AUSTRALIAN ACADEMY OF TECHNOLOGICAL SCIENCES AND ENGINEERING

Ian McLennan House, 197 Royal Parade, Parkville, Vic. 3052
Telephone: (03) 9347 0622, Facsimile: (03) 9347 8237
International: (03) 61 3 9347 0622

President
Mr M A (Tim) Besley AO FTSE

9 November 2000

Mr D Buckingham
Executive Director
Business Council of Australia
Level 1, 379 Collins Street
MELBOURNE VIC 3000

Dear Mr Buckingham

I have pleasure in enclosing a report on the likely environmental impacts of population growth in Australia and the technological, behavioural, pricing and settlement planning interventions that might be used to manage population-related issues. Also enclosed is a transmittal report from the Steering Committee that managed the project for the Academy.

The report finds that only a few of the environmental issues that are commonly linked to population have any real connection to population size. Where links have been found to exist, the report describes interventions that might be used to manage the impacts. It also recommends that there be further scientific study of the relationship between Australia's population and our ability to manage pollution of land, pollution of waters near major urban areas, depletion of freshwater stocks near major urban areas, and pollution of urban airsheds.

Should the Business Council of Australia wish to pursue in more depth the study of these relationships, the Australian Academy of Technological Sciences and Engineering would be happy to discuss ways in which such a project could be undertaken.

Yours sincerely

MA Besley

M.A. Besley

Population Futures Study – Steering Committee's Letter of Transmittal

The work of the Steering Committee and its consultants has enabled the Austarlain Academy of Technological Sciences and Engineering (ATSE) to make some observations about Australia's ability to carry a larger population by 2050 without degrading the environment from today's standards. On the basis of this review there are reasonable grounds for believing Australia can, without further damage to the environment, sustain a significantly larger population over the next fifty years. Given the prevailing and expected urbanization of Australia, population growth will be primarily urban. The application of technological, behavioural and pricing and planning strategies will enable the environmental impacts of this population growth to be managed. Our work is of a preliminary nature and gives guidance to areas of further work to enable firmer conclusions to be drawn.

This review stems from an increasing interest on the part of the Academy in population growth and its relationship to infrastructure, resource provision and environmental impact in Australia. Our discussions were brought into sharper focus when the Business Council of Australia (BCA) approached ATSE seeking advice on these general points, and the formal invitation which followed has given rise to this brief analysis and the detail contained in the accompanying report.

Our thinking at first led us to consider the development of a Population Policy. Others had attempted this and their efforts made it clear that the issues involved were essentially political, especially insofar as they involved immigration policy. Moreover, the development of a Population Policy – often referred to as a study of Australia's carrying capacity, - also requires input decisions about lifestyles, regional development, sustainability targets, ageing populations, and other matters that lie outside the core competency of the Academy. A Population Policy must necessarily cover just about every aspect of life in a future Australia. Developing such a policy was clearly a task that lay beyond the abilities of all but the Commonwealth Government.

Discussions between representatives of ATSE and BCA refined the brief so that the commission from BCA was for a study of the potential environmental impacts of population growth. As well as the impacts, the study was to cover the technological, behavioural, pricing and settlement planning measures that could be used to manage the impacts expected from future populations. Without in any way predicting these, we agreed to consider three scenarios up to the year 2050. In one, the population would continue to grow along the present trend line, leading to an Australia with 24.8 million people. In the second, we considered the effect of 1% additional growth so that the population reached 31.5 million. No assumptions were made about how this growth rate could be attained. The third 'accelerated' scenario would see a population of 37.9 million in fifty years' time, but again no consideration was given to how such population growth could be achieved. Instead, the focus of the study was to see what answers were available to the 'scenario' question - 'how would technology respond to a population of ...?'.

It became clear as the study framework developed that, in the time available, it would not be possible to develop original research-based answers to the questions that would arise. Rather, it was decided, the study would examine the current literature that bears on the issues, evaluating it for relevance and identifying any gaps in the knowledge.

The ATSE Steering Committee that developed the study framework sought the assistance of professional consultants to retrieve and assess relevant information. The consultants we selected worked closely with the Steering Committee, following up leads identified by ATSE Fellows, taking part in conferences with Fellows and providing drafts for their consideration.

Earlier studies by ATSE, by CSIRO and by scholars commissioned by the BCA had suggested that the growth of population in Australia would not be limited by the availability of resources such as food and water. These statements have been largely uncontested, but there have been repeated public statements that population growth constitutes a significant threat to the Australian environment. Soil degradation, air and water pollution, and loss of biodiversity were most often cited as dire effects that could only be avoided if Australia's population remained at or near its present level or, in the judgment of some commentators, were to be drastically reduced. Reversing the effects of past depredations also required, in this 'world view', smaller and better-behaved populations.

The present study shows that predictions of environmental disaster in Australia arising from population growth are ill-founded and arise from muddled and sometimes emotive thinking about the cause of environmental impacts. There is no question that Australia has suffered significant environmental damage, and might suffer in future if land, water and air are not better-managed. However, the most important concept developed by the consultants and the ATSE Steering Committee was that increases in many environmental impacts are not related to the population size, but they arise from other activities that might be broadly described as 'resource development'. Such developments could be undertaken, and are, almost regardless of Australia's population.

This is not to suggest that all environmental impacts are brought about by factors unrelated to population size or growth. For example, depletion of arable land through the growth of cities and pollution of land by poor waste disposal practices are strongly population-linked. Similarly, water and air pollution close to cities – the latter largely due to car and truck traffic – are directly linked to the size of populations as well as to their activities. It is the second factor upon which mitigation measures must take effect, either through technological development, lifestyle changes, market instruments, regulatory change and policies for planning and settlement. Policy and the regulations which might flow from it have key roles to play in providing incentives for technological advance, whereas education (in its broadest sense) is likely to be the essential foundation for behavioural change.

The attached report amplifies and qualifies these broad themes. First, it embarks on an assessment of the degree to which particular environmental impacts are related to growth of population. Having clearly identified those impacts which might be expected if growth were to occur in the absence of technological or behavioural change, the report then proceeds to explore strategies for mitigating the possible

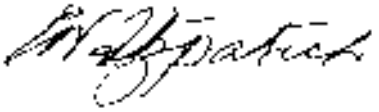
impacts. Examples of successful mitigation programs have been identified and the possibilities for their future application are explored. In the case of technological change, the report is scrupulous in avoiding the notion of the 'technological fix' which could lead to over-optimistic predictions of impact mitigation. Instead, technological advance is seen as flowing from present technology, just as policy and regulatory developments are linked to the present situation. In both instances, wider application of present 'successes' is advocated. However, we are confident that successful mitigation strategies will be developed.

Finally, the report recommends that there be further scientific study of the relationship between Australia's population and our ability to manage pollution of land, pollution of waters near major urban areas, depletion of freshwater stocks near major urban areas, and pollution of urban airsheds not only to allow for larger population but also to improve our current situation.

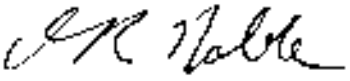
Should the Business Council of Australia wish to pursue in more depth the study of these relationships, the Australian Academy of Technological Sciences and Engineering would be happy to discuss ways in which such a project could be undertaken. The emphasis in such a project would be the study of how new and emerging technologies could be used to mitigate the pollution of land, water and air in urban areas and improve freshwater stocks for our cities.

J K Ellis FTSE
Chair

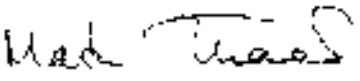
D J Blackmore FTSE
Member



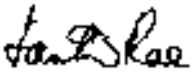
E N Fitzpatrick AM FTSE
Member



I R Noble FTSE
Member



M H Thomas AM, FTSE
Member



I D Rae FTSE
Technical Director, ATSE

Australian Academy of Technological Sciences and Engineering

POPULATION FUTURES

October 2000

SGS
URBAN ECONOMICS & PLANNING
MELBOURNE BRISBANE SYDNEY
Spiller Gibbins Swan Pty. Ltd.
ABN 58 742 358 924
6th Floor, 313 Latrobe Street
Melbourne Victoria 3000
Ph: 61 3 9606 0994
Fax: 61 3 9606 0995
email: sgsvic@sgs-pl.com.au
website: www.sgs-pl.com.au

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EXECUTIVE SUMMARY

Introduction

This paper focuses on the 'environmental constraints' to population growth in Australia. The paper has two objectives as follows:

1. To identify the environmental constraints on population growth in Australia; and
2. To identify and assess technological, behavioural, pricing and settlement planning interventions which can be used to manage population-related environmental issues.

Environmental Constraints on Population Growth

The major environmental issues in Australia are listed in the following table. Each issue is assessed in terms of whether an enlarged population would, all things being equal, deliver a significantly worse outcome for that issue. On this basis, environmental issues are classified under three headings as follows:

- Strong connection to population growth;
- Tenuous connection to population growth; and
- No direct connection to population growth.

There are four environmental issues that have a strong connection to population growth. These are shown in the table.

Qualitative Assessment of Environmental Issues Against Population Size

Environmental Issues	***Connection to Population Growth?***	
Pollution of land (and groundwater basins).	Strong	More people equals more waste generation, solid waste disposal and landfill leakage into groundwater basins.
Pollution of coastal waters, rivers and lakes near major urban areas.	Strong	More people equals more urban development, construction of hard surfaces and associated increase in stormwater runoff - with litter and liquid pollutants - and sewage discharge into urban waterways.
Depletion of fresh water stocks near major urban areas.	Strong	More people equals more water use for domestic activities such as drinking, washing and gardening.
Pollution of urban air sheds.	Strong	More people equals more fossil fuel emissions primarily from car use and to a lesser extent energy generation.
Depletion of arable land stock.	Tenuous	More people might equal suburbanisation into arable land stocks. Most depletion relates to land clearing and poor land management practices.
Depletion / fragmentation of natural habitats / ecosystems.	Tenuous	More people might equal suburbanisation into natural environments and fragmentation of natural environments by transport networks. Most depletion relates to land clearing and primary industry practices.
Depletion of animal / insect species / biodiversity.	Tenuous	More people might equal suburbanisation into natural environments and fragmentation of natural environments by transport networks. Most depletion relates to land clearing and primary industry practices.
Pollution of fresh water stocks near major urban areas.	Tenuous	More people might equal suburbanisation into, and contamination of, urban water catchments.
Alteration of river and lake systems near major urban areas.	Tenuous	More people might equal suburbanisation into water systems and consequent alteration and damming of water systems.
Greenhouse effect.	Tenuous	More people in Australia might equal a net increase in global greenhouse emissions from energy, transport and industry.
Depletion of the ozone layer in the upper atmosphere.	Tenuous	More people in Australia might equal a net increase in global ozone emissions from energy, transport and industry.
Loss of amenity.	Tenuous	More people might equal more urban noise (primarily relating to transport) and congestion at natural and cultural attractions.
Depletion of mineral, energy and timber resources.	Tenuous	More people might equal more demand for natural resources. Resource exploitation relates to primary industry practices and international demand.
Depletion of fresh water stocks in rural and remote areas.	No Direct	More people does not equal non-urban water use which primarily relates to irrigation.
Pollution of coastal waters, rivers and lakes in rural and remote areas.	No Direct	More people does not equal pollution discharge into rural and remote waterways which primarily relates to primary industry practices.
Degradation of soils (eg. salinity, acidification, erosion).	No Direct	More people does not equal soil damage which primarily relates to farming / land clearing practices.
Alteration of river and lake systems in rural and remote areas.	No Direct	More people does not equal alteration and damming of rural and remote water systems which primarily relates to primary industry practices.
Depletion of marine habitats.	No Direct	More people does not equal depletion of marine habitats which primarily relates to primary industry and shipping practices.
Depletion of fish / marine stocks and species / biodiversity.	No Direct	More people does not equal loss of marine species which primarily relates to primary industry practices.
Depletion / degradation of heritage and cultural sites.	No Direct	More people does not equal damage to heritage and cultural sites which primarily relates to resource management practices.
Harm to human and environmental health from manufactured by-products.	No Direct	More people does not equal generation and mismanagement of potentially harmful by-products from energy sector and industry (eg. pesticides, chemicals, wastes).

Environmental Outcomes to 2050

A number of models or studies postulate future environmental outcomes in Australia under different population scenarios. A review of the models shows that:

- There are significant modelling gaps for genuine population-related environmental issues;
- Urban air shed pollution has been addressed to some extent by research but outcomes are not available under different population scenarios to 2050; and
- Some models provide projections or assessments for environmental issues that have a tenuous or no direct relationship to population growth.

Strategies to Address Environmental Issues

A number of strategies can be applied to address the four population-related environmental issues (52 have been identified). The strategies can be summarised under the following headings:

- **Technological innovations** can contain or potentially reverse environmental impacts through improved efficiency, containment or 'ways of doing things';
- **Behavioural shifts** caused by education programs and regulatory measures can be applied to minimise the impact people have on the environment;
- **Pricing policies** can be applied to change behaviours by rendering the true cost of supplying a service or impacting on the environment more transparent to consumers; and
- **Planning and settlement pattern policies**, which seek to lessen environmental impacts through alternative land use and transport arrangements, can be applied to deliver superior environmental outcomes.

Conclusions

It is concluded that:

1. There are four environmental issues that have a strong connection to population growth. These are as follows:

   - Pollution of land (and groundwater basins);
   - Pollution of coastal waters, rivers and lakes near major urban areas;
   - Depletion of fresh water stocks near major urban areas; and
   - Pollution of urban air sheds.

2. The adverse impacts of population growth on the environment in Australia relate to:

   - The structure and functioning of our cities (eg. urban sprawl and dominance of car transport);
   - Australia being a high resource using and waste generating society; and
   - Australia's dry climate resulting in low stocks of fresh water near the major population centres.

3. There are significant gaps in modelling future outcomes for the four population-related environmental issues in Australia. No predictive models to the year 2050 have been identified for the four issues in Australia adopting different population scenarios and different technological, behavioural, pricing and settlement planning scenarios. (A body of related work is available for urban air shed pollution).

4. Some population and environment models in Australia provide projections or assessments for environmental issues that have a tenuous or no direct relationship to population growth. Some models incorrectly apply population size as the cause of (or only policy tool to address) environmental issues.

5. It is not appropriate (and indeed simplistic) to use population as the only policy option to address environmental concerns whilst maintaining environmentally damaging technological, lifestyle and economic arrangements into the future.

6. There are a wide number and range of technological, behavioural, pricing and settlement planning strategies (52 identified) that could be applied to address the four major population-related environmental issues. Strategies could potentially deliver superior environmental outcomes even in the context of a range of population scenarios in 2050.

7. Modelling work is required to determine precisely the extent to which strategies can off-set, or even reverse, stresses placed on the four environmental issues based on a range of population scenarios to 2050.

Recommendations

It is recommended that:

1. AATSE undertake more scientifically focussed research / modelling on the relationship between population scenarios to 2050 and the following four issues:

   - Pollution of land (and groundwater basins);
   - Pollution of coastal waters, rivers and lakes near major urban areas;
   - Depletion of fresh water stocks near major urban areas; and
   - Pollution of urban air sheds.

2. AATSE include various technological, behavioural, pricing and settlement planning scenarios (see Section 3 of this paper) in the research / modelling work.

1 INTRODUCTION

1.1 Background

Accelerating Australia's population growth through immigration policy has benefits and costs. On the one hand, it is argued that a larger population fuelled by immigration would bring substantial economic benefits through improved local productivity, expanded skill sets and greater capacity to support local business formation. On the other hand, it is suggested that an enlarged population would place an already fragile natural environment under increasing strain. Global scale issues such as global warming to local scale ecological sustainability and pollution issues have been put forward as arguments against an enlarged population in Australia.

This paper focuses on the 'environmental constraints' to population growth in Australia. The paper documents the issues and assesses Australia's capacity to manage these via technological, behavioural, pricing and settlement planning measures.

1.2 Objectives

This scoping paper has two objectives as follows:

1. To identify the environmental constraints on population growth in Australia[1]; and
2. To identify and assess technological, behavioural, pricing and settlement planning interventions which can be used to manage population-related environmental issues.

[1] The population scenarios used for reference purposes in this paper are shown in Appendix 1.

1.3 Structure and Method

This paper has three main sections as follows.

- The environmental constraints connected to population growth are presented in Section 2. This Section includes:
  - An identification of environmental issues which have strong, tenuous and no direct connection to differing population scenarios; and
  - An attempt to determine likely future environmental outcomes to 2050 under present and 'enlarged' population scenarios (see Appendix 1).

- Section 3 identifies the various technological, behavioural, pricing and planning strategies that can be applied to manage the environmental pressures attaching to population growth. An assessment of the implementability of the various management strategies in Australia is provided in this Section.

- Section 4 documents the conclusions and recommendations of the paper. The paper establishes a clear agenda for further, more scientifically focussed research.

This paper is largely based on secondary data sources and case studies and thus expresses qualitative and indicative findings rather than definitive scientific answers on the question of population growth sustainability.

2 ENVIRONMENTAL CONSTRAINTS ON POPULATION GROWTH

This section documents the environmental constraints connected to population growth and attempts to project the status of those constraints to 2050 assuming an enlarged population in Australia.

The Section begins with a listing of major environmental issues in Australia. The methodology for establishing whether an issue is connected to an enlarged population is then explained.

2.1 Environmental Issues in Australia

The major environmental issues in Australia are as follows[2]:

- Alteration of river and lake systems;
- Degradation of soils (eg. salinity, acidification, erosion);
- Depletion / degradation of heritage and cultural sites;
- Depletion / fragmentation of natural habitats / ecosystems;
- Depletion of animal / insect species / biodiversity;
- Depletion of arable land stock;
- Depletion of fish / marine stocks and species / biodiversity;
- Depletion of fresh water stocks;
- Depletion of marine habitats;
- Depletion of mineral, energy and timber resources;
- Depletion of the ozone layer in the upper atmosphere;
- Greenhouse effect;
- Harm to human and environmental health from manufactured by-products;
- Loss of amenity (eg. noise, congestion);
- Pollution of coastal waters, rivers and lakes;
- Pollution of fresh water stocks;
- Pollution of land (and groundwater basins); and
- Pollution of urban air sheds.

[2] This list is based on a review of a wide variety of literature sources and consultation with environmental groups in Australia.

2.2 Method for Establishing Whether an Issue is Connected to Population Growth

This paper seeks to identify those environmental issues that would be clearly *worse off* if Australia's population was to grow beyond its present population level to 2050. The paper seeks to pin-point only those issues that would be worse off as a *direct consequence* of additional population beyond 19 million, all things being equal.

Environmental issues are classified under three headings in this assessment:

- Strong connection to population growth;
- Tenuous connection to population growth; and
- No direct connection to population growth.

Strong Connection to Population Growth

If there is likely to be a *clear and significant* worsening in an environmental issue between a 19 million population scenario in 2050 and an enlarged population scenario in 2050, all things being equal, then the issue is deemed to have a strong connection to population growth.

For example, each person in Australia generates a certain amount of waste for landfill each year. The more people there are in Australia then, proportionally, the more waste will be generated for landfills. This issue has a direct and strong link to future population size.

Tenuous Connection to Population Growth

If there is not likely to be a *clear and significant* worsening in an environmental issue between a present and enlarged population to 2050, all things being equal, but a degree of worsening could be expected, then the issue is deemed to have a tenuous

connection to future population size. This categorisation also applies if significant assumptions about the *behaviour* of the enlarged population are made.

For example, depletion of natural environments is primarily an outcome of land clearing and to a lesser extent urban sprawl at the present time. It is not clear that such depletion in the future would be significant as a direct result of population growth in the context of land management practices generally. But it can be assumed that an enlarged population would have some impact. This issue's link to an enlarged population is therefore deemed as tenuous in this assessment.

Another example worth stating at the outset is greenhouse emissions because there are a number of complex issues surrounding this subject[3]. The question for this paper is: Will an enlarged population in Australia directly contribute to a *clear and significant* worsening in greenhouse emissions globally? The answer is 'no' because any increase in greenhouse gases from an enlarged population in Australia could be small on a global scale, might be off-set by greenhouse reductions in other nations (assuming immigration) and, importantly, would probably be caused by economic and transport patterns (as opposed to population per se). The link to population growth is deemed 'tenuous' in this assessment.

No Direct Connection to Population Growth

If there is no reasonable possibility that an enlarged population can directly cause a significant worsening in an environmental issue, all things being equal, then the issue is deemed to have no direct connection to future population size.

An example is degradation of soils (eg. salinity, acidification, erosion). A population over and above 19 million (assuming

[3] Issues include: Greenhouse is a global issue; Australia is a major greenhouse polluter on a per capita basis; Australia contributes less than 2% of global greenhouse emissions; Australia is projected to exceed its greenhouse targets to 2050 (according to CSIRO modelling); and Australia needs to show leadership and contribute to lowering greenhouse emissions.

additional growth) cannot be reasonably expected to degrade soils without making significant assumptions about the behaviour of that additional population, for example: additional population equals more demand on certain fragile / poorly managed farming land in Australia which in turn equals further degradation. There are a number of assumptions in this example. There is no direct link between land degradation in parts of Australia and an additional population quantum.

Assumptions Guiding the Assessment

The following assumptions guide the assessment of issues:

- The starting point of the assessment is 'today' (ie. the year 2000). Current environmental conditions in Australia form the baseline of the assessment;
- Most population growth in Australia to 2050 would occur in and near the major urban areas;
- Some environmental issues have different dynamics depending on their location and are therefore classified in more detail in the assessment (as being 'near major urban areas' or 'in rural and remote areas'); and
- Strategies to address environmental issues are not considered in the assessment. Environmental management strategies are introduced and explained in Section 3 of this paper.

2.3 Assessment of Environmental Issues Against Population Growth

The following chart presents the results of the assessment. Further supporting information is provided in Appendix 2.

The assessment shows that there are four environmental issues that have a strong connection to population growth. These are as follows:

- Pollution of land (and groundwater basins);

- Pollution of coastal waters, rivers and lakes near major urban areas;
- Depletion of fresh water stocks near major urban areas; and
- Pollution of urban air sheds.

It must be noted that it is difficult to disentangle the effects of population growth from associated factors such as urban settlement patterns, transport use preferences and public sector policies, among others.

The upshot from this research is that the adverse population-related environmental issues in Australia relate to:

- The structure and functioning of our cities (eg. urban sprawl and dominance of car transport);
- Australia being a high resource using and waste generating society; and
- Australia's dry climate resulting in low stocks of fresh water near the major population centres.

Qualitative Assessment of Environmental Issues Against Population Size

Environmental Issues	***Connection to Population Growth?***	
Pollution of land (and groundwater basins).	Strong	More people equals more waste generation, solid waste disposal and landfill leakage into groundwater basins.
Pollution of coastal waters, rivers and lakes near major urban areas.	Strong	More people equals more urban development, construction of hard surfaces and associated increase in stormwater runoff - with litter and liquid pollutants - and sewage discharge into urban waterways.
Depletion of fresh water stocks near major urban areas.	Strong	More people equals more water use for domestic activities such as drinking, washing and gardening.
Pollution of urban air sheds.	Strong	More people equals more fossil fuel emissions primarily from car use and to a lesser extent energy generation.
Depletion of arable land stock.	Tenuous	More people might equal suburbanisation into arable land stocks. Most depletion relates to land clearing and poor land management practices.
Depletion / fragmentation of natural habitats / ecosystems.	Tenuous	More people might equal suburbanisation into natural environments and fragmentation of natural environments by transport networks. Most depletion relates to land clearing and primary industry practices.
Depletion of animal / insect species / biodiversity.	Tenuous	More people might equal suburbanisation into natural environments and fragmentation of natural environments by transport networks. Most depletion relates to land clearing and primary industry practices.
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Alteration of river and lake systems near major urban areas.	Tenuous	More people might equal suburbanisation into water systems and consequent alteration and damming of water systems.
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Depletion of the ozone layer in the upper atmosphere.	Tenuous	More people in Australia might equal a net increase in global ozone emissions from energy, transport and industry.
Loss of amenity.	Tenuous	More people might equal more urban noise (primarily relating to transport) and congestion at natural and cultural attractions.
Depletion of mineral, energy and timber resources.	Tenuous	More people might equal more demand for natural resources. Resource exploitation relates to primary industry practices and international demand.
Depletion of fresh water stocks in rural and remote areas.	No Direct	More people does not equal non-urban water use which primarily relates to irrigation.
Pollution of coastal waters, rivers and lakes in rural and remote areas.	No Direct	More people does not equal pollution discharge into rural and remote waterways which primarily relates to primary industry practices.
Degradation of soils (eg. salinity, acidification, erosion).	No Direct	More people does not equal soil damage which primarily relates to farming / land clearing practices.
Alteration of river and lake systems in rural and remote areas.	No Direct	More people does not equal alteration and damming of rural and remote water systems which primarily relates to primary industry practices.
Depletion of marine habitats.	No Direct	More people does not equal depletion of marine habitats which primarily relates to primary industry and shipping practices.
Depletion of fish / marine stocks and species / biodiversity.	No Direct	More people does not equal loss of marine species which primarily relates to primary industry practices.
Depletion / degradation of heritage and cultural sites.	No Direct	More people does not equal damage to heritage and cultural sites which primarily relates to resource management practices.
Harm to human and environmental health from manufactured by-products.	No Direct	More people does not equal generation and mismanagement of potentially harmful by-products from energy sector and industry (eg. pesticides, chemicals, wastes).

2.4 Likely Environmental Outcomes Under Different Population Scenarios

This part of the paper reviews a raft of models that postulate what the outcomes of population-related environmental issues might be in Australia under current and enlarged population scenarios to 2050.

Nine population and environment models / studies (hereafter referred to as models unless otherwise stated) are currently available in Australia[4].

The models and their main findings are summarised below. Appendix 3 provides details on each model (ie. description, author(s), aim & objectives, findings, assumptions and references).

- CSIRO - Australian Stocks and Flows Framework. This model is currently being developed to examine the likely impact of immigration policy options on Australia's population, environment and economy to the year 2050.

- University of Queensland - Population Influences on Australia's Ecology, Economy and Society. This model assesses the impacts of population scenarios on ecological and societal domains.

- Hamilton and Turton - Population and Greenhouse Model (derived from Australian Bureau of Agricultural and Resource Economics Model of Energy Consumption and

[4] Note that a number of other models address similar issues but do not specifically deal with the population and environment subject. This includes econometric models that have population, energy and greenhouse inputs / outcomes and water / sewerage system models (eg. models by Australian Bureau of Agricultural and Resource Economics, National Institute of Economic and Industry Research, Monash University's ORANI model and water authority models).

Production). The model projects greenhouse gas emissions from an enlarged population in Australia to 2020.

- CSIRO - Land Use, Transport Emissions, Energy and Environment (LUTE3) Model. The model assesses the impact of differing urban settlement patterns on urban air pollution.

- Simpson, Petroeschevsky and Lowe – An Ecological Footprint Analysis for Australia. The model attempts to measure the 'ecological footprint' of Australians.

- CSIRO and Canberra University – Canberra's Ecological Footprint. The study applies the ecological footprint methodology to Canberra.

- Population Issues Committee – Modelling of Population Size and Greenhouse Gas Emissions. The model attempts to illustrate the relationship between population size and greenhouse emission outcomes.

- Australian Academy of Technological Sciences and Engineering – Urban Air Pollution in Australia. This inquiry looks into the causes of and solutions to urban air pollution.

- Department of Environment, Sport and Territories 1996; Newman and Kenworthy 1999 - Extended Metabolism Model of Human Settlement. This work reviews resource use and liveability indicators of cities.

The nine relevant models are compared to environmental issues in the following chart. Comments regarding projections to 2050 are made in the chart.

Australian Environment and Population Models

Environmental Issues With a Strong Connection to Population Growth	***Model Identified***	***Outcome to 2050***
Pollution of land (and groundwater basins).	None Identified	-
Pollution of coastal waters, rivers and lakes near major urban areas.	None Identified	-
Depletion of fresh water stocks near major urban areas.	None Identified	-
Pollution of urban air sheds.	CSIRO - Land Use, Transport, Emissions, Energy and Environment Model	Projects outcomes to 2011. Suggests that urban air shed pollution would be much improved under a compact city settlement pattern as opposed to a dispersed city settlement pattern (using Melbourne as a case study).
"	AATSE - Urban Air Pollution in Australia	Does not postulate a 2050 scenario. Suggests that urban air pollution in cities will worsen in the future based on present trends but this can be managed through a mix of technological, economic and other strategies.

Environmental Issues With a Tenuous or No Direct Connection to Population Growth	***Model Identified***	***Outcome to 2050***
Greenhouse effect.	CSIRO - Australian Stocks and Flows Framework	Projects outcomes to 2050. Results unavailable at time of writing.
"	Hamilton and Turton - Population and Greenhouse Model (derived from ABARE Model of Energy Consumption and Production)	Projects outcomes to 2020. Suggests that an enlarged population will result in increased greenhouse emissions from Australia.
"	Population Issues Committee - Modelling of Population Size and Greenhouse Gas Emissions	Does not postulate a 2050 scenario. Suggests that an enlarged population will increase greenhouse emissions from Australia.
General Environment / Ecology Issues.	CSIRO - Australian Stocks and Flows Framework	Projects outcomes to 2050. Results unavailable at time of writing.
"	Bryan West (University of Queensland) - Population Influences on Australia's Ecology, Economy and Society	Does not postulate a 2050 scenario. Suggests that an enlarged population will increase pressure on Australia's ecological system.
"	Simpson, Petroeschevsky and Lowe - An Ecological Footprint Analysis for Australia	Does not postulate a 2050 scenario. Suggests that Australians per capita consume a large share of resources which leads to environmental degradation. Also states that Australia has capacity to accommodate more people under existing conditions and that lifestyle changes and use of technology can lower Australia's ecological footprint.
"	CSIRO and Canberra University - Canberra's Ecological Footprint	Does not postulate a 2050 scenario. Suggests that the ecological footprint of people living in Canberra is high by international standards.
Urban Resource Flows and Liveability.	Department of Environment Sport and Territories 1996; Newman and Kenworthy 1999	Does not postulate a 2050 scenario. Suggests that: urban resource usage is trending up; the larger the city the smaller the per capita use of resources is; and urban liveability is greatest and resource use is lowest near a city's core and the further you move from the core liveability decreases and resource use increases.

It is concluded that:

- There are significant modelling gaps for genuine population-related environmental issues. No models have been identified for three of the four population-related environmental issues (ie. waste, urban waterways and urban fresh water stocks). Only urban air shed pollution has been addressed (by two models).

- The urban air shed modelling work undertaken does not provide projections to 2050.

- The other seven models identified provide projections or assessments for environmental issues that have a tenuous or no direct relationship to population growth. Some of these models incorrectly apply population size as the cause of (or only policy tool to address) environmental issues like greenhouse emissions and general environmental / ecological degradation.

- The Australian Stocks and Flows Framework is a significant body of work that will, when complete, provide information to 2050. Parts of this work may be useful for preparing projections for the four population-related environmental issues.

3 ENVIRONMENTAL MANAGEMENT STRATEGIES

This Section identifies the various technological, behavioural, pricing and settlement planning strategies that can be applied to manage the major environmental pressures attaching to population growth.

The implementability of the various management strategies in an Australian context is discussed. Where possible, data to show the extent to which strategies can mitigate any adverse environmental outcomes is provided.

3.1 Broad Strategy Types

Technological innovations can contain or potentially reverse environmental impacts through improved efficiency, containment or 'ways of doing things'. For example, improvements in the technology for re-using 'grey water' can substantially reduce effective demands for new water harvesting and treatment. Technological innovations, in turn, can be divided into two sub-categories: those that involve 'proven' methods or reasonable near term extrapolations of these; and those that rely on techniques which are still at an early stage in development but which have considerable potential for effective application within a 50 year time frame.

Behavioural shifts caused by education programs and regulatory measures can be applied to minimise the impact people have on the environment. Examples include advertising campaigns urging the careful use of water and the application of rules allowing garden watering on alternate days only.

Pricing policies can be applied to change behaviours by rendering the true cost of supplying a service or impacting on the environment more transparent to consumers. An example of

this is the application of volumetric pricing for water use in preference to charges linked to property value.

Planning and settlement pattern policies, which seek to lessen environmental impacts through alternative land use and transport arrangements, can be applied to deliver superior environmental outcomes. For example, per capita water consumption could be reduced by encouraging a greater proportion of the population to live in medium and high density housing.

Although these and other strategies could be applied to those environmental issues that have a tenuous or no direct connection to population, the following analysis focuses only on those issues with a strong population connection.

3.2 Environmental Management Strategy Options

The following charts summarise the technological, behavioural, pricing and settlement planning strategies that can be applied to the four population-related environmental issues identified in this paper. They include a discussion on implementability in an Australian context (where appropriate) and presentation of data to demonstrate the efficacy of strategies (where possible).

The charts show that there are a wide range of interventions available to policy makers to address any marginal worsening to aspects of the environment arising directly from population growth.

Based on the review of interventions (see following charts), it is concluded that:

- Various strategies should be applied to address a wide range of environmental issues in Australia. For the four major population-related environmental issues, a range of technological, behavioural, pricing and settlement planning

strategies could deliver superior environmental outcomes even in the context of a higher population scenario in 2050.

- Modelling work is required to determine precisely the extent to which strategies can off-set, or even reverse, stresses placed on the four environmental issues based on a range of population scenarios to 2050.

- It is not appropriate (and indeed simplistic) to say that the only policy option for government in addressing environmental concerns is to cap or lower population whilst maintaining environmentally damaging technological, lifestyle and economic arrangements into the future.

Appendix 4 provides details on specific strategy case studies in both Australian and international contexts. The case studies demonstrate that Australia has already turned towards management and intervention of population-related environmental issues to some extent. Overseas examples provide insight as to how Australia might broaden its intervention attempts. The case studies prove that management of the direct relationship issues is possible, and already taking place.

Introduction to Management Strategies to Address Pollution of Land (and Groundwater Basins).

Technological	***Behavioural***	***Pricing***	***Settlement Planning***
Recycling technology to reduce waste to landfills.	Education and promotion of reducing waste generation.	Charges based on amount of waste disposed of. Example: In NSW a levy applied to landfill waste contributed to a waste-to-landfill decrease of 1.5% in the year 1998/99 - 1999/2000 in the context of population growth.	Construction of high density housing settlements to reduce waste generation (eg. garden and yard wastes). This may be difficult to implement on cultural / political grounds.
Landfill construction technology to contain leakage from landfills and for capping. Example: Geosynthetic liners provide effective long-term containment of landfill waste.	Education and promotion of recycling and reuse practices.	Charges based on type of waste disposed of.	Development of regional waste management plans to utilise the most appropriate areas as landfills.
	Use of smaller municipal waste collection bins to promote less waste generation.	Establishment of commercial markets for recycled and reused goods. Example: Victoria's Eco-Recycle Market Development Grants (and waste minimisation education and promotion programs) delivered a waste-to-landfill reduction of 2% in the five years to 1996/97 in the context of population growth.	
	Restrictions on permissible waste dumping at landfills.	Cost incentives (eg. grants, tax concessions) applied to recycled goods.	

Introduction to Management Strategies to Address Pollution of Coastal Waters, Rivers and Lakes Near Major Urban Areas

Technological	***Behavioural***	***Pricing***	***Settlement Planning***
Drainage pollution-trap technology to reduce litter and pollutants entering waterways.	Anti-litter education and promotion.	Charges based on amount of waste-water / effluent generated for treatment / discharge.	Construction of settlements away from coasts, rivers and lakes. This may be difficult to implement due to cultural / preference patterns.
Sewage treatment technology to purify waste-water and reduce discharge of pollutants / effluent into waterways. Example: In NSW, the Eraring Power Station treats and uses waste-water in its operations (3.7 million litres per day releasing potable water for 10,000 people).	Promotion and organisation of 'clean up' and tree planting days for public spaces and waterways.	Housing prices to reflect development contribution charges imposed at construction stage based on connection to water and sewerage systems and amount of stormwater runoff generated.	Construction of high density housing settlements to reduce hard surface areas and consequent stormwater runoff. This may be difficult to implement on cultural / political grounds.
Construction of environmentally sustainable dwellings that capture and recycle water.	Fines imposed on littering.		

Introduction to Management Strategies to Address Depletion of Fresh Water Stocks Near Major Urban Areas

Technological	***Behavioural***	***Pricing***	***Settlement Planning***
Water treatment technology to purify 'grey' or 'black' water for drinking and other uses (eg. industrial, garden watering). Example: In NSW, the Eraring Power Station treats and uses waste water in its operations (3.7 million litres per day releasing potable water for 10,000 people). The Station's fresh water use has been cut from 8.5 million litres per day to 2.0 million litres per day.	Education and promotion to minimise use of water and monitor water quality.	Charges based on amount of water used (ie. volumetric pricing). Example: In NSW, the Hunter Water Corporation introduced user pays pricing in the early 1980s and as a consequence water usage dropped from 295 kilolitres per annum to about 205 kilolitres per annum by 1985. This initiative deferred the need to construct two new dams for the region.	Construction of high density housing settlements to reduce water use (eg. for gardens, pools, multiple car washing). This may be difficult to implement on cultural / political grounds.
Engineering technology to minimise loss of water from infrastructure networks.	Restrictions on water usage (eg. alternate day systems for gardening).	Housing prices to reflect development contribution charges imposed at construction stage based on connection to water and sewerage systems.	Construction of settlements in areas of high rainfall and water capture. This may be difficult to implement due to cultural / preference patterns.
Construction of environmentally sustainable dwellings that capture and recycle water.			

Introduction to Management Strategies to Address Urban Air Pollution

Technological	***Behavioural***	***Pricing***	***Settlement Planning***
Emission control technology to reduce vehicle emissions.	Education and promotion of public transport, walk or cycle modes of travel.	Application of vehicle user charges - petrol taxes, vehicle registration, etc.	Construction of high density housing settlements to reduce vehicle use and emission generation by promotion / making viable other travel modes (eg. public transport, walking, cycling). This may be difficult to implement on cultural / political grounds.
Non-fossil fuel based vehicle fuel / engine technology to reduce or eliminate vehicle emissions. This may be difficult to implement in the near future on affordability / cost grounds.	Education and promotion on air pollution and the need to drive economically.	Charges based on number of kilometres travelled using electronic road pricing technology on all major roads. This may be difficult to implement on cultural / political grounds.	Car pooling lanes designated on major roads.
Engineering of alternative transport vehicles (eg. light and heavy rail, bicycles).	Restrictions on permissible vehicle use times (eg. alternate days based on number plates). This may be difficult to implement on cultural / political grounds.	Application of differential tax systems for fuel types (eg. leaded petrol versus unleaded petrol).	Provision of more extensive public transport networks (eg. heavy and light rail).
Information technology to enable telecommuting (ie. home-based employment and shopping).	Education and promotion of car pooling.	Charges / pricing signals to reflect actual / true environmental cost of use of fossil fuel resources for, and emissions from, vehicle transport. This may be difficult to implement on cultural / political grounds.	Provision of more extensive pedestrian and cycle paths in cities.
Electronic road tolling / pricing technology for roads.	Application of more stringent emission control standards.		Construction of mixed land use zones to promote proximity of dwellings to employment, service and recreation opportunities.
Emission capture and treatment technology for road tunnels.	Fines imposed for not meeting emission standards.		

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Findings

It is concluded that:

1. There are four environmental issues that have a strong connection to population growth. These are as follows:

   - Pollution of land (and groundwater basins);
   - Pollution of coastal waters, rivers and lakes near major urban areas;
   - Depletion of fresh water stocks near major urban areas; and
   - Pollution of urban air sheds.

2. The adverse impacts of population growth on the environment in Australia relate to:

   - The structure and functioning of our cities (eg. urban sprawl and dominance of car transport);
   - Australia being a high resource using and waste generating society; and
   - Australia's dry climate resulting in low stocks of fresh water near the major population centres.

3. There are significant gaps in modelling future outcomes for the four population-related environmental issues in Australia. No predictive models to the year 2050 have been identified for the four issues in Australia adopting different population scenarios and different technological, behavioural, pricing and settlement planning scenarios. (A body of related work is available for urban air shed pollution).

4. Some population and environment models in Australia provide projections or assessments for environmental issues

that have a tenuous or no direct relationship to population growth. Some models incorrectly apply population size as the cause of (or only policy tool to address) environmental issues.

5. It is not appropriate (and indeed simplistic) to use population as the only policy option to address environmental concerns whilst maintaining environmentally damaging technological, lifestyle and economic arrangements into the future.

6. There are a wide number and range of technological, behavioural, pricing and settlement planning strategies (52 identified) that could be applied to address the four major population-related environmental issues. Strategies could potentially deliver superior environmental outcomes even in the context of a range of population scenarios in 2050.

7. Modelling work is required to determine precisely the extent to which strategies can off-set, or even reverse, stresses placed on the four environmental issues based on a range of population scenarios to 2050.

4.2 Recommendations

It is recommended that:

1. AATSE undertake more scientifically focussed research / modelling on the relationship between population scenarios to 2050 and the following four issues:

   - Pollution of land (and groundwater basins);
   - Pollution of coastal waters, rivers and lakes near major urban areas;
   - Depletion of fresh water stocks near major urban areas; and
   - Pollution of urban air sheds.

2. AATSE include various technological, behavioural, pricing and settlement planning scenarios (as identified in Section 3 of this paper) in the research / modelling work.

APPENDIX 1 – POPULATION SCENARIOS

The population scenarios used for reference purposes in this paper are as follows:

- Trend: 25 million by 2050;
- 1% per annum additional growth: 32 million by 2050; and
- Accelerated growth: 38 million by 2050.

APPENDIX 2 – THE LINK BETWEEN ENVIRONMENTAL ISSUES AND POPULATION: SUPPORTING INFORMATION

This appendix provides information on environmental issues and their connection to future population growth.

Note that there are a range of technological, behavioural, economic and settlement planning interventions that could be applied to address the following issues. These interventions are not discussed below. Only the broad issues are outlined, with supporting information where appropriate.

Alteration of river and lake systems – near major urban areas.

Points:

- River and lake system alteration could be related to population. A bigger population in Australia could result in suburban sprawl into water systems which may necessitate alteration to water flows.
- Urban areas need water dams.

Assessment:

- Tenuous link to population growth.

Alteration of river and lake systems – in rural and remote areas.

Points:

- Agriculture is the primary cause of damming and diversion of waterways.
- For example, all but one river in the Murray Darling Basin has been altered for agriculture. This practice impacts on the flow and mixing of water which can result in problems[5].

[5] Department of Industry Science and Technology (2000) Internet Site.

Assessment:
- No direct link to population growth.

Degradation of soils (eg. salinity, acidification, erosion).

Points:
- Soil degradation is an outcome of poor or inappropriate land management practices.
- Salinisation of land is caused by increasing the level of water within groundwater tables. Water escapes shallow rooted (introduced) vegetation species and percolates through the subsoil dissolving salt which occurs naturally in the soil. Gradually, this water causes the water table to rise to a point where it can move to the root zone, into fresh water supplies or onto surface soil.
- Acidification is a function of oxidation of sulphides, acidifying of fertilisers and sulphates, nitrogen and carbon cycle effects and weathering over time[6].
- Erosion of soils and loss of top-soils is caused by waterfall on sloping land. This is exacerbated by land clearing and replacement of native long rooted plants with introduced short rooted species[7].

Assessment:
- No direct link to population growth.

Depletion / degradation of heritage and cultural sites.

Points:
- Increased visitation at heritage and cultural attractions may be an outcome from an enlarged population (including tourism / recreation visitation).
- Increased visitation does not necessarily translate into degradation of important sites.

[6] Department of Environment, Sport and Territories (1996) State of Environment Report.
[7] Department of Environment, Sport and Territories (1996) State of Environment Report.

Assessment:

- No direct link to population growth.

Depletion / fragmentation of natural habitats / ecosystems.

Points:

- Land clearing is arguably the major cause of environmental damage in Australia at the present time.
- Much of the damage to Australia's natural environments – especially in the form of land clearing - was done when the population of the nation was much smaller (ie. less than 5 million)[8].
- Suburban development and 'exurban' development (eg. hobby farms and lifestyle living within the commuting field of large cities) can place pressure on natural environments in terms of land use and introduction of plant and animal pests.
- The development of road and rail transport networks can fragment sensitive environments.
- A study conducted by the Bureau of Rural Sciences (BRS) using satellite remote sensing technology found that between 1990 and 1995, 309,080 hectares of woody vegetation was cleared annually in Australia for agriculture and development activities. The table below summarises the findings of the study by State / Territory and principal cause of change.

Decrease (ha) in Woody Vegetation, by Cause of Change, 1990-1999[9].

State	*Agriculture**	*Grazing*	*Other ***	*Forest Management*	*Plantation Management*	*On-Farm Tree Planting*	*Fire*
Australian Capital Territory	0	0	0	210	4,380	0	0
New South Wales ##	51,860	NR	8,070	16,130	7,580	NR	123,040
Northern Territory	5,870	1,070	9,550	NR	20	NR	NR
Queensland ##	40,510	924,410	27,380	3,970	12,300	NR	140
South Australia	6,130	NR	360	10	8,040	700	66,340
Tasmania	230	3,790	440	27,270	8,270	1,060	1,310
Victoria	9,240	NR	3,480	30,280	21,640	NR	25,120
Western Australia	106,220	NR	19,400	10,920	3,960	0	193,500
Total	220,060	929,270	68,680	88,790	66,190	1,760	409,450

* Includes Orchard Management
** Includes Development
# Data principally for 1991-1995

[8] House of Representatives Standing Committee on Long Term Strategies (1994) Australia's Population Carrying Capacity.

[9] Barson, M., Randall, L. and Bordas, V. (1999).

Assessment:
- Tenuous link to population growth.

Depletion of animal / insect species / biodiversity.

Points:
- The main cause of depletion of animal and insect species is clearance of natural vegetation which disrupts animal / insect ecosystems or habitats.
- See points for depletion / fragmentation of natural habitats / ecosystems.

Assessment:
- Tenuous link to population growth.

Depletion of arable land stock.

Points:
- Poor land management practices – resulting in salinity and erosion from deforestation and farming practices - are likely to be the main agents of loss of arable land.
- The loss of arable land stock could be related to population growth to some degree through suburban sprawl into arable land stocks.
- The extent to which Australia's arable land stock (which is equivalent to the geographic area of Japan and France combined[10]) could be diminished by suburban development is likely to be minor.

Assessment:
- Tenuous link to population growth.

Depletion of fish / marine stocks and species / biodiversity.

Points:
- The main cause of depletion of fish / marine stocks in Australian waters is over-fishing within the commercial

[10] Australian Academy of Science (2000) Internet Site.

sector (for domestic and export markets) and over-exploitation near large cities by anglers.

- In both cases, resource management is the main issue.

Assessment:
- No direct link to population growth.

Depletion of fresh water stocks – near major urban areas.

Points:
- A bigger population will mean that more fresh water will be used for urban uses such as drinking and domestic activities.
- Australian cities are generally located in areas of low rainfall. Water supply is an issue for the large cities.

Assessment:
- Strong link to population growth.

Depletion of fresh water stocks – in rural and remote areas.

Points:
- Irrigation districts are major consumers of water in Australia.
- The agricultural sector consumes nearly 70% of Australia's water supplies. In 1996-97, 8,795 gigaltires of water was used for agricultural production, nearly 8.5 times the amount consumed for household uses[11].

Assessment:
- No direct link to population growth.

Depletion of marine habitats.

Points:
- Damage to marine habitats can occur from the following activities: trawling, dredging, introduction of marine pests, nutrient enrichment from ship and land runoff and gas and oil extraction practices.
- Resource management is the main issue impacting on marine habitats.

Assessment:
- No direct link to population growth.

[11] Australian Bureau of Statistics (1998) Water Account for Australia.

Depletion of mineral, energy and timber resources.

Points:

- The market for non-renewable resources is global. For example, export sales account of 55% of turnover in the mining and mineral extraction industries[12]. Export sales account for a smaller but significant proportion of timber resources (about 14%).
- Australia has traditionally relied on commodities for an export income but the balance is shifting in favour of manufactures and services.
- Between 1980 and 1997, annual average change in value of Australian exports by sector was headed by insurance and financial services (+19.5% pa in value of export), followed by travel services (13.0%), communications, computer, information and other services (9.7%), fuels (9.7%), manufactures (7.6%), transport services (5.9%), ores and metals (5.5%), agricultural raw materials (3.9%) and food (3.7%)[13].

Assessment:

- Tenuous link to population growth.

Depletion of the ozone layer in the upper atmosphere.

Points:

- The breakdown of the ozone in the stratosphere is a function of global emissions of ozone-depleting substances.
- Production of ozone depleting emissions within Australia is as follows: energy sector 54%, land use change and forestry 24%, agriculture 15%, waste 5% and industrial processes 2% (1990 data)[14].
- Most of today's ozone depleting emissions are from developing countries. Australia's contribution to total ozone depletion is likely to be small.

[12] Australian Bureau of Statistics (1999) Australian Mining Industry 1996-97.
[13] World Bank (1999) World Development Indicators.
[14] Department of Environment, Sport and Territories (1996) State of Environment Report.

- Australia is required to show leadership in reducing emissions.

Assessment:
- Tenuous link to population growth.

Greenhouse effect.

Points:
- Greenhouse effect is a global issue.
- The components of greenhouse emissions in Australia are: stationary energy 57%, agriculture 20%, transport 16%, forestry 5% and industry 2% (1998 data)[15].
- Australians are high per capita emitters of greenhouse gases. Greenhouse gas emissions in Australia are 24.3 tonnes per capita (1998 data) up from 22.8 tonnes in 1990[16].
- Australia contributes less than 2% of global greenhouse gases[17].
- Australia is required to show leadership in reducing emissions.
- Australia is projected to exceed its greenhouse targets to 2050 by a significant amount based on current trends with or without an immigration intake[18].

Assessment:
- Tenuous link to population growth.

Harm to human and environmental health from manufactured by-products.

Points:
- Health issues or risks can arise from waste disposal from the energy sector and industry.
- Health issues or risks can arise from use of chemicals in food and other production.
- Genetic engineering has given rise to concerns.

[15] Commonwealth Government Greenhouse Office (2000) Internet Site.
[16] Commonwealth Government Greenhouse Office (2000) Internet Site.
[17] Chisolm, T. (Undated) Population Growth, Resources and the Environment.
[18] CSIRO Unpublished Modelling (2000).

- Resource / waste management is the main issue here.

Assessment:

- No direct link to population growth.

Loss of amenity (eg. noise, congestion).

Points:
- Road, rail and air traffic noise and congestion is a function of city size.
- Urban growth may be associated with amenity loss for some people and amenity gains for others.
- Increased visitation at attractions may be an outcome from an enlarged population.
- Increased visitation may be associated with amenity loss for some people and amenity gains for others.

Assessment:
- Tenuous link to population growth.

Pollution of coastal waters, rivers and lakes – near major urban areas.

Points:
- Urban stormwater runoff is a function of hard surfaces in urban areas. A bigger population means construction of more hard drainage surfaces and stormwater pipes in our coastal cities.
- Urban stormwater runoff captures a wide variety of solid and liquid pollutants and is one of the major causes of river, lake and coastal pollution near Australia's cities[19].
- Sewage discharge – treated and untreated – affects coastal waters.

Assessment:
- Strong link to population growth.

Pollution of coastal waters, rivers and lakes – in rural and remote areas.

Points:
- Pollution of water systems in inland areas (away from Australia's large cities) relates mainly to farming and water and land management practices.

[19] Environment Australia (2000) Internet Site.

- Nutrient enrichment of water bodies is a key source of concern for Australia's inland waterways[20].

Assessment:
- No direct link to population growth.

Pollution of fresh water stocks – near major urban areas.

Points:
- Pollution of drinking water stocks could be related to suburban sprawl into water catchments.
- Contamination of surface water (from water or wind drift of pollutants) and groundwater (from contaminants leaking from urban uses) can be a problem in and around cities[21].
- Water quality data shows that metropolitan areas perform well against drinking water guidelines and generally outperform rural areas and remote settlements in this regard[22].

Assessment:
- Tenuous link to population growth.

Pollution of land (and groundwater basins).

Points:
- The disposal of waste in landfills not only 'pollutes' land but can contaminate ground water from 'leakage'.
- Each Australian produces about 690 kilograms of municipal solid waste each year (of which 58% is household waste). The OECD average is 530 kilograms per annum[23].
- Most of this waste finds its way into 16,900 hectares of landfill across Australia (1990 data)[24].

[20] Department of Environment, Sport and Territories (1996) State of Environment Report.
[21] Department of Industry Science and Technology (2000) Internet Site.
[22] Department of Environment, Sport and Territories (1996) State of Environment Report.
[23] Australian Bureau of Statistics (1999) Year Book Australia 1999 (based on figures published in OECD (1998)).
[24] Australian Bureau of Statistics (1992) Australia's Environmental Issues and Facts.

- Solid waste generation is a function of population size.

Assessment:
- Strong link to population growth.

Pollution of urban air sheds.

Points:
- Urban air shed pollution is primarily a function of vehicle / car use in cities.
- While cars are not the sole cause of 'brown haze' in cities, they are the main cause. For example, in Melbourne, cars contribute to 90% of carbon monoxide, 60% of nitrogen oxide, 44% of volatile organic compounds and 25% of airborne particulates[25].
- In Australia, passenger vehicle ownership per 1,000 persons rose from 364 in 1976 to 476 in 1995 and is expected to increase to 509 by 2015[26].

Assessment:
- Strong link to population growth.

[25] Environment Protection Authority (Victoria) (2000) Internet Site.
[26] Australian Academy of Technological Sciences and Engineering (1997) Urban Air Pollution in Australia.

APPENDIX 3 – POPULATION AND ENVIRONMENT MODELS

MODEL/STUDY DESCRIPTION	AUTHOR/S	AIM AND OBJECTIVES	FINDINGS	ASSUMPTIONS	REFERENCES
Australian Stocks and Flows Framework (ASFF) (Current). ▪ A simulation model of Australia's physical economy being developed as part of the CSIRO's Resource Futures Program. The model will be used by the Department of Immigration and Multicultural Affairs (DIMA) to explore immigration policy options and their likely impact on Australia's population, environment and economy to the year 2050. ▪ The ASFF consists of a database and simulation model whose modules or calculators represent only physical processes in the economy and are coupled together in such a way that feedback loops representing human choice are left open. Therefore, the model is more focussed on the exploration of possibilities rather than prediction. In exploring alternative futures the user closes the feedback loop by becoming part of it - providing human choice and innovation in the context of a complex physical world whose development is constrained to obey physical laws.	▪ CSIRO Department of Wildlife and Ecology. Collaborators include: • University of Canberra; • Australian National University; • Australian Bureau of Statistics: Environment and Natural Resource Statistics Group; • CSIRO Divisions of Atmospheric Research, Water Research and Soils; • Bureau of Population and Immigration Research; • Australian Bureau of Agricultural and Resource Economics; • National Resource Information Centre, Environmental Resources Information Network, Bureau of Resource Sciences; and • International global modelling groups.	• To produce a series of spatial analyses of future opportunities and / or impacts which might arise from the interactions between population, climate change, world trade and evolving technologies. • To design and test plausible pathways by which Australia might capture environmental opportunities and meet challenges in ways that are socially, economically and politically feasible. • By using analytical frameworks which represent Australia's population-development-environment interactions, to develop options for meeting environmental challenges. • To communicate the nature of human impact on Australia's environmental resource sectors in an integrated manner suitable for use by Australian society at large.	▪ Currently unavailable. The CSIRO is due to submit a final draft of its findings to DIMA in early 2001.	▪ The ASFF is based on a 'design approach' to socio-economic modelling. This allows the exploration of alternative futures by the user, who forms part of the system, thereby distinguishing the approach from that of macro-economics with its emphasis on prediction. ▪ The design approach is similar to *backcasting* (Dreborg, 1996) where the concern is not with what is *likely* to happen but with how desirable futures can be *attained*. ▪ The ASSF draws on a number of analytical frameworks including: • The 'stocks and flows' accounting approach developed by Robbert Associates in Ottawa, Canada; • An accounting approach developed by the University of Edinburgh which focuses on energy flows through the human economy; and • The IMAGE 2 global change framework from RIVM in the Netherlands. This model allows the ASFF framework to incorporate important 'external' factors such as global climate change and the world trading economy.	▪ http://www.dwe.csiro.au/research/futures/ ▪ http://www.dwe.csiro.au/research/futures/ecumene/DIMAModelDescript.htm ▪ Dreborg, K. (1996) 'Essence of Backcasting', in *Futures*, Vol. 28, No. 9. ▪ Gault, F., Hamilton, K., Hoffman, R. & McInnis, B. (1987) 'The Design Approach to Socio-Economic Modelling', in *Futures*, Feb.

MODEL/STUDY DESCRIPTION	AUTHOR/S	AIM AND OBJECTIVES	FINDINGS	ASSUMPTIONS	REFERENCES
Population Influences on Australia's Ecology, Economy and Society (POPEES). ▪ A model developed by an academic at the University of Queensland in response to the 1994 national population inquiry, *Australia's Population 'Carrying Capacity': One Nation, Two Ecologies* (APCC, 1994).	▪ Bryan West, University of Queensland.	• To provide a speculative model of the population impacts in the ecological, social and relational domains. • To improve the level of clarity in the 'population debate' and to provide a starting point for the development of productive frameworks for assessing the impacts of population growth in Australia. • To explore the interactions between key factors by running the model under 'stable' and 'growing' population scenarios.	• The results are largely speculative rather than quantitative. However, the model highlights the need for clear and structured thinking when considering the impacts of population growth. • A growing population is likely to result in increased domestic resource demands which require a greater intensity of landuse and therefore increased pressure of Australia's ecological systems. When this growing domestic demand is coupled with the need to increase exports in order to maintain a balance of trade, there is likely to be significant degradation of Australia's environment.	• The model is based on inductive logic, drawing general laws of relationship from particular examples and instances. • The model assumes that primary manner in which population growth will affect the environment is by increasing domestic demand for, and exploitation of natural resources. This relationship in turn affects factors such as landuse intensity, habitat loss and pollution outputs.	• West, B. (1994) 'A Speculative Model of Population Influences on Australia's Ecology, Economy and Society', in *Australian Geographical Studies*, Vol. 35, No. 2. • APCC (1994) *Australia's Population Carrying Capacity: One Nation, Two Ecologies*. AGPS, Canberra.

MODEL/STUDY DESCRIPTION	AUTHOR/S	AIM AND OBJECTIVES	FINDINGS	ASSUMPTIONS	REFERENCES
Population and Greenhouse Model derived from Australian Bureau of Agricultural and Resource Economics (ABARE) Model of Energy Consumption and Production. • This model formed the basis of a recent study of the impact of population growth on greenhouse gas emissions. The study was conducted for the Australia Institute and the Centre for Population and Urban Research at Monash University.	• Hamilton, C. and Turton H.	• The original ABARE model was designed to provide projections of energy consumption and production in Australia to the year 2014-15. • This basic model was modified for the Hamilton and Turton study in order to incorporate several different population scenarios and to extend the timeframe to 2019-20. This modified model was then used to predict the growth of greenhouse gas emissions under different population scenarios. • The principal objective of Hamilton and Turton's study was to illustrate the potential contribution of population policies, including immigration, towards meeting Australia's greenhouse emission reduction obligations under the Kyoto Protocol.	• Under current levels of immigration and fertility, Australia's greenhouse gas emissions in 2008-2012 will be 140% of 1990 levels. This is well above the target of 108% set under the Kyoto Protocol. • Australia's greenhouse emissions in 20 years time would be 16% higher under a policy of high net immigration (140,000 per annum) compared to a situation in which there was zero net migration. • The study concludes that population policy, particularly in relation to immigration, will play a major role in Australia's ability to reach its greenhouse gas emission targets.	• The ABARE model uses econometric estimation to determine energy use in the residential, commercial and transport sectors of the Australian economy. • Incorporates assumptions about the energy market, including the advent of major energy-producing or energy-consuming projects, growth of the National Electricity Market and reforms in other market sectors. • The model is heavily reliant on the results of a biannual survey of energy consumption by the 5,300 largest energy consumers in Australia (including those in the mining and manufacturing sectors). Thus, the implicit assumptions of the survey respondents about population and economic growth are embodied in the results. • Assumes that population size influences the level of activity and energy use in all sectors other than mining and agriculture as output from these sectors is primarily driven by export demand. • Assumes that factors such as GDP per capita, household income, energy prices and average fuel consumption are not influenced by the rate of population growth.	• http://www.tai.org.au/publications/DP26.shtm • Hamilton, C. and Turton, H. (1999) 'Population growth and greenhouse gas emissions: sources, trends and projections in Australia', in *People and Place*, Vol. 7, No. 4.

MODEL/STUDY DESCRIPTION	AUTHOR/S	AIM AND OBJECTIVES	FINDINGS	ASSUMPTIONS	REFERENCES
CSIRO Land Use, Transport, Emissions, Energy and Environment (LUTE [3]) Model. ▪ This model combines landuse, transport and airshed modelling in order to evaluate the air pollution impacts of different forms of urban development. ▪ The model was developed by the CSIRO's divisions of Atmospheric Research, and Building, Construction & Engineering for a study commissioned by AATSE. This project included a case study which involved the application of the model to different urban development scenarios in Melbourne until 2011.	▪ CSIRO's Divisions of Atmospheric Research and Building, Construction & Engineering. Data for the case study was supplied by the Victorian Environmental Protection Authority (EPA).	• To use Melbourne as a case study to investigate the effects of six alternative urban forms on air quality. The forms are Dispersed City, Compact City, Corridor City, Multi-Nodal City, Fringe-Development City and 'Business-As-Usual' City.	• The impacts of population growth on air pollution will vary considerably depending on the location and 'form' of this growth. • The model suggests that exposure to photochemical smog will decrease by 55% from the base year levels if a corridor form of urban development is adopted. Conversely, exposure will increase by 71% if the dispersed urban form continues (ie. business as usual scenario of urban development). • Particulate pollution will improve by 14% under a corridor city scenario but increase by 61% if business as usual is continued to 2011. • When supported by improved transport infrastructure, landuse strategies that attempt to deliberately channel and concentrate additional population and industry into specific 'zones' within a large city will deliver environmental and efficiency benefits that consistently outperform those associated with a business as usual approach to urban development.	• The case study assumes a standard level of population growth (500,000) in Melbourne to 2011, but varied the 'form' of this growth according to the six alternative urban development scenarios. The air pollution impacts of these different forms of urban growth were then modelled. However, the model is also capable of processing scenarios that involve different levels population growth (ie. overall growth figures other than an increase of 500,000).	• http://www.dar.csiro.au/publications/urban/default.htm

MODEL/STUDY DESCRIPTION	AUTHOR/S	AIM AND OBJECTIVES	FINDINGS	ASSUMPTIONS	REFERENCES
An Ecological Footprint Analysis for Australia. ▪ An application of the 'ecological footprint' methodology in order to estimate the average amount of productive land required to support the consumption patterns of the Australian population.	• Simpson, R. Petroeschevsky, A. and Lowe, I., researchers at Griffith University, Queensland.	• To provide a measure of the average area of land needed to produce the natural resources consumed by, and assimilate the wastes of, the existing Australian population. • To compare the size of Australia's ecolcogical footprint with those of other developed and developing nations. • To compare the existing ecological footprint of Australia with available arable land in order to estimate the country's 'carrying capacity'.	• The average Australian requires approximately six hectares of productive land to support them. This is four times the overall globally available 'fair share' of productive land (1.3 ha / capita) and places Australia amongst the top five countries in the world in terms of the size of their ecological footprint. • Australian's level of energy and livestock products consumption is particularly high, thereby driving the size of the ecological footprint upwards. • Australians need to reduce the size of their ecological footprint through lifestyle changes and / or more efficient technology in order to reduce their relatively high contribution to environmental degradation. • Although Australia has one of the largest average ecological footprints in the world, it still has 'available ecological capacity' (ie. there is more productive land available than is currently being consumed). Australia is one of the few nations in the world to have an ecological 'surplus'.	• The ecological footprint concept relies on conceptually simple and aggregated measures of ecological consumption. It is likely therefore that the actual amount of land consumed is higher than that which is calculated using the EF methodology. • Calculations are conservatively based on the assumption that current harvest practices are sustainable. • The study does not incorporate measures of marine resource use, water consumption or waste assimilation. This is also likely to result in an underestimation of the actual ecological footprint of Australia.	• Simpson, R. Petroeschevsky, A. and Lowe, I. (2000) 'An Ecological Footprint Analysis for Australia', in *Australian Journal of Environmental Management*, Vol. 7.

MODEL/STUDY DESCRIPTION	AUTHOR/S	AIM AND OBJECTIVES	FINDINGS	ASSUMPTIONS	REFERENCES
Canberra's Ecological Footprint. • A study conducted as part of Masters Research Degree at Canberra University with the CSIRO's Resources Future Program.	• CSIRO Division of Wildlife and Ecology in collaboration with students from Environmental Education Program at Canberra University.	• To apply the 'ecological footprint' methodology to an Australian urban area. • To illustrate the extent of Canberra's ecological footprint to the local community. • To encourage changes in the consumption patterns of the local community in order to reduce Canberra's ecological footprint.	• Australia has one of the largest average ecological footprints in the world, similar in size to countries such as the USA and Canada. • The average ecological footprint of each person living in Canberra is approximately 4.44 hectares or nearly 58 average Canberra houseblocks.	• An ecological foot print is a measure of how much land is required to supply the goods and services that we consume in our everyday lifestyle. • The exact amount of land to produce every item of consumption is very difficult to measure. Therefore, the ecological footprint relies on proxy measures that cover 5 key categories of daily consumption: food, housing, transport, consumer goods and services. The measures of each of these categories involve a series of assumptions about 'average' consumption rates.	• Close, A. and Foran, B. (1998) *Canberra's Ecological Footprint*, CSIRO Wildlife and Ecology, Canberra.
Modelling of Population Size and Greenhouse Gas Emissions conducted for the National Population Council. • This modelling was undertaken as part of a wider study of the impacts of population growth on Australian society, the economy and the environment. The time frame for the modelling was 1988-2005.	• Population Issues Committee.	• To illustrate the link between population size and environmental pressure by modelling the impact of population growth on greenhouse gas emissions. • To illustrate that population growth plays a role in the generation of greenhouse gas emissions.	• That different population growth scenarios are likely to result in substantially different levels of greenhouse gas emissions. • Population growth would significantly influence Australia's ability to meet its greenhouse gas emission targets.	• Assumes that technologies for controlling greenhouse gas emissions remain at 1988 levels.	• Population Issues Committee of the National Population Council (1991) *Population Issues and Australia's Future*, AGPS, Canberra.

MODEL/STUDY DESCRIPTION	AUTHOR/S	AIM AND OBJECTIVES	FINDINGS	ASSUMPTIONS	REFERENCES
Urban Air Pollution in Australia. • An inquiry conducted by the Australian Academy of Technological Sciences and Engineering into urban air pollution in Australia and measures to improve air quality in cities.	• Australian Academy of Technological Sciences and Engineering.	• To establish the need for action to maintain and improve air quality into the future. • To determine present and likely future levels of various air pollutants. • To identify management options to reduce or minimise air pollution in the near and long terms.	• Australian cities have generally maintained air quality over the decade to 1997. • Australia's vehicle fleet is the principal cause of urban air pollution. • Continued growth of cities will place increasing pressure on air quality especially relating to oxides of nitrogen, hydrocarbons and particulates. • Urban air pollution is expected to increase in the future with increasing vehicle kilometres travelled and increasing traffic congestion in cities. • Air quality can be maintained into the long term (15-20 years) or more with a range of initiatives. • A wide range of technical / technological, management and economic strategies are required to address air quality issues.	• The terms of reference for the inquiry require examination of six major urban air pollutants, these being: airborne lead, oxides of sulfur, oxides of nitrogen, carbon monoxide, particles and photochemical oxidants including ozone precursors.	• Australian Academy of Technological Sciences and Engineering (1997) *Urban Air Pollution in Australia*.

MODEL/STUDY DESCRIPTION	AUTHOR/S	AIM AND OBJECTIVES	FINDINGS	ASSUMPTIONS	REFERENCES
Extended Metabolism Model of Human Settlements. ▪ A model of the resource inputs and waste outputs of human settlements based on population size and consumption rates.	▪ Originally conceived by Wolman (1965) but applied to Australia by Department of Environment, Sport and Territories (1996) and Newman and Kenworthy (1999).	• To identify the physical and biological inputs of cities in order to illustrate the manner in which these are converted into useful products and wastes by dynamic biological and artificial processes that occur within human settlements. • To illustrate the influence of entropy on the level of outputs that can be achieved from a dynamic system such as a city. • To illustrate the need to reduce the level of inputs and throughput of human settlements as a means of reducing waste outputs and thus impact on the environment. • To incorporate liveability indexes in the calculations of resource throughput of cities.	• Sydney's per capita resource inputs and waste outputs increased considerably between 1970 and 1990. • The larger the city, the smaller the per capita use of resources. However, resource use is larger in absolute terms. • Despite increases in metabolic flows though most Australian cities, liveability has declined. • As you move further from a city's core, resource consumption increases, but liveability decreases. • Remote communities (especially indigenous) have low metabolic flows, but also low liveability indexes.	• The model does not consider all inputs and outputs of a city, rather it relies on a selected range of indicators. • The model has not been applied to future population scenarios, but is likely to merely extrapolate current consumption patterns if such an exercise were to be undertaken.	• Wolman, A. (1965) 'The Metabolism of the City', in *Scientific American*, No 213. • Department of Environment, Sport and Territories (1996) *State of the Environment Report*, CSIRO Publishing, Melbourne. • Newman, P. and Kenworthy, J. (1999) *Cities and Sustainability*, Island Press, Washington.

APPENDIX 4 – ADDRESSING POPULATION-RELATED ENVIRONMENTAL ISSUES: CASE STUDIES

Pollution of Land (and Groundwater Basins)

Technological Intervention - Geosynthetic Liners for Landfill Sites[27]

Problem:

- To provide effective, long-term containment of landfill waste and control of leachate generated within landfills.

Intervention:

- By utilising the latest in geosynthetic technology, a fully engineered lining system can be installed to encapsulate waste and to form a barrier to leachate movement.

- Lining technology has been used at:
  - Swanbank, QLD;
  - Summerhill Waste Facility, NSW;
  - Lucas Heights Landfill, NSW;
  - Rochedale Landfill, QLD;
  - Gurulmundi Secure Landfill, QLD;
  - Ford Tip Site, Homebush NSW; and
  - Secure Waste Repository, VIC.

- The technology has potential application in other industries such as water and waste-water treatment including sludge lagoons, treatment ponds, storage ponds, mining industry, tailings dams, process ponds and heap leach pads.

[27] Environet (2000) Internet Site.

Technological Intervention – Landfill Construction[28]

Problem:

- To decontaminate land and develop a safe landfill suitable for major development.

Intervention:

- The present day Olympic Park site at Homebush Bay, NSW, was utilised for various industrial purposes and dumping which led to severe contamination of the site. In 1989, the NSW government identified Homebush as a possible site for Olympic facilities. A key element of the siting procedure was the development of a remedial strategy that could be implemented to coincide with the 1993 Olympic bid.

- It was estimated the site contained 9 million cubic metres of landfill spread across 220 hectares of waste. Severe dioxin contamination was also identified, in some cases at levels that posed a serious threat to human health.

- Once the contamination factors were identified, a 'clean up' strategy commenced. The principle of the chosen clean up program was to contain the contaminated material on-site so that it could not pollute groundwater or watercourses. The core elements of the clean up were:
  - Consolidating scattered volumes of contaminated material into four main areas (landfills) thereby making significant areas of land with unrestricted land use available;
  - Constructing leachate drains to intercept any groundwater seeping from the site, with subsequent treatment of leachate at a liquid treatment plant before discharge to sewer;
  - Capping the landfills with geosynthetic liners and clean soil; and

[28] Environment Protection Authority, NSW (1999) Internet Site.

- Careful contouring and planting with native plants to reduce the amount of water entering the landfill and to create semi-natural habitats.

Behavioural Intervention – Recycling Programs[29]

Problem:

- To reuse discarded objects at landfills.

Intervention:

- At ACT landfill sites, labour and infrastructure are provided to retrieve reusable / recyclable items from the tip face or from direct drop-offs, and to resell them. Items are sometimes value-added through repair or creative uses.

- The technique forms part of the ACT's integrated approach to waste management and reduction at landfill sites within the Territory.

Behavioural Intervention - Recycling Programs at Community Level[30]

Problem:

- To prevent waste generation and reduce amount of waste to landfills.

Intervention:

- In Victoria, Waste Wise is a major State-wide initiative established by Eco-Recycle Victoria to encourage and assist all sectors of the community to cut waste generation. It focuses on the prevention ('reduce and reuse') side of waste and litter management. It uses methods and principles that are regarded internationally as best practice.

- Waste Wise offers substantial support to Regional Waste Management Groups, Councils and Council contractors in the planning and implementation of waste and litter

[29] Environet (2000) Internet Site.

[30] Eco-Recycle Victoria (2000) Internet Site.

education strategies for their communities. A comprehensive resource kit has been produced made up of five modules:

- Strategic Planning and Implementation;
- Waste Wise Businesses;
- Waste Wise Schools;
- Litter; and
- Promotional Materials.

Behavioural Intervention - Recycling Programs at Industry Level[31]

Problem:

- To encourage industry to use recycled materials and increase the market for recycled materials.

Intervention:

- In California, USA, the Recycling Market Development Zone (RMDZ) program is a partnership of local governments and the California Integrated Waste Management Board to provide incentives to businesses that use secondary materials from the waste stream as feedstock for their manufacturing processes.

- The RMDZs are geographic areas designated by the California Integrated Waste Management Board at the request of local governments. There are 40 zones in California. The RMDZ program combines recycling with economic development to fuel new businesses and create jobs.

- Recycling-based manufacturers located in RMDZs are eligible to apply for low-interest loans and other assistance provided by local zone administrators. In addition to loans, the Board offers financial assistance, product marketing and permit assistance. Local government incentives include relaxed building codes and zoning laws, streamlined local permit processes, reduced taxes and licensing, and increased

[31] USA EPA (2000) Internet Site.

and consistent secondary material feedstock supply. Local incentives vary from jurisdiction to jurisdiction.

Pricing Policy Intervention – Waste Disposal Levy[32]

Problem:

- To reduce generation of waste for landfills.

Intervention:

- The New South Wales State government has implemented a waste levy program attempting to decrease the amount of solid waste going to landfill, and increase recycling. State legislation introduced in 1996 imposes a Waste Disposal Levy on household and industrial waste.

- The levy is charged per tonne of waste. Current charge levels are $17/tonne for metropolitan Sydney and $10/tonne for regional NSW. Rebates are provided for recycling. If the recycled waste is segregated off site no levy is payable. If segregation takes place on site, the tonnage is calculated and a rebate provided by the EPA.

- The actual tonnage of waste is decreasing. For the financial year 1998/99 the total tonnage of waste attracting a levy was 10,652,038 tonnes. The figure for 1999/2000 was 10,488,808. This represents a decrease of 1.5%.

Pricing Policy Intervention – Creating a Market for Recycling[33]

Problem:

- To create a market for recycled goods and thus reduce resource usage and waste generation.

Intervention:

- The mission of Eco-Recycle is waste minimisation, promotion of sustainable development, and better management of residual disposal. Eco-Recycle achieves these goals through a process of waste minimisation

[32] Environment Protection Authority, NSW (2000).

[33] Eco-Recycle Victoria (2000) Internet Site.

education and information and development of a market for recycled goods.

- Eco-Recycle has a Market Development Unit to expand and diversify markets for recyclable materials. The Unit's objectives are to create viable secondary markets for recyclable materials and achieve and maintain viable prices and greater price stability for recycled materials. This involves devising strategies that provide focus for Eco-Recycle assistance programs for industry, including infrastructure, product and market development, business support and seminars. Grants of up to 30% are provided for product and market development projects designed to increase the use of recycled materials. Priority is given to projects that are likely to have a commercial outcome within 12 months.

- A total of $456,082 in grants was awarded for the financial year 1998/99.

- These programs have contributed to the total waste going to landfill from Melbourne and the major regional centres from 3.56 million tonnes in 1992/93 to 3.49 million tonnes for 1996/97. This represents a decrease of 2% over 5 years, or a reduction of 70,000 tonnes.

Pricing Policy Intervention – Pay as You Throw User Charges[34]

Problem:

- To reduce waste generation and improve recycling efforts at source.

Intervention:

- In the USA, in those communities with pay-as-you-throw programs (also known as unit pricing or variable-rate pricing), residents are charged for the collection of municipal solid waste based on the amount they throw away. This

[34] USA EPA (2000) Internet Site.

creates a direct economic incentive to recycle more and to generate less waste. Traditionally, residents pay for waste collection through property taxes or a fixed fee, regardless of how much — or how little — waste they generate. Pay-As-You-Throw (PAYT) breaks with tradition by treating waste services just like electricity, gas and other utilities. Households pay a variable rate depending on the amount of service they use.

- Most communities with PAYT charge residents a fee for each bag or can of waste they generate. In a small number of communities, residents are billed based on the weight of their waste. Communities with programs in place have reported significant increases in recycling and reductions in waste.

Settlement Planning Intervention – Regional Landfill Planning[35]

Problem:

- To strategically plan for landfill sites and services.

Intervention:

- The NSW Waste Minimisation and Management Act 1995 established eight regional waste boards throughout NSW. One of the purposes of these boards was to develop a regional plan that would deliver a 60% reduction in the amount of solid waste going to landfill by the year 2000. The planning of waste disposal infrastructure and services was a key element in each regional plan.

- For example, the Northern Sydney Waste Board identified the siting of a reuse and repair centre and regional processing facility and cluster parks as key elements in infrastructure planning that will lead to waste minimisation. The Board works with the planning departments of each of its constituent councils in the siting of facilities. The Board

[35] North Waste NSW (2000).

attracts investment and interest from the public and private sectors.

Pollution of Coastal Waters, Rivers and Lakes Near Major Urban Areas

Technological Intervention – Waste-water Reclamation[36]

Problem:

- To reclaim and reuse waste-water.

Intervention:

- Industry, such as power stations, is a potential user of recycled water. Grey / black water can be made suitable for boiler feed water (and other uses) but the quality must be better and more consistent than conventionally treated waste-water.

- The Eraring Power Plant in the Hunter Valley, NSW, was the first plant in the world to use various processes to produce high-pressure boiler feedwater. The plant was installed in early 1995. Operating cost savings compared to purchasing and treating town water are $620,000 per year on a capital cost of $4 million. The project will reuse 3,700,000 litres of sewage per day releasing potable water for 10,000 people.

Technological Intervention - Waste-water Treatment Prior to Discharge[37]

Problem:

- To treat waste-water to meet strict coastal discharge criteria.

Intervention:

- The Noosa Waste-water Treatment Plant is one of the best performing chemical free waste-water treatment plants in the

[36] Environet (2000) Internet Site.

[37] Australian Water Services (2000) Internet Site.

world. This plant delivers a leading technical solution, achieving high discharge standards using an environmentally sensitive Biological Nutrient Removal (BNR) process.

- Located in Noosa, a leading tourist destination on Queensland's Sunshine Coast, the plant treats waste-water from 35,000 residents. The location and close proximity to popular surf beaches and national parks means that the plant operations must perform consistently well. The $52 million dollar project is based on a 25-year Design, Build and Operate Contract between Noosa Council and Australian Water Services. The plant satisfies stringent environmental guidelines.

Behavioural Intervention – Engendering Stewardship for Coastal Environments[38]

Problem:

- To educate and involve the community in coastal environment management.

Intervention:

- Coastcare is a major component of the Commonwealth Government's marine and coastal conservation program: Coasts and Clean Seas. It is administered at all levels of government and provides support to the community, industry groups and government agencies. It is mainly an educational tool that is designed to engender in local communities and industry a sense of stewardship for coastal and marine areas. It also funds projects that allow residents, volunteers, business and interest groups to participate in coastal management. An example of this is a $4,900 grant awarded to Friends of the Great South Walk Inc. for continuing cape conservation at Portland.

[38] Environment Australia (2000).

Pricing Policy Intervention - Polluter Pays Charges[39]

Problem:

- To minimise discharge of waste-water to surface waterways.

Intervention:

- Belgium uses a strictly defined and applied charging system for direct and indirect waste-water discharges. The motivation for the charge is to cover the cost of treating discharge and to protect the environmental quality of inland and coastal / marine waters. The charge is tied to the cost of sewage treatment. It is applied to discharges from households and businesses.

- For households and small companies, the charge relates to assumed or metered water consumption. For large companies the charge is based either on sector-specific (conversion) coefficients or based on actual measurements where the charge is determined by the number of pollution units multiplied by the tariff, which is linked to a retail price index.

- Revenue in 1993 from the charges totalled 7 billion BFR. All revenue is earmarked for water quality management and treatment infrastructure.

Settlement Planning Intervention – Sustainable Urban Development[40]

Problem:

- To show leadership in use of sustainable urban development principles.

Intervention:

- Inkerman Oasis is a 236 unit development on the site of a former municipal depot in the City of Port Phillip, Victoria.

[39] European Commission.
[40] City of Port Phillip (2000).

It is a joint venture between the municipality and a developer. It incorporates a range of sustainable development principles (both passive and active) including best practice design. A major element of its ecologically sustainable principles is the waste-water recycling component. This is comprised of:

- Recycling of grey water from around 50% of units in the complex using an activated sludge tank and secondary filtration and absorption by a native wetland and sand filter area;
- Capture of first flush and general ground flow storm water and filtration and absorption in the wetland and sand filter; and
- The recycled water is used for both sub-ground garden irrigation and toilet flushing throughout the complex.

- The development delivers the following outcomes:
  - Reduction of potable water requirements by up to 45%;
  - Reduction of sewer loadings going to Port Phillip Bay through reuse of grey water; and
  - Alleviation of 14 tonnes of nitrogen and phosphates from entering Port Phillip Bay.

Depletion of Fresh Water Stocks Near Major Urban Areas

Technological Intervention - Reducing Industrial Use of Fresh Water[41]

Problem:

- To reduce power station consumption of fresh water supply.

Intervention:

- By switching to reclaimed sewage water, Eraring Power Station has reduced its fresh water needs by more than three-quarters. Power plants are one of the largest industrial users

[41] Environet (2000) Internet Site.

of fresh water in Australia, making this project a significant environmental breakthrough.

- Fresh water use has been reduced from 8.5 million litres per day to 2.0 million litres per day. This has been accomplished through plant modifications saving 4.5 million litres per day and through the operation of the water reclamation plant at the power station.

- Pumping effluent into the ocean has been avoided for the community, as has the need for significant new investment in upgrading an existing ocean outfall.

Behavioural Intervention - Community-Based Water Monitoring and Education Programs[42]

Problem:

- To educate communities about water quality and usage.

Intervention:

- Through the Water Watch Program in Victoria, the community, with support from State and local governments and the private sector, is now mobilising to identify and monitor water-related impacts and to take remedial actions. The monitoring projects are giving communities an understanding of the need for catchment-level planning and management as well as raising awareness of the natural environment. The key message conveyed by monitoring programs is that everything which happens in a catchment can have downstream effects, and that all communities - both rural and urban - within each catchment must work together to correct the problems.

- Water Watch aims to provide a national focus for existing community-based water quality monitoring programs such as Streamwatch (NSW) and Ribbons of Blue (WA), and to encourage the emergence of similar new programs. The program has improved community action through:

[42] Water Watch Victoria.

- Generating interest in water quality and general issues within the community to result in remedial action;
- Establishing a national network linking all community-based water quality monitoring programs;
- Providing resources necessary to facilitate the expansion of community-based water quality monitoring into a comprehensive national network; and
- Encouraging national consistency in the gathering, reporting and interpretation of water quality data.

Behavioural Intervention – Reducing Water Consumption[43]

Problem:

- To encourage efficient use of water and educate communities about water use.

Intervention:

- Recognising the need for holistic approaches to water issues, municipal governments across Canada are beginning to take action to manage the demand for water, instead of seeking new sources of supply. Demand management, incorporating water efficient applications, is rapidly gaining popularity as a low cost, effective way to get more service out of existing systems, thus deferring the need for constructing new works.

- The wide range of water efficiency initiatives currently being undertaken can be grouped under four principal categories: structural, operational, economic and socio-political. The strategies place a strong emphasis on behavioural change towards water conservation.

- Structural strategies involve the development of water metering, water recycling systems, waste-water re-use, flow control devices, distribution system pressure reduction, water saving devices, drought resistant landscaping, efficient sprinkling /irrigation technology, new process technologies and plant improvements.

[43] Environment Canada.

- Operational strategies include leak detection and repair, water use restrictions, elimination of combined sanitary /storm sewers to reduce loading on sewage treatment plants and plant improvements.

- Economic strategies include rate structures, pricing policies, incentives through rebates and tax credits and other sanctions / fines.

- Socio-political strategies include public education, information transfer and training and regulatory systems (ie. legislation, codes, standards and by-laws).

Pricing Policy Intervention – Volumetric Pricing for Water[44]

Problem:

- To discourage unnecessary use of water and defer the need for major infrastructure works.

Intervention:

- Some water authorities in Australia have implemented user pays pricing policies that have had demonstrable effects on the demand for water services. The system used by Hunter Water Corporation (HWC) was specifically designed to have a demand management effect.

- The implementation of user pays in the Hunter region began in 1982, replacing the property value charging system for water. In addition to service charges and usage charges, there is also an environmental improvement charge, used to fund a sewage backlog program.

- Prior to user pays pricing, residential consumption of water peaked in 1980 at approximately 295 kilolitres per annum. By 1985, three years after the inception of 'pay as you use' charging, consumption had dropped to 200 to 210 kilolitres

[44] Hunter Water Corporation (2000).

per annum. It has remained consistently near this level since. This reduction of demand for water supply has seen HWC able to avert the construction of two new dams to increase water supply to the region.

Settlement Planning Intervention – Sustainable Urban Design[45]

Problem:

- To minimise use of water and to re-use grey and black water.

Intervention:

- The Eco House project in the City of Port Phillip, Victoria, is a joint venture between the municipality and Melbourne Water to provide an example of how urban design can deliver ecologically sustainable outcomes. The house has been redesigned and retrofitted with a number of features that allow the processing and reuse of both grey and black water on site. These design features include water tanks, water conservation appliances, water recycling systems and composting toilets.

- The house also serves a dual purpose as an educational tool. It is open to the public and community groups to raise awareness of urban design innovation that highlights the financial, social and environmental impacts of the project. The project also identifies ways in which low-income households can gain access to this technology.

Pollution of Urban Air Sheds

Technological Intervention – Using Alternative Fuel Technologies[46]

Problem:

[45] Port Phillip Eco Centre (2000).

[46] Murdoch University and Australian Academy of Technological Sciences and Engineering.

- To improve urban air quality by using alternative fuel technologies for transport vehicles.

Intervention:

- Alternative fuel technologies can provide superior air quality outcomes compared to fossil fuels. Following is a brief description of alternative fuel technologies.
  - Liquid petroleum gas (LPG) - LPG is already established as a fuel for vehicles, but the LPG resource is limited.
  - Natural gas - Natural gas is an alternative fuel that can readily service existing land and sea transport systems.
  - Hydrogen - Hydrogen is an excellent high-energy fuel whose combustion produces a minimum of polluting emissions. However, further development of this technology is required for wider application.
  - Electric vehicles - Compact light-weight batteries cannot match the range, performance and cost of oil based fuels at the present time.
  - Hybrid vehicles - Hybrid light-weight vehicles could use a petrol or diesel engine combined with electric technology. Further development of this technology is required.

Technological Intervention – Pollution Ventilation System[47]

Problem:

- To disperse concentrated air pollutants in road tunnels.

Intervention:

- City Link in Melbourne is a $1.8 billion expressway designed to ease traffic congestion in the heart of Melbourne and reduce commuting time from the Eastern and Western suburbs. A key element in reducing this congestion is the Domain Tunnel, which carries traffic from the Monash Freeway, under the Yarra River to the West Gate Freeway at Southbank, providing an effective bypass route.

[47] Transurban (2000) Internet Site.

- The concentration of traffic in a confined space creates a large airshed of pollutants in the vicinity of the Tunnel and, by proximity, the city. This is compounded by the fact that use of the Freeway is increasing, with weekday average use rising from 145,709 transactions per day in January 2000 to 342,782 transactions per day in June. A ventilation system is in place to alleviate the airshed problem.

- The ventilation system exhausts air from the Tunnel. The aim is to disperse contaminants so when the plume reaches the ground the concentration of contaminants is almost undetectable above the existing background concentrations. Furthermore, instrumentation allows control of the various pollutants to specified air quality levels by air-flow adjustments.

- Air test data collected by the Victorian EPA for the period of 1 March 2000 to the 31 May 2000 shows that emissions for the vent are much lower than EPA license limits, and that emissions have not changed ambient air quality in the vicinity of the vent in South Melbourne.

Behavioural Intervention – Using More Stringent Road Vehicle Regulations[48]

Problem:

- To improve the emission standards of road vehicles and reduce air pollution.

Intervention:

- The Australian Academy of Technological Sciences and Engineering recommends improvement of road vehicles and better emission standards generally. Data analysis and projections support these recommendations.

- Delivery of clean vehicles to the market - New vehicle emissions standards to be increased in line with United

[48] Australian Academy of Technological Sciences and Engineering (1997) Urban Air Pollution in Australia.

Nations Economic Commission for Europe (ECE) regulations. This would improve air quality in the long term.

- Maintaining compliance - To fully realise the benefits of tighter new vehicle standards, it is necessary to ensure that emissions control systems remain effective via inspection and maintenance programs.

- Cleaner diesel fuel – Reduce emissions of potentially carcinogenic fine particulate levels of sulphur in diesel fuel.

- Evaporative emissions - A major determinant in the level of these emissions is the vapour pressure of petrol (gasoline). A reduction in vapour pressure is considered to be one of the more cost effective of the fuel-related approaches available.

Pricing Policy Intervention - Reducing Road Use Demand[49]

Problem:

- To reduce car use and encourage alternative transport use in pursuit of improved air quality.

Intervention:

- In response to rising car ownership and use, and the growing awareness of the problems of traffic congestion on air pollution, pricing instruments are increasingly being viewed as an effective means to reduce traffic levels as part of an integrated transport strategy.

- Bristol City Council in the UK has drawn together a group of 10 major cities from 6 European member states who aim to work closely in order to progress road pricing initiatives in their areas. EUROPRICE is the network investigating road pricing as a demand management tool. The aim of the network is to jointly address the key issues involved in implementing road-pricing schemes.

[49] Bristol City Council, UK (2000) Internet Site.

Pricing Policy Intervention - Differential Taxation for Petrols[50]

Problem:

- To discourage use of leaded petrol.

Intervention:

- Australia has used very high levels of lead in petrol, the permitted level being between 0.30–0.84 grams per litre. Very few OECD countries allow lead concentrations exceeding 0.15 grams per litre. It has been estimated that approximately 90% of all lead emissions in urban areas can be contributed to petrol use.

- In 1993, the National Health and Medical Research Council estimated that between 25 and 50% of Australian children aged up to four years had blood lead concentration exceeding the nationally recommended figure.

- In the 1993/94 budget, the Commonwealth Government announced an increase on the excise on all dutiable petrol items, other than aviation turbine fuel and aviation gasoline, to phase in a differential tax between leaded and unleaded petrol.

- While the full outcome on lead emissions has yet to be observed, by 1995 sales of leaded petrol had declined to 43% of the petrol market. The differential tax system contributed to the decline of leaded petrol usage.

Settlement Planning Intervention – Improving Air Quality[51]

Problem:

[50] Commonwealth Environment Department (1997).

[51] Australian Academy of Technological Sciences and Engineering (1997) Urban Air Pollution in Australia.

- To influence car use and air quality through changes to urban form.

Intervention:

- The CSIRO has modelled the effect on air pollution and smog generation for Melbourne under a series of urban form scenarios. The main findings show that a dispersed city pattern of urban development results in continued growth in emission levels, particularly for carbon monoxide and carbon dioxide due primarily to growth in vehicle kilometres travelled. A compact city form achieves the largest relative reductions of emissions, due to significantly lower vehicle kilometres travelled. A corridor city form performs moderately.

- On the basis of this evidence, urban development of a more compact nature produces less daily emissions.

- Using this research, it is now possible for local or State government planning agencies to evaluate a range of possible development futures and use the outcomes as a basis for guiding major infrastructure investment decisions and broad development strategies for a city.

Settlement Planning Intervention – Pedestrian Access and Mobility Planning[52]

Problem:

- To encourage walking as a travel mode.

Intervention:

- Pedestrian Access and Mobility Plans (PAMPS) is an initiative of the NSW Roads and Traffic Authority in conjunction with local governments. Councils in the Sydney metropolitan area have been invited to work with the RTA to prepare pedestrian friendly initiatives in urban areas.

[52] Roads and Traffic Authority, NSW (1998).

- The objective of PAMPS is to provide safe and useable pedestrian access throughout Sydney, and provide a realistic alternative to private vehicle use. The plans will identify existing facilities and proposed pedestrian infrastructure, such as marked footcrossings and traffic lights, and determine where access and mobility can be improved. The outcomes of these plans are then integrated into the wider transport system for the relevant area.

Settlement Planning Intervention – Public Transport Infrastructure Development[53]

Problem:

- To develop public transport infrastructure and provide an alternative to car transport.

Intervention:

- The Building Better Cities program sought to promote improvements in the efficiency, equity and sustainability of Australian cities through infrastructure planning. As part of its commitment to improve the capacity of ecologically sustainable development, one of the stated outcomes was to reduce traffic congestion and pollution costs.

- To this end, $66.8 million was allocated to Victoria up to 1996 for public transport improvements in Melbourne and Geelong. This money was used for projects such as the electrification of the Cranbourne rail line, which was completed in March 1995. In the case of public transport improvements such as this, the objective was to reduce the level of car utilisation by providing productive public transport alternatives. Auditing of the Cranbourne rail project soon after completion revealed that:
  - Weekly patronage of the rail line increased from 8,000 in June 1995 to 10,000 in March 1996; and
  - The number of cars parked at the Cranbourne and Merinda Park stations increased by approximately 80% between April 1995 and March 1996.

[53] Building Better Cities (1996).