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Future thinking: exploring future scenarios for climate change and effects on the National Highway System

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Abstract

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The paper examines the interactions between climate change, population distribution patterns, transport demand and the impacts of passenger and freight demand on the life cycle performance of the road asset. Each of these areas involves uncertainty and the paper demonstrates how the application of future thinking techniques, such as scenario construction, enables the transport analyst to navigate uncertain pathways into the future.

The paper describes the results of climate change modeling undertaken by CSIRO and the application of climatic variables (in particular, precipitation and temperature) to road pavement deterioration using the ARRB Transport Research Pavement Life Cycle Costing (PLCC) model and HDM-4. Results are presented illustrating likely climate change effects on the maintenance and rehabilitation costs of the national highway.

The paper notes that although the future climate is expected to be hotter and drier, there are likely to be significant regional variations, as well as uncertain impacts due to extreme weather events which have not been considered within the scope of the present study.

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Introduction

This paper reviews recent work undertaken by ARRB Transport Research in association with CSIRO Division of Atmospheric Research and Monash University Centre for Population and Urban Research that examined the long term effects of Greenhouse gas emissions and climate change on major road infrastructure. In 2001, the Australian road network length was around 900,000 km with just under half of the total road network sealed. Project resources constrained the focus of this project to effects on the National Highway System which, in 1999, was over 18,000 km in length. The total road network length in Australia is around 900,000 km of which around 40% is sealed.

Currently, most policy development takes place within the boundaries of existing knowledge and limited time horizons. Approaches such as trend analysis, extrapolation and explorative forecasting let us learn from the past and assist in developing knowledge based on hindsight. The purpose is concerned with predicting the future. Future studies, in contrast, require us to step outside these knowledge boundaries into areas of uncertainty. These studies also use knowledge (such as key trends, drivers, events and patterns) about the present and the past, but also challenge us to build knowledge based on foresight. Strategic foresight can stimulate the imagination, initiate discussion and debate, and add insight to policy development processes. The purpose is not to predict the future, but to learn from the process of exploration. This approach allows us to develop a deeper understanding of the underlying issues. This is the context of the study described in this paper.

In looking at the influence of climate change on major road infrastructure, this paper examines a number of areas of uncertainty. Climate change is one of those. The study on which this paper is based used a range of climate change scenarios to describe a possible envelope of change. Study scope and resource limitations did not allow all possible effects of climate change to be considered. For example, it is likely that climate change may alter the severity and frequency of extreme weather events that may cause road infrastructure damage. This is an area requiring further exploration. In this paper we are concerned only with the effects of changes in temperature and rainfall patterns. Temperature and rainfall changes, in addition to directly affecting pavement life cycle performance, are likely to influence population settlement patterns, which will influence transport demand and freight demand. Increasing freight demand and changes to heavy vehicle traffic flows on the road network will change road pavement loading and influence pavement life cycle performance. How do we begin to address such problems? Futures thinking is one useful approach.

Climate Modelling

A precautionary principle approach invites us to begin exploration of the long term future to the year 2100 and the potential for climate change. In this project the climate change modeling was undertaken by CSIRO Division of Atmospheric Research. A regional climate model was used to generate future climates out to the year 2100. The model produced a variety of climatic variables relevant to road pavement deterioration (in particular, precipitation and temperature) for a 0.5 degree geographical grid across the Australian continent. Data sets enable future climates to be generated by any selected year (for example, 2020, 2040, 2060, 2080, 2100). Only the 2100 results are presented in this paper.

The future climates were based on an average of the estimated global warming for 6 emission scenarios developed by the International Panel on Climate Change Special Report on Emission Scenarios (IPCC, 2000). Other data (not presented in this paper) were produced to examine the sensitivity of climate change and road costs to the full spectrum of emission scenarios (2.0^{o}C global warming as a minimum, 3.08^{o}C as an average of the IPCC scenarios and 4.5^{o}C as a maximum).

Data from the CSIRO model were processed to obtain suitable inputs to the ARRB TR pavement deterioration models, which included a Pavement Life Cycle Costing (PLCC) model (Linard et al, 1996) and the Highway Development and Management model (HDM-4) (ISOHDM, 2002). The key processing steps included:

- Calculation of a Thornthwaite Moisture Index, which provides a climate classification, based on precipitation (P), temperature (T) and potential evapotranspiration (PET) as the key variables. A Visual Basic Calculator was developed to automate the processing of the climate data.
- Data interpolation to determine a Thornthwaite index for a specific longitude/latitude pair corresponding to a specific location on the national highway system.
- The effects of different future climates can be illustrated through changes in the Thornthwaite Moisture Index as well as temperature and rainfall changes. See Figures 1, 2 and 3, which also include selected data for major cities.

Figure 1. Changes in Average Annual Temperature (°C) - Year 2100 (average of climate change scenarios) relative to base climate

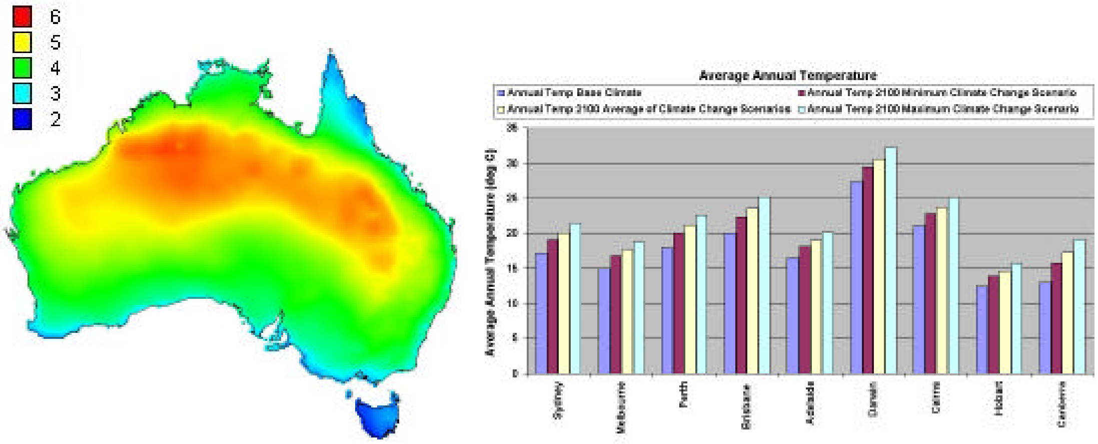


Figure 2. Percentage Change in Mean Monthly Precipitation - Year 2100 (average of climate change scenarios) relative to base climate

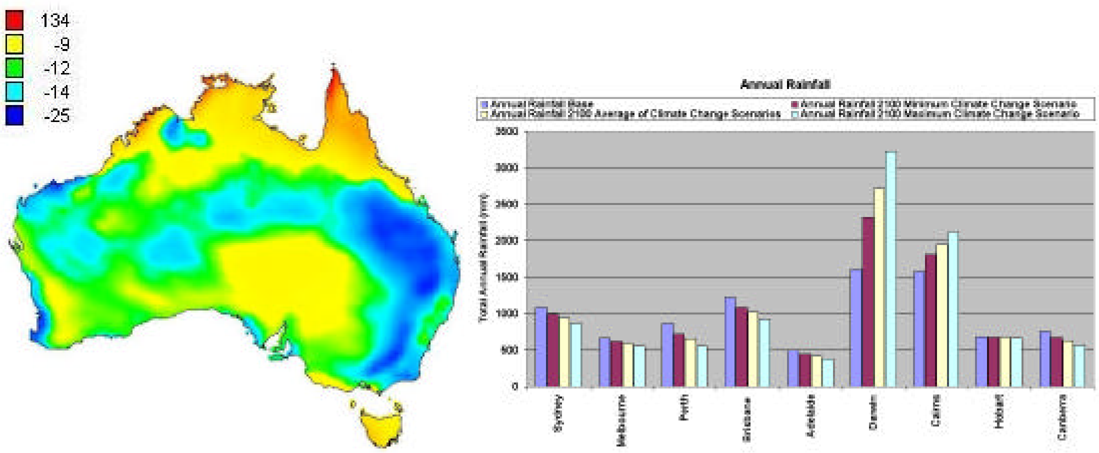
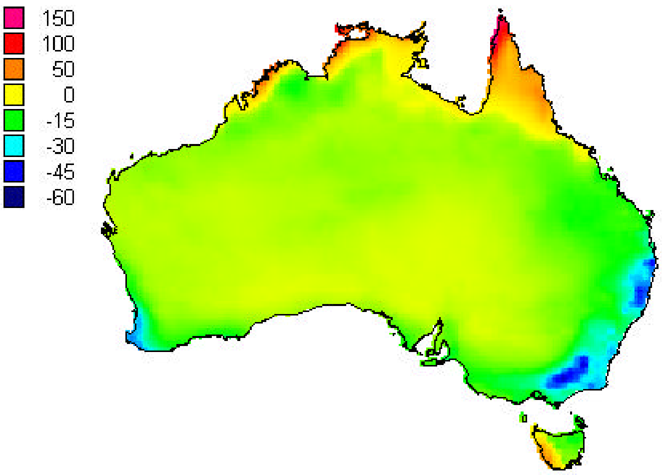


Figure 3. Changes in Thornthwaite Index (1990 to 2100)



The following observations can be made about climate change in Australia:

- There will be a warmer and drier climate overall (indicated by the negative change in Thornthwaite Index).
- Central Australia will be significantly warmer but rainfall changes are not significant (as they are already low).
- The South-West (Perth region) of Western Australia will have an estimated 25% reduction in rainfall (up to 46% under the most pessimistic of the IPCC greenhouse emission scenarios). This has major social implications as growth in the area is already restricted by water supply.
- Southern South Australia will have 16% to 29% reduced rainfall, with most of this reduction occurring in Spring. This will have implications for agricultural production.
- Areas of North-East Victoria and Southern NSW (across the Great Dividing Range) will experience 25% (best estimate) to 46% reduction in rainfall.
- The Far North of the continent will experience much higher summer rainfall due to the monsoonal rain band shifting south by a few hundred kilometres. Darwin will have 69% higher rainfall under the average IPCC greenhouse emissions scenario and up to 727% higher under a high emissions scenario, with nearly all rainfall in summer.

From an infrastructure perspective, the areas with the highest Thornthwaite Index change (and hence greatest change in maintenance costs) are the South-West of Western Australia, North-East Victoria, Southern NSW, South-West Tasmania and the Far North.

Population

The Australian Bureau of Statistics (ABS) has provided different population projections for Australia based on assumptions relating to fertility rate, immigration levels and mortality rates. Under the 'Series 2' projection, Australia's population will increase from 18.9 million in mid-1999 to 25.4 million in 2051, subsequently peak at 25.5 million in 2063, and thereafter decline slightly to 25.3 million by 2101 (ABS, 1999). Since the majority of the population growth occurs in the first decade of the 21st Century, there will be implications for infrastructure investment (including roads) over this period.

Table 1 provides a summary of projected population growth in Australia by region to 2051.

Table 1. Projected population growth in Australia by region, 1999 to 2051

Location	Population 1999 '000	Population 2051 '000	Increase 1999-2051 '000	Share of Australia's population 1999 %	Share of Australia's population 2051 %	Share of Australia's projected increase 1999-2051 %
Sydney	4,041	5,857	1,816	21.3	23.0	28.2
Rest of NSW	2,370	2,390	20	12.5	9.4	0.3
Melbourne	3,417	4,393	976	18.0	17.2	15.1
Rest of Victoria	1,295	1,154	-141	6.8	4.5	-2.1
Brisbane	1,601	2,864	1,263	8.4	11.3	19.6
Rest of Qld	1,911	3,237	1,326	10.1	12.7	20.6
Adelaide	1,093	1,102	9	5.8	4.3	0.1
Rest of SA	400	308	-92	2.1	1.2	-1.4
Perth	1,364	2,231	867	7.2	8.8	13.5
Rest of WA	497	806	309	2.6	3.2	4.8
Hobart	194	146	-48	1.0	0.6	-0.7
Rest of TAS	276	173	-103	1.4	0.7	-1.6
Darwin	88	192	104	0.5	0.8	1.6
Rest of NT	105	177	72	0.5	0.7	1.1
ACT	310	372	62	1.6	1.5	0.9
Australia	18,987	25,408	6,441	100	100	100

Assumptions;
Total Fertility Rate 1.6
Net overseas migration 90,000 per annum
Source: ABS, Population Projections Australia, 1999-2101, 2000

Table 1 indicates a number of significant patterns for the regional distribution of population. These include:

- Metropolitan dominance which will see a greater concentration in Sydney, Melbourne, Brisbane and Perth. These cities are projected to absorb over 76.5 per cent of Australia's total 6.4 million total population growth to the year 2051.
- A significant increase in the share of Australia's population living in non-metropolitan Queensland. (Queensland is projected to receive over 40 per cent of Australia's population growth between 1999 and 2051).
- Other social and economic factors such as industry restructuring (in particular 'new economy' and service industries) are also seeing greater employment opportunities in the metropolitan areas. In regional areas there has been a pattern of out-movement of young people looking for work and education opportunities.

Modified Population Distribution due to Climate Change

Population projections were modified based on the future 2100 climate for selected Statistical Divisions (this work was undertaken by Monash University Centre for Population and Urban Research in conjunction with the Australian National University). Table 2 summarises the results showing the forecast population changes (with no climate change impact) and a Climate Change population adjustment factor.

Table 2. Population (with and without Climate Change effects)

Selected Statistical Division	2100 Population as a percentage of 2000 population (no climate change)	Year 2100 population adjustment factor (with climate change)	Climate change factors driving population change
Sydney	159%	1.00	Temps higher but not expected to affect population growth
Melbourne	125%	1.15	Temperatures higher resulting in more attractive climate
Brisbane	211%	0.96	Temperatures higher resulting in less attractive climate
Moreton	305%	0.98	Temperatures higher resulting in less attractive climate
Adelaide	63%	0.79	Restricted water supply, especially in Spring
Perth	195%	0.88	Less attractive climate; restricted water supply
Darwin	275%	1.34	Temperatures high but heavy rainfall drives increased agriculture
ACT	93%	1.00	Temperatures higher but not expected to affect population growth
Cairns	279%	0.83	Temperatures higher resulting in less attractive climate

Transport demand

In order to examine the road pavement effects of future traffic flows, both the passenger and freight tasks must be considered. A demand forecast calculator was developed which used the climate adjusted population distributions above as a key driver of transport demand out to the year 2100. Baseline AADT values for the National Highway system were sourced from Austroads.
Based on the modified population projections a set of Origin-Destination Population Factors was developed that were used in the travel demand analysis. These are shown in Table 3.

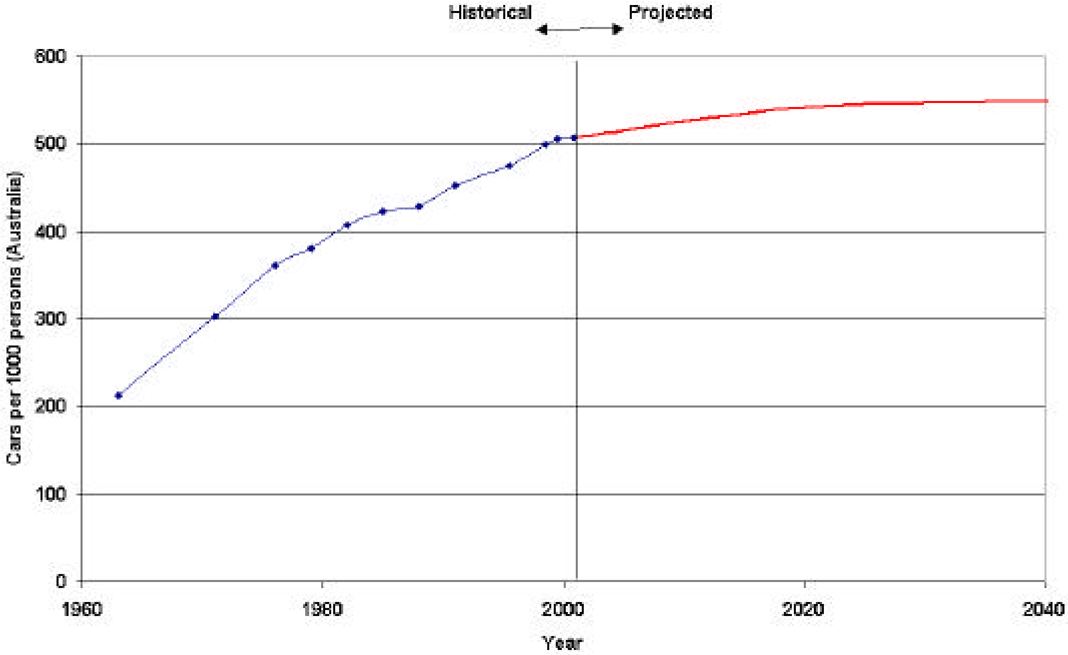
Table 3. Origin-Destination Population Factors (Climate Adjusted)

Origin-destination pair	2000	2020	2040	2060	2080	2100
Sydney-Melbourne	1.00	1.19	1.33	1.41	1.46	1.52
Sydney-(Brisbane/Morton)	1.00	1.27	1.51	1.68	1.79	1.85
Sydney-ACT	1.00	1.21	1.38	1.47	1.52	1.54
(Brisbane/Morton)-Cairns	1.00	1.38	1.73	2.00	2.19	2.31
Melbourne-Adelaide	1.00	1.12	1.19	1.20	1.19	1.22
Adelaide-Perth	1.00	1.18	1.30	1.31	1.26	1.17
Perth-Darwin	1.00	1.30	1.56	1.72	1.80	1.83
(Brisbane/Morton)-Darwin	1.00	1.38	1.73	2.01	2.22	2.36
Brisbane-Morton	1.00	1.37	1.72	1.99	2.19	2.31
Adelaide-Darwin	1.00	1.07	1.06	0.98	0.87	0.74
ACT -(Brisbane/Morton)	1.00	1.35	1.65	1.89	2.05	2.15
ACT -Adelaide	1.00	1.06	1.03	0.92	0.76	0.59

Passenger Task

In terms of the passenger transport task, travel per passenger vehicle has remained fairly constant over the last decade and is not projected to change in the future. Car ownership per head of population follows an S-shaped logistic curve that will flatten out at around 550 cars per person, 8% higher than current levels (see Figure 4).

Figure 4. National Average Passenger Cars per 1000 Persons



Projection curve based on the (BTE car ownership model) logistic equation cars per capita = k/(1 + a*exp(-bt)) where k=550, a=12, b=0.087

This paper uses a simplified approach to project the future transport task between key origin-destination pairs on the National Highway System. For passenger travel the approach is illustrated in Equation 1.

$$PassengerCarTravel = BaselineAADT \times (1 - \%HV) \times PopulationFactor \times CarsPerCapitaFactor$$

(Equation 1)

Based on the population projections, the logistics curve in Figure 4 and Equation 1, it is possible to estimate future passenger vehicle flows that can be used in road pavement performance models.

Freight task

A similar approach was used for the freight task as illustrated in Equations 2 and 3.

$$HeavyVehicleTravel = \frac{BaselineAADT \times \%HV \times PopulationMultiplier \times FreightPerCapitaFactor}{PayloadFactor}$$

(Equation 2)

$$HeavyVehicleAverageESAs = BaselineAverageESAs \times ESAFactor$$

(Equation 3)

For the freight task a number of additional issues need to be considered:

Light Commercial Vehicle (LCV) traffic

Light Commercial Vehicle traffic is growing quite strongly, however this is largely urban traffic and has little impact on road wear. It will be ignored in this paper which is focusing on impacts to the National Highway System.

Heavy vehicle fleet

There has been an increase in the use of larger freight vehicles including B-doubles and road trains. The 'Survey of Motor Vehicle Usage' (ABS, 2000) published by the Australian Bureau of Statistics can be used to look at trends to select a future composition of the freight vehicle fleet. Calculations have assumed that the B-double share of articulated truck freight will plateau at 35%, up from 22% currently.

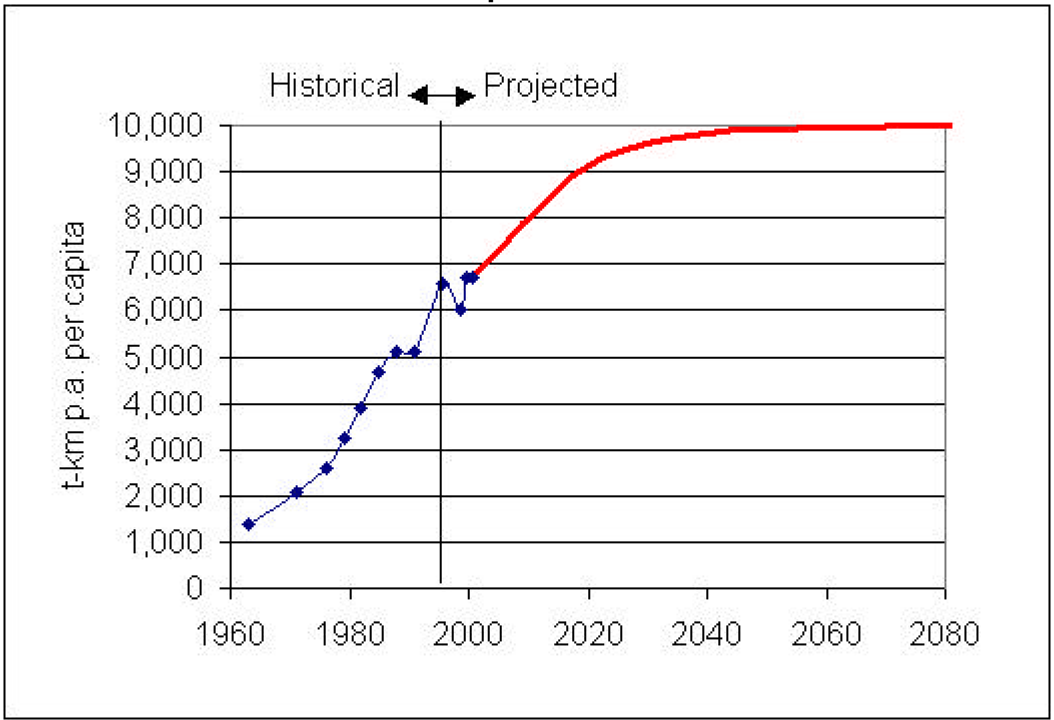
Growth in the total freight task

In the shorter term, growth in the freight task is typically modelled as a function of GDP and freight rates. On the basis of a flat 3.2% growth per annum in GDP, total road freight (measured in tonne-km) is projected to rise by 4.1% per annum through to 2015, with the oft-quoted "doubling of road freight by 2015" (GARGETT, 1999).

Extending projections beyond 2015 is a difficult task. If we assume 3.2% growth in GDP to the year 2100, this represents a 23-fold growth in the economy with population growth of 42% over the same 100 year period - a 16 fold increase in GDP per capita! Some other approaches are indicated. This has also been recognised in the Federal Government announcement in May 2002 of the AusLink initiative which notes the unsustainability of ongoing growth in the freight task.

In this paper, a logistic-curve relationship between road freight and population is used which assumes that current levels of road freight growth are not sustainable, either economically or physically (in terms of road infrastructure). The logistics curve is shown in Figure 5, illustrating an increase of approximately 49% in road freight per capita by 2100. This approach is supported by historical trends in the rise of other transport infrastructures, including canals, rail and air transport (GRUBLER, 1990).

Figure 5. Logistics Curve relationship between Road Freight and Population



<u>Axle Mass Limits</u>

From a road deterioration perspective, the major factor determining road wear is axle loading, measured in Equivalent Standard Axles (ESAs). A number of different axle mass limit scenarios were built into the Travel Demand Forecast, including the 1999 Mass Limits Review (MLR). It should be noted that the widespread use of 'spray seals' in Australia's road infrastructure would require a significant upgrade of the road system to accommodate increased axle loads above levels set in the 1999 Mass Limits Review.

It has been assumed (as postulated in BTCE,1997) that axle limits will be increased in one further increment subsequent to the MLR, as shown in Table 5.

Table 5. Assumed freight vehicle axle loadings

Axle group	Current	MLR	2020 and beyond
single steer	6	6	6
single drive	9	9	9
tandem drive	16.5	17	19
tri-axle drive	20	22.5	26

A combination of the assumptions above results in the factors shown in Table 6 for freight transport in 2100 relative to 2000. Rural and urban usage are as distinguished by the ABS in the Survey of Motor Vehicle Usage (ABS,2000).

Table 6. Estimated freight related parameters for the year 2100 relative to 2000

Freight per capita factor	Urban payload per heavy vehicle factor	Urban ESAs per heavy vehicle factor	Change in urban ESAs per tonne payload[1]	Rural payload per heavy vehicle factor	Rural ESAs per heavy vehicle factor	Change in rural ESAs per tonne payload
1.49	1.19	1.45	22.3%	1.26	1.66	31.9%

In terms of road maintenance, the increase in ESAs per tonne of load is additional to the increased wear resultant from growth in the actual freight task. This is obviously a very important factor in the determination of future road costs.

Because average ESAs are route specific, the baseline average ESA figure for each national highway section was used and factored up accordingly using the values in Table 6.

Pavement Modelling

The pavement deterioration analysis component of this project included the use of the ARRB TR network pavement life-cycle costing (PLCC) model and the HDM-4 model.

Briefly, the ARRB TR Network PLCC model estimates the minimum total life cycle cost (LCC) for the unconstrained annual agency budgets based on achieving the minimum present value (PV) sum of road agency and road user costs, over a 60 year analysis period using a real discount rate of 7%. The model uses a genetic algorithm to achieve optimisation of a very large number of options, subject to any specified constraints on maximum network roughness and annual agency budget limits. (See, for example, Martin 1994; Martin and Ramsay 1996, and Martin and Roberts 1998).

The PLCC analysis was applied to the National Highway road network and requires the following key input parameters:

- Lane lengths of the road types that comprise the road network,
- Annual average daily traffic (AADT),
- Percentage heavy vehicles (%HV),
- Pavement/subgrade strength,
- Thornthwaite climate index,
- Pavement age,
- Pavement roughness.

[1] Different to rural areas because of the higher fraction of rigid trucks.

The HDM-4 model provides more detailed results than PLCC, but also has more extensive input requirements. Refer to (ISOHDM, 2002) for details on the HDM-4 model. The HDM-4 model requires the following key parameters:

- Rehabilitation type (Granular or Asphalt),
- Average age of pavement,
- Average strength,
- Average initial roughness,
- Thornthwaite Moisture Index,
- Rise and fall,
- Average AADT,
- Percent heavy vehicles,
- Average ESA's per heavy vehicle.

The analysis was undertaken in two stages:

- Stage 1 applied existing traffic volumes to the national highway system and future (year 2100) climate parameters.
- Stage 2 applied projected traffic volumes to the national highway system and future (year 2100) climate parameters.

PLCC Model Results

The PLCC model outputs include an optimised Agency Cost (maintenance and rehabilitation) which are summarised in Table 7 for the year 2000 Base Climate and the year 2100 'Average' Climate (which refers to the average prediction of a range of climate models over 6 different IPCC emission scenarios). Table 7 includes both the climate change and the transport demand influences on Agency Costs. The traffic growth component is an increase of $99m in the year 2100 (a 35% increase), while the climate change component is a decrease of $10.8m (or a 3% decrease).

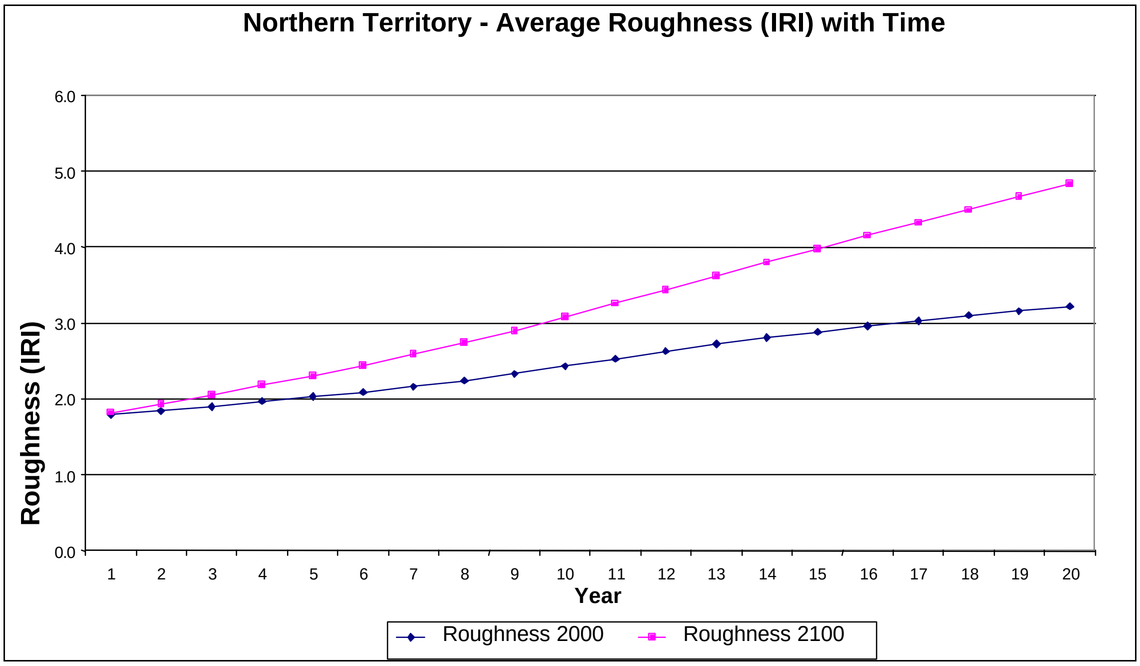
Table 7. Summary of Optimal Agency Costs ($million) for the 2000 Base and 2100 Average climate change scenarios

State	2000 Base Climate	2100 Average Climate
NSW	72.3	90.1
VIC	32.0	37.6
QLD	82.0	124.2
WA	48.3	56.1
SA	27.6	23.4
TAS	6.5	6.8
NT	17.9	37.3
ACT	0.6	0.7
Total	287.3	376.1

HDM-4 Model Results

The HDM-4 model produced results with similar trends to those outlined in the PLCC. The HDM-4 Model is also able to provide detailed estimates of specific pavement performance parameters such as roughness (Figure 6), cracking, ravelling and potholing.

Figure 6. HDM-4 Roughness Output



The results indicate that the effects of increasing transport demand heavily outweigh the influence of climate change on maintenance and rehabilitation costs of the national highway. Nationally, increased traffic demand associated with climate change will increase costs by 35%, whereas climate change alone reduces total costs by 3%. This is not unexpected given the generally warmer and drier climate expected in year 2100. There are significant regional variations to this trend however, as indicated in Table 8.

It should be noted that this result does not take into account the damage impacts associated with increased flooding and other extreme weather events.

Table 8. Summary of Optimal Agency Costs due to Travel Demand Changes

State	Optimal agency cost for national highways ($million)			% change in costs		
	2000 Base Climate	2100, with increased travel demand but no climate change	2100, with increased travel demand and climate change	Due to traffic growth alone	Due to climate change alone	Due to climate change and traffic growth combined
NSW	72.3	88.1	90.1	21.8%	2.8%	24.6%
VIC	32.0	40.8	37.6	27.4%	-10.1%	17.3%
QLD	82.0	130.3	124.2	58.9%	-7.4%	51.5%
WA	48.3	57.2	56.1	18.4%	-2.4%	16.0%
SA	27.6	24.4	23.4	-11.7%	-3.6%	-15.3%
TAS	6.5	6.2	6.8	-4.0%	9.0%	5.0%
NT	17.9	39.0	37.3	117%	-9.7%	107.6%
ACT	0.6	0.8	0.7	24.8%	-19.6%	5.2%
Australia	287.3	386.9	376.1	34.7%	-3.8%	30.9%

Summary

This paper has reviewed recent work undertaken by ARRB Transport Research in association with CSIRO Division of Atmospheric Research and Monash University Centre for Population and Urban Research that examined the long term effects of Greenhouse gas emissions and climate change on major road infrastructure.

The paper has discussed the use of futures thinking tools and techniques as a means to explore the long term future and look at the interactions between climate change, population distribution patterns, transport demand and the impacts of passenger and freight demand on the life cycle performance of the road asset. Each of these areas involves uncertainty and the paper demonstrates how the application of future thinking techniques, such as scenario construction, enables the transport analyst to navigate uncertain pathways into the future.

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The paper notes that although the future climate is expected to be hotter and drier, there are significant regional variations, as well as uncertain impacts due to extreme weather events.

References

ABS (1999). *Population Projections, Australia, 1999-2101*. Australian Bureau of Statistics. Cat. No. 3222.0.

ABS (2000). *Survey of Motor Vehicle Use, Australia*. Australian Bureau of Statistics. Cat. No. 9208.0.

BTCE (1997). *Roads 2020*. Bureau of Transport and Communications Economics, Canberra.

GARGETT, D and MITCHELL, D (1999). *Information Sheet 15 : Trends in Trucks and Traffic.* Bureau of Transport Economics.

GRUBLER, A. (1990). *The Rise and Fall of Infrastructure: Dynamics of Evolution and Technological Change in Transport*. Physica, Heidelberg.

IPCC (2000). *Special Report on Emission Scenarios – A Special Report of Working Group* III *of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge.

ISOHDM, (2002). *HDM-4 Highway Development and Management Model (Version 1.3), Software and Documentation, International Study of Highway Development and Management*, PIARC, Paris, France.

LINARD, K., MARTIN, T. and THORESEN. T. (1996). *TASK 2 A Pavement Life-Cycle Costing Optimisation Procedure, TASK 3 Pavement Life-Cycle Costing Optimisation Computer Package.* Draft Contract Report prepared for National Road Transport Commission, ARRB Transport Research, May 1996, CR TE 821. (ARRB TR: Vermont South, Vic.).

MARTIN, T.C. (1994). *Pavement Behaviour Prediction for Life-Cycle Costing*, Australian Road Research Board Ltd., Research Report ARR 255, December 1994, pp 45. (ARRB TR: Vermont South, Vic.).

MARTIN, T.C. and RAMSAY, E. (1996). *Rural pavement improvement prediction due to rehabilitation*. ARRB Transport Research Report ARR 283, June1996, pp 20. (ARRB TR: Vermont South, Vic.)

MARTIN, T.C. and ROBERTS, J.D. (1998). *Network and Project Level Pavement Life-Cycle Costing Modelling for Asset Management*, 9th Road Engineering Association of Asia and Australia (REAAA) Conference, Wellington, New Zealand.

THORNTHWAITE, C.W. (1948). An Approach Toward a Rational Classification of Climate, The Geographical Review, pp.55-94.

THORNTHWAITE, C.W. (1931). The Climates of North America According to a New Classification, The Geographical Review, Vol 21(1), pp.633-654.