Transport Pollution Futures for the City of Gold Coast: SoE Reports for 2011 and 2021

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ABSTRACT

Gold Coast City is a highly car-dependent city and, with its population growth and associated growth in motor vehicle usage, there is increasing traffic congestion and emissions of motor vehicle pollutants. This paper reports a modelling study of energy use and pollutant impacts from land transport sources for the City of the Gold Coast. It estimates, for 2011 and 2021, strategic level information on the environmental implications of current and future transport systems in the City. The modelling is based on the Griffith University TRAEMS model. TRAEMS uses the extensive data available on estimated flows on the transport networks to provide estimates of current and future transport energy use, transport pollution emissions, and the exposure of the City's population to these emissions. TRAEMS has been designed to inform planners and decision makers of the current "State of the Environment" with respect to transport in the City, and of prospective "States" for future decades. The system produces results that should be used to assist in strategic policy development for land use and transport, as well as pollution management, by providing good information of their influence on future environmental outcomes.

INTRODUCTION

Gold Coast City is the second largest Local Government Area in Australia in terms of population and is currently Australia's sixth largest city with an estimated population of 438 473 residents as at 30 June 2002 (GCCC, 2004). It is a highly car dependent city, and with the population growth and associated growth in motor vehicle usage there is increasing traffic congestion and emissions of motor vehicle pollutants. This is not commensurate with the City's mission to sustainably manage its growth. The City's Transport Plan has included options for developing a sustainable transport system with focus on the need to increase public transport use through improvement in existing bus public transport systems and an improved line haul public transport system of light rail along the north-south coast (GCCC, 1998). Another major transport infrastructure is an extension of the main Brisbane railway line from Robina to Tugun. This paper reports modelling of energy use and pollution from land transport sources for Gold Coast City.

For the Gold Coast study area, the length of the modelled road network for the base year (2000) was 1092 kilometres, and represents 31% of the total road network (about 3525 kilometres). The modelling includes only those links in the road system that carry significant traffic. For example, culs-de-sac and other low volume residential streets are not included on the (reasonable) assumption that they contribute little to adverse environmental effects, and that excluding them from the study has minimal effect on the strategic assessment of transport pollution levels.

The modelling was based on the Griffith University TRAEMS model. Brown, Affum and Chan (2004) have used Griffith University's TRAEMS modelling procedure in a demonstration project in the City of Gold Coast. Full details of methods, assumptions and criteria are available in that report and in Brown & Affum (2002). TRAEMS is an acronym for **TR**ansport planning **A**dd-on **E**nvironmental **M**odelling **S**ystem and is a GIS-based tool for the estimation and evaluation of the environmental impacts of multi-modal transport proposals. Within the GIS, the model combines the extensive data available on the transport networks with land use information of dwellings that may be impacted by transport pollutants. Computations are based on link-by-link predictions and are aggregated to obtain the overall network level impacts. As well as providing global results, they also assist with identification of local hot spots. Transport and environmental planners can use this approach as an add-on program to travel demand models to provide information on the environmental impact of any transport-planning scenario. The modelling system can be used for comparison of different scenarios and is designed to produce results that can assist in strategic policy and planning of land use and transport. It also provides evidence of the success, or otherwise, of current transport pollution control strategies.

The environmental factors modelled by TRAEMS include transport energy use, greenhouse gas emissions, transport noise and air quality.

Brown, Affum and Chan (2004) provided modelling estimates for the City of Gold Coast for the years 2011 and 2021 (as compared to a base year 2000) of energy consumption and emissions from existing and proposed transport modes in Gold Coast City of: road traffic (which includes buses operating on the road system); rail (including the proposed Robina –Tugun Rail extension); and the proposed Gold Coast Line Haul public transport system.

Full results are available in the original report but, except for energy use and greenhouse gas emissions, the results presented in this paper are of road-based modes. These future dates depend only on the available future traffic flow estimates available. Road transport data sets for the Gold Coast were obtained from the Gold Coast City Council and comprised output data generated from their EMME/2 transport model.

NOISE

Noise, along with other forms of pollution, has figured on the action agenda of communities, governments and researchers for well over three decades. We know that road traffic noise has significant effects on quality of urban life, potentially even on human health. The focus has been on both non-transport and transport sources, and in the latter, each of air, road and rail modes has had attention.

The distribution of road traffic noise exposure levels at dwelling units in the City of Gold Coast is shown in Figure 1. Only dwelling units exposed to noise levels of 50 dB(A) or above are shown. In year 2000, 7701 dwelling units in the City (some 4% of the total dwelling units) were exposed to noise levels of 68 dB $L_{A10,\,18h}$ and above, and another 8288 (4%) were exposed to levels of 63-67 dB, $L_{A10,\,18h}$. These road traffic noise exposures are of the same order as those reported in the national survey of Australian Capital cities (Brown and Bullen, 2003) particularly those of Adelaide and Perth, and exceed acceptable standards.

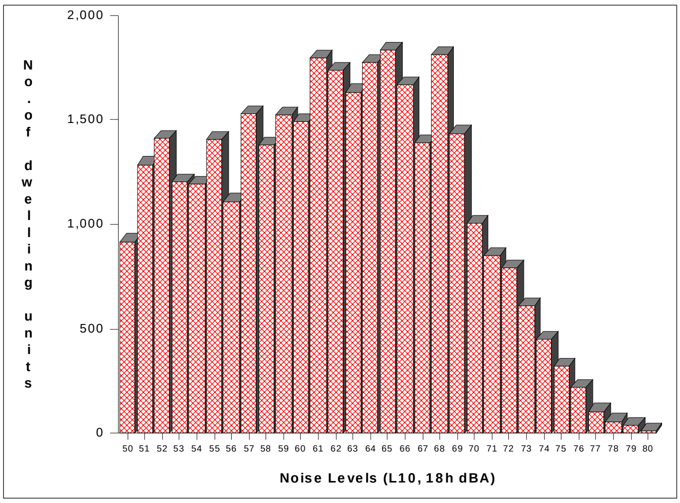

Figure 1 Distribution of noise emission levels at the facade of dwellings for the year 2000 modelled network for the City of Gold Coast

The TRAEMS modelling also provides future estimates of exposure, based on predicted traffic flows. Table 1 shows estimates for years 2011 and 2021. The situation overall does not improve, with the number of dwelling units above 68 dB(A) in 2021 increasing 9% over the 2000 estimates. There are two aspects of the futures modelling that should be noted. Firstly, all estimates of future noise exposure are based on year 2000 dwelling unit stock - potential infill in the housing stock along the road network has not been included in these results. As a consequence, years 2010 and 2021 underestimate the extent of future exposure. Secondly, the traffic flows in 2011 and 2021 assume a new light rail network will be in place with a consequent shift of significant traffic flows from the roadway to the light rail network. Without this, the number of dwelling units exposed to excessive noise levels will be much higher.

Table 1 Number of dwelling units in Gold Coast City exposed to different road traffic noise levels for each of 2000, 2011 and 2021 scenarios (and percentage total dwelling units)

	2000	**2011**	**2021**
Number of dwelling units exposed to levels of 68 dB(A) and above	7701 (4.1%)	7452 (4.0%)	8382 (4.5%)
Number of dwelling units exposed to 63-67 dB(A)	8288 (4.4%)	8367 (4.5%)	8297 (4.4%)

It is instructive to examine how these high noise exposures are distributed across the city. Figures 2 and 3 provide the approximate location of the dwellings in Table 1 relative to the year 2000 road network - Figure 2 shows these for the entire City of the Gold Coast while Figure 3 presents the same data, but for a part of the City at a larger scale. The problem of high noise exposures is not confined to major roadways in the road network but can be found along a high proportion of the non-local roads in the City’s network.

Further analysis allows examination of whether certain socio-economic group are disproportionately exposed to high levels of road traffic noise. This analysis was based on the 2001 median household income levels at the census collection district (CCD) level, and 2000 traffic flows. Table 2 shows some evidence that there is a differential exposure (chi-square test is significant, $p<.001$) with high noise-exposure dwellings being disproportionately represented in the lower income bands. For example, 45% of dwellings with high noise exposure have a median income of less than $600, but this income range represents only 32% of the number of dwelling units in the City.

Table 2 Analysis of differential exposure of different socio-economic groups to noise levels of 68 dB(A) and above (based on CCD median household incomes).

Median weekly household income	Dwellings units in the City with this median income		Dwelling units exposed to noise levels of 68 dB(A) and above	
	Number of dwelling units	Percentage of City dwelling units in income range	Number of dwelling units	Percentage of high noise exposure dwellings in income range
$1 - $399	6 785	4%	542	7%
$400 - $499	24 526	13%	1 417	18%
$500 - $599	28 619	15%	1 541	20%
$600 - $699	36 578	20%	1 999	20%
$700 - $799	28 479	15%	810	11%
$800 - $999	41 679	22%	1 063	14%
$1000-$1199	16 150	9%	294	9%
>=$1200	4 311	2%	35	1%
Total	187 127	100%	7 701	100%

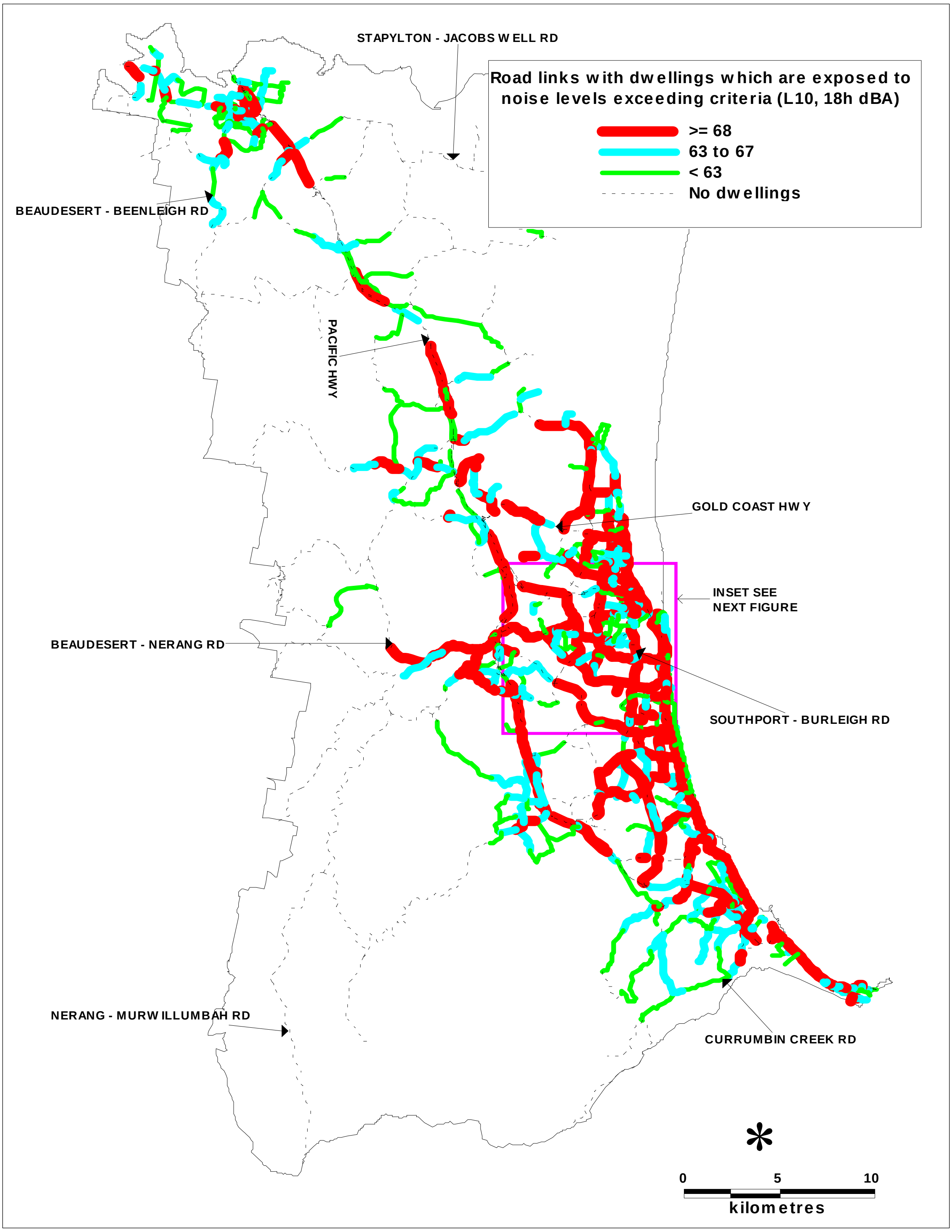

Figure 2 Noise emission levels resulting from the 2000 modelled network for the City of the Gold Coast.

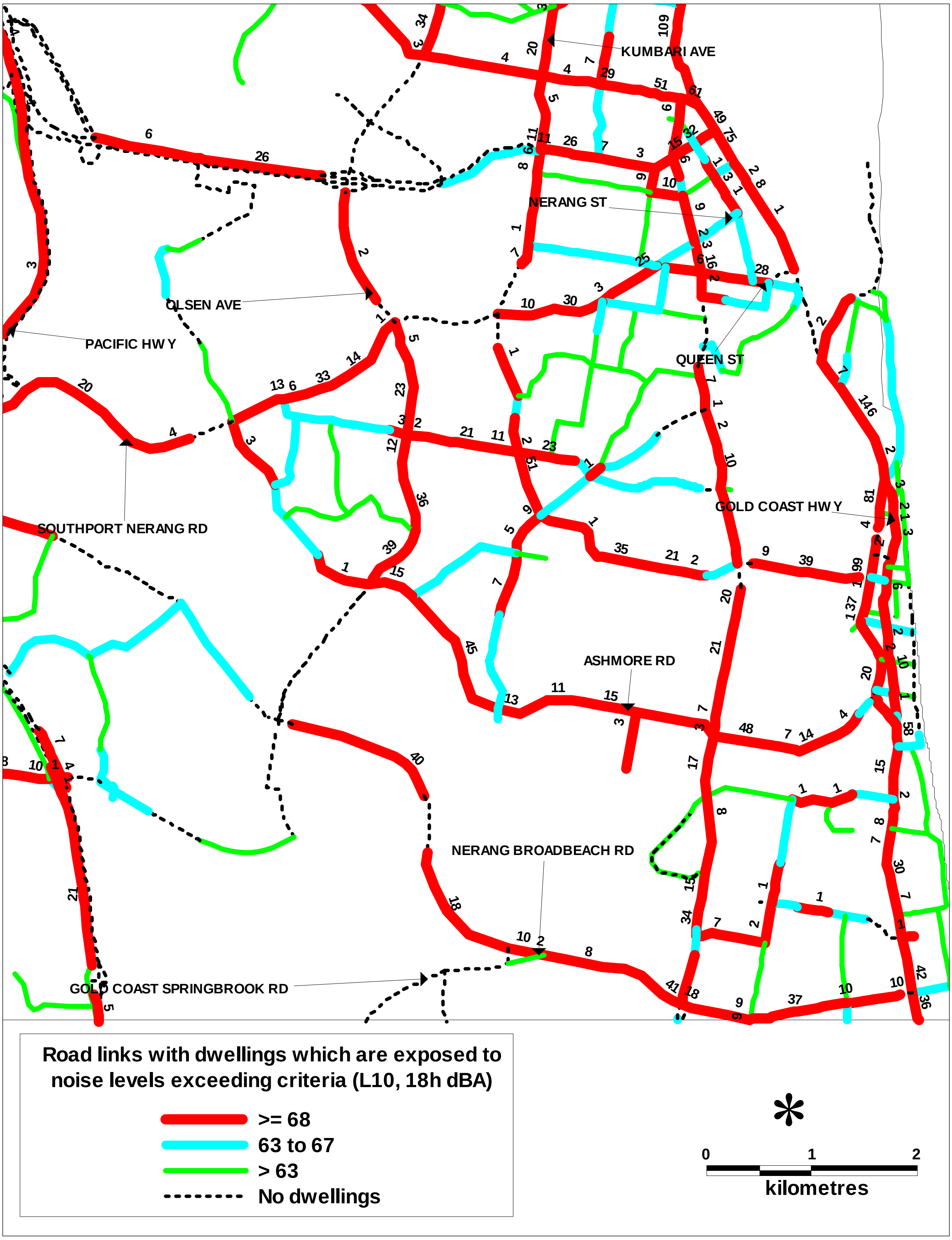

Figure 3: Noise emission levels resulting from the 2000 modelled network for the part of the City that includes the Light Rail corridor. Link labels show the number of dwellings on that link whose exposure exceed 68 dB.

In summary, there is a significant segment of the Gold Coast City population that is exposed to unacceptably high levels of noise - and there is no evidence that this will decrease in future. Further, as Gold Coast City is not atypical of Australia cities in this respect, the conclusion must be drawn that current approaches and policies to control road traffic noise in our urban areas have significant limitations. Why and where is road traffic noise policy failing us? Despite several decades of national noise controls for new vehicles; environmental noise legislation and Environmental Protection Agencies, or equivalent, in each State; a competent and skilled acoustical knowledge base with respect to road traffic noise; road traffic authorities that now generally adopt noise control as an integral or add-on component of new roadway design, as will be shown, we appear to have made little progress in controlling this exposure.

The limiting of emissions from individual motor vehicles has been a major strategy in the control of road traffic noise. Australia, as elsewhere, has regulated new vehicle noise levels since the late 1970s through application of Australian Design Rules (ADRs) for vehicles. Changes in these rules successively reduced the emissions from individual vehicles, but since last revised in 1989, the limits imposed by the ADRs has lagged behind overseas trends and become substantially less stringent than those established overseas (Close and Apelbaum, 2001). New limits for vehicles in Australia will take effect from 2005. However, increasingly stringent noise emission limits on individual vehicles are not leading to a reduced exposure of the population to road traffic noise levels. An I-INCE report (Sandberg, 2001) provides convincing evidence as to why there should be no expectations that current high levels of exposure to road traffic noise in cities will be reduced in the future through the technical solution of vehicle noise limits.

Another dominant engineering strategy to reduce exposure to road traffic noise has been the construction of roadside noise control barriers. A very large amount of effort, and funds, have been expended on this strategy, particularly to limit exposure to noise from newly constructed roadways. This engineering solution is capable of tackling only the tip of the iceberg of the urban traffic noise problem, leaving much of the highly noise exposed population untouched. The reason is that most of the highly exposed urban population (as, for example, shown for Gold Coast city in Figure 2) is unprotectable by any strategy that sees the mitigation of road traffic noise to consist primarily in the provision of noise barriers, or walls. In all but exceptional circumstances, such walls can only be constructed along what are generally termed no-access roadways, and in Australian cities these tend to be freeways and a very limited length of major arterial roadways. Only a small proportion of dwellings in Australian cities are located adjacent to such no-access roadways. Most roadways in urban areas in Australia, be they arterial, sub arterial or collector roadways, are “immune” from this form of road traffic noise mitigation.

Other well-known strategies to manage this problem - land use planning, traffic management, dwelling insulation, compensation etc – exist, but we have applied, or at least recited, these as solutions for many years, but obviously with little impact on overall outcomes. These strategies need to be bolstered and earnestly utilized. New ideas need to be introduced, and the experience in Europe arising from the application of the EU Directive on environmental noise (European Union, 2002), and the inclusion of noise as a transport sustainability indicator (OECD, 2000), must be closely monitored, and the useful parts of these adopted in Australian cities.

ENERGY CONSUMPTION AND GREENHOUSE GAS EMISSIONS

Transport energy consumption and greenhouse gas emission for the City of Gold Coast was estimated. This modelling included fossil fuels consumed by road transport within the City as well as the energy utilised by electrically powered transport systems in the City, though the latter is generated outside the City boundaries.

Daily fuel consumption on the road network

Estimated daily fossil fuel consumption by surface transport on Gold Coast networks is shown in Table 3. The percentage increase from 2000 to 2011 and 2021 are 33% and 52% respectively, an annual compound growth rate of 2.0 to 2.6%. The 2011 increase approximately matches the increase in vehicle kilometres travelled over the same period. The estimated increase in 2021 is slightly lower than the increase in vehicle kilometres travelled due to an increasing proportion of fuel-efficient vehicles in the vehicle fleet by that date.

Table 3 Energy consumption estimates for surface transport in Gold Coast City: 2000, 2011, 2021 (excluding vehicles powered by electricity)

	Daily Energy Consumption in Transport in kilolitres per day (expressed as GJ in brackets)		
	2000	**2011**	**2021**
Total	1069 (36 960)	1422 (49 181)	1629 (56 222)
Percentage increase over 2000		33%	52%

Table 4 shows the breakdown of future road network energy consumption by vehicles using petrol, diesel and LPG fuels. The percentage of the road network energy consumed by diesel and LPG vehicles increases slightly, with a concomitant reduction in the percentage of energy consumed by petrol-fuelled vehicles from 86% to 79% by 2021. Much of the increase in vehicles using non-petrol fuels is additional cars and buses using LPG; 4wd and some cars and heavy vehicles using diesel fuel.

Table4 Percentage of total energy consumption on the road network by vehicles using different fuel types

Vehicle Fuel Type	**2000**	**2011**	**2021**
Petrol	86%	83%	79%
Diesel	12%	14%	16%
LPG	2%	3%	5%
Total	100%	100%	100%

The increasing trend in diesel-fuel use is similar to that occurring in Europe, with the market share for diesel-fuelled vehicles there doubling over the past 12 years. In 2003, diesel accounted for 44% of all new car sales in Europe (DeHavilland Information Services plc, 2004a). Already in some countries (e.g. France, Spain, Austria, Belgium and Luxemburg) more diesel-fuelled vehicles are being sold than petrol vehicles (DeHavilland Information Services plc, 2003), and a similar trend is being experienced in some Asian countries. For example, in Korea, the diesel share of car sales in 2003 was 49.8 %. This represent an increase of 16.7% compared to sales in 2000 **(**DeHavilland Information Services plc, 2004b).

In is useful to examine the energy use on the road network in the context of the total energy requirements of the surface transport system in the City. The operational energy consumed by the electricity-powered rail system is estimated to be 1660 GJ per day in 2000, and based on forecast train service frequency in 2011 and 2021, estimated to increase to 2 970 GJ and 3 919 GJ per day respectively.

The light rail system energy consumption has been estimated as 296 GJ in 2011, and assuming the energy used by the light rail system will increase in proportion to the projected increase in patronage in future years, the daily energy consumed in 2021 will be 367 GJ.

The total daily energy consumption of vehicles on all networks is shown in Table 5. It can be seen that, despite planned investment in rail systems, over 96% of total energy consumption for the surface transport task in Gold Coast City remains with road transport. This proportion will reduce slightly to about 94% in 2021 provided the rail systems are in place and the predicted shift in load occurs.

Table 5 Daily Energy Consumption estimates for all surface transport networks in Gold Coast City: 2000, 2011, 2021 in Gigajoules/day (percentages of total daily transport energy consumption on the transport networks in parentheses).

Modelled Year	Road Network	Rail and Light Rail Networks	Total Daily Energy Consumption on Transport Networks
2000	36 960 (96%)	1 660 (4%)	38 620 (100%)
2011	49 181 (94%)	3 266 (6%)	52 447 (100%)
2021	56 222 (93%)	4 286 (7%)	60 508 (100%)

TRAEMS models greenhouse emissions from both road and rail networks based on the fuel consumed. Daily greenhouse gas (CO_2) produced by road transportation is modelled for 2000 and future scenarios 2011 and 2021 (Table 6). Since CO_2 production is related linearly to the energy consumed, the percentage changes to 2011 and 2021 are the same as those for energy usage.

Table 6 Daily CO_2 production estimates from road transport in Gold Coast City: 2000, 2011, 2021

	CO_2 production on the Road Network (tonnes per day)*		
	2000	**2011**	**2021**
Total	2436	3240	3706
Percentage increase over 2000		33%	52%

* Results for all year scenarios are based on the same Fuel to CO_2 conversion factors

When CO_2 production from electrically powered vehicles (train and line haul routes) is taken into account, the total CO_2 production in the city is shown in Table 7. The percentage of the total CO_2 production contributed by each of the transport modes is also shown in the Table.

It is observed that the proportion of total energy consumed by rail transport (rail and light rail) is far lower (4 to 7% - see Table 5) than the proportion of CO_2 produced by rail transport (17-24% - see Table 7). This is due to the inefficiency of electricity production from coal in terms of the amount of CO_2 produced per GJ of energy used. However it should be noted that when CO_2 production per person kilometre travelled is taken into account, electrically powered transport is more efficient than road transport.

Table 7 Daily CO_2 production estimates from all surface transport in Gold Coast City: 2000, 2011, 2021

	CO_2 production in Transport (Percentage of Total in parentheses) (tonnes per day)			
Year	**TOTAL**	**Road**	**Rail**	**Light Rail**
2000	2934	2436 (83%)	498 (17%)	-
2011	4220	3240 (77%)	891 (21%)	89 (2%)
2021	4990	3706 (74%)	1176 (24%)	108 (2%)

In summary in the City:

- The total energy consumption due to road traffic in 2000 was 36 960 GJ (1069 kL), and is expected to increase by 33 and 52 percent in 2011 and 2021 respectively.

- The combined total energy consumption due to all transport sources in 2000, including vehicles powered by electricity, is estimated to be 38 672 GJ.
- Despite current and future investment in rail systems, over 96% of total energy consumption for the surface transport task in Gold Coast City is by road transport. This proportion will reduce slightly to about 93% in 2021 with the light rail system and the heavy rail extension in place.
- Daily CO_2 production from all transport sources is estimated at 2 934 tonnes per day in 2000 (83% from road traffic), increasing by 33% and 52% in 2011 and 2021.

There is little to suggest, from these results, that the City of Gold Coast transport system is moving in a more sustainable direction in terms of energy use or greenhouse gas output in the next two decades.

NEAR FIELD AIR QUALITY

City of Gold Coast modelling was conducted for two air pollutants, namely carbon monoxide (CO) and particulate matter (PM_{10}) from road transport sources only. Emissions from electrically powered systems are excluded as the electricity is generated, as are the air pollutants from electricity generation, away from the City.

The results presented here are for carbon monoxide (CO) and particulate matter (PM_{10}) from road traffic sources only. Similar outputs can be generated for the other pollutants: oxides of nitrogen (NO_x), hydrocarbons (HC) and sulphur dioxide (SO_2). Results for these other pollutants would be of a similar order of magnitude to those reported.

Air pollution modelling has been used to estimate the generated emissions of CO and PM_{10} from road traffic for 2000, 2011 and 2021, and the exposure of near-field receptors (dispersion to dwellings and people near the roadways) in terms of a distribution of the exposure concentrations.

Emission levels of CO and PM_{10} from road traffic

The total CO and PM_{10} emission levels for the three modelled years and the percentage increase over the base year 2000 are shown in Table 8. Both CO and PM_{10} emissions will increase by a modest 5 and 2 percent respectively by 2011, but by 23 percent and 29 percent respectively by 2021. It should be noted that this increase is far lower than the increase in vehicle kilometres travelled of about 32 and 53 percent respectively, the lower increase attributable to estimated improvement in vehicle technology and lower emission factors for both pollutants in future years, and a shift in mode of travel from passenger cars to the light rail system.

Table 8 Total CO and PM_{10} emissions levels (summer weekday) in 2000, 2011 and 2021 for Gold Coast City (from road traffic)

Pollutant	**CO**		**PM_{10}**	
Modelled Year	Emission levels (tonnes per day)	Percentage increase over year 2000	Emission levels (tonnes per day)	Percentage increase over year 2000
2000	162	-	1.37	-
2011	170	4.8%	1.39	1.5%
2021	199	23.4%	1.76	28.5%

As would be expected, the highest emissions for CO are from the major road through the City, the Pacific Highway, with most of its links with emission rate of over 40 kg/km/h. The pattern for daily PM_{10} emissions from the roadway network across the city is similar to that of CO.

Table 9 compares total CO emission and PM_{10} estimated in this study with previous available estimates. These include the 1993 South East Queensland Air Emission Inventory (QDEH, 1995), the 2000 South East Queensland Air Emission Inventory (Queensland EPA, 2003) and the National Pollutant Inventory (NEPC, 2003). Though there are differences in the values from the different studies – the current estimates are of the same order of magnitude as previous estimates (the NPI average estimate includes winter emission levels – 23% more than summer levels) and are adequate for the strategic purposes for which TRAEMS is intended.. The value of the TRAEMS modelling is that it provides estimates for future scenarios (2011 and 2021) as well as information on the distribution of these emissions across the City, and, most importantly, estimates of human exposure.

Table 9 Comparison of computed CO emissions from different sources

Study source	Year	Total Emissions (tonnes per day)	
		CO	PM_{10}
This study	2000 (summer weekday)	162	1.4
NPI (NEPC, 2003)	2000-2001 (annual average)	197	1.1
QDEH (2003)	2000 (summer weekday)	211	1.2
QDEH (1995)	1993 (summer weekday)	132	1.5 (TSP)

The Caline4 model was used for dispersion modelling. Figure 4 shows the spatial distribution of the estimated 8-hour CO concentrations (in ppm) at the façade of dwellings along each road link for the base year 2000 scenario. In 2000, for CO the maximum concentration exposed at any near-field receptors due to road transport was 2.0 ppm while the maximum daily average PM_{10} concentration exposed at the near-field receptors is 12.8 $\mu g/m^3$. The corresponding winter season concentrations for CO and PM_{10} are estimated to be 2.5 ppm and 14.1 $\mu g/m^3$ respectively. The dwellings that are exposed to higher concentrations are located mostly along the Pacific Highway and some along a few roadways, mostly in the south-east of the City, where the dwellings are located very close to the roadway (ie 3m to 6.2m from the roadway).

These modelled levels are only those emitted by the closest roadway, and it is necessary to estimate the background concentration levels that need to be added to the near- field sources in order to estimate the total level of exposure, and hence compare estimated exposure to health limit criteria. For the purpose of this study the background concentration for each pollutant is assumed to be equal to the 50th percentile of the observed concentration at the nearest available EPA Monitoring Stations in 2000 (Table 10). It is highly likely that these background levels, at least for CO, will be conservative (high) when applied to Gold Coast City.

Table 10 Background concentration levels for CO and PM_{10} in 2000

Pollutant	Background concentration	Monitoring station
CO (ppm)	0.4	Brisbane CBD
PM_{10} ($\mu g/m^3$)	16.3	Helensvale

Source: Qld EPA (2001)

The combined maximum locally emitted concentration, together with the assumed background concentration for CO, is 2.9 ppm (winter estimate), still much lower than the ambient air quality objectives of 9 ppm. Similarly, for PM_{10}, when the background concentration level of 16.3 $\mu g/m^3$ is included, the maximum near-field concentration levels (30.4 $\mu g/m^3$) is still below both the NEPC standard and EPP ambient air quality objectives of 50 $\mu g/m^3$ (NEPC standard) and 150 $\mu g/m^3$ (EPP goal). In short, near-field air quality in the Gold Coast City from road traffic is currently estimated to be better than required standards.

Nor, given similar levels of background concentrations in the future, are near-field concentrations of CO and PM_{10} predicted to exceed ambient air quality objectives in the 2011 and 2021 scenarios.

For example, Figure 5 depicts the spatial distribution of the estimated 24-hour average PM_{10} concentrations (in $\mu g/m^3$) at the façade of dwellings along each road link for 2021. This is illustrated further in Figure 6, where the summer weekday near-field concentrations of CO pollutants are predicted for every near-roadway receptor in the City for 2000 and 2021 and summaries of their distribution of both pollutants are shown in Table 11. Mean concentration levels of both pollutants at dwellings decrease for both future year scenarios though there is an increase in the maximum predicted levels. The maximum levels of CO and PM_{10} at any dwelling, including background concentrations, are 2.9 ppm and 33.5 $\mu g/m^3$ respectively, both less than current ambient air quality objectives.

Table 11 Statistics of the distribution of near-field concentration levels at all receptor in 2000, 2011, 2021 – Summer weekday (background concentrations not included).

Pollutant	Parameter	Modelled near-field concentration levels			Percentage change over 2000 (%)	
		2000	2011	2021	2011	2021
CO (ppm)	Maximum	2.0	2.1	2.5	**5.0**	**25**
	Mean	0.14	0.11	0.11	-21.4	-21.4
PM_{10} ($\mu g/m^3$)	Maximum	12.8	13.5	17.2	**5.5**	**34.4**
	Mean	0.95	0.77	0.89	-18.9	-6.3

In addition to modelling near-field exposure, the ATDL dispersion model was used over the City to estimate ground level concentrations within 3 km x 3km grid cells were calculated over the whole of the City. Resultant concentrations were found to be very low for both CO and PM_{10} - maximum summer weekday concentrations in any grid cell in 2000 were 1.8ppm and 11 $\mu g/m^3$ for CO and PM_{10} respectively, and little different for 2011 and 2021.

The modelled worst-case 8-hour average CO and worst-case 24-hour PM_{10} near-field concentration levels at dwellings along the roadways are below their respective ambient air quality objectives throughout the city. However, it would be useful to monitor air quality at several of the locations where the highest air pollution levels have been modelled in order to confirm whether modelling matches reality. It should be noted that, as is the case with most urban air pollution modelling of road traffic, the standard models assume constant emissions (and hence constant exposure for dwellings located at similar distance from road links) along transport links. Quite differential emissions along particular links may occur where interrupted and congested flow conditions apply. Despite this caveat, the modelling suggests that, in contrast to common perception of the relative intensity and extent of pollution problems from urban transport, there is limited (if any) exposure of the Gold Coast City population to near-field air pollution concentrations that exceed standards, but there is to traffic noise levels that exceed standards.

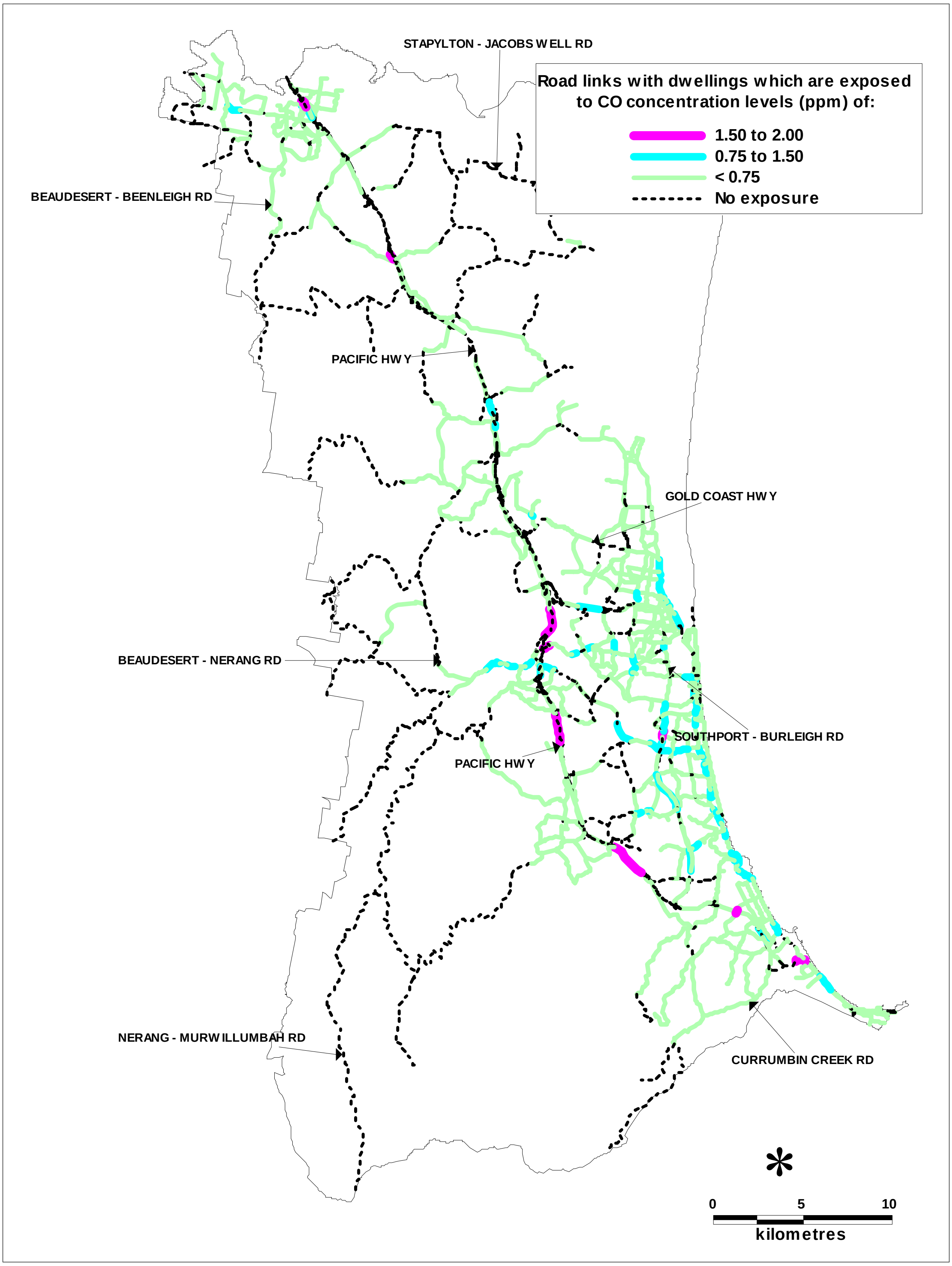

Figure 4 The summer weekday 8 h average CO concentration levels (in ppm) due to road traffic at the façade of the nearest dwelling along each road link in 2000. Note: a background concentration level has not been added to the above modelled concentrations. When background of 0.4 ppm is added (see text), maximum concentration levels throughout the city remain below the ambient air quality objectives of 9 ppm.

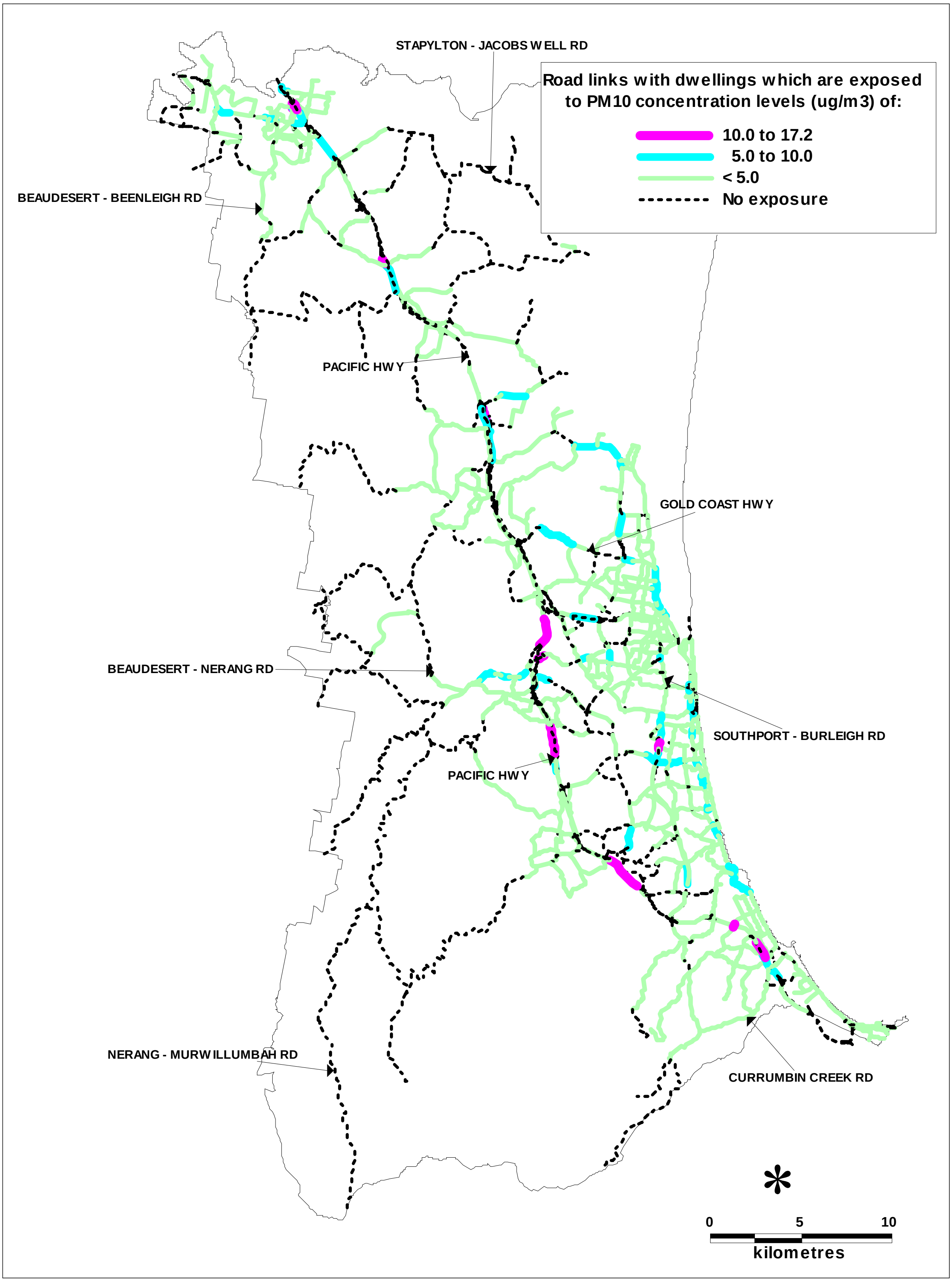

Figure 5 24 h average PM_{10} concentration levels (in $\mu g/m^3$) due to road traffic at the façade of the nearest dwelling along each road link in 2021. Note: a background concentration level has not been added to the above modelled concentrations. When background of $16.3 \mu g/m^3$ is added, maximum concentration levels throughout the City remain below the ambient air quality objectives of $50 \mu g/m^3$.

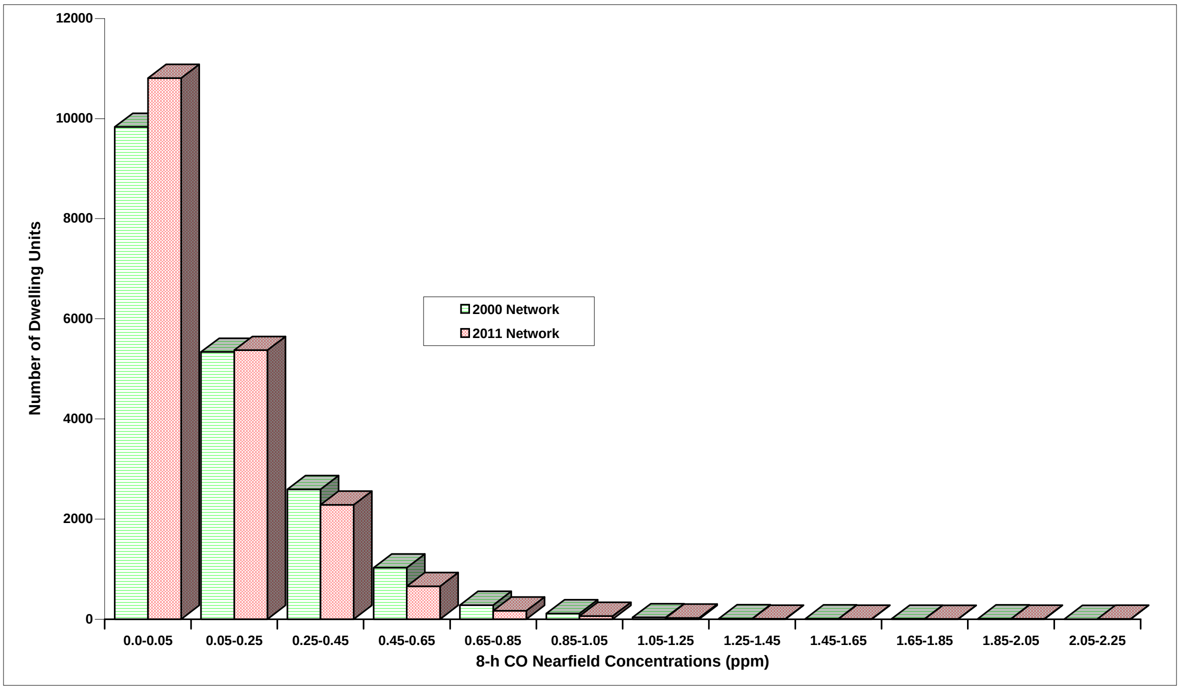

Figure 6 Distribution of the 8-hour CO concentration levels (ppm) at dwellings fronting the roadways for both 2000 and 2011 (background concentration is not included).

CONCLUSIONS

The Griffith University system TRAEMS has made efficient use of existing data sets from the City of Gold Coast - transport networks, traffic flows, and land use data base - to model current and future transport pollution exposures and both transport energy consumption and greenhouse gas emissions. The system enables planners to be aware of, and test, transport related environmental impacts at the same time as they are testing the traffic carrying efficiencies of different network and land use plans. Options testing is based primarily on the availability of different traffic flow scenarios on the transport network, but other options testing is possible, including changing fleet composition or, with more effort, examining different land uses near the network.

TRAEMS provides strategic level information - it is not designed (and should not be used) for individual site or link investigations or design of mitigation strategies. It provides a range of city-wide and location-specific information on transport pollution effects that can provide input to a diversity of policy development and planning activities. At the city-wide level, it is a tool that provides a rapid State of Environment report for transport pollution impacts. While the results provided in this paper are for one city, there is nothing to suggest that the results would be any different (in terms of relative magnitude of the different effects, and future trends in these) for most Australian cities.

However, the importance of this work is not just in terms of its findings for Gold Coast City (as critical as some of these are) but in its demonstration of our ability for quantification and prognosis of the future transport pollution states of our cities. Further, for those pollutants whose impact is on people (as distinct from impacts on the global atmosphere or on the depletion of energy resources, quantification in term of human exposure (i.e. emissions) is of much greater value that quantification of emissions loads. The latter may be of interest to the specialist, but the former is far more meaningful for determining the need for action, and the actions which may have impact on the problem - and for gaining much needed political commitment to them.

Of particular note in terms of policy and action is the relative extent of exposure, above accepted limits, to road traffic noise as compared to near-field air pollutants.

REFERENCES

Brown, A.L. Affum, J.K and Tomerini, D (1988). TRAEMS: The Transport planning Add-on Environmental Modelling System. Proceedings of the 19th ARRB Transport Research Conference, Section C, pp. 114-138

Brown, A.L. and Affum, J. (2002). A GIS-based environmental modelling system for transportation planners. *Computers, Environment and Urban Systems* 26 577-590.

Brown, A.L. and Bullen, R.B. (2003). Road traffic noise exposure in Australian capital cities. *Acoustics Australia*, 31(1), 17- 22.

Brown, A.L., Affum, J. and Chan, A. (2004). Transport Pollution Futures Gold Coast City: 2000, 2011 & 2021, based on the Griffith University TRAEMS Modelling System (TRAEMS). Griffith University, Faculty of Environmental Sciences, Urban Policy Program. Research Monograph 7, http://www.gu.edu.au/centre/urp/.

Close, W.H. and Apelbaum (2001). Consulting, A review of the noise related Australian Design Rules and engine brake noise. Research Report, National Road Transport Commission.

DeHavilland Information Services plc (2003). Diesel penetrates European automotive market http://www.platinum.matthey.com/media_room/1067850002.html. [Accessed on 16 February 2004].

DeHavilland Information Services plc (2004a) Diesel market grows in South Korea. http://www.platinum.matthey.com/media_room/1076522404.html [Accessed on 16 February 2004].

DeHavilland Information Services plc (2004b). European diesel sales hit record high for 2003. http://www.platinum.matthey.com/media_room/1074528005.html. [Accessed on 16 February 2004]

European Union Directive 2002/49/EC of the European Parliament and the Council. Assessment and management of environmental noise. Official Journal of the European Communities, L189/12-L189/25, 2002. Available: http://europa.eu.int/comm/environment/noise/home.htm [6 May, 2003].

GCCC (1998). Gold Coast City Transport Plan CD

GCCC (2004) Our Community: A social profile of Gold Coast City. The Social Research Section, GCCC, http://www.goldcoast.qld.gov.au/attachment/oc10_housing.pdf . [Accessed on 11 May 2004]

OECD (2000). *Environmentally Sustainable Transport Guidelines*. [13]

Sandberg, U. (2001). Noise emission of road vehicles: Effect of regulations. Final Report 01-1. International Institute of Noise Control Engineering.