are included in **Table A1** and **A2** respectively.

	DESCRIPTION	LEVEL OF SERVICE					
		A	B	C	D	E	F
2U	2 Lane Undivided	540	630	720	810	900	F
4UP	4 Lane Undivided with Two Parking Lanes	540	630	720	810	900	F
4U	4 Lane Undivided with Some Parking	900	1050	1200	1350	1500	O
4UC	4 Lane Undivided with Clearways	1080	1260	1440	1620	1800	R
4D	4 Lane Divided with Clearways	1140	1330	1520	1710	1900	C
6U	6 Lane Undivided	1440	1680	1920	2160	2400	E
6D	6 Lane Divided with Clearway	1740	2030	2320	2610	2900	D

Table A1: Level of Service Interrupted Flow Conditions along Urban Roads (One Way Hourly Volumes)

	DESCRIPTION	LEVEL OF SERVICE					
		A	B	C	D	E	F
2U	2 Lane Undivided	760	880	1000	1130	1260	F
4U	4 Lane Undivided with Some Parking	1260	1470	1680	1890	2100	O
4UC	4 Lane Undivided with Clearways	1510	1760	2010	2270	2520	R
4DC	4 Lane Divided with Clearways	1600	1860	2130	2400	2660	C
4DCL	6 Lane Undivided with Clearways	2250	2620	3000	3380	3740	E
6DC	6 Lane Divided with Clearway	2440	2840	3250	3660	4060	D

* 40% higher than base volumes in Table F1

Table A2: Level of Service Uninterrupted Flow Conditions along Urban Roads (One Way Hourly Volumes)

Appendix B

Guidelines for 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)*