LAND TRANSPORT EXTERNALITIES

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LAND TRANSPORT EXTERNALITIES

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

1. Introduction

Works Consultancy Services Ltd with assistance from Steer Davies & Gleave (NZ) Ltd and the New Zealand Institute of Economic Research were commissioned by Transit New Zealand in 1992 to undertake a preliminary study into the external effects (hereafter called externalities) on the environment created by the land transport system. The study is part of the first phase of Government review of land transport pricing and has the objective of establishing a research programme and priorities for further work.

The research will be combined with parallel research on road pricing to develop a comprehensive framework for establishing a pricing and regulatory basis considering all effects, costs and benefits of the land transport system.

The objective of this study is to undertake a literature review and to develop a detailed recommended research plan describing further research projects needed to quantify or value external effects of land transport and to determine the efficiency and effectiveness of instruments and mechanisms for internalising transport-related costs. This executive summary compiles the recommendations contained in the report and forms the overall research plan proposed by the study.

2. Scale and Significance of Land Transport Effects

The study has identified a wide range of transport externalities associated with the construction, maintenance and operation of the land transport system which have been structured under four groups on the basis of the characteristics of effects:

- POLLUTION EFFECTS
    - Air Pollution
    - Impacts on the Global Atmosphere
    - Effects on Water Systems
    - Noise
    - Vibration
    - Dust
    - Disposal of Waste
- INTRUSION EFFECTS
    - Visual Effects
    - Plant and Animal Habitat
    - Effects on Physical Landscape
    - Effects on Archaeological Sites
    - Cultural and Spiritual Effects and The Treaty of Waitangi

- Recreation Effects
- Strategic Effects

- INTERFERENCE EFFECTS

  - Community Disruption
  - Urban and Rural Blight and Stress of Change
  - Lighting Effects
  - Community Severance and Accessibility
  - Hazard Effects

- URBAN FORM AND LAND USE

The study has reviewed the scale and significance of each of these factors. In many areas information at a national scale is lacking. International literature and a review of some New Zealand Environmental Assessments have been used to assist in identifying the priority factors that should form the focus of further research.

Recommendation 1 - Priority Effects

That the research plan should focus on addressing the priority issues of:

Local Air Pollution
Impacts on the Global Atmosphere
Effects on Water Systems
Noise
Urban Form - which has an overlapping relationship with the other factors

Recommendation 2 - Scale and Significance of Effects

That the research plan should focus on scale and significance of effects for:

Local Air Pollution

- **Review the methodologies used overseas to estimate the total cost of air pollution from land transport and to prepare an estimate of such costs for New Zealand**

Impacts on the Global Atmosphere

- **Monitor, in conjunction with Ministry for the Environment, world-wide research and co-ordinate transport-related research with other environmental research programmes**

- **Advance proposed research projects**

Effects on Water Systems

- **Undertake research on the accumulation rate of pollutants on different types of roads in terms of both road environment and pavement surface to provide a clear estimate of traffic load generation**

- **Identify priorities for mitigation through pre-treatment and road management**

Noise

- **Review overseas methodology on estimates of overseas population exposed to road noise and refine estimate for New Zealand**

3. Techniques to Quantify and Value External Effects

The application of a range of valuation approaches to transport effects have been discussed and include:

- Market-derived opportunity costs
- Hedonic pricing
- Travel cost method
- Contingent valuation
- Shadow projects
- Indirect costs

Overseas studies have found the following values for effects:

Noise: One unit change in Leq (equivalent continuous sound level) causes a house price effect of between 0.08% and 1.26%.

Air Pollution: A possible percentage fall in property value of 0.01-0.22% for a 1% rise in air pollution.

All costs: OECD 2.5% of GDP compared with Quinet (1989) 18.3% GDP.

The database for valuing transport externalities in New Zealand is extremely limited and needs developing.

Recommendation 3 - Valuing Externalities

That the research plan should focus on valuing externalities and:

- **Undertake New Zealand studies that assess priority effects using hedonic pricing and contingent valuation methods: methodology to be consistent with overseas methods**

- **Follow up with comparative analysis and scaling study to establish more reliable values for New Zealand**

The recent study by Chivers, Allan and Hunt (1992) on quantification of intangibles has been reviewed. The study included recommendations for further research.

Recommendation 4 - Quantification of Externalities

That the research plan should focus on quantification of the following externalities:

Visual Impact

Visual Obstruction
- **Trial the UK Manual of Environmental Appraisal (MEA) procedure on a typical New Zealand roading project**

Visual Intrusion
- **Further investigate visual impact techniques before choosing a method**

View from the Road
- **Follow up on the drive-over technique for quantifying a scenic landscape reported by Smith and Smith (1991)**

Special Areas
- **Identify techniques and costs for moving all buildings and replacing lost or damaged ecological areas, and produce guidelines**

Effects on Water
- **Carry out before and after studies of the effects of road construction on water quality: also investigate the range, costs, and benefits of mitigation measures**

Overshadowing
- **Investigate usefulness of non-market valuation techniques**

Global, National or Regional Environmental Goals
- **Investigate how conformity or otherwise with such goals should be quantified**

Miscellaneous
- **Monitor the possible significance of wind, litter, security, urban blight and pedestrian and cyclist intimidation**

4. Approaches to Treating Externalities

The study has reviewed a wide range of techniques and instruments under the headings of:

- Economic Instruments
- Regulations and Standards
- Education
- Planning
- Demand Management
- Investment
- Institutional Changes

The experiences and merits of techniques used in a wide range of countries have been reviewed with particular reference to the priority effects of air pollution, greenhouse effects, noise, water pollution and urban form.

The study has shown that a co-ordinated approach to externalities associated with pollution of land, air and water is essential. In many countries instruments to address one effect have been found to exacerbate another effect.

Mechanisms need to be considered in the context of ensuring that transport users pay the full environmental costs of transport, but a policy package needs to consider sympathetic economic, regulatory and education instruments.

The success of economic instruments for air pollution effects relies on the elasticity of demand for goods, in many cases petrol. Noise effects are more suited to regulatory approaches associated with vehicle technology, while water pollution requires a combination of economic instruments to clean up existing problems together with regulation to ensure that environmental standards are achieved.

The role of more sustainable urban form is important for many effects. Particular attention has been paid to the potential use of development impact fees to ensure that infrastructure costs are reflected in development costs.

Recommendation 5 - Mechanisms and Instruments

That the research plan should focus on the following mechanisms and instruments to internalise the cost of externalities with:

Price Elasticity

- **To refine estimates of New Zealand petrol price elasticity by means of methodology consistent with OECD countries, to facilitate comparisons with regard to fuel price, availability of public transport, trip length and other key factors**

Residential Location Decisions

- **To analyse cost variables in residential location decisions and to develop models that will enable changes in transport costs to be tested along with corresponding changes in housing costs: in conjunction with this to design and test charge mechanisms for each type of cost to be recovered**

New Technology

- **To model the implications for New Zealand cities of developing and established technologies in terms of implications for travel demand**

Development Impact Fees

- **To develop a policy and assessment framework for the calculation of impact fees building on work overseas**

5. Legal Duties and Constraints

The Resource Management Act 1991 and the Transit New Zealand Act 1989 form the dominant legislation for developing a sustainable land transport policy.

The Resource Management Act provides the starting point for examination of a wide range of instruments but further legislation may be required for many economic instruments and regulations.

Recommendation 6 - Legal Duties and Constraints

That the research plan integrate into the specific tasks, the investigation of legal issues. A number of areas require further legal consideration, and in particular:

- **The extension of the concept of economic instruments**

- **The investigation of a framework for development impact fees under the financial contributions provisions of the Resource Management Act to address transport externality costs on a national scale**

ABSTRACT

The report provides a literature review and research plan describing where further research is needed to quantify or value external effects, otherwise known as externalities, from the land transport system. It examines the efficiency and effectiveness of economic and regulatory instruments and mechanisms for internalising transport-related costs. The report examines how the principles of sustainable management apply to the land transport system under the Resource Management Act 1991.

The project was broken down into four main tasks and include 1. a preliminary identification of external effects, 2. a comprehensive literature review of actual and proposed approaches used to quantify or value externalities and the types of non-market instruments and mechanisms that are been used in New Zealand, 3. an assessment of legal duties and statutory constraints relevant to valuing, pricing or regulating externalities and 4. provision of a recommended research plan suggesting where further research is required to internalising transport-related costs.

SECTION 1

INTRODUCTION

1. INTRODUCTION

1.1 The Research Brief

Works Consultancy Services Ltd with assistance from Steer Davies & Gleave (NZ) Ltd and the New Zealand Institute of Economic Research were commissioned by Transit New Zealand in 1992 to undertake a preliminary study into externalities on the environment created by the land transport system. The study is part of the first phase of Government review of land transport pricing and has the objective of establishing a research programme and priorities for further work.

The research will be combined with parallel research on road pricing to develop a comprehensive framework for establishing a pricing and regulatory basis considering all effects, costs and benefits of the land transport system.

The objective of this study is to undertake a literature review and to develop a detailed recommended research plan describing further research projects needed to quantify or value external effects of land transport and to determine the efficiency and effectiveness of instruments and mechanisms for internalising transport-related costs.

1.2 Study Context

Land transport involves the movement of people and goods over land. It embraces walking and cycling as well as other forms of public and private transport by both road and rail.

The research brief required the scope of the study to consider all the potential effects of land transport that are not wholly contained within the land transport system. It expressly excludes congestion and accidents and also will exclude effects of one mode on another such as the effects of vehicles on pedestrians and cyclists. These issues are being recently addressed in a separate study undertaken by Halcrow Fox and Associates and the Institute of Transport Studies at Leeds University (Halcrow Fox and Associates 1993)[(3)]*.

Section 3 of the Resource Management Act provides a comprehensive definition of the "effects" in relation to the use, development or protection of natural and physical resources or in relation to the environment and includes:

- Any positive or adverse effect;
- Any temporary or permanent effect;

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* A superscript to a reference indicates the annotated bibliography in Appendix 3 in which it is listed, as follows:

(1) Annotated Bibliography - List 1
(2) Annotated Bibliography - List 2
(3) Bibliography - List 3

- Any past, present or future effect;
- Any cumulative effect which arises over time or in combination with other effects regardless of the scale, intensity, duration and frequency of the effect;
- Any potential effect of high probability;
- Any potential effect of low probability which has a high potential impact.

The scope of this definition is substantially broader than the economic concept of externalities. This is so particularly when externalities are viewed from the national perspective where it is particularly important to distinguish between the real resource effects and the transfer effects which are effectively a redistribution of costs.

1.3 Structure of the Report

The report has been structured to meet the requirements of the research brief. As the scope of externalities addressed is extremely broad, Section 2 reports on the scale and significance of the full range of externalities in New Zealand and establishes priority groups for the focus of further effort.

Section 3 focuses on the issues associated with valuing externality effects and reports on recent work on the quantification of effects. Preferred techniques are identified together with areas of further research.

Section 4 analyses the mechanisms and instruments available for treating externalities. The analysis focuses in detail on the top priority effects established in Section 2 and considers the use of mechanisms in other countries.

Finally Section 5 considers the legal duties and constraints that could effect the implementation of initiatives in New Zealand.

Each section identifies the research requirements that have been established. These have been brought together into a research plan which has been located at the front of the report as it also serves the function of an Executive Summary.

Appendix 1 includes a survey of the scale and significance of factors addressed in New Zealand environmental assessment of highway projects over the last 10 years. Appendix 2 examines application of pricing approaches to externalities and Appendix 3 contains two annotated bibliographies and a general bibliography.

1.4 Research Methodology

The overall project has a four stage methodology as follows:

Task 1: Preliminary Identification of External Effects

Task 2: Literature Review

Task 3: Assessment of Legal Duties and Constraints

Task 4: Research Plan

A preliminary list of external effects was prepared early in the study and formed the basis of the scope of the study. The aim was to identify as comprehensively as possible a list of effects of the land transport system and the focus is on those effects that do not lie entirely within the transport system. In recognition of the wide range of potential externalities that may effect the environment, they were initially grouped into three levels as follows.

Level 1 Externalities associated with the Construction, Maintenance and Operation of Land Transport Systems (including short term or transitional and more permanent effects)

1. Local air pollution
2. Impacts on global atmosphere (CO_2, other greenhouse gases, CFCs used in vehicles, ozone depletion)
3. Effects on water systems, surface and ground waters
4. Loss and disruption of plant and animal habitat
5. Visual effects
6. Dust
7. Vibration
8. Noise
9. Effects on physical landscape, e.g. land stability
10. Community severance and local accessibility
11. Community disruption
12. Urban and rural blight and stress of change

13. Cultural, spiritual, historic and Treaty of Waitangi effects, including archaeological effects

14. Effects on recreation values

15. Lighting effects, e.g. vehicle headlights on property, street lights

16. Strategic effects (Civil and Military Defence)

Level 2 Externalities on the Urban/Regional Systems

1. Accessibility to facilities, e.g. employment services

2. Effects on pedestrians and cyclists - intimidation from motor vehicles (NB Pedestrians and cyclists are considered to be part of the land transport system, see Section 1.2)

3. Effects on urban form and land use, and subsequent impact on urban sustainability

4. Effects on personal safety (risk) and community vitality, e.g. the security provided by retaining movement in central areas

Level 3 Dependent and Related Activities of Land Transport Systems

1. Extraction activities of energy resources

2. Risks associated with refining, storage and delivery of hazardous fuels including LPG and CNG

3. Hazards associated with the transport of other hazardous materials

4. Disposal of waste and redundant units, e.g. vehicle bodies, waste oil, waste from construction activities

5. Effects on a range of land transport-dependant industries, e.g. vehicle assembly industry

The list has been subsequently re-organised to better explore the scale and significance of both construction and operation effects, and this version is set out in Section 2.

The list formed the basis of a comprehensive literature search using the New Zealand Bibliographic Network, a database containing nearly 7 million records of books and reports published worldwide. This database covers all subject areas from all types of publishers, including government agencies, research organisations, publishing houses.

The search involved in this exercise used the following databases, with particular use focused on the first three databases listed below.

- TRIS (Transportation Research Information Services) - provides information on air, highway, rail, mass transit and other transportation modes. Subjects included are regulations and legislation, energy, environmental and maintenance technology, operations, traffic control and communications.

- ENVIROLINE - covers world environmental information. The primary and secondary sources report on all aspects of the environment, i.e. planning, law, geology, biology, political science etc., as they relate to environmental issues.

- ENVIRONMENTAL BIBLIOGRAPHY - covers the fields of general human ecology, atmospheric studies, energy, land resources, water resources, nutrition and health.

- GEO MONTHLY CATALOG - contains records and reports, studies, fact sheets, maps, handbooks, conference proceedings, etc. issued by all US federal government agencies and the US Congress. Also included in this database are records of all Senate and House hearings on private and public bills and laws.

- BRITISH OFFICIAL PUBLICATIONS (HMSO) - database containing bibliographic records of United Kingdom parliamentary, regulatory, and non-parliamentary government and official documents published by Her Majesty's Stationery Office. Also included are publications from the British, European, and international organisations for which HMSO is the UK agent.

- PAIS (Public Affairs Information Service) INTERNATIONAL - a bibliographic index to the public policy literature of business, economics, finance, law, international relations, government, political science and other social sciences.

- ECONOMIC LITERATURE INDEX - an index of journal articles and book reviews from 260 economic journals and from approximately 200 monographs per year. The database corresponds to the quarterly *Journal of Economic Literature* and to the annual *Index of Economic Articles*.

SECTION 2

SCALE AND SIGNIFICANCE OF LAND TRANSPORT EFFECTS

2. SCALE AND SIGNIFICANCE OF LAND TRANSPORT EFFECTS

2.1 Introduction

The objective of this part of the report is to establish which factors should be given priority in research and development of techniques to internalise costs. This needs to be approached from a number of different perspectives. First it is important to identify those factors that are judged to have the greatest scale and significance in terms of costs to individuals and the community that are not currently compensated.

Second it is essential to identify those factors that are most critical to the long-term goal established by the Resource Management Act 1991 of sustainable management of natural and physical resources.

Third it is important to remember that, when considered from a national perspective, "transfer costs", i.e. the adverse or beneficial costs transferred from one location to another as a result of transport development, lie outside the economic concept of externalities.

The approach to assessing the scale and significance of the effects of land transport has had to rely on inputs from a number of different perspectives. Overall there is a shortage of nation-based research on the overall scale of effects. A survey of environmental assessments for highway projects (see Appendix 1) has been undertaken to provide indications of the factors of greatest impact and where possible to identify the relative weight to these factors to reach a recommendation. These studies, of course, focus on the impacts of new investment and generally do not consider the ongoing operational effects of the land transport system. They have also generally been prepared using standard methodologies that have tended to exclude certain effects. The relevance of evidence from overseas literature has also been considered.

In many cases there is a clear distinction in terms of the overall scale of effects between inter-regional transport and urban transport.

In terms of significance, factors that have been considered include the extent to which the effects are:

- Local or global (site-specific or generic)
- Permanent or temporary, and ongoing or intermittent
- Associated with downstream effects
- Associated with the long-term goal of sustainable management of natural and physical resources
- Associated with trade-offs against other effects
- Suitable for amelioration and mitigation
- A real externality cost or partially a transfer cost.

The preliminary list of effects has been reformatted into a more appropriate list that allows a clearer assessment of operational effects, and links dependent and related activities to their principal effect. The list involves four groupings:

1. pollution;
2. intrusion;
3. interference; and
4. urban form and land use.

However before advancing the analysis further it is useful to explore the important context and relevance of sustainable management.

2.2 Transportation and the Sustainable Management of Natural and Physical Resources

The Australian Ecologically Sustainable Working Group (1991)[1]sought to identify the characteristics of sustainable land transport and forms a useful context in which to consider specific effects.

2.2.1 Improvement in Material and Non-Material Wellbeing

A principal goal of transport is to meet community aspirations for sustained improvements in well being or quality of life over time. Transport affects quality of life by servicing the needs for movement of goods and personal travel, but also by its impacts on social mobility, air pollution noise, etc. Improvement in well being requires the integration of economic, social and environmental objectives.

Sustainable management requires that:

- the transport sector be technically efficient,
- the transport activity associated with a particular level of "goods and services" is minimised, and
- the decisions on transport activities take account of the full environmental and social cost.

Improving wellbeing may not require corresponding increases in transport activity. The aim is to examine means of satisfying more of people's needs and desires without the need for unnecessary transport.

2.2.2 Intergenerational Equity

Sustainable management requires the potential of natural and physical resources to be managed to meet the needs of future generations as well as safeguarding the life-supporting capacity of air, water, soil and ecosystems.

This has implications for the technology, the mix of modes used in and levels of activity of the transport sector. It requires a move towards

- cleaner transport technologies,
- more environmentally benign sources of transport energy,
- ways to reduce the need for transport or ways to satisfy growing transport demand using less resources.

The provision of transport should be conducted in a manner that does not destroy or put at risk natural systems and resources that are non-substitutable, multi-functional, and the impacts upon which are uncertain and irreversible (Pearce et al. 1989)[1]. This includes the "natural capital" of biodiversity, fresh water supplies, clean air and productive soils.

The discussions on sustainable management raise a number of different perspectives on the use of natural capital. One is to say that we should aim to preserve resources so that the next generation inherit no less than we have. An alternative argument is that the next generation should be given a total stock of assets, both natural and human-made. This assumes that it is possible to compensate future generations for the loss of natural systems and resources by an enhanced stock of human-made assets.

2.2.3 Protecting Biodiversity

Transport has an impact on the ecological systems both directly and through its role in development which also impacts on the environment. It influences urban forms which play a significant role in competing land uses. Factors that contribute to this objective include minimising the destruction of natural habitats and limiting transport emissions which impact on ecological systems.

2.2.4 Global Issues

Some of the world's major environmental problems are global rather than local in nature, such as the accumulation of greenhouse gases.

The Framework Convention on Climate Change signed at the 1992 United Nations Conference on Environment and Development formed an agreement for developed countries to reduce greenhouse gas emissions to 1990 levels by the year 2000. The New Zealand Government has a planning target of a 20% reduction in emissions below 1990 levels.

2.3 Pollution Effects

2.3.1 Air Pollution

Air pollution is caused by the emission of chemical substances into the atmosphere which have adverse effects for human health, animal and plant life.

Many studies have looked at the emissions from transport, e.g. European Economic Community (EEC)(1992). These suggest the important emissions to be:

- Carbon dioxide (CO_2) emitted by the burning of fossil fuel;
- Methane (CH_4) produced during the production of some transportation fuels (e.g. synthetic petrol from natural gas);
- Carbon monoxide (CO), hydrocarbons (HC) and volatile organic compounds (VOCs) resulting from incomplete combustion;
- Nitrogen oxides (NO_x) generated at high combustion temperatures;
- Lead (Pb) ethylene dibromide and dichloride added to gasoline to attain desired octane rating and greater volatility of combustion by-products;
- Sulphur dioxide (SO_2) from the high sulphur content of diesel;
- Formaldehyde and other aldehydes;
- Fine particulates present in diesel;
- Chlorofluorocarbons (CFCs) and halons emitted from refrigerated transport and air-conditioned vehicles.

The build-up and diffusion of pollutants differ by nature and according to geographical, meteorological and morphological conditions. The effects of some pollutants such as lead remain concentrated within the vicinity of the source, and the impacts are therefore localised in urban areas while the greenhouse effect, ozone layer depletion, acid rain, the build-up of ozone in the troposphere are all topical issues on a global scale.

The depletion of the ozone layer, which reduces the protection of the earth against ultraviolet radiation from the sun and therefore increases the incidence of skin cancer, is caused by emissions of CFCs and halons. CFCs are emitted from millions of point sources such as aerosol sprays. The direct contribution of transport is mainly from refrigerated transport of goods and air-conditioned vehicles. In New Zealand only the former is of significance.

Acid rain affects animal and plant life and corrodes building materials. Transport contributes directly through sulphur dioxide and nitrogen oxide emissions and indirectly through use of thermal electricity by rail transport.

Ozone build-up in the troposphere has harmful effects on human and animal health and results from the emission of volatile organic compounds (VOCs) and nitrogen oxides.

Hydrocarbons, VOCs, aldehydes, lead ethylene dibromide and dichloride have potential carcinogenic effects. Lead, carbon monoxide and diesel particulates are generally detrimental to human health.

The economic costs of atmospheric pollution include the cost of health problems such as problems of the respiratory system, toxicity from lead accumulation and reduced human productivity from morbidity and mortality. In addition there are costs associated with corrosion damage to buildings.

Soulas (1992)[3] provides a five-fold classification of effects:

1. Direct effect on human health (and to a lesser degree the direct effect on domestic animals health and on plants);

2. Sensory pollution, especially olfactory and visual, is a contributor to psychological effects of pollution;

3. Direct effect on the deterioration of buildings; dirt and damage to stone and other building materials; the cost of renovation and maintenance and the damage to historical monuments (e.g. the Coliseum in Rome);

4. Indirect effects caused by distant pollution, for example as a result of acid rain which can effect flora (contributing to the decline of forests), fauna (for example in lakes), the state of agriculture soils and crops, etc.;

5. Contribution to the greenhouse effect through the emission of certain gases which, in the case of transport, is predominantly CO_2 but also of other pollutants such as nitrogen components which have a direct or indirect effect on the ozone layer.

Collins (1990)[3] has presented a useful table of spatial incidence of different air pollutants which is reproduced here in Table 1.

Table 1. Spatial incidence of pollutants. Source: Collins 1990[3]

Pollutant	Global	Regional	Local
Carbon dioxide	X		
Methane	X		
Nitrogen oxide	{X}	X	X
Sulphur dioxide		X	X
Hydrocarbons	{X}	{X}	X
Carbon monoxide	{X}		X
Lead			X
Particulates			X

Notes:
- X — significant - has a significant impact on the ozone
- {X} — contributor - is emitted but does not impact the ozone
- global: — contributing to global warming
- regional: — acid rain and nitrogen deposits
- local: — smog and high levels of toxins in air

The spatial impact of emissions varies considerably. Thus the effects of some pollutants remain close to the source and the impacts are therefore localised, for example lead. Other pollutants may have their effect well away from the source, for example "acid rain" from sulphur dioxide and nitrogen oxide. Other emissions may have a "global" impact, such as carbon dioxide in the greenhouse effect.

Air pollution within the transport sector is nearly entirely caused by fuel use (CFCs are an exception), with road transport accounting for most of the energy consumption. In the EEC, road transport accounts for 85%, air 11%, rail 3% (the remaining 1% is to inland waterways) of energy consumption.

The CORINAIR programme being carried out in the EEC has looked at the emissions of NO_x, VOC and SO_2 emissions by road transport. Only partial data are available for railways and none for inland waterways, shipping and air aviation. The share of road transport in total industry-wide emissions is 53.6% for NO_x, 27% for VOC, and 3% for SO_2.

For particulates and lead, few comprehensive databases are available. Data for Germany show transport to be responsible for 13% of particulate emissions and in the Netherlands 22%, with 30% of that 22% being attributable to the car (Cerwenka and Rommerskirchen 1991)[3].

Road transport emissions are concentrated within urban areas. For example, 26% of NO_x and 61% of VOCs are emitted on urban roads of Netherlands and Germany (Cerwenka and Rommerskirchen 1991)[3].

In the UK, it was recorded that of the total transport emissions, in 1990, 97% of non-methane VOCs are emitted by road transport, 2% by rail and 1% by shipping; 95% of NO_x are emitted by road transport, 3% by rail, 1% by air and 1% by shipping.

While there is little evidence to suggest that accepted standards of local air pollution are generally being exceeded in New Zealand it is also clear that overall urban amenity could be enhanced with a reduction in emissions in general.

Pollution from public transport and freight vehicles differs from that of cars in that the fuels used are predominantly diesel. Diesel vehicles can be substantial polluters if not maintained.

From the review of environmental assessments it can be considered that air pollution is not given any great significance as an adverse effect on the environment. Reviewing the emissions statistics given above, air emissions statistics need to be more carefully examined in future environmental impact assessments.

Emissions arise from the use of energy fuels. Reducing the consumption of non-renewable resources in transportation is a key factor in the move towards sustainable management for which energy efficiency together with the need for benign emissions must be related. In some areas there is a direct trade-off, for example the removal of lead from petrol has resulted in an increase in CO_2 from vehicles.

The economic cost of the local air pollution of all registered vehicles in Australia in 1988-1989 was estimated to be A$787 million, with cars responsible for A$671 million of this (Inter-State Commission 1990)[3]. This air pollution cost is about 0.2% of the GDP. These costs include health costs and damage to structures and to plant life, but do not include other ecological and social costs such as discomfort and anxiety caused by pollution.

Results from studies worldwide vary, largely owing to different estimation techniques, but average costs of 0.3% to 0.4% of GDP have emerged. A German study attributed 91% of the costs to road, 4% to rail, 3% to inland waterways and 2% to air (Transport 2000 1989)[3].

Quinet (1989)[3] for example has estimated the cost of road transport-related air pollution to be in the order of 0.4% of GDP for industrialised countries, and 0.1% (including noise) for other modes of transport. In comparison to the total cost of land transport (i.e. including noise accidents, time and use expenditure, infrastructure management and air pollution) which accounts for 23% of GDP, the costs of air pollution alone are quite small i.e. 0.4%.

No such estimate has been carried out for New Zealand but if the Australian figure was used it would amount to an annual cost of approximately NZ$150 million.

A priority then for the Research Plan is to review the detailed methodologies of these estimates used overseas and prepare a cost estimate for New Zealand.

However even without estimates it is clear that the scale of the problem is substantial and highly significant in terms of long-term sustainability.

2.3.2 Greenhouse Gas Emissions

The contribution of CO_2 to an accelerated greenhouse effect has emerged in recent years as an important issue. The 1989 and 1990 Scientific Assessments of the Intergovernmental Panel on Climate Change (IPCC) has drawn world-wide attention to the causes and consequences of the "greenhouse effect". Without any greenhouse effect the world's air temperatures would be 33°C lower. Thus the greenhouse effect makes the world habitable, by warming the earth and its atmosphere through the entrapment of energy by gases in the atmosphere. CO_2, water vapour, methane, nitrous oxide, ozone and chlorofluorocarbons (CFCs) contribute to the trapping process but CO_2 is considered to the biggest contributor.

Excluding water vapour, greenhouse gases comprise less than 0.1% of the atmosphere and their ability to have such a significant effect on the earth's climate indicates how effective they are in trapping outgoing heat. Greenhouse gases do not remain in the atmosphere indefinitely as natural processes operate as "greenhouse sinks" on the different contributors. This makes it possible to give each contributor an expected "lifetime". By combining this with its efficiency to trap outgoing heat and its current concentration, each contributor can be assigned an estimated Global Warming Potential (GWP) relative to CO_2 which has been arbitrarily set at one. The Intergovernmental Panel of Climate Change (1990)[3] has tabulated (Table 2) the following GWPs:

Table 2. **Atmospheric lifetimes, concentrations (as at 1989) and global warming potentials (GWP) of the most important greenhouse gases (GHG). Source: IPCC (1990)[3]**

GHG	Lifetime (year)	Concentration in 1989 (ppmv)	GWP Integration Intervals (years) 20	100	500
Water vapour	0.02	3000	ng	ng	ng
Carbon dioxide	120	350	1	1	1
Methane	10	1.7	63	21	9
CFC-11	75	0.00025	4500	3500	1500
CFC-12	110	0.00045	7100	7300	4500
Nitrous oxide	150	0.310	270	290	190

Notes: ppmv parts per million by volume ng not given

Table 3. **Contribution of anthropogenic emissions (as at 1990) to potential global warming. Source: IPCC (1990)[3]**

GHG	1990 Anthropogenic Emissions (Mt)	Proportion of Total Effects for Differing Integration Intervals (%) (years) 20	100	150
Carbon dioxide	26000	51	68	81
Methane	300	37	17	8
Nitrogen oxide	6	3	5	4
CFC-11	0.3	3	3	1
CFC-12	0.4	6	7	6
		100	100	100

Notes: Mt Megatonne

Combining GWPs with rates of release allows the total contribution of each greenhouse gas to be calculated (Table 3). Carbon dioxide contributes over half the emissions and is therefore the biggest contributor to global warming.

The most detailed work on the geographic and industry sector contributions to the greenhouse effect has concentrated on CO_2. The International Energy Agency (IEA 1989)[3] presents the following analysis for 1988, 1995 and 2005 (Table 4).

Table 4. Percentage share of global carbon dioxide emissions contributed by world region. Source: IEA 1989[3]

Region	CO_2 Emission (%) 1988	1995	2005
North America	25.1	23.4	20.7
OECD Europe	14.5	13.7	12.5
OECD Pacific	5.8	6.1	5.9
E. Europe & CIS	23.5	22.5	21.8
Less developed countries	31.0	34.3	39.0

For industrial sources, a background paper by the Ministry of Commerce (MoC 1991)[1] provides a breakdown in which, interestingly, the CFC percentage proportion differs markedly from that in Table 5, which is 16%. Energy production and use, of which transport is a major component, contributes 57% of the global greenhouse impact mainly in the form of carbon dioxide.

Table 5. Global greenhouse gas sources (GHG)(%) produced by different sources. Source: adapted from EPA (1991)[3]

Source of GHG	% GHG
Energy production & use	57
CFC use	16
Agriculture	16
Land use changes	8
Industrial processes	3
	100

The complexities and uncertainties in projecting the effect on world temperatures and the associated economic and ecological impacts are challenging. Emsley (1992)[3] writes that from a survey of 400 leading climate scientists conducted by Greenpeace International, only 15 were willing to reply that they thought man-made global warming was likely. Indeed some scientists argue that the complexities and uncertainties are such that the measuring "do-nothing" option is appropriate, e.g. Moran and Chisholm (1991)[3].

The EEC concludes:

> *" Although scientific evidence is not conclusive as to the scale of the problem, there is general agreement that the high atmospheric concentrations of "greenhouse gases" will have an effect on the earth's climate causing the "warming" of the globe and the ensuing rise in the average sea levels. "*

The Industry Commission (IC 1991)[3] wrote:

> *"The greenhouse effect is a well understood natural phenomenon. But what is not clear is how increasing emissions of greenhouse gases from human activity will affect the world's climate. "*

In the UK the emission inventory approach has estimated that vehicles are responsible for 14% of CO_2 emissions. The equivalent figure for the United States is 24% and for Australian 28% while on a global scale a value of 15% has been estimated. The contribution to other greenhouse gases is less well known but on the basis of best available information it appears that transport sources are responsible for between 8% and 10% of greenhouse gas levels. However another source in Australia has estimated 15%.

Table 6. Carbon dioxide emissions (kilotonnes per petajoule) by road and rail, according to fuel type, for Australia. Source: IC (1991)[3]

Fuel Type	Petrol	Diesel	LPG	Electric	Coal	Industrial Diesel
Road	71.2	73.8	65.0			
Rail		73.8		25.3-28.7	94.2	70.0

While New Zealand contributes only a small proportion of the global emission of greenhouse gasses there is a firm commitment to the international and domestic policy of control of greenhouse gas emissions. There is an ongoing programme of work into the climatic changes that may arise as a result of global warming that considers:

- Land use production changes
- Ecological effects
- Hazardous events

The issue is first of substantial scale in terms of the contribution of transport to the problem and second of major significance in terms of the potential effects of climate change and its implications for sustainable management.

The Ministry for the Environment has a programme of work and research on the issues and these will enhance understanding of the state and significance of the overall problems. The specific contribution of the transport sector in New Zealand will require further research and monitoring if the scale of effect is to be more accurately judged.

Transit New Zealand has included two research studies in the 1992 Research Programme to look further at methods to assess the monetary value of limiting carbon dioxide emissions. New Zealand should look to develop a programme of research that takes full advantage of worldwide effort in this topical area and is able to interpret these findings to New Zealand conditions.

2.3.3 Effects on Water Systems

The development and operation of transport infrastructure can have an impact on the water resources on the area. The amount of paving on streets, roads, carparks, railway stations, etc., reduces the area through which water can penetrate the ground surface and enter groundwater storage areas. The run-off from transport infrastructure is polluted by the emissions from vehicles and by surface and tyre degradation in both soluble and particulate form. The pollutants include rust, petroleum hydrocarbons, tyre rubber, lead, brake lining and brake pad particulates, dust and dirt are which are all washed into surface streams or percolate into ground water. The volume of traffic, and the characteristics of pavement and road, all have a direct bearing on the degree of polluted run-off with significant variability between sites.

The quality of water can also be affected during project construction and maintenance with concentrated run-off from exposed areas, modifying of water courses and drainage patterns.

While highways occupy only 5-8% of the urban catchment area, highway drainage can contribute as much as 50% of the total suspended solids, 16% of total hydrocarbons and 75% of the total metals discharged to streams.

The pollutants discharged in road run-off may affect the receiving area in two ways: initially through the immediate impact of the pollutant on the environment, and gradually through the build-up of pollutant concentrations, typically those in sediments.

Construction-related problems can be ameliorated with appropriate measures. Control of operational effects rely on traditional gully trap stormwater systems and drainage ditches. The scale of effect is most evident in urban areas. Stormwater treatment is being seriously considered in some major centres including Auckland and Christchurch.

There is evidence that stormwater pollution in urban areas is having as severe an effect on the environment as that caused by overloaded systems that combine sewage and stormwater. However sewage discharges are largely organic and biodegradable so their impact is transient, while stormwater-sourced sediments and heavy metals are much more persistent. Some urban areas and most rural areas in New Zealand do not have stormwater sediment traps for controlling water pollution so that the stormwater is passed directly into the drainage system and is discharged unchanged to the receiving water. The severity of the

problem is beginning to be appreciated and efforts to address stormwater pollution are increasing throughout New Zealand.

The problem has been incurred recently when, to keep New Zealand's major ports operational, polluted sediment brought in by urban stormwater systems must be dredged and disposed of elsewhere. In other words, the maritime transport system has inherited a significant environmental problem from the land transport system.

Run-off from railway formations can also be significant. Discharges include oils, heavy metals, brake pad dust, and faecal bacteria and viruses from untreated human sewage from passenger trains.

The effects of new transport projects on water quality are regularly assessed in environmental impact assessments but the effects do not generally emerge as key determining factors because of the ability to ameliorate the worst impacts and protect sensitive environments.

To better understand the national scale and significance of the effects of stormwater pollution there is a need to understand the accumulation rate of pollutants on different types of roads, both urban and rural, and on different pavement surfaces. This will provide a clearer estimate of traffic load generation and also will enable priorities to be established for mitigation through pretreatment and road management.

2.3.4 Noise

In most countries transport noise in urban areas is a significant problem for a large proportion of the population. In OECD countries, it is estimated that 119 million people are exposed to levels over the acceptable limit of 68 decibels (ECMT 1990)[3]. In Australia, surveys reveal high levels of annoyance for people from transport noise (Munro 1990)[3]. The vast majority of this noise comes from road traffic, excluding cycling and walking which have the lowest noise impact.

Community response to noise occurs when annoyance is caused by disrupted sleep, disrupted conversation and interference with activities. Noise pollution is the factor most often cited by complainants about road development projects.

Individual vehicle noise is a combination of noise produced by the engine; the transmission; the exhaust; combustion air intake; the interaction of tyres and road pavement; air turbulence; body and load rattles; and the occasional anti-theft alarm. Apart from individual vehicle noise there are five main factors upon which the level of road traffic noise depends: traffic volume; traffic speed; traffic composition (i.e. percentage of heavy vehicles); road gradient; and pavement texture. In addition there are six major factors that influence the propagation of traffic noise: road profile (at grade, depressed or elevated); distance from the source to the reception point: topography between the source and the reception point; presence of screening (by fences, earthmounds, barriers or buildings); and weather.

A study of the 14 countries shown in Table 7 suggested that between 5% and 31% of the population were exposed to road traffic noise levels of over 65 dB(A), in comparison to between 0.4% and 4% for equivalent noise levels from railways (OECD 1990)[3].

However there are difficulties in comparing road and rail noise. Whereas road noise tends to be continuous with little variation in frequency or amplitude, rail noise is discontinuous with extensive variations in frequency and amplitude. Also for the same amount of freight or number of passengers at the same speed, rail has been estimated to be on average 5 to 10 decibels quieter than road transport noise.

While considerable work has been done in New Zealand on noise prediction and the refinement of noise prediction models, there is no reliable estimate of the number of people affected by transport noise.

Table 7. Percentage of populations of northern hemisphere countries exposed to road transport noise in the early 1980s. Source: OECD (1988)[3]

Country	Sound Level in Leq (dB(A)) Outdoor					
	*	>55	>60	>65	>70	>75
Japan	a,d	80.0	58.0	31.0	10.0	1.0
Spain	a	74.0	50.0	23.0	7.0	1.0
Belgium	a	69.0	39.0	12.0	1.0	-
Switzerland	a	54.0	28.0	11.0	4.0	1.0
Austria	a	50.0	35.0	16.0	7.0	1.0
Greece	b	50.0	30.0	20.0	10.0	2.0
UK	a,e	50.0	25.0	11.0	4.0	0.6
France	a	44.0	25.0	13.0	4.0	0.4
Netherlands	a	40.0	18.0	6.0	0.6	-
Denmark	b	38.0	24.0	12.0	4.0	1.0
Sweden	b	38.0	24.0	11.0	4.0	1.0
USA	b	37.0	18.0	7.0	2.0	0.4
Germany	a	34.0	17.0	8.0	3.0	-
Norway	b	18.0	10.0	5.0	1.8	-
Europe	c	47.0	-	12.5	-	-

* Notes a: Daytime Leq (6-22 hours)
b: Leq over 24 hours
c: Percentages are cumulative and not additive (e.g. % persons exposed to >55 dB(A) includes % persons exposed to >60 dB(A), etc.)
d: OECD estimates
e: Road traffic noise: Leq averaged (06.00-24.00), 1973 survey, England only

In general, New Zealand has achieved a high standard of residential amenity when compared with many OECD countries and would therefore fall at the lower end of the OECD countries listed in Table 7. If it was assumed that the percentage for New Zealand lay in the range of 5-9%, then between 160 000 and 300 000 people would be subject to the adverse effects of road transport noise.

It would be possible to gain further insight into the total number of people affected by transport noise by reviewing all noise-modelling exercises undertaken in New Zealand and their interpretation against land use data. It would also be valuable to look at the detailed methodology used in the OECD studies to make more accurate interpretation of the applicability of that work to New Zealand.

Various attempts have been made to assess the cost of noise but these tend to take into account quantifiable factors such as productivity loss, medical expenditure and reductions in the value of assets, together with the costs of various noise reducing measures. As such they tend to omit a number of less easily quantifiable social and environmental costs. However the cost of road noise in a number of European countries was estimated to represent between 0.06% and 0.2% of Gross Domestic Product, with Germany at 1.0% which reflects its higher noise standards. If applied to New Zealand the costs would range between $44 million and $150 million.

Noise is generally regarded as one of, if not the, most significant externality associated with land transport. It features as a major issue in most environmental assessments and is subject to careful scrutiny in terms of potential amelioration.

2.3.5 Vibration

Vibration from land transport combines both psychological and physiological elements, in terms of the body being subject to vibration combined with the effect on the condition of dwellings. It is generally perceived as nuisance or as worry about damage from rattling window panes and fittings that is often of greatest concern. There is little evidence of significant problems in New Zealand but the increase in long haul heavy goods vehicles most likely will increase the scale of effect for those living close to major routes in rural areas. Amelioration is best achieved by providing improved road surfaces and improved suspension of lorries.

As vibration nearly always occurs in association with noise, it can significantly increase the overall disturbance when it arises and therefore it can be of greater significance. Although the scale of the problem is not fully understood, the information on scale and significance does not merit a high priority for further research on its own but should be linked with any further work on noise.

2.3.6 Dust

Dust effects arise from construction effects and from unsealed roads. Road construction and maintenance in the vicinity of cropping and particularly horticultural operations can be a significant problem at certain times of the year. Operational effects impact on the road user

through increased vehicle operating costs which are internal both to the transport system and on adjacent land uses.

Although a recent review by Works Consultancy Services (1993)[3] recommended that further work be done on the economic disbenefits of dust, under current land use regimes the scale of impact on adjacent land uses is not considered to be a priority factor when compared with other environmental effects of land transport.

2.3.7 Disposal of Waste

Disposal of waste arising from the land transport system has increased significantly in recent years with an awareness of the issues associated with the sustainability of existing solid waste operations. The scale of the problem is substantially greater for road vehicles compared with rail. Waste products are made up as follows:

2.3.7.1 Used lubricating oil

An high proportion of used oil is now recovered and re-refined. However the re-refining process generates residues in the order of 5000 tonnes per year which are currently dumped at landfills. Research has shown that using residues as a bitumen extender for roads has proved to be successful. There are other potential uses for the oil such as furnace fuels.

2.3.7.2 Waste tyres

The number of waste tyres in New Zealand has increased with the increase in imported Japanese-assembled used vehicles (with used tyres) as well as Japanese-made used tyres. The effect has been to reduce the number of tyres that are being retreaded. While a small proportion of the country's used tyres are used by the farming community, e.g. to hold down plastic covers on silage pits, the supply far outweighs the demand. Most used tyres are disposed at landfills.

Research has been carried out on uses for road tyres on road-related works such as embankment stabilisation. In the USA legislation has been enacted in some states making it mandatory that ground-up tyres be used as a filler in publicly funded roading projects.

2.3.7.3 Lead acid batteries

The value of scrap lead means that recycling of batteries is common. There are however difficulties with recycling the polypropylene battery cases which may be contaminated by lead and other metals.

2.3.7.4 Waste vehicle bodies

Vehicle bodies are currently crushed and reprocessed through the scrap metal and steel industries, but a large amount of unwanted metal seating and glass still has to be disposed of at landfills. Estimates of the average life span of UK motor vehicles vary between 7-8 years and 12-14 years. In comparison the average life of the US car fleet between 1985 and 1989 was 7.6 years. For heavy goods vehicles average life is in the region of 8-10 years while for public passenger vehicles the figure is 14-18 years. Rail vehicles on average have a longer life of 30 to 40 years.

With total vehicle registrations in New Zealand at 2 400 000 in 1991 and an estimated average life span of 10 years, 240 000 waste vehicle bodies per annum would be generated.

It could also be argued that waste litter from vehicles and trains is waste arising from the land transport that should be taken into account.

The Ministry for the Environment planned in 1992 to commission further research on transport wastes which should assist in refining the scale of the problem.

2.4 Intrusion Effects

2.4.1 Visual Effects

The effect on the landscape and townscape of land transport projects is consistently addressed in Environmental Impact Assessment surveyed for this report. Amelioration measures are identified and incorporated into the cost of the project but residual effects that are not completely internalised include:

- The temporary effect of construction
- The temporary effect before revegetation plantings are established
- Residual effects on private views including the vehicles themselves
- Residual effects on the quality of the landscape

In general New Zealand roads are well integrated with the landscape although some site-specific effects may be significant. From a national perspective, changes in the transport system will include an element of transfer of costs between land owners/occupiers.

In some cases there is a direct trade off between the benefits to the road user of a scenic view from the road and the intrusion of the road into views from private properties. There may also be trade offs against other mitigation measures such as noise barriers and bands. Similar issues arise for rail transport.

These effects are generally difficult to quantify in collective terms, as they reduce over time or can be further reduced with a high standard of management and maintenance.

2.4.2 Plant and Animal Habitat

Loss and degradation of plant and animal habitats may result from the construction and operation of inter-urban transport infrastructure. The impacts are most severe in areas of native vegetation, coastal areas, wetlands and reserves. Impacts associated with construction are immediate and include:

- Removal of vegetation with subsequent loss of plant, bird and animal habitat
- Loss of topsoil
- Changes to natural drainage

Environmental degradation caused by the operation of interurban transport includes:

- Wildlife fatalities caused by collisions
- Effects on bordering vegetation such as windthrow, moisture loss, etc.
- Spread of introduced species of flora and fauna
- Spread of pathogens such as fungi
- Physical barriers to movement of fauna and causing habitat isolation
- Effects on water systems (discussed in Section 2.3.3)

There are no figures detailing the impact of, say, a kilometre of two-lane highway through a non-urban area. It would be impractical to attempt to establish "average" figures for these effects because of variations in terrain across the country, and impacts can only be determined on a case by case basis.

The NZ Institute of Horticulture have placed values on specific trees which are rare. More recently, habitat effects are being given greater weight in project environmental assessments. An example is the highway widening on State Highway 2 at Silverstream where habitat and visual effects have been of sufficient scale and significance to outweigh a benefit-cost difference of 3.5.

The scale of construction effects in recent times is not considered great but where effects do occur they are permanent and may have significant downstream ecological effects. Amelioration measures can normally only reduce effects in part.

2.4.3 Effects on the Physical Landscape

This factor relates largely to effects on land stability and soil erosion related to steep cuttings and embankments, and associated with both the operation and construction of transport infrastructure. The external effects relate to loss of productivity of rural land that has not been acquired for the road project.

The scale and significance are not high although the unusually high rainfall in the North Island in the spring of 1992 resulted in a very large number of earthslips in erosion-prone areas, only part of which were related to the effects of transport infrastructure.

2.4.4 Effects on Archaeological Sites

In recent years greater attention has been given to ensuring that archaeological sites are not unnecessarily affected by development of transport infrastructure. However it is not clear what the cumulative effect on such sites has been over the decades of development of the country's infrastructure.

The Historic Places Act 1980 places a major responsibility on the industry to seek specific consent to affect a known archaeological site and also requires physical work to cease if a site is revealed in the course of construction. This allows for specific archaeological investigation to be undertaken before further damage occurs. Many sites relate to maori occupation of the land and are of spiritual and cultural significance to iwi. However this may not be adhered to in all cases.

No evidence suggests that the problem is of such a scale that it should be given a high priority in assessing externalities.

2.4.5 Cultural and Spiritual Effects and The Treaty of Waitangi

Sites of extreme value to iwi have significantly greater value than that of archaeological sites. Iwi have many sites of spiritual and cultural value that are vulnerable to disturbance through transport development and maintenance. As with archaeological sites there is no information on the cumulative effect over the years on the area from the development of transport infrastructure, but more thorough consultation with iwi over new projects should ensure that adverse effects are minimised. Where effects do occur they are tending to be given a high weighting in terms of significance in environmental assessments.

2.4.6 Recreation Effects

Such effects includes the loss of public open space such as parks, beaches, reserves, etc. where the cost of land acquisition does not fully compensate the public value of the asset. Other issues may include adverse effects on access to a recreation facility such as foreshore. This cost may fall on the road user or other forms of land transport such as pedestrians and cyclists. Benefits of improved access to recreation facilities are internalised to the road user and taken into account by travel-time cost savings. The review of environmental assessments would indicate that the external effects are not of major scale and significance.

2.4.7 Strategic Effects

This factor includes both military and civil defence issues regarding security of access in an emergency. For example the civil defence issues have been taken into account in some projects such as the possible new SH1 route through Transmission Gully, but overall this factor is of low scale and significance in terms of external effects.

2.5 Interference Effects

2.5.1 Community Disruption

This factor is associated with the disruption associated with the development of new projects once they are underway. Construction effects can cause significant disruption particularly in urban areas, and this has been a factor in the community opposition to the extension to the Wellington Urban Motorway. It includes the need to manage the process of relocation of households and businesses and to minimise the stresses and other effects associated with the construction process.

Clearly there is a relationship with other construction effects such as noise and vibration. Amelioration is possible which internalises the effect if managed effectively. The residual cost to the community should not be of a scale that it needs to be given a high priority in externalities policy.

2.5.2 Urban and Rural Blight and Stress of Change

This factor is similar to that described in Section 2.5.1 above but focuses on the uncertainty and economic effects before construction and often before land acquisition. The effects may relate to the maintenance of community infrastructure, amenities and particularly buildings. Long-term blight can have community benefits in providing low cost accommodation for community-based activities and small firms, as has been the case in the Upper Cuba Street area of Wellington.

Other significant problems can occur where the developer is not prepared to take purchase action should the land owner be required to move. This action can result in significant external effects and was a major factor in the uplifting of the Levin Bypass route designation in the Horowhenua District Scheme.

This problem will be reduced in future because the Resource Management Act 1991 allows designations to remain for only 5 years before lapsing and will therefore require early land acquisition if a route is to be protected for the long term. Early land acquisition should also ensure that externality costs are of a minor scale.

2.5.3 Lighting Effects

Glare from headlights (both road and rail) and street lighting could be seen as an external effect, but in general it is carried by property owners who arrange their own mitigation through fencing or screen planting. The scale of effect and cost is not generally considered to be of great significance.

2.5.4 Community Severance and Accessibility

Transport infrastructure affects different parts of the community in different ways depending to some extent on mobility. Improved transport provides improved access to community, recreation and employment opportunities and has benefits for freight distribution. There is a tendency for road improvements to increase the reliance on the car which in itself creates other external costs such as noise, air pollution, etc. For those without ready access to cars the effect may be a decline in accessibility.

Severance is the divisive effect on communities that results from the provision and use of transport infrastructure. Feelings of danger, fear and intimidation are inhibiting factors that reduce the propensity to travel, effects which fall heavily on the young and the elderly.

There is no overall picture of the scale of the problem in New Zealand although Tate (1993)[3] suggests that a sample survey of communities using the proxy measure of management of children's travel to primary school could provide a clearer picture of the scale and significance of the problem.

Amelioration can be achieved through traffic management, traffic calming, pedestrian and cycle links, and provision of public transport.

Further research would be necessary if this factor was to be addressed in externalities policy.

2.5.5 Hazard Effects

A number of different types of transport-related hazards exist that can be argued to impose the following externality costs.

2.5.5.1 Personal safety/community vitality

This factor is in part related to severance in that traffic causes a perception of danger which in turn results in modified behaviour. Conversely in some town centres the removal of traffic can have a significant adverse effect on perceptions of personal safety and urban vitality. This is therefore in part a benefit to non-transport users, although the issue is somewhat marginal in terms of scale and significance and does not merit a high ranking for further attention.

2.5.5.2 Effects on cyclists and pedestrians

The introduction to this report identifies that cyclists and pedestrians have been considered as part of the land transport system and have therefore not been the subject of priority attention in this study. However it is clear that there are a range of potential effects of one mode on another and to some extent these have been discussed under Severance and Personal Safety/Community Vitality. This area therefore may require further consideration as part of the overall transport pricing study.

2.5.5.3 Alternative fuels and hazardous materials

The hazard associated with living or working adjacent to an arterial road or rail network is influenced by the scale and type of hazardous goods that are transported along that part of the network. This alludes to delivery of alternative vehicle fuels such as CNG and LPG and also to a wide range of industrial hazardous chemicals. The effect is one of marginally increasing risk as traffic of this nature increases, but to have any significant externality effect the risk would need to rise above normally accepted community levels.

The government has however proposed to establish an Environmental Risk Management Authority (ERMA) to deal with hazardous substances. The ERMA may impose charges to cover externalities associated with all phases of using hazardous substances, i.e. their production, transportation, storage, use, and disposal.

2.6 Urban Form and Land Use

Travel is a derived concept of accessibility that combines how conveniently land uses are located in relation to each other and how easy or difficult it is to reach those land use activities through the transport network.

The development of the land transport system improves accessibility and encourages a more dispersed form of urban growth. It is considered that residential location decisions take advantage of improved accessibility in terms of residence or work place location.

The very fact that this study is assessing the scale and significance of costs that lie outside the land transport system means that transport users, particularly road users, are not currently paying the full cost to the environment of road transport. This in itself has led to distortions in the market place that have encouraged peripheral and dispersed growth of urban systems.

This in turn imposes greater transport costs on the broader community, not only in terms of an increase in externalities but in the need for the capital cost of new roads servicing new areas of development that are traditionally paid for by local ratepayers together with some Transit New Zealand subsidy.

If both developers and transport users were paying directly the true costs of development and transport, both housing and transport costs at the periphery of urban centres would rise, leading to market pressure for a more concentrated form of urban growth.

For some of our larger metropolitan areas the present level of dependence on the motor vehicle, at least in its present form, is unlikely to be sustainable in the long-term.

These issues lie at the heart of sustainable management. The scale of the problem is greatest in cities such as Wellington and Auckland but all New Zealand cities will need to address these effects both in terms of their responsibilities under the Resource Management Act and the requirement to prepare a Land Transport Strategy under the 1992 Amendment to the Transit New Zealand Act.

As discussed this factor can not be taken on its own, and its significance is demonstrated by the need to pay the full cost of transport services. In many respects it forms the overriding issue that embraces all the other factors discussed in this section of the report.

2.7 Conclusions

The analysis in this section has sought to identify those externalities of greatest scale and significance. In many areas reliable information is scant. Areas of research that would assist in the understanding of the scale and significance of the most important factors have been identified.

The overarching issue that relates to most other factors is the relationship between transport and urban form. If the most significant pollution, intrusion and interference costs are internalised this will contribute significantly to addressing sustainable urban form. However this must be combined with mechanisms to ensure that developers pay the full costs of infrastructure associated with their developments.

From this analysis Priority 1 issues are considered to be:

Local Air Pollution
Impacts on the Global Atmosphere
Effects on Water Systems
Noise

Priority 2 factors are:

Loss of Natural Habitat
Community Severance
Disposal of Wastes

Recommendation 1 - Priority Effects

That the research plan should focus on addressing the priority issues of:

Local Air Pollution
Impacts on the Global Atmosphere
Effects on Water Systems
Noise
Urban Form - which has an overlapping relationship with the other factors

Recommendation 2 - Scale and Significance of Effects

That the research plan should focus on scale and significance of effects for:

Local Air Pollution

- **Review the methodologies used overseas to estimate the total cost of air pollution from land transport and to prepare an estimate of such costs for New Zealand**

Impacts on the Global Atmosphere

- **Monitor, in conjunction with Ministry for the Environment, world-wide research and co-ordinate transport-related research with other environmental research programmes**

- **Advance proposed research projects**

Effects on Water Systems

- **Undertake research on the accumulation rate of pollutants on different types of roads in terms of both road environment and pavement surface to provide a clear estimate of traffic load generation**

- **Identify priorities for mitigation through pre-treatment and road management**

Noise

- **Review overseas methodology on estimates of overseas population exposed to road noise and refine estimate for New Zealand**

SECTION 3

TECHNIQUES TO QUANTIFY AND VALUE EXTERNAL EFFECTS

3. TECHNIQUES TO QUANTIFY AND VALUE EXTERNAL EFFECTS

3.1 Introduction

As the research brief excludes consideration of congestion and safety issues, the aim is to focus on the long-term impact on the environment enjoyed by the non-user. However factors such as traffic congestion can not be entirely ignored as congestion costs are more often than not both highly and positively correlated with effects such as air pollution, vibration and noise.

It is also important to recognise that policies to optimise congestion costs for road users are unlikely to produce an optimal outcome in terms of the physical environment enjoyed by others.

Other factors are that congestion costs have effects on prices of all transported goods and also road-related accidents which create external costs in terms of additional demands on medical resources. Therefore the literature search has inevitably included the review of a large quantity of information on congestion and safety.

3.2 The Economic Definition of Externalities

Economists point to the importance of the definition of externality, yet the literature review demonstrated the lack of a coherent and consistent definition of externality. The economic definition of externalities requires a clear distinction between the real resource effects which are relevant and the pecuniary or transfer effects which are not.

Real gains only occur when transport investment enables existing resources to achieve a higher level of utilisation which does not adversely affect resource use elsewhere. It is argued that if a road makes an area economically exploitable for forestry, from which products are exported, the new production represents a real gain with no transfer effect.

There can be real resource gains through increased values on residential or commercial property, but few of the empirical studies consulted in the literature review attempt to disentangle the real trade-creating and pecuniary trade-diverting components in the value change.

Similarly many studies of regional impacts of schemes focus on inter-regional transfer effects - such as "business expansion", "business attraction" and tourism development (e.g. Seskin 1990)[2] - which from a national perspective are irrelevant or, worse, may detract from investment efficiency if they result in cross-subsidised local schemes in neighbouring districts competing against each other.

Further distinctions in externalities are between their public good attributes (Baumol and Oates 1988)[3], which relate to inability of private suppliers to recover full costs of supply because of either:

Non-excludability in consumption, i.e. it is impossible to exclude non-payers from enjoying the benefits provided; or

Non-rivalry in consumption, i.e. one person's consumption does not detract from that available for others, and so charging is inefficient in that it does deter additional use which could be accommodated at no additional cost (i.e. setting a price above the marginal cost of zero).

Pure public goods are non-rival and/or non-excludable and can only be provided by collective means, with cost recovery through taxation across the population which benefits. Goods and services which are non-rival but excludable at reasonable cost may be regarded as "club goods", financed by a combination of unit charges and fixed "subscriptions" levied across a definable population of beneficiaries: many local facilities (including some roads) fit this description. Rivalry but non-excludability are the determining characteristics of common property resources of which road congestion is an example - although new technology may make congestion more excludable. The ability to price external effects depends on correctly assessing their rivalry/excludability characteristics.

3.3 Valuing Effects for Policy Purposes

A primary aim of cost-benefit analysis, when used as a tool for public investment appraisal, is to identify and bring into account the divergence which exists between observed costs and benefits on which private decisions are made and the social costs and benefits felt in the community. The values required for an efficiency-oriented cost-benefit appraisal represent the loss of community wellbeing which would result from degradation of environmental resources which, for reasons of non-rivalry or non-excludability, may not be prevented through market mechanism. These include:

Current use values: are from both productive uses, such as agricultural outputs, and consumption uses, such as those from informal recreation, pleasant landscapes and so on.

Option values: correspond to a "premium" which the community may be prepared to pay to retain the option of using resources in the future. A variant is the **quasi-option value,** which corresponds to a premium which the community may be prepared to pay to defer transformation of the resource until fuller information on its potential uses is available in the future.

Existence values: are expressions of preference individuals may have for retaining resources irrespective of any expectation of future use. A variant is the ***bequest value***, an expressed preference to pass resources onto future generations.

Various techniques of non-market valuation are available, which attempt to impute values either by observing revealed preferences in actual behaviour, or by inquiring into stated preferences elicited from hypothetical market-like processes. These supplement more direct estimates of costs involved in environmental changes caused by transport.

Broad categories identifiable are:

(a) Opportunity costs of lost output values, usually derived from market prices adjusted for transfer items like taxes and subsidies.

(b) Indirect costs derived from market responses, such as costs incurred on installing insulation against noise pollution.

(c) Willingness to pay (WTP) or willingness to accept (WTA) compensation for changes in environmental status through "revealed preference" techniques.

(d) WTP or WTA compensation through "stated preference" techniques.

(e) "Shadow project" estimates which use the cost of replacing, removing or recreating a threatened resource elsewhere as a proxy for its lost value (a pragmatic but theoretically incomplete approach to environmental valuation).

All the approaches with the exception of (d) above are based on current observed prices, and hence reflect only current use components of value. Stated preference techniques are the only means of estimating option and existence values of resources with non-rival or non-excludable characteristics. Non-market valuation methods most commonly encountered are:

Travel-cost analysis: a revealed preference technique which analyses travel costs of a current recreational patterns to derive a demand curve for particular sites. This has a number of drawbacks in application, including how to handle travel costs incurred jointly by visiting more than one site (Clough and Meister 1991)[3]; how to value the travel time; and how to allow for demand from those who do not use the resource in the survey period. It depends on a survey of users taken on site, and works best with a wide catchment area within which there are marked variations in travel costs (i.e. rural, rather than urban, sites).

Its main application to date has been on discrete recreational resources such as national parks, but it could conceivably be used in cases where, for instance, a transport development required the destruction or modification of a natural or culturally significant site which attracts widespread recreational use.

Hedonic pricing of amenity attributes: a revealed preference technique that employs multiple regression of house sales data to isolate the "neighbourhood amenity" component in house prices. It has an eminent requirement of cross-sectional data (time-series would allow too many other factors to change) and can suffer from multicollinearity (an econometric problem in which two or more of the explanatory variables in a regression analysis are highly correlated with each other), due to inter-related variables; distortions in the housing market; and intertwining of current and some future use values which can lead to overvaluation of the amenity attribute. In New Zealand this technique has been used to value the amenity impact of the Auckland gas pipeline (Kask et al. 1989)[3] and could conceivably be used for impacts of other network facilities such as roads and railways or airports. It has also been used to value safety by analysing wage rates for jobs with different levels of risk, and it could conceivably be used to examine costs of different transport modes

to establish the value of safety in each one. But its practical application is limited by the volume of data required, and it does not clarify the transfer and real resource components of price differentials.

Contingent valuation: a stated preference technique which entails surveying respondents to elicit their behaviour in the context of a hypothetical "market" existing for the resource in question. It requires careful application to avoid a number of well-documented biases which may be introduced, but under certain circumstances it can be designed to replicate closely the behaviour of actual markets (e.g. for hunting permits, Cummings et al. 1986)[3]. A common application is valuing wildlife resources (Kirkland 1988)[3] or recreation resources (Weber et al. 1992)[3] but it has also been used for valuing safety improvements (Guria and Miller 1991)[3]. It is the only technique which purports to elicit information on all three value elements outlined above (p.46) - current use, option and existence values - and could be applied to transport projects which impinge on these, given the time and resources to conduct the necessary survey and analysis.

These three non-market techniques are relatively data-intensive and have not been widely applied in New Zealand. Each has well-documented limitations and as yet unresolved problems in application, and some of the imputed values for resources have been so large as to raise questions about the validity of results. However, their main drawback for applying to sustainability issues is that "by their nature such studies are usually case specific and hence general valuations do not emerge" (Button 1990)[1]. They do not yield marginal values which can be extrapolated beyond the specific study areas. In the studies carried out to date in New Zealand, the question these techniques have been applied to address has been "What reduction in community welfare would result if this resource were lost in its entirety?". The revealed preference techniques cannot be structured to reveal values for incremental changes in quantity or quality of a resource. Contingent valuation could be, but only by making studies considerably more complex than those already conducted.

All the non-market values outlined above are derived from human preferences about resource use. The Resource Management Act places emphasis on "intrinsic values", which it defines as "those aspects of ecosystems and their constituent parts which have value in their own right"; in particular intrinsic values address biological and genetic diversity, and the essential characteristics of an ecosystem's integrity. This definition implies a non-instrumental "intrinsic worth" which is not dependent on human preferences, and emphasises the importance placed on environmental protection over efficiency in the aims of the Act.

A report by the UK Transport and Road Research Laboratory (TRRL 1992)[3] attempts to assess the various valuation approaches to different transport effects. Specifically it considers the appropriateness to costing transport effects of market-derived opportunity costs (OC), hedonic pricing (HP), travel cost method (TCM), contingent valuation method (CVM), "shadow projects" (SP) and indirect costs (IC) as summarised in Table 8. "X" denotes clear applications of the techniques and "?" indicates applications where there are some difficulties. For instance, it is difficult to isolate separate effects of noise, pollution and visual intrusion using hedonic pricing, contingent valuation or indirect cost valuation (e.g. insulation against sound also has heating benefits). Note also that valuation of driver stress is proposed through analysing costs incurred in avoiding stressful situations (e.g. the added costs of diverting onto a longer route to avoid congestion). Although listed as "travel cost analysis" by TRRL

(1992)[3], analysing travelling costs in this matter is more akin to an indirect cost procedure than to the travel cost method of site valuation. Table 8 sets out in more detail the application of these techniques to a wide range of externalities (TRRL 1992)[3].

Table 8. Application of valuation approaches to transport effects. Source: derived from TRRL (1992)[3]

Effects	Valuation Approach					
	OC	HP	TCM	CVM	SP	IC
Property demolition	X					
Land take	X		X	X	?	
Traffic noise		X?		X?		X?
Visual intrusion		X?		X?		
Air pollution		X?		X?		
Community severance						X
Loss of natural/cultural sites			X?	X		
Impacts on pedestrians/cyclists				X		
Construction disruptions		X?		X?		X?
Driver stress			X	X		X

Notes: OC Opportunity costs; HP Hedonic pricing; TCM Travel cost method; CVM Contingent valuation method; SP Shadow pricing; IC Indirect costs

Application of travel-cost analysis to transport effects can be expected to be limited to situations where the resource under threat is well defined, geographically concentrated, and has near-unique attributes which would suffer transformation from its current use by the proposed development. This is likely to be misleading where there are adequate substitutes for the resource being threatened by transport developments, but it can be useful in the absence of such attributes.

With regards to contingent valuation methods, "validation" of estimates remains the technique's main weakness. It has been shown to be comparable for goods which are rival and excludable to some degree (such as hunting permits), or in other abstract "laboratory" tests, but validation of non-rival non-excludable resources remains problematic, particularly since the values derived are often very large. One approach to this problem is to undertake more than one contingent valuation of the same effect: Guria and Miller (1991)[3] asked respondents five separate questions to ascertain their willingness to pay for risk reduction, before concluding that the range of results was sufficiently narrow to recommend a final result near the mid-point. Despite its drawbacks, contingent valuation remains the non-market valuation technique with widest potential application to transport externality effects.

Table 9. Monetary appraisal techniques and environmental effects of road schemes (from TRRL Report 1992)[3]

IMPACT	MONETARY APPRAISAL TECHNIQUE					
	Present Analysis	**Indirect Costs (IC) or Opportunity Costs (OC)**	**Contingent Valuation Method (CVM)**	**Hedonic Pricing (HP)**	**Travel Cost Method (TCM)**	**Comments/Recommendations for potential technique**
Time savings	Monetised					No Change
Vehicle operating costs	Monetised					No Change
Accident reduction	Monetised					No Change
Construction Costs	Monetised					No Change
Land Costs	Monetised					No Change
Compensation Costs	Monetised					No Change
Maintenance Costs	Monetised					No Change
Demolition	Monetised					Total Economic Value may exceed market price - no change
Land take	Monetised and quantified (area, land quality)	a. Use of output value b. Cost of substitutes c. Shadow project for public open space	For open space		For open space	No change if competitive
Traffic Noise	Quantified (number of premises identified in either distance from road bands or by level of noise change)	Based on insulation and noise barrier costs for all property	Problems with perception of noise - further research required		Indirect methods initially. Possibly CVM in future	
Visual Obstruction	Quantified		Research required			No change
Visual Intrusion	Deacriptive		Possible use in limited cases			Combination of description and CVM
Community Severance	Descriptive/ qualitative		WTP to avoid severance			
Agriculture	Monetised including compensation and accommodation works	For severance, noise air pollution and land take impacts				Current compensation give indication of values

IMPACT	MONETARY APPRAISAL TECHNIQUE					
	Present Analysis	**Indirect Costs (IC) or Opportunity Costs (OC)**	**Contingent Valuation Method (CVM)**	**Hedonic Pricing (HP)**	**Travel Cost Method (TCM)**	**Comments/Recommendations for potential technique**
Air Pollution	Quantified when assessed	Dose-response relationship required				Indirect method
Built Environment/ Heritage	Descriptive	a. Dose-response b. Cost of re-routing	For well defined sites especially with high existence value		For well defined sites with high existence value	CVM in general but also indirect and TCM are appropriate
Ecological Sites	Descriptive	Shadow projects: defensive exp; management costs; relocation of habitat & re-route highway	For important sites			CVM for important sites (NNNRs, SSSIs)
Pedestrians & Cyclists	Descriptive	Extension of COBA values of time	For value of time and amenity			Extend COBA and CVM
Disruption during Construction	Descriptive/ qualitative	Compensation payments; insulation costs capitalised but only for duration of works	WTP to avoid disruption/ severance effects			Comprises noise, construction vibration and severance. Similar techniques are recommended, i.e. indirect & CVM
Night Time Noise		Extend noise assessment to include extra premises affected by night noise (insulation costs)				Indirect method initially; possibly CVM in future
Urban Blight		a. Review compensation payment b. Maintenance expenditure			Extra time/ distance to facilities	Combination of indirect and TCM are appropriate
Driver Stress			Possible use in limited cases		Possible use in limited cases	CVM and TCM

Further important issues include regarding separate value estimates as additive, and the reliance on perceived effects rather than objective measures in contingent valuation responses. TRRL (1992)[3] notes that "no study has attempted to derive values for such a comprehensive range of impacts from a single development" and concludes that experience in applying the techniques should be gained on comparatively simple examples, e.g. the loss of public open space where other impacts are minimal.

3.4 Application of Valuation Procedures

Non-market valuation techniques could be applied to the land transport system in two ways:

Specific project appraisals: where a valuation is obtained for a non-market effect, e.g. loss of wildlife habitat from transport infrastructure construction, it can be incorporated explicitly in a cost-benefit analysis. In some cases these results may have general application: e.g. an average value of transport safety can be incorporated as a "value per life saved" in safety features applied across all project appraisals (Guria and Miller 1991)[3]. However for a number of reasons outlined above, caution is required as to what extent standards values can be applied.

A basis for road pricing: because these techniques provide estimates for discrete, rather than continuous, changes in environmental quality and do not provide marginal values, they do not directly indicate what rate of "corrective charge" is required to remove the divergence between private and social costs. In principle, contingent valuation could be used to value gradations in WTP and WTA for different levels of environmental effect, which could then be the basis of a corrective charge in some circumstances. But to date most studies have been location specific and their results are not so readily applied to other situations. If the environmental costs of building a transport facility such as, a toll road or rail-line, can be internalised into its provision, they could be recouped from user charges. Before this can happen, a major exercise in applying non-market valuation techniques to transport issues in a variety of New Zealand settings would appear to be necessary.

3.4.1 Noise

The environmental cost which attracts most research in urban areas is the loss of comparative peace and quiet. Serious noise problems (usually defined as noise levels above 65 dB(A)) also exist around major airports. High noise levels affect concentration and productivity and, by causing a loss of sleep, affect health. Measures of consumers' willingness to pay associated with different levels of noise have been derived by the estimation of hedonic price functions using data on the prices of houses with exposure to different levels of noise.

Pearce and Markandya (1989)[3] have produced evidence on traffic-noise nuisance from the USA, using hedonic techniques, that suggests values of between 0.08% and 0.88% of the house price per one dB(A) change in Leq, with somewhat higher values being found in Swiss and Canadian cities (see Table 10). Similar ranges of values are found in the context of aircraft-noise nuisance.

The characteristics of the hedonic pricing technique is that it seeks to filter out the impact of noise effects from all other house pricing attributes. One study that looked at proximity to highway issues in a broader sense was undertaken in Washington by Palmquist (1982)[3]. The study concluded that property prices in the area of a new highway increased at a faster rate than other areas because of the value of improved accessibility. However houses close to the highway suffered negative effects because of noise by 0-7.2% depending on the noise level and character of the neighbourhood. These studies have generally been location specific and cannot be used as a guide to effects in New Zealand. Furthermore the concern is that the method does not distinguish between real and transfer elements in value change.

Overall hedonic pricing has produced inconsistent results for noise effects. Contingent valuation is not appropriate because the impact is difficult to specify. TRRL argue that, to use contingent valuation, an adequate noise nuisance quality index needs to be developed relating to the magnitude of noise to impact on amenity and health.

Indirect costs are often used at present such as noise insulation of buildings and external mitigating measures such as noise barriers. Such costs are only a partial measure because they take limited account of noise effects outside buildings. Also other effects of noise insulation such as heating savings are not included and as a result willingness to pay for noise reduction may be overstated.

Table 10. The impact of traffic noise on house prices (% of house price). Source: Pearce and Markandya (1989)[3]

Location	Impact on House Price of one unit change in Leq (% house price)
United States	
North Virginia	0.15
Tidewater	0.14
North Springfield	0.18-0.50
Towson	0.54
Washington	0.88
Kingsgate	0.48
North King County	0.30
Spokane	0.08
Chicago	0.56
Canada	
Toronto	1.05
Switzerland	
Basle	1.26

Notes: Equivalent continuous sound level (Leq) = a level of constant sound (in dB(A)) which would have the same energy over a given period as the measured fluctuating sound under consideration

3.4.2 Air Pollution

In terms of property value the evidence from Pearce and Markandya (1989)[3], on seven large North American cities is that the percentage fall in property value for a 1% rise in air pollution is in the range 0.01-0.22%, with part of the variation explained by the nature of the pollution.

Most countries do not include monetary costs of emissions in transport appraisals. Nearly all undertake Environmental Impact Assessments which measure emissions in non-monetary units and necessitate trade-offs of emissions with monetised benefits.

Sweden and Denmark are exceptions as both include emissions directly in their cost-benefit appraisals of road projects. Sweden includes a value of 15 500 Swedish Kroner for every person suffering carbon monoxide levels above World Health Organisation guidelines. Denmark includes a value of 1 650 Danish Kroner per household. Interestingly, the two values differ markedly as the Swedish valuation is ten times more than the Danish valuation.

3.4.3 Visual Effects

Visual effects are not well suited to contingent valuation methods because the visual effect is difficult to isolate from other impacts such as noise. Clearly the values would be location specific and few studies have been identified.

3.4.4 Community Severance

A partial evaluation of community severance based on the value of the additional journey time to reach social/community facilities has been used in Denmark, Sweden and Germany to value severance effects. These values make no allowance for psychological and loss of amenity impacts. Contingent valuation is the only technique that can, in theory, place values on these effects. Hedonic pricing is inappropriate because the local nature of severance restricts the availability of the house price changes which are needed for estimating the value of the effect.

3.4.5 Plant and Animal Habitat

It is critical that ecological impacts are well understood. Specific ecological sites can in principle be valued using contingent valuation or travel cost methods. But it is essential that each aspect of the functions or uses of the ecological system of the area is understood. For example a wetland may provide flood alleviation, pollution/nutrient trapping, spawning and recreational functions amongst others.

In some cases shadow project costs have been considered such as:

- Expenditure on protecting the existing site;
- Increased management costs to maintain the site following new road construction;
- Costs of relocation, restoration or recreation of the habitat.

It should be recognised that the Resource Management Act embraces the concept of environmental compensation and allows a wider range of conditions to be attached to projects thus ensuring that overall resource management values can be protected.

For many of the remaining effects identified in this study, willingness to pay/contingent valuation methods could be used but they would be resource-demanding, and care would be necessary in devising appropriate methodologies.

3.4.6 Aggregation of Environmental Costs

Aggregating the results of individual studies to provide some global impression of the overall environmental costs of transport is problematical. The very tentative indications produced by Quinet (1989)[3](see Table 11 for example), are that the total costs of transport constitute overall about 23% of the gross domestic product of most industrialised economies. This can be compared with an OECD (1990)[3] estimate of 2.5% of GDP.

However these figures are derived using a diverse range of methodologies and it is far from clear that the individual elements are necessarily comparable. Looking at the issue from another perspective, estimates from the USA indicate that, if the associated noise, air pollution and accident costs which are not internalised were added to road vehicle operating costs, these would rise by 20% to 33% (Deakin 1990)[3]. Button (1990)[1] argues that such aggregations are almost certainly understatements. Certainly the list of items is not comprehensive when compared with the list identified in this report. In particular there is a tendency when evaluating environmental damage to consider only the direct impact on those immediately affected. However it is becoming recognised that there are other economic costs, such as existence values and option values discussed earlier in Section 3.3.

Table 11. Broad estimates of the costs of selected environmental damage related to land transport, expressed as percentage of gross domestic product (GDP). Source: Derived from Quinet (1989)[3]

Environmental problem	Costs (% of GDP) from Land Transport	
	Road	Other transport modes
Noise	0.10	0.01
Pollution	0.40	-
Accidents	2.00	-
Total	2.50	0.01

3.5 The New Zealand Response

The database for valuing externality effects in New Zealand is extremely limited. Thus a strategy for valuing external effects should focus on valuation studies that address the priority 1 effects identified in Section 2.7. The methods with greatest potential application to transport are Contingent Valuation and Hedonic Pricing. Research priorities should balance the need to generate New Zealand data with comparative analysis of overseas studies. This requires at least one major exercise in New Zealand using each of these methods for specific transport issues. Greater confidence in the representative accuracy of the results would come from either:

- Repeating the exercise in more than one location, or
- Structuring a large exercise sufficient to differentiate between subgroups in the results.

The New Zealand application should be consistent with methodologies used elsewhere to facilitate comparison. If the methods yield results that are comparable to those elsewhere, scaling factors could be devised to translate a wider range of overseas results to New Zealand situations. For example if suburban studies in New Zealand yield similar results to suburban studies overseas, it may be possible to scale city centre studies from overseas to New Zealand conditions without undertaking another full study.

Priority should also be given to areas which lack a current specific policy commitment. This is particularly relevant to global atmosphere effects where Government has set specific policy targets. Research effort in this area should focus on the means of reaching those targets rather than valuing the external effect.

3.6 Quantification of External Effects

Attempts to value effects clearly have the advantage of a common measure of effect in dollar terms. Quantification involves the development of methodologies to measure external effects in non-monetary terms. There are two elements to this, first the quantification of individual effects and second, overall appraisal techniques to arrive at a conclusion.

Transit New Zealand commissioned consultants Chivers, Allan and Hunt (1992)[3] to investigate and improve on existing techniques for quantifying intangible effects. This work recommended the following quantification techniques and changes to existing practices.

Noise: Continue with the existing techniques shown in the Transit New Zealand Project Evaluation Manual which focus on measurement and prediction models for $18hL_{10}dB(A)$. Other criteria that are used in conjunction with the predictions are:

- Number and length of frontage properties affected;
- Description of the types and numbers of those people and properties affected and degree of effect.

Vibration: Vibration is measured using an accelerometer and recording equipment. Peak particle velocity (mm/s) and peak amplitude (mm) are measured.

Community Severance: The study recommended a combination of time delays in crossing roads with a number of qualitative factors such as:

- Resulting changes in destinations;
- Suppressed trips related to fear and intimidation;
- Management of young children and effects on the elderly.

Local Air Pollution: The existing instructions refer to air quality standards for carbon monoxide, nitrogen oxides, lead, and photochemical smog measured in mean concentration (mg/m^3) over a specified period of measurement. Chivers et al. (1992)[3] suggested using only carbon monoxide as the first indicator to assess the scale of the problem.

Visual Impact: Techniques recommended include:

- Visual Obstruction - use measurement of solid angles.
- Visual Intrusion - use the VAMPLAN method of evaluating landscape quality.
- View from the road - use the Smith and Smith (1991)[3] drive-over technique for scenic quality.

Effects on Water: Possible use and cost of environmental clean up.

Ecology: Measurement of areas affected, relative risks to species diversity and abundance, and synthesis of shadow projects.

3.7 Conclusions

A range of non-market valuation techniques is available for application to transport externalities but no one technique is suitable for all factors. Hedonic pricing and contingent valuation methods offer the greatest potential.

The database for valuing external effects in New Zealand is limited. The research strategy should focus on valuation studies that address the priority 1 effects identified in Section 2 and include comparative analysis with overseas studies.

Recommendation 3 - Valuing Externalities

That the research plan should focus on valuing externalities and:

- **Undertake New Zealand studies that assess priority effects using hedonic pricing and contingent valuation methods: methodology to be consistent with overseas methods**

- **Follow up with comparative analysis and scaling study to establish more reliable values for New Zealand**

The recent study by Chivers et al. (1992)[3] on quantification of intangibles has been reviewed. The study included recommendations for further research.

Recommendation 4 - Quantification of Externalities

That the research plan should focus on quantification of the following externalities:

Visual Impact

Visual Obstruction

- **Trial the UK Manual of Environmental Appraisal (MEA) procedure on a typical New Zealand roading project**

Visual Intrusion

- **Further investigate visual impact techniques before choosing a suitable method**

View from the Road

- **Follow up on the drive-over technique for quantifying a scenic landscape reported by Smith and Smith (1991)[3]**

Special Areas

- **Identify techniques and costs for moving all buildings and replacing lost or damaged ecological areas, and produce guidelines**

Effects on Water

- **Carry out before and after studies of the effects of road construction on water quality: also investigate the range, costs, and benefits of mitigation measures**

Overshadowing

- **Investigate usefulness of non-market valuation techniques**

Global, National or Regional Environmental Goals

- **Investigate how conformity or otherwise with such goals should be quantified**

Miscellaneous

- **Monitor the possible significance of wind, litter, security, urban blight, and pedestrian and cyclist intimidation**

SECTION 4

APPROACHES TO TREATING EXTERNALITIES

4. APPROACHES TO TREATING EXTERNALITIES

4.1 Introduction

This section of the report seeks to identify and review the range of mechanisms and instruments used to address effects and costs that exist outside the land transport system, i.e. of the externalities. Initially the range of instruments and their general characteristics are discussed and then the more specific tools available to deal with each of the Priority 1 effects are discussed in turn.

In practice a range of measures is likely to apply to transport questions and, in reviewing transport policy in a range of countries, it has been found that attributing mechanisms to particular effects entails a degree of artificiality. In most countries policy packages have been developed that embrace a variety of instruments to address a variety of effects and other issues.

It must also be remembered that externalities are only a part of transport policy, and policy in many countries has been developed with a view to reducing externality effects rather than ensuring that the costs are internalised within the land transport system. Mechanisms to address congestion for example may increase environmental effects.

The aim is to attempt to identify which mechanisms are preferred for each effect and to identify in what areas further research should be directed. General criteria have been developed to assist in evaluating mechanisms as follows:

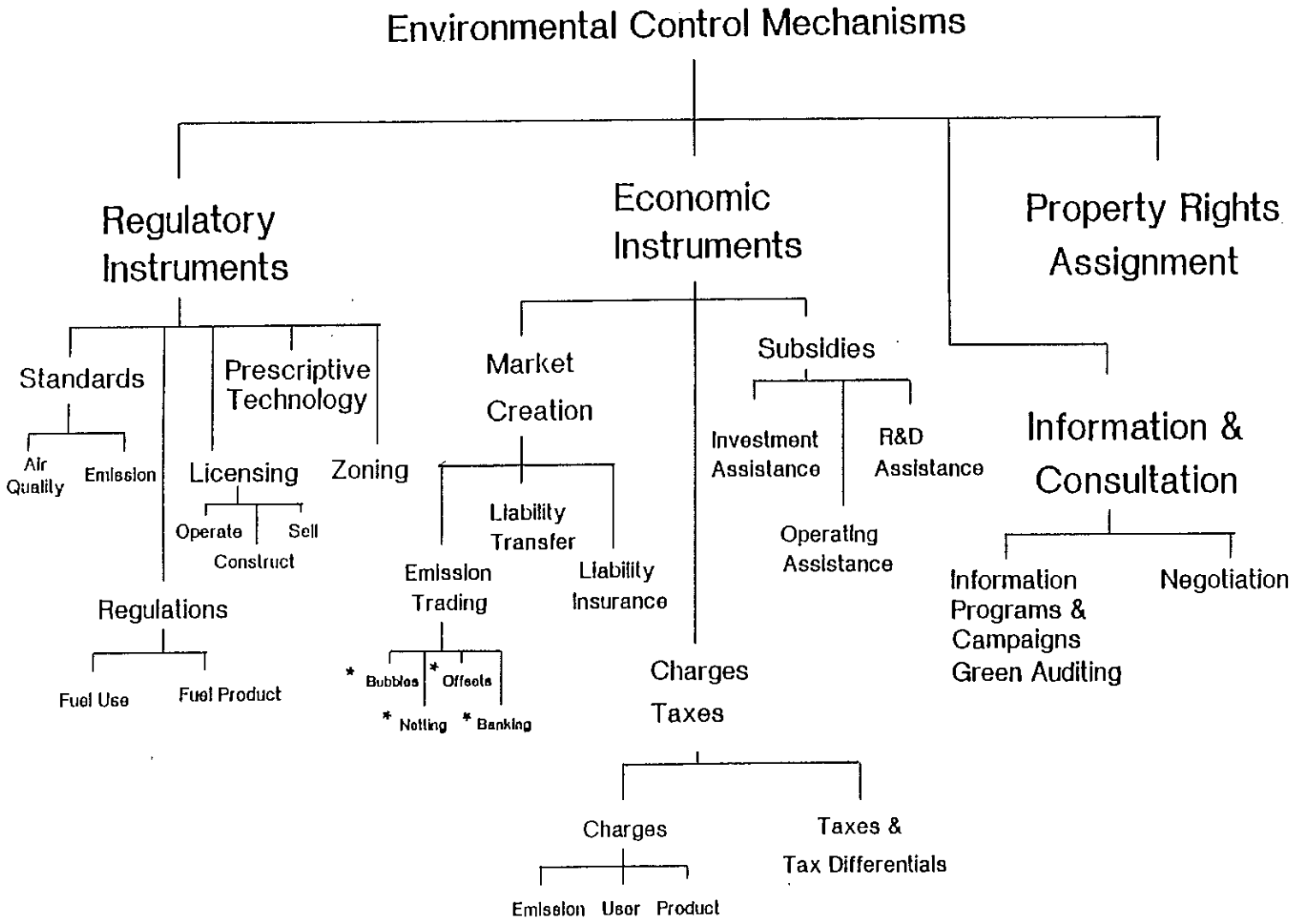
- They should be effective in internalising assessed costs.
- They should be effective in changing behaviour and promoting sustainable management.
- They should be efficient in achieving this outcome at minimum economic cost including administration and enforcement.
- They should be equitable in distribution of benefits and costs across society and between generations.
- They should not involve trade-offs against other external effects.

The following categories of instruments are considered initially in the following sections:

4.2 Economic Instruments;
4.3 Regulations and Standards; and
4.4 Education and Public Information

To place these in the full range of policy options, planning, demand management, infrastructure investment and institutional changes are briefly mentioned in Section 4.5. Table 12 shows the relationships between control mechanisms.

Table 12.



Bubbles: Allows for the relocation of emission limits within geographic areas
Netting: Relocation of emission limits but is applied to modified or renovated point sources
Offests: Allows new point sources within areas which have not met an air quality standard
Banking: Temporal storage of Emissions Reduction Credits and can be used in bubbles, netting or offsets

4.2 Economic Instruments

Economic instruments include measures such as taxes and charges, tradable emission rights and subsidies. These instruments work directly through markets to influence consumer decisions; that is, following relative price changes consumers are left to choose those transport services which they consider best match their perceived needs.

4.2.1 Taxes and Charges

Taxes and charges can be imposed in order to move towards reflecting the full cost of all resources consumed. However, adjustment costs are associated with taxes and charges and these costs may be reduced if increased taxes and charges are phased in over time.

Many types of taxes are used in the transport sector. To control greenhouse gas emissions, for example, a carbon tax can provide a comprehensive instrument which directly reflects the cost of carbon dioxide emissions. Other impacts such as local air pollution can be charged for by differential vehicle taxation for less polluting vehicles as discussed in more detail later in this section.

While taxes and charges are generally the least cost option when the full cost of resource use is not being charged, there are some qualifications to this conclusion. When such charges are imposed on the input side, there may be a loss of competitiveness of industry unless similar taxes are imposed by other countries. In addition, if the motive for applying a tax is to change consumer demand, and if demand is inelastic with respect to price, then the level of tax required to achieve significant reductions in demand may be so high as to be impracticable. On the other hand, if demand is inelastic, even relatively small rates of tax can yield significant amounts of revenue, revenue that could then be made available for specific purposes such as research and development in alternative technologies, provision of affordable housing and improvement in public transport. The elasticity of petrol prices is also explored in more detail later in this section.

The effects on income distribution of taxes and charges also need to be studied, since there may be adverse equity effects that temper the application of the tax.

4.2.2 Subsidies

A subsidy may be used to rectify market failure when beneficial externalities are produced. Subsidies are generally most efficient as a supplement when a benefit cannot be fully recovered through price. However, as an instrument to establish full cost charging across all energy consuming sectors, subsidies suffer a number of disadvantages. It is difficult to decide what subsidy should be provided to compensate for the additional costs not being recovered from other modes.

Subsidies may have perverse effects. For example by reducing the incentive for producers to adopt more environmentally efficient technologies, they may have unanticipated consequences on other sectors of the economy or, by reducing price, they may act to increase the overall transport task. To the extent that there may be no close substitutes for some tasks, subsidies may inhibit modal shifts to more environmentally benign modes.

Subsidies can be used in a variety of ways including financial assistance to:

- Firms, operators or consumers considered environmentally friendly, or
- Polluters to alter their behaviour, or
- Firms facing difficulties in meeting environmental standards.

4.2.3 Market Creation and Property Rights Assignment

Property rights in an economic sense are entitlements to use things which do not necessarily coincide with legal instruments relating to property. They can be held as private or collective rights, and created through statute, regulation, custom or presumption. For instance, the Resource Management Act requirement to mitigate adverse effects has created a collective right to an environment untroubled by those effects. Previously when such effects were unchecked, their generators enjoyed a customary or presumptive right to inflict them on others.

Unlike land, property rights are rarely assigned to the atmosphere and it remains freely available. Being free but ultimately scarce, the atmosphere tends to be used excessively - the "problem of commons" (Dasgupta 1990)[3].

Greenhouse gases are an example of such "global commons". Free to emit CO_2 and CFCs we emit too much, free to cut down vegetation which acts as a "carbon sink" we cut down too much, because the costs inflicted on the individuals are less than the global social costs.

Property rights approaches have been proposed for a number of environmental externalities, but their application to transport situations appears limited. In a seminal article Coase (1960)[3] demonstrated that externalities could be resolved by private negotiation, if property rights held by the parties were properly defined. He also showed that the initial distribution of rights between the parties was not critical to the outcome of a negotiation: the same amount would be spent whether the polluter was buying the right to pollute from its sufferers, or the sufferers were paying it to clean up its activities.

Unfortunately practical applications of such approaches are limited by the need to properly define complex rights and by the characteristics of the bargaining process. Negotiations can be subject to free riding by those who stand to benefit, and can suffer high transaction costs in the case of many parties, or strategic bidding in the case of few parties, all of which can thwart the achievement of a least cost outcome.

The most obvious examples of property rights solutions to environmental problems are the tradeable permit systems applied to air pollution in the USA, or the individual transferable quotas applied to New Zealand's commercial fisheries. In each case the permit/quota conveys an entitlement to a share of a common property resource which, with open access, is subject to rivalry in consumption, leading eventually to over-use. Tradeable permits reduce the tendency to over-use by clearly indicating individual use entitlements, and have a value and an opportunity cost which encourages redistribution through trade to those who value them most highly.

In theory tradeable permits can be cost effective even when the regulator has very little information on the behaviour and costs of individual polluters. The theory suggests that a polluter faced with tradeable permits will abate pollution up to the point where it does not make economic sense to increase abatement. This means that polluters would tend to minimise abatement costs. Thus tradeable permits are seen as an effective instrument for changing polluter behaviour. An additional advantage of tradeable permits is that desired environmental targets can be set and achieved.

Trading of tradeable permits may reduce the property rights of others. If it is considered by society that the level of pollution must not exceed a certain level, tradeable permit is one option to control it. At optimal price it is expected that the total emission will not exceed the desired level. If it does, it reduces the property rights of those who control their own vehicle emissions. Any market creation must therefore consider this aspect.

A further disadvantage of tradeable permits is that they may be inequitable as they may favour those with more resources, and current owners may be favoured over new entrants.

The practical experience with tradeable permits is mixed (Hahn and Stavins 1992)[3], in many cases with "thin" markets and very few trades curtailing the advantages of individual transferability. Such instruments also require observability if they are to be enforceable, as in situations with few, static, readily-identified permit holders, but they are less well suited to non-point sources of pollution (such as vehicle emissions). In practice the initial distribution of permits or quota rights, and possible speculation in permits held in expectation of future capture of economic rent, raise questions of distributional equity.

The potential for property right solutions to transport externalities is unclear at this stage. Since they appear most applicable to rival, excludable resources with clearly identifiable users, they may have little role in non-rival, non-excludable externalities such as noise and air pollution but further issue-specific research may be necessary to establish their uses for these purposes.

4.3 Regulations and Standards

Regulations and standards are a direct means of achieving a desired result which, if mandatory, are an assured way of producing certain outcomes. They find particular application where matters such as public safety are concerned (design standards, road regulations, and so on), but also have wider application in the introduction of stringent policies (for example, the limiting of vehicle emissions).

In strictly economic terms, regulations are sometimes seen to introduce distortions and consequent loss of efficiency into market processes. The efficiency losses can arise if the regulations do not allow individuals to choose the lowest cost response, and do not ensure that the cost of reducing environmental damage is allocated to those who can do so at least cost. Furthermore, regulations may have a negative aspect of not providing an incentive to do better than what is prescribed, and may have considerable often hidden compliance costs. Against this, however, regulatory approaches may be more generally acceptable where it would require a very large tax to achieve the same result.

Performance-based regulations offer greater flexibility than prescriptive regulations. They allow more scope for compliance and hence the opportunity to reduce costs.

4.4 Education and Public Information

Education covers a number of activities, ranging from providing the community with an awareness of environmental issues such as global warming, to the training of drivers in practices which are energy- and emission-efficient. Creation of an awareness of the need for energy conservation is a vital element in any community education strategy. The development of an ethos that it is socially desirable to conserve non-renewable fuels and reduce emissions is important to long-term sustainable management. This can occur in the formal education system, in on-the-job training (for example, for truck and train drivers), and in the mass media. In keeping with the nature of the problem it must be subtle and long term to be effective.

Green consumerism has begun to influence purchase behaviour and consequently firm strategy. Knowledge is far from perfect however, and programmes which heighten awareness can be effective in affecting behaviour. Negotiated response involves the setting of environmental targets at national/local levels on a yearly basis, environmental targets are usually negotiable between polluters and authorities.

Studies have shown environmental factors to be of some importance in influencing travel behaviour. In New Zealand, a survey of Wellington residents by Steer, Davies and Gleave (1991)[1] for the Wellington Regional Council found environmental factors to be of significance, albeit small, in determining travel mode choice. Unsurprising was the distribution of importance; slow mode users (walk and cycle), who tended to be also younger, were more environmentally conscious than car commuters. In terms of willingness to pay, environmental factors amount to about 1-3% of current public transport fares.

Awareness is also increasing, green consumer guides are proliferating, and as a result, Elkington (1990)[3] writes:

> *"Thinking about the environment inside companies is no longer just about P.R. ... it's also about competitive and strategic policies".*

In transport, oil firms are beginning to see the competitive advantage of marketing "green fuels", e.g. unleaded gasoline or lubricant oil made from recycled oil. Car firms are emphasising environmental aspects of some car designs. Larger public transport companies (bus and train) are marketing their environmental advantages over car. Other companies such as British Airways are presenting Environmental Audits.

In New Zealand the Resource Management Act will cause an increase in Environmental Audits in order to manage risks and liabilities under the Act.

4.5 Other Policy-Based Instruments

A range of other transport policy instruments contribute to reducing external effects rather than to internalising the costs. Some of these are driven by internal costs such as congestion but have significant implications for externalities.

4.5.1 Planning

Planning is an important wider tool of transport policy. Planning provides the opportunity for a partnership between policy makers and the community for achieving an overall optimum solution to land use and transport network allocation problems, taking externalities and individual behaviour into account.

Planning can create broad opportunities for increased efficiency which the market can allocate. For example, it can facilitate patterns of urban land use (zonings) which place non-polluting jobs, shops, and residences in closer proximity, thereby allowing shorter trips to work and to shop. It can co-ordinate these employment and housing locations with public transport links and nodes. In these ways it can contribute directly to the efficient operation of urban form and their transport links.

4.5.2 Demand Management Programmes

Essentially all of the policy measures considered in this section affect demand and can be considered as demand management options.

The aim of demand management is to reduce the need to travel, the amount of travel and the impact of this travel on the transport system at critical locations and times of day, without restricting access to urban opportunities. It can be achieved through management of transport assets, physical constraints and pricing policies, and through urban, social, and technological change.

Available measures include:

- Development in the long term of a more transport-efficient urban form;
- Staggered working hours, flexible working hours, compressed working week, or deregulation of weekends;
- Encouragement of ride sharing through such measures;
- Regulation of the flow of traffic in a corridor by traffic management measures;
- Regulatory methods controlling access to certain areas such as the CBD;
- Parking controls;
- Road pricing.

4.5.3 Infrastructure Investment

This includes investments in improved interchanges, and other public transport infrastructure to improve the quality of service, reliability, and overall efficiency of mass-oriented, less polluting transport modes.

Government investment in, and ownership of, both transport infrastructure and operating units provides a direct means of regulating the scale of specific transport industries and the way they operate. Government investment or lack of it in certain parts of the transport infrastructure can encourage or discourage use of the modes relying on that infrastructure.

One disadvantage of government investment is that it creates enterprises which have to rely on the public purse for financial survival. Some of the problems in this respect can be overcome by use of rigorous investment appraisal which take into account the financial, environmental, and social aspects of investment projects seeking funds from government, and improved management of public enterprises.

4.5.4 Institutional Change

The removal of institutional barriers to location change of residence or employment, or other activities, can help reduce trip lengths and facilitate a switch to lower energy modes. These institutional barriers include non-transferability of home loan mortgages and employment superannuation, the imposition of stamp duties, conveyancing costs, agents fees, and so on. The removal or reduction of these constraints would provide a "footlooseness" to activities in the urban area facilitating efficient relocation of residence, employment and other activities in response to pricing and other policies and thereby having a positive attribute of increasing the rate of adaption to sustainable development patterns.

4.6 Application of Mechanisms to Air Pollution

4.6.1 Regulatory Instruments

A range of relevant regulations relate to air quality, fuel quality and fuel use. Other instruments are emission standards, national emission targets, prescriptive technology standards and licensing procedures.

4.6.1.1 Quality standards

Air quality standards also relate in many cases to biological and exposure standards. European Economic Community directives for the control of lead pollution, for example, set biological standards in terms of lead levels which must not be exceeded in the human bloodstream.

The most common form of environmental regulation is the ambient air quality standard. Nearly all OECD countries employ a quality standard to control major air pollutants (SO_2, NO_x, CO, Pb, PM - Particulate Matter).

The United States regulates air pollution through the Federal Clean Air Act as well as through state and local laws and regulations. Under the Clean Air Act, the Environmental

Agency (EPA) is charged with setting national ambient air quality standards for those pollutants considered harmful to public health welfare.

Considerable progress has been made as the EPA estimates that, between 1987 and 1989, air emissions dropped some 90%, CO dropped 32%, NO_x declined 14%, SO_2 37% and lead 87% (due to be phased out of leaded petrol). Nevertheless about 75 metropolitan areas did not meet the target. With projected uncertainties over the costs of pollution and the benefits of control, disagreements about air quality importance in comparison to personal mobility and convenience, and conflict among agencies were all barriers to achievement.

4.6.1.2 Fuel quality regulations

Fuel quality regulations are set in many OECD countries include limitations on benzene, lead content and volatility although the range and stringency of regulation vary. The regulations for lead have gradually been raised to determine the lowest level compatible with existing engines, and for new vehicles to run on unleaded fuel. Seasonal regulations over fuel volatility are enforced in the USA when ozone levels are high.

California has been at the forefront of policies to reduce emissions. In 1989, the California Clean Air Act was introduced with the aim of reducing emissions by 5% pa with the immediate emphasis on cleaning up petrol. Reformulated gasoline which evaporates less, the use of oxidising agents to reduce the production of carbon monoxide (by converting it into carbon dioxide), and tighter limits on diesel have been or are being introduced.

4.6.1.3 Emission standards

Emission standards set a maximum allowable emission rate for each generic type of source (transport, industry, etc.) and for each type of pollutant. They are usually based on the availability and cost effectiveness of control or new "clean" process techniques.

4.6.1.4 Prescriptive technology

Prescriptive technology standards define the type of control technique. NO_x emission limits from land transport vehicles often require three-way catalytic converters to be fitted. In the UK, exhaust and silencer regulations have been gradually introduced since 1973.

Forced introduction of new car categories is now part of California's programme to reduce air pollution. By 1994, transitional low emission vehicles emitting half the reactive organic gases of the conventional car must be on sale. Low emission vehicles (emitting a quarter of present levels of reactive emittants) and ultra-low emission vehicles (emitting an eighth of present reactive emittants) to be on sale by 1997. The first zero-emission vehicles (electric) are required to be on sale by 1998 (Hamer 1992)[3]. Physical controls on design of vehicles play a part in transportation policy in many countries, and although results are generally achieved there is considerable doubt whether it is the most efficient mechanism.

4.6.1.5 Licensing

Licences are applied to selling a particular model of vehicle based on its technological performance which usually has been assessed under laboratory conditions. Licences are also used to control emission performance by vehicle testing.

4.6.2 Economic Instruments

4.6.2.1 Emission charges and subsidies

Emission charges include mechanisms to control the quantity and characteristics of emissions and may be levied as:

1. User charges;
2. Product charges; or
3. Taxes.

User charges are direct payments for the costs of collective or public treatment of pollution and are commonly levied in the costs for water treatment. France and Japan do have air pollution charges however. The French pollution charge was introduced to encourage the early adoption of pollution control equipment. Charge revenues were returned to those paying the charge as a subsidy for installing the equipment. Tietenberg (1990)[3] considers that the charge was too low to have had any significant effect on improving air quality.

Product charges are added to the price of a product at the manufacturing stage or retail phase and are invariably set according to the characteristics of the product (e.g. sulphur content of mineral oil). Their use is and are widespread in the energy field. All EEC countries except Denmark apply product charges on lubricating oils.

Taxes and tax differentials are common incentives for emission control in transport. However they tend to be imposed on inputs (fuel) rather than outputs (emissions) although fuel consumption and emissions (directly and via engine size) are strongly correlated.

Since 1985, Germany, Sweden, Netherlands and Norway have imposed tax differentials relating to environmental cleanliness on cars. Japan has considered a tax differential favouring vehicles emitting low NO_x. The USA has levied a "gas guzzler" tax which penalises large cars and encourages the purchase and manufacture of smaller, more fuel-efficient vehicles.

Fuels are subject to different taxation levels. The most widespread are higher taxes on leaded fuel and lower taxes on diesel. Between March 1988 and October 1989, the UK share of unleaded petrol has risen firstly from 0.1% to 26% as a result of tax differentials and secondly has contributed to the withdrawal of two star petrol to provide pump capacity for unleaded fuel and limiting the fuel choice for smaller cars (Button 1990)[1].

There has been considerable debate about the relative merits of vehicle and fuel taxation. Cousins and Potter (1982)[1] have looked at the distributive effects of policy change. A move to fuel taxation was favoured because it penalises larger cars and encourages greater fuel efficiency. Rural areas could be disadvantaged as a result of greater average trip lengths. Also the incidence of taxation would shift towards companies and away from the private motorist (as a result of lower tax perks for company cars). Metcalf (1978)[3] has questioned whether fuel costs are as well perceived as vehicle taxation which could lower effectiveness of such a tax.

Sweden has introduced a vehicle taxation system based on whether a catalytic converter is fitted or not. Cars without are taxed more heavily, those with receive a subsidy. The policy

has been viewed as successful in promoting low pollution vehicles but has not been revenue neutral because subsidy payments have exceeded tax payments.

Switzerland is considering the introduction of fuel tax related to vehicle model (either on purchase or annually) or according to vehicle use. The tax level is envisaged at one Swiss Franc per litre of fuel once 15,000 kilometres has been travelled.

New Zealand has promoted the use of CNG and LPG, both benign in tailpipe emissions, by differential fuel taxation and incentives. However, unavailability of the fuel has limited take-up and usage of both fuels is now declining.

4.6.2.2 Carbon taxes

Carbon taxes could reduce greenhouse gas emissions. The literature on their effectiveness is expanding but the general consensus seems to favour a tax, graduated according to the carbon content of a fuel. The tax would aim to encourage a switch in fuel use and energy conservation, favouring renewable and non-carbon based fuel sources such as hydro and nuclear, and disadvantaging fossil fuel sources such as oil, gas and coal.

The carbon tax would be based on the before-tax fuel price. Consequently, the incidence of the tax would depend on the amount of tax already levied. For petroleum, tax accounts for 45% of the pump price in New Zealand and 75% in Italy. The carbon tax would therefore cause a much lower percentage increase in the price to consumers than for coal where existing taxes are considerably less.

The Ministry of Commerce (1991)[1] has looked at the effects of a carbon tax, and their assessment assumed that a carbon tax would be set equal to the anticipated price of tradeable emission permits. The tax would be set at the point of production or import (if imported fuel is not taxed at source), with the carbon tax related to the carbon emissions produced by different fuels, as shown in Table 13.

Table 13. Carbon emissions in kilograms per gigajoule (GJ). Source: Ministry of Commerce (1991)[1]

Gas	Coal	Petrol	Diesel
15	25	20	21

International discussions have suggested a tax of $200 per tonne of carbon which, if applied to the five fuels, would produced the taxes given in Table 14.

Table 14. Carbon taxes and resulting fuel prices

	Gas	Coal	Petrol	Diesel
Carbon tax ($/GJ)	3	5	4	4
Tax (usual units)	$3/GJ	$115/t	14c/ℓ	15c/ℓ
% Price increase	50	50	15	38

Notes: The percentage increases in petrol and diesel are modest in contrast to the increase for gas and coal, being a result of a higher base tax

The Ministry of Commerce analysis concludes that the large increase in gas price would make the Synfuels plant (which produces synthetic petrol from natural gas) uneconomic. Closure of the plant would reduce use of that gas and therefore the emissions attributable to the transport sector would be reduced by 10%.

A review by Delsey and Dobias (1991)[3] suggests a higher carbon tax of US$1 per litre of fuel would be more effective. In 1991 the Général des Mines of France recommended a new type of taxation which would gradually increase the taxation of energy from fossil fuels. Such a tax would have two advantages:

1. It would distribute effort between countries fairly; and
2. It would restrict the costs of the greenhouse effect to those using fossil fuels.

The projected range of the tax would be between 1,000 and 2,000 francs per tonne of carbon, i.e. equivalent to between 0.7 and 1.4 F per litre of vehicle fuel.

Crucial to the evaluation of carbon taxes is the responsiveness of transport fuel demand to changes in pump prices. Raising pump prices via tax increases could stimulate changes in purchase behaviour to encourage:

1. The purchase of smaller engine cars offering greater fuel efficiency;
2. Reduced car usage;
3. Higher car occupancies through car pooling;
4. A switch to public transport.

There is no doubt that economic instruments are an important component of strategies to change behaviour and direct technological development. However it is also clear that their success is related to demand elasticities, and thus levels of taxes need to be carefully determined.

4.6.2.3 Market creation and property rights assignment

Market creation for air pollution refers to the purchase and selling of pollution permits. In the USA, emission trading has been adopted as an alternative to emission charges and taxes. It is mainly used to control industrial pollution and is less appropriate for transport emissions. Net accounting is the most common form allowing firms to sell pollution permits (or credits) to other firms or plants.

There are four main derivations: bubbles, netting, offsets and banking. Bubbles allows for the relocation of emission limits within geographic areas. Netting is similar to bubbles but is applied to modified or renovated point sources. Offsets allow new point sources within areas which have not met an air quality standard. Banking is the temporal storage of Emission Reduction Credits and can be used in bubbles, netting or offsets.

In other countries emission trading is far less common although Germany has introduced more restrictive emission trading.

Of greater significance to the report is that emission trading is being increasingly considered at the national level to control CO_2. Some USA firms are already voluntarily offsetting their emissions by planting trees in other countries.

At current stages of development permit trading is not a suitable instrument for addressing transport emissions and has not been given priority in the Research Plan.

4.6.2.4 Education

Public knowledge of air pollution and of the specifics of the greenhouse gas issue is poor. There is a limited perception of the extent, level and effect of transport emissions. A 1992 Mori Poll in the UK revealed that 60% of respondents considered that switching to unleaded petrol would reduce CO_2 emissions (Emsley 1992)[3].

An extensive survey of air pollution by Shultz (1985)[3] of Berliners considered the stated willingness to pay for air quality. Four types of air were defined: (i) Berlin Air (smog alarms); (ii) Big City Air (no smog alarms); (iii) Small Town Air; (iv) Vacation Spot or Holiday Resort Air. Respondents were asked to express a willingness to pay for each category.

The survey found that, although people were prepared to pay for air quality improvements or pay to be compensated for not having them, there was a poor level of knowledge about the extent and consequences of air pollution. Two thirds of respondents answered incorrectly about harmful substances. Knowledge was also found to be correlated with willingness to pay, as the better informed were prepared to pay more (70%) (although income and knowledge could have been positively related).

As with the Steer Davies and Gleave (NZ) Ltd (1992)[1] Wellington Survey, the willingness to pay was higher for younger respondents: an eighteen-year old was prepared to pay three times more than a 75-year old.

Public information strategies will be critical to the success of policy packages to address the effects of air pollution, particularly for global issues and must form a part of a co-ordinated policy on externalities at local and global levels.

4.7 Noise

4.7.1 Regulatory Instruments

Vehicle Noise Standards are the most common form of regulatory instrument for attempting to internalise noise effects. In the USA the Noise Control Act (1972) directed all federal agencies to carry out their programmes in a manner that promotes an environment free from unhealthy noise and directed the EPA to set certain noise standards both at Federal and State level noise standards for various classes of motor vehicles have been promulgated. In many countries the law requires the replacement of all faulty silencers.

In most EC countries the basis of noise level measurement for standards has been criticised because:

- Noise level peaks are not taken into account, despite the fact that they can cause severe nuisance;
- The absence of criteria for night noise means no incentive to limit noise during the night, a time when impacts are greatest.

In many cases there appears to be a lack of adequate criteria for addressing policies in terms of noise reduction.

Regulations for safety can also have adverse implications for noise. In particular the control of driving hours has in many countries increased the amount of night driving with consequent implications for noise.

Nevertheless regulatory mechanisms have proved effective in reducing transport noise and must be considered further in the overall strategy for New Zealand.

4.7.2 Economic Instruments

In France an important trade-off between emissions control and noise has arisen as the new anti-pollution legislation, the annual road user's tax and vehicle insurance penalise vehicles with larger engines even if they are quieter than vehicles with smaller engine capacity. Similarly the tax system favours diesel engines which emit 3 to 6 dB(A) more than a similar petrol engine.

The long life span of older vehicles can hinder progress on reducing overall noise levels as new technology can only be implemented as fast as vehicles are replaced. In France a system of reduced annual taxes for cars over five years old has a social objective but has negative implications for both noise and air pollution.

Economic instruments can therefore only be considered in a comprehensive manner with careful consideration the trade offs associated with different issues.

4.7.3 Information

In France noise levels are shown on a vehicle's licence card. But research has found that they are practically ignored by the public because no tax or traffic incentives are attached to quieter vehicles. Information strategies are being used increasingly in transport policy but there is little research on the effectiveness of the approach.

4.7.4 Traffic Management

The nature of traffic management plans often produce negative effects in terms of noise emissions including:

- Dispersion of traffic onto previously quiet streets spreads noise effects without a corresponding improvement in previously over-congested streets.
- Building of new infrastructure tends to increase speeds and overall travel, creating more noise.
- Bypasses and relief roads direct faster and heavier traffic to outlying residential areas which have less noise protection than town centres.

Similarly toll roads can have negative effects on pollution as the introduction of a toll will generate a redistribution of traffic onto lesser roads close to urban areas. Quinet (1989)[3] has estimated that this could amount to 10% of inter-urban HGV traffic (Heavy Goods Vehicles) diverting onto more problematic routes to avoid tolls.

Mitigation measures can also have an adverse effect on visual intrusion such as the extensive use of noise barriers.

4.7.5 Summary

The discussion in Section 4.7 illustrates that instruments and mechanisms to control noise should not be developed in isolation for individual noise effects and that a co-ordinated policy to achieve clear targets is required.

4.8 Effects on Water Systems

Few instruments have been proposed or used to internalise the cost of water pollution derived from roads, other than investment in systems that will control the release of polluted sediments.

The technological developments targeted at safety and air quality have potential to also to reduce water pollution. Two examples are the development of Anti-lock Braking System (ABS) which will reduce both tyre deposits and the need for particulate traps in diesel engines.

Economic instruments could be used to address the externalities of water pollution on the environment. Indeed these would be appropriate ways to address the need for environmental clean-up in a number of ports and estuaries, and also to put in place appropriate pre-treatment for existing infrastructure.

These instruments would be more effective than regulation, other than the need to develop appropriate standards management of existing roads and new construction.

4.9 Urban Form

Most countries with land use control systems have sought to influence the rate of urban development so that infrastructure can be used efficiently and expanded in a planned manner. However in many countries including the USA, the co-ordination of transportation and land use plans was lacking. Many countries have been in a phase of continual transport expansion and now, with a growing awareness of the environmental implications, this approach is being seriously questioned.

A range of new instruments are being developed to address the transport costs associated with new development, particularly at the periphery of the urban area where travel and infrastructure costs will be highest.

4.9.1 Development Impact Fees

This concept requires developers and/or employers to help provide or pay for the transportation facilities and services they create by means of exactions, impact fees and occasionally "benefit assessment districts".

Impact fees have been assessed as:

- Flat fees based on the size of the development.
- Variable fees depending on the type and location of the development.
- Negotiated fees determined by the required investments, the interests of the local communities, and the resources of the developer.

Variable fees are analogous to roadway user taxes in that roadway user costs vary with traffic and a desired revenue target is met. Techniques used in highway cost allocation studies can be applied to the design of equitable variable impact fees.

Although similar to the requirements for New Zealand developers to provide the costs of servicing new subdivisions and making a reserve contribution to the local authority, impact fees are more explicitly tied to externality generation (mainly second party externalities) and may be variable according to such factors as expected trip generation by new land use, expected growth rates, and changes in the mix of development.

An impact fee is a limited substitute for a pricing system, since its costs are borne up front and once paid, provide no continuing incentive for subsequent occupiers to alter their use patterns.

The Resource Management Act introduces a broader range of economic instruments that can be used in planning and would allow the development of such techniques in New Zealand.

4.9.2 Demand Management Programmes

Implementation of such programmes designed to reduce travel demand can also be shared with the development industry. In the USA, where it is known as "transportation systems management", there is a practice of imposing measures such as car pooling, flexitime and transit users' subsidies either through their incorporation into the conditions of approval for new development projects or through special purpose ordinances. This emphasises reductions in car travel, especially peak hour car travel, rather than continually accommodating for its increase.

4.9.3 Travel Demands and Urban Form

The travel demands of urban residents can be affected substantially by urban form. The spatial pattern of urban activities affects the journey to work and to shop as well as other more discretionary urban travel demands. Urban form influences the travel mode, travel distances and travel frequencies of pollution.

Urban form features that relate to more sustainable transport systems include:

- Higher residential population which improves the viability of urban public transport.
- A greater mix of land uses which decreases travel distances.
- Establishment of urban villages and sub-centres of high population and employment density.

This report has mentioned repeatedly the need for transport to reflect full environmental costs. As this would establish a different relationship between housing and transport expenditure, the need is to explore the implications of this change further in terms of the potential reduction in transport demand. Part of this is the need to understand the values and priorities that contribute to decisions over residential location.

Thus one priority for the research plan is to undertake research into residential location decisions in New Zealand and to develop models that will enable changes in transport costs to be tested along with corresponding changes in housing costs.

4.9.4 The Role of New Technology

New technologies also affect the need for transport. For instance the development of telecommunications technologies and their integration with other information technologies can change the pattern of transport and energy demand, and the nature of transport infrastructure provided, in a number of ways.

For example information-based industries can generally be established outside the central business district thereby reducing the need to travel into it. Some activities can be undertaken at home, invoking the concept of the electronic cottage. There is a need to explore in more detail the implications for New Zealand cities of the continuing developments in technology as part of this research plan.

4.10 Price Elasticities of Demand for Petrol

The review has shown that economic instruments in the form of taxes applied to the quantity of transport have a major role to play in addressing externalities. However the extent to which behaviour will change as a result of additional transport costs relates to the price elasticity of demand for petrol. The total demand for petrol has been widely studied and invariably is related to the price of gasoline, real income, vehicle utilisation and vehicle stock.

Consumption of motor vehicle fuel is commonly assumed to be insensitive to changes in price, i.e. its demand is price inelastic. Price elasticity indicates the percentage change in consumption associated with a percentage change in price and is negative for most goods. An inelastic demand is defined by a ratio of less than -1.0, indicating that a rise in price would lead to a less than proportionate fall in consumption, that total expenditure on fuel would rise.

Table 15. Long run (>15 years) petrol price and income elasticities
Source: Sterner et al. (1992)[3]

Country	Price	Income
Canada	-2.0	0.5
USA	-1.2	1.0
Austria	-1.2	1.2
Belgium	-1.5	1.3
Denmark	-0.8	0.7
Finland	-1.2	1.3
France	-0.4	1.2
Germany	0.1	0.5
Greece	0.2	2.0
Ireland	-1.0	0.9
Italy	-0.7	1.3
Netherlands	-3.2	0.6
Norway	-2.5	1.3
Portugal	-0.7	1.9
Spain	-1.2	2.1
Sweden	-0.1	1.2
Switzerland	0.2	1.5
UK	-1.4	1.5
Australia	-0.2	0.7
Japan	-0.3	0.8
Turkey	-1.1	1.3
Mean	-1.0	1.2

Ashton and St Johns (1985)[3] quote one study of price elasticities in various OECD countries (excluding New Zealand) in which petrol is price inelastic in the short run (typically around -0.12), but becomes price elastic in the very long run (15 years and over), ranging from -1.1 to -1.6. A more recent survey of studies of individual countries confirms the pattern of short

run inelasticity and long run elasticity but little agreement over the level of elasticity. Long run elasticities for Canada, for instance, are variously estimated at -0.26 to -1.07 (Ministry of Commerce 1991)[1]. Such variations in individual estimates reflect a number of factors, including differences in data periods, estimation techniques and in external variables.

Table 16. New Zealand petrol elasticities.
Source: Ministry of Commerce (1991)[1]

Price	Income
-0.07	0.5

Using the Ministry of Commerce (1991)[1] price elasticity of -0.07 implies that petrol consumption would decline by 0.7% following a 10% rise in petrol price compared to an 8% decline implied by Sterner et al. (1992)[3] elasticity figures. Previously suggested increase of 14 cents per litre (14% increase) would have a negligible effect (Ministry of Commerce 1991)[1].

The implications of inelastic demand for petrol is that taxes intended to correct prices for externalities will need to be substantial to bring about the desired change in behaviour. Conversely reductions in current petrol tax in a switch to more direct road pricing are unlikely to result in ballooning consumption.

Note that in economic terms where taxes are used to "correct" prices for externalities, it is not necessary for revenues thus raised to be used for alleviating the externality. To do so would risk inefficiency through remedial expenditures being driven by revenues collected rather than determined by real need. Externality taxes on price inelastic goods may therefore contribute to general government revenues, and can have widespread implications on the economy if the rates of other taxes are thereby reduced.

To develop economic instruments and be able to forecast the extent of change in behaviour that may arise, it is essential that research has a reliable estimate of petrol price elasticity in New Zealand. The methodology should be consistent with other OECD countries for comparative purposes and would allow further comparative analysis by reference to base level pump prices, availability of public transport, average trip length and other key factors.

4.11 Conclusions

A wide range of mechanisms exist that can be used to address transport pollution. However it is also critical that instruments and mechanisms are developed in a co-ordinated manner to address effects on land, air and water in order to achieve sustainable transport.

As no single mechanism is likely to be both efficient and effective, a package combining regulatory, economic and information instruments should be carefully designed to meet the criteria established in the introduction to this section.

A number of countries are now putting in place co-ordinated policies that combine instruments such as:

- Subsidies to maximise use of clean technologies
- More rigorous emission limits per vehicle
- Improvement in urban air quality
- Sustainable land use policies
- Road pricing
- Investment of revenue in research and development

Recommendation 5 - Mechanisms and Instruments

That the research plan should focus on the following mechanisms and instruments to internalise the cost of externalities with:

Price Elasticity

- **To refine estimates of New Zealand petrol price elasticity by means of methodology consistent with OECD countries, to facilitate comparisons with regard to fuel price, availability of public transport, trip length and other key factors**

Residential Location Decisions

- **To analyse cost variables in residential location decisions and to develop models that will enable changes in transport costs to be tested along with corresponding changes in housing costs: in conjunction with this to design and test charge mechanisms for each type of cost to be recovered**

New Technology

- **To model the implications for New Zealand cities of developing and established technologies in terms of implications for travel demand**

Development Impact Fees

- **To develop a policy and assessment framework for the calculation of impact fees building on work overseas**

SECTION 5

LEGAL DUTIES AND CONSTRAINTS

5. LEGAL DUTIES AND CONSTRAINTS

5.1 Legal Duties

This section of the report focuses on the existing legal framework in New Zealand and reviews the duties and constraints to the implementation of the mechanisms and instruments discussed in Section 4. In addition the legal implications for the valuing of externalities in terms of potential compensation to those affected are considered.

Review of the legal framework for land transport in New Zealand involves considering the following different pieces of legislation:

1. **Transport Act 1962** provides the focus of legislation relating to motor vehicles, road traffic, and to commercial transport services carried by means of motor vehicles or harbour ferries.

2. **Transport (Vehicle and Driver Registration and Licensing) Act 1986** provides legislation for registration and licensing of vehicles, and licensing of drivers.

3. **Transit New Zealand Act 1989** which established the current system of funding the land transport system. It also promotes policies and allocates resources to achieve a safe and efficient transport system that maximises national and economic benefits.

4. **Local Government Act 1974** which deals with local authority roading and some transport related undertakings.

5. **Transport Service Licensing 1989** introduces a new framework for provision of public transport, including taxis.

5.2 Resource Management Act 1991 and Land Transport

In addition transport issues are included in the **Resource Management Act 1991** which effectively forms overarching legislation and establishes an important new context in which transport policy and the effects of land transport must be considered.

The issues associated with the development of sustainable transport policy have already been discussed in Section 2 and can now be considered in terms of the legal responsibilities to achieve the purposes of the Resource Management Act.

The all-embracing purpose of the Resource Management Act is to achieve the concept of "sustainable management". This is defined in the Act as

> *" .. managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to*

provide for their social, economic and cultural wellbeing and for their health and safety while -
(a) Sustaining the potential of natural and physical resources to meet the reasonably foreseeable needs of future generations; and
(b) Safeguarding the life-supporting capacity of air, water, soil and ecosystems; and
(c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment."

Sustainable management relates not only to the physical environment in which the land transport system operates but also to the management of the transport network itself. The definition of natural and physical resources includes all forms of structures including road and rail systems. The effects on communities are also important both in terms of the balance to be achieved in sustainable management and also in the inclusion of people and communities in the definition of environment.

The Resource Management Act presents a major challenge to the land transport system. The Act binds the Crown and in carrying out his functions the Minister of Transport is required to take into account all the relevant pieces of legislation and resolve any conflicts.

The Act promulgates the need for Transit New Zealand in conjunction with the Ministry of Transport to develop a sustainable land transport policy to meet the responsibilities and duties of the Act. The policy should also comply with the Transit New Zealand Act. The research into land transport externalities forms the beginning of a process of the development of sustainable land transport policy.

Under the Resource Management Act 1991, the Minister for the Environment is given the responsibility for guiding Central Government policy on Resource Management through National Policy Statements and National Environmental Standards which must be adhered to by Regional and District Councils.

Regional Councils and Territorial Authorities are also given major responsibility for implementing the Act, and the operation of the land transport system will be heavily influenced by the policies and rules that are adopted by these agencies. Projects may require consents in accordance with the Act and there is also a general duty in Section 17 for every person to avoid, remedy or mitigate any adverse effects of their activities on the environment.

Regional Councils are currently developing policies that address the issues of sustainable land transport in their respective areas, initially in Regional Policy Statements now under preparation and also through Regional Plans.

In implementing policy the Resource Management Act places a specific responsibility on all parties with functions under the Act to explore a wide range of alternative methods of implementation. This may include education, training and investment, as well as regulatory controls. In addition the Act establishes the framework for the extensive use of economic instruments.

Specific tools are provided in the Act including:

- Financial contributions
- Bonds and covenants
- Occupation and other charges
- Transfer of resource consents

There is therefore an important link between the implementation of the Resource Management Act and other transport-related legislation. In particular there must be a close link between Resource Management Plans and Land Transport Programmes prepared by Regional Councils and Territorial Authorities under the Transit New Zealand Act 1989.

The Transit New Zealand Act has established a system of prioritising transport investment from a bottom-up basis involving both Territorial Authorities and Regional Councils in close consultation with Transit New Zealand.

The 1992 Amendment to the Transit New Zealand Act introduces a requirement for each region to prepare a Land Transport Strategy that will form the policy framework for individual programmes. These strategies are to assess the transport needs of the region and determine the role of different modes including cyclists and pedestrians. Nothing in the strategy shall be inconsistent with the provisions of any Regional Policy Statement or Plan in force under the Resource Management Act 1991.

5.3 Legal Constraints of the Range of Effects

At present, the legal "constraints" on the majority of these effects are contained in the Resource Management Act 1991. They are all matters to take into account when considering the total effect of a land transport proposal.

The effects identified are largely "negative" effects, or, in other words, are the adverse effects of a proposal which need to be weighed against the "positive" effects, or value of a proposal, in order to ascertain the sustainability of a particular proposal.

In addition, certain guidelines deal with some of the effects which will need to be taken into account in any proposal. For example, noise is a particular effect which needs to be addressed. There will be provisions in District Plans which deal with noise, perhaps limiting the noise level permitted from certain activities. There is an obligation in the Act (Section 16) to avoid unreasonable noise.

As well, the New Zealand Standard on noise provides recommendations on acceptable noise levels from activities. As this standard may be adopted by a number of local authorities in District Plans, the guidelines may well become the standard against which proposals are tested.

5.4 Legal Constraints of Instruments

5.4.1 Information and Consultation

There are no legislative constraints to the use of information programmes and consultation at any level of Government. Indeed the Resource Management Act requires the consideration of this type of initiative in any policy development under the Act, and both the Ministry of Transport and Transit New Zealand use this mechanism extensively in their operations.

5.4.2 Regulatory Instruments

The Resource Management Act 1991 can be used to identify and manage certain effects of the land transport system.

In addition, there are other mechanisms which could be developed to deal with specific effects of land transport system.

5.4.3 Subsidies and Investment

The Transit New Zealand Act has established a comprehensive mechanism for providing for investment and subsidy of land transport in a wide range of areas including training, new project, maintenance and subsidy of services. No further legislative changes are likely to be necessary.

5.5 Property Rights Assignment

This area has extensive legal ramifications and would require very careful legal study. It is an area of growing interest and in some cases can be seen together with market creation initiatives such as the purchase and selling of tradeable pollution permits. The Resource Management Act limits tradeable permits initially to water permits but expansion of this instrument is to be investigated.

A less formal trading concept also exists within the Act that relates to the rights to make a submission. For example, it may be that the land of an individual is not directly affected by the proposal, as identified by the Public Works Act 1981, but the emission of noise from the proposal will be above "acceptable" levels. That person may, however, be prepared to forego any right to make submissions opposing the proposal on the basis of trading any "rights" to an environment of a certain noise level.

This could entail the identification of a certain noise level emanating from a land transport proposal which is acceptable. Then, if the promoter of the land transport proposal wished to go above that noise level, it would "purchase" relaxation of that noise limitation.

Prior to the Resource Management Act 1991, this process may have taken place on an informal ad hoc basis in that prospective objectors to a proposal could be approached, and their acceptance of the proposal obtained. However, given the requirements of the Resource Management Act 1991 for an in-depth inquiry into any land transport proposal, such an informal approach to the situation may not be acceptable. Further, such an approach was not used in a consistent manner.

Under the Act, both a District Plan and a Regional Plan could identify effects of an activity which are sustainable. If a proposal goes beyond those effects, then it would be necessary for the promoter of the proposal to acquire the rights to extend beyond the effects identified, either from the local authority if the effects are to the public at large, or from the individual if the effects are to the individual.

The framework is therefore available to be used, in that the particular plan can be used to identify effects which are at an acceptable level, and to which an area would be subject. Any extension beyond that level could require the purchase of the right to so exceed.

Care would need to be taken with any such approach, in that it could merely provide for the ability to create adverse effects on the environment to be based on price.

Further, as such an approach would be open to challenge by an aggrieved party, if the authorisation for such action was not specifically provided and followed, care would need to be taken in the drafting of any such proposal.

The legal constraints on such a proposal therefore would be an action by a third party who was also adversely affected by the proposal, on the basis that the requisite authority was not held, or the correct procedure not followed.

5.6 Economic Instruments

The review of legal provisions has confirmed that legislative amendment or regulations will be required for the introduction of economic instruments on a national scale. However no legal difficulties have been identified in putting into place economic instruments including those required for road pricing.

The provisions of the Resource Management Act can be used to address the mechanism of development impact fees. District Plans could develop costing frameworks for financial contribution that ensure that developers pay for the infrastructure associated with peripheral development.

5.7 Valuing Effects and Compensation

The consideration of applying dollar values to the effects of transport on specific interests raises the issue if, under existing law, claims for compensation on this basis could be successfully sought.

The position is that at present Transit New Zealand is authorised by statute to do certain things including the construction, operation and maintenance of roads. As a consequence of carrying out such works which are deemed to be in the public good, by providing service for the public, certain private loss may be suffered. In other words one person's land may be required for the construction of a road for the public good.

Provision exists within the Public Works Act 1981 for the compensation of people where loss is suffered through the execution of a public work. The emphasis under that Act is that it is land which is either taken or acquired or which suffers damage or injurious affection, and for which compensation is payable.

Accordingly, there is a statutory code for the assessment of compensation in such cases. It has long been argued that if there is a statutory code for the payment of compensation, then that code is paramount, and an individual is not entitled to compensation outside that code.

The ability to claim for injurious affection where no land is taken, but the land is perhaps close to the proposed work, was introduced in the Public Works Act 1981 and, in fact, it is very restricted. It applies only to the construction of the proposed work and does not extend to the operation or maintenance of the work. Further, the injurious affection must be substantial, and cannot be related to the change in traffic flows, or the widening, upgrading or deviation of an existing road. Therefore under the present compensation regime, placing a dollar cost of factors such as noise should not affect the amount of compensation payable in respect of a proposed work.

However, other issues are involved. While the valuation of compensation is based on statutory provisions, if a person is entitled to compensation, their claim may be affected by any "cost" which has been identified as arising from a proposal. In other words, in the situation where part only of the land is acquired, the landowner's expectation of what he/she is entitled to may well be affected by costs attributed to the effect of noise. It may well be more difficult in this situation to negotiate purely on land value with the landowner, and the cost attributed to the effect of noise may well have a persuasive effect.

The above is based on the assumption that the provisions of the Public Works Act 1981 are available for the proposed work. If that is not the case, then the conclusion would be different, in that it would not be an issue of "compensation" but rather of ensuring that the proposal could be undertaken, and that it would not be subject to claims from aggrieved neighbours.

If the Public Works Act 1981 was not available, then any cost attributed to an effect such as noise could well have an affect on the amount required to be paid in a particular situation. In that case the position could be that an affected person could have expectations raised above the cost to the project of the proposed undertaking, and accordingly that could be the measure of what was required to satisfy any objections.

5.8 Conclusion

The importance of the Resource Management Act and Transit New Zealand Act has been confirmed in terms of defining the legal duties associated with externalities. Implementation of new mechanisms will in many cases require legislative change, either by amendment to existing legislation or a new statute or regulation.

The Resource Management Act does provide some scope for the introduction of economic instruments and should form the focus for further work in the research plan on Development Impact Fees in Section 4.

Recommendation 6 - Legal Duties and Constraints

That the research plan integrate into the specific tasks the investigation of legal issues. A number of areas require further legal consideration, and in particular:

- **The extension of the concept of economic instruments**
- **The investigation of a framework for development impact fees under the financial contributions provisions of the Resource Management Act to address transport externality costs on a national scale**

APPENDIX 1

SURVEY OF NEW ZEALAND ENVIRONMENTAL IMPACT ASSESSMENTS

SURVEY OF NEW ZEALAND ENVIRONMENTAL IMPACT ASSESSMENTS

The purpose of the survey of Environmental Impact Assessments (EIA) was to assess the scale and significance of the externalities identified in recent EIA studies in New Zealand. This was achieved by first examining the scale of effects associated with each externality in land transport projects in New Zealand and second the relative importance (or weighting) that was given to each factor in reaching a decision. A total of 19 studies carried out over the last ten years were reviewed in the survey.

The survey results are presented in Table 1. Column 1 records the number of studies in which each of the specific external effects was recognised and examined.

It helps identify the factors that feature most frequently in environmental work undertaken in New Zealand over the last 10 years. The following stand out as important effects:

- Visual effects
- Loss and disruption to plant and animal habitat
- Community severance and local accessibility
- Community disruption
- Effects on water systems
- Noise
- Effects on personal safety and community vitality

From each study the scale of effect involved was assessed and these were averaged and then ranked, i.e. they were placed in order from the most severe scale of effect to the least severe. This shows that on average the following factors were assessed to have the most severe effects:

- Strategic effects (civil and military defence)
- Effects on physical landscape
- Effects on personal safety
- Effects on urban form and land use
- Accessibility to facilities
- Noise
- Effects on pedestrians and cyclists

The relationship between the number of studies that considered an effect and the scale of impact must be acknowledged in drawing conclusions. For example the Strategic Effects externality was only recorded once and received a high scale of impact. This should clearly not be ranked as highly as factors that:

1. have a high impact of significance; and
2. occur in the majority of studies.

TABLE 1. RESULTS OF EIA SURVEY

Level 1 Construction, Maintenance and Operation Effects of Land Transport Systems	No. of studies where external-ities were recognised	Ranked scale of external effects	Ranking of weights used for each externality					
			1	2	3	4	5	6
1. Local air pollution	4	23		1	1			
2. Impacts on global atmosphere (CO_2, other greenhouse gases, CFCs used in vehicles, ozone depletion)	1	12			1			
3. Pollution of water, e.g. stormwater run-off, sedimentation	7	21	1					
4. Effects on water systems, surface and ground waters	12	14	1		1	2	1	
5. Loss and disruption of plant and animal habitat	14	19	4	2		1	1	
6. Visual effects	19	10	3	1	3		1	
7. Dust	3	15	1					
8. Vibration	2	18						
9. Noise	11	6			4			
10. Effects on physical landscape, e.g. land stability	6	2	2			1	1	
11. Community severance and local accessibility	13	8	2			1		
12. Community disruption	12	8	3	2				
13. Blight, stress of change	9	10		1				1
14. Cultural, spiritual, historic and Treaty of Waitangi effects, including archaeological effects	8	15	2	1			2	
15. Effects on recreation values	8	21	3	1				
16. Lighting effects, e.g. vehicle headlights on property, street lights								
17. Strategic effects (civil and military)	1	1	1					

Level 2 Effects on the Urban/Regional Systems	No. of studies where external-ities were recognised	Ranked scale of external effects	Ranking of weights used for each externality					
			1	2	3	4	5	6
1. Accessibility to facilities, e.g. employment services (this may be adequately internalised at present)	6	4		1	2			
2. Effects on pedestrians and cyclists - intimidation from motor vehicles (this may be adequately internalised at present)	7	6	3	1	1			
3. Effects on urban form and land use, and subsequent impact on urban sustainability	9	4	3	3				
4. Effects on personal safety (risk) and community vitality, e.g. the security provided by retaining movement in central areas	11	3						

Level 3 Dependent and Related Activities	No. of studies where external-ities were recognised	Ranked scale of external effects	Ranking of weights used for each externality					
			1	2	3	4	5	6
1. Extraction activities of energy resources								
2. Risks associated with refining, storage and delivery of hazardous fuels including LPG and CNG	1	12						
3. Hazards associated with the transport of other hazardous materials	3	19						1
4. Disposal of waste and redundant units, e.g. vehicle bodies, waste oil, waste from construction activities	2	24						
5. Effects on a range of land transport-dependant industries, e.g. vehicle assembly industry	3	15	1					

The Table also analyses the relative importance of each factor. The data show the number of studies where each factor was weighted in a ranked order from 1-6, i.e. the factor given the highest weighting was given a rank of 1, the second highest rank 2 etc.

Externalities which demonstrated the greatest significance were:

- Loss of disruption of plant and animal habitat
- Visual effects
- Effects on urban form and land use
- Cultural, spiritual, historic, etc.
- Effects on pedestrians and cyclists
- Effects on water systems, surface and ground waters
- Community disruption

In drawing conclusions regarding the scale and significance of effects on the land transport system, a number of factors are taken into account. First the methodologies used in many studies will be in accordance with Transit New Zealand Policies and Procedures and they direct practitioners to certain externalities on the list. They do not necessarily ensure that all potential externalities are assessed.

Second the project assessments by their nature tend to give greater weight to local and site-specific effects over more global issues. The results therefore need to be treated with caution in terms of national policy issues.

The analysis has been used to develop an overall ranking of factors based on past practice, but for the reasons above the results should be used with caution.

From the list of externalities the following effects are considered to be the most common in respects to the effect occurring in most of the EIAs examined. The effects have been ranked and are listed under each level.

Level 1. Land Transport Construction, Maintenance and Operation Effects:

1. Visual effects
2. Loss and disruption of plant and animal habitat
3. Community severance and local accessibility
4. Community disruption
4. Effects on water systems, surface and ground waters
6. Noise
7. Urban and rural blight and stress of change
8. Cultural, spiritual, historic and Treaty of Waitangi effects, including archaeological effects
9. Effects on recreation values
10. Pollution of water, e.g. stormwater run-off, sedimentation
11. Effects on physical landscape, e.g. land stability
12. Local air pollution
13. Dust
14. Vibration
15. Impacts on global atmosphere (CO_2, other greenhouse gases, CFCs used in vehicles, ozone depletion)
16. Strategic effects (civil and military defence)
17. Lighting effects, e.g. vehicle headlights on property, street lights

Level 2. Effects on the Urban/Regional Systems:

1. Effects on personal safety (risk) and community vitality, e.g. the security provided by retaining movement in central areas

2. Effects on urban form and land use, and subsequent impact on urban sustainability

3. Effects on pedestrians and cyclists - intimidation from motor vehicles (this may be adequately internalised at present)

4. Accessibility to facilities, e.g. employment services (this may be adequately internalised at present)

Level 3. Dependent and Related Activities:

1. Effects on a range of land transport-dependant industries

2. Hazards associated with the transport of hazardous materials

3. Disposal of waste and redundant units, e.g. vehicle bodies, waste oil, waste from construction activities

4. Risks associated with refining, storage and delivery of fuels including LPG and CNG

5. Extraction activities of energy resources

The analysis of recent environmental impact assessments did not reveal any additional external effects that should be addressed by the study that are not in some way already covered in the list. In terms of international literature the OECD in its Compendium of Environmental Data (1987)[3] provided the classification of environmental effects for all transport modes shown in their Table 2.

A cross reference of this table shows that, with the exclusion of safety effects which are not covered in this study and land taken which is already internalised within the transport system, all other relevant factors are included in the list. From the rest of the literature search the one factor that does not adequately emerge from the list is the effect on heritage values, particularly in regard to the built environment.

APPENDIX 2

APPLICATION OF PRICING APPROACHES TO A RANGE OF TRANSPORT EXTERNALITIES

APPLICATION OF PRICING APPROACHES TO A RANGE OF TRANSPORT EXTERNALITIES

1. Introduction

This Appendix explores further the total social cost of transport and the way in which pricing approaches can be developed to internalise these costs.

The aim of road pricing (or pricing for any other transport system) is to internalise externalities across the community of road users, so that road users are faced with the full costs imposed on the community by their use of the system (ideally the long run marginal cost). This should improve the allocative and production efficiencies in the economy, and also assist in the move to a more sustainable land transport system.

The design of road charges can be broken into three stages:

1. Identifying the marginal social cost of a particular vehicle making a particular trip;
2. Determining how those costs should be distributed between road-user charges and less targeted taxation;

3. Selecting an effective charging mechanism or instrument to collect the revenues indicated above.

2. Determining Full Social Costs of Transport

The social cost of transport is described by Newbery (1990)[3] as comprising those direct private costs of vehicle use (fuel, wear and tear, driver time, etc.) plus the social road-use costs which include repair and maintenance costs borne by highway administration, delays borne by other transport users and pure public good elements such as reducing accident risk and pollution. Direct private costs are internalised into drivers' decisions, whereas road-use costs are largely borne in ways which do not affect drivers' decisions at the margin, i.e. they are externalities.

It is particularly important for this study to distinguish between third party externalities borne by non-users of the transport network (e.g. air pollution, severance, loss of public land) and second party externalities which are imposed by transport users on other transport users, of which congestion is the obvious example.

In addressing how social costs can be quantified, Newbery categorises them under four headings: accidents, pollution, road damage and congestion. While three of these categories are largely internalised within the system it is worth exploring accident issues in terms of "Effects on pedestrians and cyclists - intimidation from motor vehicles (Level 2, Item 2 on the study list of effects). The only reference to this factor identified is by Jones-Lee (1990)[3] who argues that there is no externality between vehicles if the rate of accidents has fallen as traffic has increased, i.e. additional cars do not increase the risk of accident in any

predictable sense. However he also suggests pedestrians or cyclists are constant per kilometre driven, i.e. vehicles do impose an accident externality on non-motorised traffic.

A major problem in this line of argument is in ascertaining whether accidents and traffic volumes are related or independent, for which empirical evidence is inconclusive. Even if there is no vehicle-vehicle accident externality, this does not preclude incorporating safety features into the provision of transport infrastructure, but suggests rather it cannot be attributed to individual traffic generators and must be provided as a public good. Accident benefits can be valued by a mix of opportunity cost (for property damage) and contingent valuation (for health risk reductions).

Pollution costs relating to emissions have been discussed in Section 5. Many of the other factors on the list such as dust, noise or visual intrusion are location-specific and can be tackled through a mix of policies, including mandatory standards on silencers and horn bans, and adding the factor of damage into infrastructure project appraisals through non-market valuation procedures.

3. Principles in Allocation of Full Social Costs

Newbury describes a split of funding responsibility which would have freight transport paying the costs of highway maintenance which it is chiefly responsible for, and private motor cars paying most of the cost of congestion which they cause. The reason is that an ideal tax structure in a competitive economy would aim to correct prices and internalise externalities, yet raise revenue for other purposes in as non-distortionary fashion as possible. Freight transport is an intermediate service used in production which should pay for its road use costs, for the externalities it creates, and the cost of maintenance (which is a form of externality created by trucks). Passenger transport is characterised more as a final consumption activity and should be taxed more on its dominant externality which is occupation of road space and impact on vehicle flow speeds.

Additional taxes (a "pure tax element") can be set on passenger transport and collected as general revenue. The reason is that the demand for personal transport is derived from the demand for access to work, shops, leisure areas, etc., and as such it is likely to be price-inelastic and insensitive to the imposition of taxes. In other words, taxing personal transport is likely to be a good revenue earner for government. But it is not necessary for these tax revenues to be earmarked or "tagged" for transport applications, since this could result in inefficiency if transport spending by government becomes revenue-driven.

For the same reason it is not necessary for road charge revenue to be earmarked for spending on transport or environmental activities in the areas where it is collected, or to be additional to current road funds from general revenues, as is suggested in a report (The Chartered Institute of Transport 1990)[1]. As Newbery (1990)[3] points out, "the whole point of charging for road use by electronic licence plates [or other direct measures] is to replace less well-designed road charging schemes, such as fuel taxes and licence fees". The reason for this displacement of general revenues by specific road charges is to raise the efficiency of tax collection across the economy as a whole, since..."there are clear advantages in raising

corrective taxes to their efficient level, as they allow other distortionary taxes, which incur deadweight losses, to be reduced (Newbery 1990, p.31)[3].

If road costs are to be allocated on principles similar to those outlined above, it is necessary to first estimate the full costs of the road system. Newbery presents one calculation for the UK road network whose components are interest on capital sunk in the road system, maintenance, policing and wardening. Road damage costs are a small proportion of the whole, and the largest component is the balance which is attributable to passenger vehicles. He also suggests pollution costs would be relatively small so that passenger vehicle charges, including congestion charges, might be expected to contribute a major part of roading revenue. A similar breakdown for New Zealand with its attenuated road network might attribute a larger share to road damage and a smaller share to congestion, but this exercise has yet to be done.

4. Choice of a Charging Instrument

Choice of a charging instrument to correct for externalities depends on the feasibility of application, given the nature of the externality. Fuel taxes might be reasonable proxies for the damage caused by emissions, but they provide no incentive to avoid causing congestion (other than a general discouragement of motoring by adding to its cost). Charging instruments need to be specific to the problem they are addressing and include:

Direct unit charges or taxes, that are intended to raise the variable costs faced by transport users, and hence provide a continuous spur to reduce the level of use. They include direct road user charges (based on distance and axle loadings), taxes on transport inputs (such as fuel), access tickets, road tolls and electronic pricing.

Periodic charges, that add to the standing charges (fixed costs) of using transport facilities, and include such items as driver licensing, vehicle excise duty and vehicle registration fees. They may discourage vehicle ownership but provide little disincentive to vehicle use. In some circumstances they may be counter-productive: e.g. owners may seek to reduce the average cost of such charges by using vehicles more; and sales taxes on new vehicles may retard scrappage of older, less fuel efficient vehicles.

Untargeted taxes, that have a principal function to earn revenue earning, and include general indirect taxes (GST), direct (income) taxes and local authority rates. Their collection pays little regard to variations in use of particular transport facilities, and their role in pricing is negligible.

Road damage costs and congestion are suited to instruments on a unit basis such as road-user charges, vehicle-specific distance taxes, parking charges and area licensing. Many of the externalities addressed in this report are characterised by non-point sources and are difficult to observe and charge for on a unit basis, so pricing is likely to remain indirect. Where noise level is controlled through vehicle standards, the price faced by drivers is effectively the expected value of penalty if detected infringing the standard. This "price" can be raised by either increasing the probability of being detected (e.g. by increasing enforcement) or by increasing the size of penalty once detected.

Pollution caused by the disposal of transport wastes can be priced by means of disposal taxes placed on purchase of those inputs, or by deposit-refund systems on such things as car bodies and old batteries (as in Sweden). In principle the latter provides continuous incentive to dispose of equipment in a responsible manner, e.g. it guards against the externality of dumping along roadsides. The disposal tax simply makes some provision for recovering costs of dealing with the externality when it occurs, without any long-term incentive to reduce it. The size of deposit required for incentives to work is open to question: if the deposit is large, the scheme may be viewed as regressive in effect and having some adverse incentive effects (e.g. to continue to use older, more polluting vehicles which pre-date the deposit scheme).

Market creation or tradeable permit systems do not appear to have received much attention for transport issues, partly because they are mainly associated with point-source pollution for which it is easier to monitor each source's contribution. It is conceivable that access to transport facilities run as private goods or club goods could have an exclusivity which results in trading of "use slots" between subscribers, but such a system does not appear to have been put into practice.

5. Some Examples of Road Pricing in Practice

A survey of mechanisms is provided by Buchan (1991)[3]. Examples from six countries include:

- **Netherlands**: a combination of charges for land use planning, encouragement of home working, and public transport investments out of a single "infrastructure fund". Specific mechanisms include "electronically collected tolls imposed on existing main roads and bridges" and "double tariff vehicle excise duty for cars used in peak hours", but the meaning of the latter is unclear, since excise duties are normally charged on sale or import of vehicles and hence cannot be used to distinguish between peak and off-peak use.

- **Sweden**: after abandoning a proposed access ticket scheme for major cities, a new policy has been introduced including road tolls and differential charges for vehicles with and without catalytic converters. Also uses deposit-refund schemes on car hulks and batteries.

- **Italy**: Milan distributes to residents and businesses a displayable windscreen permit for access to the city centre. This effectively is a quota rather than a pricing mechanism. The intention is to exclude through-traffic but it is not clear whether this system discriminates against delivery vehicles sourced from other areas, and so acts as a form of protectionist "barrier to entry".

- **UK**: quantity restrictions in the form of truck bans in certain areas or periods have been applied in various locations. Cambridge has an experimental system of charging vehicles that are found to be contributing to traffic jams.

- **Singapore**: a purchased ticket is required for entry into the city centre during peak hours, and an electronic system is to be introduced in 1994. The effectiveness of the scheme is evident in declining vehicle use despite rising car ownership since its introduction, but the influence of other factors, such as public transport investment, is unclear.

- **Hong Kong**: an experimental electronic access charge met strong public opposition, partly because offsetting reductions in other taxes were not apparent and because of privacy concerns (Newbery 1990)[3].

Parking controls and charges are a commonly used method of attaching a "price" to motorists ending their journeys in a city, but they create external effects of their own. They may attract through-traffic by clearing inner city streets, and there is some evidence of parking and business relocating outside of parking-controlled zones.

6. Other Approaches to Road Pricing Recorded in the Literature

A report on energy, transport and environment by Transnet (1990)[1] reviews pricing for roads and vehicles and tax policy, noting that drivers of company cars, which tend on average to have larger engines, be less fuel efficient and have higher annual mileages, do not pay for all their petrol consumption, and may be relatively immune to attempts to adjust road prices in line with social costs. It also stresses the point that demand for transport is derived from commercial and personal activity, and in turn has demands derived from it for vehicle maintenance, vehicle manufacture and infrastructure provision which impact on the demand for raw materials. The implication is that minor shifts in demand for transport may have negligible effect on total transport-related demands.

A monograph from OECD (1990)[3] provides preliminary estimates (from existing literature) of the social costs of the land transport sector, focusing on air pollution, noise and accidents. It concluded that these amounted to 2.5% of GDP, with accidents accounting for around 80% of this total. It also concluded that land transport represented "almost all" of the social costs within the transport sector as a whole. This possibly understates the scale of marine pollution, localised effects such as aircraft noise, and the inter-modal components of transport externalities - for example, the contribution to road externalities caused by siting of air, sea and rail terminals.

Another report (OECD 1988)[3] focuses on road transport, with particular emphasis on air and noise pollution in the urban environment. It concludes that there is considerable scope for expanded use of economic instruments in transport policies, but does not demonstrate how this can be done.

Seskin's (1990)[2] framework for highway economic impact assessment identifies user benefits from roading as travel time, operating costs and safety, and additional regional benefits in business expansion, business attraction and tourism. While the user benefits are appropriate for inclusion in a national perspective cost-benefit analysis, this list excludes most third party externality effects. Regional benefits as described are largely pure transfer effects and are not appropriate for inclusion in a cost-benefit analysis.

Kane and Cooper (1987)[1] examine potential sources of revenue for highway finance in the US context, noting how traditional user fees (such as fuel taxes, vehicle and driver licensing etc.) are far removed from short run marginal costs, and externalities are not charged for. Berg (1990)[1] discusses some options for taxation and revenue policies for future Federal highway programmes, again within a US institutional context with limited application to New Zealand.

Palmquist (1982)[2] examines highway impacts on property values through empirical analysis which applied hedonic pricing to a house sales database of more than 9,000 entries. It concludes that access gains from a new road more than offset losses from noise, but does not address the distinction between real and transfer components in the observed value changes.

Golenberg and Keith (1970)[1] examine the effect of land use planning and transport pricing policies in express transit planning. The focus is not on pricing for externalities, but rather on examining the relationship between settlement density, public transit use and the estimation of price elasticity for public transit services.

APPENDIX 3

ANNOTATED BIBLIOGRAPHIES

ANNOTATED BIBLIOGRAPHY - LIST 1

The literature referred to in this bibliography examines specific techniques and approaches which address ways of treating externalities and are considered useful material for further research recommended by the research plan.

Allard, E.J. 1991. Project evaluation in the 1990's - the incorporation of intangible items into decision making. *Proceedings IPENZ Annual Conference 1991* Vol 1, IPENZ.

Transportation engineers are working in a world where new pressures for environmental assessment of transport projects means that many old practices must change. While the means to evaluate local effect are well known but still require greater application, the correct approach to the assessment of global effects has still to be worked out. One appropriate way may be to insist on a national policy review with schemes then assessed within the parameters of the policy.

Evaluation of intangibles has been chosen based on a narrow set of criteria (often just the cost-benefit ratio) then this chosen option has been subject to environmental and social Assessment - often with the aim only of finding the effects and trying to mitigate them. There have been cases where the knowledge of the intangible effects of the proposal have led to the original decision in favour of the scheme being changed. Practice must improve and be included in all stages in the decision-making process. However, this type of approach does not really help as it only leads to debate about the values used and diverts attention from the effects themselves.

The alternative to the big cost-benefit sum approach is variously called the decision framework, balance sheet or multi-criteria method. In such an approach all the effects are noted for each alternative in whatever units are applicable. A number of studies carried out recently in the Wellington region have used this method and seem to have produced good information (e.g. the Environmental Impact Report on State Highway 2 Te Marua to Kaitoke, Synergy Applied Research Limited, 1990).

In the Kaitoke evaluation each effect once identified is given a positive or negative number for each options. To find the preferred option the numbers are simply summed. This process seems to be less defensible than the attribution of monetary values since it requires the arbitrary allocation to each of the factors of a number representing some subjective view of the severity of that factor, and of that factor against the other factors listed. A worse approach is simply to list all the factors and note how many favour one option and how many the other, with the option having more factors in favour being chosen.

One option would be to use more sophisticated models which not only forecast the distribution and mode effects, i.e. road construction, but also provide feedbacks to the basic

trip generation stage of the model to land use effects and so on. Whole network estimates of exhaust emissions, noise, road crashes, etc., could then be made and included in the environmental assessment.

Allard proposes that all projects must be assessed in the context of clear national or regional policies which have themselves been subject to review in the new climate. The policies should cover all the global effects of concern and should help to determine how transport can meet the targets increasingly being set, e.g. for CO_2 emissions. There may even be a case for a Royal Commission of Inquiry. Once the policies are in place individual project appraisal should be carried out without the need to re-examine how the project may or may not affect the global interests (the projects should be designed to help achieve the policies). Thus, for example, if the national or regional review concluded that extra road capacitated free flow of traffic and led to a net decrease in greenhouse gases, this would be sufficient for suitable road schemes not to need to report on this effect.

While local effects can and should be analysed individually for each road scheme (on a scale appropriate for the project), it is equally unrealistic and illogical to examine the wider global effects. These effects, however, are real and important and must be included in the analysis of national and regional transport policy. Once established they provide the framework within which the local projects can be examined. One particular aspect to which engineers should give attention now is in preparing before and after studies of a number of road schemes. The plank of much of the environmental argument rests on the theory that "roads generate traffic" and that new facilities simply become as congested as the old very soon after opening. While there have been odd instances of studies of the effects of new schemes, a more comprehensive base is required.

Anders, C., Olsten, J. 1990. GIS risk analysis of hazardous materials transport. Pp.248-261 in *State and Local Issues in Transportation of Hazardous Waste Materials: Towards a National Strategy. Proceedings of the National Conference on Hazardous Materials Transportation*, St Louis, Missouri. New York. ASCE.

The Geographic Information System (GIS) was used to assess the risks and vulnerability of transporting hazardous materials on the Arizona Highway system. This paper discusses the methodology used insofar as its application to evaluate hazardous externalities for policy in New Zealand.

Risk Assessment Model
The objective for this study was to obtain a comparative analysis for the entire state whereby the spatial relationships were important than the specific values obtained, i.e. relative risks across the network were the principal objective.

A basic risk model consists of:

- The frequency of hazardous material shipments
- Probability of an event at a location

- The nature of dispersion based on meteorological factors
- The density of population in the area
- The nature of the incident consequences

Application of GIS Analysis
The potential application of the analysis is very broad because of its flexibility and the extensive special databases that are being developed, and it is likely to be a primary risk analysis tool for:

- Highway construction and maintenance prioritisation
- Routing of hazardous materials and waste
- Transportation-made alternative analysis
- Siting emergency response units
- Evaluating risks to sensitive population centres
- Evaluating risks to sensitive ecological areas

In concluding, the GIS risk analysis was able to assess the vulnerability of each highway segment bases of the proximity of the emergency response units and the response time. However, one criticism of these segments is that they are too long and the demographic data not detailed enough.

Australian Ecologically Sustainable Development, Transport Working Group (AESD). 1991. *Final report - Transport.* Canberra. Australian Government Publishing Service.

The issues of concern to an ecologically sustainable transport sector are:

- Vehicle exhaust emissions, especially in relation to greenhouse effect
- Urban form and design
- Inter-urban (long distance) freight and passenger movement

The policy context of the above issues are/have been overhauled within a new legislative framework. Institutional, economic and social impediments have to be overcome for Ecological Sustainable Development (ESD) policies to be achieved. In regard to institutional impediments, the structure of government enterprises in the transport sector may need further review. Further, there may be institutional barriers to the introduction of alternative fuels. Economic impediments include budgetary constraints. Social impediments to change include entrenched preferences, habits and behavioural patterns in the Australian community.

Available policy instruments in the ESD context should be effective in reducing environmental impacts, efficient in achieving this outcome at minimum economic cost, equitable in distribution of benefits and costs across society and between generations, and feasible in practicality and ease of implementation. For example:

- Taxes and charges - carbon tax to reflect the cost of carbon dioxide emissions
- Subsidy - reducing the incentive for adopting more environmentally efficient technologies
- Marketable or tradable permits - define overall levels of emission rights for all polluters and that allows polluters to trade the right to emit
- Regulations and standards
- Planning - allows a partnership between policy makes and community
- Education - training drivers, community awareness
- Demand management - reduce the need to travel, the amount of travel and the impact of this travel on the transport system without restricting access to urban opportunities. Apart from pricing, this instrument involves a number of regulatory and other measures of influence demand for and use of transport
- Government investment - in both transport infrastructure and operating units, provides direct means of regulating the scale of specific transport industries and the way they operate
- Institutional barriers - remove bariers to locational change of residence and employment to thus reduce trip lengths and switch to lower energy transport modes

The Working Group then recommends 40 policies to help undertake and achieve the above three goals to implement ESD.

Barde, J.R., Button, K. (Eds). 1990. *Transport policy and the environment - six case studies*. London. Earthscan Publications Ltd.

There needs to be a trend for governments to seek more efficient tools and policies to protect the environment. For instance, while implementing environmental regulations, one should make sure that existing regulations, tax structure or practices within sectors like energy and transport do not actually counteract environmental protection measures.

Transport, in particular motor vehicles, is a major cause to environmental disruption and the OECD has undertaken a study to identify and analyse the elements in transport policy which can induce adverse effects.

The following material summarises studies from six countries looking at policy response that has been or is proposed to mitigate externalities. This précis will outline various techniques used by other countries to quantify or measure external effects for possible policy formulation in New Zealand.

In the USA
Recently, concerns about the state of the US transportation systems has lead to a renewal of transportation policy at federal and state levels. Research is directed at new road and vehicle technology, alternative fuels, and at different legal, institutional and financial frameworks.

Some of these initiatives have opened up opportunities for more effective use of economic instruments in transportation management, e.g. new road tolls. While planned tolls neither approximate congestion pricing nor incorporate social costs, they may serve to increase public awareness of transport costs and their acceptance to road pricing.

It is considered that direct regulation will probably remain the major means of regulating transportation environmental impacts and the development of pricing may be the preferable means of intervention.

In the Federal Republic of Germany
Possibilities of environmental policies in transport include:

- The question of optimal allocation of material consumption goods and natural environmental resources for the economy
- How to achieve a desired level of environmental quality by a policy mix comprising all sectors influencing the environmental situation
- A list of measures which could be undertaken in transport policy to contribute to goal achievement

In the Netherlands
Government Policy Concerning Transportation - Objectives and Instruments
In relation to air pollution:

Main objective

- To foster and maintain optimum air quality

Sub-objectives

- Foster an optimal state of physical, mental and social wellbeing of the population, in terms of the conditions set by WHO
- Foster preservation of the natural biological environment in such a way that human activities causing air pollution should be ecologically neutral

- Prevent, as far as possible, any damage either to goods with economic value and to cultural monuments

Policy Developments

- New regulations concerning further educations of emissions were established
- Financial support of research concerning cleaner engines will be continued
- Developing more rigorous, internationally accepted, car type approvals
- Introduction of unleaded petrol
- Rigorous maintenance of speed limits, to reduce NO_x emissions

Recent Policy Development

- Specific policies directed to groups of polluters, e.g. farmers, [chemical] industry and car owners
- A stimulation of maximum use of clean technologies

Instruments to reduce traffic noise could be:

- Taxes to cover the "gap" in price between cheaper but noisier, older technologies and the latest less noisier, but more expensive technologies - the so-called regulating taxes
- Taxes to cover various government outlays for indirect noise abatement, e.g. the construction of anti-noise walls and government policy and research - the so-called destination taxes
- Subsidies for private research

In Greece
An integration of transport and environmental policies has lead to the following issues:

- The cross sectoral character of environmental problems
- The need for a balance between environmental protection and development
- The protection of cultural heritage
- The promotion of accelerated economic growth with a parallel improvement in life quality

The proposed changes to control vehicle emissions cover the following main areas:

- Increase use of electric vehicles in urban areas, i.e. trolley buses, etc.
- Introduction of "cleaner" technologies on all vehicles achieved by enforcing a proper taxation policy, i.e. reduction of import duties for cleaner CO_2-emitting cars
- Reversal of the rising emissions trends through better maintenance of vehicles, i.e. modernisation of garages
- Improvements of traffic infrastructure
- Development of a system to monitor the pollution levels and trends, to allow evaluation of results and improved feedback

Policies that have been adapted include measures which have been introduced successfully in a rather fragmented way. They include:

- Efforts to improve the quality of fuels (reduction of SO_2 in mineral oil by 30%, in diesel by 40% and of lead in petrol by 62%)
- Creation of Vehicle Control Centres for taxis, buses and passenger cars
- 10% increases in the carrying capacity of buses, better management of bus route scheduling, 30% increases in carrying capacity in trolley buses, computerisation of traffic lights, 20% increases of carrying capacity in the metro line and the creation of the new stations

Berg, J.T. 1990. Taxation and revenue policies for future federal programs. *Transportation Research* 24A(4): 251-264.

This paper provides a background for addressing the development of current Federal highway tax and revenue policies, describing recent trends in Federal highway finance, and discussing several limitations on the productivity of existing Federal highway revenue sources. Principles of taxation that can be used to guide the search for future revenue sources are then described, current Federal highway user fees are reviewed within the context of those principles, and the additional revenue potential of the existing highway tax structure is discussed. Potential alternative sources of highway revenue are then discussed and selected alternative funding mechanisms are described.

Button, K. 1990. Environmental externalities and transport policy. *Oxford Review of Economic Policy* 6(2): 61-75.

The aim of this paper is to look at the importance of environmental externalities stemming from the transport sector in terms of the costs they impose on society and to consider possible policy solutions. Section II examines the nature and scale of environmental externalities in transport; it includes consideration of physical measures of environmental damage and the valuation of these in monetary terms. Questions of how these problems come about are briefly considered, in terms of the role played by regulation (or intervention) failures and by market failures. A wide variety of policy options for tackling the environmental damage caused by transport are regularly advocated. Section III considers the economic principles underlying these policy options and the policies which are currently in place. Section IV discusses whether there are more effective economic instruments available, and Section V draws together concluding comments.

The literature suggests three routes to solving environmental externalities - assignment of property rights, pollution taxes and "command-and-control" measures. If the underlying causes of environmental externalities lie in missing markets it might then seem reasonable to seek a solution in the assignment of property rights.

Policies in Practice

- Investment: expenditure on new design standards which help protect surrounding areas from many of the visual and noise costs of inter-urban roads
- Taxation: the use of a pollution tax is the adoption of differentials between leaded and unleaded petrol
- Subsidies: to stimulate the use of less environmentally intrusive modes through subsidies
- Command-and-control: the use of regulations and controls are widely used because they are understood by transport users and policy makers, and are relatively easy to enforce

Looking Forward

There are a number of alternative ways the price mechanism could be employed more effectively to reduce the environmental degradation associated with transport. The classic economic approach is to adopt Pigouvian taxes designed to make polluters fully cognisant of the external costs they are generating, i.e. higher tax on leaded petrol. There is mounting evidence that the introduction of road pricing to optimise congestion costs is now being recognised as being practical. A further area where the deployment of Pigouvian taxes may be seen as offering significant improvement is in the context of carbon dioxide pollution. This is highly correlated to the amount of fuel burned and hence is a clear physical base for a tax.

Another possible instrument is marketable permit. This approach was adopted in the USA's lead-trading programme of the early 1980s when it was decided to remove lead from petrol and thus from exhaust fumes. Here a partial system of lead credits was given to petroleum refineries based upon existing production levels. Once allocated these credits became tradeable so that the most efficient refineries could sell their credits to less efficient producers. The procedure achieved its objective of reducing lead emissions from transport.

From a policy perspective it is important that in the future these effects are fully incorporated in the investment appraisal process. Since the mid-1960s cost-benefit analysis has been a common element in appraising virtually all major investments in transport infrastructure in the UK using for instance the COBA package in road appraisal resulting in a significant degree of standardisation in this sector. However, while COBA puts money values on travel time, changes in operating costs and accidental effects, environmental effects are treated separately in an impact matrix which contains some quantitative detail and verbal comments. COBA generates to reflect the quantified benefits and costs.

Coupled with changes in appraisal methodology, institutional reforms are also necessary. The problems lie in the differing legal frameworks within which various modes operate.

Charney, A.H., Horn, C.M. 1990. *Financing Arizona's Highways*. Tucson. Arizona University.

The economics of Arizona's highway finance are examined, and its funding sources are discussed. The funding sources considered here include licences, fees and taxes (driver licences and certificates of title, motor vehicle registration fees, motor fuel taxes, motor carrier tax), the highway user revenue fund, state highway fund, regional area road funds and federal highway aid. The nature of highway expenditures are described and policy implications are considered. Some weaknesses of the existing highway finance structure are pointed out, and several recommendations are offered. The latter include the imposition of congestion tolls, alterative measures for indexing highway fees, and broadening the framework for imposing highway user fees to deal with externality problems, particularly pollution and congestion, and to include other governmental costs, i.e. police costs, etc.

Cousins, S., Potter, S. 1982. Annual vehicle taxation policies in Europe: who gains and who loses from change? *Transportation Research Record* 858: 1-5.

Annual vehicle taxes can be replaced by taxes on fuel. This may be desirable for energy or transport policy purposes but the effects of this abolition option are examined first between interest groups in a single nation and second between member nations of the European Economic Community (EEC). In EEC countries, abolition of annual taxes would result in more fuel tax paid by larger vehicles in the United Kingdom and Ireland; about the same level of tax in Denmark, Holland and Germany; and less tax in France, Belgium and Italy. The different annual automobile taxes provide some non-tariff protection of national car manufacturing industries. A mix of higher fuel taxes, higher initial purchase taxes and

improved consumer information is recommended if annual automobile taxes are abolished in the EEC for reasons of energy and transport policy.

European Conference of Ministers of Transport (ECMT). Economic Research Centre. 1989. *Environment and Transport Infrastructures.* Report of the Seventy-Ninth Round Table on Transport Economics, Paris, 8th-9th December 1988. European Conference of Ministers of Transport.

This book addresses the environmental studies carried out when infrastructures are being built and shows how these findings can be incorporated in the decision-making process for example, measuring degrees for disamenity, threshold values, and the assignment of a monetary value to effects.

Golenberg, M., Keith, R. 1970. The effect of land use planning and transport pricing policies in express transit planning. *Highway Research Record* No. 305. Highway Research Board, National Research Council, Washington DC.

The effect of variation in the future land use and transport pricing on an express transit system is investigated. Through travel forecasting and mode choice estimating processes, changes in land densities and residential-employment locational patterns were studied for their impact on travel patterns and the mode of travel during a peak period for a single fixed regional express transit and highway system. The land use elements were held constant, and differing transport charges were investigated for the effect on the mode of travel.

Transit usage was significantly increased when the centralisation of employment and the length of the corridor land use development were increased, but not in a simple way: travel patterns were altered substantially, trip lengths were changed, and other aspects of travel were shifted.

The study of transport pricing showed a significant increase in the use of transit to the central area. This example reflects a technique to assess different land transport operations and quantify the variations which will have the least amount of external effects on a transit and highway system through transport pricing.

Haikalis, G., Jordan, J.D. 1984. Stringent transportation measures to reduce vehicular emissions in the New York City Metropolitan Area. *Transportation Research Record* 963: 45-52.

The analysis performed for the revised 1982 state air quality plans for New York and New Jersey revealed that significant reductions in pollutant emissions would be achieved as newer cars that cause less pollution replaced older cars that cause more pollution. More stringent transportation measures would be required to achieve clean air. Impacts of measures such

as higher bridge and tunnel tolls, parking surcharges, and major transit service improvements were analysed by using an iterative, elasticity-based sketch-planning model (SPIZZIE). The analysis suggests that although generally not justifiable on pollution reduction merits alone, these measures when packaged together may achieve multiple regional objectives. Pricing measures and service improvements that are most effective in achieving an efficient balance among modes while providing a source of revenue for maintaining and operating the transportation system are recommended for further consideration and implementation.

Hansson, L. 1991. Pricing of air pollution in the Swedish Transport Policy. *Transportation Research Record* 1312: 83-89.

This article looks at the change of the Swedish transportation policy whereby it focuses on the internalisation of some of its traffic emissions. There are explicit to the infrastructure charges for road, rail traffic and domestic aviation. The explicit evaluations of external effects in Sweden imply road charges (gasoline and kilometres taxes) amount to a 3.5 times higher cost recovery than the budget costs for highways and roads. This material may be used as an actual approach to internalising external effects costs.

Hughes, H. 1992. *Sustainable energy management in New Zealand: Improvements required in Government Policy.* Parliamentary Commissioner of the Environment Summary Volume.

Over the last five years Hughes has repeatedly advocated the need for a national energy policy and in particular Government direction on issues of energy efficiency, renewable energy, transition to Maui Gas substitutes and greater encouragement of public transport. An energy policy which has been manifested to date as essentially "laissez faire market forces" will not present well in this forum. The Commissioner recommends to the Minister of Energy:

- That a national sustainable energy management policy be developed urgently which explicitly addresses:

  National goals and responsibilities with regard to energy efficiency

  A stated intention of achieving by the year 2000, a 20% reduction of the 1990 total consumer energy used per unit of DGP

  Government intentions regarding removal of market barriers to energy efficiency

  Government intentions regarding reduction of greenhouse gases from energy use

Energy implications of transport and land use decisions

A strategy for orderly transition to greater reliance on renewable energy sources

The Commissioner recommends to the Minister of the Environment:

- That once Government has developed a national sustainable management policy (Recommendation 1), that consideration be given to aspects which may be appropriately implemented by way of a National Policy Statement under the Resource Management Act in order to give guidance to district and regional councils.

The Commissioner recommends to the Minister of Transport:

- That once the Government has developed a national sustainable management policy (Recommendation 1), the Transit New Zealand Act 1989 be reviewed and amendments made as required to ensure that the Act is consistent with both policy and the Resource Management Act 1991.

Johansson, P.O. 1990. Valuing environmental damage. *Oxford Review of Economic Policy* 6(1): 35-40.

The purpose of this paper is to review the most important parts of the economic theory and measurement of environmental damage. The paper is structured as follows:

Section II introduces the willingness-to-pay concept and money measures such as the compensation variation and the equivalent variation. This section also offers an interpretation of money measures in terms of the outcome of a referendum.

Section III defines the total value of an environmental asset, in order to give the reader an idea of the complexity of the money measures used in recent empirical studies.

Sections IV and V introduce risk or uncertainty and discuss the choice of money measure in a risky world.

In section VI three frequently employed methods for the estimation of money measures are introduced. The paper ends with some remarks regarding the limitations of these approaches to decision making.

Johnson, G.T. 1990. Impact fees for off-site road improvements : Guidelines for evaluating the practicality of the approach and for designing local programs. *Transportation Research* 24A (4): 277-282. Pergamon Press.

Impact fees are rapidly becoming the most widely considered non-traditional financing technique for off-site road improvements in the United States. A review of the literature related to such fees suggests that a variety of factors need to be considered in evaluating the appropriateness of the approach for any particular community. These factors include: the legal authority of the jurisdiction; the type of improvement for which funding is being sought; the local political palatability of the approach; the competitiveness of development within the local economy; and potential social implications of such fees.

Once it has been determined that impact fees are legally permissible and are considered to be in the best overall interest of a given community, other issues need to be considered in the design of an effective local program. These issues relate to the area to be covered by the program and the method to be used in calculating payments, how the program will be administered, and the legal constraints imposed on communities by the rational nexus text. While impact fees are no panacea, in a situation where they are appropriate, a well designed impact fee program can provide significant sums of revenue and address local transportation needs.

Kane, A.R., Cooper, T.W. 1987. A preliminary evaluation of potential sources of revenue for highway finance. *Transportation Research Record* 1124.

Various types of potential revenue sources for highway finance are looked at in this article. User fees include motor fuel taxes, registration fees, special motor carrier fees, tolls, and parking charges. Non-user fees include sales and property taxes, income taxes and severance taxes. Hence, as this article is titled, it is only a preliminary evaluation of various types of fees for highway revenue.

McNeil, S., Rossi, T., Hendrickson, C. 1987. Impact fee assessment using highway cost allocation methods. *Transportation Research Record* 1107: 73-80.

This article outlines a possible technique in applying impact fees to developers in relation to road construction externalities. Impact fees have been assessed as flat fees based on the size of the development; variable fees depending on the type and location of the development; and negotiated fees determined by the required investments, the interests of the local communities, and the resources of the developer.

Variable fees are analogous to roadway user taxes in that roadway costs vary with traffic and a desired revenue target is met. Techniques used in highway cost allocation studies can be directly applied to the design of equitable variable impact fees.

Highway cost allocation studies have received considerable attention and have been widely applied. These allocation methods might be usefully adopted for impact fee assessment. Economic implications of roadway cost allocation methods for impact assessment are discussed.

Ministry for the Environment (MFE). 1992. *CO_2 reduction action programme.* Ministry for the Environment, New Zealand.

Actions already committed:

- A requirement in the Transport Amendment Bill for the development of regional transport strategies which consider the most desirable share of the total transport demand to be met by each transport mode.

- Introduction of a regional petrol tax to fund public passenger transport which, inter alia, gives some competitive advantage to LPG and CNG and ensures that public passenger transport services are maintained.

- Development of a directive to Transit New Zealand to incorporate CO_2 emissions in their decision making on funding.

- Introduction of additional methods of speed limit enforcement.

- Publicity on driving that reduces fuel use : to be implemented over the next year and reviewed with the intention that it be continued if found to be effective.

- Development of Resource Management Act Guidelines on responses to climate change.

- Electricity industry reforms.

- A land transport pricing study (to be undertaken over the next two years) which includes, inter alia, consideration of CO_2 emissions. (In addition to pricing changes, this study could lead to the development of a sustainable land transport and land use policy that would be implemented through appropriate legislation.)

- Investigation of measures to improve vehicle fuel economy.

- Investigation of measures that could be used to increase the CNG and LPG shares of motor vehicle fuel consumption. (It is estimated that increasing the share of CNG and LPG could reduce emissions by the year 2000 by an amount equal to about 1% of 1990 emissions.)

Government has agreed to the following:

- A direction to the Ministry for the Environment, with the Department of Conservation, Treasury, and the Ministries of Commerce, Transport, Agriculture and Fisheries, and Forestry, to undertake a comparative evaluation of carbon taxes, tradeable CO_2 emissions in the context of the Government's environmental energy, tax and growth policy, and to report by 30 June 1993.

- A direction to the Ministry for the Environment, with the Ministries of Commerce and Transport and the Officials Committee on Energy Policy, to review existing and proposed pricing structures for fossil fuels and electricity and the effect they have on fossil fuel consumption and CO_2 emissions, and to report by 30 June 1993.

- A direction to the Officials Committee on Energy Policy, taking into account other pricing work, to report by 30 June 1993 with a work programme to further investigate how taxes and other economic instruments or regulation could be used to make energy prices better reflect the full costs of its production and consumption.

Ministry of Commerce (MoC). 1991. *Energy management and the Greenhouse Effect - A background paper on energy management and the 1988 Toronto Goal.* Ministry of Commerce, New Zealand.

This background paper presents **one scenario** of how New Zealand could achieve the Toronto goal reduction of carbon dioxide emissions of 20% by the year 2005. Current estimates are that carbon dioxide emissions resulting from energy use account for 33% of New Zealand's greenhouse gas emissions. The energy sector is estimated to account for approximately 90% of New Zealand's carbon dioxide emissions.

The analysis presented in this background paper shows that it is technically possible for New Zealand to achieve the Toronto Goal using a combination of energy management and supply side measures. At the same time, the magnitude of the task is highlighted.

Clearly, there are more economic, social and market barriers which would need to be overcome if the scenario presented is to be achieved in practice. The scenario presents an integrated range of measures that would all have to be fully achieved to meet the goal given the following key assumptions:

- A 2% per annum increase in energy end-users (e.g. motor vehicle passenger-km) across all sectors of the New Zealand economy.

- The widespread use of the most advanced currently available energy efficient technologies and techniques.

- The consideration of only those technologies that are expected to be cost effective from the consumer's perspective.

Energy management in the transport sector can be approached in four basic ways:

- New energy efficient technology can be introduced, such as high efficiency cars.
- Fuels that result in lower greenhouse gas emissions can be substituted for existing transport fuels.
- Changes to transport user behaviour can improve efficiency by the promotion of improved driving skills.
- The transportation method can be changed from, say, private cars to public transportation, carpooling or enhanced telecommunications.

Energy Management Options
In the transport sector a wide range of possible options exists for reducing carbon (dioxide) emissions. The options are:

1. Improve driving skills: Promotion would have to be sustained as experience demonstrates that drivers tend to revert to less efficient driving habits if the message is not reinforced.

2. Improve condition of cars: If all petrol- and gas-fuelled vehicles were better maintained, total fuel savings of around 4% could be achieved.

3. Replace petrol vehicles with CNG or LPG : CNG has a lower carbon to hydrogen ratio than petrol. This means that less carbon dioxide is emitted for the same quantity of fuel consumed. A 19% reduction in emissions per equivalent quantity of fuel has been assumed.

4. Replace synfuel with refined petrol.

5. Reduce urban fuel use: The percentage urban fuel use is taken as 74%. Fuel savings can be achieved by likely mixtures of car pooling, public transport, cycling and telecommunications in New Zealand, but as these are not currently available a conservative saving of 13% has been chosen.

   Higher savings could be possible in the longer term if there were a substantial change to the present public transport infrastructure and a re-ordering in resource planning and urban transportation policy priorities. This would essentially involve a staged transition from a car-dominated city to a public transportation-orientated city. If current consumer trends and regional planning policy continue unchanged, then public transportation will continue to be gradually replaced by private and company vehicles.

6. Improvements to the New Zealand vehicle fleet fuel usage.

Ministry of Transport. 1992. *Green Paper on the impact of transport on the environment, a community strategy for "sustainable mobility".* UK Ministry of Transport, England.

In order that impacts of transport on the environment are recognised, the analysis in this Green Paper is based on a number of criteria related to the quality of the environment. These criteria include the operational impact of transport on air, water and soil as well as the quality of life, the impact of transport infrastructure on space, the consequence of congestion as well as the risk inherent to the transport of dangerous goods. The analysis provides an assessment of the specific problems caused by transport and traffic in the urban environment.

The assessment of the impact on the environment of the above criteria shows that the impact differs for each transport sector. For example:

- Operational pollution is the key component for all transport sectors, but more particularly for the road, sea and air sectors.
- Land use, particularly in the road and railway sectors.
- Congestion, although important, constitutes a secondary factor which exacerbates operational pollution and puts pressure on existing infrastructure capacity.
- The risk inherent to the carriage of dangerous goods constitutes an important potential impact on the environment.

A common strategy for "sustainable mobility" will require:

- Market organisation measures that will further the freedom to provide services and the elimination of distortions of competition, while aiming more specifically to encourage more environment-friendly modes as well as efficient use of existing capacity.
- Additional risk prevention measures to ensure safer carriage of dangerous goods.
- Traffic management schemes in areas most vulnerable to congestion and the introduction of advanced telematics to improve efficiency to transport operations.
- The use of fiscal and economic instruments in order to influence the user's and operator's choice in favour of cleaner technology and the more environment-friendly transport modes, i.e. the "soft" means of transport.

A new framework under "sustainable mobility" includes:

- Measures that lay down strict environmental standards for motor vehicles, aircraft, ships, trains and fuel quality as well as measures to enforce and check the implementation of the standards.
- Environmental measures laying down strict air and water quality standards.
- Transport policy measures to implement environment-friendly modes, to ensure that transport contributes to CO_2 stabilisation in the community.
- An overall action plan for the transport of dangerous goods.
- Fiscal and economic instruments and a framework for the use of such instruments.
- The development of alternatives to road transport, such as railway, inland waterways and combined transport, as well as urban and inter-urban collective transport.
- Guidelines for the conversion and upgrading of relinquished infrastructure, particularly for the purpose of "soft" transport.
- Guidelines to market environment-friendly fuels, such as bio-fuels, natural gas and electric vehicles.

Moore, W.B., Muller, T. 1990. Developing defensible transportation impact fees. *Transportation Research Record* 1283: 39-44.

This article pursues alternative funding sources for the construction of transportation infrastructure, particularly roads. Transport impact fees is becoming a prevalent technique in many countries and is directed at developers, new residents and existing residents. Each group has an interest in ensuring that a proposed fee is affecting it equitably.

Defensible transportation impact fees must address quantifying the benefits that are derived from new transportation infrastructure; identifying the recipients of the benefits; and calculating the size for an equitable impact fee. A methodology is described that employs an equity-based approach utilising net-present-value techniques and addresses the legal criteria of "rational nexus".

Organisation for Economic Co-operation and Development (OECD). 1986. *Environmental effects of automotive transport - the OECD COMPASS Project.* Paris. OECD.

In the context of the OECD COMPASS Project (Comparative Assessment of the Environment Implications of Various Energy Systems), this report has been prepared on the environmental implications of energy use in provision of transportation. It considers, in quantitative and qualitative terms, several alternatives to the conventional, gasoline-fuelled automobile, including lead-free gasoline, diesel-fuelled engines, two-stroke engines, gaseous fuels for automobiles, and technical improvements to gasoline vehicles and their engines. These alternatives are compared for a range of effects, such as emission of pollutants to the air, vehicle energy consumption, and costs. The COMPASS Project is geared towards end-uses of energy, with the objective of proving that there can be parallel strategies leading to environmental improvement and to better efficiency of energy use.

There is an enormous importance of vehicles to energy use and, in particular, to petroleum consumption in OECD countries. Small changes per vehicle in emission profiles or fuel consumption can mean very large changes nationwide and worldwide.

The three main approaches to decreasing petroleum consumption by vehicles are:

- Substitution of gasoline and diesel fuel in automobiles by alternative fuels.
- More efficient use of fuels by vehicles.
- Use of alternative transportation modes that may be more energy efficient (e.g. car pooling or electric public transport).

The first two options relate to the same end-use service to consumers - private cars remain the primary mode of transport. Thus COMPASS' intention is to examine alternative ways of providing current end-use demands and so only the first two options are the subject of this study. This article addresses approaches that will reduce the effects of externalities on the environment as a whole, i.e. alternative fuels.

Pearce, D., Markandya, A., Barbier, E.B. 1989. *Blueprint for a Green Economy.* London. Earthscan Publications Ltd.

The text selected is on carbon tax, and this would be graduated according to the carbon content of the fuels. Thus coal would attract a higher tax than oil, and electricity would not be taxed directly but would pay the taxes on the carbon fuels. The effects of carbon tax on household consumers is to encourage conservation. Thus carbon tax would encourage:

- a switch in the fuel mix of the industrial and electricity sector
- a switch in the fuel mix of the household sector
- energy conservation in all energy-using sectors

Steer Davies & Gleave (NZ) Ltd. 1992. *Energy use, sustainability and transport.* Steer Davies & Gleave (NZ) Ltd, Wellington, New Zealand.

This report explores sustainability within the transport sector from New Zealand and global perspectives. The authors argue that restricting oil usage should not be an end in itself but rather a means of protecting the environment. Energy use can be reduced by implementing policies at a regional level.

Regional policies can be the most effective at reducing transport fuel demand. For example, Wellington Regional Council has developed six policy themes reflecting different emphases on public and private transport. These are based on the assumption that there will be significant increases in CO_2 emissions. The amounts spent on public transport and roads varied across the six themes. However, in terms of energy efficiency, they only varied by only 12% over 20 years. This implies that achieving reductions in energy usage and emissions will be most difficult.

In concluding, the authors state that New Zealand can develop sustainable transport but transport, energy and land use policies need to be integrated and directed to achieve a defined sustainable goal. New Zealand must develop and co-ordinate policies within a land use and transport planning framework.

The Chartered Institute of Transport. 1990. *Paying for progress - a report on congestion and road use charges.* London. The Chartered Institute of Transport.

The Chartered Institute of Transport (CIT) has become increasingly concerned with the congestion on the urban roads and the cost and damage it imposes on the environment. **Road Pricing** has been suggested as one way to reduce the worst effects of traffic congestion and this report sets out the results of this technique, quantifying external effects from congestion.

Improvement of the road network is needed through physical construction and better management. Improved public transport also has an important part to play and modifications to vehicle technology can significantly reduce vehicle emissions and, to a lesser extent, noise.

The theory of road pricing is based on the more vehicles that use the road the busier it gets. After a while congestion sets in and a few extra vehicles lead to disproportionate delays for all - for both the new and the existing traffic. Road pricing has in the past been doubted but its practicality is now stronger than ever for the following reasons. First, traffic congestion is now worse than ever before. Second, it is generally accepted that transport constructions and improvements will not on their own solve the congestion problem. Third, the technology of road pricing has improved considerably, and fourth the movement towards an increasingly market-oriented transport sector makes road pricing more appropriate.

Road Pricing has been studied in Hong Kong using Electronic Road Pricing (ERP) and other European cities, Milan, Bergen and Oslo, implement the system.

Designing an effective road pricing scheme must identify the following criteria:

- Improve transport efficiency
- Be flexible enough to cope with a variety of traffic environments
- Inform drivers in advance what they will pay, and at the time
- Provide anonymity for those who want it
- Provide reasonable operating costs and a not unduly intrusive infrastructure
- Be easily enforceable
- Provide for exemptions and concessions
- Allow visitors in from outside the control area
- Avoid sharp time and spatial boundaries if possible
- Recognise and address transitional problems

Of the main options of road pricing, ERP is clearly the most effective to satisfy the above list. Other options, such as Automatic Vehicle Identification (AVI) operated by an "electronic" number plate, employ pre-paid cards from which the value is deducted through an on-board meter, similar to a Phonecard.

Road pricing will generate considerable revenue which should not be treated as a tax but as a user charge, with the proceeds being reinvested into improving roads, transport and related environmental matters. General road expenditure should continue to be funded from general taxes.

Transnet. 1990. *Energy, transport and the environment.* London. Transnet.

This book looks at policy responses and transport costs that can be applied to internalise externality costs. Recommendations are for local government to implement land use and traffic management policies, and for central government to implement pricing and taxation policies to assist in the development of alternative fuels, improvement in efficiency and intermodal shift, as well as reducing unnecessary travel.

A chapter elaborates on Transport Pricing Policies in terms of encouraging the demand onto more efficient modes and reducing the level of demand for transport altogether. It points out that these Policies will be effective when a price rise is necessary to change consumer behaviour, that is "elasticity" of demand. Unless the prices are right none of the solutions in previous chapters may be effective unless they are imposed on drivers, manufacturers and

planners through regulation. Consequently, if policy makers wish to avoid the regulation route, they are almost bound to use the pricing route.

The book then discusses advantages, disadvantages and assessment of the following pricing techniques:

- Road Pricing
- Fuel Pricing and Taxation Policies
- Company Car Tax Policies
- Vehicle Pricing and Taxation
- The Equity Effects of Taxation and Pricing Policies

Wellington Regional Council. 1991. *Transport Policy: Public Information Booklet.* Wellington Regional Council, New Zealand.

The following information is from the Wellington Regional Council's *Public Information Booklet*, seeking comments on questions raised and themes proposed for the development of transport in the region.

Level of Funding:
Funding should be dictated by need. The following was suggested:

- Carbon taxes i.e. $0.30 per litre
- Regional transport levies, not necessarily charged at a flat rate for the whole region
- Levies on CBD parking
- Surcharges for peak hour road use
- Electronic road pricing

Another possibility is for Transit New Zealand to take over responsibility of the maintenance of all public roading and let public authorities pay for footpaths and public transport infrastructures.

Policy Themes:

- Free flow roading
- Improved roading
- Mixed investment
- Modern public transport systems
- Low fares

Proposed new theme:

- Detailed policies to cut CO_2 emissions, to be in place by 1994
- Emissions falling by 1996
- Emissions to be back at 1991 levels and falling at 2% per year by 2001

The proposed policies are to meet these targets.

ANNOTATED BIBLIOGRAPHY - LIST 2

This bibliography contains a variety of summarised extracts that may be worth exploring further, for particular techniques and approaches to treating externalities.

Alexander, E.R., Beimborn, E.A. 1987. Highway priority setting through alternative use of multiple-objective decision methods. Pp.183-191 in *Appraisal of the social and economic effects of road network improvements, expert meeting and symposium*, Yokohama, May 1987. Paris, OECD Road Transport Research: Tokyo, Japanese Ministry of Construction.

This paper examines the effects of various assumptions on the multi-objective decision-making (MODM) process. MODM is used to rate alternative plans and projects in order to find a preferred alternative or to set priorities among a set of projects. In this paper, the sensitivity of project rankings to calculation procedures used to rank alternative highway projects is tested. Those issues addressed include methods of standardisation, aggregation of weights and scores and inclusion of a benefit-cost element. This is done through the use of sensitivity indicators developed for the project.

Results of the MODM techniques can be sensitive to computational assumptions. Failure to use standardisation can have a major effect while differences in standardisation have some effect and differences in weighting techniques have a moderate effect. The selection of criteria and their arrangement in the hierarchy is also critical: improper utilisation can have significant unintended consequences. Unexpected turbulence and sensitivity of applied MODM models may be the result of their size and complexity, suggesting the need to reduce the numbers of criteria and alternatives.

Beckham, B., Reilly, W., Becker, W. 1990. Clean Air Act Amendments and highway programs. Perspective of State and Local Air Administrators. *Transportation Research News* No.148 (May 1990): 17-21. Transportation Research Board, Washington DC.

The US Congress is currently considering amendments to the Federal Clean Air Act that will have significant impacts on the transportation community. This article discusses some of the changes under consideration, and the extent to which they will help improve US air quality. Among the subjects discussed are the National Ambient Air Quality Standards, health effects of air pollution, stationary and mobile sources of air pollution, integration of air quality and transportation goals, and transportation control measures.

Bellon, C.A. 1980. *Landscaping of highway projects.* National Highway Department, Argentina.

The author underlines the importance of landscaping with trees on highway rights-of-way, and presents methods of obtaining plantings that are both useful and ornamental. He emphasises the role of vegetation in the control of erosion, improvement of ground that is prone to flooding, stabilisation of slopes, and protection of forested lands bordering on the road. Previous studies of soil and climate conditions are necessary before undertaking the landscaping program to ensure successful growth and integration of the new trees into the natural landscape. He outlines the aesthetic considerations, such as colour, shape and size of trees, and the grouping and placement of plants.

Better Roads. 1988. Environment taxes top state's legislative moves. *Better Roads* (United States) December: 36-40.

Arizona's HB 2206 was its most significant piece of transportation-related legislation adopted in 1988. The law deals with air quality and, for instance, all gasoline supplied or sold in the Phoenix metropolitan area must be an oxygenated fuel. Leaded fuel must be an ethanol or methanol blend. The bill created an actual ADOT public transportation demonstration program, backed by the annual $400 000 distribution from air quality funds whereby these funds supply grants for air quality-related public transportation pilot projects.

Bickmore, C., Dutton, S. 1984. Water pollution in motorway runoff. *Surveyor* 3 May: 12-13.

Run-off from motorways is collected from the road surface in a number of ways: by gully pots into drainage ditches; open retention lagoons into drainage ditches or soakaways; catchpots into drainage ditches or soakaways; or by french drains into drainage ditches.

These drainage systems intercept pollutants, thus preventing them from entering the receiving stream. They provide for the settlement of sediments and for the trapping of oily material. Oil traps are installed in the drainage systems of some service stations and also in rural areas where a motorway drainage system discharges to a particularly sensitive watercourse. Reservoir, wet area or aquifer French drains are more effective than piped or channelled drains at filtering out suspended material and so tend to be used more frequently.

Box, J.D., Forbes, J.E. 1992. Ecological considerations in the environmental assessment of road proposals. *Highways and Transportation* April: 16-23.

This paper describes key areas which road engineers and planners need to be aware of including specific references to the Environmental Assessment Process. For policy purposes it was concluded that:

- Environmental considerations should be taken into account at the earliest stage of project-planning.
- Due weight should be given to the nature conservation resource. Sites of Special Scientific Interest should not be traded off.
- Consultation should take place at the most earliest stage and be ongoing throughout the construction.
- Professional consultants with appropriate expertise should carry out the ecological parts of the Environmental Assessment.
- Relevant mitigation and enhancement measures should be carefully considered as a integral part of the Environmental Assessment process.
- Monitoring of environmental change during and after construction will allow more accurate predictions to be made in the future.

Bradley, R., Holsman, B.R. 1983. *Some observations on the impact of main road traffic noise in Sydney.* Pp.98-118 in Transport Road and Research Laboratory, Australian Government Publishing Service, Canberra.

This study investigates some of the social and economic effects of main road traffic externalities, in particular those associated with traffic noise in Sydney. Short and long term residential property price movements on main roads and control streets and the impact of noise on property price are analysed. The study shows that the economic and social implications of main road traffic noise are variable across Sydney. In certain areas of Sydney, in both the short and long term, there are considerable depressive effects on property prices resulting from combined main road externalities. It was considered that the role of noise in determining property price is minor.

Braun, R.L. 1977. *Benefits of pedestrian separation can be quantified.* Stanford Research Institute, Arlington, Virginia, USA.

The objective of this research is to identify and develop techniques for quantifying all the significant direct and indirect benefits associated with the separation of pedestrian and vehicle traffic and to develop a methodology for relating these benefits to the evaluation of proposals for separation. The methodology developed was a unitless scoring system that combined subjective values reflecting community preferences with objective measurement for 36 variables such as travel time, ease of walking, accident threat concern, effects of air pollution, and residential dislocation.

Unitless scoring reduces the need for assigning dollar values to the many non-economic impacts of pedestrian facilities. To ensure that the methodology could be applied to real-life

situations, the techniques developed were tested at both existing and proposed pedestrian-vehicle separation facilities. Results of the measurement techniques and methodology indicated a comprehensive and consistent, yet flexible and responsive tool for traffic engineers, planners, developers, architects, evaluators, political decision makers, lobbyists, and community civic groups.

In addition, the inclusion and quantification of the many subjective variables reflected the presence of needs and desires within the community that are usually excluded from economic analysis.

Burkhardt, J.E., Wozny, M.C. 1984. Comparative assessment of selected models of community cohesion. *Transportation Quarterly* 38(3): 375-392.

Because questions concerning the extent and severity of community consequence of highway improvements have created considerable controversy in recent years, the ability to accurately forecast these consequences has become extremely important. One method of determining the socioeconomic impacts of highways would be to measure community status and change at key points in the highway development process.

A major drawback to these longitudinal studies is the large amounts of time and money necessary to monitor the entire highway improvement process over a 10 to 20 year period. As an alternative to using the real time, on-site longitudinal analyses, "compressed longitudinal analyses", relying on historical observations and secondary data sources are being tested to determine if they can be used to show the socioeconomic effects of highway.

Coit, R.J. 1974. Legal issues surrounding roadway pricing on city streets and bridges. *Transportation Research Record* 494: 1-10.

This paper focus on the legal issues of two schemes: placing a commuter tax on central city streets and adjusting bridge tolls to meet congestion pricing goals. These issues may be relevant but, because of the date of the article, material on these two legal issues has been explored in more recent documentation.

Cohn, I.F., McVoy, G.R. 1982. *Environmental analysis in transportation systems.* Bumpus, Haldane and Maxwell Ltd, Documentation Centre, Olney, Buckinghamshire, England.

This book introduces recent modelling tools and techniques for the quantitative analysis of environmental factors (e.g. noise, air quality, and water quality), in transportation systems including highways, aviation, and railroads. It discusses the legislative steps involved in conforming to the regulatory process for each environmental parameter, and explains the technical tools for performing analyses to complete the project development process. It fully

examines the utilisation of modelling techniques such as STAMINA and the integrated noise model for highway and aviation noise predication, as well as CALINE-3 and HIWAY-2 for air quality analyses.

Colwill, D.M., Hickman, A.J., Waterfield, V.H. 1983. Estimating air pollution around highways. *Planning & Transport Research & Computation, Proceedings of Summer Annual Meeting Report No.* P239: 113-123.

New motorways, bypasses and traffic management schemes give rise to changes in traffic flows which have a consequent effect on the concentration of air pollutants nearby. A method of estimating the maximum levels likely to be experienced at a given receptor close to a road network has been developed and it is intended to be used to indicate areas where atmospheric pollution may be a problem. The inputs required for the computer program are traffic flow, traffic speed, road layout and simple meteorological data.

It is recommended that the estimates are made for the "before" and "after" situations so that pollution levels at sensitive locations can be compared. Where this cannot be done predicted values can be related to air quality data and an additional computer program used to estimate the distribution of pollutants likely to occur, so that the frequency of occurrence of high concentrations can be assessed. The methods predict concentrations of carbon monoxide. Information on levels of hydrocarbon, oxides of nitrogen and lead can be obtained from relationships described in the paper.

Colwill, D.M., Peters, C.J., Perry, R. 1985. Motorway run-off, the effect of drainage systems on water quality. *TRRL Research Report* 37: Transport and Road Research Laboratory, Department of Transport, UK.

This extract researched actual methods used in mitigating motorway run-off. The effectiveness of a sedimentation tank, a lagoon and a french drain in removing motorway pollutants resulted in the drainage system reducing the levels of suspended solids but had no effect on the concentration of dissolved material with seasonal variations determining its effectiveness. The lagoon and the french drain produced substantially larger reductions in pollutants than the sedimentation tank and they also have predicted longer periods of effective operation.

Department of the Environment and Department of Transport. 1979. Local Government Finance (England and Wales). The Rate Support Grant Order 1979. The House of Commons, London.

Section 1 of the Local Government Act requires the Secretary of State to make grants known as rate support grants to local authorities. Under the Act the aggregate amount of supplementary grants for transport purposes and for national parks are required to be

prescribed by the Rate Support Grant Order. This aggregate amount is to be divided into three parts known as the needs element, the resources element and the domestic element.

The needs element is payable to councils of non-metropolitan counties and districts and metropolitan districts and boroughs. The resource element is payable to any rating authority if its rateable value per head of population of the authority's area falls short of the national standard prescribed for the year in the Order. The domestic element is payable to all rating authorities who are required by the Secretary of State to reduce the rate on dwelling by amounts prescribed in the Order. This rate system is an actual approach to distributing grants to authorities who should implement expenditure into transport purposes.

Department of Transport. 1991. *Transport and the environment.* London, Department of Transport.

In September 1990, the UK Government published *This Common Inheritance*, a White Paper setting out policies on all aspects of the environment, including transport. It identifies a number of areas where the growth in travel may damage the environment and commits the government into action.

The Government aims to achieve a balance between the various forms of transport so that each of them can make its proper contribution to a safer more environment-friendly and more efficient transport system. For transport, this means thinking about the way we travel and implementing ways in which we can reduce environmental damage. It also means that we must accept that preserving the environment has a cost and be prepared to bear it.

Douglas, N., Nuttall, H. 1992. *Planning transport: the user's view.* Steer Davies & Gleave (NZ) Ltd, Wellington, New Zealand.

This report contains results of a survey on attitudes from Wellington residents towards transport improvements. This information would be the most up to date in respects to public response to Wellington transport systems and hence may be of practical use for establishing specific techniques to formulate policy.

Respondents indicated that two-thirds of funds should be allocated to public transport, with only a third going to roads. It was determined by respondents that money should be spread across the following public transport improvements by:

- Improving existing public transport (24%)
- Cheaper public transport (21%)
- New forms of public transport such as Light Rapid Transport (18%)
- Improving existing roads (27%)
- Building new roads (9%)

Respondents supported the concept of user pays for roads, for instance:

- Journey-based toll (40%), i.e. pay for a new road
- Petrol surcharge (23%), similar to the regional petrol tax
- Rate surcharge (22%)

With tolling techniques, the following percentages were obtained:

- Pre-paid electronic card (34%)
- Paying at a ticket barrier (26%)
- Window stickers allowing access to an area for a specific period (22%)
- Electronic credit cards linked to a central billing system (17%)

Daily commuters favoured pre-paid electronic cards (42%) more than irregular users who had a strong preference for cash payment.

Car commuters would be prepared to pay a toll of $12.22 to save an hour of driving time. Non-commuters would pay $7.42 per hour of travel time.

There was no aversion to paying tolls. In other words people would act rationally if tolls were introduced and pay tolls up to the value of their time saving.

Erickson, P.A., Camougis, G., Robbins, E.J. 1978. *Highways and ecology: impact assessment and mitigation.* National Technical Information Services, Virginia, USA.

The enactment of the National Environmental Policy Act 1969 (NEPA) expanded the requirements for the highway professional to consider all aspects of a highway development project. Part of this assessment are the effects of highway projects, highway operations, and highway maintenance on natural resources. These effects occur at both biological and ecological levels.

This book uses an ecosystem approach to impact assessments. The components and dynamics of terrestrial, aquatic and wetland ecosystems are described. Potential biological and ecological impacts of a highway project are also described. This analysis is broken down into pre-design, design, construction and operation and maintenance phases. Extensive discussions on methods of mitigating adverse impacts and enhancing the existing biological resources are included.

Fingland, D., Gurney, A. 1985. Urban roads appraisal: planning and environmental aspects. *PTRC Education and Research Services Ltd.* Vol P270: 51-66.

The first section of the paper considers environmental evaluation at the strategic level. A method is suggested which allows problem identification and solution testing over a wide network, while being readily usable by the decision maker. Methods developed in the 1970s provided network-wide assessment by aggregation of the effects on a number of issues. The problems of this approach are examined. An alternative methodology is recommended, based on the use of representative issues for network-wide analysis, coupled with examination of other localised issues.

The paper then concentrates on appraisal at the route selection and design states. The means by which the different aspects can be effectively included in the appraisal are considered. The integration of policies in the appraisal process is logically provided within the problem-orientated approach. The techniques available for assessing effects on people in terms of intimidation, severance, noise, air pollution, visual impact and vibration are discussed.

Finally, an adaption of the Manual of Environmental Appraisal approach is recommended, which involves a series of frameworks; the first summarises all the issues and options examined; the second on the information on which a decision can be based; with the last providing a summary to enable "trading off" between options.

Fitzsimmons, J. 1992. Extract and impact. *Terra Nova* (July): 48-49.

Fitzsimmons argues that the removal of Part 9 from the Resource Management Act has meant that Crown Minerals can not be managed sustainably. Therefore the sustainable management of fossil fuels is not being achieved.

Natural and physical resources are defined, including minerals and energy and are clearly expressed in Section 5(1) a and b. The first of these cannot be achieved without stabilising and then substantially reducing greenhouse gas emissions - particularly carbon dioxide, which comes mostly from burning fossil fuels. Fossil energy use is a principal cause of many other threats to the sustainability of air, water, soils and ecosystems; acid rain, smog, run-off from roads into water systems; marine oil spills; land and water damage from open-cast mining.

But outputs can never be entirely separated from inputs. Pollution and resource depletion are two sides of the same coin. The carbon which is adding to the greenhouse effect is the carbon which was unnecessarily mined because we use energy inefficiently. The lead which pollutes road dust, air and waterways is accelerating the depletion of finite lead resources.

In the case of transport fuels the two most promising renewable options are: compressed biogas from plant and animal materials, especially agricultural wastes, and hydrogen made from solar electricity. We need to adjust to a gaseous rather than a liquid fuel so widespread use of natural gas for CNG would create a valuable bridge to sustainable transport fuels.

Forester, J. 1983. *Bicycle transportation.* MIT Press, London.

This book presents the basic principles of cycling transportation engineering. It begins by reviewing the traffic laws governing the behaviour of road users and examines the cyclist "inferiority complex" vis à vis car drivers. Parameters of practical bicycling which include distance, hills, traffic, carrying capacity, weather, origins and destinations are given together with the history and demographic aspects of cycling, proficiency required from cyclists, accidents, effect of cyclists on traffic, effect of bikeways on traffic, flow of cycle traffic, economics of cycling, cycling organisations and effective educational programmes.

A cycling transportation programme is recommended and the need for a change in governmental policy is stressed. Law enforcement, roadway design standards with cyclist safety in view, and the improvement of bicycling facilities are other areas discussed. Finally, mention is made of standards, specifications and regulations for bicycles, night time protective equipment, and the most useful types of maps for cyclists.

Harrop, O. 1983. *Stormwater pollution from highway surfaces: a review.* Middlesex Polytechnic Research & Consultancy Stormwater Pollution Research Centre, England.

The study evaluates the quality of road surface run-off, in respect to the presence of heavy metals and hydrocarbons, with the following objectives: (a) the identification and quantification of pollution loadings, and (b) the provision of an adequate base for modelling studies of quantity-quality data. The report represents the first literature review for a modelling study being undertaken in an urban catchment area in north-western London. Pollutants identified are associated with the wear of **vehicle tyres, vehicle lubricants and emissions, atmospheric fallout**, and other sources.

Himanen, V., Makela, K., Alppivuori, K., Aaltonen, P., Louhelainen, J. 1989. The monetary valuation of the environmental hazards of road traffic. *Nordic Road & Transport Research* 1(1): 11-13.

This report estimates the quantity of noise, exhaust emissions and dust caused by road traffic in Finland along with the monetary value of their effects. The valuations are mainly based on the estimated costs of the prevention of these hazards. In addition, the cost related to losses caused by traffic noise and exhaust emissions are estimated. The results contain a substantial amount of uncertainty and hence the validity of such an approach can be questioned.

Hodgen, R., Ford, C.D. 1985. The planning, design and construction of a bypass through an area of outstanding beauty. *Proceedings of the Institution of Civil Engineers, Engineering Management Group: Part 1:* 78: 1065-1083.

The bypass discussed in this paper was built through an area in which its environmental impact was substantial. The paper concentrates on traffic impacts, route selection and integration, bridge forms, impacts on local activities and construction criteria. This may be useful in reviewing actual approaches used in treating these externalities.

Hokanson, B., Minkoff, M., Nichols, S., Cowart, S. 1981. Measures of noise damage costs attributable to motor vehicle travel. *Iowa University Institute of Urban and Regional Research, Iowa City, December Report,* No. 135.

One way to calculate the total cost of highway noise pollution is to determine the overall reduction in residential property values resulting from use of the highways, an approach which emphasises people's willingness to pay to avoid high levels of noise in their living environments. This study investigates such an approach, applying a methodology and then examines its strengths, weaknesses, and feasibility.

The basic model consists of the following relationship: noise damage costs = housing units impacted multiplied by noise level at midpoint of distance range minus threshold noise level (excess dBA) multiplied by reduction in property value per dBA beyond threshold level. Greater noise damage costs might be expected to correlate with highways of greater usage. For this reason, noise damage costs are calculated for multiple traffic volume ranges, allowing a cost breakdown. These traffic volume range damage costs can then be summed to yield a grand total cost for that highway class.

Holtman, R.E., Associates Ltd. 1975. Urban boulevard plan for Federal Hill-Montgomery Street historic district in Baltimore. *Transportation Research Record* 551: 25-29.

An Interstate Highway planned to go through the Federal Hill-Montgomery Street historic district would have had adverse impacts to the district. The Interstate Division developed a new highway alignment and mitigation plan which was endorsed by the community. Mitigation features that protected the community and treated against externalities, i.e. noise, traffic danger, air pollution and aesthetic impairment, included:

- Landscape treatment of the roadside environment involving earth berms, brick walls, trees and shrubs, and
- Creation of new urban parks in keeping with the historic character of the district.

Compromise between the differing groups was achieved primarily by direct involvement and open communication with the residents of the district.

Horner, R.H., Mar, B.R. 1985. Assessing the impacts of operating highways on aquatic ecosystems. *Transportation Research Record* 1017: 47-55.

This extract looks at a technique that has been developed for assessing the impacts of highway operations and maintenance, and determining the need for impact mitigation measures, and is specifically aimed at mitigating highway run-off. The basic premise of this technique is that the impact of highways on the receiving water can be assessed most realistically in the context of the aggregate burden that is created by all the activities in that watershed. The technique offers opportunities to forecast potential highway run-off at an early stage of project development.

Hothersall, D.C., Salter, R.J. 1977. *Transport and the Environment.* London. Crosby Lockwood Staples.

In assessing a formal technique that can analyse such environmental effects as air pollution, noise and visual intrusion, it is suggested that an approach called the Leopold matrix could be implemented whereby an assessment of probable impacts should consist of three basic elements:

- A listing of the externalities and magnitude of them by the proposed development
- An evaluation of the importance of each of these effects
- Combining the magnitude and importance estimates in terms of summary evaluation

These three elements are analysed using a matrix, for which one axis represents the actions which cause the environmental impact and the other axis the existing environmental conditions which might be affected. This approach helps to visualise the variety of interactions which involve environmental impacts and to identify alternatives that might lessen the impact.

After all anticipated actions have been checked with environmental effects, consideration should be given to the weighting, the magnitude, and the significance of the interaction. A weighting factor ranging from 1 to 10 is introduced, with 10 indicating the greatest effect and 1 the least interaction.

Assignment of numerical weights to the magnitude and importance of impacts should be based on factual data rather than preference.

This matrix system could determine what action could be taken to reduce impact of a transportation proposal or whether alternative proposals are likely to have lower environmental impacts.

Huddart, L. 1990. The use of vegetation for traffic noise screening. *TRRL Research Report* 238. Transport and Road Research Laboratory, Department of Transport, UK.

Noise barriers such as walls, fences or earth moulds are often used to reduce noise pollution. An alternative, which is more likely to be environmentally and aesthetically pleasing, is a belt of vegetation. This report describes a literature survey to investigate the effectiveness of vegetation in reducing traffic noise annoyance, and a field study which measured traffic noise attenuation through five vegetation types up to a depth of 30 m. Both the literature and the field study found that the foliage is effective in reducing high frequencies (above 2000 Hz), while low frequencies (250 to 500 Hz) are attenuated by the absorbing qualities of the ground enhanced by plant root systems and leaf litter.

Hunt, M. 1989. A synthesis of surveys on reaction to road traffic noise in New Zealand. *NRB Road Research Unit Occasional Paper.* National Roads Board, Road Research Unit, Wellington, New Zealand.

The results of several social surveys on reaction to traffic noise are presented in a comparative way so that common trends have been identified. These surveys may be applicable to quantifying suitable techniques for formulating policy for noise externalities. Traffic noise is the single most identifiable noise source in residential areas. An average dose/response relationship is given following consideration of relevant data on reaction and physical noise measurements. The dose/response relationship is in general agreement with overseas results and can be used as a predicator of human response as a function of traffic noise level.

Conclusions presented are intended to establish the current level of reaction to traffic noise in New Zealand residential areas and are also intended to develop an understanding of the requirements of an integrated noise control programme.

Irwin, N.A., Johnson, W.F. 1990. Implications of long-term climatic changes for transportation in Canada. *Transportation Research Record* 1267: 12-25.

A preliminary, strategic assessment for the implication of long-term climatic changes related to the greenhouse effect and likely impacts of such developments on Canadian transportation are presented. A number of implications for policy and research and development are as follows:

Policy Issues

- Control of greenhouse gas emissions
- Sovereignty and defence
- Northern environmental protection
- Transportation system planning and investment
- Transportation system operation, regulation, and adaptation

- Transportation cost minimisation
- Continuing surveillance, research and forecasting

Suggested Actions
- Monitoring of climatic-related variables
- Climatic-transportation research studies
- Environmental protection studies
- National and international co-operation

Japanese Ministry of Construction. 1987. *Appraisal of the social and economic effects of road network improvements.* Paris, OECD Road Transport Research. Tokyo, Japanese Ministry of Construction.

This expert meeting and symposium consisted of four sessions:
Session I - Concepts and Issues discussed traditional cost-benefit analysis and new evaluation concepts.
Session II - Evaluation Procedures reviewed the limitations and validity of present cost-benefit analysis focusing on evaluation methods for indirect effects.
Session III - Case Studies was a practical assessment of the impacts of road improvements on the social and economic sectors including prediction models for prior evaluation of urban and regional developments.
Session IV - Outlook, Road Policy and Research examined policy measures for promoting large scale projects with respect to the effectiveness of public resource allocation and the potential offered by the private sector investment in road network improvements.

Johnston, R.B., DeLuchi, M.A., Sperling, D., Craig, P.P. 1990. Automating urban freeways: policy research agenda. *Journal of Transportation Engineering* 116(4): 442-460.

This paper describes the staged development of automated urban freeways and then suggests a series of research topics related to major policy issues of road capacity, air quality, noise, safety and liability, cost and equity, privacy and organisational complexity. This material offers approaches to automating freeways to relieve congestion.

Jonathan Coppel International Energy Agency. 1991. *An analysis of energy policy measures and their impact on CO_2 emissions.* Greenhouse Research Initiatives in the ESCAP Region - Energy ESCAP, Thailand.

Of all the measures assessed in this paper, only two scenarios would stabilise OECD energy-related CO_2 emissions at the current level by the year 2005. These are the $200 tax per tonne of carbon and the $100 tax combined with the 50% nuclear case. Even for these two scenarios stabilisation would be temporary unless further actions were taken post-2005.

According to the scientific community, stabilisation of CO_2 concentration levels, and hence climate, implies a 50 to 80% reduction in CO_2 emissions and subsequently a 50 to 80% reduction in the use of coal, petroleum and natural gas. It is important to recognise that small, easy and low-cost initiatives, while helpful from an institutional and procedural viewpoint, are not however going to have much of a impact on the total CO_2 accumulations.

King, S.J., Barrett, J.R., Bamford, W.E. 1984. The economic advantages of tunnels replacing urban road networks. *Fifth Australian Tunnelling Conference,* Sydney, 22-24 October 1984: 137-141.

Tunnels reduce noise, air pollution, community disharmony and are not visually unattractive as are surface roads. The intangible costs, such as effect on community health, air pollution and noise, make tunnelling viable if they also are assessed. The aim of the study was to determine the effects that large volumes of traffic have on property values, noise intrusion, and fuel consumption.

It was found that 80% of the capital costs of constructing a tunnel can be traded-off against the cost of existing roads over the useful life of the tunnel, if values are placed upon these intangibles. The trade-off could be greater if the gain in surface space, health costs or visual aspects were included in the analysis. When these costs are assessed, tunnelling can become a cheaper alternative to new or planned surface roads, and has an environmental advantage over present roads in such inner city areas.

Kober, W.W., Kehler, S.E. 1987. An analysis of design features in mitigating highway construction impacts on streams. *Transportation Research Record* 1127: 50-60.

This research project evaluated the biological conditions in two streams before, during and after the construction of two large arch culverts and the relocation of approximately one mile of stream. In addition the cost and effectiveness of the mitigative design features incorporated into the culverts and the stream relocation to promote recovery were analysed and the results clearly showed that the mitigation was effective in accelerating stream recovery. The overall cost of including mitigation measures was slightly less than the development without mitigation measures. This paper shows actual methods used to treating external effects created from culvert construction.

Lasiere, A., Bowers, P. 1972. *Studies on the social costs of urban road transport (noise and pollution).* Report of the 18th Round Table on Transport Economics, Paris, France. Department of the Environment, London, UK.

The social costs of urban road transport in terms of noise, air pollution, visual intrusion, pedestrian/vehicle conflict and severance, are large and growing. A model of an economy is developed in which negative external effects of this type occur, and the tax on polluters

required to reach a Pareto optimum is derived. If the model is to be made operational, the disadvantages for those affected must be measured and valued.

Five methods of environmental evaluation are being developed concurrently in the United Kingdom. These are (1) analysis of the housing market, (2) analysis of amenity improving expenditure, (3) game methods, (4) simulation techniques, and (5) social surveys. A review of these suggests that economic valuations of environmental effects will not be obtained by devising a charging system to allow fully for all the social costs created by vehicle users. Nevertheless charges may have a role to play in the control of urban transport pollution.

Mantynen, J. 1988. *The economic valuation of traffic.* Neste Ltd. Keilaniemi Espoo, Finland.

This study aims at widening the viewpoint of classical methods of transport economics. Transport policy and decision-making concerning transportation are connected to, among other things, community structure, and environment, the flow of freight transport and the convenience of passenger traffic. Noise, exhaust emissions and barrier effects are the most significant environmental effects of traffic. In this study a method has been developed which estimates the **amount of exhaust emissions and their calculated costs.** Road investments may reduce the driving costs of freight transport by half a billion Firm a year

McDowell, B.D. 1988. Transportation institutions in the year 2020. *Transportation Research Board Special Report 220 - A Look Ahead : Year 2020*: 507-524.

This paper approaches the rethinking of transportation institutions by examining the external forces that appear to be shaping existing transportation programs and future demands, and then by speculating how future transportation needs might be repositioned in the political mainstream from their increasingly marginal location among public policy concerns. This analysis allows institutional implications to be drawn and played out among the central, local and regional units. This article may reflect new policy directions in how regional government should regulate externality costs.

McLachlan, S., Samuels, S. 1989. *Road traffic noise control into the nineties.* The Victoria Division of the Australian Acoustic Society Symposium : Traffic noise - whose problem? Australian Acoustical Society, Kew, NSW, Australia.

This paper is concerned with techniques for traffic noise control other than with those related to reducing vehicle noise emission. Several noise control techniques are considered and an attempt is made to assess their effectiveness when applied to each particular problem category. The techniques include road design, traffic management, barriers, planning, building design, incentives and promotion campaigns. Since the ultimate effectiveness and acceptance of these techniques depend on how well they are technically and socially

implemented, an appropriate strategy for development, co-ordination and implementation of the techniques is proposed.

Ministry of Transport (MOT). 1991. *Transport directions 1991-1996 - strategic policy initiatives for the next five years.* Ministry of Transport, Wellington, New Zealand.

This discussion document sets out a series of strategic initiatives for the transport sector. For instance, the concept of the safety audit will be a primary means of ensuring acceptable levels of safety. Greater attention will also be paid to the environment with environmental issues being incorporated in both cost structure and planning activities. Vision and strategy initiatives are a message for central and local government activities in relation to transport, being confined to policy, planning, regulation and the audit with minimal bureaucracy. The strategic initiatives outlined in this document make up six key areas of transport policy - safety, efficiency, environment, social goals, international issues, systems, and structures.

The issue of environment covers:

- A research strategy will be developed in association with other Government agencies to examine detailed options, including the development of alternative fuels.
- Policies will be developed so that a Ministerial directive can be issued to Transit New Zealand, to require the Authority to give preference to transport methods producing lower CO_2 emission levels.
- A national transport policy statement will be prepared in association with the NZ Ministry for the Environment to ensure the total transport system has a minimal effect on the natural environment.

Moore, B. 1990. M40 extension - the environmental approach. *Highways and Transportation (December):* 15-22.

The M40 extension through the West Midlands will decrease traffic flow on alternative transport routes by 50% and in particular the flows of heavy goods vehicle which will benefit some communities. However, the construction of such a major link as the M40 across an attractive and rural part of England has other environmental problems such as noise and visual intrusion for people living near the new link. This article gives an account of mitigating these externalities on a very large scale by planting trees and shrubs and by sowing 22 hectares of wild flowers. Therefore the purpose of this article is to explain some techniques used in assessing environmental effects and to describe some of the measures carried out in mitigation.

Nielsen, O.H., Rassen, J. 1986. Environmental traffic management in Odense, Denmark. *Built Environment* 12(1/2): 83-97.

This paper looks at actual transport policy changes from a car-orientated policy to a public transport policy, with bicycle use and the restrictive measures against the car in the urban areas in Odense. Such measures include the enlargement of pedestrianised areas, construction of additional cycle tracks and future policies for car parking.

Oderwald, W.H., Sontag, M.A. 1990. Evaluation of hazardous material - transportation by rail. Pp.191-204 in *State and Local Issues in Transportation of Hazardous Waste Materials: Towards a National Strategy. Proceedings of the National Conference on Hazardous Material Transportation*, St Louis, Missouri. New York. ASCE.

This paper summarises a computer model, the Rail Hazardous Materials Routing System, which provides historical accident rates and population exposure data for rail routes studied for the purpose of transporting hazardous substances. This system suggests alternative routes which will minimise routing criteria such as hazardous accident rate and population exposure. The method of analysing hazardous material movement can be extended to other transport modes and are discussed in this paper.

Palmquist, R.B. 1982. Impact of highway improvements on property values in Washington State. *Transportation Research Record* 887: 22-29.

The purpose of the study is to examine the effects of major highways on the value of surrounding properties. The study applied several tested theoretical techniques to a database derived from 9359 sales records and interviews with owners of homes and businesses. In each of five study areas, hedonic pricing techniques, with all variables kept constant except those under examination, produced a quality-adjusted price index.

Improved access to residential areas provided by highway construction resulted in property appreciation 15-17% greater than comparable properties that lacked such access advantage. Even where highest noise level readings occurred, accessibility-induced property appreciation more than offset noise-induced depreciation.

Highway noise had little effect on commercial properties greater than 600ft from the highway. Validity to the 95% confidence level was the norm for hedonic regressions and related statistical computations. The results provide an accurate, reliable method for predicting the potential access benefits and noise costs in terms of relative changes in property value. This evidence will provide facts for detailed discussions during project planning.

Pickering, D. 1974. *Environmental factors - noise and visual intrusion.* Pp.256-275 in Planning and Transport Research and Computation Co. Ltd, London.

Some "shorthand" techniques which have been applied to strategic and route selection studies, are described for the quantification of noise and visual intrusion. Noise prediction methods applied at each stage of the planning process are discussed. Such techniques differentiate between source noise and noise between source and receiver, as well as between freely flowing traffic and that which is interrupted or congested.

The main forms of visual effects are categorised. A simple quantification of the visual intrusion, the measurement of the solid angle, and the position factor in human vision are also discussed.

Politano, A., Mills, F. 1980. Reducing urban blight: a reconnaissance of current highway experiences. *Transportation Research Record* 747: 49-54.

A wide variety of measures to overcome blight have been implemented or proposed, including:

- Co-ordination of highway projects with urban renewal plans and the construction of community facilities.
- Construction of express ways and parking facilities.
- Transportation systems management measures, automobile-restricted zones and the construction of pedestrian and bicycle facilities.

The investigation into these areas along with institutional and procedural problems shows they are significant and prompts a need for more research in these areas.

River, E.G., Allen, C.J. 1975. Silt barriers as erosion pollution control in a large recreational lake. *Transportation Research Record* 551: 13-24. Transportation Research Board, National Research Council, Washington DC.

This article examines an actual technique to treating soil erosion from Interstate construction, resulting in extensive run-off pollution into Lake Jackson, a large recreational lake in northern Florida. Floating silt barriers were deployed in two arms of the lake to abate movement of turbid waters into the main body of water. Clay and silt fines were the main factor creating turbid conditions in the lake while erosion controls were effective in controlling movement of sand-size sediments but ineffective in controlling clay and silt. The silt barriers were up to 93% effective in preventing the spread of suspended silt and clay into the main body of the lake.

Roads and Transportation Association of Canada. 1990. *Environmental implications overview for the National Highway Policy Study.* Roads and Transportation Association of Canada.

The National Highway Policy study that was initiated in 1988 has developed a proposed national highway program (see "National Highway Policy for Canada : Steering Committee Report on Phase 1" - IRRD 807292). This report provides an overview of the environmental implications associated with that proposed program. The report discusses existing environmental assessment procedures that are in place at the Federal level and at the Provincial level in the province of Ontario. The conclusions indicate a number of potential benefits that may result from the program in the areas of accessibility, operating costs, safety components and interprovincial travel. Significant negative affects are identified relating to agriculture, surface water, wetlands and terrestrial wildlife. The ability to mitigate the negative effects is discussed in Chapter 4. It is concluded that the concentration of the program on improvements of the existing highway system will tend to limit the potential negative environmental effects while providing potential positive social and economic benefits.

Seskin, S.M. 1990. Comprehensive framework for highway economic impact assessment: methods and results. *Transportation Research Record* 1274: 24-34.

A framework for assessing economic impacts of highway improvements that are comprehensive in scope, diverse in methodology, and useful both for ranking improvements and in making investment decisions is presented. Current user assessment techniques are expanded by adding an assessment of regional benefits. These benefits are measured in terms of changes in business costs, both in absolute terms, and in relation to costs experienced by areas or regions not affected by the proposed improvement.

Regional economic benefits include opportunities for business expansion, business attraction, and tourism development. Expansion benefits include the indirect and induced effects of user benefits, time savings, operating cost changes, and safety benefits. Business attraction include the effects of the highway investment on the types and quantity of economic activity that may occur in the affected region as a result of the highway.

Three case studies are presented. The case studies suggest that the regional benefits had the value equal to 50 to 150% of benefits alone. Regional benefits are sensitive to the level of improvements of affected links, and to the implementation of related public policies.

Sharp, C. Jennings, T. 1976. *Transport and the environment.* Leicester University Press.

This book examines the impact of noise, air pollution, vibration, accidents, and delays caused by slow-moving vehicles, road wear, visual intrusion and severance on communities, as well as policy that might reduce these externalities.

The difficulties in measuring costs and benefits and the value judgements which may guide transport policy are reviewed. The role of local and central authorities are considered particularly with methods that allow environmental benefits when planning new transport investment.

Shearin, G. 1988. "After" benefit-cost analysis of the Elko, Nevada, railway relocation. *Transportation Research Record* 1197: 68-76.

The main result of the benefit-cost study was the quantification and pricing of the primarily social and environmental benefits of the railroad relocation, including flood control as well as the reduction in noise, vibration, accidents and considerable delay and disruption in the downtown area. Depending on the discount rate, benefit-cost ratios of .61 to 1.12 were calculated. Approximately 80% of the benefits went to the community and 20% to the railroads. This is an actual method used to define the extent of externalities so that the lowest impact of effects incurred on the community.

Smith, V.K. 1989. Can we measure the economic value of environmental amenities? *Resources for the Future Discussion Paper QE90-06* (46). Bowker.

The conceptual basis for valuing environmental amenities is reviewed. Travel cost recreation demand and hedonic property value models are discussed as strategies that rely on observed choice to measure use values for environmental resources. The growing importance of measuring non-use values is noted since people experience satisfaction from environmental resources without actually using them. Non-use values do not require a choice, so measuring them requires analysis of other behavioural indicators. Recent advances are reported in using surveys as conservational sources of information about people's values within a contingent valuation framework.

Tasman Institute. {199?}. Carbon abatement: the cost to the economy. *Tasman Institute Background Note* No.1. Tasman Institute, Melbourne, Australia.

One of the options of achieving carbon abatement is by imposing carbon tax - either a tax on emissions or a tax on outputs or inputs associated with emissions. The tax is a superior policy instrument to command and control regulation because it offers producers and consumers the incentive to save money by applying low cost means of reducing their emissions.

In the US the Bush administration resisted strong pressure from the green lobby for a carbon tax. The studies also estimated that there would be an annual loss of GDP of between .7% and 2.0% from the year 2005 if tax rates were imposed.

Tempest, W. 1982. *Prediction of traffic noise.* Traffic Committee Road Research Unit, National Roads Board, Wellington, New Zealand.

The aim of this research was to examine the "Calculation of Road Traffic Noise" (CRT) procedure with particular reference to:

- Facade correction
- Influence of heavy vehicles on traffic noise levels
- Attenuation of levels with distance

This method was found to predict traffic noise levels with the same accuracy in New Zealand as in the UK. The main deficiency in the CRT predictions is that they fail to deal with the types of road surfaces experienced in New Zealand. A more detailed correction term for road-roughness is clearly needed. The facade effect correction was modified slightly to suit New Zealand conditions and heavy vehicles in the traffic stream is greater at motorway speeds than the CRT predicted. No modification is proposed to the treatment of the attenuation of sound with distance. This method may be a actual approach to treating noise externalities.

ter Brugge, R. 1991. Logistical development in urban distribution and their impact on energy use and the environment. *Freight Transport and the Environment (Studies in Environmental Science)* 45: 331-341.

This article reports on the growing use of automobiles and the need to focus on the problems they create. Subsequently, the possibilities and limits of technological developments are given. A recent study shows that these technological advancements can only curb energy consumption by 17%. With respects to the expected growth rates, these solutions are not enough. Based on other research, the logistical organisation of transport can be instrumental in achieving higher efficiency in transport. Looking at freight transport in urban areas the paper asks for better logistical organisation, implementation of information technology and new transport technologies, and for better measures in the field of physical planning within the cities.

Thrasher, M.H. 1983. Highway impacts on wetlands: assessment, mitigation, and enhancement measures. *Transportation Research Record* 948: 17-20.

The conservation of wetland acreage in the United States, wherever and whenever practicable, is a national policy objective. This had led to an increased awareness of the need for making wise land use decisions, especially when modification of the natural environment is anticipated.

General wetland types and their basic functions and values are identified, and highway construction impacts, impact assessment, and mitigation and enhancement procedures are discussed. Special emphasis is given to the reconstruction of wetlands affected by highway construction.

Twark, R.D., Eyerly, R.W., Nassi, R.B. 1980. Quantitative technique for estimating economic growth at nonurban, limited-access highway interchanges. *Transportation Research Record* 747: 18-19.

A quantitative modelling technique for estimating the economic development that is likely to occur at a given non-urban interchange site on the Interstate highway system is described. Problems in the quantification of variables and restrictions imposed by the lack the data for certain variables were discussed. Simple, multiple, and stepwise linear regressions were helpful in identifying promising variables for the modelling technique. The model can be a useful tool in helping planners to predict land use changes at existing or proposed non-urban interchange sites. When applying it to a specific interchange, the user is cautioned to observe the total environment setting for peculiar or unique characteristics.

Underwood, R.T. 1980. Environment assessment procedures for road proposals. *Australian Road Research* 10(1): 3-7.

This paper outlines environment assessment procedures for road proposals that are followed in the State of Victoria. These procedures have evolved within a legislative framework that allows a flexible approach, with a view to ensuring that environmental effects are adequately considered.

Washington, E.J., Pinnoi, N., Stokes, R.W. 1990. *State highway investment and economic development: state of the art review.* Interim report. State Department of Highways and Public Transportation Planning Division, Texas.

This report presents a review of the literature, a survey of current practices regarding policies used to foster economic development through intercity highway improvements and the identification of current analytical techniques for assessing the economic development impacts of highways. The review contains extensive documentation of economic development programs in other states which should be useful to the Texas State Department of Highways and Public Transportation (SDHPT) in developing guidelines for evaluating the economic development potentials of highway expenditures in Texas. The results of a preliminary survey indicate that nine state Departments of Transport give some consideration to, or use the promotion of economic development as part of, their long range statewide highway planning criteria.

Watkins, L.H. 1991. *Air pollution from road vehicles.* State of the Art Review 1. Transport and Road Research Laboratory, Department of Transport, London, UK.

National and international legislation concerned with limiting exhaust emissions focuses on pollutants in the vehicle exhaust phase. The book states that the problems with defining air quality standards involve health, subjective and ecological effects, and these complications have meant that in most countries air quality itself is not given the attention that is given to exhaust emissions as produced by a vehicle. Field surveys of air quality are described in Chapter 6, together with methods of predicting the concentrations of pollutants in the air, emanating from any specified network of roads and pattern of traffic flows. Changes in traffic flow will change the pattern of emission and hence the study recommends a new internationally based study to investigate the extent to which air quality might be improved by traffic control measures.

It can be concluded that actual and proposed methods available to reduce or eliminates air pollution from exhaust emission are:

1. *Short term (present vehicles)*

   (a) Encourage the use of unleaded petrol
   (b) Enforce and reduce speed limits

2. *Medium term (modified present vehicle design)*

   (a) Complete the removal of lead
   (b) Use catalytic converters and/or lean burn for petrol engines
   (c) Tighten pollution limits for diesel engines
   (d) Improve traffic flow
   (e) Introduce fuel efficiency standards

3. *Long term*

   (a) Tighten fuel efficiency standards
   (b) Develop pollution-free vehicles

Watson, H. 1985. Landscape considerations. *Current Issues in Highway Design, Paper* 5: 95-100. Thomas Telford Ltd, London.

An appraisal method to treat landscape externalities for vertical and horizontal road alignments whereby, if finance is made available for better landscape treatment, will enable environmental improvements. Trees act as dust filters and gas exchange systems to purify air and emphasise scenery. Good design will achieve such improvements.

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The Trenton Complex was an exercise showing that through extensive and meaningful co-ordination, a highly complex and controversial highway project can move through the process of the National Environmental Policy Act (NEPA). The Trenton Complex basically shows how a project which had intricately interrelated environmental concerns, i.e. cultural resources and wetlands, was thought through with public consultation, minimising construction costs, delays and creation of potential new environmental problems. It is an example of public consultation under the NEPA that was successful.

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A road/environment typology is proposed which recognises the function of the road and its impact on the road environment. This paper summarises research carried out into friction and impact, and the policies and guidelines which have been derived by it. It also examines the implementation of road/environmental management and proposes that corridor management plans should be prepared and that planning options and implementation options should be developed concurrently.

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The analysis of traffic and transport alternatives by means of mathematical models is well-established as an aid to design and economic assessment. The emphasis in the past has been on the traffic effects of the policies involved, and it is only recently that methods have been devised to give approximate estimates of the levels of and degree of exposure to noise, air pollution, and pedestrian interference as an essential part of the study of traffic and transport proposals.

This paper covers the design and use of a special model, and the collection and analysis of noise and pollution data in a form that is suitable for forecasting. The application of the techniques is illustrated by means of models in Coventry, drawn from the Transportation Study report. The strengths and weaknesses of this approach are brought out by an illustrative application. Special attention has been paid to the different pollution estimation equations as a basis for forecasting, and the degree to which a particular choice could affect the results.

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