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Gabites Porter		

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Gabites Porter		

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Gabites Porter		

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Gabites Porter		

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Gabites Porter		

SCC Review Gabites Porter	**Alignment 171 Network With and Without Moss Vale Road Link (West Cambewarra Rd to Narang Rd)**	**Figure 12**

ADDENDUM

NOWRA/BOMBADERRY TRANSPORT MODEL

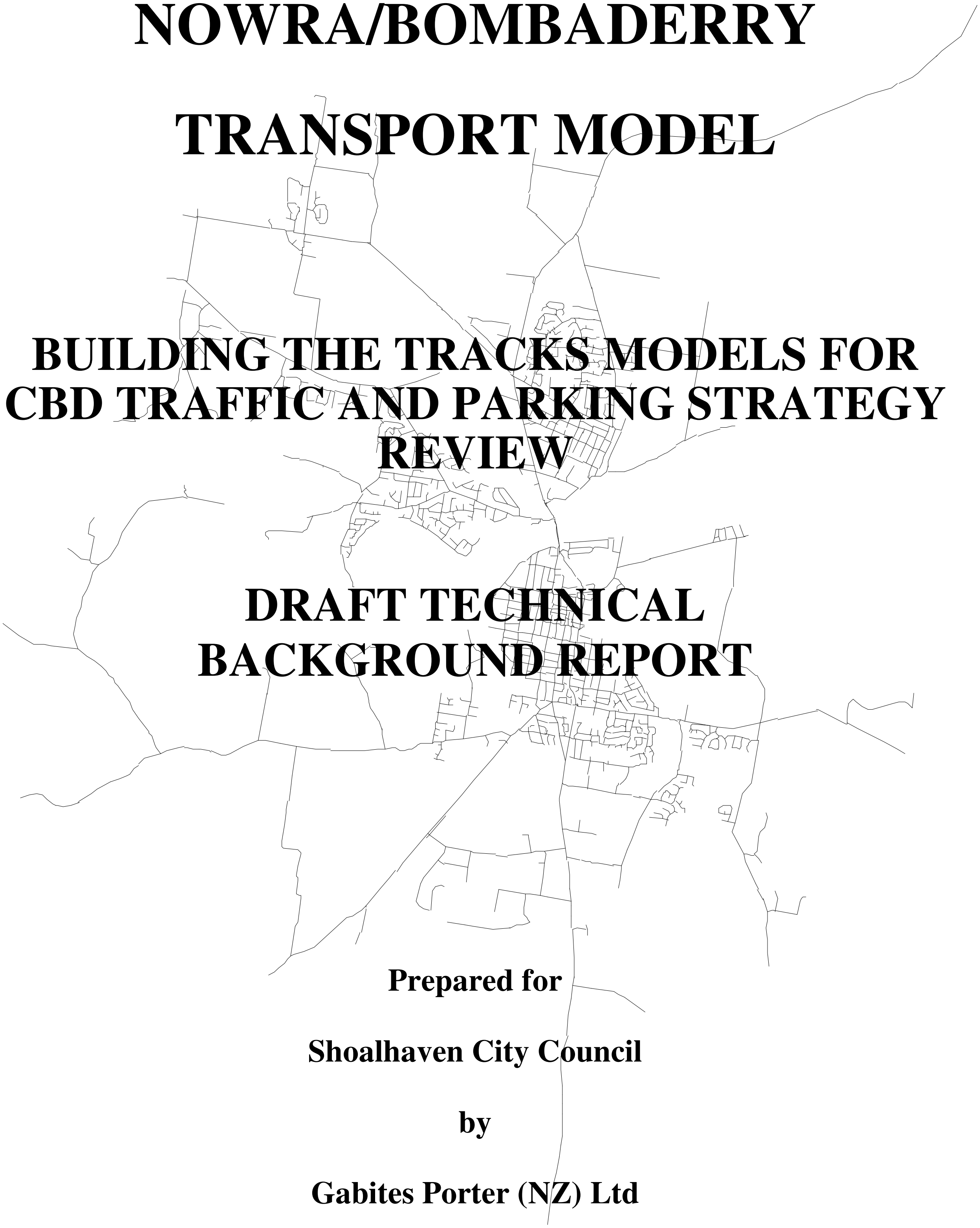
BUILDING THE TRACKS MODELS FOR CBD TRAFFIC AND PARKING STRATEGY REVIEW

DRAFT TECHNICAL

BACKGROUND REPORT – July 2002

NOWRA/BOMBADERRY

TRANSPORT MODEL



BUILDING THE TRACKS MODELS FOR CBD TRAFFIC AND PARKING STRATEGY REVIEW

DRAFT TECHNICAL BACKGROUND REPORT

Prepared for

Shoalhaven City Council

by

Gabites Porter (NZ) Ltd

July 2002

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1. INTRODUCTION

1.1 Background

In August 1993, Wollongong City Council, the RTA, Shellharbour Municipal Council and Shoalhaven City Council jointly decided to establish a land use transportation model to address issues in the Illawarra region, and in the area administered by the first two Councils.

Accordingly Gabites Porter (NZ) Ltd submitted a proposal to develop a TRACKS transportation model which outlined three stages of work comprising:

Stage 1 Preparation of a model which will enable the arterial road network of the Illawarra region to be analysed for an average weekday, and for peak tourist traffic.

Stage 2 Refinement of the model to enable simulation of commercial centre parking and traffic circulation for the morning peak, Offpeak and evening peak.

Stage 3 An optional stage which will provide training in the use of the models with real problems as examples.

As part of Stage 3, Shoalhaven Council engaged Gabites Porter to develop models of Nowra/Bomaderry.

With the release of the 1996 Census data Shoalhaven Council commissioned Gabites Porter NZ Ltd to update their model and to incorporate the latest technology of movement based delays during traffic assignment.

In early 2002, Shoalhaven City Council prepared a consultant's brief to investigate, advise and report to Council on the transport and traffic management aspects of Council's Nowra CBD Strategy. The project will also require investigation to assess the short and long term impacts on a possible expansion of the retail core of the Nowra CBD to the eastern side of the Highway, and to advise on measures to mitigate possible impacts.

The study has been grouped into four projects, as follows:
- Project One – Survey, data collection, coding and reporting.
- Project Two – Model development.
- Project Three – Development of draft Strategy.
- Project Four – Preparation of concept plans.

The Council commissioned Gabites Porter (NZ) Ltd to undertake the model development phase (i.e. Project Two) of this study. This requires:

- Review the data supplied by the Council from Project One.
- an offpeak model for 1996 to be developed and updated to movement based delays (to be consistent with the technology used in the three other models).
- confirmation that the 24 hour, AM, offpeak and PM models validate to 1996 parking surveys and traffic counts using the latest versions of TRACKS software.

- that 24 hour, AM, offpeak and PM models be developed for 2016 using a ‘do minimum’ network and landuse as agreed with Shoalhaven City Council.

- That future parking requirements be assessed in the AM and offpeak models.

- Updating all models into the ‘Trailhead’ user interface.

This report outlines the development and validation of the 1996 models as well as the development of the 2016 models and supersedes the following reports:

- “Nowra Transportation Model – Building the Transportation Model”, *Technical Background Report*, Transportation & Traffic Systems Ltd, January 1996.

- “Nowra Transportation Model – Updating the Transportation Model to 1996 Census Data”, *Supplementary Technical Background Report*, Transportation & Traffic Systems Ltd, March 1999.

1.2 Summary of the Model

This section provides a brief overview of the model with a more detailed description in subsequent sections.

Geographic Coverage

The study area covers the townships of Nowra and Bomaderry.

Periods

The Nowra model comprises four discrete models covering:

- 24 Hour Model — 24 hour travel demand and assignment
- AM Peak — 0700-0900 travel demand (Assigned 8-9am peak traffic)
- Offpeak — 0900-1600 travel demand (Assigned 11-12 noon traffic)
- PM Peak — 1600-1800 travel demand (Assigned 5-6pm peak traffic)

Network Detail

The road network was initially obtained from GIS systems in 1995 and hence includes all roads within the District. Key additional roads have been manually added by the Council to the network such that it is an accurate model of the District’s road network as at 2002.

Modelling Techniques

This is a standard three-step model comprising vehicle driver trip generation, distribution and assignment. The current three steps are outlined below.

Private/Internal Trip Generation
Trip productions are calculated from 9 categories – three employee categories by three vehicle availability categories. The generation rates come from the 1991/92 Sydney Home Interview Survey carried out by the Transport Study Group (TSG).

Trip attractions and commercial vehicle generations are calculated from regression derived equations.

Existing 1996 land use data was obtained from the Council.

Trip Distribution
Trip ends are formed into origin/destination matrices using a standard gravity model. A function of travel time is used for spatial separation.

Assignment
Assignment of trips to the network uses an incremental time slice process. This does not have the convergence issues associated with an equilibrium assignment, and permits intersection delays to be directly calculated during the assignment process.

Intersection delays are calculated by movement using the algorithms in ARR123 (SIDRA) and Tanner's queuing theory extended by Fisk and Tan, and later by Gabites Porter. All traffic signals use variable cycle times.

External Traffic

The model has been validated using actual counts at the external points.

Vehicle Types

Vehicle types used in the model include cars and heavy (HCV) and light commercial (LCV) vehicles.

Software Platform

The model has been developed using TRACKS, which is the proprietary land use and transport planning software developed, maintained and marketed by Transportation & Traffic Systems Ltd. It has been assumed that the reader is familiar with the software, and has read the User Manual as this includes the theoretical background to the algorithms, and hence the models.

The user interface for the model is the TRACKS application 'Trailhead'. This allows users to view and run existing models, create new landuse and network options and run them. All model outputs may be accessed through the Trailhead interface.

1.3 Study Approach

A transportation model for a given time period comprises a group of linked mathematical formulae that approximate the traffic network and the general behaviour of drivers using it. It is accepted that the analysis may not take into account extremes of human behaviour, nor will it reflect all the subtle complexities of the transport system. Nevertheless the model which has been developed is capable of identifying the more significant factors and is adequate to test adjustments to the road network and land use system which are likely to show the greatest benefit in relation to their costs.

Four period models were developed, with the following application in mind.

Transportation Model	Modelling	Application
24 Hour Model	24 hour average Weekday	• Broad landuse options • Travel characteristics • Economic evaluations • Strategic network considerations
AM Peak	One hour peak Between (0700 – 0900 hrs)	• Central area access • Intersection performance • Design issues • Long term parking demand • Site specific issues
Inter Peak	One hour peak Between (0900 –1200 hrs)	• Intersection performance • Design issues • Site specific issues • Parking Demand • CBD Design
Evening Peak	One hour peak Between (1600 – 1800 hrs)	• Intersection performance • Design issues • Site specific issues

These models have the same basic zone system and network structure, but clearly are designed to address different questions.

Modelling necessitates a series of compromises because of the constraints of current techniques, or because data is not available by which to utilise the techniques, or because resources are not available at the time. Nevertheless, a model is a `living' tool, which has and should continue to be improved incrementally over the years, as needs dictate and resources permit.

1.4 Report Content

This report as its title suggests is designed as a technical document. It is intended to be a reference volume of how the transportation model was built and, we believe, contains all the information necessary to completely build the analytical system. It highlights the assumptions made, the techniques adopted, and the relationship used. As well, it demonstrates the extent to which the model used was validated that is how well it replicated travel demand and actual traffic flows.

The volume is intended to be of interest to transportation planners and engineers. It is unashamedly technical and uses jargon without apology.

2. MODEL OVERVIEW

2.1 Model Form

Planning of a land use transport system requires that the system can be adequately modelled and the effects of any change can be reliably forecast.

A useful method is to build mathematical models that simulate travel behaviour. The land use and traffic modelling used for this study comprised four sequential stages. That is, trip generation, trip distribution, trip assignment and evaluation.

The transportation model was developed within the transportation planning package TRACKS.

Trip End Generation The generation of trip ends for each sub area (zone) within the study area. The trip ends were generated according to the pattern of households and employment activity, and then allocated accordingly.

The model was based on vehicle trips, rather than person trips. As a result, the modal split phase was inherent in the trip end generation rather than following the distribution stage.

Trip Distribution The conversion of trip ends to trips distributed within the study area according to a function of activity and travel cost.

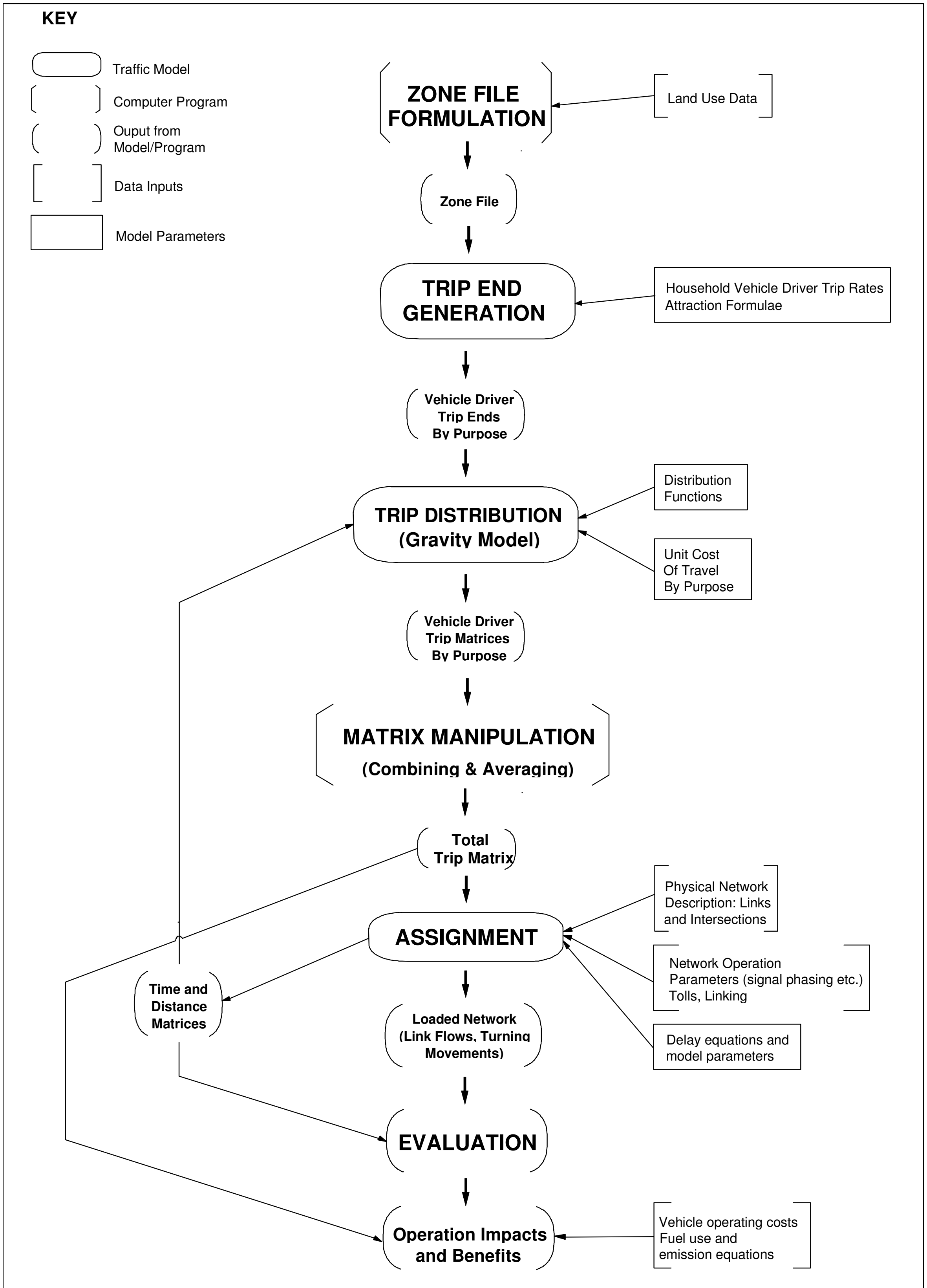
Trip Assignment The loading of trips between zones onto the road network as traffic flows.

Evaluation The final stage of the process where operational impacts are assessed.

The relationships between the different components are summarised schematically in Figure 1. The study and this report cover the first three stages. Evaluation and operational impacts of particular projects will be the subject of later reports for Council decision making and funding.

There is an iterative process where the interzonal times and distances which result from the assignment phase feed back into the trip distribution phase. The process can be started by assuming times and distances as initial impacts to distribution, or by assuming initial trips as input to assignment. In any event, the assignment/distribution loop is repeated until there is little or no change in the vehicle hours and vehicle kilometres of travel between iterations. Note that this will only occur if there is sufficient capacity in the network. More detail on convergence is given in Chapter 8.

The actual TRACKS programs used and the relationships between these programs are depicted in flow diagrams which are included as Appendix 6. Each of these correspond to the model form of the all day, AM peak, offpeak and evening peak models respectively. They are simplified in that some of the MATRIX programs contain multiple matrix operations. Subsequently not all of the matrix manipulation inputs and outputs are presented as a means of reducing the complexity of the diagrams.



Nowra District Transport Model Gabites Porter Consultants	**VEHICLE DRIVER MODEL COMPONENTS**	Figure 1

The key relationships are presented however and it is recommended that these flow diagrams be studied in conjunction with the parameter file contents themselves and the TRACKS manual to gain a full understanding of the composition.

2.2 The Study Area and TRACKS Zone System

The study area covers the townships of Nowra and Bombaderry as is depicted in Figure 2. This study area was divided into subareas to form a zone system. The zone system was originally developed in 1995 and contained 185 zones. This was expanded to 200 zones when the model was updated to 1996 census data in 1998. More recently the model has been further expanded to a total of 250 zones so that a sufficient number of spare zones exist to model future development. Zones 242-250 (formerly zones 188 to 196) are external entry points which cross the study area boundary. The four special attractor zones which are discussed later tin this report have also been renumbered to 236 to 239 (formerly 197 to 200). The external zones and locations of the special attractor zones are specified on Figure 2.

A small number of zones have been further refined for the future network to better model additional development between 1996 and 2002 and to highlight areas for future development,

2.3 The Road Network

The network used in the study was built from scratch. The network was taken from the Council's GIS system in 1995. It included all the roads within the study area. It has since been updated by the Council to include key additional development to bring it up to 2002. All signalised and priority intersections were coded into the network.

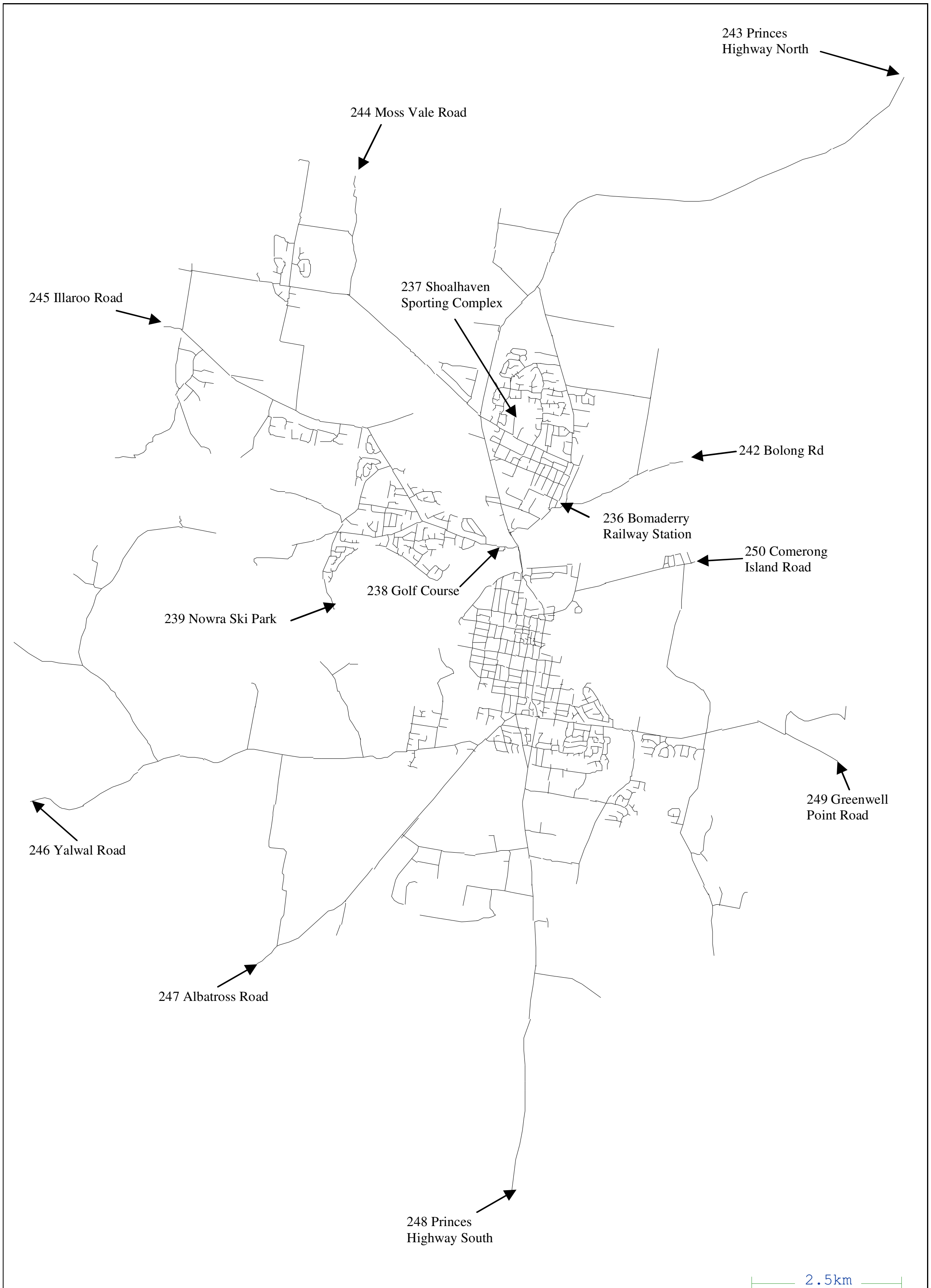
Because the network is a true representation of the road infrastructure, then the distances are calculated directly from the coordinate data. This removes the need to manually code distances and also removes the potential for coding errors.

All other components of network coding were prepared from visual inspection or from the Council's set of aerial photos, for example:

- Link lanes
- Link free flow speeds
- Approach controls
- Approach lanes and disciplines

.

All roundabouts and priority intersections were coded into the network. One of the features of TRACKS is the ease of intersection coding, whereby only the lane disciplines are required for priority intersections. Conflicting movements are internally identified from the geometry of the network.



Nowra District Transport Model	THE ROAD NETWORK FOR THE STUDY AREA	Figure 2
Gabites Porter Consultants		

Nowra District Transport Model	**NOWRA DISTRICT MODEL ZONE SYSTEM**	Figure 3a
Gabites Porter Consultants		

Nowra District Transport Model	**NOWRA CBD ZONE SYSTEM**	Figure 3b
Gabites Porter Consultants		

3. LAND USE DATA

3.1 Existing Land Use

The key land use variables used by the modelling system, which were compiled from 1996 Census CCD level to traffic zone level were:

At the home CCD

- Households (number occupied on census night)	**(HH)**
- Average number of employees/household	**(EMP/HH)**
- Average number of vehicles available/household	**(VEH/HH)**

At the workplace CCD the number of jobs available are represented by ASIC classification:

- Retail & Wholesale Trade, Restaurants and Hotels	**(RET)**
- Community, Social and Personal Services	**(COM)**
- Office and Finance	**(OFF)**
- Manufacturing	**(MAN)**
- Total jobs	**(TOT)**

Total jobs include those jobs, which do not fall under the aforementioned ASIC classifications.

Additional variables used were:

CBD Total Parking	**(CBDT)**
Primary School Roll	**(PSCH)**
Secondary School Roll	**(SSCH)**
TAFE Roll	**(TAFE)**
NOWRA Fair Retail Jobs	**(NFRJ)** (used in offpeak model only)

The landuse has been modified since that used in the 1998 validation report as a number of zones have been split as follows (all of these changes are reflected in the zone boundaries depicted in figures 3a and 3b):

- Zones 66, 69 and 70 now form zones 66, 69, 70 and 220.
- Zones 67 and 68 now form zones 67, 68 and 158.
- Zone 128 now forms zones 128, 221 and 223.
- Zone 111 now forms zones 111 and 226.
- Zone 79 now forms zones 79 and 235.
- Zone 78 now forms zones 78, 232, 233 and 234.
- Zones 66 and 165 have been redistributed.

Table 1 summaries the 1996 land use totals that apply to the study area.

TABLE 1

LAND USE DATA SUMMARY

Variable	Study Area Totals (1996)
Households	9615
Employees	9780
Employees/HH	1.02
Vehicles	12326
Vehicles/HH	1.28
Primary School Roll	3987
Secondary School Roll	4116
TAFE Roll	1851
Community etc. Jobs	2813
Retail etc. Jobs	3617
Office and Finance Jobs	1037
Manufacturing Jobs	1485
Total Jobs	10326
CBD Total Parks	6795
Nowra Fair Retail Jobs (off peak only)	360

The land use zone files used for the model are included in Appendix 1.

4. TRIP END GENERATION

Trip end generation is divided into three main categories: private, commercial and external. The balance of the external flow (including through traffic) is assumed to be a combination of all the other purposes. Hence the balance includes both through traffic and external to internal traffic. (See later section)

4.1 Household Category Curves

In line with recent transportation models, a `category model' approach to private trip end generation was adopted. For the category model the two variables of persons per household and vehicle availability per household were used to determine the total number of vehicle trips made within the study area on an average weekday. Fifteen categories were used – five person categories by three vehicle availability categories. The curves describing the percentage of households within each category for a specific household composition are shown on Figure 4.

These curves are calibrated with persons per household, or vehicles per household plotted against the proportion of households in that category. These were subject to the constraints that the sum of proportions at any point was equal to 1.0, and that when multiplied out the average for the point was maintained.

The assumption inherent in the use a category generation model is that the two variables (persons/household and vehicles/household) are not highly correlated. Certainly, experience has shown that persons and vehicles are less correlated than employees and cars. The second reason for choosing these variables was the need to have categories that can be readily forecast, and persons, and vehicles are perhaps the easiest.

The number of households in each of the fifteen categories for a zone depends on the average number of persons and vehicles per household giving a combined probability.

i.e. $\rho_{1,\,2+} = \rho_1 \times c_{2+}$

where: $\rho_{1,\,2+}$ = proportion of households in category 1 person, and 2+ vehicles
ρ_1 = proportion of households with one person
c_{2+} = proportion of households with 2+ vehicles.

For any particular zone the average number of vehicles per household and number of employees per household were provided in the land use zone files for 1996.

4.2 Private Trip End Productions

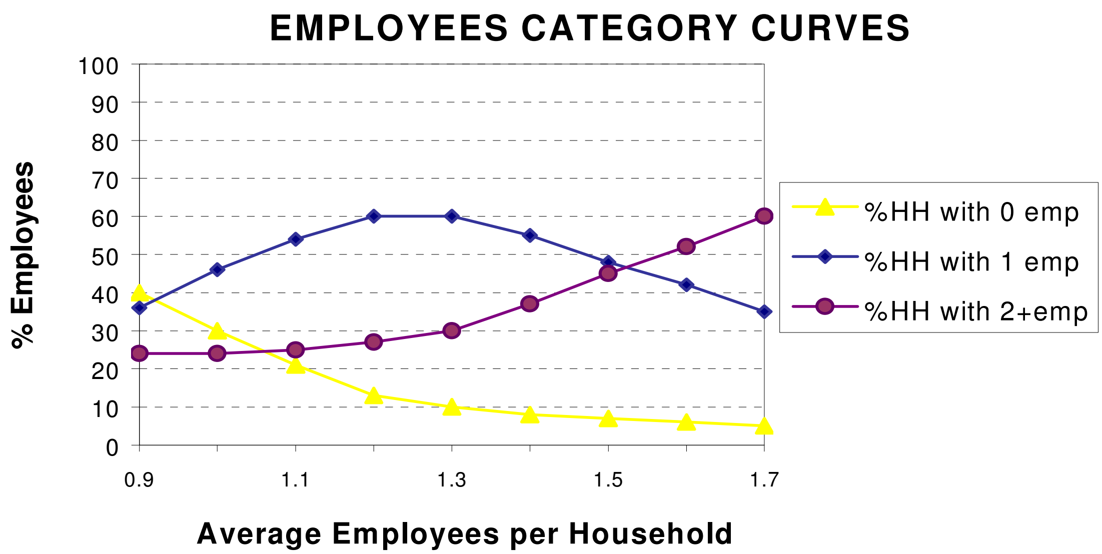
The Private Trips were divided into the following separate purposes, namely:

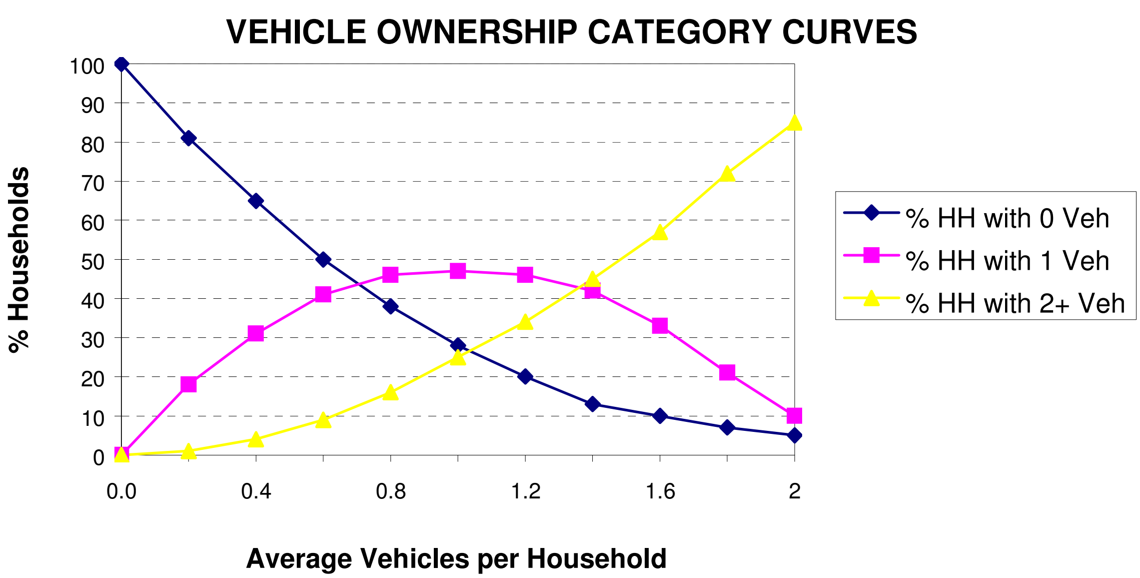
HBW	=	Home Based Work
HTW	=	Home to Work
WTH	=	Work to Home
HBB	=	Home Based Business (includes Shopping, Employer's Business and Personal Business)
HTB	=	Home to Business
BTH	=	Business to Home
HBO	=	Home Based Other (includes Education, Recreation and Other trips)
HTO	=	Home to Other
OTH	=	Other to Home
NHB	=	Non Home Based

These purposes were applied over all time periods for consistency, but in some cases the number of trips are insignificant.

Experience has shown that where possible 'from home' and 'to home' should be modelled separately in order to preserve the directionality of the trips. This is particularly important in the morning peak where the directional differences are significant.

This can result in some categories for some purposes having a small number of observations, but in general these produce only a handful of trips and the lesser confidence in the trip rates will have negligible effect on the results. It was considered more important to retain consistency between purposes and time periods.





Nowra District Transport Model	**HOUSEHOLD CATEGORY CURVES**	Figure 4
Gabites Porter Consultants		

4.2.1 24 Hour Private Trip End Productions

Private car driver trip ends were produced by using the ‘category model’ derived from the 1991/1992 Sydney Home Interview Survey by the Transport Study Group. The 24 hour model generation was carried out as ‘Home Based’ trips which generates both ‘Home To’ and ‘To Home’ trips for each purpose.

The trip rates used are shown in Table 2 below.

TABLE 2

24 HOUR ‘HOME TO’ TRIP END PRODUCTION RATES BY PURPOSE AND CATEGORY MODEL

Category	Employees /HH	Cars /HH	Trip Purpose			
			HBW	HBB	HBO	NHB
1	0	0	0	0	0	0
2	0	1	0.022	1.683	1.173	1.189
3	0	2+	0.206	1.773	1.706	1.020
4	1	0	0	0	0	0
5	1	1	0.677	1.093	1.181	1.619
6	1	2+	0.997	2.218	2.616	3.579
7	2	0	0	0	0	0
8	2	1	0.796	2.040	1.540	2.384
9	2	2+	1.093	2.206	2.818	3.747

4.2.2 Morning Peak Private Trip End Productions

Private car driver trip ends were produced by using the ‘category model’ derived from the 1991/1992 Sydney Home Interview Survey by the Transport Study Group. The morning peak period generation is for the two hours for trips beginning between 7am and 9am. Generation was carried out as ‘Home to’ and ‘to Home’ purposes to be consistent with the peak periods calculated later.

The trip rates used are shown in Tables 3A and 3B below.

TABLE 3A
AM PEAK PERIOD ‘HOME TO’ TRIP END PRODUCTION RATES BY PURPOSE AND CATEGORY MODEL

Category	Employees /HH	Cars /HH	Trip Purpose			
			HTW	HTB	HTO	NHB/2
1	0	0	0	0	0	0
2	0	1	0.008	0.084	0.025	0.004
3	0	2+	0.037	0.147	0.110	0.032
4	1	0	0	0	0	0.070
5	1	1	0.258	0.056	0.145	0.102
6	1	2+	0.330	0.190	0.291	0.172
7	2+	0	0	0	0	0.075
8	2+	1	0.326	0.080	0.280	0.176
9	2+	2+	0.379	0.310	0.259	0.207

TABLE 3B
AM PEAK PERIOD ‘TO HOME’ TRIP END PRODUCTION RATES BY PURPOSE AND CATEGORY MODEL

Category	Employees /HH	Cars /HH	Trip Purpose		
			WTH	BTH	OTH
1	0	0	0	0	0
2	0	1	0	0.064	0.028
3	0	2+	0	0.067	0.039
4	1	0	0	0	0
5	1	1	0.032	0.018	0.007
6	1	2+	0.038	0.038	0.085
7	2+	0	0	0	0
8	2+	1	0.078	0.110	0
9	2+	2+	0.24	0.100	0.055

4.2.3 Offpeak Private Trip End Productions

Private car driver trip ends were produced by using the 'category model' derived from the 1991/1992 Sydney Home Interview Survey by the Transport Study Group. The Offpeak period generation is for the seven hours for trips beginning between 9am and 4pm. Generation was carried out as 'Home to' and 'to Home' purposes to be consistent with the peak periods calculated later.

The trip rates used are shown in Tables 4A and 4B below.

TABLE 4A
OFFPEAK PERIOD 'HOME TO' TRIP END PRODUCTION RATES BY PURPOSE AND CATEGORY MODEL

Category	Employees /HH	Cars /HH	Trip Purpose			
			HTW	HTB	HTO	NHB/2
1	0	0	0	0	0	0
2	0	1	0.007	0.522	0.260	0.487
3	0	2+	0	0.714	0.422	0.459
4	1	0	0	0	0	0
5	1	1	0.053	0.322	0.227	0.476
6	1	2+	0.067	0.704	0.589	1.230
7	2+	0	0	0	0	0
8	2+	1	0.032	0.135	0.126	0.634
9	2+	2+	0.072	0.579	0.423	1.079

TABLE 4B
OFFPEAK PERIOD 'TO HOME' TRIP END PRODUCTION RATES BY PURPOSE AND CATEGORY MODEL

Category	Employees /HH	Cars /HH	Trip Purpose		
			WTH	BTH	OTH
1	0	0	0	0	0
2	0	1	0	0.418	0.253
3	0	2+	0.037	0.571	0.281
4	1	0	0	0	0
5	1	1	0.098	0.258	0.199
6	1	2+	0.063	0.563	0.660
7	2+	0	0	0	0
8	2+	1	0.040	0.108	0.128
9	2+	2+	0.167	0.463	0.459

4.2.4 Evening Peak Period Private Trip End Productions

Private car driver trip ends were produced by using the ‘category model’ derived from the 1991/1992 Sydney Home Interview Survey by the Transport Study Group. The evening peak period generation is for the two hours for trips beginning between 4pm and 6pm. Generation was carried out as ‘Home to’ and ‘to Home’ purposes to be consistent with the peak periods calculated later.

The trip rates used are shown in Tables 5A and 5B below.

TABLE 5A
PM PEAK PERIOD ‘HOME TO’ TRIP END PRODUCTION RATES BY PURPOSE AND CATEGORY MODEL

Category	Employees /HH	Cars /HH	Trip Purpose			
			HTW	HTB	HTO	NHB/2
1	0	0	0	0	0	0
2	0	1	0	0.041	0.085	0.071
3	0	2+	0	0.077	0.109	0
4	1	0	0	0	0	0
5	1	1	0.025	0.055	0.085	0.112
6	1	2+	0.020	0.114	0.096	0.220
7	2+	0	0	0	0	0
8	2+	1	0	0.041	0.135	0.228
9	2+	2+	0	0.139	0.224	0.324

TABLE 5B
PM PEAK PERIOD ‘TO HOME’ TRIP END PRODUCTION RATES BY PURPOSE AND CATEGORY MODEL

Category	Employees /HH	Cars /HH	Trip Purpose		
			WTH	BTH	OTH
1	0	0	0	0	0
2	0	1	0.007	0.066	0.156
3	0	2+	0.027	0.129	0.242
4	1	0	0	0	0
5	1	1	0.075	0.172	0.145
6	1	2+	0.137	0.244	0.298
7	2+	0	0	0	0
8	2+	1	0.209	0.106	0.340
9	2+	2+	0.156	0.336	0.371

4.3 Private Trip Attractions

Trip end attractions are calculated using regression equations derived from other transportation studies. Because the actual trip productions have been determined by the category model generation the attraction equations effectively distribute the trip destinations throughout the study area according to the type and amount of land use in each zone. The following land uses have been used as the independent variables:

HH	Households
RET	Retail Jobs
COM	Community Jobs
OFF	Office and Finance Jobs
MAN	Manufacturing Jobs
TOT	Total Jobs
CBDT	Total CBD Parks
PSCH	Primary School Roll
SSCH	Secondary School Roll
TAFE	TAFE Roll
NFRTS	Nowra Fair Retail Jobs

Please note that the CBD Parks variables have the effect of attracting a proportion of trips directly to a parking space. The alternative is that vehicles will travel directly to their destination and then locate a parking space as is modelled in the TRACKS parking program 'CALM'. It is reasonable to assume that some but not all vehicles will adopt this code of behaviour. CALM operates as part of the AM and offpeak models, and allocates vehicles to employee only parks if the parks are in the same zone as the workplace destination. Subsequently in these two models, the CBDP landuse variable is used whereas the CBDT variable is used in the 24 hour and PM models.

Please note that by using the total number of parks as a landuse variable in the trip generation phase of the model, the TRACKS program CENTRL is no longer required to distribute trip ends in the CBD (see section 6.1).

For further details on the operation of CALM refer to section of this report and the user guide in Appendix 7.

4.3.1 24 Hour Private Trip Attractions

		'Home to' and 'To Home'
Work	=	0.79RET+0.79MAN+0.54TOT
Business	=	0.74HH+1.31COM+2.334(RET+MAN+CBDT)
Other	=	1.52HH+3PSCH+1.6SSCH+0.8TAFE+2.92(COM+CBDT)+ 0.68(RET+MAN)+0.61TOT
Non Home Based	=	0.036HH+0.184(RET+MAN+CBDT)+0.032TOT

4.3.2 Morning Peak Private Trip Attractions

		'Home to'	'To Home'
Work	=	0.06HH+0.5COM+0.502RET+0.07 TOT+0.28CBDT	0.06HH+0.5COM+0.502RET+0.07 TOT+0.28CBDT
Business	=	0.52HH+1.31COM+2.334(RET+2. 4CBDT)	0.52HH+1.31COM+2.334(RET+2. 4CBDT)
Other	=	0.3PSCH+0.48SSCH+1TAFE	0.3PSCH+0.16SSCH+.08TAFE
Non Home Based	=	0.74HH+1.31COM+4.668RET	

4.3.3 Offpeak Private Trip Attractions

		Home to	To Home
Work	=	0.2COM+0.502RET+0.17TOT	0.2COM+0.502RET+0.17TOT
Business	=	0.332COM+2.725RET+7.22OFF+7 .5CBDT+0.305TOT+40NFRJ	0.332COM+2.725RET+7.22OFF+7 .5CBDT+0.305TOT
Other	=	1.52HH+5TAFE+2.92COM+ 1.16RET+7OFF+0.305TOT+ 2.1CBDT+40NFRJ	1.52HH+5TAFE+2.92COM+ 1.16RET+7OFF+0.305TOT+ 2.1CBDT
Non Home Based	=	1.31COM+1.334RET+29.43OFF+1.2CBDT	

4.3.4 Evening Peak Private Trip Attractions

		Home to	To Home
Work	=	0.251TAFE+0.251MAN+ 0.841OFF+0.17TOT+ 0.125CBDT	0.251TAFE+0.251MAN+ 0.841OFF+0.17TOT+ 0.125CBDT
Business	=	0.036HH+0.184(TAFE+RET)+ 1.23OFF+0.032TOT+ 0.092CBDT	0.251TAFE+0.251MAN+ 0.841OFF+0.17TOT+ 0.125CBDT
Other	=	0.5HH+1.2SSCH+3.6TAFE+ 9.78OFF+2.92COM+ 0.61TOT+1.46CBDT	0.5HH+1.2SSCH+3.6TAFE+ 9.78OFF+2.92COM+ 0.61TOT+1.46CBDT
NHB Short Trips	=	0.377COM+1.729RET+3.458OFF+0.276TOT	
NHB Long Trips	=	0.377COM+1.729RET+3.458OFF+0.276TOT	

4.4 Commercial Vehicle Trips

The commercial vehicles in the model are represented as either light commercial vehicles (LCV) or heavy commercial vehicles (HCV). The generation rates identical to those used in the original 1996 census update. For commercial trips, productions are set equal to attractions.

The following equations were used each of the models

24 Hour Model

LCV = 0.3HH + 2.18 RET + 0.51COM+0.57MAN

HCV = 0.14HH + 0.7RET+0.18COM + 0.79MAN

Morning Peak

LCV = 0.031HH + 0.521 RET + 0.471OFF

HCV = 0.019HH + 0.1RET + 0.33MAN

Inter Peak

LCV = 0.064HH + 0.218COM + 0.934RET + 0.244OFF

HCV = 0.030HH + 0.078COM + 0.3RET + 0.338OFF

Evening Peak

LCV = 0.039HH + 0.066COM + 0.074RET + 0.074MAN

HCV = 0.018HH + 0.023COM + 0.031RET + 0.103MAN

4.5 External Trips

Any traffic entering the study area via roads crossing the study area boundary is called external traffic. There were 9 external cordon stations entering or leaving the study area (these are zones 242 to 250 in Figure 2).

The external traffic comprises of through traffic and external to internal traffic or internal to external traffic.

4.5.1 Through Trips

The through trips are those travelling through the study area, largely those to/from the south to Wollongong/Sydney via the Princes Highway. The through trips were established by a number plate survey carried out by Shoalhaven City Council staff. The traffic volumes and through trips modelled are tabulated in Tables 6A through 6D.

TABLE 6a

24 HOUR MODEL THROUGH TRAFFIC

Location	Zone	242	243	244	245	246	247	248	249	250
Bolong Rd	**242**	0	184	21	8	4	79	786	147	28
Princes Hway Nth	**243**	187	0	223	9	6	51	1184	158	27
Moss Vale Rd	**244**	101	154	0	24	2	43	366	94	19
Illaroo Rd	**245**	14	8	23	0	0	0	0	0	0
Yalwal Rd	**246**	5	5	2	0	0	2	3	2	0
Albatross Rd	**247**	77	44	27	0	2	0	98	33	2
Princes Hway Sth	**248**	783	1102	409	11	3	53	0	362	2
Greenwell Pt Rd	**249**	145	162	128	0	2	57	375	0	0
Comerong Isld Rd	**250**	24	29	17	0	0	2	4	0	0

TABLE 6B

AM PEAK (7-9AM) MODEL THROUGH TRAFFIC

Location	Zone	242	243	244	245	246	247	248	249	250
Bolong Rd	**242**	0	3	36	0	0	7	32	10	2
Princes Hway Nth	**243**	0	0	17	0	0	0	31	1	3
Moss Vale Rd	**244**	0	17	0	8	0	0	0	2	3
Illaroo Rd	**245**	0	0	11	0	0	0	0	0	0
Yalwal Rd	**246**	0	0	0	0	0	0	0	0	0
Albatross Rd	**247**	0	0	0	0	0	0	0	0	1
Princes Hway Sth	**248**	79	65	39	8	0	0	0	11	2
Greenwell Pt Rd	**249**	47	3	3	0	0	0	4	0	0
Comerong Isld Rd	**250**	15	12	3	0	0	2	1	0	0

TABLE 6c OFFPEAK (9AM-12NOON) MODEL THROUGH TRAFFIC										
Location	**Zone**	**242**	**243**	**244**	**245**	**246**	**247**	**248**	**249**	**250**
Bolong Rd	**242**	0	37	4	2	1	16	157	29	6
Princes Hway Nth	**243**	37	0	45	2	1	10	237	32	5
Moss Vale Rd	**244**	20	31	0	5	0	9	73	19	4
Illaroo Rd	**245**	3	2	5	0	0	0	0	0	0
Yalwal Rd	**246**	1	1	0	0	0	1	1	1	0
Albatross Rd	**247**	15	9	5	0	1	0	29	10	1
Princes Hway Sth	**248**	157	220	82	2	1	16	0	109	1
Greenwell Pt Rd	**249**	29	32	26	0	1	17	113	0	0
Comerong Isld Rd	**250**	5	6	3	0	0	1	1	0	0

TABLE 6d PM (4-6PM) PEAK MODEL THROUGH TRAFFIC										
Location	**Zone**	**242**	**243**	**244**	**245**	**246**	**247**	**248**	**249**	**250**
Bolong Rd	**242**	0	0	0	0	0	0	35	15	14
Princes Hway Nth	**243**	0	0	0	0	0	2	108	31	12
Moss Vale Rd	**244**	0	0	0	0	0	0	37	0	7
Illaroo Rd	**245**	0	0	0	0	0	0	0	0	0
Yalwal Rd	**246**	0	0	0	0	0	0	0	0	0
Albatross Rd	**247**	25	0	0	0	0	0	0	0	1
Princes Hway Sth	**248**	95	84	48	0	0	0	0	49	1
Greenwell Pt Rd	**249**	2	3	15	0	0	0	5	0	0
Comerong Isld Rd	**250**	3	3	3	0	0	2	1	0	0

4.5.2 Other External Traffic (excluding Through Components)

Once through trips have been excluded from the external road flows, all other external trips are treated as a composite of the other purposes. The productions are therefore the observed road flow less the through traffic component.

The production and attraction equations used for each time period are shown below where:

EXI External inbound total traffic
ETI External inbound through traffic
EXO External outbound total traffic
ETO External outbound through traffic

Those in bold determine the total generation.

	Productions	Attractions
24 Hour Model		
Inbound Ext	**EXI – ETI**	0.036HH+0.33RET+0.82OFF+ 0.092MAN+0.032TOT
Outbound Ext	0.036HH+0.33RET+0.82OFF+ 0.092MAN+0.032TOT	**EXO - ETO**
Morning Peak		
Inbound Ext	**EXI – ETI**	0.05HH+0.33RET+0.65OFF+0.092MAN+0.032TOT
Outbound Ext	0.05HH+0.33RET+0.65OFF+0.092MAN+0.032TOT	**EXO - ETO**
Offpeak		
Inbound Ext	**EXI – ETI**	0.036HH+0.82(RET+OFF)+ 0.092MAN+0.032TOT
Outbound Ext	0.036HH+0.82(RET+OFF)+ 0.092MAN+0.032TOT	**EXO – ETO**
Evening Peak		
Inbound Ext	**EXI – ETI**	0.108HH+0.092(RET+MAN+ CBDT)+0.82OFF+0.032TOT
Outbound Ext	0.108HH+0.092(RET+MAN)+ 1.13OFF+0.032TOT+ 0.046CBDT	**EXO – ETO**

4.5.3 External Traffic Summary

The external traffic flows used in the 1996 models are summarised below in Table 7.

TABLE 7

EXTERNAL ROAD FLOWS

24 Hour Model

Zone No.	Description	All External Traffic 2 Way	Through Traffic 2 Way
242	Bolong Rd	7300	2622
243	Princes Hway Nth	9510	3565
244	Moss Vale Rd	3030	1683
245	Illaroo Rd	830	116
246	Yalwal Rd	22	38
247	Albatross Rd	3140	590
248	Princes Hway Sth	16510	5572
249	Greenwell Point Rd	5880	1684
250	Comerong Island Rd	1000	172

Morning Peak (7-9am)

Zone No.	Description	All External Traffic		Through Traffic	
		Inbound	Outbound	Inbound	Outbound
242	Bolong Rd	722	437	90	141
243	Princes Hway Nth	678	527	52	100
244	Moss Vale Rd	161	194	30	109
245	Illaroo Rd	93	31	11	16
246	Yalwal Rd	16	11	0	0
247	Albatross Rd	145	524	1	9
248	Princes Hway Sth	1634	608	204	68
249	Greenwell Point Rd	643	175	57	24
250	Comerong Island Rd	87	38	33	11

TABLE 7 (cont.)

EXTERNAL ROAD FLOWS

Zone No.	Description	All External Traffic		Through Traffic	
		Inbound	Outbound	Inbound	Outbound
Offpeak (9am-12noon)					
242	Bolong Rd	750	626	252	267
243	Princes Hway Nth	814	802	369	338
244	Moss Vale Rd	232	251	161	170
245	Illaroo Rd	80	80	10	11
246	Yalwal Rd	13	25	5	5
247	Albatross Rd	260	280	70	70
248	Princes Hway Sth	1897	1881	588	611
249	Greenwell Point Rd	508	705	218	200
250	Comerong Island Rd	101	116	16	17
Evening Peak (4-6pm)					
Zone No.	**Description**	**All External Traffic**		**Through Traffic**	
		Inbound	**Outbound**	**Inbound**	**Outbound**
242	Bolong Rd	486	716	64	125
243	Princes Hway Nth	675	715	153	90
244	Moss Vale Rd	240	231	44	66
245	Illaroo Rd	66	92	0	0
246	Yalwal Rd	8	15	0	0
247	Albatross Rd	498	157	26	4
248	Princes Hway Sth	944	1740	277	186
249	Greenwell Point Rd	272	673	25	95
250	Comerong Island Rd	55	110	12	35

4.6 Special Generators

Shoalhaven Council staff have identified four sites in the Nowra District which generate traffic at a specified rate. These sites are included in Figure 2 and are treated much as externals are by defining each site as a zone (236-239) and specifying the inbound and outbound flows of each site. The generation rates of these sites are as below in Table 8.

TABLE 8

SPECIAL ZONE GENERATORS

Location	Zone	24 Hour	AM Peak		Offpeak		PM Peak	
			Inb	Outb	Inb	Outb	Inb	Outb
Bomaderry Railway Station	**236**	1300	110	110	160	140	122	93
Shoalhaven Sporting Complex	**237**	870	62	62	75	75	91	91
Golf Course	**238**	940	62	76	165	165	76	62
Nowra Ski Park	**239**	140	7	7	10	10	7	7

This generation was then regressed around Nowra according to the following attraction equations:

24 Hour Model

Attractions = 0.036HH + 0.33RET + 0.82 OFF + 0.092MAN + 0.032TOT

All Three Period Models

Attractions = 1.52HH + 2.92COM + 0.68RET + 0.61TOT

4.7 Additional Trip Purposes

In previous model validations for the Nowra District Transport Model additional trip purposes have been required to adequately model traffic and/or parking demand. These are External Non Home Based trips, School to Work trips, Additional Households Generation and Parking Circulation which are described in the following sections.

4.7.1 External Non Home Based Trips

There are a number of vehicles which enter the study area as an external trip that make internal non home based trips. For example, an external home to internal work trip may then go shopping thereby creating an extra non home based trip not otherwise generated in the model. A trip purpose has been included in the 24 hour, offpeak and PM peak models to generate such trips which seldom occur in the morning peak period.

The production and attraction regression equations used for these three models are as follows:

24 Hour Model

Productions = 0.074HH + 0.131COM + 0.467RET + 0.467MAN
Attractions = 1.31COM + 2.334RET

Offpeak Model

Productions = 0.908RET
Attractions = 0.908RET

PM Peak

Productions = 0.6CBDT
Attractions = 0.033COM + 0.393OFF

4.7.2 School to Work Trips

For the morning peak period, the Home to Other trips are primarily Home to School trips. The continuation trip from this is either a return trip to home or a continuation trip to some other destination, primarily work (i.e. if children are dropped off at school prior to work). Accordingly, these School to Work trips are generated for the morning peak model only, subject to the following regression equations:

AM Peak Model

Productions = 0.075PSCH + 0.04SSCH + 0.06TAFE
Attractions = 2.09OFF + 0.17TOT

4.7.3 Additional Household Generation

Further analysis of traffic counts and modelled flows in the validation process consistently showed the model to be underestimating traffic from Nowra East (south of Kalandar St and East of Albatross Rd) and from Bomaderry (south of Cambewarra and east of Princes Highway) in the 24 hour and AM peak models. The evening peak model generated additional household trips from a subset of these zones in both the north and south suburbs of the network. In the offpeak model the area which was underestimated was the portion of the model to the south of Plunkett Street.

To try to improve modelled flows an additional variable was established in the zone file that only included households in those areas from which additional trips were generated. The zones included are shown in the zone file in Appendix 1 (N.B. the zones are different in the offpeak and evening peak models from those used in the other two models).

The additional household generation has been included in all four models with production and attraction regression equations as follows (where ADD represents number of additional generation households):

24 Hour Model

Productions = 5ADD
Attractions = 1.31COM + 2.33(RET + MAN) + 2CBDT

AM Peak Model

Trips from Households
Productions = 0.6ADD
Attractions = 1.31(HH + COM) + 2.334RET + 1.94MAN

Offpeak Model

Trips from Households:
Productions = 2.45ADD
Attractions = 0.336CBDT

Trips to Households:
Productions = 0.336CBDT
Attractions = 1.6ADD (used to generate the trips)

PM Peak

Trips from Households:
Productions = 0.6ADD
Attractions = 1.31COM + 5RET + 1CBDT+6.7OFF

Trips to Households:
Productions = 1.31COM + 5RET + 1CBDT+6.7OFF
Attractions = 0.6ADD (used to generate the trips)

4.7.4 CBD Parking Circulation

In the CBD of an town or city, some vehicles are likely to circulate about the major retail and parking area locating a parking space near to their destination. This occurs primarily during the morning peak and offpeak periods but is seldom evident during the evening peak as parks are rapidly being vacated at the end of the working day.

The CALM parking model which is included as part of the AM and offpeak transport models generates these circulation trips, however no allowance is made in the 24 hour model for such trips. Subsequently the 24 hour model includes a parking circulation purpose with production and attraction regression equations as follows:

24 Hour Model

Productions = 0.5CBDT
Attractions = 0.5CBDT

4.8 Total Trip End Generation Summary

The relationships outlined in the preceding sections describe the trip end generation for the four model time periods, namely the 24 hour model, 7-9am morning peak, the 9-4pm Offpeak and the 4-6pm evening peak. **These generation periods are chosen to be consistent with the HIS results used in the category model.** The trip end totals for each purpose are shown below in Tables 10A to 10D.

It is important to note that to make later assignments easier to interpret the final trip matrices have been factored to equivalent peak hourly matrices. The offpeak model is a little more complex in that the 7 hour generation is factored back to a 3 hour parking model (9am-12noon) to be consistent with surveyed parking occupancies. For this reason the external traffic and special generation zone traffic reported in sections 4.5 and 4.6 respectively, report 3 hour flows. All other traffic is reduced from 7 hours (9am to 4pm) to a 3 hour period (9am to 12 noon) by a factor of 0.4 prior to running the CALM parking model. The factoring from 2 hours (AM and PM) or 3 hours (Offpeak) back to a peak hour for assignment allow the assigned traffic volumes to be interpreted more easily, and are as follows in Table 9.

TABLE 9

FACTORING TO HOURLY MATRICES

Trip Purpose	AM Factor	Offpeak Factor	PM Factor
Private Internal Trips	0.55	0.34	0.55
External Trips	0.55	0.34	0.55
Through Trips	0.55	0.34	0.55

TABLE 10A

ALL DAY TRIP END PRODUCTION SUMMARY

Trip Purpose	Trip Ends	% of Private	Private Trips/HH	% of Total
Home Based Work	5262	7.72%	0.547	
Home Based Business	14069	20.64%	1.463	
Home Based Other	14453	21.20%	1.503	
Non Home Based	18273	26.81%	1.900	
Additional Household Generation	12710	18.65%	1.322	
Parking Circulation	3398	4.98%	0.353	
PRIVATE TRIPS	**68165**	**100.00%**	**7.089**	**51.33%**
External Non Home Based	3462			2.61%
External and Special Generator Inbound	17215			12.96%
External and Special Generator Outbound	17215			12.96%
External Throughs	8138			6.13%
Light Commercials	13051			9.83%
Heavy Commercials	5557			4.18%
TOTAL TRIPS	**132805**	Intrazonals	**3276**	**100.00%**

TABLE 10B MORNING PEAK TRIP END PRODUCTION SUMMARY				
Trip Purpose	**Trip Ends**	**% of Private**	**Private Trips/HH**	**% of Total**
Home Based Work To Work To Home	 1859 234	 18.28% 2.30%	 0.193 0.024	
Home Based Business To Business To Home	 1100 461	 10.82% 4.53%	 0.114 0.048	
Home Based Other To Other To Home	 1494 294	 14.68% 2.89%	 0.155 0.031	
Non Home Based	2062	20.27%	0.214	
School to Work	575	5.65%	0.060	
Additional Household Generation	1525	14.99%	0.159	
CALM CBD Circulation Trips	784	7.71%	0.082	
PRIVATE TRIPS	**10171**	**100.00%**	**1.058**	**49.33%**
External and Special Generator Inbound	3942			19.12%
External and Special Generator Outbound	2322			11.26%
External Throughs	478			2.32%
Light Commercials	2671			12.95%
Heavy Commercials	1034			5.02%
2 Hour Trips	**20618**			**100.00%**
Peak Hour Trips	**11455**	Intrazonals	**355**	

TABLE 10C OFFPEAK (9-12) trip end PRODUCTION SUMMARY				
Trip Purpose	**Trip Ends**	**% of Private**	**Private Trips/HH**	**% of Total**
Home Based Work To Work To Home	 134 219	 0.71% 1.16%	 0.014 0.023	
Home Based Business To Business To Home	 1548 1239	 8.23% 6.59%	 0.161 0.129	
Home Based Other To Other To Home	 1099 1092	 5.84% 5.80%	 0.114 0.114	
Non Home Based	4720	25.09%	0.491	
Additional Generation To HH From HH	 1685 280	 8.96% 1.49%	 0.175 0.263	
CALM CBD Circulation Trips	4499	23.91%	0.468	
PRIVATE TRIPS	**18815**	**100.00%**	**1.957**	**53.06%**
External Non Home Based	1313			3.70%
External and Special Generator Inbound	3376			9.52%
External and Special Generator Outbound	3467			9.78%
External Throughs	1689			4.76%
Light Commercials	4860			13.70%
Heavy Commercials	1943			5.48%
3 Hour Trips	**35463**			**100.00%**
Peak Hour Trips	**12058**	Intrazonals	**455**	

TABLE 10D

EVENING PEAK TRIP END PRODUCTION SUMMARY

Trip Purpose	Trip Ends	% of Private	Private Trips/HH	% of Total
Home Based Work				
To Work	80	0.69%	0.008	
To Home	807	6.98%	0.084	
Home Based Business				
To Business	617	5.33%	0.064	
To Home	1421	12.28%	0.148	
Home Based Other				
To Other	910	7.87%	0.095	
To Home	1964	16.98%	0.204	
Non Home Based	2550	22.04%	0.265	
Additional Generation				
To HH	1610	13.92%	0.167	
From HH	1610	13.92%	0.167	
PRIVATE TRIPS	**11301**	**100.00%**	**1.201**	**46.79%**
External Non Home Based	4077			16.49%
External and Special Generator Inbound	2939			11.89%
External and Special Generator Outbound	4101			16.58%
External Throughs	601			2.43%
Light Commercials	938			3.79%
Heavy Commercials	503			2.03%
2 Hour Trips	**24728**			**100.00%**
Peak Hour Trips	**13590**	Intrazonals	**480**	

5. TRIP DISTRIBUTION AND THE COSTS OF TRAVEL

5.1 The Gravity Distribution Model

Having derived the trip end generation as discussed above the task was then to distribute trips between the zones. That is, knowing that trips want to be made for a particular purpose, to what zone are they likely to travel. This process is called trip distribution and creates the trip matrices that like the origin-destination pairs.

The gravity model form chosen for this work was

$$T_{ij} = P_i.K_i\ A_j.L_i\ f(c_{ij})$$

subject to the double constraints of

$$K_i = P_i \frac{}{\Sigma_j\ T_{ij}}$$

$$L_j = A_j \frac{}{\Sigma_j\ T_{ij}}$$

Where:

T_{ij} = Trips between zones i and j
P_i = Productions at zone i
A_j = Attractions at zone j
$f(c_{ij})$= Some function of the travel cost between zones i and j
$K_i\ L_j$= Balancing factors

The balancing factors are successively applied until there is convergence. Some 50 iterations were used, and all purposes converged so that there was no difference between iterations to five decimal places.

The derivation of P_i and A_j has been discussed in Section 4. This section will deal with the distribution function $f(c_{ij})$ and the costs of travel.

5.2 The Distribution Function

The distribution function can be approximated to an exponential line of the form

$$f(c_{ij}) = e^{-\beta C_{ij}}$$

where:

c_{ij} = at + bd
t = time between zone i and zone j
D = DISTANCE ZONE I AND ZONE J
a = perceived time cost
b = perceived distance cost

The β values were based on the distribution functions used successfully in previous Transportation Studies which were originally time only based. If an average network speed of about 40km/h is assumed then:

$$\beta = \alpha/(\alpha + 40\beta/60)$$

where:

$$\alpha = \text{time based distribution function value}$$

and $\beta c_{ij} = \alpha\, t_{ij}$

The distribution function values used (β) are shown in Table 11. It should be noted that the alpha values are the same for 'from home' and 'to home' purposes, and the matrices combined prior to trip length frequency analysis.

TABLE 11

DISTRIBUTION FUNCTION VALUES

Trip Purpose	Perceived time cost: a (cpm)	Perceived distance cost: b (cpk)	GENERALISED COST β			
			24hr	AM peak	OFF peak	PM peak
Home Based Work	12.20	15.27	0.0034	0.0049	0.0034	0.0049
Home Based Business	12.20	15.27	0.0049	0.0082	0.0049	0.0082
Home Based Other	17.52	15.27	0.0079	0.0079	0.0079	0.0079
School to Work	17.52	15.27		0.0034		
Non Home Based (long)	29.67	15.27	0.0039	0.0049	0.0039	0.0049
Non Home Based (short)	29.67	15.27		0.0082	0.0049	0.0079
External NHB	29.67	15.27	0.0039	0.0082	0.0079	0.0079
Light Goods Vehicles	32.59	42.26	0.0034	0.0034	0.0034	0.0049
Heavy Goods Vehicles	27.81	52.80	0.0018	0.0034	0.0018	00.034
Additional HH Generation	21.66	15.27	0.0049	0.0082	0.0049	0.0049
Externals (inb and outb)	23.31	20.32	0.0034		0.0079	
Special Zone Generation	23.31	20.32	0.0034	0.0082	0.0018	0.0082
CBD Parking Circulation	21.66	15.27	0.0018			

6. CENTRAL AREA PARKING

6.1 Central Area Logistics Model (CALM)

For the morning and shopping period models a more detailed analysis of the central area parking was required. Hence a redistribution of trips to parking location was used within the CBD after the gravity distribution.

The Central Area Logistics Model takes the total trips coming into the CBD and redistributes the trips to the closest available parking space to the trip destination. ‘Closest’ is defined as the least cost including parking charges and the walking time from parking place to destination. If a park is not available in the zone required, then circulating trips are generated to the nearest park taking into account the walk back time. The resulting circulation trips are added to the full trip matrix before assignment.

The trips are loaded in slices by purpose. As the analysis period progresses the model keeps count of the number of available spaces of each type if parking and updates that information.

The previous Nowra model included a program called CENTRL in the 24 hour and PM peak models. This program distributed trips travelling to and from the CBD parking zones based on the number of parking spaces in the inventory. As such, the trip origins and destinations in the zones reflected parking supply and not parking demand. It also assumed all trips travel directly to the parking zone.

CENTRL has been removed from these models and the CBD parking landuse variable is used in the trip generation process instead, to attract a proportion (determined in the traffic validation process) of trips for each purpose directly to these parks. A CBD circulation purpose is included in the 24 hour model also to reflect the level of circulation which is apparent. Refer to sections 4.3 and 4.7.4 for more details.

For further details of the operation of CALM refer to the User Guide in Appendix 7.

6.2 Trip Purpose and Parking Durations

All trip purpose matrices from the distribution phase have been allocated to central area parking spaces. Some trip purpose matrices have been divided to better represent the behaviour characteristics of thing such as designated employed parking and duration of stay. These variations and the model parameters are summarised below.

	Morning Peak	Inter Peak
Nominal Analysis Period	15 min	30 min
%age of trip matrix loaded per iteration	12.5%	16.7%
Number of parking categories	12	12

TABLE 12A
MORNING PEAK PARKING MODEL VARIABLES

	Perceived Costs		Average	To	Outbound
	Time (c/min)	Distance(c/km)	Parking Duration	Work	Create a space
240 min employee parking	6.10	7.63	240	Y (to staff parking)	Y
120 min employee parking	6.10	7.63	120	Y (to staff parking)	Y
240 min leased parking	6.10	7.63	240	Y (to leased parking)	Y
120 min leased parking	6.10	7.63	120	Y (to leased parking)	Y
Home based business/other 120 min parking	10.83	7.63	120	N	Y
Home based business/other 60 min parking	10.83	7.63	60	N	Y
Home based business/other 30 min parking duration	8.76	7.63	30	N	Y
Non home based 60 min parking	14.83	7.63	60	N	Y
Non home based 15 min parking	14.83	7.63	15	N	Y
Special generation trips 60 min parking	14.83	7.63	60	N	Y
External trips 30 min parking	11.65	10.16	30	N	Y
External trips 60 min parking	11.65	10.16	60	N	Y

TABLE 12B
INTER PEAK PARKING MODEL VARIABLES

	Perceived Costs		Average	To	Outbound
	Time (c/min)	Distance(c/km)	Parking Duration	Work	Create a space
240 min employee parking	6.10	7.63	240	Y (to staff parking)	Y
120 min employee parking	6.10	7.63	120	Y (to staff parking)	Y
240 min leased parking	6.10	7.63	240	Y (to leased parks)	Y
120 min leased parking	6.10	7.63	120	Y (to leased parks)	Y
Home based business/other 120 min parking	10.83	7.63	120	N	Y
Home based business/other 60 min parking	10.83	7.63	60	N	Y
Home based business/other 30 min parking duration	15.83	12.63	30	N	Y
Non home based 120 min parking	14.83	7.63	120	N	Y
Non home based 30 min parking	14.83	7.63	30	N	Y
External non home based 60 min parking	14.83	7.63	60	N	Y
Special generation trips 60 min parking	11.65	10.16	60	N	Y
External trips 120 min parking	11.65	10.16	120	N	Y

6.3 The Parking File

The parking file for the CBD zones was set up from the surveyed inventory and costs of parking.

In all models an allowance has been made for parks in zones 25, 27-30, 35 and 37 to form a consistent set of trip generation criteria with the future models. The number of onstreet parks has been included as those surveyed in 2001, however these correspond to parks on the CBD frontages are not presently occupied by workers or shoppers in the CBD so are not reflected in the parking inventory. The number of customer parks has been included as 1 park per retail job and staff parks are calculated as 1 park per job (regardless of classification) from the 1996 landuse. The exception here is zone 27 for which the number of offstreet parks was surveyed for 2001 and have been included accordingly.

The practical capacities in the 1996 models have been set to 100% for offstreet categories but have been reduced for onstreet categories in the validation process. This was necessary to model the greater surveyed occupancy of offstreet relative to onstreet parking, particularly unrestricted offstreet (surveyed as 79% occupied at 12 noon) versus onstreet (surveyed as 51% occupied at 12 noon).

The capacities have all been restored to 100% in the 2016 model to give the future model as much parking supply as possible, to form an effective though saturated "do minimum" inventory.

The parking was split up into the categories shown in Table 13:

												TABLE 13
CATEGORIES OF PARKING AND CHARGES												
	Cost of Parking (cents)										**Practical Capacity**	
Time (Minutes)	15	20	30	35	60	65	120	125	180	185	**1996**	**2016**
On Street												
Unrestricted											55%	55%
-<P15	0	9999									75%	75%
-<P30	0	0	0	9999							75%	75%
-<P60	0	0	0	0	0	9999					75%	75%
-<P120	0	0	0	0	0	0	0	9999			75%	75%
Off Street											100%	100%
Unrestricted											100%	100%
-<P30	0	0	0	9999							100%	100%
-<P120	0	0	0	0	0	0	0	9999			100%	100%
-<P180	0	0	0	0	0	0	0	0	0	9999	100%	100%
Customer	0	0	0	9999							100%	100%
Leased											100%	100%
Employee											100%	100%

It was assumed that all parks would be available at 7am.

A full parking inventory is included in Appendix 2 of this report.

7. TRIP ASSIGNMENT

7.1 Costs of Travel

When undertaking transportation analyses it is important to make the distinction between the travel costs seen by the driver, (commonly termed perceived or behavioural costs), and the true cost of a trip from the viewpoint of the country as a whole.

Behavioural costs give the best empirical fit to the observed behaviour of travellers. They represent the cost or price that travellers perceive they are paying in terms of time, distance, comfort and convenience. For example, it can be argued that most car drivers, when deciding whether or not to make a trip by car, consider as their mileage costs only the cost of the fuel that they buy. The cost value of time that people place on travel depends on the type of journey undertaken, so that behavioural time costs for journeys to work, journeys during working hours and shopping trips are different.

Resource costs are defined as the whole of resources consumed per unit of travel to the nation as a whole. The difference between resource and behavioural cost lies in the distance cost. For example, resource cost per km does not include fuel tax, as this is purely an internal or “paper” transfer, but does include allowances for oil, maintenance and other operating costs. The discrepancy between behavioural and resource costs has been termed “driver misperception,” that is the hidden costs that play little or no part in a driver's trip making decisions.

The values that resulted were 23.44 cents per minute and 20.51 cents per kilometre.

Brown Copeland and Co. Consulting Economists prepared these values. In effect, it is only the relatively between the costs that is important, rather than the absolute values.

7.2 Loading Profile

The total traffic matrix was assigned to the road network using an incremental time dependent assignment procedure with multiple iterations and a loading profile for different time periods as shown in Tables 14A to 14D. Traffic is loaded in time slices onto the network at flow rates that approximate the traffic flow profile over the time period modelled. The TRACKS assignment program ASSIGN version 5.40 was used.

Interzonal time and distance matrices were extracted during the assignment process which are weighted sums corresponding to the points on the loading profile.

The assignment procedure is explained in the TRACKS user manual. To summarise, in each iteration, a proportion of the matrix is loaded according to the loading profile which is derived from traffic counts over the period. As a consequence the profiles for each period are different. In effect, where there are a number of iterations before a skim (i.e. skim at iterations 6, 7, 8 and 9) it is an incremental assignment for that proportion of traffic. Times and distances are accumulated at the skim point. If iterations are successively skimmed, then the assignment is an 'all or nothing' assignment for the proportion being loaded.(e.g. iteration 8 with 6% being loaded in table 14A).

The profile can be altered for future runs, if there is a reason to do so, but it must be kept constant for all assignments (do min and options) of any given year.

TABLE 14A

24 HOUR PERIOD ASSIGNMENT PARAMETERS

Assignment Increment	% Trip Matrix Loaded	% of Peak Hourly Flow Rate Experienced	Steady State Time (Minutes)	Perceived Assignment Costs	
1	3.9	3.9	360		
2	8.9	-	-	23.44	20.51
3	8.9	21.7	240	c/min	c/km
4	10.6	-	-		
5	10.6	42.9	120		
6	9.0	-	-		
7	9.0	60.9	120		
8	6.8	-	-		
9	6.9	74.6	300		
10	6.8	-	-		
11	6.9	88.3	120		
12	5.8	-	-		
13	5.9	100.0	180		

TABLE 14B
MORNING PEAK PERIOD ASSIGNMENT PARAMETERS

Assignment Increment	% Trip Matrix Loaded	% of Peak Hourly Flow Rate Experienced	Steady State Time (Minutes)	Perceived Assignment Costs	
1	10.0	-	-		
2	13.0	-	-	23.44	20.51
3	14.0	-	-	c/min	c/km
4	14.0	-	-		
5	14.0	-	-		
6	14.0	-	-		
7	6.2	-	-		
8	6.1	91.3	30		
9	4.4	-	-		
10	4.3	100.0	30		

TABLE 14C
OFFPEAK PERIOD ASSIGNMENT PARAMETERS

Assignment Increment	% Trip Matrix Loaded	% of Peak Hourly Flow Rate Experienced	Steady State Time (Minutes)	Perceived Assignment Costs	
1	10.0	-	-		
2	17.0	-	-	23.44	20.51
3	18.0	-	-	c/min	c/km
4	18.0	-	-		
5	9.4	-	-		
6	9.3	81.7	15		
7	8.6	90.3	15		
8	6.0	96.3	15		
9	3.7	100.0	15		

TABLE 14D

EVENING PEAK PERIOD ASSIGNMENT PARAMETERS

Assignment Increment	% Trip Matrix Loaded	% of Peak Hourly Flow Rate Experienced	Steady State Time (Minutes)	Perceived Assignment Costs	
1	10.0	-	-		
2	15.0	-	-	23.44	20.51
3	15.0	-	-	c/min	c/km
4	15.0	-	-		
5	15.0	-	-		
6	8.0	-	-		
7	7.9	85.9	15		
8	6.1		-		
9	6.0	98.0	30		
10	2.0	100.0	15		

7.3 Network Links

Travel Journey times were established by a combination of link times and delays at intersections. The simplest form of calculating journey times in the 1960's and 70's was where all delay (link and intersection) was attributed to a link. Volume/delay relationships were derived for various types of road. Selection of the appropriate curve was made on the basis of a number of variables which physically described the road.

Results from more recent surveys have allowed link only delays to be empirically separated from intersection delays. The volume delay relationships used in this study were for delays on links only and were based on those analytically derived by Akcelik:(1991) using a time dependent Davidson model. As a result, these curves give 'link only' delays, allowing intersection delays to be separately calculated. The J_A parameter, or friction factor, in Akcelik's equation for travel time was set for each link type so that Vcapacity/Vfree flow = 0.5. This is consistent with standard traffic theory and Fisk's behavioural model and matches the data collected in Wellington. As a result these curves give 'link only' times, allowing intersection delays to be separately calculated. Each link in the network is given a volume delay curve depending of the speed limit, function and characteristic of the road the link represents. A steady state period of one hour was used.

Akcelik's formula is:

$$t \;=\; t_o \left\{ 1 + 0.25\, r_f \left[(x - 1) + \left((x-1)^2 + (8J_A x) / (Qt_o r_f) \right)^{1/2} \right] \right\}$$

Where:

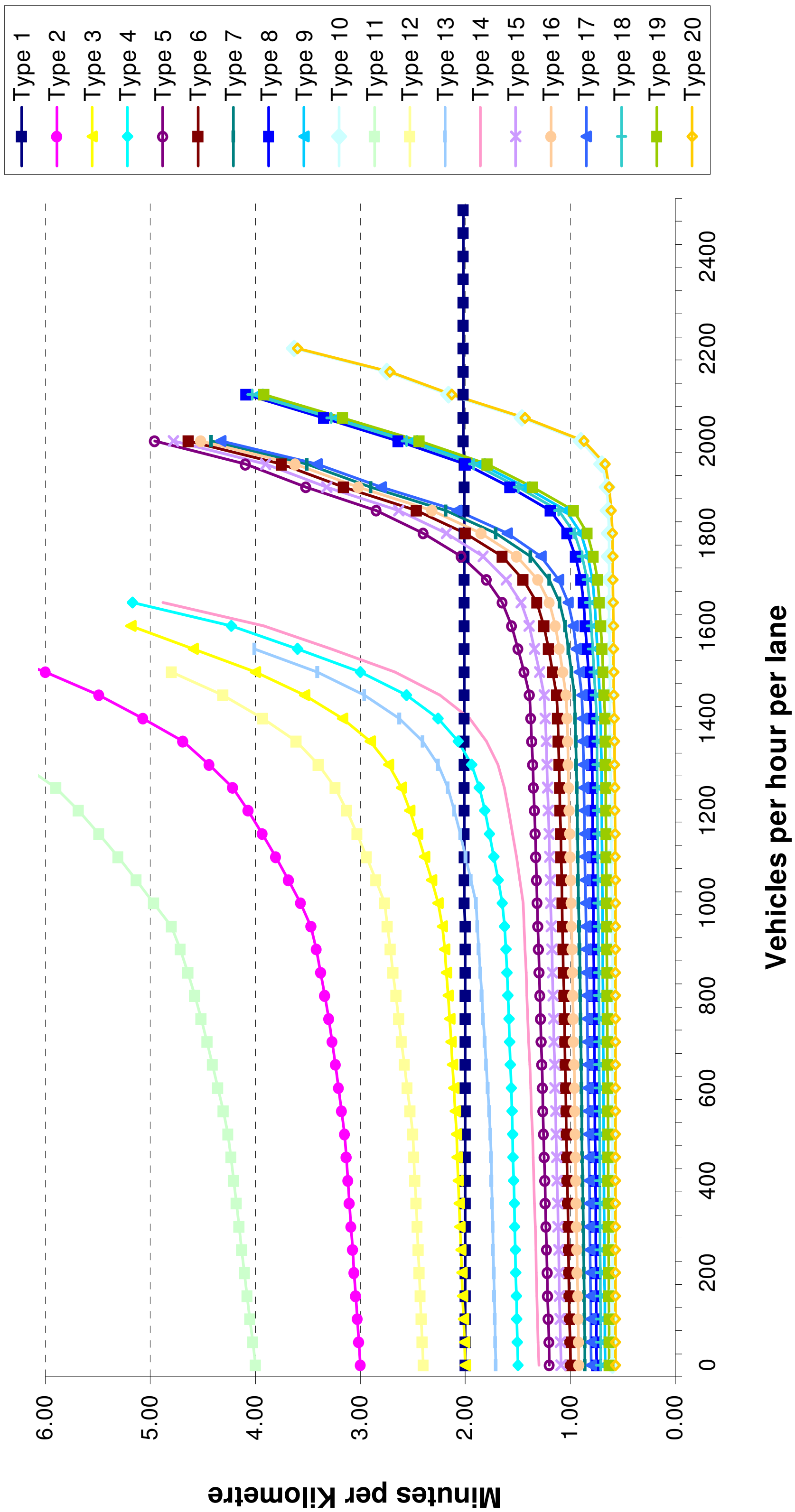
t = travel time per unit distance (e.g., secs/km)
t_o = minimum (zero flow) travel time per unit distance (e.g., secs/km)
J_A = delay (side friction, level-of-service(LOS)) parameter
x = q/Q = degree of saturation
q = demand (arrival) flow rate (veh/sec)
Q = capacity (veh/sec) per lane
r_f = ratio of flow period T_f, to minimum travel time t_o

Twenty curves were developed with free flow times at 5km/hr intervals. The capacities and J_A values used for each curve are given below. Curve number 1 is a flat line for a centroid connector.

The resulting volume/delay curves used for this study are shown in Figure 5.

Each link in the network was allocated a curve from an assessment of the free flow speed, its capacity and the environmental conditions of the link.

New future links should be coded by assessing the environment in which the link will operate, and choosing a curve with an appropriate free flow speed and capacity, given the way in which link with a similar curve operate under current traffic condition. During evaluation of a project it would be useful to test the sensitivity of the choice of curves on traffic flows, and benefits.



Nowra District Transport Model	**VOLUME – DELAY CURVES**	Figure 5
Gabites Porter Consultants		

7.4 Network Intersections

Each intersection on the road network is coded explicitly. The coding adopted in TRACKS to represent the different types of approach control is:

Type 0	-	Not controlled, has priority
Type 1	-	No controls marked, non priority
Type 2	-	Merge
Type 3	-	Roundabout
Type 4	-	Give Way, non-priority
Type 5	-	Stop, non-priority
Types 6,7	-	Signals
Types 8,9	-	Signals

a) Priority Intersections

Delays at priority intersections are calculated at the movement level. That is, left, right and through movements on all legs have delays calculated specifically.

The approach lanes at each intersection are coded as one of eight movement types as shown below. The opposing traffic flows are calculated from the intersection geometry, determined from the link coordinates.

1. Left, Through and Right
2. Left and Right
3. Left
4. Left free
5. Left and Through
6. Through
7. Through and Right
8. Right

The way each lane type was treated came from the publication titled, "Performance Analysis of Priority Intersections - A Practitioner's Guide" by Gabites Porter:(1991).

A queuing theory model is used to calculate the delays. The queuing theory formulation adopted is that described by Fisk:(1989) which uses an M/M/1 model (indicates a queuing system with negative exponential distributions for arrival headway and service times, with one service channel) and a coordinate transformation approximation to allow for over-saturated conditions.

The formulation is:

$$d = \begin{cases} r/\mu\,(1 - r) & \text{steady state conditions, } r<1 \\ (r - 1)\,t/2 & \text{deterministic conditions, } r>1 \end{cases}$$

Where: r $= q_2 / \mu$

$$\mu = \frac{q_1 e^{-q_1 t}}{1 - e^{-q_1 b}}$$

t	=	duration of time period over which a steady state is assumed
q_1	=	major road flow rate
q_2	=	minor road flow rate, always defined as approach being delayed
t	=	critical gap
b	=	move-up time for minor road traffic.
μ	=	mean service rate
r	=	traffic intensity

Fisk shows that the delay equation can be written:-

$$d = \frac{-(2 + \mu t - r\mu t) + \sqrt{(2 + \mu t - r\mu t)^2 + 8r\mu t}}{4\mu} + \frac{1}{\mu}$$

when the coordinate transform is included and this formulation is used.

The following critical gaps and move-up times were used:

Lane Type	Critical Gap (sec)	Move-up Time (sec)
Left turn-non-priority	5.18	3.00
Left turn-priority	5.18	3.00
Thru/Right-non-priority	5.18	3.00
Thru/Right-priority	5.18	3.00
Merge	2.50	1.80
Roundabout	4.00	2.50
Bottleneck	5.18	3.00

NB: a bottleneck is automatically recognised at a node where the number of lanes leaving the node is less than the number of lanes entering the node.

Other parameters used include:

Tracking Headway 1.5 seconds	
Lane Sharing Convergence Parameter	0.01000
Number of external iterations	50
Number of internal iterations (lane sharing algorithm)	200

b) Roundabouts

Delays at roundabouts are calculated using the formulae described in the SIDRA 5 User Manual.

c) Signalised Intersections

Delays at signalised intersections are calculated according to turning movements using the formulations in ARR123, including equations 6.4, 6.3 and 6.1 shown below. While ARR123 is the basis for SIDRA it does not give exactly the same results, especially for the more recent versions of SIDRA.

A general formula for the average delay per vehicle, d (in seconds) is

d	=	D/q	eqn (6.4)
D	=	total delay (veh/hr/hr)	
q	=	flow rate (veh/s)	

$$D = \frac{qc(1-u)^2}{2(1-y)} + N_0 x \qquad \text{eqn (6.3)}$$

Where:

qc	=	average number of arrivals in vehicles/cycle
q	=	flow (veh/sec)
c	=	cycle time (sec)
u	=	green time ratios = g/c
y	=	flow ratio = q/s
s	=	saturation flow (veh/sec)
No	=	average overflow queue (vehicles)
x	=	q/Q = degree of saturation

$$N_0 = \begin{cases} \dfrac{QT_f}{4}\left[z + \sqrt{z^2 + \dfrac{12(x - x_0)}{QT_f}}\right] & \textit{for} \;\; x > x_0 \\ \\ 0 & \textit{for} \;\; x \le x_0 \end{cases} \qquad \text{eqn (6.1)}$$

Where:

Q	=	capacity (veh/hr)
Tf	=	flow period (hours)
z	=	x - 1
xo	=	degree of saturation below which the average overflow queue is approximately zero = 0.67 + sg/600

Signalised intersections were modelled specifically and each required a SIDRA input data file.

d) Geometric Delays

The delays calculated above are the stopped delays for vehicles. As vehicles decelerate to stop or negotiate a corner a geometric delay is encountered. The geometric delay is calculated from the formulations in Gabites Porter:(1991).

8. MODEL CONVERGENCE

8.1 Assignment and Distribution Loop

Time and distance matrices are required as input for trip distribution. As these matrices are generated by assigning the trips to the network, after each assignment the trip distribution needs to be re-run and the trips re-assigned until the time and distances matrices converge. The assignment and distribution steps are run iteratively until the totals of both the time and distance matrices between successive runs remain constant.

Absolute convergence was achieved with the four Nowra models.

The totals for the final time and distance matrices (after many previous runs) are shown below.

TVM = Total Vehicle Minutes
TVK = Total Vehicle Kilometres

PERIOD	24 Hour	24 Hour	AM Peak	AM Peak	Offpeak	Offpeak	PM Peak	PM Peak
	TVM	TVK	TVM	TVK	TVM	TVK	TVM	TVK
Prev. Run	1051637	959941	87663	77417	73837	64322	102642	86951
Final Run	1051935	959773	87662	77385	73826	64311	102635	86938
%age Diff	-0.03%	0.02%	<0.01%	0.04%	0.01%	0.02%	<0.01%	0.01%

9. VALIDATION

9.1 General

One of the requirements of model building is that the model should replicate actual conditions, that is the travel patterns and traffic flows that exist within the Nowra District study area. The process is called validation.

9.2 Parking Validation

Section 6 of this report discusses the use of a Central Area Logistics Model to redistribute vehicle trips destined to the CBD to parking spaces. It is therefore required that the model allocation of vehicles to parking spaces reflect that which occurs in reality.

The parking model is used for both the morning peak and shopping period models. The validation therefore is to match the number of parking spaces used at the end of each of those time periods, i.e, the parks used at 9am and 12noon.

Tables 15A and 15B show the parking occupancy by parking type for each zone in the AM peak and offpeak models respectively. Table 16 shows the validation results for both models by comparing the model performance to survey results.

The model cannot achieve 100% accuracy but you can see that it has reflected the major parking demand areas very well.

TABLE 15A

1996 PARKING MODEL OCCUPANCY - 9AM

Parks Zone	Occupied ONUNR	To ON15-60M	End ON120M	Of OFUNR	Period OF120M	OF180M	OFCUST	OFLEAS	OFEMPL	Model Total	Total Parking Inventory	%age ALL PARKS	Of Onstreet Unrest	Parks Onstreet Rest	Occupied Offstreet Unrest	Offstreet Rest	Customer Parks	Leased Parks	Staff Parks
1	16	3	3	-	-	-	8	3	29	62	151	41%	41%	46%	-	-	24%	10%	83%
2	-	1	-	-	59	-	1	2	21	84	330	25%	-	6%	-	23%	3%	100%	100%
3	-	1	1	-	45	-	-	38	18	103	264	39%	-	17%	-	24%	0%	100%	100%
4	-	5	-	-	117	-	4	1	73	200	378	53%	-	21%	-	46%	14%	100%	100%
5	10	3	-	84	30	-	3	3	56	189	467	40%	25%	7%	48%	27%	8%	100%	100%
6	23	14	-	99	-	-	20	1	34	191	352	54%	55%	54%	100%	0%	26%	100%	32%
7	-	2	-	-	52	68	2	37	53	214	463	46%	-	11%	-	45%	7%	100%	48%
8	-	18	-	-	-	-	15	23	31	87	169	51%	-	62%	-	-	30%	100%	46%
9	-	9	-	-	-	-	7	15	20	51	100	51%	-	43%	-	-	17%	100%	87%
10	-	28	-	-	-	-	-	-	-	28	37	76%	-	76%	-	-	-	-	-
11	-	28	-	-	-	-	-	-	-	28	38	74%	-	74%	-	-	-	-	-
12	-	33	-	-	-	-	-	-	-	33	44	75%	-	75%	-	-	-	-	-
13	-	32	-	-	-	-	-	-	-	32	44	73%	-	73%	-	-	-	-	-
14	2	4	-	31	28	-	7	4	53	129	394	33%	18%	13%	31%	30%	9%	100%	69%
15	13	8	-	128	-	-	5	4	64	222	563	39%	28%	14%	54%	-	8%	100%	41%
16	-	2	-	-	-	158	27	28	144	359	1,356	26%	-	10%	-	26%	7%	33%	59%
23	74	31	13	-	-	-	85	4	262	469	725	65%	55%	73%	-	-	56%	100%	70%
24	32	3	-	-	-	-	12	-	32	79	214	37%	55%	60%	-	-	13%	-	58%
25	4	-	-	-	-	-	-	-	3	7	34	21%	20%	-	-	-	0%	-	33%
27	30	4	-	-	-	-	7	1	31	73	279	26%	31%	17%	-	-	9%	100%	38%
28	6	-	-	-	-	-	-	-	5	11	47	23%	26%	-	-	-	0%	-	22%
29	6	4	-	-	-	-	5	-	22	37	147	25%	55%	80%	-	-	29%	-	19%
30	9	1	-	-	-	-	2	-	8	20	71	28%	43%	25%	-	-	12%	-	28%
35	11	-	-	-	-	-	1	-	7	19	59	32%	44%	-	-	-	33%	-	23%
37	7	-	-	-	-	-	1	-	10	18	69	26%	58%	-	-	-	100%	-	18%
TOTAL	243	234	17	342	331	226	212	164	976	2,745	6,795	40%	42%	44%	56%	31%	17%	66%	55%

TABLE 15B

1996 PARKING MODEL OCCUPANCY – 12 NOON

Parks Zone	Occupied ONUNR	To ON15-60M	End ON120M	Of OFUNR	Period OF120M	OF180M	OFCUST	OFLEAS	OFEMPL	Model Total	Total Parking Inventory	%age ALL PARKS	Of Onstreet Unrest	Parks Onstreet Rest	Occupied Offstreet Unrest	Offstreet Rest	Customer Parks	Leased Parks	Staff Parks
1	21	5	4	-	-	-	13	8	32	83	151	55%	54%	69%	-	-	39%	26%	91%
2	-	3	-	-	108	-	3	2	21	137	330	42%	-	18%	-	42%	9%	100%	100%
3	-	2	1	-	77	-	-	38	18	136	264	52%	-	25%	-	40%	0%	100%	100%
4	-	14	-	-	220	-	8	1	73	316	378	84%	-	58%	-	87%	29%	100%	100%
5	16	11	-	131	69	-	7	3	56	293	467	63%	40%	27%	74%	61%	18%	100%	100%
6	23	17	-	99	1	-	36	1	41	218	352	62%	55%	65%	100%	33%	47%	100%	39%
7	-	6	-	-	78	106	5	37	62	294	463	63%	-	33%	-	69%	17%	100%	56%
8	-	21	-	-	-	-	25	23	34	103	169	61%	-	72%	-	-	50%	100%	51%
9	-	15	-	-	-	-	11	15	22	63	100	63%	-	71%	-	-	27%	100%	96%
10	-	28	-	-	-	-	-	-	-	28	37	76%	-	76%	-	-	-	-	-
11	-	28	-	-	-	-	-	-	-	28	38	74%	-	74%	-	-	-	-	-
12	-	33	-	-	-	-	-	-	-	33	44	75%	-	75%	-	-	-	-	-
13	-	33	-	-	-	-	-	-	-	33	44	75%	-	75%	-	-	-	-	-
14	3	8	-	48	47	-	12	4	61	183	394	46%	27%	26%	48%	51%	15%	100%	79%
15	22	28	-	213	-	-	14	4	75	356	563	63%	47%	47%	89%	-	24%	100%	48%
16	-	7	-	-	-	352	71	57	170	657	1,356	48%	-	35%	-	59%	17%	67%	69%
23	74	31	13	-	-	-	121	4	276	519	725	72%	55%	73%	-	-	79%	100%	74%
24	32	4	-	-	-	-	21	-	36	93	214	43%	55%	80%	-	-	22%	-	65%
25	10	-	-	-	-	-	1	-	4	15	34	44%	50%	-	-	-	20%	-	44%
27	48	11	-	-	-	-	15	1	36	111	279	40%	50%	48%	-	-	19%	100%	44%
28	11	-	-	-	-	-	-	-	6	17	47	36%	48%	-	-	-	0%	-	26%
29	6	4	-	-	-	-	11	-	25	46	147	31%	55%	80%	-	-	65%	-	22%
30	12	3	-	-	-	-	4	-	9	28	71	39%	57%	75%	-	-	24%	-	31%
35	14	-	-	-	-	-	3	-	8	25	59	42%	56%	-	-	-	100%	-	26%
37	7	-	-	-	-	-	1	-	11	19	69	28%	58%	-	-	-	100%	-	20%
TOTAL	299	312	18	491	600	458	382	198	1,076	3,834	6,795	56%	52%	58%	80%	60%	31%	80%	61%

TABLE 16A

1996 AM PEAK PARKING VALIDATION

ZONE	On Street Model	On Street Survey	%age of Survey	Off Street Model	Off Street Survey	%age of Survey	Customer Parks Model	Customer Parks Survey	%age of Survey	Leased Parks Model	Leased Parks Survey	%age of Survey	Staff Parks Model	Staff Parks Survey	%age of Survey	All Parks Model	All Parks Survey	%age of Survey
1	22	31	71%	0	0	-	8	9	89%	3	31	10%	29	19	153%	62	90	69%
2	1	10	10%	59	89	66%	1	12	8%	2	2	100%	21	15	140%	84	128	66%
3	2	1	200%	45	92	49%	0	3	0%	38	38	100%	18	11	164%	103	145	71%
4	5	15	33%	117	143	82%	4	9	44%	1	0	-	73	32	228%	200	199	101%
5	13	34	38%	114	167	68%	3	9	33%	3	2	150%	56	39	144%	189	251	75%
6	37	16	231%	99	72	138%	20	12	167%	1	0	-	34	50	68%	191	150	127%
7	2	7	29%	120	44	273%	2	8	25%	37	27	137%	53	86	62%	214	172	124%
8	18	7	257%	0	0	-	15	11	136%	23	8	288%	31	45	69%	87	71	123%
9	9	5	180%	0	0	-	7	12	58%	15	9	167%	20	17	118%	51	43	119%
10	28	30	93%	0	0	-	0	0	-	0	0	-	0	0	-	28	30	93%
11	28	17	165%	0	0	-	0	0	-	0	0	-	0	0	-	28	17	165%
12	33	22	150%	0	0	-	0	0	-	0	0	-	0	0	-	33	22	150%
13	32	18	178%	0	0	-	0	0	-	0	0	-	0	0	-	32	18	178%
14	6	31	19%	59	33	179%	7	23	30%	4	2	200%	53	59	90%	129	148	87%
15	21	50	42%	128	202	63%	5	7	71%	4	4	100%	64	34	188%	222	297	75%
16	2	4	50%	158	87	182%	27	13	208%	28	49	57%	144	146	99%	359	299	120%
23	118	84	140%	0	0	-	85	53	160%	4	4	100%	262	312	84%	469	453	104%
24	35	9	389%	0	0	-	12	21	57%	0	0	-	32	31	103%	79	61	130%
25	4	2	200%	0	0	-	0	0	-	0	0	-	3	na		7	na	200%
27	34	22	155%	0	0	-	7	12	58%	1	1	100%	31	19	163%	73	54	135%
28	6	9	67%	0	0	-	0	0	-	0	0	-	5	na		11	na	67%
29	10	5	200%	0	0	-	5	0	-	0	0	-	22	na		37	na	200%
30	10	8	125%	0	0	-	2	0	-	0	0	-	8	na		20	na	125%
35	11	7	157%	0	0	-	1	0	-	0	0	-	7	na		19	na	157%
37	7	3	233%	0	0	-	1	0	-	0	0	-	10	na		18	na	233%
TOTAL	494	447	111%	899	929	97%	203	214	95%	164	177	93%	921	915	101%	2681	2682	100%

TABLE 16B

1996 OFFPEAK PARKING VALIDATION

ZONE	On Street Model	On Street Survey	%age of Survey	Off Street Model	Off Street Survey	%age of Survey	Customer Parks Model	Customer Parks Survey	%age of Survey	Leased Parks Model	Leased Parks Survey	%age of Survey	Staff Parks Model	Staff Parks Survey	%age of Survey	All Parks Model	All Parks Survey	%age of Survey
1	30	35	86%	0	0	-	13	11	118%	8	31	26%	32	21	152%	83	98	85%
2	3	11	27%	108	103	105%	3	16	19%	2	2	100%	21	23	91%	137	155	88%
3	3	8	38%	77	105	73%	0	5	0%	38	36	106%	18	17	106%	136	171	80%
4	14	10	140%	220	230	96%	8	15	53%	1	1	100%	73	35	209%	316	291	109%
5	27	49	55%	200	186	108%	7	11	64%	3	3	100%	56	45	124%	293	294	100%
6	40	37	108%	100	90	111%	36	26	138%	1	1	100%	41	65	63%	218	219	100%
7	6	16	38%	184	154	119%	5	24	21%	37	32	116%	62	97	64%	294	323	91%
8	21	15	140%	0	0	-	25	30	83%	23	12	192%	34	51	67%	103	108	95%
9	15	15	100%	0	0	-	11	23	48%	15	11	136%	22	19	116%	63	68	93%
10	28	37	76%	0	0	-	0	0	-	0	0	-	0	0	-	28	37	76%
11	28	27	104%	0	0	-	0	0	-	0	0	-	0	0	-	28	27	104%
12	33	30	110%	0	0	-	0	0	-	0	0	-	0	0	-	33	30	110%
13	33	32	103%	0	0	-	0	0	-	0	0	-	0	0	-	33	32	103%
14	11	34	32%	95	60	158%	12	42	29%	4	4	100%	61	62	98%	183	202	91%
15	50	63	79%	213	234	91%	14	15	93%	4	4	100%	75	49	153%	356	365	98%
16	7	8	88%	352	356	99%	71	31	229%	57	60	95%	170	182	93%	657	637	103%
23	118	110	107%	0	0	-	121	71	170%	4	4	100%	276	311	89%	519	496	105%
24	36	20	180%	0	0	-	21	46	46%	0	0	-	36	35	103%	93	101	92%
25	10	6	167%	0	0	-	1	0	-	0	0	-	4	na		15	na	167%
27	59	32	184%	0	0	-	15	13	115%	1	1	100%	36	23	157%	111	69	161%
28	11	2	550%	0	0	-	0	0	-	0	0	-	6	na		17	na	550%
29	10	7	143%	0	0	-	11	0	-	0	0	-	25	na		46	na	143%
30	15	6	250%	0	0	-	4	0	-	0	0	-	9	na		28	na	250%
35	14	13	108%	0	0	-	3	0	-	0	0	-	8	na		25	na	108%
37	7	4	175%	0	0	-	1	0	-	0	0	-	11	na		19	na	175%
TOTAL	629	627	100%	1549	1518	102%	362	379	96%	198	202	98%	1013	1035	98%	3751	3761	100%

9.3 Network Validation

Network flow comparisons are tested using a number of statistical measures. Traffic counts were grouped into cordons, or screenlines, and the following measures calculated.

- Comparisons of individual links
- Comparisons of total trips over each screenline
- Percentage difference
- Correlation coefficient
- % Root mean square
- *GEH*.

The correlation coefficient is a first order measure of the correlation, using the formula:

$$P_{x,y} = \frac{\frac{1}{n} \Sigma (x_i - \overline{x_i}) \ (y_i - \overline{y_i})}{\sigma_x \, \sigma_y}$$

The *GEH* is a form of the Chi-squared statistic that incorporates both relative and absolute errors. It is designed to be more tolerant of the large percentage differences in lower flows. The form of the statistic is:

$$GEH = \sqrt{\frac{2(m-o)^2}{m+o}}$$

Where m is the modelled flow and o is the observed count.

It should be noted that where the model assignments are other than one hour, the traffic volumes have been adjusted for GEH comparisons. A GEH value of no greater than 4 is most desirable.

The available traffic counts have been arranged into screenlines where possible. In many cases there are roads on a screenline that have not been counted and hence these have had to be omitted. In other cases it was not been possible to create screenlines and hence the extra counts are grouped in the area in which they occur. A summary of the cordon results can be found below in tables 17A to 17D with full cordon outputs in Appendix 3.

A plot of the existing traffic flow for the Nowra District study area is shown as Figures 6 to 9.

TABLE 17A

24 HOUR TRAFFIC VALIDATION SUMMARY

Screenline	Observed Count	Modelled Count	Difference		Correlation Coefficient	GEH
			Actual	%age		
1 Bomaderry Cordon	89900	90514	614	101	0.996	0.6
2 North of Bolong Rd	34300	32229	-2071	94	1.000	3.3
3 CBD Cordon	106367	110180	3813	104	0.994	3.3
4 Nowra Fair Cordon	11520	12806	1286	111	0.996	3.4
5 North of Kalandar Street	45590	44924	-666	99	0.976	0.9
6 South of Kalandar Street	45630	43637	-1993	96	0.993	2.7
7 East of Princes Highway	33059	32509	-550	98	0.996	0.9
8 West of Princes Highway	57200	60477	3277	106	0.986	3.9
9 South Nowra Cordon	9450	9332	-118	99	0.940	0.4
10 North Bomaderry Cordon	8590	8066	-524	94	0.978	1.6
11 North Bomaderry Cordon	13950	14413	463	103	0.795	1.1

TABLE 17B

MORNING PEAK TRAFFIC VALIDATION SUMMARY

Screenline	Observed Count	Modelled Count	Difference		Correlation Coefficient	GEH
			Actual	%age		
1 Bomaderry Cordon	7441	7682	241	103	0.973	2.8
2 North of Bolong Rd	2701	2665	-46	98	0.991	0.9
3 CBD Cordon	8715	8818	103	101	0.988	1.1
4 Nowra Fair Cordon	902	789	-113	87	0.975	3.9
5 North of Kalandar Street	3456	3626	170	105	0.994	2.9
6 South of Kalandar Street	3580	3512	-68	98	0.980	1.1
7 East of Princes Highway	2707	2703	-4	100	0.966	0.1
8 West of Princes Highway	4522	4832	310	107	0.954	4.5
9 South Nowra Cordon	949	835	-114	88	0.774	3.8
10 North Bomaderry Cordon	711	790	79	111	0.973	2.9
11 North Bomaderry Cordon	1197	1202	5	100	0.656	0.1

TABLE 17C

OFFPEAK TRAFFIC VALIDATION SUMMARY

Screenline	Observed Count	Modelled Count	Difference Actual	Difference %age	Correlation Coefficient	GEH
1 Bomaderry Cordon	5875	5571	-304	95	0.997	4.0
2 North of Bolong Rd	2115	1945	-170	92	0.988	3.8
3 CBD Cordon	8177	8034	-143	98	0.970	1.6
4 Nowra Fair Cordon	1262	1391	129	110	0.989	3.5
5 North of Kalandar Street	3273	3395	122	104	0.985	2.1
6 South of Kalandar Street	3444	3213	-231	93	0.982	4.0
7 East of Princes Highway	2269	2269	0	100	0.980	0.0
8 West of Princes Highway	4398	4367	-31	99	0.884	0.5
9 South Nowra Cordon	613	644	31	105	0.847	1.2
10 North Bomaderry Cordon	467	465	-2	100	0.951	0.1
11 North Bomaderry Cordon	868	778	-90	90	0.472	3.1

TABLE 17D

EVENING PEAK TRAFFIC VALIDATION SUMMARY

Screenline	Observed Count	Modelled Count	Difference Actual	Difference %age	Correlation Coefficient	GEH
1 Bomaderry Cordon	8223	8091	-132	98	0.993	1.5
2 North of Bolong Rd	2917	2889	-28	99	0.998	0.5
3 CBD Cordon	10298	10128	-170	98	0.952	1.7
4 Nowra Fair Cordon	1091	1124	33	103	0.995	1.0
5 North of Kalandar Street	4083	4253	170	104	0.970	2.6
6 South of Kalandar Street	4062	3930	-132	97	0.955	2.1
7 East of Princes Highway	3354	3180	-174	95	0.982	3.0
8 West of Princes Highway	5459	5739	280	105	0.950	3.7
9 South Nowra Cordon	990	982	-8	99	0.770	0.3
10 North Bomaderry Cordon	772	744	-28	96	0.870	1.0
11 North Bomaderry Cordon	1464	1343	-121	92	0.755	3.2

Nowra District Transport Model	24 HOUR LINK VOLUME PLOT	Figure 6
Gabites Porter Consultants		

Nowra District Transport Model	AM PEAK LINK VOLUME PLOT	Figure 7
Gabites Porter Consultants		

Nowra District Transport Model	**OFFPEAK LINK VOLUME PLOT**	Figure 8
Gabites Porter Consultants		

Nowra District Transport Model	**PM PEAK LINK VOLUME PLOT**	Figure 9
Gabites Porter Consultants		

9.4 Discussion

As a pre-requisite to using the transportation model to test road improvement and land use options, the model must be "validated". That is, the model must be seen to be simulating "reality".

"Reality" as termed here is illustrated by observed values of such variables as traffic counts, vehicle travel times and car park occupancies. In measuring "reality" there are a number of inherent difficulties. These can be caused by:

a) The impact of human behaviour on "reality".
b) The methods used to survey "reality".

The first point tells us that there is no such thing as a typical or average day. There will never be a day where every vehicle driver makes exactly the same trips at exactly the same time as any other day. That said we are at best trying to simulate indicative travel patterns.

The second point is that survey techniques can have a significant amount of error. For example, a vehicle travelling very slowly over a traffic counter tube will register a count, or not, differently to one travelling at a normal speed. Such difficulties are minimised by careful selection of traffic counter placements but cannot be fully avoided.

A document put out by the US Department of Transportation titled "Calibration and Adjustment of System Planning Models", December 1990 summarises validation as follows.

> *"...A regional transportation planning model consists of a complex series of steps with many built-in assumptions. When validating a model, one should not be overly optimistic about matching the simulated volume to ground counts....*
>
> *A reasonable expectation is for the model to be accurate enough so that it will not affect the number of lanes required to handle the volume. For example, if the model forecasts an ADT of 5,000 and the actual ADT is 2,000 a design change would not result. The number of lanes necessary for an ADT of 5,000 is two lanes and the number of lanes needed for an ADT of 2,000 is still 2 lanes. In spite of having an error of 150% the required number of lanes remains the same.*
>
> *As the ADT on a facility increases, the expected accuracy of the models should increase as well. For example, links with an ADT of 100,000 would have an acceptable range of accuracy of ± 15% or 85,000 to 115,000. The number of required lanes would not change. In general, the lower the volume, the higher the anticipated deviation.*

***A word of caution**: When comparing forecasted volumes to ground counts, it is important to recognise that the ground counts probably contain a significant amount of error.*

Traffic volumes vary greatly by season and by day of week. Count errors can be caused by variation in the mix of vehicles in the traffic stream. Regularly occurring local events, special events, and accidents can destroy the counts on large portions of the highway system. Errors can also be due to mechanical counter failure, field personnel mistakes, or improper counter location. Procedures have been developed to help correct for some of this variation, but these procedures are imperfect. There is often no way to ensure that ground counts correspond to the same time period as base-case socioeconomic data.

Base-case ground counts should be thought of as approximations of existing traffic, just as the base-case model estimate is an approximation to existing traffic."

10. FUTURE PROJECTIONS

The Planning Department at Shoalhaven City Council have provided landuse projections and external traffic volumes from which to generate the 2016 traffic demand. A number of network improvements and additional offstreet parking facilities have been introduced to accommodate the resultant traffic and parking demand for all models. The following sections outline the development of the 2016 Nowra District model.

10.1 Population and Household Growth

From the demographic profiles the key indicator of future growth is that of population. In the last few years, Shoalhaven City Council Planners have predicted the growth into the future such that there will be in the range of 45,000-50,000 persons in the Nowra model area at the year 2016. Recent trends point towards more modest growth in the years leading up to 2002 such that this population prediction for 2016 may more likely not be realised until 2018 or 2020. Regardless, it is accepted under this understanding as a 2016 landuse to be consistent with the project brief and to adhere to TRACKS file name convention.

The future population needs to be converted to households to be included in the model landuse. The trend is currently such that the number of persons per household is on the decline. From a current value of 2.84 this is anticipated to reduce to 2.46. As a result the required number of households at 2016 will be around 19,000. This household growth is distributed to each zone as shown in the 2016 zone files which are included as Appendix 4.

10.2 Employment per Household and Vehicle Ownership

In consultation with Shoalhaven Council it was agreed that the reduction in predicted persons per household would be offset by an increase in the proportion of persons employed who live in the region. Subsequently the number of employed persons per household remains unchanged from those figures applied in the 1996 landuse files. The number of employed persons per households has been averaged across broad regions of the study area, as the specific distribution of this category model variable in the future is difficult to predict on a zone by zone basis.

Historically in the New South Wales region, vehicle ownership per 1000 population has increased over time by approximately 0.5% per annum (*Smith and Milthorpe (1995)*). In 1996, there were approximately 450 vehicles per 1000 population, a rate which can be expected to rise to 495 vehicles per 1000 population by 2016. Given the household occupancies discussed in section 10.1, this translates to a drop from 1.28 vehicles per household in 1996 to 1.22 vehicles per household in 2016. As with the number of employees per household, the vehicle ownership has been averaged across broad regions of the study area, as the specific distribution of this category model variable in the future is difficult to predict on a zone by zone basis.

10.3 Workplace Employment

Future workplace employment has been predicted in its entirety by the Shoalhaven Council.

10.4 Future Zonal Land Use Summary

The projected land use totals are summarised in the table below. The landuse data for all four 2016 models is shown in the Appendix 4.

TABLE 18

LAND USE DATA PROJECTION SUMMARY

Variable	Study Area Totals 1996	Study Area Totals 2016	Growth %
Households	9615	18914	96.7%
Employees	9780	19073	95.0%
Employees/HH	1.02	1.01	-1.0%
Vehicles	12326	23074	87.2%
Vehicles/HH	1.28	1.22	-4.7%
Primary School Roll	3987	6555	64.4%
Secondary School Roll	4116	7140	73.5%
TAFE Roll	1851	3700	99.9%
Community etc. Jobs	2813	2425	62.6%
Retail etc. Jobs	3617	5052	39.7%
Office and Finance Jobs	1073	4574	126.0%
Manufacturing Jobs	1485	2325	56.6%
Total Jobs	10326	16675	61.5%

10.5 External Traffic and Special Zone Generation

Traffic entering the study area via roads crossing the study area boundary is called external traffic. Projected 24 hour two-way external traffic has been prepared by Shoalhaven Council for the 2016 all day model. The 1996 24 hour through traffic has been factored by the growth in traffic volumes at each respective external, to determine a 2016 24 hour through matrix.

Similarly the 1996 inbound and outbound traffic volumes have been factored up by the growth in the 24 hour two-way external traffic volume between 1996 and 2016, to calculate 2016 inbound and outbound flows. The through traffic matrices were also factored up accordingly.

A summary of the 2016 external traffic total volumes and through volumes is provided in Table 19.

Shoalhaven Council have also provided all day 2016 projections for the volumes of traffic generated and attracted to the four special zone generators. The period models have been factored up from 1996 data in the same manner as the external traffic. The 2016 special zone generator volumes are presented in Table 20.

TABLE 19

EXTERNAL ROAD FLOWS

24 Hour Model

Zone No.	Description	All External Traffic 2 Way	Through Traffic 2 Way
242	Bolong Rd	9553	3661
243	Princes Hway Nth	14250	5199
244	Moss Vale Rd	493	2534
245	Illaroo Rd	1461	178
246	Yalwal Rd	241	58
247	Albatross Rd	7730	1034
248	Princes Hway Sth	23032	7901
249	Greenwell Point Rd	9114	2510
250	Comerong Island Rd	1010	236

Morning Peak (7-9am)

Zone No.	Description	All External Traffic		Through Traffic	
		Inbound	Outbound	Inbound	Outbound
242	Bolong Rd	945	572	127	194
243	Princes Hway Nth	1016	790	76	145
244	Moss Vale Rd	262	316	47	160
245	Illaroo Rd	164	55	18	25
246	Yalwal Rd	18	12	0	0
247	Albatross Rd	357	1290	2	16
248	Princes Hway Sth	2279	848	287	95
249	Greenwell Point Rd	997	271	82	35
250	Comerong Island Rd	88	38	47	16

TABLE 19 (cont.)

EXTERNAL ROAD FLOWS

Offpeak (9am-12noon)

Zone No.	Description	All External Traffic		Through Traffic	
		Inbound	Outbound	Inbound	Outbound
242	Bolong Rd	981	819	352	373
243	Princes Hway Nth	1220	1202	539	492
244	Moss Vale Rd	377	408	243	256
245	Illaroo Rd	141	141	15	17
246	Yalwal Rd	14	27	8	8
247	Albatross Rd	640	689	119	124
248	Princes Hway Sth	2646	2624	835	869
249	Greenwell Point Rd	787	1093	326	296
250	Comerong Island Rd	102	117	23	24

Evening Peak (4.6pm)

Zone No.	Description	All External Traffic		Through Traffic	
		Inbound	Outbound	Inbound	Outbound
242	Bolong Rd	636	937	87	178
243	Princes Hway Nth	1011	1071	223	129
244	Moss Vale Rd	390	376	63	97
245	Illaroo Rd	116	162	0	0
246	Yalwal Rd	9	16	0	0
247	Albatross Rd	1226	387	43	8
248	Princes Hway Sth	1317	2427	391	264
249	Greenwell Point Rd	422	1043	38	139
250	Comerong Island Rd	56	111	18	49

TABLE 20

SPECIAL ZONE GENERATOR 2016 TRAFFIC VOLUMES

Location	Zone	24 Hour	AM Peak		Offpeak		PM Peak	
			Inb	Outb	Inb	Outb	Inb	Outb
Bomaderry Railway Station	**236**	1400	118	118	181	158	131	100
Shoalhaven Sporting Complex	**237**	824	59	59	75	75	86	86
Golf Course	**238**	896	59	72	165	165	72	59
Nowra Ski Park	**239**	200	10	10	16	16	10	10

10.6 Future Parking Model

The parking model study area has been increased from a 24 zone region of the CBD (N.B. zones 17 to 22 are unused) to a 37 zone model of which zones 26, 31-34 and 36 are not included, giving a total of 25 CBD parking zones.

In agreement with Shoalhaven Council, it was assumed that the quantity of customer and staff parks in 2016 would be unchanged from 1996. All 1996 leased parking spaces are included in the 2016 model.

The number of private parking spaces available in 2002 has not been surveyed in zones 25, 28-30, 35 and 37. Upon agreement with Shoalhaven Council, one customer park was included for each retail/wholesale job in each of these respective zones, and one staff park was included in the inventory for each job (regardless of category) in these zones. If this concession for private parking availability were not made, all employee's and customer's vehicles trips would be directed into adjacent CBD zones to occupy public parking spaces if there were insufficient on street parking in that same zone.

The TRACKS CALM model requires that all parking zones to be modelled are sequentially numbered. Zones 26, 31-34 and 36 are not intended to be included in the parking model, however they must be included in the inventory as is the requirement of the TRACKS software. To isolate these zones from interacting with the actual CBD parking zones, each of these zones is allowed a free offstreet parking facility of infinite size which is included in the parking inventory as a 'Dummy' parking type. This ensures all vehicles travelling to these zones do not park other CBD zones. In order to ensure that vehicles travelling to CBD parking zones don't utilise this infinite capacity, an infinitely large cost is applied to walk trips between the 'Dummy' parking zones and all other zones in the model. Please note that this convention must be followed for all other future parking models in which these zones are inactive.

A list of potential additional public parking facilities was made available by Shoalhaven Council, should the existing public parking inventory be inadequate to meet the 2016 morning peak and offpeak parking demand.

It was found that the following public car parks were necessary to meet the said demand and were consequentially added to the parking inventory for 2016:

- Zone 14 receives an additional 250 all day parks.
- Zone 15 receives an additional 200 3 hour and 100 all day parks.

A further 420 parks were required over and above these proposed public carparks. To model an effective "do-minimum", these were evenly distributed as onstreet unrestricted parking spaces in zones 25, 28, 29 30, 35 and 37. This represents an onstreet parking "sprawl" as the CBD fills up.

All parking types have been attributed 100% practical capacity to all the model to efficiently use all available parks under saturated parking conditions.

In Tables 21 and 22, the onstreet and offstreet parking availability and occupancy at 9am and 12 noon respectively, for 2016 is presented. The full 2016 parking inventory is included in Appendix 5 to this report.

TABLE 21

2016 PARKING OCCUPANCY - 9AM

Parks Zone	Occupied ONUNR	To ON15-60M	End ON120M	Of OFUNR	Period OF120M	OF180M	OFCUST	OFLEAS	OFEMPL	Model Total	Total Parking Inventory	%age ALL PARKS	Of Onstreet Unrest	Parks Onstreet Rest	Occupied Offstreet Unrest	Offstreet Rest	Customer Parks	Leased Parks	Staff Parks
1	34	4	5	-	-	-	9	22	35	109	151	72%	87%	69%	-	-	27%	71%	100%
2	-	3	-	-	112	-	4	52	41	212	410	52%	-	18%	-	43%	10%	100%	100%
3	-	1	2	-	59	-	1	38	18	119	264	45%	-	25%	-	31%	20%	100%	100%
4	-	8	-	-	142	-	5	10	73	238	387	61%	-	33%	-	56%	18%	100%	100%
5	36	8	-	161	55	-	5	28	56	349	492	71%	90%	20%	91%	49%	13%	100%	100%
6	42	19	-	99	-	-	25	36	61	282	387	73%	100%	73%	100%	0%	33%	100%	58%
7	-	4	-	-	73	96	4	37	85	299	463	65%	-	22%	-	63%	14%	100%	77%
8	-	24	-	-	-	-	18	23	53	118	169	70%	-	83%	-	-	36%	100%	79%
9	-	11	-	-	-	-	7	15	23	56	100	56%	-	52%	-	-	17%	100%	100%
10	-	37	-	-	-	-	-	-	-	37	37	100%	-	100%	-	-	-	-	-
11	-	27	-	-	-	-	-	-	-	27	38	71%	-	71%	-	-	-	-	-
12	-	44	-	-	-	-	-	-	-	44	44	100%	-	100%	-	-	-	-	-
13	-	44	-	-	-	-	-	-	-	44	44	100%	-	100%	-	-	-	-	-
14	3	4	-	90	22	-	5	18	77	219	660	33%	27%	13%	26%	24%	6%	90%	100%
15	23	9	-	171	-	64	4	9	106	386	868	44%	49%	15%	50%	32%	7%	100%	68%
16	-	4	-	-	-	198	31	45	203	481	1,356	35%	-	20%	-	33%	8%	53%	83%
23	133	39	18	-	-	-	74	17	361	642	738	87%	99%	95%	-	-	48%	100%	97%
24	56	3	-	-	-	-	15	-	53	127	214	59%	97%	60%	-	-	16%	-	96%
25	14	-	-	-	-	-	-	-	8	22	107	21%	16%	-	-	-	0%	-	80%
27	41	5	-	-	-	-	7	6	49	108	284	38%	43%	22%	-	-	9%	100%	60%
28	18	-	-	-	-	-	-	-	13	31	125	25%	19%	-	-	-	0%	-	42%
29	49	1	-	-	-	-	3	-	43	96	278	35%	60%	20%	-	-	12%	-	26%
30	24	-	-	-	-	-	1	-	17	42	159	26%	26%	0%	-	-	4%	-	44%
35	26	-	-	-	-	-	-	-	15	41	142	29%	27%	-	-	-	0%	-	35%
37	29	-	-	-	-	-	-	-	22	51	164	31%	35%	-	-	-	0%	-	27%
TOTAL	528	299	25	521	463	358	218	356	1,412	4,180	8,081	52%	53%	57%	54%	42%	17%	87%	75%

TABLE 22

2016 PARKING OCCUPANCY– 12NOON

Parks	Occupied	To	End	Of	Period					Model	Total Parking	%age ALL	Of Onstreet	Parks Onstreet	Occupied Offstreet	Offstreet	Customer	Leased	Staff
Zone	ONUNR	ON15-60M	ON120M	OFUNR	OF120M	OF180M	OFCUST	OFLEAS	OFEMPL	Total	Inventory	PARKS	Unrest	Rest	Unrest	Rest	Parks	Parks	Parks
1	39	7	6	-	-	-	19	31	35	137	151	91%	100%	100%	-	-	58%	100%	100%
2	-	12	-	-	217	-	11	52	41	333	410	81%	-	71%	-	84%	26%	100%	100%
3	-	6	5	-	175	-	2	38	18	244	264	92%	-	92%	-	92%	40%	100%	100%
4	-	21	-	-	249	-	16	10	73	369	387	95%	-	88%	-	99%	57%	100%	100%
5	40	34	-	176	112	-	21	28	56	467	492	95%	100%	83%	100%	99%	55%	100%	100%
6	42	24	-	99	2	-	56	36	86	345	387	89%	100%	92%	100%	67%	74%	100%	82%
7	-	15	-	-	113	146	14	37	109	434	463	94%	-	83%	-	97%	48%	100%	98%
8	-	29	-	-	-	-	37	23	64	153	169	91%	-	100%	-	-	74%	100%	96%
9	-	19	-	-	-	-	13	15	23	70	100	70%	-	90%	-	-	32%	100%	100%
10	-	37	-	-	-	-	-	-	-	37	37	100%	-	100%	-	-	-	-	-
11	-	37	-	-	-	-	-	-	-	37	38	97%	-	97%	-	-	-	-	-
12	-	44	-	-	-	-	-	-	-	44	44	100%	-	100%	-	-	-	-	-
13	-	44	-	-	-	-	-	-	-	44	44	100%	-	100%	-	-	-	-	-
14	6	11	-	191	47	-	13	20	77	365	660	55%	55%	35%	55%	51%	17%	100%	100%
15	38	34	-	273	-	136	13	9	151	654	868	75%	81%	58%	81%	68%	22%	100%	97%
16	-	16	-	-	-	524	120	69	245	974	1,356	72%	-	80%	-	87%	30%	81%	100%
23	134	42	18	-	-	-	132	17	374	717	738	97%	100%	100%	-	-	86%	100%	100%
24	58	5	-	-	-	-	31	-	55	149	214	70%	100%	100%	-	-	32%	-	100%
25	51	-	-	-	-	-	1	-	10	62	107	58%	57%	-	-	-	14%	-	100%
27	70	13	-	-	-	-	17	6	68	174	284	61%	73%	57%	-	-	22%	100%	83%
28	37	-	-	-	-	-	-	-	21	58	125	46%	40%	-	-	-	0%	-	68%
29	78	4	-	-	-	-	13	-	61	156	278	56%	96%	80%	-	-	52%	-	37%
30	45	1	-	-	-	-	4	-	27	77	159	48%	49%	25%	-	-	16%	-	69%
35	86	-	-	-	-	-	1	-	24	111	142	78%	91%	-	-	-	25%	-	56%
37	81	-	-	-	-	-	1	-	33	115	164	70%	99%	-	-	-	100%	-	41%
TOTAL	805	455	29	739	915	806	535	391	1,651	6,326	8,081	78%	81%	85%	77%	87%	42%	96%	87%

10.7 Future Road Network

A 2002 road network was developed by Shoalhaven Council from which to develop a ‘do minimum’ for the 2016 network. It was agreed that should this network need to be modified in order to achieve convergence of the four 2016 models, then network improvements could be made in agreement with the Council.

The following changes were proposed by Shoalhaven Council and were subsequently included in the model:

- Intersection of Plunkett and Berry Streets (node 719) upgraded to signals with 3 approach lanes for each approach (equivalent to a LT TR 2 approach lane operation).
- Intersection of Kinghorne and Worrigee Streets (node 723) upgraded to signals with 3 approach lanes for each approach (equivalent to a LT TR 2 approach lane operation).
- Intersection of Princes Highway and Hillcrest Ave (node 387) upgraded to 2 lane rotary.
- Intersection of Princes Highway and Browns Rd (node 365) upgraded to 2 lane rotary.
- Intersection of Princes Highway and Central Ave (node 323) upgraded to 2 lane rotary.
- Flinders Road has been realigned to meet the Quinns Lane and Princes Highway intersection (node 344) This newly formed intersection is upgraded to a 2 lane rotary.
- Intersection of Berry Street and Albatross Street (node 570) upgraded to 1 lane rotary.
- Worrigee Street westbound from Haigh Street to Kinghorne Street upgraded to 2 lanes (links 527-591-1938-723).
- Worrigee Street eastbound from Kinghorne Street to adjacent one-way lane upgraded to 2 lanes (links 723-1938-591).
- Kinghorne Street northbound from Worrigee Street to the adjacent carpark entry upgraded to 2 lanes (link 723-583).
- Princes Highway southbound from Kinghorne Street to existing 2 lane section (south of Quinns Lane) upgraded to 2 lanes (links 389-387-365-345-344-1776).
- Princes Highway northbound from south of Central Ave to Kinghorne Street upgraded to 2 lanes (links 1775-323-1928-1776-344-345-365-387-389).
- Intersection of Kalandar Street and Wallace Street is upgraded to signals.

As well as these proposed improvements, the following were also included in the model:

- Maximum cycle times increased from 120 seconds to 180 seconds on the signals at the intersections of Princes Highway and Illaroo Rd (node 385), Princes Highway and Kalandar St (node 482), Princes Highway and Moss Street (node 654) and Princes Highway and Worrigee St (node 856) to increase the capacity of these intersections.
- The practical capacity of these two intersections along with the signalised intersections of Princes Highway and Illaroo Rd (node 385), Princes Highway and Kalandar St (node 482), Haigh and Worrigee Streets (node 527), Princes Highay and Worrigee Street (node 719), Plunkett Street and Berry Street (node 856) and Princes Highway and Plunkett Street (node 925) was increased to 99% as a further means of increasing the intersection capacity.
- The western approach of the signals at the intersection of Illaroo Rd and Princes Highway allows a free left turn on red. The most suitable method of modelling this in NEX is to permit a free left with a give way control. The intersection has been

modified accordingly with two right turn approach lanes at the traffic signal, and two through and two right turn lanes from the northern approach.

- A free left has been added to the western approach of the signals at the intersection of Kalandar St and Princes Highway with two signalised right turn lanes and a through lane from this approach. The eastern approach has been modified with a left lane, a through lane and two right turn lanes. Three through lanes are provided at the northern approach.
- The intersection of Plunkett Street and Princes Highway includes three through lanes for both the northern and southern approaches.
- The intersections of Graham Street and Bridge Road, and McGrath Avenue and Graham Street have been upgraded to two approach lanes from each approach.

A number of approach lanes at Nowra traffic signals share turning movements (i.e. left and through lane, through and right lane, or a left, through and right lane). The SIDRA delay calculations do not allow through traffic to continue to flow freely when the other shared movement has opposing flow.

For example, in a 2 approach lane configuration with a left turn lane and a through and right shared lane, should a right turning vehicle hold up the outside lane, through traffic following it are likely to use the inside lane. SIDRA delay calculations do not model this. To correctly model this behaviour the following approaches have been modified:

- The western and eastern approaches of the intersection of Princes Highway and Plunkett Street.
- All approaches of the intersection of Kinghorne Street and Plunkett Street.

A number of intersections have shared left and through lanes which are attracted larger delays than through lanes due to a reduced utilisation for through traffic. To increase the capacity of the more congested of these intersections, the shared lanes have been modelled as a left lane and a through lane as a means of reducing the calculated delays at congested signalised intersections. Though some of these configurations are deemed infeasible by Shoalhaven Council, they are necessary improvements to remove enough delay from the 2016 models to allow convergence. Nodes 719 and 723 which are listed on the previous page of proposed intersection upgrades fall into this category and are modelled as having three approach lanes when two approach lanes (a LT TR configuration) is the likely configuration. The following intersections have also been modified accordingly:

- Southern approach of the intersection of Princes Highway and Bridge Road.
- The northern and southern approaches of the intersection of Princes Highway and Plunkett Street.
- All approaches of the intersection of Princes Highway and Kalandar Street.

10.8 Future Traffic Generation and Distribution

The projected land use and external traffic flows were then used to generate the future traffic demand. The resulting number of trips over the entire study area is compared against 1996 values is shown in Table 23.

TABLE 23

FUTURE TRAFFIC GENERATION

	Number of Assigned Trips		% Traffic Growth
	1996	2016	1996-2016
24 Hour	132805	227093	71.0% (3.5% pa)
AM Peak	11455	19622	71.3% (3.6% pa)
Inter Peak	12058	20481	70.0% (3.5% pa)
PM Peak	13590	21977	61.7% (3.1% pa)

Note that the future traffic flows are generated from projected land use and not merely a "factoring up" of the traffic volumes. Consequently the increase in traffic on individual roads is due to the change in land use affecting those roads. This will vary between periods as different levels of CBD parking circulation and additional household generation occur.

The final totals for the time and distance matrices (after many previous runs) are shown below with convergence results also.

TVM = Total Vehicle Minutes
TVK = Total Vehicle Kilometres

PERIOD	24 Hour	24 Hour	AM Peak	AM Peak	Offpeak	Offpeak	PM Peak	PM Peak
	TVM	TVK	TVM	TVK	TVM	TVK	TVM	TVK
2016 Prev.Run	1913761	1559172	168792	126691	135720	102956	191507	137901
2016 This Run	1914619	1559067	168761	126686	135675	102960	191416	137872
%age Diff	-0.04%	<0.01%	0.02%	<0.01%	0.03%	-<0.01%	0.05%	0.024%
1996 Final Run	1051935	959773	87662	77385	73826	64311	102635	86938
Growth 1996-2016	82.0%	62.4%	92.5%	63.7%	83.8%	60.1%	86.5%	59.0%

Clearly, with the increase in the number of trips there has been a similar increase in the total number of vehicle network kilometres travelled. However, increased congestion in parts of the network has resulted in significant increases in the total network vehicle minutes during the busier periods modelled.

10.9 Future Traffic Volumes

A plot of the modelled 2016 traffic volumes for the Nowra District study area is shown in Figures 10 to 13.

Nowra District Transport Model	2016 ALL DAY TRAFFIC VOLUMES	Figure 10
Gabites Porter Consultants		

Nowra District Transport Model	**2016 MORNING PEAK TRAFFIC VOLUMES**	Figure 11
Gabites Porter Consultants		

Nowra District Transport Model	**2016 OFFPEAK TRAFFIC VOLUMES**	Figure 12
Gabites Porter Consultants		

Nowra District Transport Model	**2016 EVENING PEAK TRAFFIC VOLUMES**	Figure 13
Gabites Porter Consultants		

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Appendix G

Acoustic terminology

Appendix G Acoustic terminology

The following is a brief description of acoustic terminology used in this report.

Sound power level	The total sound emitted by a source
Sound pressure level	The amount of sound at a specified point
Decibel [dB]	The measurement unit of sound
A Weighted decibels [dB(A])	The A weighting is a frequency filter applied to measured noise levels to represent how humans hear sounds. The A-weighting filter emphasises frequencies in the speech range (between 1kHz and 4 kHz) which the human ear is most sensitive to, and places less emphasis on low frequencies at which the human ear is not so sensitive. When an overall sound level is A-weighted it is expressed in units of dB(A).
Decibel scale	The decibel scale is logarithmic in order to produce a better representation of the response of the human ear. A 3 dB increase in the sound pressure level corresponds to a doubling in the sound energy. A 10 dB increase in the sound pressure level corresponds to a perceived doubling in volume. Examples of decibel levels of common sounds are as follows:

0dB(A)	Threshold of human hearing
30dB(A)	A quiet country park
40dB(A)	Whisper in a library
50dB(A)	Open office space
70dB(A)	Inside a car on a freeway
80dB(A)	Outboard motor
90dB(A)	Heavy truck pass-by
100dB(A)	Jackhammer/Subway train
110 dB(A)	Rock Concert
115dB(A)	Limit of sound permitted in industry
120dB(A)	747 take off at 250 metres

Frequency [f]	The repetition rate of the cycle measured in Hertz (Hz). The frequency corresponds to the pitch of the sound. A high frequency corresponds to a high pitched sound and a low frequency to a low pitched sound.
Equivalent continuous sound level [L_{eq}]	The constant sound level which, when occurring over the same period of time, would result in the receiver experiencing the same amount of sound energy.
L_{max}	The maximum sound pressure level measured over the measurement period
L_{min}	The minimum sound pressure level measured over the measurement period
L_{10}	The sound pressure level exceeded for 10% of the measurement period. For 10% of the measurement period it was louder than the L_{10}.
L_{90}	The sound pressure level exceeded for 90% of the measurement period. For 90% of the measurement period it was louder than the L_{90}.
Ambient noise	The all-encompassing noise at a point composed of sound from all sources near and far.

Background noise	The underlying level of noise present in the ambient noise when extraneous noise (such as transient traffic and dogs barking) is removed. The L_{90} sound pressure level is used to quantify background noise.
Traffic noise	The total noise resulting from road traffic. The L_{eq} sound pressure level is used to quantify traffic noise.
Day	The period from 0700 to 1800 h Monday to Saturday and 0800 to 1800 h Sundays and Public Holidays.
Evening	The period from 1800 to 2200 h Monday to Sunday and Public Holidays.
Night	The period from 2200 to 0700 h Monday to Saturday and 2200 to 0800 h Sundays and Public Holidays.
Assessment background level [ABL]	The overall background level for each day, evening and night period for **each day** of the noise monitoring.
Rating background level [RBL]	The overall background level for each day, evening and night period for the **entire length** of noise monitoring.

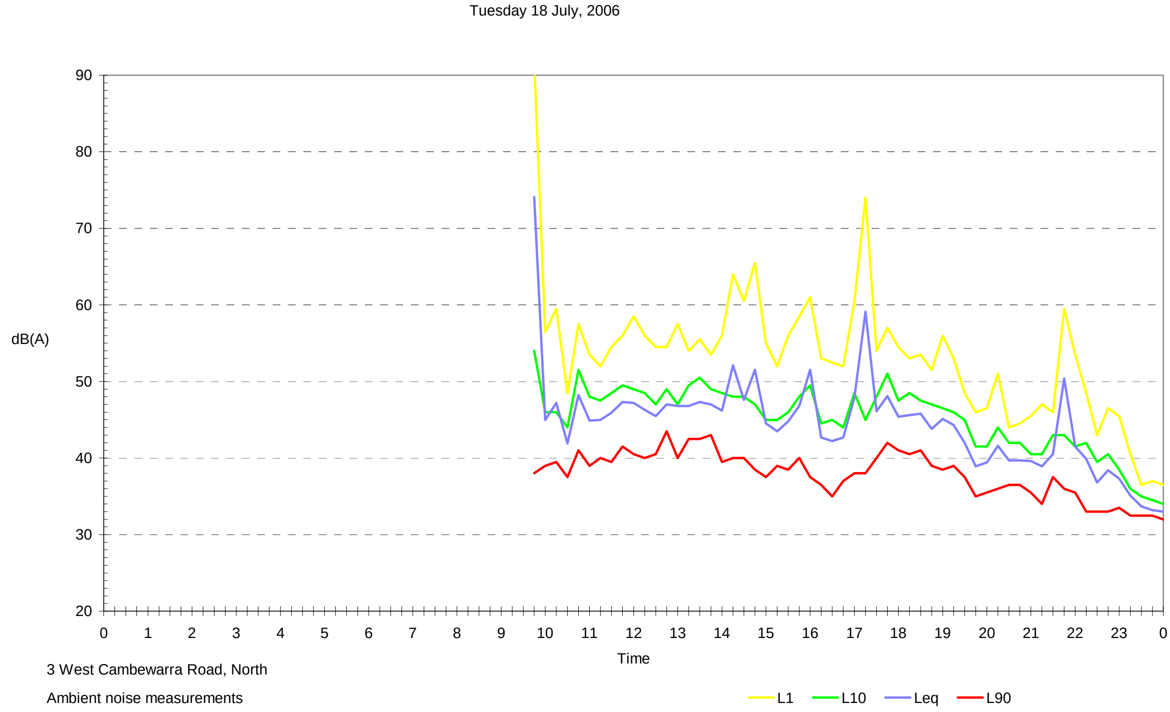
*Definitions of a number of terms have been adapted from Australian Standard AS1633:1985 *"Acoustics – Glossary of terms and related symbols"*, the DECCW's NSW Industrial Noise Policy and the DECCW's Environmental Criteria for Road Traffic Noise.

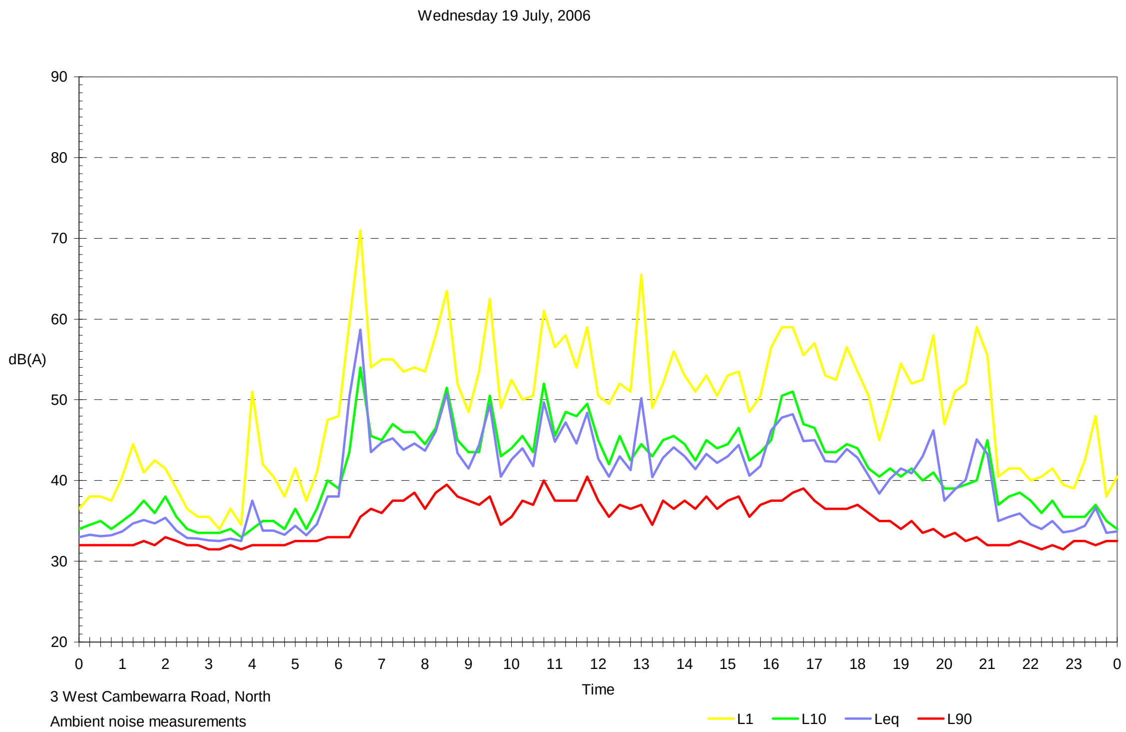
Appendix H

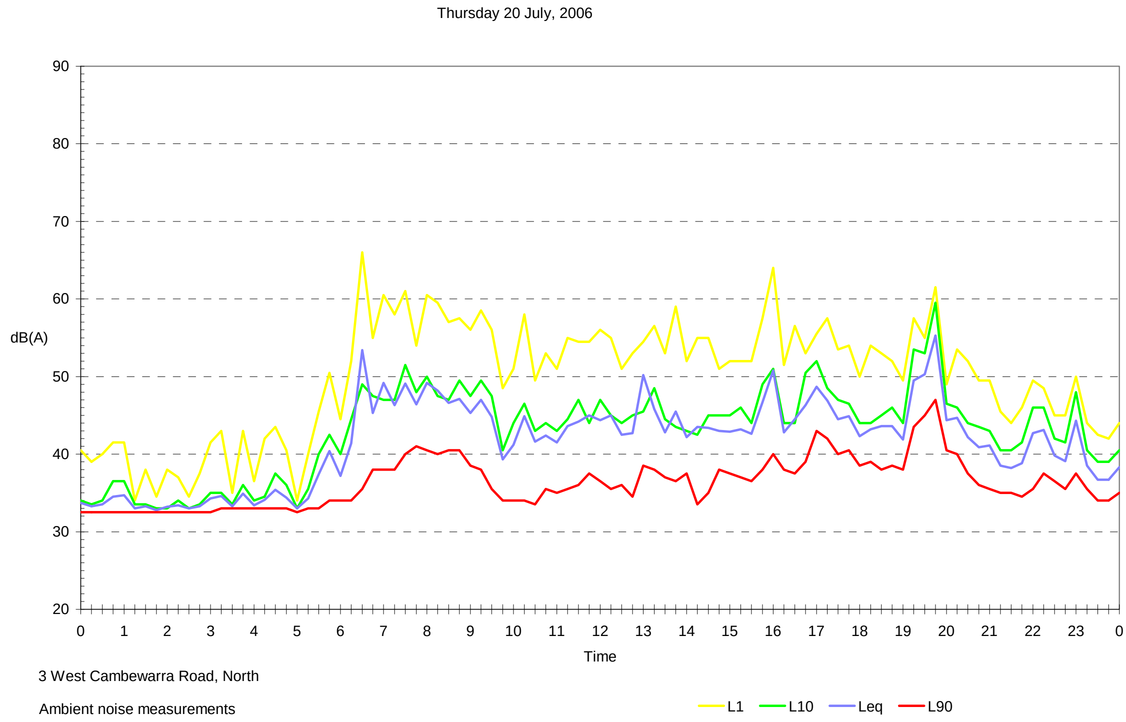
Unattended noise measurements

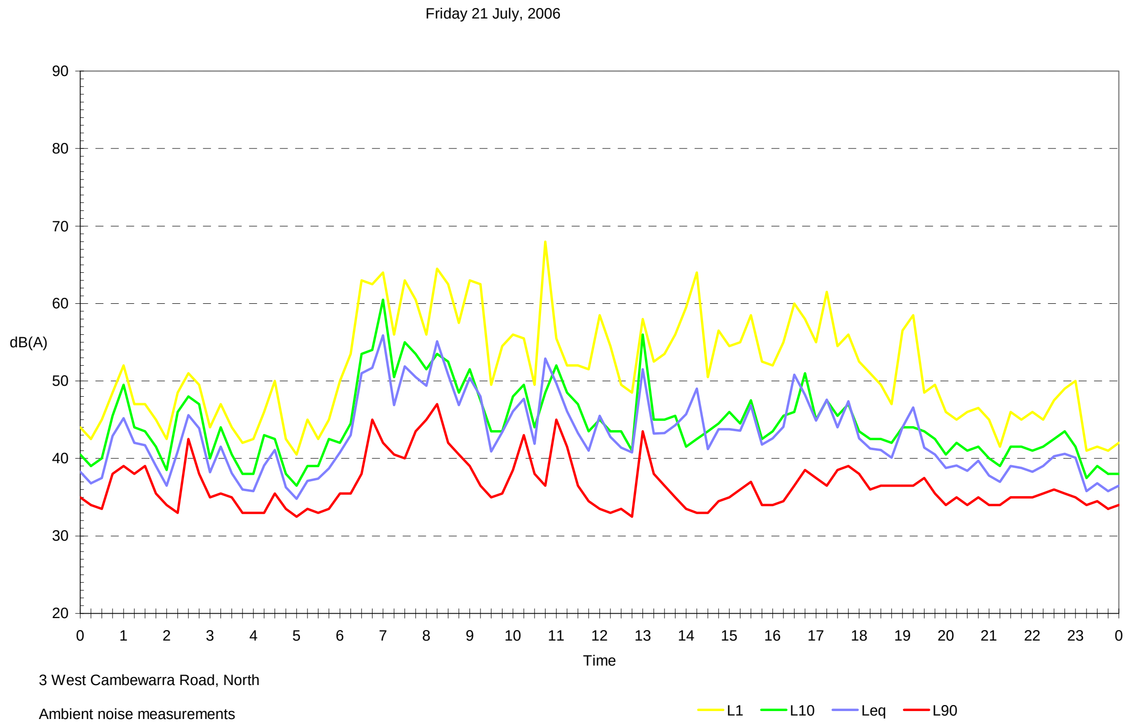
Appendix H Unattended noise measurements

3 West Cambewarra Road, North Nowra






Thursday 20 July, 2006
90
80
70
60
50
40
30
20
dB(A)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0
Time
3 West Cambewarra Road, North
Ambient noise measurements
L1
L10
Leq
L90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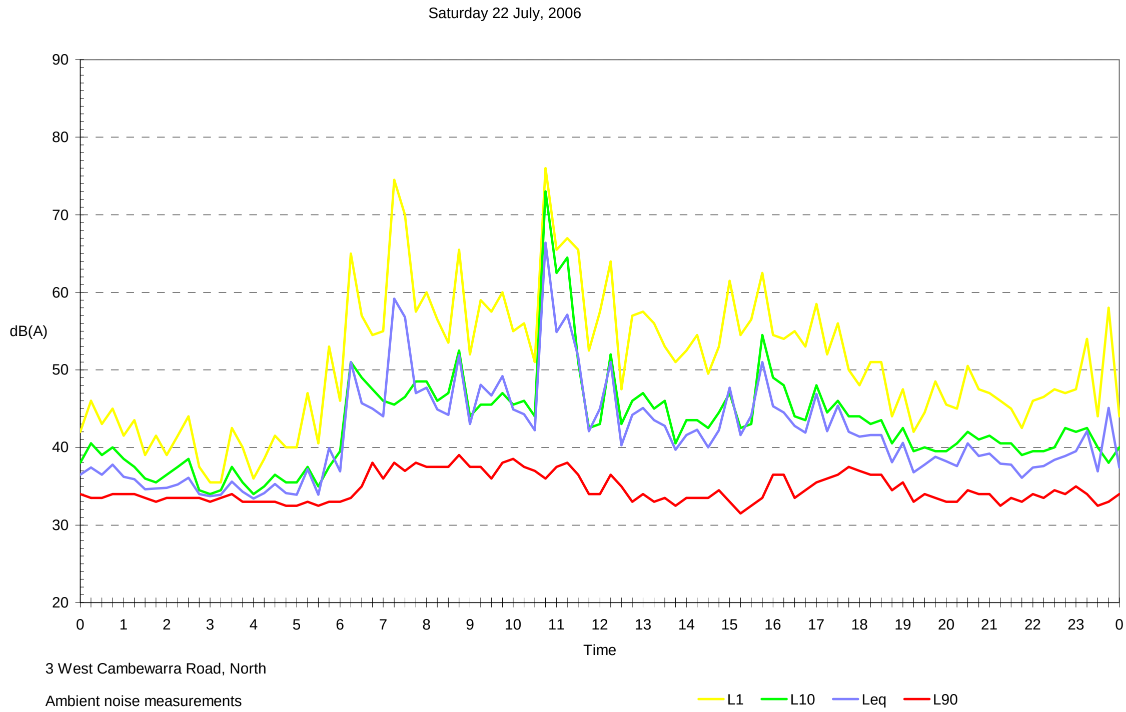
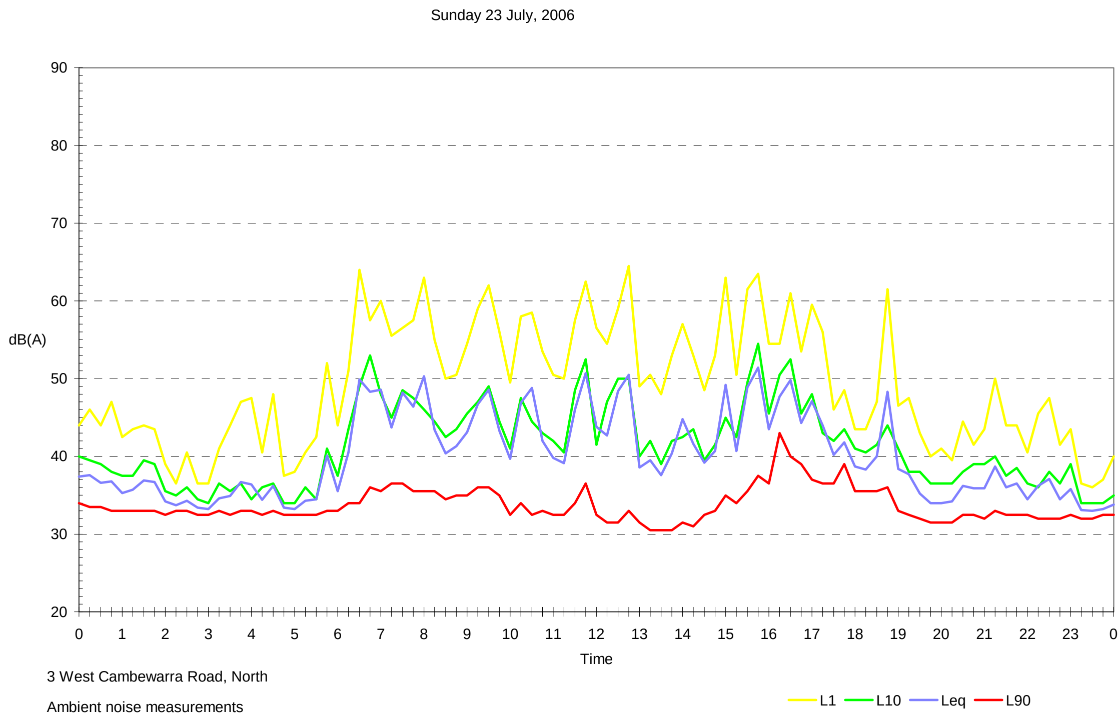
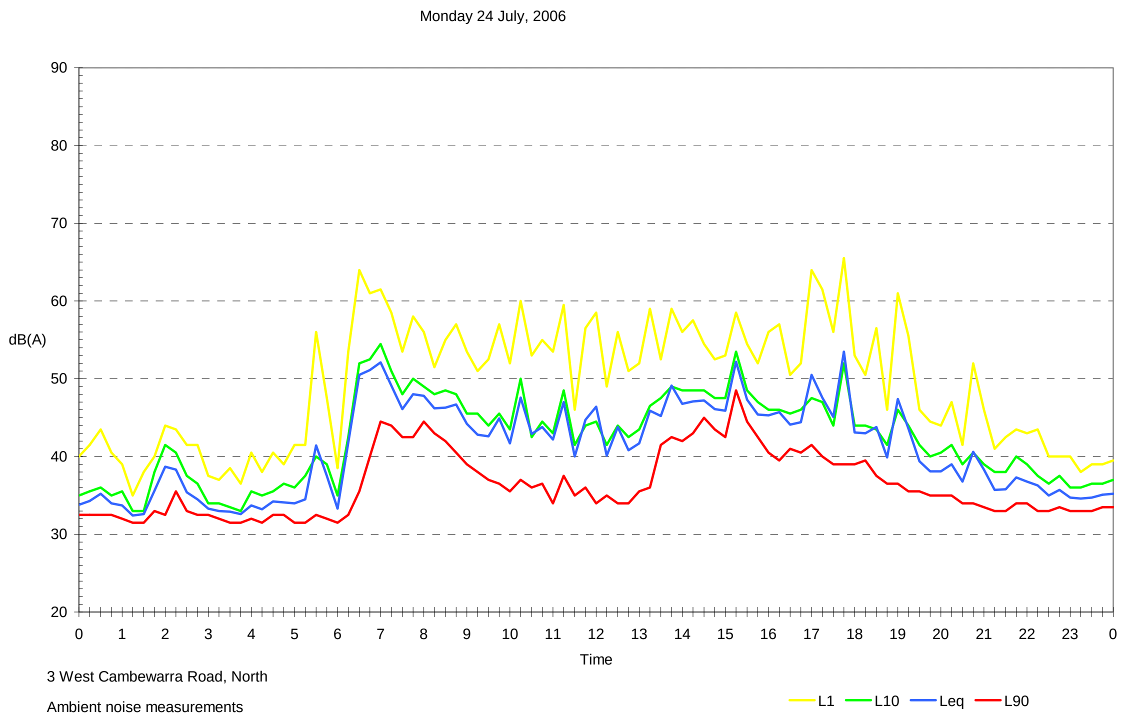
90
80
70
60
50
40
30
20
dB(A)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0
Time
3 West Cambewarra Road, North
Ambient noise measurements
L1
L10
Leq
L90


Saturday 22 July, 2006
dB(A)
90
80
70
60
50
40
30
20
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0
Time
3 West Cambewarra Road, North
Ambient noise measurements
L1
L10
Leq
L90


Sunday 23 July, 2006
dB(A)
90
80
70
60
50
40
30
20
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0
Time
3 West Cambewarra Road, North
Ambient noise measurements
L1
L10
Leq
L90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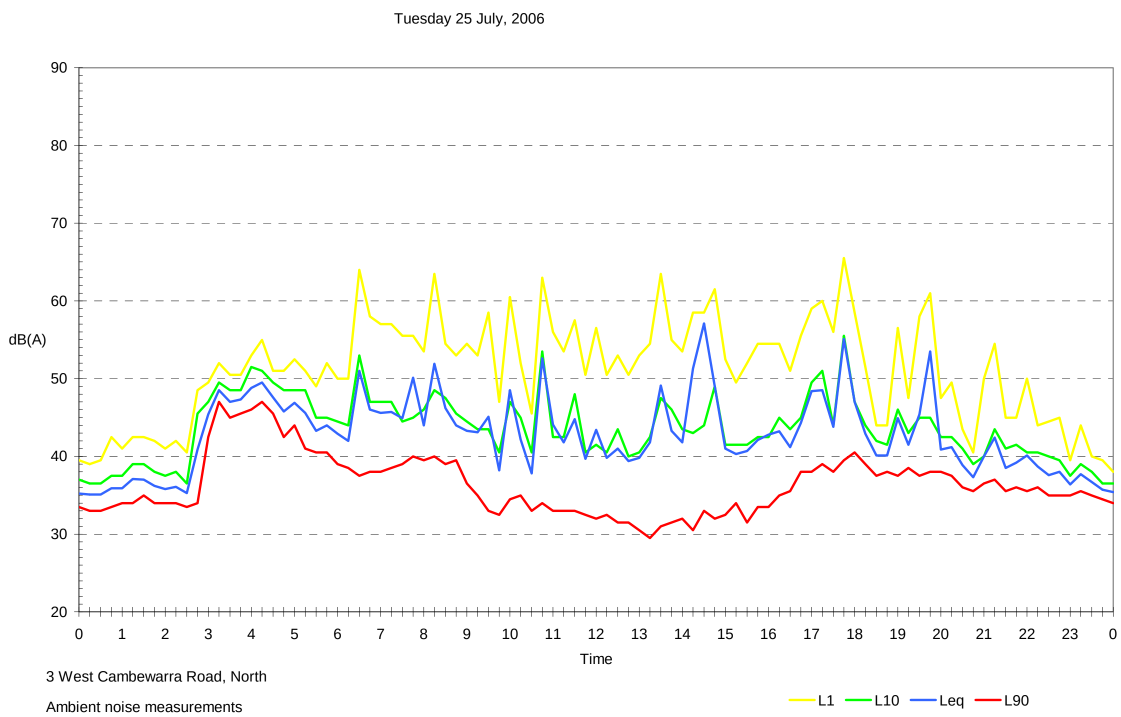
90
80
70
60
50
40
30
20
dB(A)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0
Time
3 West Cambewarra Road, North
Ambient noise measurements
L1
L10
Leq
L90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80
70
60
50
40
30
20
dB(A)
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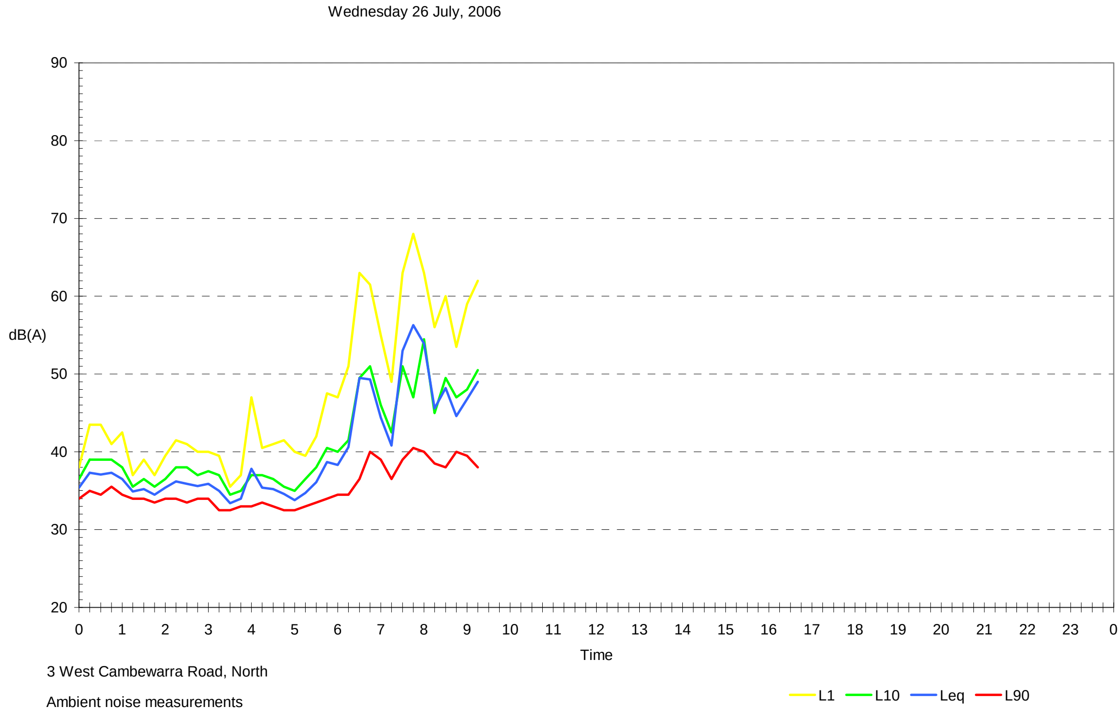
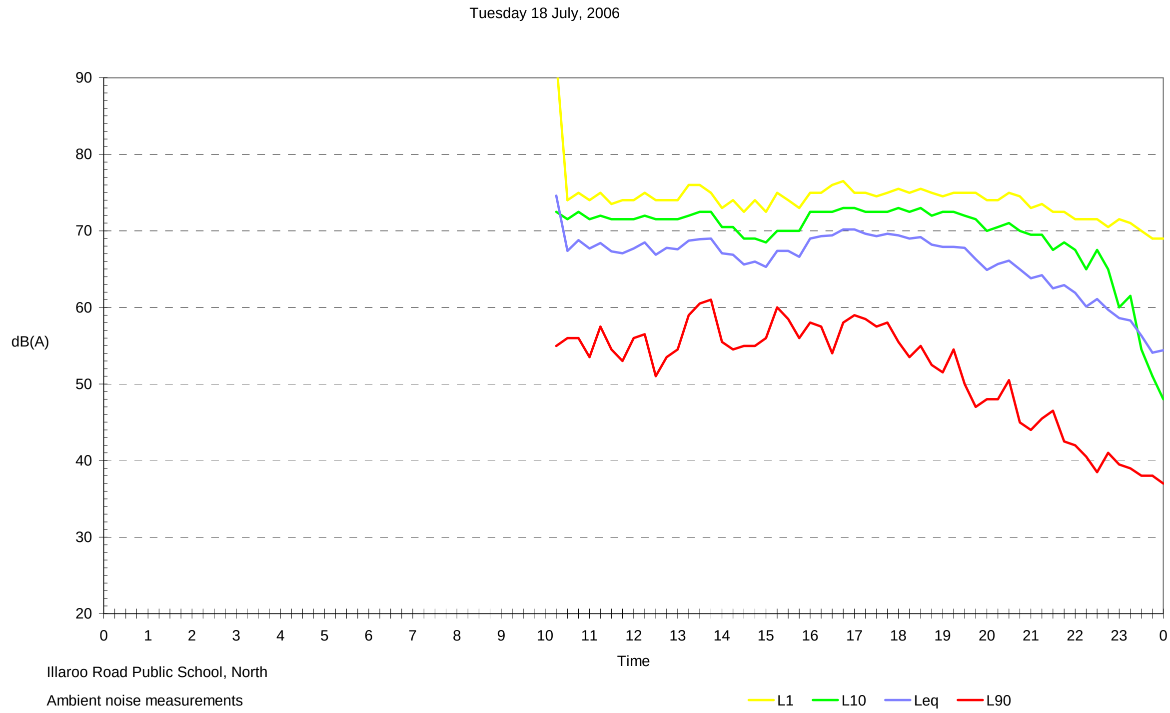
Time
3 West Cambewarra Road, North
Ambient noise measurements
L1
L10
Leq
L90

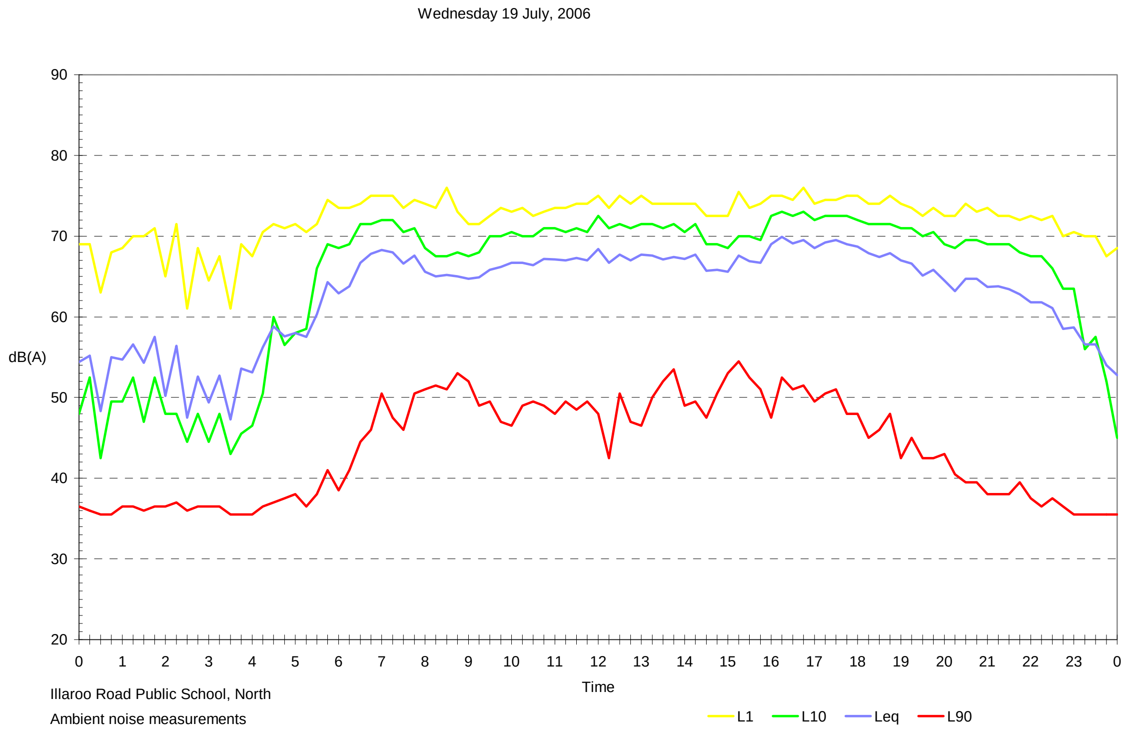


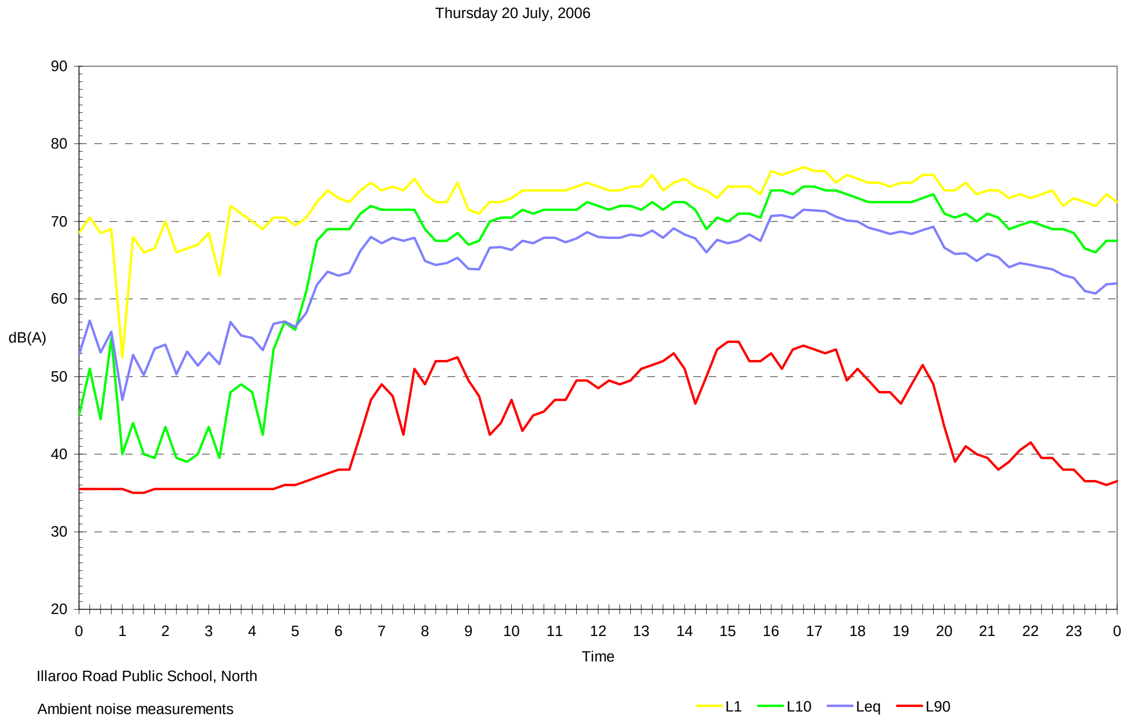
3 West Cambewarra Road, North

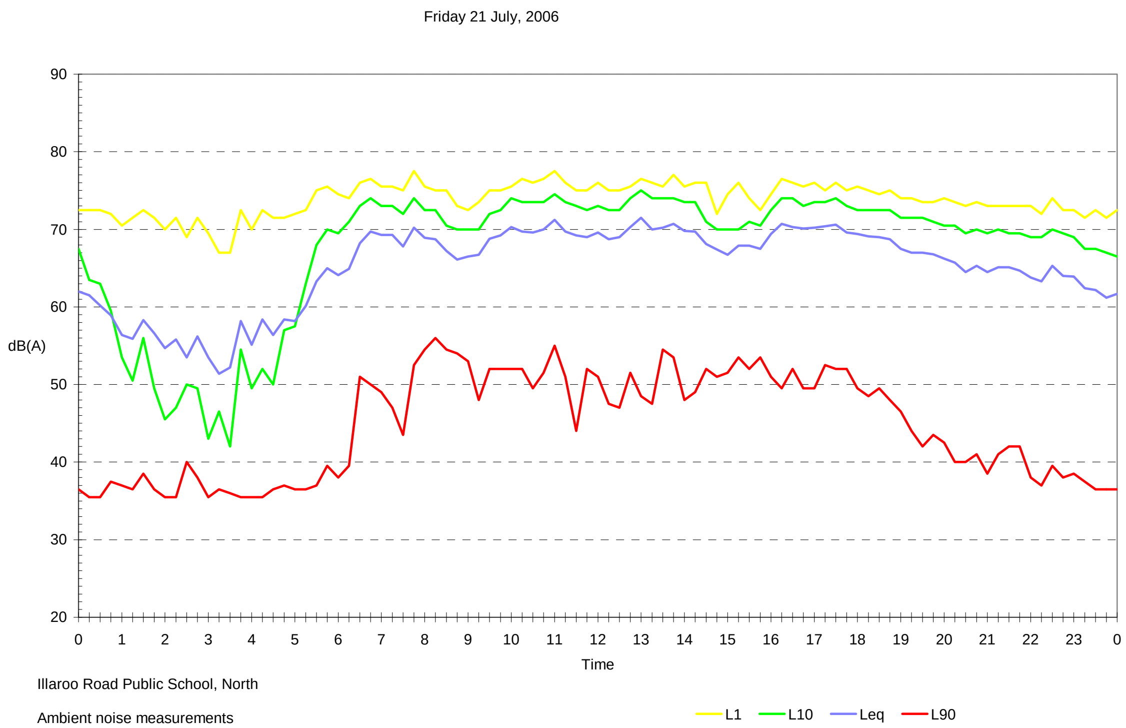
Ambient noise measurements

Illaroo Road Public School, North Nowra






Thursday 20 July, 2006
90
80
70
60
50
40
30
20
dB(A)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0
Time
Illaroo Road Public School, North
Ambient noise measurements
L1
L10
Leq
L90


Friday 21 July, 2006
90
80
70
60
50
40
30
20
dB(A)
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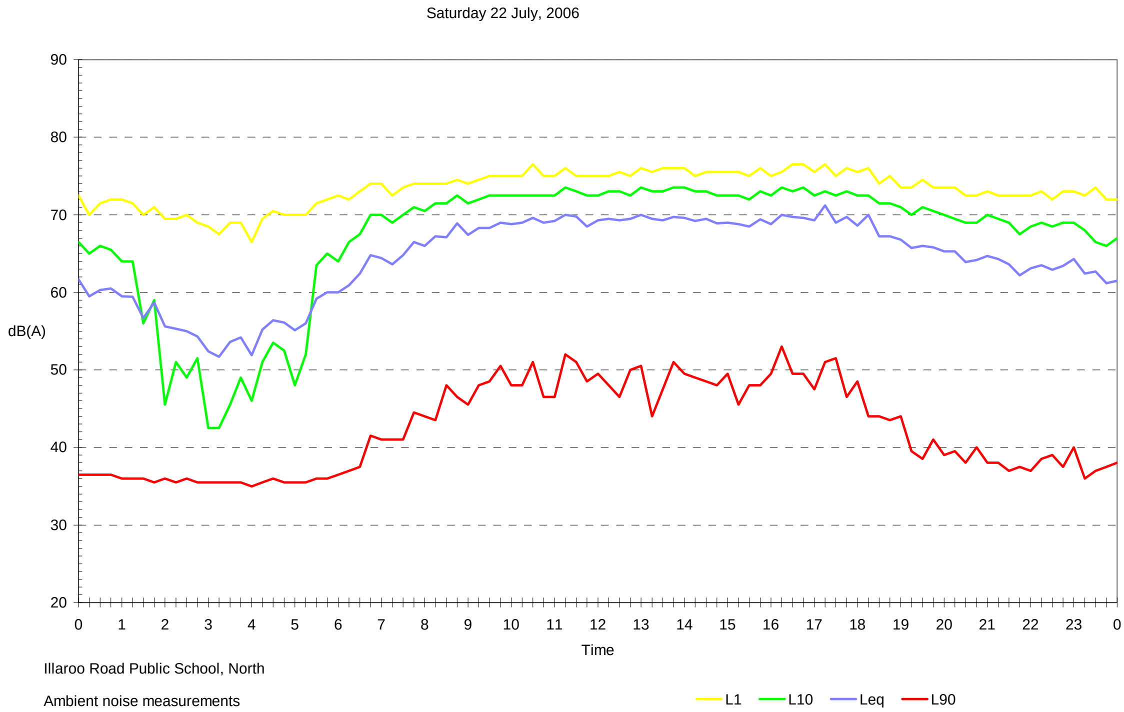
Time
Illaroo Road Public School, North
Ambient noise measurements
L1
L10
Leq
L90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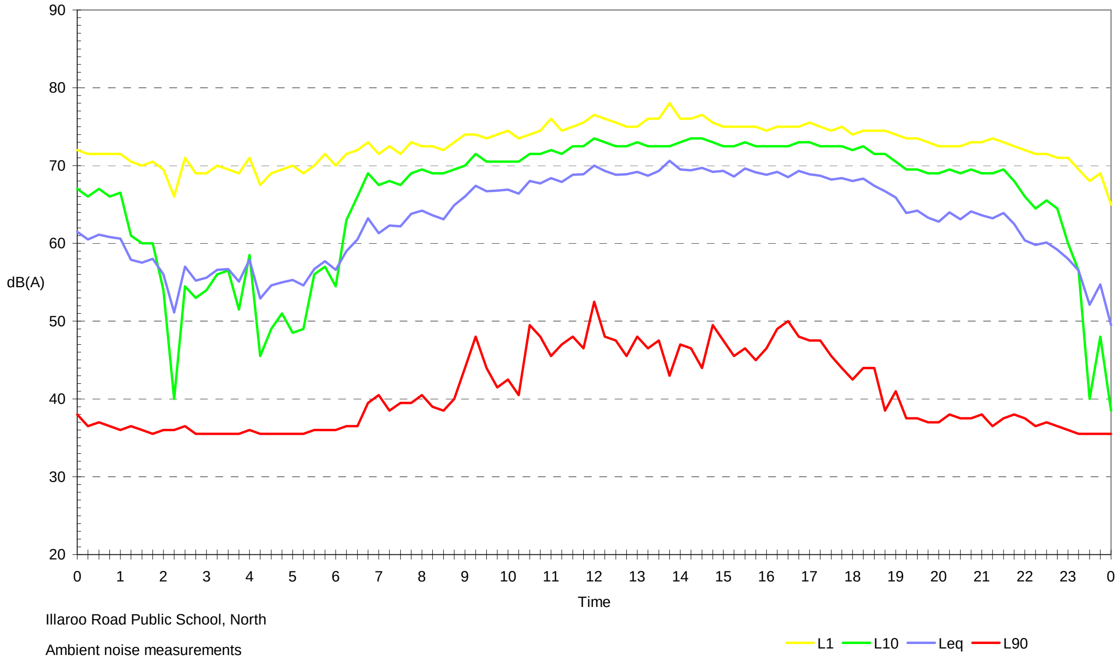
Time
Illaroo Road Public School, North
Ambient noise measurements
L1
L10
Leq
L90

Sunday 23 July, 2006



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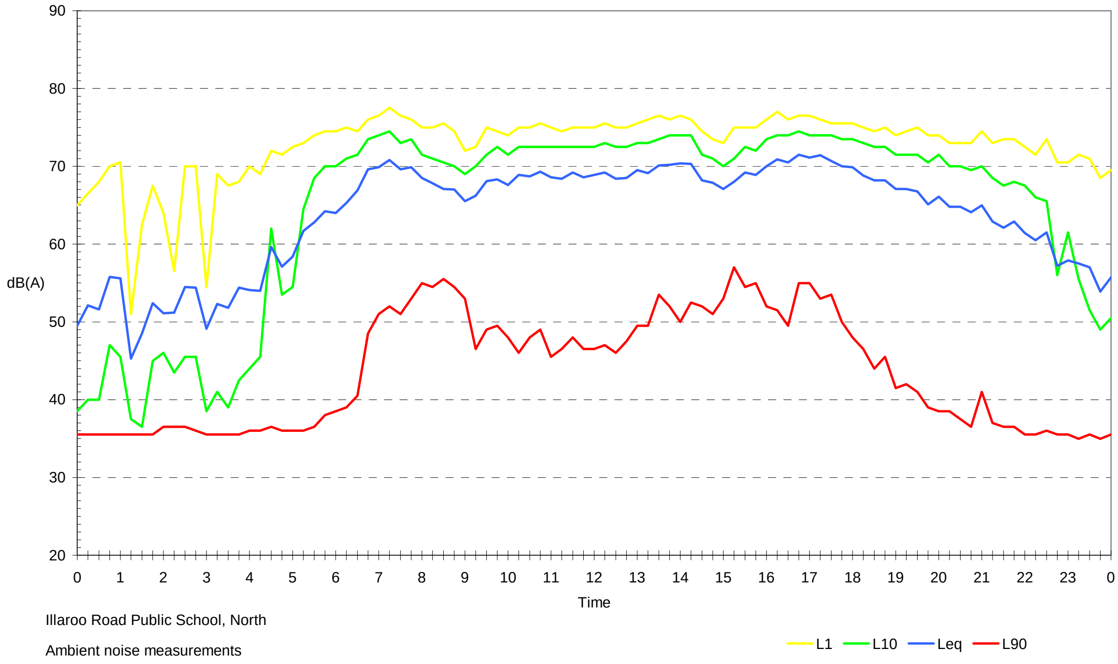

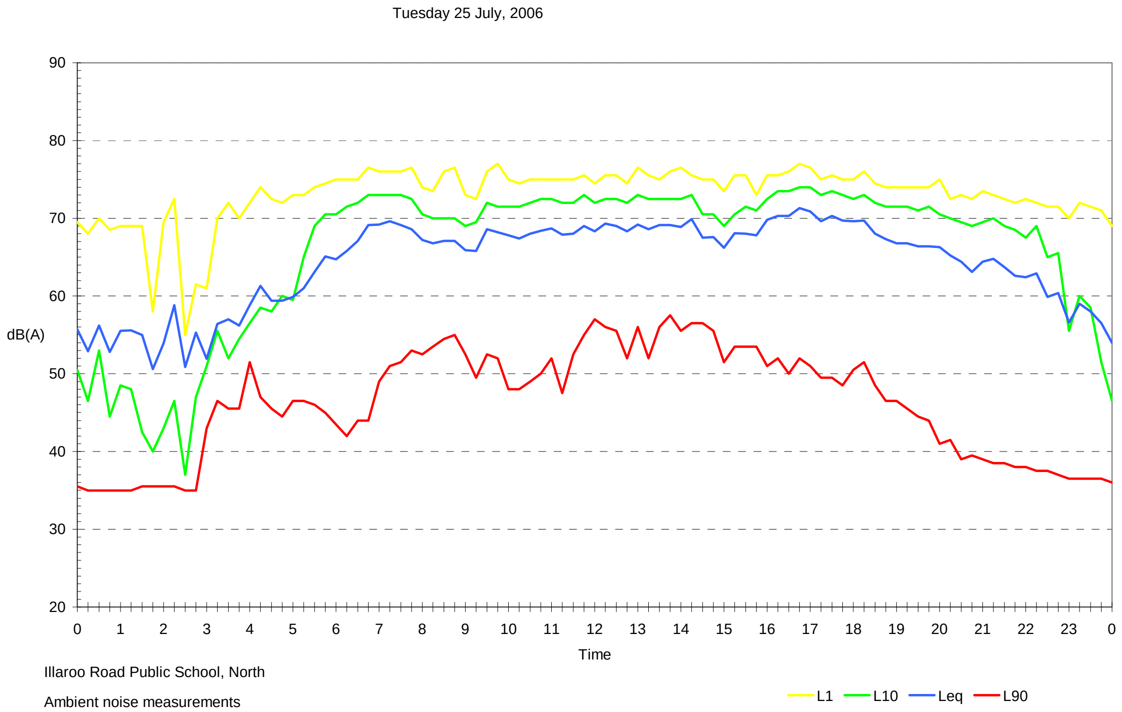
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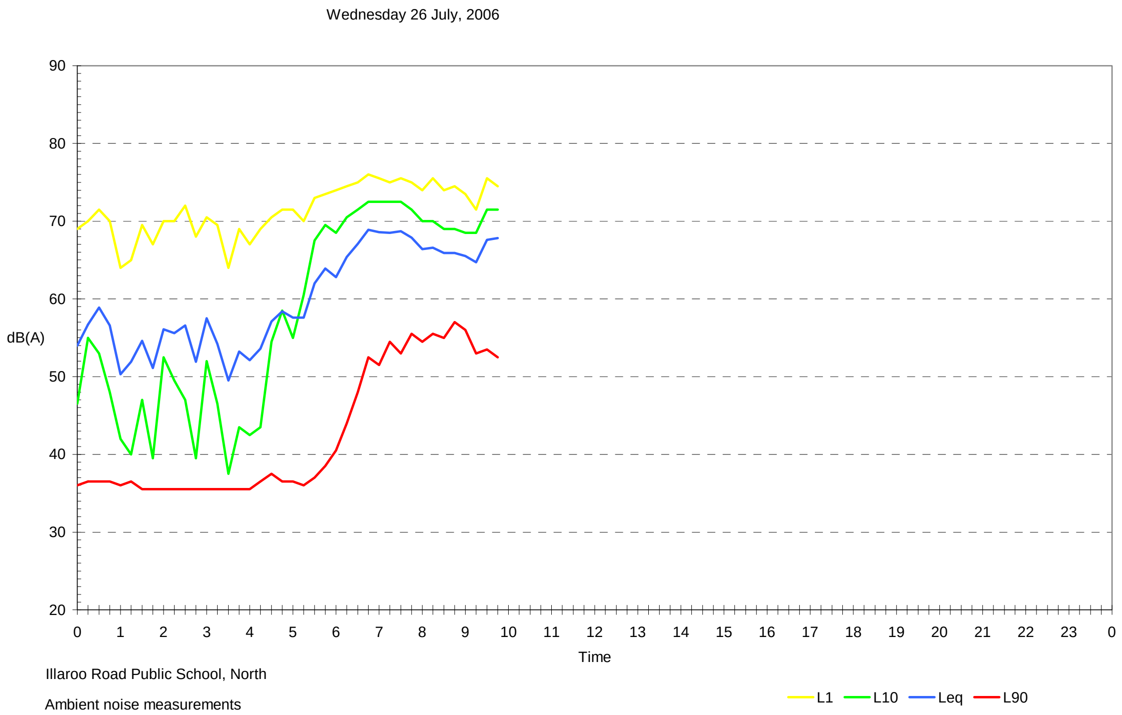
Illaroo Road Public School, North
Ambient noise measurements
L1
L10
Leq
L90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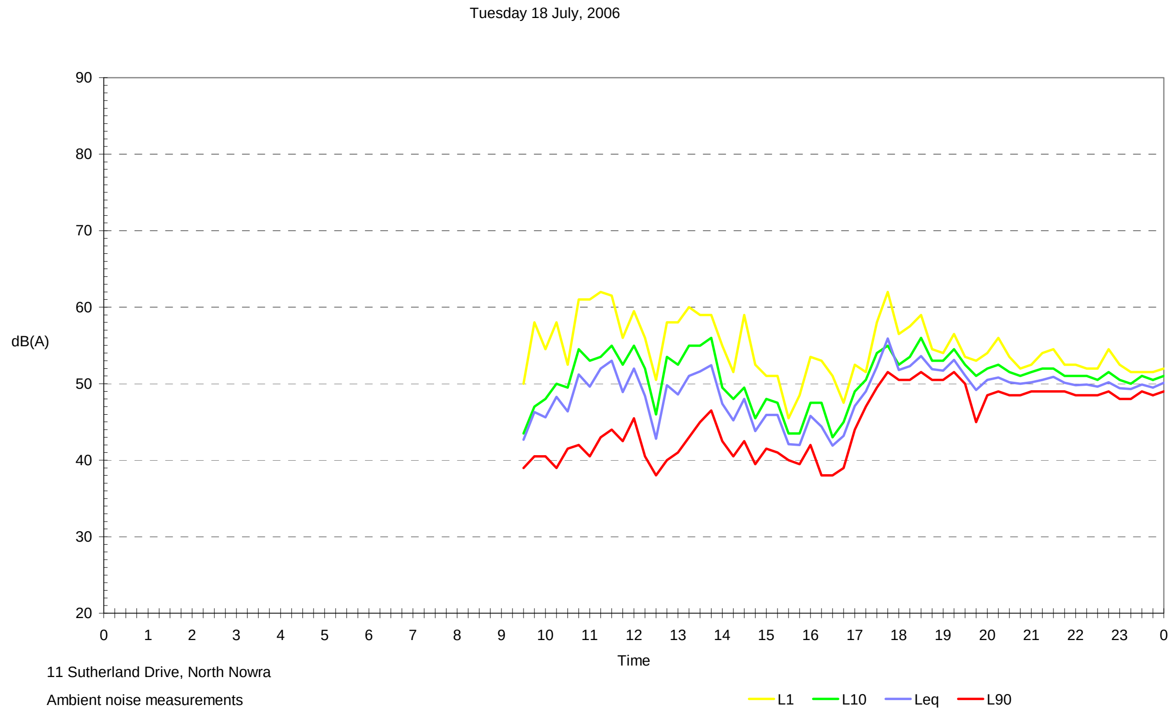
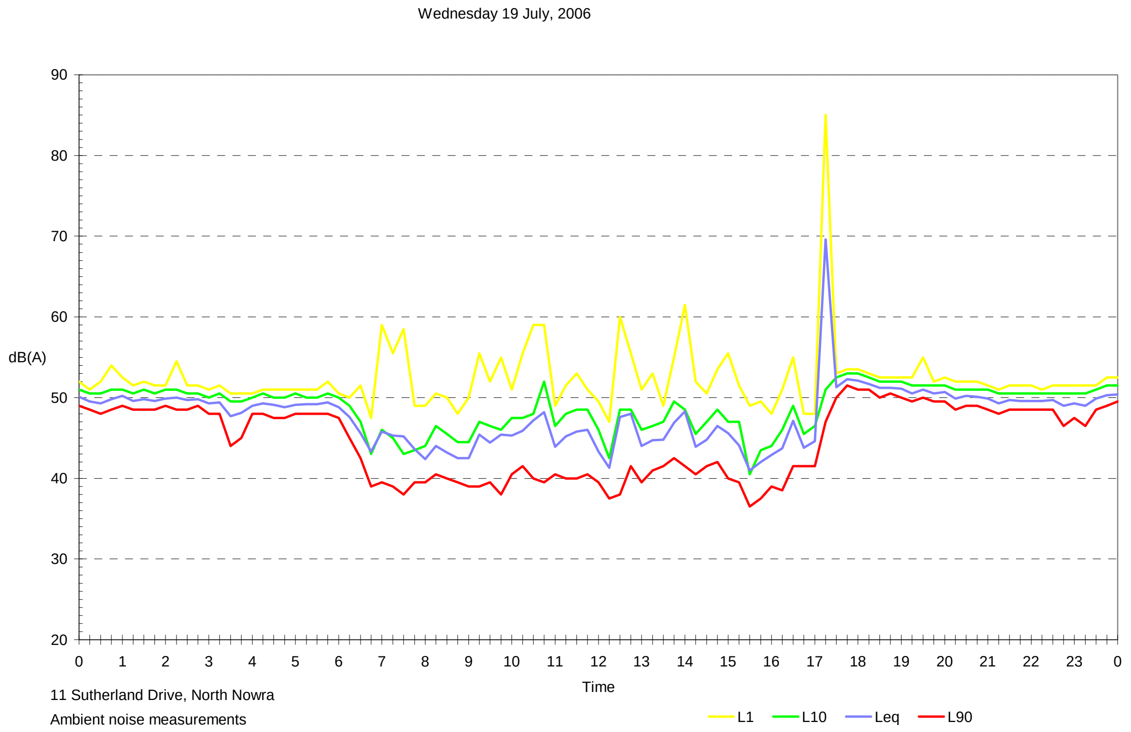
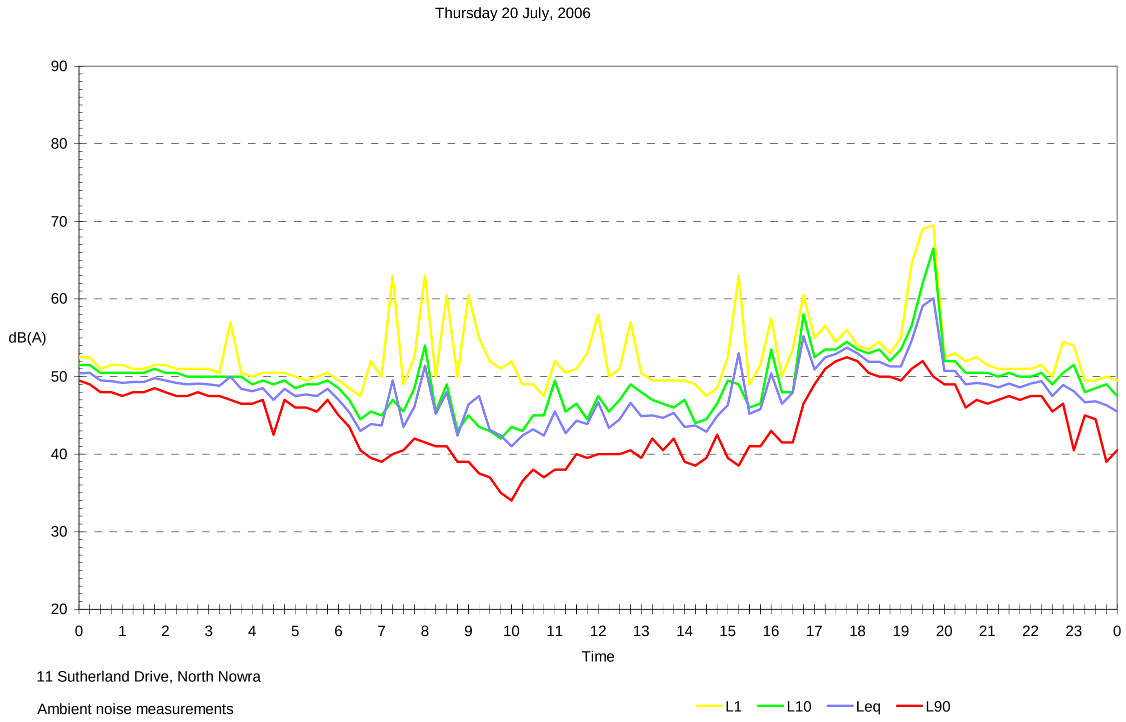
Time
Illaroo Road Public School, North
Ambient noise measurements
L1
L10
Leq
L90

11 Sutherland Drive, North Nowra



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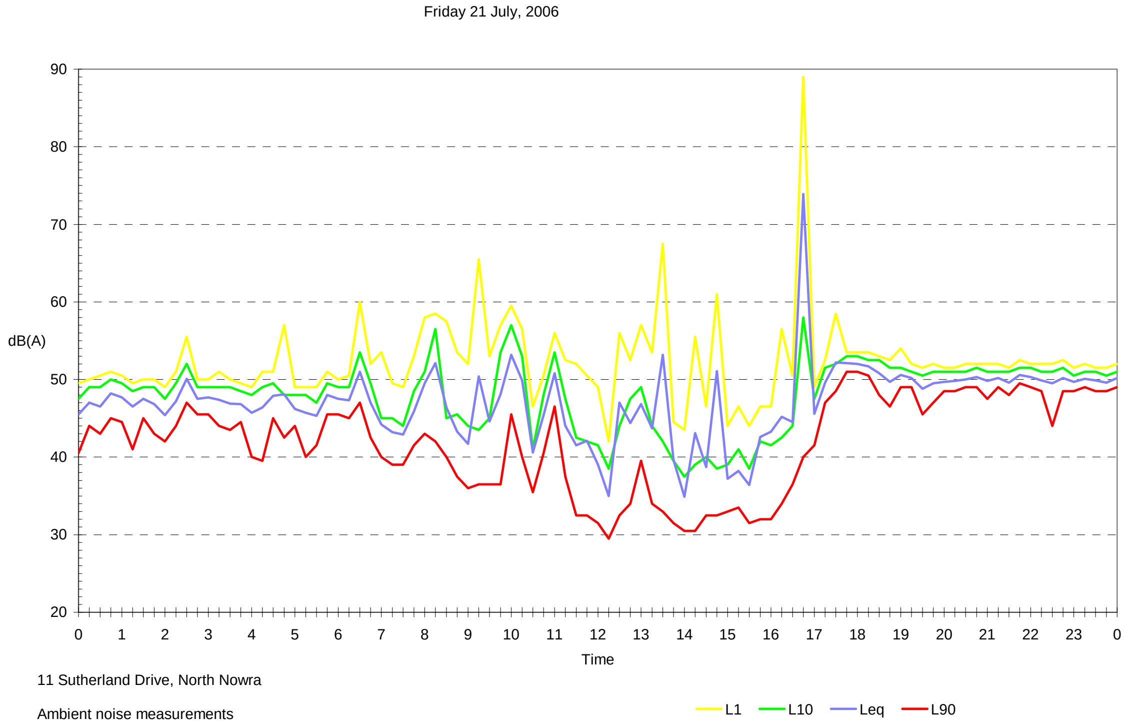
11 Sutherland Drive, North Nowra
Ambient noise measurements
L1
L10
Leq
L90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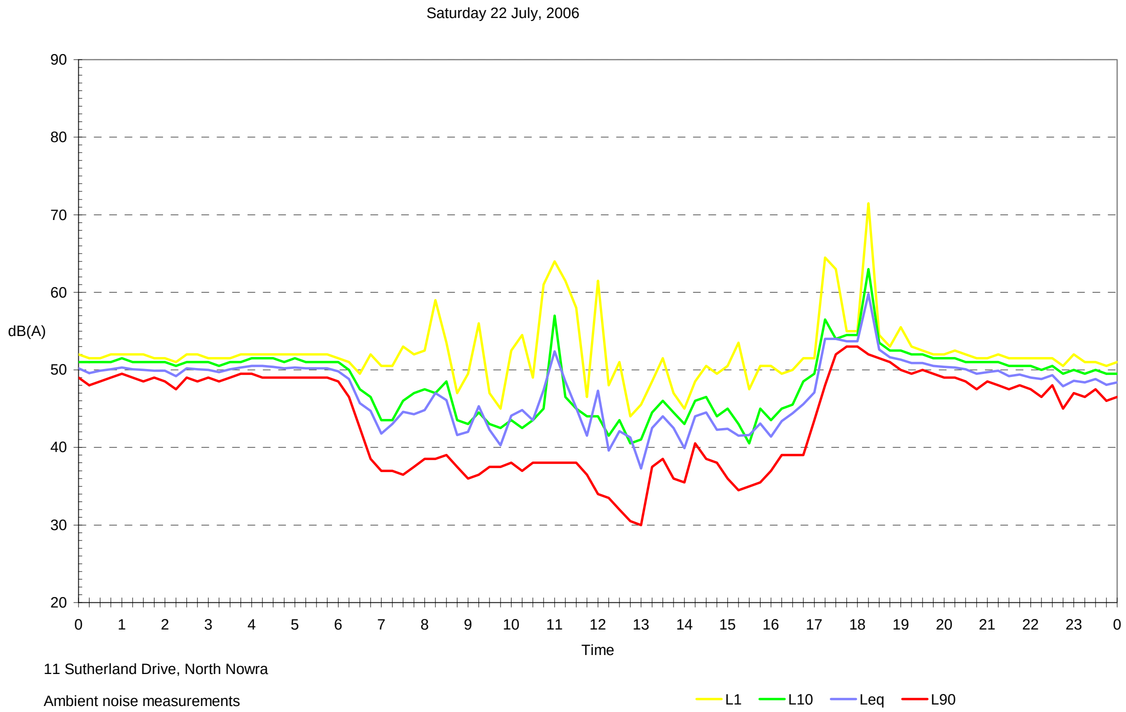
11 Sutherland Drive, North Nowra
Ambient noise measurements
L1
L10
Leq
L90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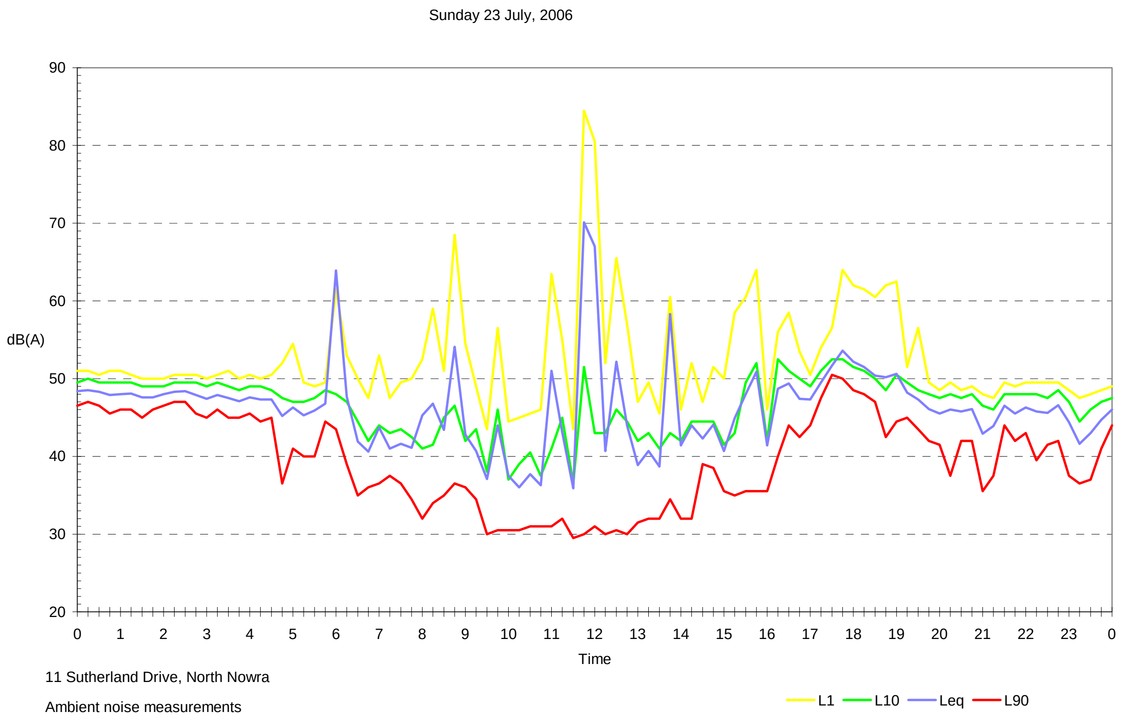
Ambient noise measurements
L1
L10
Leq
L90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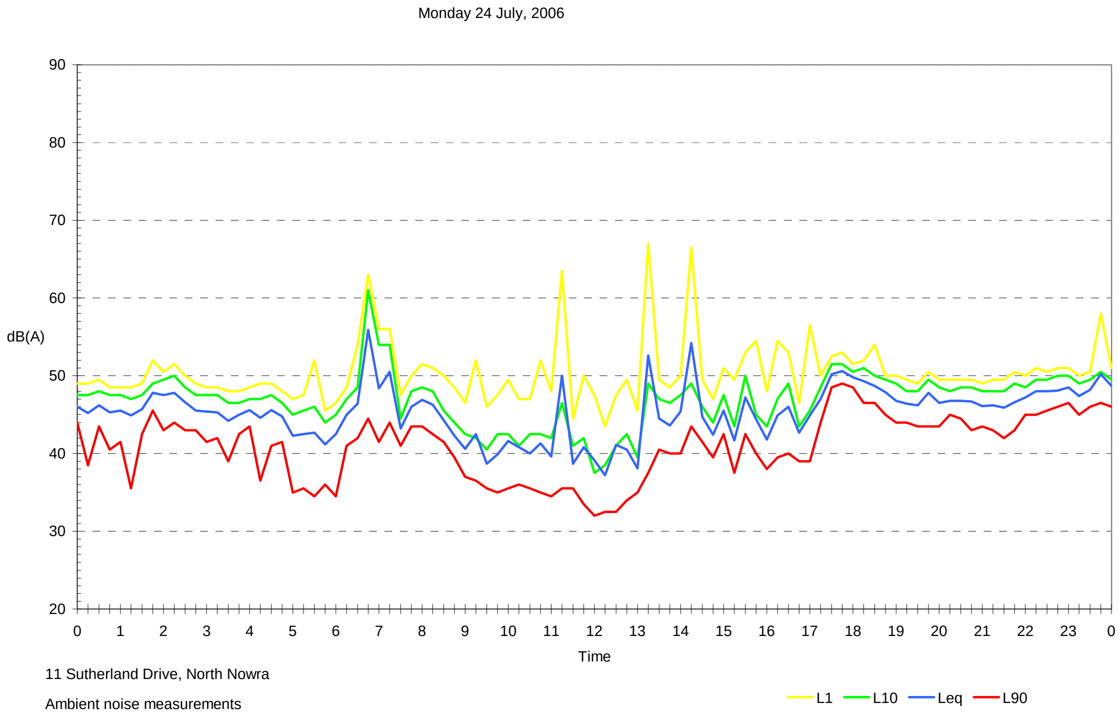
Ambient noise measurements
L1
L10
Leq
L90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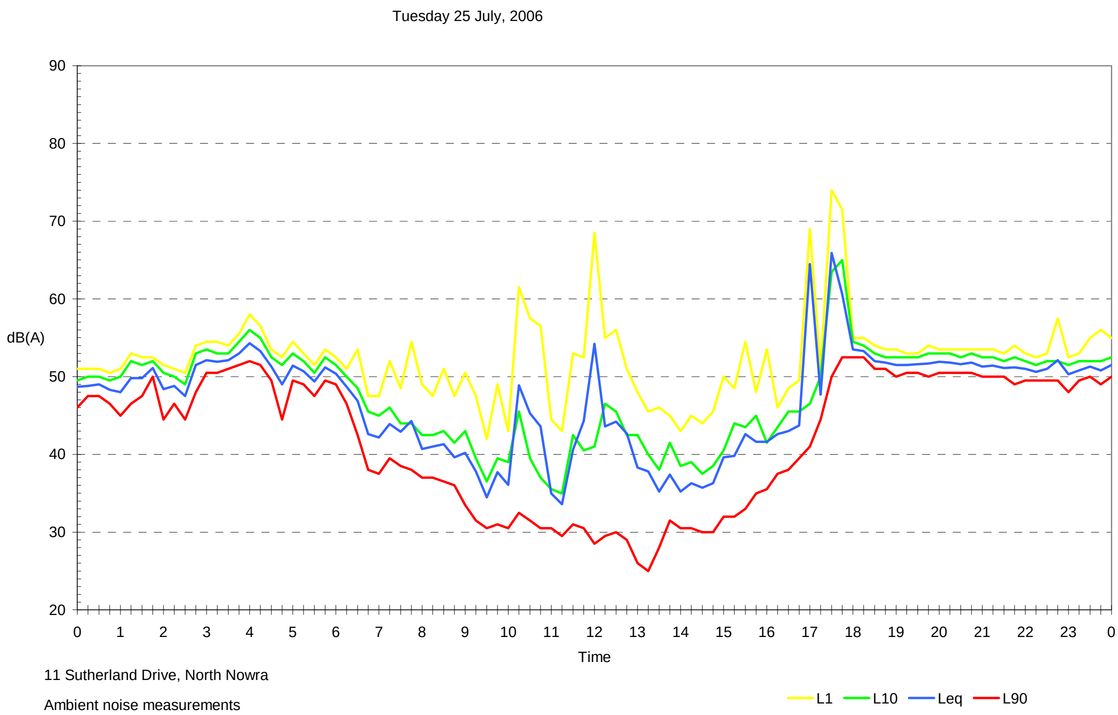
Ambient noise measurements
L1
L10
Leq
L90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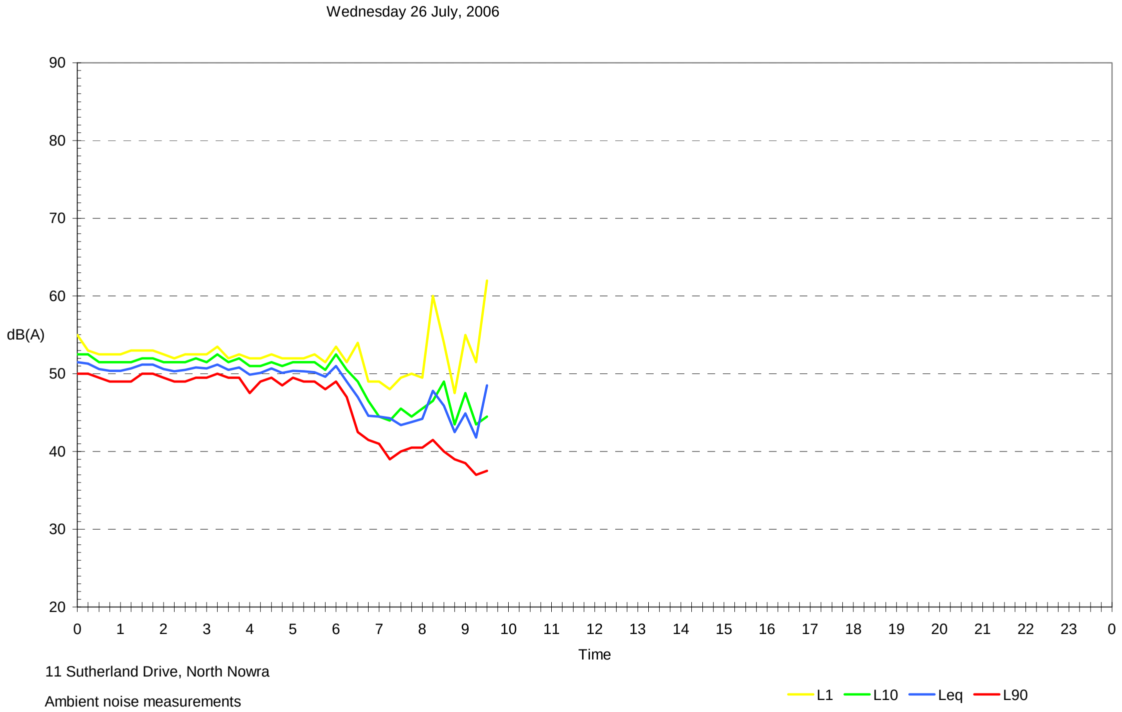
Ambient noise measurements
L1
L10
Leq
L90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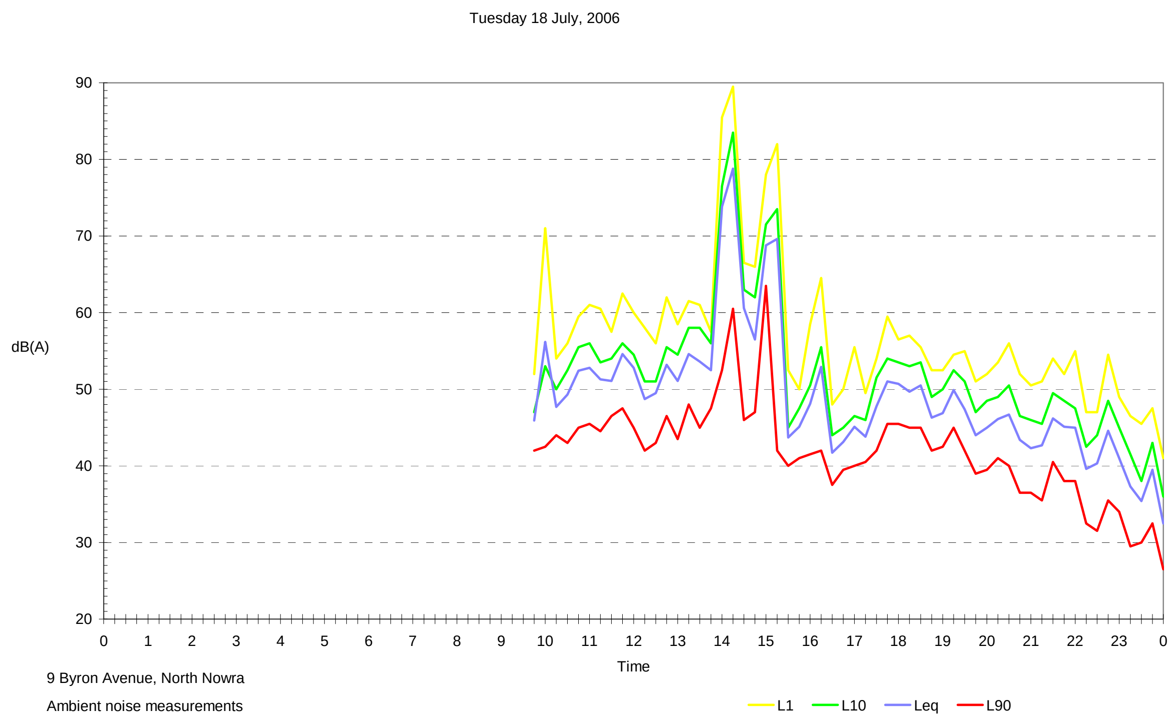
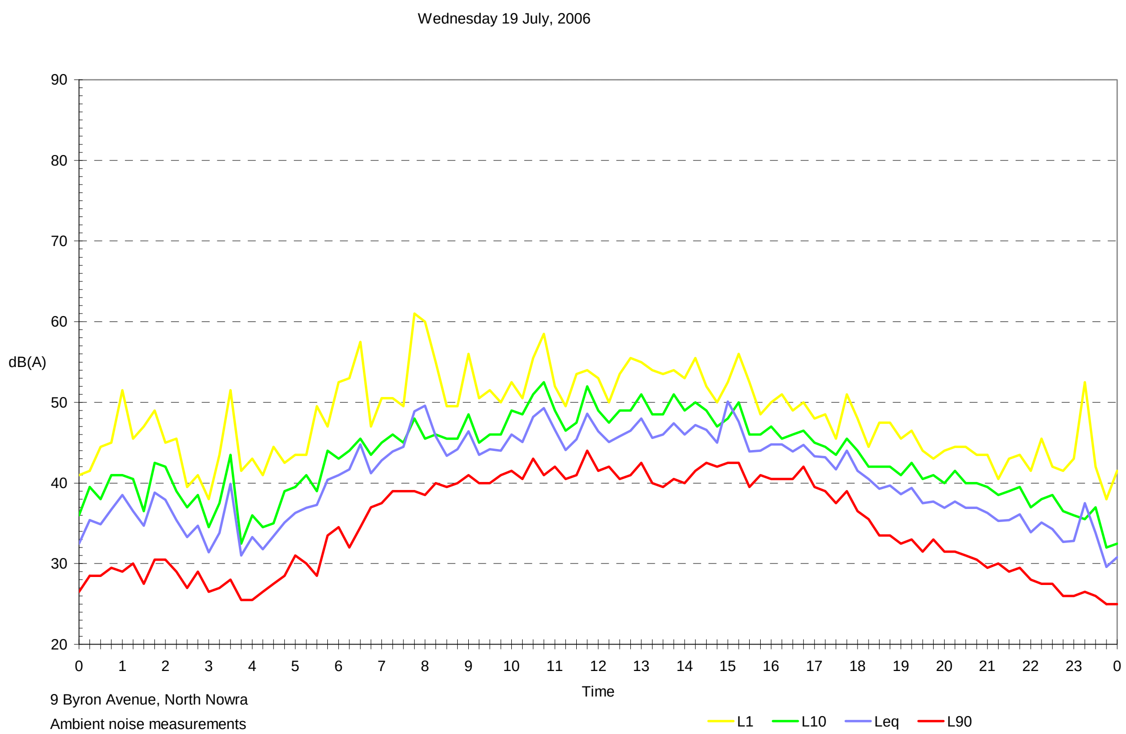
Time
11 Sutherland Drive, North Nowra
Ambient noise measurements
L1
L10
Leq
L90

9 Byron Avenue, North Nowra





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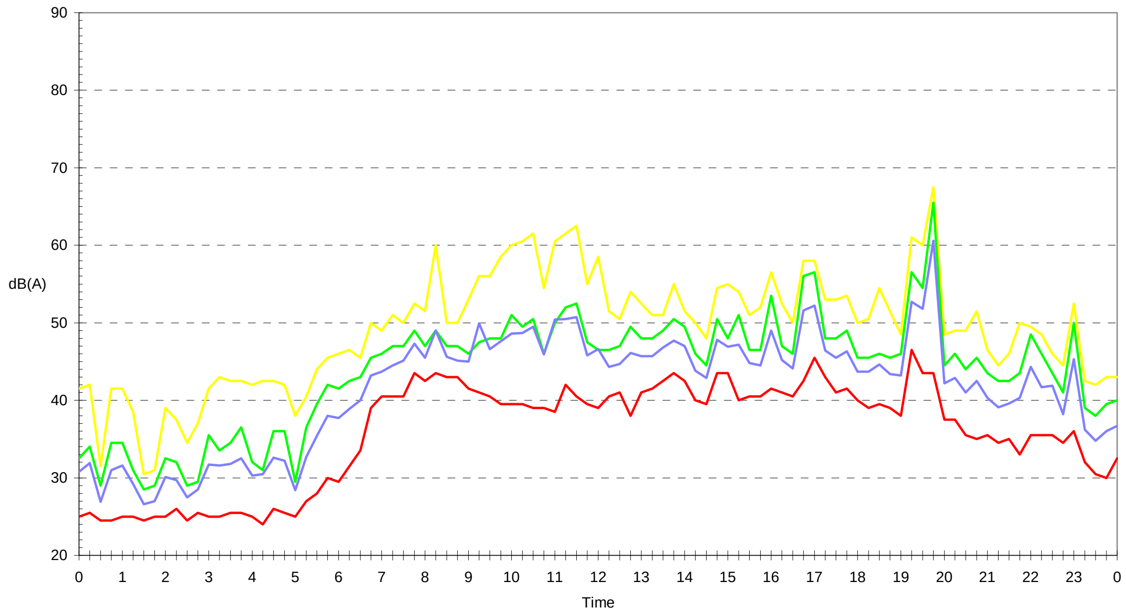
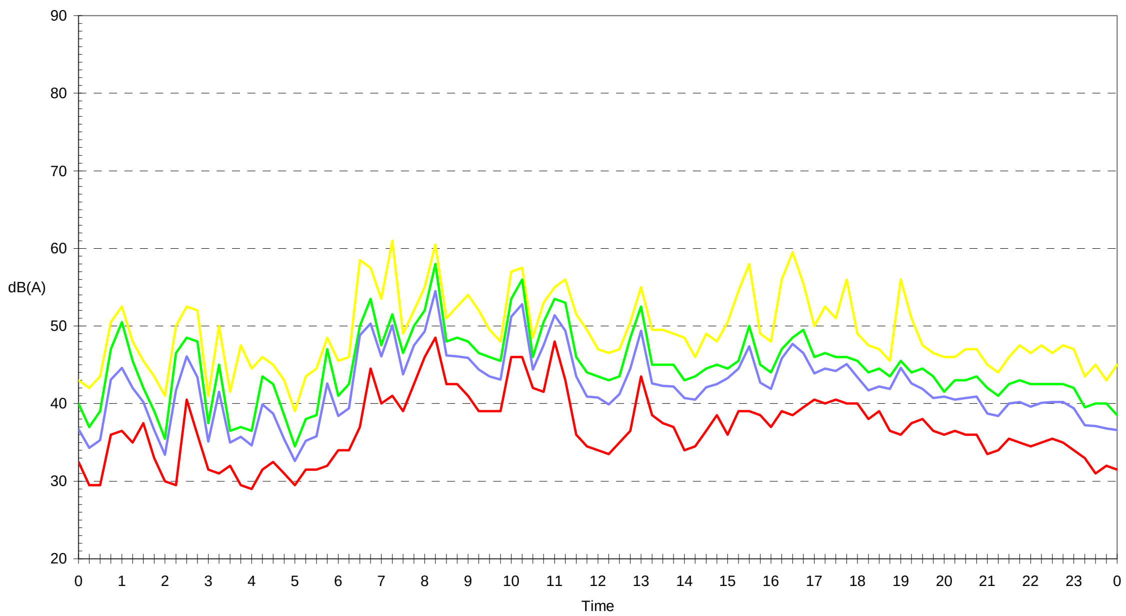


9 Byron Avenue, North Nowra

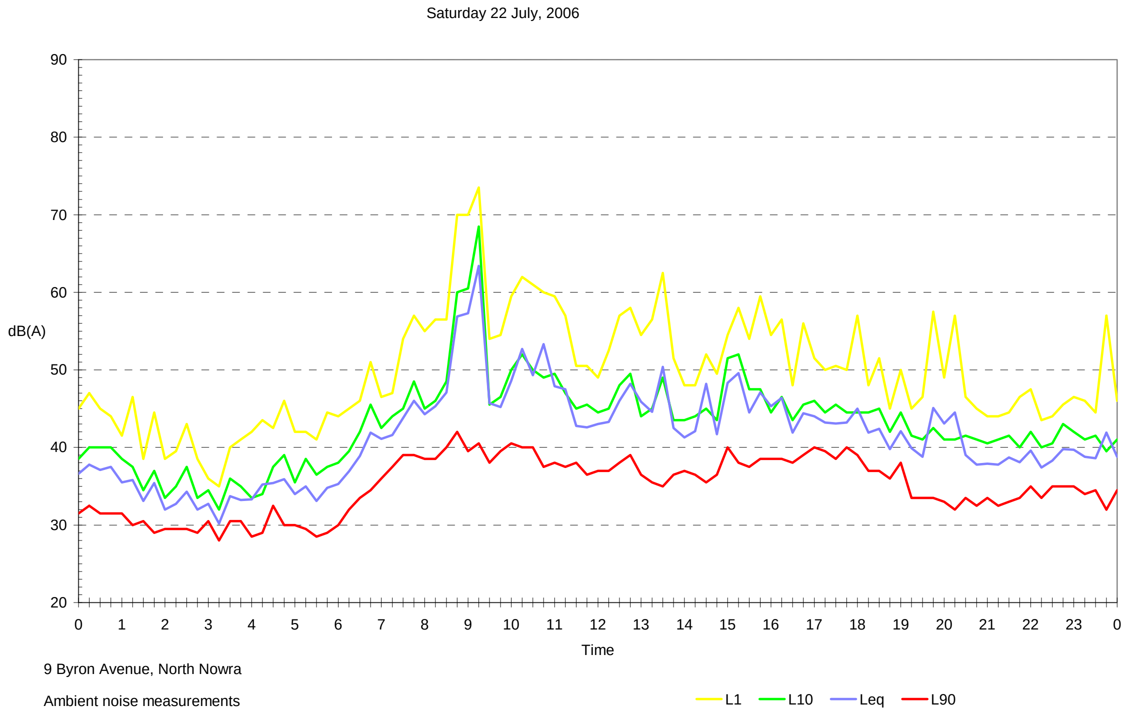
Ambient noise measurements

Friday 21 July, 2006



9 Byron Avenue, North Nowra

Ambient noise measurements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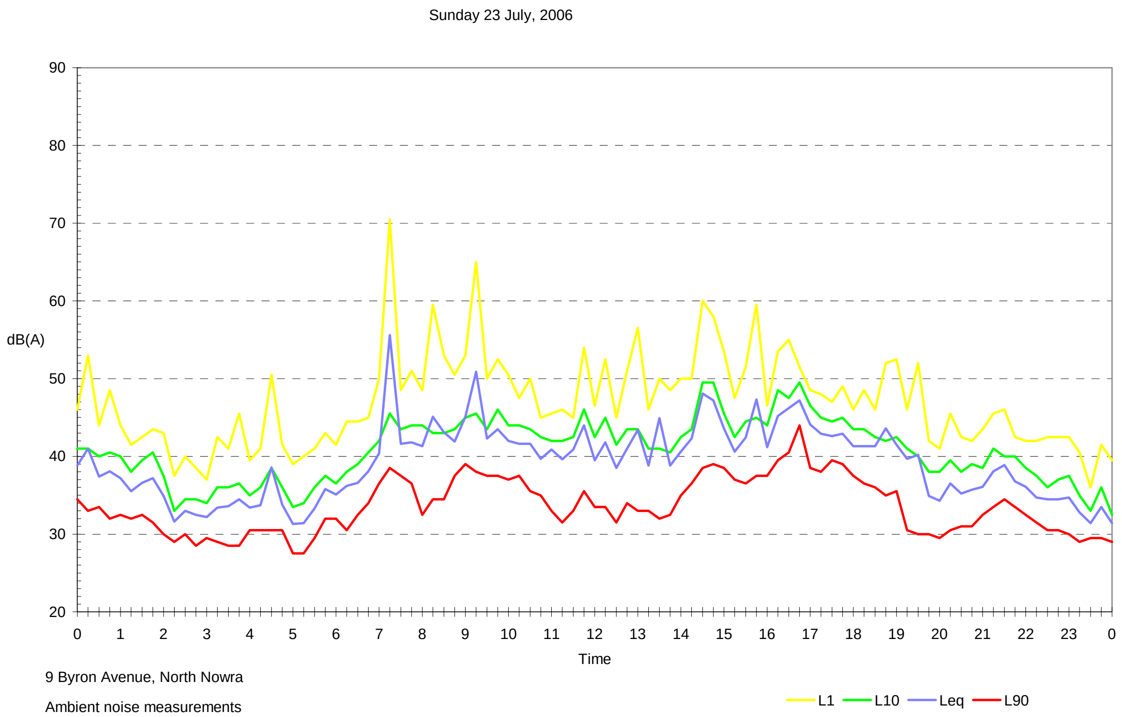
Time
9 Byron Avenue, North Nowra
Ambient noise measurements
L1
L10
Leq
L90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dB(A)
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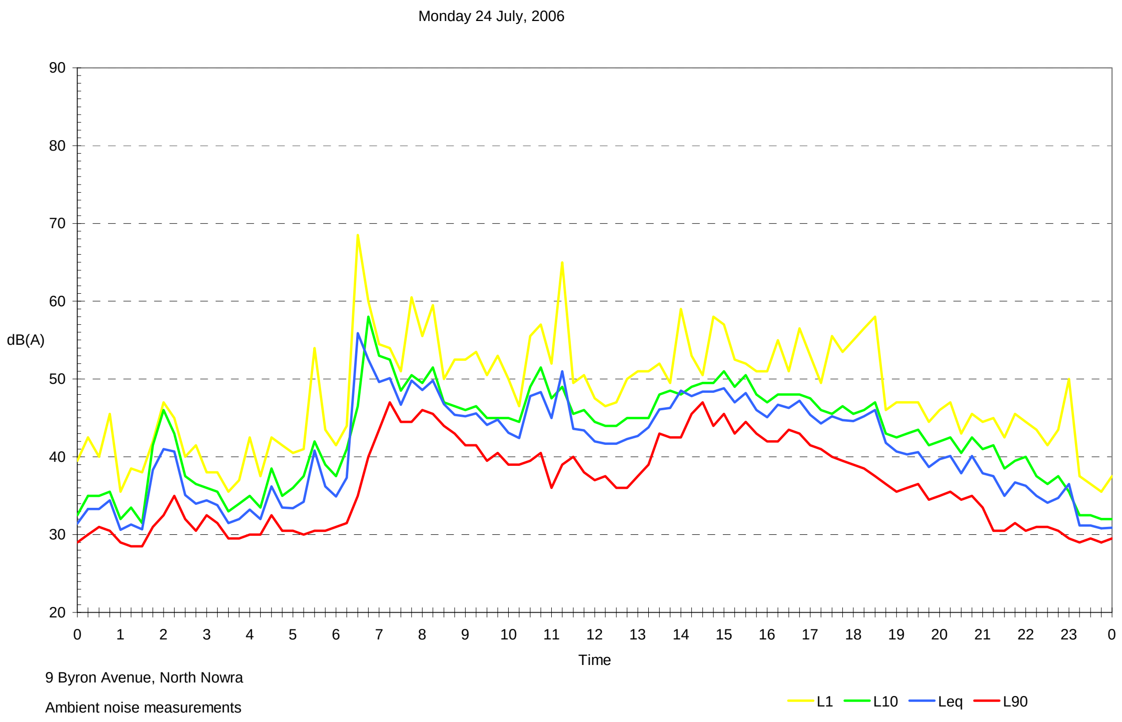
9 Byron Avenue, North Nowra
Ambient noise measurements
L1
L10
Leq
L90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dB(A)
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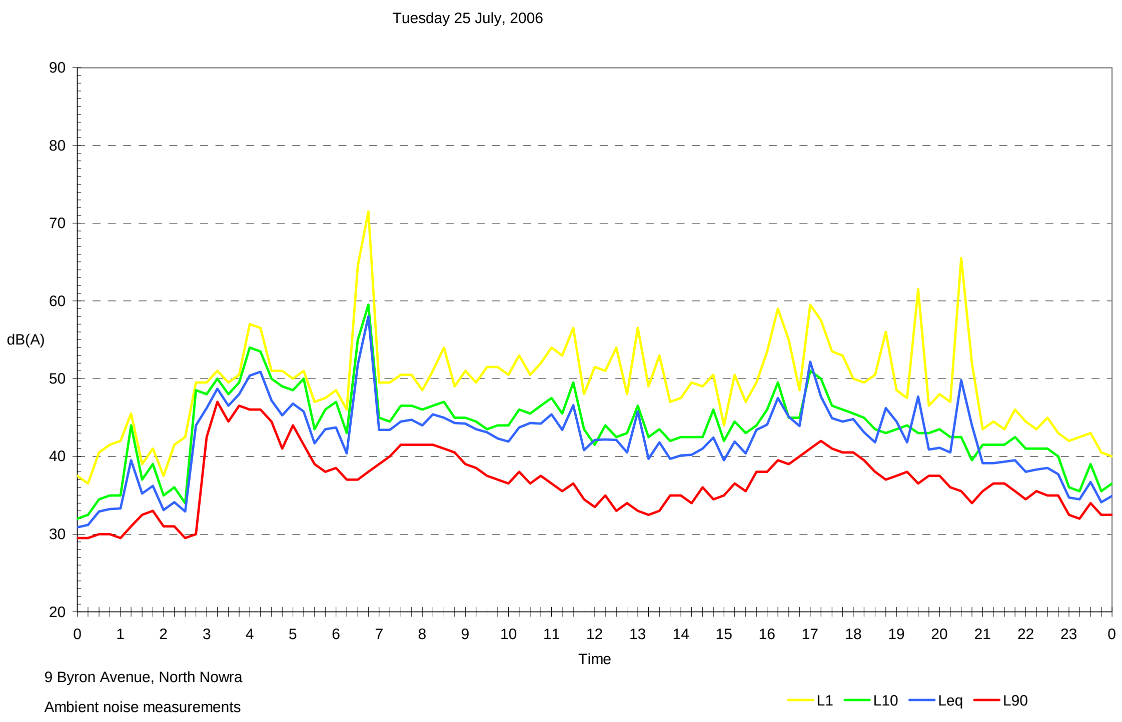
Time
9 Byron Avenue, North Nowra
Ambient noise measurements
L1 L10 Leq L90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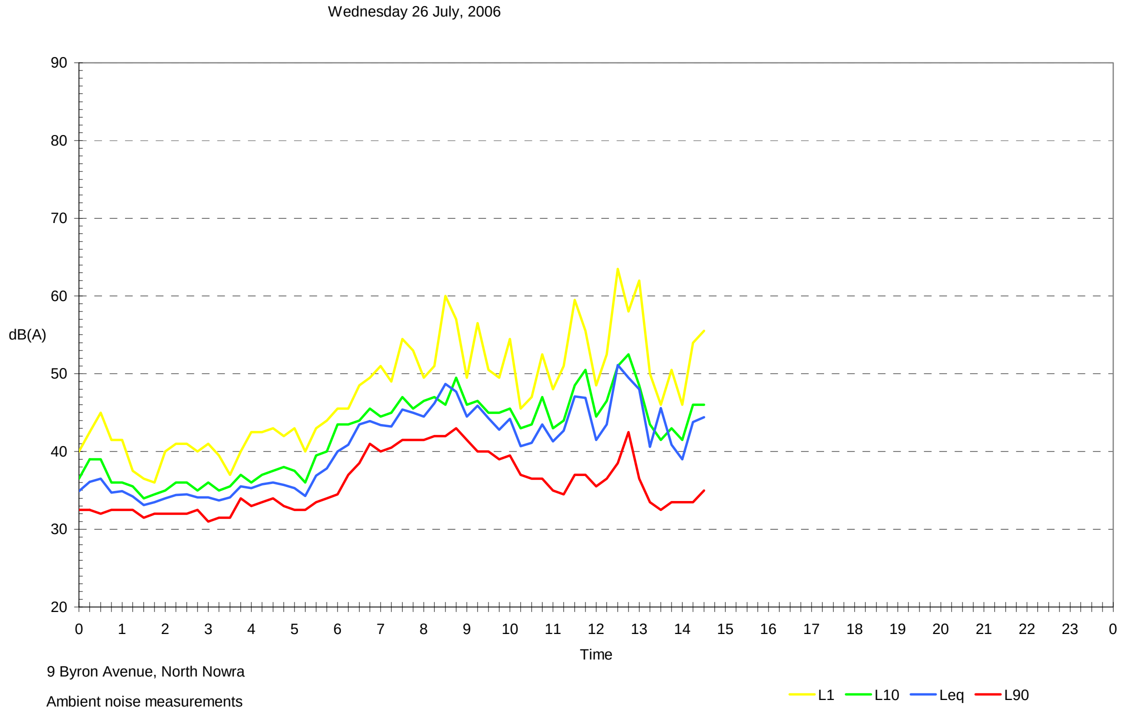
9 Byron Avenue, North Nowra
Ambient noise measurements
L1 L10 Leq L90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dB(A)
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50
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30
20
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0
Time
9 Byron Avenue, North Nowra
Ambient noise measurements
L1
L10
Leq
L90

Appendix I

Road traffic volumes

Appendix I Road traffic volumes

Option 1 and Option 1 + MVRDLK

Mid Block Summary			Option1 Car	Option1 Truck	Option1 + MVRDLK Car	Option1 + MVRDLK Truck
Cambewarra Rd	P Hwy to Comea	W	528	46	530	46
		E	573	50	518	45
	Comea to Meroo	W	492	43	473	41
		E	497	43	454	39
Meroo Rd	Cambewarra Rd to W. Bunderra	N	370	4	362	4
		S	484	5	444	4
	W. Bunberra to Bolong	N	555	6	559	6
		S	648	7	557	6
Bolong Rd	East	N	558	42	558	42
		S	540	41	510	38
	Meroo Rd to Beinda	W	1067	80	1017	77
		E	953	72	952	72
	Beinda to P Hwy	W	950	71	910	69
		E	897	67	913	69
W. Bunberra		W	75	1	76	1
		E	215	2	181	2
Beinda		W	175	2	201	2
		E	113	1	134	1
Comea		N	55	1	60	1
		S	56	1	58	1
Meroo N		N	278	3	266	3
		S	372	4	326	3
W. Cambewarra		W	16	0	22	0
		E	41	0	31	0
Pitt		W	121	1	157	2
		E	150	2	122	1
Page		W	196	2	187	2
		E	182	2	162	2
McMahons		W	391	12	251	8
		E	369	11	252	8
Crest		N	149	2	169	2
		S	58	1	67	1
Narang		W	270	3	232	2
		E	270	3	269	3

Mid Block Summary			Option1		Option1 + MVRDLK	
			Car	Truck	Car	Truck
Moss Vale		W	404	60	484	72
		E	435	65	489	73
Illaroo	West	N	206	9	251	10
		S	161	7	178	7
	Cambewarra to Pitt	N	382	16	354	15
		S	176	7	205	9
	Pitt to Page	N	521	22	545	23
		S	371	15	286	12
	Page to McMahons	N	596	25	637	27
		S	432	18	357	15
	McMahons to Crest	N	832	35	819	34
		S	596	25	513	21
	Crest to P Hwy	N	853	36	859	36
		S	605	25	582	24
P Hwy	To Kiama	N	611	76	627	77
		S	629	78	663	82
	Cambewarra to Narang	N	1102	136	1065	132
		S	1220	151	1163	144
	Narang to W. Bunberra	N	1062	131	1045	129
		S	1267	157	1290	159
	W. Bunberra to Beinda	N	1088	134	1088	134
		S	968	120	1044	129
	Beinda to Bolong	N	1126	139	1123	139
		S	1059	131	1141	141
	Bolong to Illaroo	N	1982	245	1991	246
		S	1857	230	1906	236
	Illaroo to Bridge	N	2600	321	2593	321
		S	2244	277	2225	275

Option 2

Mid Block Summary			Option 2 Car	Option 2 Truck
Cambewarra Rd	P Hwy to Comea	W	466	41
		E	544	47
	Comea to Meroo	W	482	42
		E	546	47
Meroo Rd	Cambewarra Rd to W. Bunderra	N	383	4
		S	539	5
	W. Bunberra to Bolong	N	606	6
		S	628	6
Bolong Rd	East	N	538	41
		S	493	37
	Meroo Rd to Beinda	W	1008	76
		E	930	70
	Beinda to P Hwy	W	967	73
		E	870	66
W. Bunberra		W	135	1
		E	144	1
Beinda		W	146	1
		E	165	2
Comea		N	69	1
		S	48	0
Meroo N		N	299	3
		S	347	4
W. Cambewarra		W	25	0
		E	32	0
Pitt		W	147	1
		E	131	1
Page		W	210	2
		E	189	2
McMahons		W	435	13
		E	330	10
Crest		N	161	2
		S	69	1
Narang		W	73	1
		E	38	0
Moss Vale		W	405	60

Mid Block Summary			Option 2	
			Car	Truck
		E	393	59
Illaroo	West	N	183	8
		S	147	6
	Cambewarra to Pitt	N	246	10
		S	171	7
	Pitt to Page	N	553	23
		S	377	16
	Page to McMahons	N	610	25
		S	414	17
	McMahons to Crest	N	901	38
		S	560	23
	Crest to P Hwy	N	931	39
		S	603	25
P Hwy	To Kiama	N	615	76
		S	645	80
	Cambewarra to Narang	N	1057	131
		S	1001	124
	Narang to W. Bunberra	N	1094	135
		S	1277	158
	W. Bunberra to Beinda	N	1027	127
		S	1010	125
	Beinda to Bolong	N	1134	140
		S	1110	137
	Bolong to Illaroo	N	1962	243
		S	1869	231
	Illaroo to Bridge	N	2654	328
		S	2242	277
Link Road		W	186	8
		E	253	11

Option 3 and Option 3 +MVRDLK

Mid Block Summary			Option 3		Option3 MVRDLK	
			Car	Truck	Car	Truck
Cambewarra Rd	P Hwy to Comea	W	458	40	510	44
		E	605	53	633	55
	Comea to Meroo	W	464	40	455	40
		E	516	45	511	44
Meroo Rd	Cambewarra Rd to W. Bunderra	N	354	4	354	4
		S	493	5	480	5
	W. Bunberra to Bolong	N	554	6	542	5
		S	631	6	585	6
Bolong Rd	East	N	487	37	537	40
		S	481	36	529	40
	Meroo Rd to Beinda	W	996	75	1002	75
		E	930	70	949	71
	Beinda to P Hwy	W	955	72	960	72
		E	882	66	905	68
W. Bunberra		W	80	1	63	1
		E	201	2	166	2
Beinda		W	150	2	153	2
		E	181	2	161	2
Comea		N	59	1	55	1
		S	64	1	54	1
Meroo N		N	267	3	235	2
		S	338	3	364	4
W. Cambewarra		W	179	2	204	2
		E	256	3	182	2
Pitt		W	102	1	126	1
		E	148	1	133	1
Page		W	173	2	185	2
		E	216	2	152	2
McMahons		W	403	12	285	9
		E	358	11	236	7
Crest		N	162	2	146	1
		S	61	1	63	1
Narang		W	110	1	121	1
		E	0	0	32	0
Moss Vale		W	420	63	553	83

Mid Block Summary			Option 3		Option3 MVRDLK	
			Car	Truck	Car	Truck
		E	400	60	474	71
Illaroo	West	N	214	9	263	11
		S	193	8	176	7
	Cambewarra to Pitt	N	311	13	358	15
		S	215	9	193	8
	Pitt to Page	N	515	21	446	19
		S	378	16	310	13
	Page to McMahons	N	538	22	544	23
		S	444	19	375	16
	McMahons to Crest	N	790	33	775	32
		S	601	25	524	22
	Crest to P Hwy	N	836	35	813	34
		S	635	26	579	24
P Hwy	To Kiama	N	539	67	587	72
		S	684	84	723	89
	Cambewarra to Narang	N	1007	124	1072	133
		S	1024	127	1014	125
	Narang to W. Bunberra	N	1088	135	1146	142
		S	1253	155	1268	157
	W. Bunberra to Beinda	N	1093	135	1165	144
		S	993	123	999	124
	Beinda to Bolong	N	1160	143	1232	152
		S	1047	129	1083	134
	Bolong to Illaroo	N	1991	246	2093	259
		S	1816	224	1916	237
	Illaroo to Bridge	N	2541	314	2614	323
		S	2171	268	2220	274
Link Road		W	185	8	201	8
		E	249	10	177	7

Do Nothing

Mid Block Summary			Do Nothing	
			Car	Truck
Cambewarra Rd	P Hwy to Comea	W	460	40
		E	489	42
	Comea to Meroo	W	464	40
		E	488	42
Meroo Rd	Cambewarra Rd to W. Bunderra	N	374	4
		S	481	5
	W. Bunberra to Bolong	N	570	6
		S	615	6
Bolong Rd	East	N	561	42
		S	455	34
	Meroo Rd to Beinda	W	1096	83
		E	930	70
	Beinda to P Hwy	W	1029	77
		E	895	67
W. Bunberra		W	88	1
		E	113	1
Beinda		W	185	2
		E	153	2
Comea		N	48	0
		S	57	1
Meroo N		N	284	3
		S	347	4
W. Cambewarra		W	23	0
		E	39	0
Pitt		W	125	1
		E	147	1
Page		W	179	2
		E	198	2
McMahons		W	398	12
		E	336	10
Crest		N	153	2
		S	70	1
Narang		W	69	1
		E	42	0
Moss Vale		W	359	54

Mid Block Summary			Do Nothing	
			Car	Truck
		E	400	60
Illaroo	West	N	220	9
		S	152	6
	Cambewarra to Pitt	N	285	12
		S	171	7
	Pitt to Page	N	505	21
		S	413	17
	Page to McMahons	N	618	26
		S	548	23
	McMahons to Crest	N	981	41
		S	771	32
	Crest to P Hwy	N	1062	44
		S	771	32
P Hwy	To Kiama	N	546	68
		S	658	81
	Cambewarra to Narang	N	945	117
		S	1071	132
	Narang to W. Bunberra	N	974	120
		S	1279	158
	W. Bunberra to Beinda	N	1040	128
		S	1121	139
	Beinda to Bolong	N	1080	133
		S	1178	146
	Bolong to Illaroo	N	1917	237
		S	2043	252
	Illaroo to Bridge	N	2403	297
		S	2245	277

Appendix J

Future existing noise levels (without new route)

Key

Leq, dB(A) Free Field

ISOVALUE

- 55
- 60

Recreation Area Noise Level

Do Nothing 2016

A3 size

AECOM
0
125
250
500
Metres
1:0
(when printed at A3)
Key
Leq, dB(A) Facade Corrected
ISOVALUE
60
62
64
66
68
70
External Noise Level
Do Nothing 2016

A3 size

Appendix K

Predicted external noise levels

AECOM

N

0 125 250 500
Metres

1:10,000 (when printed at A3)

60 dB(A) L_{eq} (Facade corrected)

Affected residential cadastral lot

Noise level increase, dB(A)

0.5

Option 1 Facade noise levels - Impact from new roads (increase of 0.5 dB(A))