Traffic Growth Prediction

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An Important Note For The Reader

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Executive Summary

This research reviews previous work on traffic growth prediction and identifies which factors have the most significant effect on traffic growth. A comparison between historical changes in the factors affecting traffic growth and actual traffic growth has been made. The project was carried out in New Zealand during 1998-2000.

The objectives of this research were:

- to review the literature on traffic growth procedures in New Zealand and overseas
- to survey local traffic growth forecasting practice in New Zealand
- to review the traffic growth procedures in the Project Evaluation Manual
- to identify the factors that affect traffic growth and establish to what extent

The literature review found:

a) In Great Britain traffic growth for cars; lighter and heavy vehicles is estimated:
   i) on a national basis for 35 years by GDP; relative price of fuel; car ownership; car use and population growth. Forecasts were modified to take account of constraints
   ii) on a district basis based on the national forecasts and taking into account local car ownership (a sub-model based on household income and accessibility); and forecast trips (a sub-model that uses the number of origin and destinations in each district based on households, workers and jobs)
b) In USA, each state has its own approach, most appear to use network modelling:
   i) one of the most advanced was a gravity model with over 2,000 zones, thousands of special generation zones; 5 trip purpose types. This requires an enormous effort to build and maintain
   ii) other states use simple time series forecasting of AADT
   iii) other states use a combination, they use a network model to determine the key origin destination pairs influencing traffic growth and then use time series analysis to forecast traffic volumes that pivot at the site of interest
c) In Australia:
   i) the Bureau of Transport Economics in 1998 described a gravity model of all modes (including air) for interregional travel (with mode split determined by distance) between cities and explained 97% of the observed traffic. The modelling of highways was linked to this with forecasts by traffic category
d) Urban traffic growth is much more complex than “big picture” forecasts
   i) the important factors are: the level of service provided by the roads in question; modal choice available; traffic restraint measures in operation; peak spreading; travel and work habits

e) Previous New Zealand work:
   i) there is no NZ traffic growth model as such (cf. UK)
   ii) important factors are: land use; demographics; economic growth; car use varies with the petrol price; ownership varies with income levels; level of service

A local practice survey of regional and road controlling authorities found:

a) about 70% use the PEM and historical count data
b) cities are more involved in forecasting than regions or districts
c) there is no common approach
d) there are some very simplistic approaches (some notable exceptions)
e) no freight traffic growth forecasting
f) very little alternative-mode traffic forecasting
g) considerable interest in improving their forecasting by RCAs

A review of the Project Evaluation Manual (PEM) found:

a) The PEM currently requires
   i) actual traffic counts to be used where possible
   ii) use of arithmetic not geometric growth rates
   iii) use of default regional growth rate otherwise
   iv) future traffic should not exceed capacity
   v) land use changes should be taken into account
b) it is not clear how capacity affects traffic growth
c) it may be possible to use Bayesian methods to improve forecasts, by combining local historic growth with national growth trends.

An attempt to identify factors relevant to traffic growth on New Zealand roads found:

a) traffic growth data was regressed against: population; FTEs; Dwellings; number of business enterprises by major category; road type for a number of areas. The data was poor
b) no equation tried was satisfactory - it was felt that the data was too localised given the explanatory variables. The only significant variable in all equations was road type. It was clear that more work needs to be undertaken

Key conclusions are:

c) there is a demand for guidance in traffic growth prediction
d) the current guidance is simplistic but there is no evidence to show it does not work
e) there is no uniformity of approach by those who do additional work
f) there is a lack of knowledge of how well the current methods work
g) the Bayesian method set out above potentially offers an easy improvement on current methods
h) more needs to be done in areas where growth is significant and or land use is changing and driving traffic growth. Moreover, freight traffic growth needs to be modelled and predicted

Recommended next steps are:

a) investigate the Bayesian method
b) develop a national traffic growth forecasting programme by road type and mode
c) develop how to relate the national to regional and local traffic growth
d) investigate the effects of capacity improvements on traffic growth
e) investigate the effects of seal extension projects on traffic growth
f) develop methods of forecasting local traffic growth by vehicle type and time period

Abstract

This research reviewed the literature on traffic growth prediction in New Zealand and overseas, surveyed local traffic growth forecasting practice in New Zealand, reviewed the traffic growth procedures in the Project Evaluation Manual, and attempted to identify the factors that affect traffic growth and establish to what extent.

Although there is a demand locally for guidance in traffic growth prediction, there is no uniformity of approach by roading authorities and a lack of knowledge of how well the current methods work. More needs to be done in areas where growth is significant and/or land use is changing and driving traffic growth. Moreover, commercial freight traffic growth needs to be better modelled and predicted. Areas for further investigation include using a Bayesian method to predict growth, developing a national traffic growth forecasting programme, investigating the effects of capacity improvements and seal extension projects on traffic growth, and developing methods of forecasting local traffic growth by vehicle type and time period.

1. Introduction

This research reviews previous work on traffic growth prediction and identifies which factors have the most significant effect on traffic growth. A comparison between historical changes in the factors affecting traffic growth and actual traffic growth has been made. The project was carried out in New Zealand during 1998-2000.

Likely traffic growth over the lifetime of a roading project is an important consideration in the assessment of the project's feasibility. As roading projects in New Zealand are currently assessed by their Benefit/Cost Ratio (BCR) evaluated over a twenty-five year project period, the estimation of traffic growth throughout this period is a vital component of life cycle analysis. In a normal Project Evaluation Manual (PEM) economic analysis over twenty-five years, a 1% increase or decrease in traffic growth can affect the overall benefits by 6 – 9% (depending on whether high or low growth is used) when a constant rate of growth is assumed (derived from Transfund 1999). However, potential growth rates are very difficult to determine accurately. Simplistic approaches commonly used are often not very satisfactory in accurately predicting the true long-term growth.

There are many factors which are thought to influence traffic growth, including:

- Population Growth/Migration
- Land Use Changes
- National/Regional Economy
- Vehicle Operating Costs
- Capacity Restraints
- Induced Traffic due to new road facilities nearby
- Vehicle ownership levels
- Availability of alternative transport modes

At the most basic level, historical growth rates have often been used as the basis for extrapolating future traffic growth. Alternatively, Transfund New Zealand's Project Evaluation Manual (PEM) provides a simple table of growth rates by region and road type. These simplistic approaches are often not very satisfactory in accurately predicting the true long-term growth. To that end, many of the major regional councils have developed independent prediction models for their own forecasting purposes.

1.1 Objectives

The main objectives of this research were:

- to review existing traffic growth prediction procedures in New Zealand and overseas. This includes an extensive literature review and a survey of local practice by Regional and Road Controlling Authorities.
- to identify which factors affect traffic growth, and to what extent. Historical traffic count data and relevant statistics are compared.

These are discussed in more detail below.

1.1.1 Review of Existing Traffic Growth Procedures (Task 1)

A review of overseas and local literature on traffic growth prediction has been carried out, in conjunction with a review of the PEM traffic growth procedures. This was to identify how traffic growth prediction has been undertaken elsewhere (both at national and local levels) and what factors are taken into account. The PEM review provides a comparison with these procedures.

Additionally, Regional and Road Controlling Authorities have been surveyed to determine what different methodologies or special procedures are adopted in this country. The key factors that these authorities take into account have also been investigated.

1.1.2 Significance of Factors Affecting Traffic Growth (Task 2)

The review undertaken as part of Task 1 identifies a list of factors that are considered to have an effect on traffic growth. Such factors include demographics, economic performance measures, adjacent land uses, and transport statistics.

These factors have been examined in light of their historical trends and compared with the corresponding traffic growth rates. A statistical study has then been undertaken to assess the relative importance of each factor.

A brief review of the available data sources has been made, and from this a number of routes throughout New Zealand have been selected for detailed analysis. Information has been obtained from a variety of sources (Transit New Zealand, Statistics New Zealand, Ministry of Transport). Information has also been sought from local authorities within the survey undertaken in Task 1.

1.2 Report Outline

Section 2 of this report summarises literature reviewed on traffic growth and forecasting, from around the world and locally.

Section 3 then details the results of a local survey of traffic growth practice by road controlling and regional authorities.

Section 4 reviews the current Transfund PEM traffic growth procedures and suggests possible modifications.

Section 5 details statistical analyses undertaken to relate local traffic count data with relevant factors such as demographic and economic measures.

Conclusions and recommendations from this report are summarised in Section 6, followed by a list of references and appendices.

2. Literature Review

Roading projects in New Zealand are currently assessed by their Benefit/Cost Ratio (BCR) evaluated over 25 years. Traffic growth throughout this period, and the rate of traffic growth (e.g. uniform, greater at the start, or greater at the end) has a significant impact on the BCR.

Little available research has been found on traffic growth prediction procedures. The research that has been undertaken tends to be focused on particular factors that influence traffic growth. There are very few documented models that incorporate all factors that influence traffic growth. This may be a reflection of the difficulty of this exercise.

The following review firstly discusses the larger models that have been located in the literature search. Following this, a summary has been made of smaller models that have been developed to derive information on factors relevant to traffic growth prediction. In addition, a list has been prepared and discussion presented on other factors that have been identified as being important when determining future traffic growth.

2.1 Overseas Models of Traffic Growth Prediction

2.1.1 Great Britain

Traffic growth in Great Britain was the subject of much study in conjunction with the issues of induced traffic (SACTRA 1994). The main standard used in Britain are the National Road Traffic Forecasts (NRTF) developed and maintained by central government (DETR 1997). These are then considered in conjunction with local estimates and circumstances.

The process commonly used is one in which forecasting is made at both national and district levels. The national forecast is used as a control for the district level. Predictions at the district level are factored so that the sum over all districts is constrained to be equal to the forecast national total.

2.1.1.1 National Level

The NRTF provide forecasts up to 35 years out. These are presented as a range, with low, high and most likely values, as the influencing factors cannot be forecast with greater precision. First determined in 1989, a revised set of estimates was produced in 1997. Growth in vehicle travel is determined for cars, Heavy Goods Vehicles, and Light Goods Vehicles separately. Like the PEM, separate forecasts are also available by road type, however additional forecasts are also available by time period (e.g. peak/ inter-peak).

As an indication of how this range compares over a typical 25-year (i.e. PEM) period, the 2021 estimates (from a 1996 base) have car traffic growing by between 26% and 59%, with a most likely value of 43%. Looking at the breakdown in growth during each five-year period, it can also be seen that annual growth is expected to decline with time (as opposed to the constant rate of growth often applied here).

At the national level the main determinants of growth are considered to be growth in the economy (income or GDP) and, to a lesser extent, changes in fuel price.

For cars, the prediction of growth in travel is based on forecasts of car ownership (cars/person), car use (vehicle-km/car), and population growth.

Two models are used to determine car ownership. The numbers that are derived from these models are summed and averaged. The first model uses data from a family expenditure survey and the second model uses information from a national travel survey. In both models, income is the main determinant, with survey results and historical trends used to quantify the relationship between this and ownership.

Growth in car use is predicted in the same way from travel survey results and historical trends. This is related to both income and expected real fuel price.

Forecasts of increased travel for heavy vehicles are derived from relationships between tonne-kilometres and Gross Domestic Product (GDP) growth, as well as the distribution of that growth between different sizes of vehicles. Forecasts for light goods vehicles are stated to relate directly to the growth in GDP.

The predicted growth is applied to the existing road network to confirm that such growth is realistic. Capacity constraints are considered when estimating expected growth. If existing roads or time periods already operate at or near full capacity then no additional traffic growth is allowed for. Some spreading of any latent traffic demand into suitable alternate routes or time periods is done where this is sensible, but is probably under-estimated.

An interesting observation made is that overall traffic growth is largely independent of growth in road capacity. In Great Britain for example, lane-kilometres have increased by about a third since 1960, while traffic has roughly quadrupled. As it is, the NRTF does not take into account any planned changes in road network or land use, although a “background growth” factor is applied to account for efficiency improvements in travel.

Despite the considerable amount of work that has gone into development of the NRTF, DETR (1997) acknowledge that there are a number of unresolved difficulties in the existing model. Some of these are in using constant values for parameters (e.g. household types, income distribution) when it is quite feasible that these will change over time. There are also over-simplifications such as the limited detail on minor road types and no allowance for rural bottlenecks. These provide the potential to make the model even more realistic in the future, although whether they will greatly affect the estimates is unclear.

2.1.1.2 District Level

Two sub-models are used to make predictions for individual districts. The first is the district car ownership model, which uses household income and an accessibility measure as basic inputs. Predictions of car ownership are aggregated across all districts and factored to equal the national total.

The second model is the national trip end model, which estimates the number of vehicle trips by estimating the numbers of origins and destinations in each district. Origins and destinations are related to planning data, including population, household, worker, and job numbers. The model uses this data, along with the car ownership predictions, to estimate future trip numbers (trip ends).

The estimated growth in trip numbers at the district level is finally factored according to the ratio (growth in travel at the national level)/(the sum of growth in trip ends across all districts) to constrain total growth to the national prediction. The process is ultimately one of adjusting for local or district-level variations while constraining the total to the national figure.

Constraints on traffic growth in urban areas are also taken into account where appropriate. These include common sense adjustments, simple cut-offs, and methods involving the use of elasticities of demand (SACTRA 1994).

Figure 2.1 graphically explains this process.

2.1.2 United States

2.1.2.1 Regression Model

Memmott (1983) developed a simple model for predicting future Average Daily Traffic (ADT) volumes. This method was developed using data from Dallas County, Texas. The estimations are made using historical data from individual highways. It was found that multiple regression produced the most accurate estimations and reduced the margins of error. Margins of error were found to be higher if:

- there had been a capacity change on the route,
- commercial and industrial land development is still in progress, or
- the time period between the present time and the date of prediction of traffic growth increases.

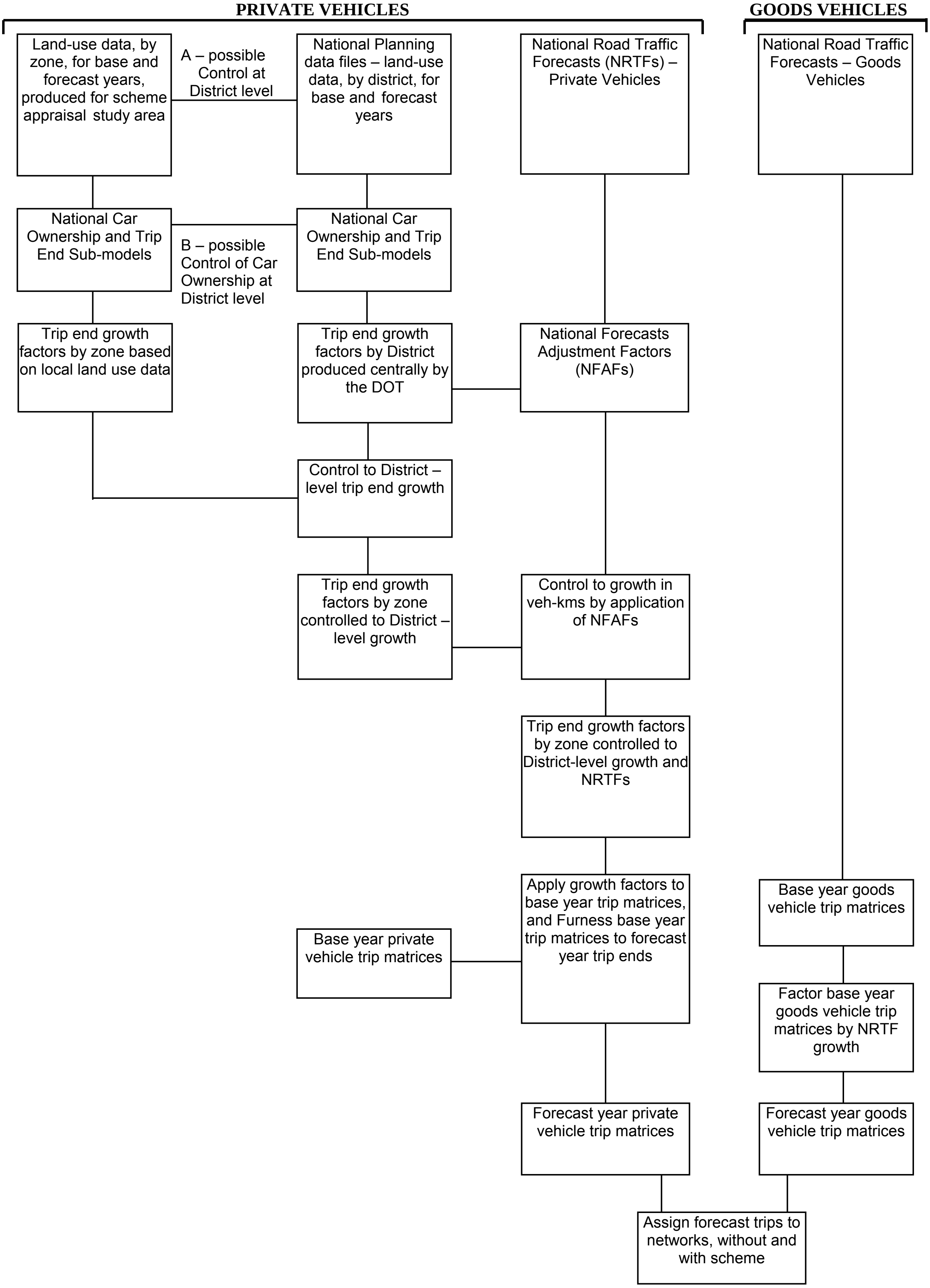
Equations that describe different forms of growth rate are given and are listed below. The formula that most closely fits the historical ADT data is used to make the projections.

$$\ln ADT_t = a + bt + cC \tag{1}$$
$$\ln ADT_t = a + b.\ln t + cC \tag{2}$$
$$\ln ADT_t = a + b.\exp(-t/10) + cC \tag{3}$$

where

ADTt = Traffic volume in year *t*
C = 1 if capacity of the road has increased, 0 otherwise
a, b, c = coefficients to be determined

Figure 2.1 Great Britain Department of Transport's Traffic Forecasting process for Trunk Road Scheme Appraisal.
(Standard Advisory Committee on Trunk Road Assessment, 1994)



One purpose for the study was to determine the appropriateness of the requirement at that time in the Texas Department of Transport project evaluation procedures for a constant growth rate in partially-developed areas, and a declining growth rate in fully-developed areas. The study confirmed the importance of the stage of development of the adjacent areas, and found a significant difference in growth rates between partially-developed and fully-developed (measured as having more than 10% of land area abutting the highway in commercial or industrial land use) areas. However, it was not possible to substantiate the need for a declining growth rate.

With a capacity increase, the change in ADT was typically between 6% (developed) and 16% (developing), however the numbers of lanes varied between some cases.

It was proposed that ultimately an evaluation procedure be devised in which automatic growth projections are made, based on one of the above formulae most closely fitting the historical ADT data used to make the projections.

2.1.2.2 Survey of Current Practice

Horowitz & Farmer (1999) have carried out a review of the methods currently used for state-wide traffic forecasting throughout the fifty US states.

Seven states were identified as using network modelling, with many more having such models in various stages of development. The Michigan model is described as one of the “most mature” and one that retains most of the characteristics of urban modelling. Details given for the model are:

- 2392 traffic analysis zones,
- 85 of these zones representing the other 47 contiguous states, Canada, and Mexico,
- “thousands” of special generation sites, divided into 10 categories,
- 5 trip purpose types,
- input data for 5 different household sizes and 3 income groups.

The model itself is a gravity model, in which trip numbers are generated from origin and destination socio-economic data, and are assigned with the use of generalised cost friction factors. To assist calibration there are 3 types of geographic adjustment factors, which are applied to the various types of origin–destination pairs (county-county, city-city, etc). Each type has a range of values.

These details affirm the sophistication of the model, and the effort involved in its preparation and operation. The appropriateness of this approach might be questioned, particularly when adjustment factors are required to ensure accuracy in the intended output. However, it appears that further refinement of such models will be seen in the future. Horowitz & Farmer note that there are improved algorithms available to overcome many of the problems experienced, and that there is a considerable gap between what the states are doing and what they could be doing.

One problem noted was the difficulty in obtaining appropriate data, with available statistical data not being designed for this particular use.

Other states not involved with modelling make use of time series forecasting, i.e. the extrapolation of existing traffic count data. Some of the methods used allow the introduction of factors of influence into the process. In particular it was noted that time series forecasting works best for state-wide prediction when income data is introduced at a regional level.

One other method considered to have promise was that termed the “pivot” method, which is a hybrid form of modelling. This makes use of network modelling to determine the origin-destination pairs having most significant influence on the traffic of the highway under consideration. Time series forecasting is then used on these origin-destination pairs to produce an extrapolation that pivots around the recorded traffic volumes at the site.

The above methods apply to passenger transport, but it is noted that many states apply the same approach to freight transport, with some in fact using similar network gravity models.

2.1.3 Australia

The Bureau of Transport Economics (BTE 1998) has carried out modelling of traffic growth on the nation’s highways. This was undertaken as a research project to provide input into an enquiry on wider transport issues, and does not represent a process yet adopted for day-to-day project evaluation. However, it provides an example of a different and apparently successful way of approaching the problem.

Existing (base-case) traffic has been divided into three categories – inter-regional car travel, rural/local car travel, and commercial travel. Projections have been made separately for each category.

Inter-regional travel has been determined from a gravity model of demand for total travel by all transport modes, including air travel, between pairs of cities. The gravity model assumes that demand is a function of the population of the two cities in each pair, as a travel generator, and generalised travel cost as a moderator of travel. Generalised cost includes egress and access times, travel time, fares, and vehicle operating costs. This model accounted for 85% of the variation in travel between city pairs. Other consistent differences were accounted for by the use of dummy variables to fine-tune corridors and cater for special events, leading to a final model which explained 97% of the variation in total passenger travel on the links.

In considering modal share of the total it was found that growth was weighted differently by mode within the total according to transport distance. Four distance categories were established, ranging from very short (<200 km) to long (>800 km), and adjustments to the growth rate in car trips were made within these.

Rural/local light vehicle travel (car and commercial) is assumed to have similar components of growth to that of an urban region. Rural local traffic growth is assumed to vary according to:

$$\text{Growth in rural local traffic} = 100 \times \{(1 + \text{Growth in Population}) \times (1 + \text{Growth in Non-urban VKT/light vehicle})$$

$$\times (1 + \text{Growth in light vehicle ownership/person}) - 1\} \quad (4)$$

For long term forecasting, the vehicle kilometres travelled (VKT) per light vehicle can be assumed constant, so the middle term in the equation above, equals 1.

2.1.4 Urban travel

The calculation of future traffic in urban areas requires the consideration of a greater variety of factors, as the nature of developed areas is more complex. Difficulties in calculating traffic growth are highlighted in urban areas, particularly in areas or on roads that are nearing full traffic capacity. Hounsell (1989) discusses how it can be easy to over-estimate traffic growth in urban networks. It is stated that this is likely to occur when calculating traffic growth in urban areas where the network capacity limits growth, particularly in peak periods. Likewise as traffic conditions deteriorate, increasing proportions of travellers will change their travel habits. They may change their origin/destination, mode or time of travel, or choose not to travel at all. For these reasons it is difficult to calculate traffic growth when the network is nearing full capacity. Traffic growth in such a network is likely to depend on behavioural responses to traffic conditions and the availability of alternatives.

The literature review in Hounsell's study cited a range of factors that can potentially limit traffic growth:

- *Modal choice*
  Networks with dense, efficient public transport services, particularly rail services, have been found to have lower levels of congestion and usually less traffic growth.

- *Traffic restraint*
  Measures can be introduced to restrict growth e.g.: parking restriction, supplementary licensing, road prices, physical/signing restriction etc.

- *Peak spreading*
  There is limited evidence of this, and more research is required. However, some allowance should be made for this in evaluations.

- *Travel/Work habits*
  Changes in habits that could affect growth include working hours (flexi-time), work practices, government policies (tax on company cars), vehicle usage (car-pooling) etc. Congestion itself may cause gradual changes in land use (e.g. movement of business/industry to outlying areas), which may help reduce congestion or may simply relocate it.

In order to try and compensate for over-estimation, Hounsell uses average travel speed and variability as measures of network performance. Travel speed is inversely related to journey time, which is a key determinant in travel behaviour. A hybrid approach to saturation level prediction was used. Initially predicted growth was attenuated for origin–destination (O-D) movements when average travel speed on set routes dropped below minimum tolerable values. Hounsell then proposed that a 'network saturation capacity' be determined, beyond which no further growth is allowed on O-D pairs. The methodology was tested on three networks and found to be practicable. With a 15 km/h minimum speed the gradual redistribution of traffic demands in the network with increasing growth caused network saturation to be predicted a few years later in the evaluation.

A number of other issues in addition to those discussed above were considered by Hounsell to influence traffic growth. Congestion is one such factor that is problematic in most countries and can be controlled by influencing behaviour. Hounsell's four factors, as discussed above, may be useful in influencing behaviour.

2.2 Local (New Zealand) Work on Traffic Growth Prediction

Read (1971) outlined some of the problems in selecting suitable data for assessment of highway projects. He pointed out that "simple extrapolation from volumes observed in the past is not sufficiently accurate especially when forecasts are required up to 20 years in the future." Although traffic growth is often linked to motor vehicle ownership, Read also considers the effects of "saturation" of ownership levels which could have a limiting effect on growth. In New Zealand however the already high vehicle ownership rate contrasts with a relatively low traffic density, so the expected effect is not clear. At the time of Read's report, the growth in second-hand imported vehicles over the last decade could not be predicted, which is also a feature not common around the world.

Read suggests an approach for assessing the benefits due to generated traffic. He considers it likely that the benefit to new traffic varies from zero up to the benefit for existing traffic. On that basis he suggests that the average benefit for per generated vehicle be taken as half the average benefit per existing vehicle. This is similar to our current PEM practice for congested conditions (although in already congested conditions there may also be disbenefits too). However additional vehicles arising from "normal" future traffic growth are given the full benefits. Arguably this "full benefit" approach may be giving priority to projects that stimulate traffic growth rather than, say, those that promote safety or efficient movement of existing traffic.

Some simple approaches to estimating the growth in generated traffic are listed by Read, based on work in the UK. These include:

- Allowing a traffic increase of **twice the percentage decrease in total journey time**. For example, a 10% travel time saving implies a 20% growth in traffic.
- Allowing a traffic increase **equal to the square of the ratio of total journey costs on the old and new routes**. For example, a 10% reduction in travel costs (ratio of 1.11) implies a 23% growth in traffic.

Read makes the interesting point that any under-estimation of future traffic can usually be remedied by carrying out deferred works later as required, whereas an over-estimation leads to over-supply of road capacity that could have been better used elsewhere. While acknowledging that there are often economies of scale in carrying out all works at once, this does seem like a good justification for being conservative in all growth estimates. Read suggests the use of a reducing multiplier to acknowledge the greater uncertainty of future benefits, although it is not clear whether this is in addition to standard discounting of future values.

Clark (1982) investigated the accuracy of roading economic evaluations. Amongst the many potential areas of uncertainty, he identified traffic growth as being "very important", rated above virtually every other variable. The difficulty for a roading engineer of predicting something largely determined by macroeconomic trends was acknowledged, particularly given the lack of readily available medium-term projections of economic activity in New Zealand.

Although linear extrapolation from historical growth had served New Zealand well, Clark identified that this could not continue if major national changes in energy policy, roading fiscal policy and economic outlook were envisaged. Like Read (1971) he advocated the development of a national traffic forecasting model, on which analysts could base their traffic growth projections (adjusting for local conditions). Even by doing this, Clark acknowledged that the projections could still be "wrong" and perhaps less accurate than those developed solely from local data. However, he envisaged that it would provide more consistency between projects (if not accuracy), meaning that analysts could at least have better faith when ranking different projects. This is an important consideration, given the underlying reason for evaluating individual roading projects in the first place.

Booz Allen & Hamilton (2000) developed a vehicle-ownership forecasting model for New Zealand to assist with regional and national growth predictions. Among the things found world-wide were the good correlation between income growth and vehicle ownership growth, and the lack of clear evidence for flattening growth due to saturation of ownership levels.

2.3 Factors Affecting Traffic Growth

DETR (1997) put it quite succinctly when they state:

> Traffic is forecast to increase mostly because people are expected to become richer, and to enjoy longer lives, because economic activity increases, and because households are forecast to become more numerous. The main single factor leading to traffic growth is increasing car ownership.

Discussion on these and other factors that have a significant impact on traffic growth is given below.

2.3.1 Land Use

Memmott & Buffington (1981) reviewed 18 case study areas in Texas receiving highway improvements. They investigated how land use and population projects affect Average Daily Traffic (ADT) for 47 highway segments. The findings show that there is no clear distinction between growth rate trends in "developing" areas as contrasted to "developed" areas, although there is likely to be a significant difference in the rates themselves. Improvements along primary routes affect growth rates for both parallel routes and intersecting routes. However the impact on ADT virtually disappears four years after improvement. More recent growth projections (e.g. 1970s) have been made more accurate than earlier projections (e.g. 1950s). However the population and land use projections are still, generally, not very accurate.

The form of the urban environment is also likely to influence traffic growth. Cities and towns that have several similar zones, growth in land use on the motorway network, and areas that are very spatial are more likely to have higher volumes of traffic than those cities that have kept this type of land use to a minimum (Marshall *et al.* 1997).

2.3.2 Demographics

Older adults are experienced with car use and ownership, and are therefore more likely than their predecesors to drive. The research in this area tends to focus on travel reduction strategies, and little of the research covers the prediction of traffic growth.

The lifestyle and demographics of a population have an influence on people's propensity to use cars (Ogden *et al.* 1986). Prevedouros & Schofer (1989) have found that the following factors influence traffic growth:

- the availability and cost of activities
- household structure
- household income
- societal values and norms
- technology.

Changes in the demographics of the population (such as reduced size of households, the aging population, more people working) have influenced the way people live and how they travel (Prevedouros & Schofer 1989; Marshall *et al.* 1997)

2.3.3 Economy

Economic factors have the potential to influence all other factors discussed. Therefore it is important to look at economic change when considering traffic growth prediction. (Ogden *et al.* 1986). In Europe, economic growth is stable and GDP has been increasing. Private transport is also relatively cheap. This combination only contributes to increasing traffic growth.

UK DoT's national road traffic forecasts (NRTF) take income or GDP as the main determinant of traffic growth, with fuel price exercising a lesser influence (Royal Town Planning Institute 1991).

One factor that needs to be considered in terms of the economy is that of employment changes and their effect on travel patterns. Income levels (GDP) have also been found to strongly influence the number of cars on the roads (Tanner 1983). The rate of growth in car ownership is correlated with income. Changes in this are likely to have longer term effects (Tanner 1983).

Ogden *et al.* (1986) state that "the stronger the economy the greater the amount of wealth and the greater the demand for travel, all else being equal". Economic growth models should incorporate the following factors:

- changes in real GDP and population
- indices of production in the country and related countries
- changes in exchange rate, levels of imports and exports, migration, air fares and sea freight rates, real fuel prices and real prices of exports.

The Royal Town Planning Institute (1991) goes so far as to say that GDP is the main determinant of traffic growth , with fuel price exercising a lesser influence.

2.3.4 Car use

Marshall *et al.* (1997) discuss travel trends in Europe. They highlight that trends point to an increase in travel. In particular car use and peoples dependence on car use is growing. This increases the number and length of trips made. Growth in both the road network length, and car ownership are greater than population growth. The growth rate in the number of cars is ten times that of population growth, and the growth rate in car use is higher still.

Vehicle kilometres have increased in Europe by 47% and there is some indication that vehicle occupancy is declining, while individual vehicle distances per trip are increasing. Recent travel surveys here in New Zealand have also found this pattern (LTSA 2000).

Petrol price changes are likely to influence travel patterns in the short term (Tanner 1983). Tanner (1983) gives an elasticity of -0.9 in the long term, and an elasticity of -0.3 in the short term. This means for example, in the long term, that a 10% price increase will cause a 9% decrease in travel.

2.3.5 Vehicle ownership

Vehicle ownership is largely influenced by income increase (TRB 1998). Changes in petrol price have also been found to strongly influence car purchasing decisions, i.e. the size of the cars and how often the cars are used (Tanner 1983).

Variables that have been found to influence car ownership include income, petrol prices, economy and public transport measures. Income has been found to be the main factor that dictates whether an individual or household owns one car or more. The petrol price dictates to some degree the size of the cars in the area, while the kilometres travelled per year are affected by short-term changes in petrol prices.

2.3.6 Induced Traffic / Roading Improvements

Another issue of considerable debate is whether introducing a new road, increasing capacity, or making improvements to existing roads increases the traffic growth in the area. This issue is of particular concern to city planners who are attempting to reduce traffic congestion within their cities.

The Standing Advisory Committee on Trunk Road Assessment (SACTRA 1994) has completed a thorough review on induced traffic and have concluded that it does occur. However the size and significance of traffic increases vary widely in different circumstances. They have found that induced traffic is more likely to occur when the network is operating close to capacity; and when travellers are responsive to changes in travel times or roading costs.

In a review completed by Wellington's Campaign for a Better City (CBC 1999), the reviewer discusses the argument of whether induced traffic results from roading improvements. After a review of available research it was concluded that induced traffic does occur and that it is likely to occur in the Wellington region on sections of road that are nearing full capacity. They also make the pertinent point that in many cases, there is not an increase in personal trips but an increase in vehicle traffic due to modal switch, trips to farther destinations, or a reduction in car sharing.

In the US a number of “traffic level of service (LOS) standards” have been implemented in various cities (Dowling 1989). These limit new developments where they will put strain on the roading network above the acceptable LOS. There are problems however in dealing with already “over-limit” roads, traffic from neighbouring authorities, exceptions to the rules/laws, and conflicts with other community goals. There is the potential to apply a similar approach in New Zealand via the Resource Management Act, as an extension to the current processes for new developments. Such approaches will have to be accounted for in any traffic growth prediction scheme.

2.3.7 Freight movement

McKinnon & Woodburn (1993, 1996) discuss how traffic growth has been affected by the logistical restructuring of road freight transport. They have summarised that the important aspects to the industry are where the product is made and consumed. McKinnon & Woodburn state that the process of prediction is too complicated to simply use GDP as an indicator of growth. Growth of lorry traffic within the United Kingdom is due to the net result of a complex interaction between factors operating at four levels of logistical management:

- strategic planning of logistical systems;
- choice of suppliers and distribution;
- scheduling of freight deliveries; and
- management of transport resources.

The first level includes the following factors: the placing of the factories, warehouses and freight terminals and their number, location and capacity. The second level – the choice of suppliers and distributors, includes the policies of the company governing this, and the degree to which their market has expanded. The third level involves the scheduling of product flow. For example the advent of Just in Time (JIT) Delivery, due to changes to improve customer service, has resulted in smaller, more frequent trips by suppliers. It is thought that JIT delivery is the main cause for the increase in lorry traffic in the UK (McKinnon & Woodburn 1996). Finally, the fourth level determines the choice of vehicle, planning the loads and the routes.

As mentioned before, Great Britain’s NRTF looks at relationships between total tonne-km and GDP and the share of each mode in the total (Royal Town Planning Institute 1991).

2.3.8 Technology

Improvements in technology are also more likely to make travel by road more desirable. An example for this is the provision of information systems on congested motorways to indicate the best routes (Marshall *et al.* 1997).

Conversely, technology may also arrest traffic growth, if activities like telecommuting and "internet shopping" increase. This is a difficult area to predict, given the relatively recent appearance of these trends and the ongoing changes in technology.

2.4 Implications for New Zealand Traffic Growth Procedures

The modelling discussed in many of the above papers is essentially concerned with determining the appropriate shape of the growth curve from historical records. In this respect the research is not conclusive, but does show that there are a range of possibilities and individual circumstances are important. What the papers do highlight is that there are a number of issues that must be considered at any site, namely if a capacity change has recently taken place or is proposed, and the stage of development of the surrounding area.

A number of possible growth rate forms have been put forward as being appropriate for different road sections:

	Growth Rate	Comment	
$\ln ADT_t = a + bt + cC$	b	Geometric growth	(5)
$\ln ADT_t = a + b.\ln t + cC$	b/t		(6)
$ADT_t = a + bt + cC$	b / ADT_t	Arithmetic growth	(7)
$ADT_t = a + b.\ln t + cC$	$b / t.ADT_t$		(8)
$(ADT_t)^2 = a + bt + cC$	$b / 2ADT_t^2$	Declining rate	(9)

where

ADTt = Traffic volume in year *t*
C = 1 if capacity has increased, 0 otherwise
a, b, c = coefficients to be determined

This contrasts with the New Zealand approach of applying arithmetic growth in virtually all cases. The use of "step" function increases with capacity is also not common practice.

The Great Britain (NRTF) and Australian (BTE) forecasts for heavy vehicles are considered separately from light vehicles such as cars. Again, this is not standard practice here for simple traffic growth prediction, but has considerable merit. Discussion is often made here, for example, about how certain areas will have considerable logging truck demand when forests mature. On low volume roads, this is likely to be a significant proportion of the total traffic, so existing default growth values are not likely to be representative.

The issue of a national traffic forecasting model for New Zealand does not appear to have been addressed in recent times, and it is worthwhile to consider how easy it would be to identify the necessary inputs. The National Road Traffic Forecasts (NRTF) developed for Great Britain (DETR 1997) provide an interesting case study to compare against.

Locally, there are a number of forecasting elements already in place:

- The vehicle-ownership forecasting model developed by Booz Allen & Hamilton (2000), as discussed above.
- Statistics New Zealand provide a range of forecasts, both nationally and regionally, of key demographic indicators up to 50 years out. These include:
  - Population Levels
  - Number of Households
  - Labour Force Growth

  A useful feature of many of these projections is that different growth scenarios are provided for comparison.
- The National Traffic Database contains an inventory of all public roads in New Zealand as at 1994, including information on road type and estimated volumes (Works Consultancy Services 1996). Information not readily on hand from this source includes capacity (for speed-flow relationships) and origin-destination data. Transfund is currently reviewing how to update and maintain this data source.
- The LTSA (previously MOT Land Transport Division) has conducted two household travel surveys in the past decade (MOT 1991, LTSA 2000). A series of these could provide useful background data, similar to that used from Great Britain's National Travel Survey for NRTF estimates.
- A number of economic agencies produce forecasts of financial and industry indicators. For example, the NZ Institute of Economic Research provides a monthly bulletin with five-year forecasts including GDP expenditure, employment levels, retail sales, and import/export growth.
- Regional or District Plans usually identify planned future land uses, such as new residential development in a currently rural area.

Other factors may need to be assumed constant to create a stable base for prediction. For example, government policies towards alternative transport modes, and the relative predominance of various industry types.

What is missing from some of the potential data sources is a long-term forecasting ability, i.e. over 25 years as currently used for economic evaluations. For some predictors listed (such as economic indicators) this is understandable, as the intended target audience is often only interested in the next five years or less. The reliability of projections over twenty years out is also questionable. However one needs to remember that transport project future benefits are discounted to present values and therefore longer-term benefits (and any errors in them) will not be as significant as equivalent short-term ones.

3. Survey of Local Practice

As part of this research, a survey was undertaken of regional and road controlling authorities (RCAs). The aim of the survey was to determine how often each RCA conducted traffic growth prediction calculations, the methods they used to do the calculations, and the influencing factors they took into account when calculating predicted traffic growth. Information was also collected on whether the authorities used Transfund's PEM.

3.1 Survey selection procedures

RCAs within New Zealand were contacted by phone and asked to participate in an interview. They were given the choice of conducting the interview immediately, at a later date, or in a written format. The interviews took approximately 15 minutes by phone to complete.

All territorial authorities with populations over 50,000 were selected, and 35% of authorities with populations under 50,000 were selected. The 35% contained a mix of population size and predicted growth. In addition all regional and unitary authorities were contacted. This selection process gave a sample of 51 authorities. From these a total of 42 authorities participated significantly in the survey. This total was made up of 23 district councils, 10 city councils, 8 regional councils and 1 Transit NZ regional office. Three unitary authorities (i.e. they combine the roles of a local authority and a regional council) are also included in the district/city council numbers. Their relatively small coverage means that for the purposes of this project, they are more likely to act in a local capacity. Reasons given for not completing the survey were primarily because the usual contact person was on leave or had recently left the RCA permanently, or because traffic growth prediction was not work they undertook.

3.2 Results

Table 3.1 summarises some of the key findings from the survey. The sections below highlight some of the main findings, as broken down by type of RCA. More detailed results can be found in Appendix A.2.

Table 3.1 Summary of Key Responses from Local Practice Survey

Survey Question	Districts	Cities	Regions	TOTAL
Use PEM methods for traffic growth?	74%	80%	38%	67%
Use historical count data?	78%	70%	25%	67%
Use PEM default growth rates?	30%	40%	0%	26%
Take into account Capacity Exceeded?	9%	50%	13%	21%
Vary growth by Vehicle Type?	44%	30%	25%	38%
Vary growth by Time of Day?	17%	50%	13%	24%
Consider Peak Spreading?	13%	50%	13%	21%
Consider effects of Capacity Changes?	17%	50%	25%	26%

The figures below summarise the data in each of the three types of RCA. The information provided in these figures has been grouped into sets of factors that influence traffic growth prediction. The factor sets and individual factors are listed in the following Table 3.2.

Table 3.2 Factors Considered to Influence Traffic Growth

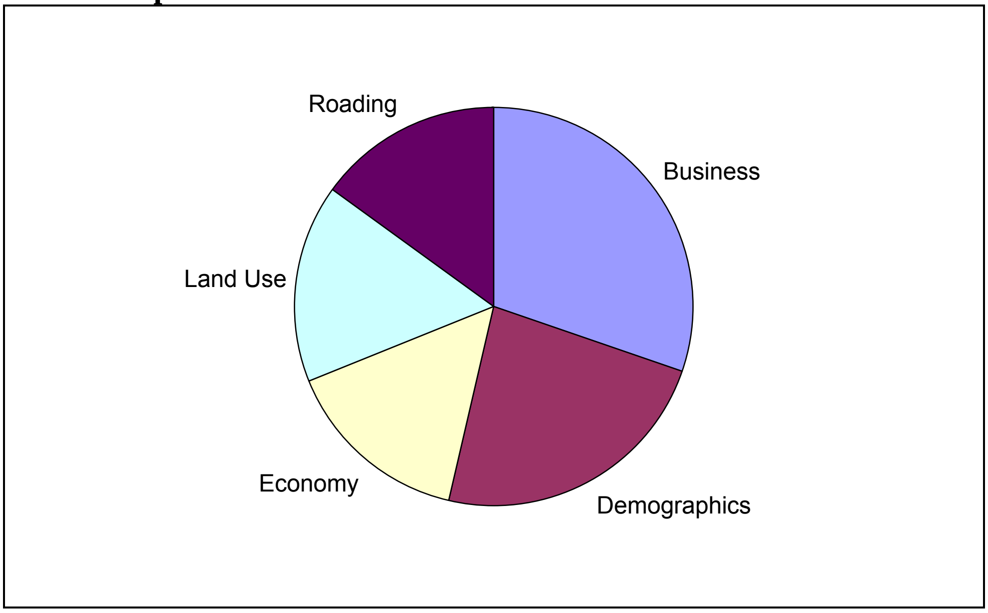
Business	Demographics	Economy	Land Use	Roading
Tourism Freight movements Weather/season Vehicle type	Demographics Population migration Population growth	Regional economy National economy Vehicle operating costs Vehicle ownership	Different areas/roads Type of land use Urban sprawl Land Prices Development pressure	Changes in road capacity Induced traffic Number of junctions Exceeded Capacity Time of day Peak Spreading Roading improvements

3.2.1 Regional Councils

In the process of contacting regional councils it was found that most do not need to predict traffic growth for project evaluation. This role was seen by the interviewees to be more relevant to other types of authorities and Transit New Zealand. However, the regional authorities that participated in the survey indicated that they did use traffic growth prediction at some level, often in regional transport models. Proper development of Regional Land Transport Strategies requires consideration of growth forecasts. Of the authorities that participated, 50% used modelling techniques and 25% used historical data to calculate traffic growth. Perhaps not surprisingly, traffic growth prediction was more likely to be used in highly populated, growing areas. The most relevant factor when calculating traffic growth at a regional level appears to be tourism, followed by different types of areas/roads, demographics, freight movement and the type of land use.

Figure 3.1 shows that business-related activities tend to be weighted as important to consider, along with the regional demographics.

Figure 3.1 Factors seen by Regional Councils to be relevant to traffic growth prediction.

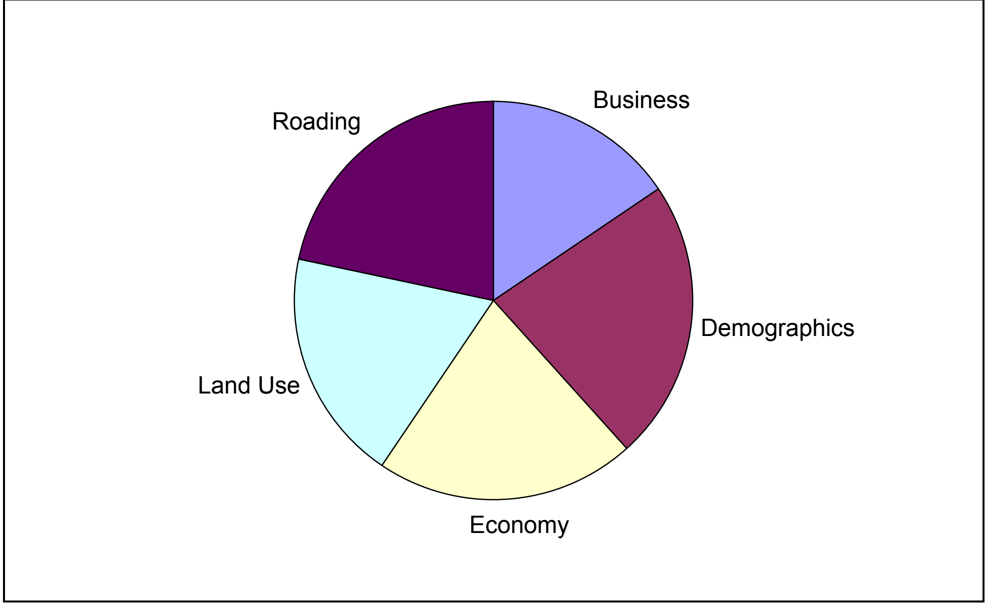


3.2.2 City Authorities

60% of those city authorities contacted stated that they used modelling to calculate traffic growth. Traffic growth prediction modelling was used only in cities with growing populations. The top factors necessary to consider were found to be the type of area/road or land use, population growth, and the regional economy.

Figure 3.2 shows that the relative importance of each set of factors is similar to Regional authorities, with more weight on roading information and less on business. Economic and roading related factors are viewed as being more important to consider in the city environment, relative to district and regional traffic environments.

Figure 3.2 Factors seen by City Authorities to be relevant to traffic growth prediction.

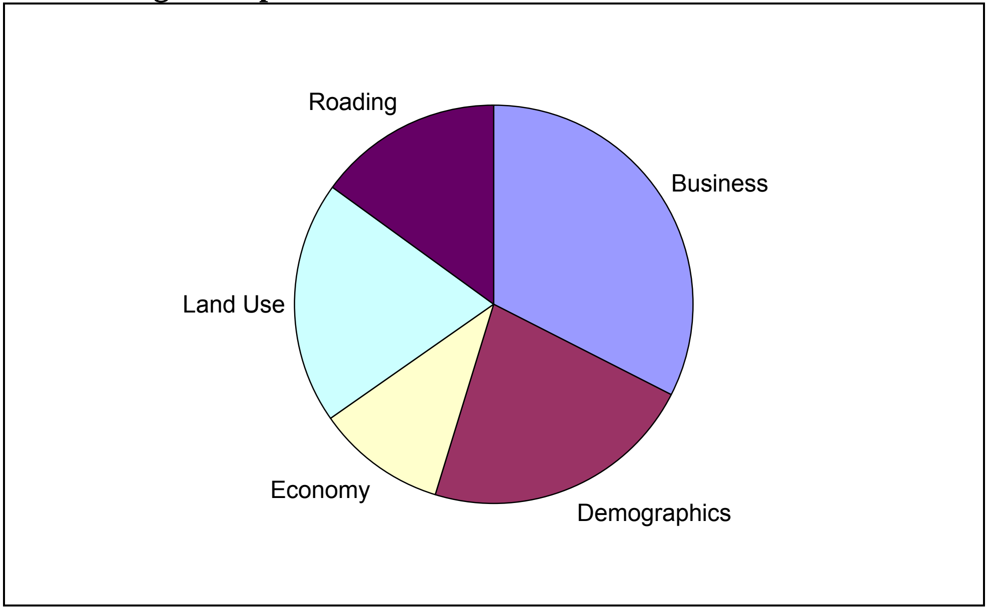


3.2.3 District Authorities

District authorities were found to commonly use historical data, which is then extrapolated using linear estimation or, in some cases, "guess–timation". Data is collected from traffic counts, and often PEM growth rate tables are used to aid the prediction. All of the district authorities we contacted, regardless of degree of growth in their area, stated that they considered traffic growth in their project. However the amount of growth in the area dictated to some degree the amount and detail to which influencing traffic growth factors were considered in the predictions. The most important factors were seen to be tourism and the type of road/area or land use. Vehicle type, population growth, freight movements and season or weather also had some significance.

Figure 3.3 shows that business related activities and land use factors are recognised to be important considerations when predicting traffic growth in districts.

Figure 3.3 Factors seen by District Authorities to be relevant to traffic growth prediction



3.3 Discussion

Although the survey tried to identify what factors RCAs took into account, the level of detail or specific procedures used by them was not explored much further. Therefore it is not always clear just how much weight some of the factors are given compared to others, or whether some factors are only considered in certain applications.

A common point amongst many of the RCAs with low or declining growth is that the lack of growth in their areas precludes any need for detailed estimation of traffic growth. This would seem to be not strictly correct, as even a near-zero or declining growth rate has implications on future benefits assumed. In fact the sensitivity of changes in estimated traffic growth on future benefits has a greater proportional effect near 0% growth than at a high growth rate. Therefore a certain level of accuracy is still required.

City authorities were found to use existing models to estimate traffic growth. However, the standard of traffic growth prediction procedures in district authorities varied. This variation was largely dependent on the amount of population growth and the population size of the area. Perhaps not surprisingly, given their more limited resources, it seems that district authorities are most in need of improved or standardised traffic growth prediction procedures.

Many RCAs indicated that they vary traffic growth rates by either vehicle type or time of day. The PEM does not discuss these approaches, and it is not clear without further investigation how RCAs are doing this and to what extent. However there does appear to be merit in making these distinctions, where traffic growth differs markedly for different groups of vehicles. It should be noted that "time of day" categories could also consider the differences in growth between weekday and weekend traffic. The growing popularity of recreational trips on the weekends is an important consideration, especially for rural/urban fringe routes.

Other points worthy of noting, that were highlighted in the interviews are listed below:

- School holidays in Auckland (mentioned by Waitakere City Council) cause problems with Transit NZ's traditional methods of traffic growth prediction.
- Fuel consumption was suggested as another predictive measure. Presumably this is one way of identifying vehicle-km travelled.
- In some areas it is necessary to consider the type of vehicular traffic that will increase. For example heavy commercial vehicles and 4-wheel-drive tourist vehicles have been stated to cause damage to the roads.
- In many areas seal extension projects give particular concern about the likely impact on volumes once sealed. It is not at all clear what the traffic generation is likely to be.

Given that a lot of roading evaluation work is outsourced to consultants, it may have been useful to survey consulting firms as well. However, it is hoped that the roading personnel spoken to at the RCAs had an adequate understanding of what methods their consultants have used for them in the past, and reflected that in their answers. Contacting RCAs also enabled a broader policy-based perspective to be obtained, rather than a project-specific viewpoint that a consultant may have, based on the work they have done.

4. Review of Project Evaluation Procedures for Traffic Growth

From the local authority survey conducted, it is evident that most roading authorities use Transfund's Project Evaluation Manual (PEM) for guidance on traffic growth. It is therefore pertinent to review the existing material provided.

4.1 Basic Concepts (PEM Section 2)

The vagaries of traffic growth prediction are touched on early in the PEM in Section 2.19 (Uncertainty and Risk). It stipulates that "sensitivity testing shall be undertaken for those analysis inputs which are subject to uncertainty". The use of sensitivity testing on growth rates is a common procedure by roading practitioners. It helps to answer the fundamental question "*does an accurate traffic growth rate affect the viability of this project?*"

An alternative approach suggested is to use probability distributions to describe input variables. This type of risk analysis then produces a distribution of possible output values, such as range of possible benefit/cost ratios. The "rate of future traffic growth" is given as an example where such risk analysis may be applied. Such probabilistic analyses require more sophisticated evaluation tools (than, say, Transfund's standard Project Evaluation software) and are generally not considered for non-major projects.

4.2 Specific Procedures (PEM Section 3)

Section 3.4.3 of the PEM (Traffic Data) then discusses the determination of traffic growth (although specific detail is referred to later in PEM Appendix A2). It states that:

> Where the traffic growth is likely to vary from the normal traffic growth, future traffic volumes shall be predicted by taking account of:
> - normal traffic growth
> - diverted traffic
> - generated traffic
> - intermittent traffic
> - suppressed traffic
>
> For major projects in congested conditions it may be necessary to consider growth suppression or variable matrix techniques.

Although some of the specialised terms used are discussed in more detail later in the PEM, it would be helpful for practitioners to have a short glossary of all relevant terms in one place within the PEM. Appendix A.5 gives a suggested list that may be useful.

The discussion on congested conditions needs to be read in conjunction with Section 3.13 of the PEM (Evaluation of Congested Networks and Induced Traffic Effects). This introduces PEM Appendix A11, which contains guidelines "for modelling situations where very high levels of congestion are anticipated over the economic life of the scheme". This is a fairly specialised area and not expected to be used for simple projects not affecting the surrounding road network.

4.3 Traffic Data (PEM Appendix A2)

The key section relating to traffic growth is in PEM Appendix A2 (Traffic Data), particularly Sections A2.5 and A2.6. Readers are also referred to Transit New Zealand's traffic counting guidelines (Transit NZ 1994) for further information on estimating traffic volumes from count surveys. Some key recommendations made are:

- The use of arithmetic growth rates, not geometric growth.
- Actual historical traffic counts at the site to be used where possible.
- The use of default regional growth rates (provided in the PEM), where no local growth rate can be established.
- Future traffic volume should not exceed the capacity available, "taking into account the potential for trip diversion, peak spreading, and trip suppression".
- The capacity of nearby bottlenecks may also constrain growth (subject to peak spreading).
- Changing land-use patterns from a development may result in a one-off step in volumes.

These points will be discussed in more detail below.

4.3.1 Arithmetic and Geometric Growth Rates

Transfund states that traffic growth rates should be expressed as *arithmetic*, not *geometric*, growth rates. This has been the source of much confusion in the past for practitioners, and from the roading authority survey it appears that there are still a handful of areas using geometric growth methods. As an example, a 3% arithmetic growth rate will see volumes in 25 years that are 1.75 times greater than the initial volume. A 3% geometric growth would produce volumes 2.09 times greater, or 20% higher than the arithmetic value. Higher growth rates will produce an even greater difference, e.g. 5% geometric growth is 50% higher than arithmetic growth over 25 years. Again, definitions for these items within a glossary may help avoid confusion.

There is the separate issue of whether an arithmetic growth rate is in fact appropriate. As has been discussed in the literature, different land use scenarios may suggest differing growth patterns, including geometrically increasing or declining growth rates (the latter especially with developed areas or capacity constrained areas).

4.3.2 Default Traffic Growth Rates

Where local traffic growth rates cannot be established reliably, some default traffic growth rates are provided, categorised by both region and road type. The PEM states that these were "determined principally from counts taken over the period 1984-93, taking into account factors such as trends in population growth, gross domestic product and car ownership." Given that some regional transport models have already developed highly detailed growth forecasts (especially in the main centres), it would seem sensible to make use of these where possible instead.

One thing that is not provided is an indication of the likely uncertainty in the figures given. Although analysts testing sensitivity could arbitrarily adjust the growth rates by (say) 1%, the likely variation may differ between regions or road types and no guidance is provided on what is a reasonable range.

The key concerns with the default figures provided are:

- There is a lack of transparency in how the figures were derived. It is also not clear what programme is in place to update the figures. Arguably this is because the PEM is designed as an operational manual, not a research report. However, reference in the PEM to the appropriate background documents would seem sensible.
- The figures are not disaggregated by other factors that may be significant, e.g. time of day (peak-period traffic growth may be more constrained for example) and vehicle type (heavy vehicle growth may be quite different to light vehicles).
- There is no guidance available on how to modify the default factors to allow for the local specifics of each project.

For the latter point, it may be worthwhile considering an Empirical Bayesian approach similar to crash predictions, whereby local historic growth data is combined with generic growth data to produce a best estimate. Hauer (1997) provides a detailed overview how this works for crash data, and an attempt is set out below to translate this into a possible procedure for traffic growth. Bear in mind that crashes and traffic growths have somewhat different distributions, which may influence the final form.

Assuming that both the default growth data provided and the historical local growth data have known means and variances, the following combination is possible:

$$\text{Expected Growth Rate} = a \times G + (1-a) \times g \tag{10}$$

where

G = Default PEM Growth rate, based on N years of data
g = Local historic growth rate, based on n years of data
a = $G / (G + n/N \times \text{var}\{G\})$
var{G} = Statistical variance of default growth rate G

Such an equation would allow practitioners to make the most of both local (site-specific) and national (general trend) traffic growth information. However more research is required to investigate this approach.

4.3.3 Capacity Constraints

The PEM guidelines mention issues of growth constraint due to capacity and one-off increases in traffic. However they do not provide specific details on applying this generally. Appendix A11 of the PEM, mentioned previously, introduces some additional guidance for situations where congested networks or induced traffic effects are likely to be encountered. This is generally only encountered in urban situations, where transportation models are being used to assess the impact of the road project on the whole network. Indeed, the section is generally only applicable for making changes to the trip matrices (origins and destinations) of these models.

Given that any additional traffic growth guidance required is largely for local authorities who do not do network modelling and do not have major problems with capacity constraints, it may not be very critical to include further guidance on how to treat traffic growth in congested situations (such as peak spreading).

What may be useful however is more information on how changes in road capacity affect traffic growth. A common type of project that is affected by this is four-laning an existing two-lane road. The literature suggests that a one-off jump in traffic volume may be appropriate, but there is little guidance locally on this.

4.4 Discussion

The point should be made here that the PEM is not a complete “recipe book” to be followed exactly. Practitioners are expected to exercise some judgement and indeed depart from standard where it can be justified. However, it is probably also fair to say that people are loath to do this if they have little guidance available about other options. Based on existing documents available locally, such guidance would probably have to come from either the PEM or Transit’s traffic counting guidelines (Transit NZ 1994), with the former probably being more widely available.

Given that a number of Regional Councils (and some local authorities) have already developed fairly detailed transport models for future growth, it is worth considering how much can be made of these to provide both specific local estimates and an indication of the likely “growth drivers” in different areas. In the long-term a centralised growth model may be more desirable, but it can of course be partly based on existing regional work (which also provides a short-term solution to more accurate regional forecasting).

5. Significance of Factors Affecting Traffic Growth

5.1 Introduction

Future traffic growth can have a high influence on the assessment of the benefits that are attributable to roading projects. In order to determine the extent of the influence of various factors on traffic volumes, counts were taken from several types of road across the country. Demographic measurements were obtained, such as population, employment levels, numbers of dwellings, and vehicle registrations, as well as various industry measures.

Earlier reports have indicated the potential for determining predictive factors. Memmot (1983) developed a model for projecting traffic growth rates pertaining to highway projects. The single external factor used in that model is the percentage of commercial and industrial land (in some, unspecified area relevant to the project). However, the model was quite simplistic and resulted in a coefficient of determination, from the regression analysis, of only 0.24. The other major factor was an indicator variable for whether the projection was made before or after the project was completed.

In BTE (1998), a logistic model was developed for estimating total growth in VKT within urban areas. Predictors were overall measurements such as cars per thousand people, population (within the city), VKT per car. This produces a general model that may be used for overall urban planning purposes. It does not give sufficient detail for incorporation into a project evaluation process.

The purpose of the present analysis was to determine whether or not there are readily available demographic or usage data in New Zealand, which could provide a useful addition to estimating traffic growth at a local level.

The analysis conducted with the current data extracted from documented and reliable sources has not found strong associative factors. In fact, the analysis and the data gathering processes suggest that an alternative approach may yield more useable results.

5.2 Data

A number of data sources were used to obtain comparative time series. The ready availability and quality of these however varied, as discussed below.

5.2.1 Traffic Volumes

In order to obtain a reasonable sample of road sites, ADT data was obtained from twelve districts, covering fifty-three sites. The sites were chosen over a range of usage types, covering commercial, residential, rural, arterial. Appendix A.3 contains the sites for which ADT data was available from the local authorities. The traffic volumes on these sites had been counted on various dates ranging from 1977 through to 1998.

On inspecting the data further, many of the counts did not provide a sufficiently reasonable history for further analysis. From the point of view of determination of traffic growth, the most comprehensive data was available from sites in:

1. Palmerston North City:

Broadway Ave	– Commercial site – twelve counts between 1983 and 1998;
Cuba St	– Commercial site – twelve counts between 1982 and 1999;
Limbrick St	– Residential site – thirteen counts between 1982 and 1999;
Slacks Line	– Residential site – ten counts between 1982 and 1998.

2. Tasman District:

Tabbot St	– Commercial site – six counts between 1995 and 1999;
Queen St	– Commercial site – three counts between 1992 and 1997;
Wensley Rd	– Residential site – four counts between 1991 and 1999;
Hill St	– Residential site – six counts between 1993 and 1997.

Unfortunately, only eight of the listed measurements for Tasman were actually counts. The remainder were estimates, of unknown validity.

3. South Waikato District (all Rural sites):

Tapapa Rd (S of Okoroire Rd)	– fifteen counts between 1976 and 1999;
Tapapa Rd (N of Okoroire Rd)	– fifteen counts between 1976 and 1999;
Tapapa Rd (W of Okoroire Rd)	– fifteen counts between 1976 and 1999;
Kinleith Rd (S of Old Taupo Rd)	– thirteen counts between 1976 and 1998;
Kinleith Rd (E of Old Taupo Rd)	– thirteen counts between 1976 and 1998;
Kinleith Rd (N of Old Taupo Rd)	– thirteen counts between 1976 and 1998;
Waotu Rd (S of Arapuni Rd)	– sixteen counts between 1976 and 1997;
Arapuni Rd (W of Waotu Rd)	– sixteen counts between 1976 and 1997;
Arapuni Rd (E of Waotu Rd)	– sixteen counts between 1976 and 1997.

4. Kapiti District:

Kapiti Rd	–	Urban sites – twenty-one counts on Kapiti Rd, between 1994 and 1998. Unfortunately, the counts were made on different sections along Kapiti Rd.
Otaki Gorge Rd	–	Rural site – eight counts between 1990 and 1997. Again, counts made on different road sections along Otaki Gorge road.

The net effect of these data supplied from the councils is that only the Palmerston North and South Waikato information appeared reasonably promising. Following analysis of these areas, which did not prove very successful, it was decided not to continue with the remaining areas of lesser quality.

5.3 Demographic and District Measurements

Data was available on various population characteristics for ten Regional Councils, covering the initial twelve districts, e.g. Manawatu-Wanganui Region included Palmerston North City. For each of these regions, the following demographic data was obtained:

- Population – by age and gender
- Employment Levels – by type (paid employee, self employed, unpaid worker, full time, part time, not working)
- Family demography – by number of children
- Number (and type) of dwellings
- Income levels – by gender
- Industry (Numbers employed in: Agriculture; Mining; Manufacturing; Utilities; Construction; Wholesale & Retail; Transport; Finance; Community).

In addition, number of vehicles registered and vehicle operating costs were available – both of these at a nation-wide level.

This data was available for most regional areas for the years 1981, 1986, 1991 and 1996 (corresponding to Statistics NZ Census periods).

5.4 Analysis

Analysis was conducted separately for Palmerston North traffic count sites and for South Waikato sites. This was done partly because the road sites in Palmerston North are listed as either Commercial use or Residential whereas those for Waikato are Rural. In addition, these districts had several sites with counts repeated over several years. Other districts were not as complete.

5.4.1 Palmerston North

A multiple linear regression analysis was run, using the following variables as predictors:

- Population
- Number of Full Time Employed
- Number of Dwellings
- Number of Enterprises in Agricultural or Mining Industry
- Number of Enterprises in Wholesale or Retail Industry

All of the variables above were obtained from Statistics New Zealand. The data was defined at a regional level. This was consistent for the five-year periods of the census data (1981, 1986, 1991, 1996).

In addition, the numbers of vehicles registered were included as a predictor. This was available only as measured at a national level.

Other predictor variables were road-type (urban, rural, commercial etc.) and year of count.

The full model is thus:

Traffic Count = f{ *Year of Count, Road-type, Vehicle Registrations (National),*
Population (Manawatu-Wanganui),
Full Time Employment (Manawatu-Wanganui),
Number of Dwellings (Manawatu-Wanganui),

Number Agricultural & Mining Industries (Manawatu-Wanganui),
Number Wholesale/Retail Industries (Manawatu-Wanganui) }

In some variables, data was not available for years in which counts were made. This resulted in some "data singularities" and the loss of ability to estimate the effect of some of these variables. At best, the regression process was reliant on only four points – those for which population and general demographic data was available for the five year census cycle.

The primary analysis produced:

Coefficients: (5 not defined because of singularities)

	Value	**Std. Error**	**t value**
(Intercept)	-23662.82	21149.35	-1.1188
Veh Registrations	-26.26	16.09	-1.6321
Road-type	-5881.27	455.97	-12.8983
Count Year	1046.79	617.71	1.6946

The parameters for the other factors were not estimable due to data singularities. Co-linearity of data was evident for several of the variables, i.e. one variable gives (essentially) the same information as another variable, meaning only one is worth including. Road-type was the single most significant factor. This is not surprising, and is reflected in how the current PEM breaks down default growth rates by road types.

Various other regressions, omitting selected variables from the full set, were also examined. In each case, only road-type is evident as a significant factor. All other variables contribute less than a significant amount to explanation for the variability in the recorded counts. As well as the three parameters mentioned above, regional population also showed some effect, but not to a significant level.

A more detailed table of regression results is contained in Appendix A.4.

5.4.2 South Waikato

The base data variables were the same as for Palmerston North. However, road-type this time could not be examined, as all of the sites were similar rural sites. The general interpretation for the influence of the variables in predicting traffic volumes is also similar.

The full model is, as before:

Traffic Count = f{ *Year of Count, Vehicle Registrations (National),*
Population (Waikato), Full Time Employment (Waikato),
Number of Dwellings (Waikato),
Number Agricultural & Mining Industries (Waikato),
Number Wholesale/Retail Industries (Waikato) }

The summary table is:

Coefficients: (3 not defined because of singularities)

	Value	Std. Error	t value
(Intercept)	-6414.661	14604.36	-0.4392
Veh Registrations	0.267	17.17	0.0155
Count Year	76.556	531.94	0.1439
Population	-0.010	0.017	-0.5999
FT Employed	0.026	0.046	0.5713

In this case, none of the explanatory variables showed a significant effect, although regional population had the greatest (non-significant) effect.

As with before, various other regressions, omitting selected variables from the full set, were also examined. Even using fewer variables for prediction to possibly improve on the explanatory process, led to results for each which were similar in effect. None of them was able to improve on the original grouping in terms of identifying significant variables. A more detailed table of regression results is contained in Appendix A.4.

5.5 Analysis of State Highway Telemetry Data

One of the problems encountered with much of the local road data examined was the limited number of time series available with both sufficient length and accuracy. A separate exercise investigated State Highway sites, which have had a programme of ongoing counts for a much longer period than most TLAs. Analysis was conducted separately for eight separate Transit NZ telemetry (i.e. continuously counted) sites in the Bay of Plenty region, as detailed below:

Hwy	Location	Name	Type	TLA
SH2	143 (N of Tauranga)	Te Puna	Rural	W. Bay of Plenty
SH2	204 (W of Rogers Rd)	Ohinepanua	Rural	W. Bay of Plenty
SH5	46 (N of Fairy Springs Rd)	Rotorua	Urban	Rotorua
SH5	57-67 (S of SH30)	Waipa	Rural	Rotorua
SH29	34-46 (W of Tauranga)	Lower Kaimai	Rural	W. Bay of Plenty
SH30	148 (NE of Rotorua)	Te Ngae	Urban	Rotorua
SH30	188 (W of Kawerau Rd)	Lake Rotoma	Rural	Rotorua/Whakatane
SH33	31 (S of SH2)	Paengaroa	Rural	W. Bay of Plenty

AADT (exact) figures for each of the four years: 1981, 1986, 1991, 1996 were taken as the independent variables (which coincided with the Statistics NZ census data available). Each site was treated separately. During this period, the average annual growth in AADT was 5.5% at these sites, ranging between 3.7% and 8.4%.

For each of the sites, a simple linear regression analysis was run using the following variables as predictors (all for the Bay of Plenty region only):

- Regional Population
- Number of Enterprises in Agricultural/Fishing/Forestry Industry
- Number of Dwellings
- Total in Employment (Full time + Part time) within the region.

These variables were treated singularly, since only four points were available for the regression, (thus precluding any multiple regression). This was, as before, a reflection of the demographic and census data available.

In some variables, data was not available for all years in which counts were made. This resulted in the loss of ability to estimate the effect of some of these variables. At best, the regression process was reliant on only four points – those for which population and general demographic data was available for the five-year census cycle. This does highlight a problem in obtaining reasonable data in between census years for many key parameters.

Some of the regressions produced a ‘significant’ result for the estimated slope parameter. However, since each regression was based on only four points, the results must be treated with considerable circumspection. In fact, ‘trends’ over four points are distinctly unreliable.

The table below summarises the t-statistics produced from each regression. The reference t-value for comparison (at the 5% level, on 3 degrees of freedom) is 4.30.

Table 5.1 t-Values for "Regresion" (significant values in bold).

Hwy	Location	Population	Ag/Fish Ind.	Dwellings	Employment
SH2	Te Puna	**4.78**	2.40	2.11	2.80
SH2	Ohinepanua	**4.84**	1.49	2.88	1.32
SH5	Rotorua	**5.04**	**6.01**	**7.45**	3.89
SH5	Waipa	**9.94**	**6.40**	**9.75**	1.79
SH29	Lower Kaimai	**5.35**	NA	3.79	2.12
SH30	Te Ngae	**4.50**	**18.76**	**12.44**	3.71
SH30	L Rotoma	**9.57**	**5.08**	**14.90**	2.72
SH33	Paengaroa	2.56	2.96	1.17	**4.75**

As can be seen from the table, there are many ‘significant’ results. However, for the reasons above, these are to be regarded with an element of scepticism. The variable that most consistently demonstrates the potential for predictive ability, is population.

This exercise highlights the fact that even where accurate and long-term count data is available at sites, the limited availability of equivalent predictor variables (such as population and employment) over the same period minimises the ability to identify traffic growth trends based on them.

5.6 Alternative Approach for Traffic Growth Prediction

The ability of the present project to develop a method for broad estimation of the factors affecting traffic growth has been restricted by the mismatch of the traffic measurements and the environmental measurements that may have been useful.

The traffic measurements are very localised and subject to day-to-day and seasonal variation (although a good traffic count programme will minimise this variation). The environmental measurements are drawn from statistics that were developed for other national and regional planning requirements. These statistics may well be applicable at district or regional levels, but fail to provide insight to factors affecting local travel activity patterns. In addition, the demographic data must be concurrent with the traffic count data. In the present study, the matching was made as close as possible. However, there remains a mismatch in the time window of the measurements.

In addition, the data used for this study was drawn from various sources. It suffers from the ‘what was available’ problem in that data was drawn from several sources for which the original purpose of collection was not specific to this project.

In order to determine traffic growth predictive factors more closely and accurately, it may be appropriate to examine a highly localised study (one which includes measurement of local rather than general or national factors of influence). While the exact prediction determined from such a study technically applies only to the sites under study, the identification of the factors may be more widely applicable. If the road sections/sites are chosen in a representative manner from the population of road sites, the predictive factors may be useful at other sites within the same road grouping.

To approach this problem systematically, it may be useful to consider the nature of the New Zealand road inventory according to “road-use category”. These categories are documented in Transit New Zealand’s traffic count guidelines (Transit NZ 1994) and are also referred to in other research (Works Consultancy Services 1996, Mara 1997).

The road-use categories were originally defined as follows:

1a Urban Arterial (a)
1b Urban Arterial (b)
2 Urban Commercial
3 Urban Commercial
4 Urban Other
5 Rural Urban Fringe
6a Rural Strategic (a)
6b Rural Strategic (b)
7a Rural Recreational (Summer)
7b Rural Recreational (Winter)

In addition, two other road-use categories were added for completeness – those of Rural Feeder (low volume rural roads), group 8 and Residential, group 9

Each of the road sections in the National Traffic Database (Works Consultancy Services 1996) has been allocated a road-use code. The breakdowns (as at 1994) are summarised as follows:

Group 1a	4797 sections,	total length	1176.6km
Group 1b	6770 sections,	total length	1826.9km
Group 2	2365 sections,	total length	417.7km
Group 3	1707 sections,	total length	411.0km
Group 4	16739 sections,	total length	3421.8km
Group 5	545 sections,	total length	514.5km
Group 6a/6b	7228 sections,	total length	12531.4km
Group 7a	1333 sections,	total length	2216.7km
Group 7b	353 sections,	total length	971.9km
Group 8	32033 sections,	total length	57455.3km
Group 9	48700 sections,	total length	11814.4km

The Land Transport Safety Authority has a programme to sample many of these sites and count traffic over a prescribed period of time.

In conjunction with this work, it may be appropriate to select several sites from several of the above categories. In particular, some from Urban Arterial sites (1a and 1b), Rural Strategic sites (6a and 6b), Recreational sites (7a and 7b) as being those sites which are most likely to be systematically affected by local changes. Sites within the last two groups (Rural Feeders and Residential) are, *a priori*, more likely to be influenced by general, larger scale changes such as economic or population changes. This is also a convenient approach as these Group 8/9 sites are much less likely to be regularly counted by roading authorities.

Part of the purpose for using these pre-identified road sections is that day to day and week to week variation is already estimated, at least within the road class (Transit NZ 1994). This enables clearer identification as to whether or not any changes in traffic flows are associated with external factors, rather than simply part of the background variability. In addition, different growth factors are likely to influence different types of road, so a ‘global’ approach will be too blunt.

For each of the identified sites, it should be possible to obtain (at a small grid level) New Zealand census data (for, say, the most recent census).

This should include some of:

- population demographics – number of households,
- local industry (number of industries, employment.)
- local income levels
- farming changes

i.e., similar to those examined in the present study, but at a very local level.

Since there may well be different factors affecting different road types, these factors may not all be relevant to all sites.

Traffic volumes should be measured over a several year time horizon at the same site. If historical count data is to be used, the possible predictor data for exactly the same period should also be used.

Any change in the traffic flows can be calibrated against the general growth measures obtained from the Transit New Zealand State Highway telemetry counts.

The data gathered in this way would then be examined firstly for influences at the national and regional level. In many instances, particularly in the growth of freight traffic, there would be a significant component of through-traffic, and this can be identified using a reasonably simple analysis such as is given by the UK approach (2.1.1). Finally, the influence of local factors can be determined, using the data described above.

6. Conclusions

The forecasting of traffic growth can be carried out at different focus levels, each with a place in the overall context of assigning a rate to a specific site.

The most general is the national level. This is the simplest to deal with under the approach adopted in the UK, in which traffic growth (measured as vehicle-km travelled) is related to a small number of very basic parameters. The most important of these are population growth, GDP growth, and fuel price. Traffic growth at this level serves as a constraint to the sum total of the predictions at regional level, and also as an input to regional analysis.

The next and more detailed level of evaluation is that of inter-regional traffic growth. This requires a more complex approach such as that proposed in Australia, which makes use of a simple gravity model. In this approach total trips between larger cities, including road, air and rail trips, are related to urban population numbers.

Regional traffic growth is predicted in many US states by the use of detailed gravity models. These are built up specifically for each state, and generally make use of external generator zones to represent the other states. This approach then incorporates the above level of inter-regional prediction within the regional model. The literature does not discuss the degree of co-operation among model developers regarding the generation of external traffic, which is a factor that all have in common. In these complex models, trip numbers are related to household numbers, employment and other trip generating factors.

Urban traffic growth is widely evaluated with the use of models, including gravity models as above. This level incorporates the greatest detail, mostly with the purpose of dealing with detail, such as intersection design.

Traffic levels at any specific road site can be formed from a combination of trip types, and it is important that through trips as well as local trips be taken into account. It is of interest to note that in the local practice survey, regional authorities highlighted business and demographic factors (properties of the cities that make up the regions) as very important in traffic growth, whereas city authorities highlighted the regional economy. Each, perhaps, is comfortable with its own domain, but less able to accommodate external influences – showing the need for an integration of effort at the different levels.

The above discussion points to one approach that can be taken to the prediction of traffic growth rates, namely that of using network models. To be effective, however, this requires a co-ordinated approach from the national level down and from the urban/regional level up. While the latter models are likely to be already formed, they need to be integrated into the national context.

Another approach is that of extrapolating historical traffic data at any site. This is, however, likely to miss the important factors that have an impact on traffic growth, unless the site is one where there is expected to be no change at all from circumstances in the past. One means of incorporating factors of influence is the use of pivot analysis where modelling is used to determine the trip origins and destinations most affecting the site, and extrapolation is used on the causes or drivers of these trips.

The Empirical Bayes method, combining national trends with local specifics, may offer promise as an alternative way of getting a useable prediction process. The present project has left the authors sceptical that there is any 'global' solution, but intelligent application of the theory at a very local level may give the best answers.

A broader approach is that evaluated in this study of seeking a causal relationship with many of the land-use and demographic parameters of the surrounding area. This approach has, however, been found to be non-viable through lack of suitable data. Despite a determined effort in assembling acceptable data and an extensive analysis of this, it was not possible to find a statistically significant link between the variables tested and historical growth figures. This was due to the fact that the records needed are not complete or are not consistent. The data had to be obtained from a number of different sources, none of which have been recording this information specifically for the type of analysis carried out.

A final and recommended approach is one which incorporates further statistical evaluation, but is based on the assumption that the mix of trip type at any site is reflected in the road category, e.g. a rural strategic road could be expected to consist predominantly of inter-regional traffic. In this case it is possible that roads of the same category will be affected by similar factors of influence, giving the statistical approach a greater chance of success. Again, however, consideration has to be given to the suitability of data. Co-ordination is required to ensure that future data collection meets the needs of this research.

Whatever way, it is clear from the local practice survey that there is a demand for more guidance on effective traffic growth prediction, particularly from the smaller roading authorities. This is both evident from the variety in what they do take into account and what they don’t consider. Development of such information can only help to provide a more consistent approach to traffic growth prediction throughout the country.

6.1 Recommendations

The following areas have been highlighted in this report and warrant further investigation locally:

- Consideration of the use of traffic growth relationships other than the standard “arithmetic growth” method currently in standard use. This appears to be particularly relevant when comparing varying levels of land use development or remaining highway capacity.
- Development of a national traffic growth forecasting programme, as this appears to be a logical step up from the existing default growth rates in the PEM. This should provide a sound basis for up-to-date estimates of national traffic growth for the next 25-30 years. Breakdowns by road type, region, vehicle type, and possible time of day would be desirable.

- Definition of an appropriate approach for this, including type of prediction system, data needs, and collection programme.
- Further work to identify, provide and maintain key "non-traffic" data sources for traffic growth prediction is needed. The exercises in this current research highlighted a lack of readily available data, particularly for future estimation and for years outside of the regular census cycle. A programme of consultation and liaison with agencies collecting data may be worthwhile to ensure future data needs are met.
- Further consideration of how to relate national estimates of growth to local circumstances needs to be looked at. The use of some Empirical Bayes style combination of national estimates and local historic data merits further research.
- Investigation of the effects of capacity improvements on traffic growth. Literature suggests that a one-off increase in traffic volume is likely, but no change in the rate of traffic growth is likely. This needs to be validated against some local case studies.
- Similarly, investigation of the effects of seal extension projects on traffic generation. Many local authorities find this to be one of their major works programmes, and it is not at all clear how it will affect future volumes. Some case studies of recent seal extension projects around New Zealand would provide useful guidance.
- Consideration for providing separate growth estimates for light and heavy vehicles (or private and commercial vehicles). Many of the existing PEM benefits such as travel time and vehicle operating costs are already provided separately for different vehicle types. Where appropriate, the growth projections applied to these benefits should also vary by vehicle type. Forecasting methods for commercial vehicles are under-researched in New Zealand.
- Separating growth estimates by time period should also be considered where appropriate. Peak period growth is often different to inter-peak growth (partly because of congestion constraints). Weekend traffic growth can also be quite different to weekday growth in New Zealand, particularly on some arterial routes surrounding towns.

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Appendices

A.1 Traffic Growth Survey used for Road Controlling Authorities

Traffic Growth Prediction Survey

Telephone Interview

Section 1:

As much of this section as possible should be filled in before undertaking the survey. Confirm relevant details with interviewee.

Date: ___________
Rater: ___________

Contact Details:

Name of Authority:	____________________	Phone:	____________________
	____________________	Fax:	____________________
Contact person:	____________________	Address:	____________________
	____________________		____________________
Position:	____________________		____________________
	____________________		____________________
		E-mail:	____________________

Type of Authority

- District ☐
- Regional ☐
- TNZ ☐
- Unitary ☐

Type of Area Covered
(Tick one or more boxes)

- Main City ☐
- Main Town ☐
- Rural ☐

Section 2: Interview

Greeting, Name and Affiliation.

Opus is currently conducting a ***review of traffic growth prediction procedures*** *throughout New Zealand. This research has been commissioned by* ***Transfund*** *New Zealand. The aim of the research is to ultimately* ***improve demand forecasting****. These interviews with* ***Road controlling Authorities*** *will determine how traffic growth prediction is currently calculated. The interviews will also help us determine the* ***best methods for calculating traffic growth****.* (Refer to proposal summary for more detailed information, if it is requested by the interviewee).

1. How **many** traffic growth prediction calculations have **you** done in the last year?

____

2. How **frequently** does **your authority** need to make traffic growth predictions?

Never ☐

Seldom ☐

Occasionally ☐

Frequently ☐

All the time ☐

3. **How** do you calculate traffic growth? OR: What methods do you use?

Based upon historical growth and then extrapolated into the future ☐

Using: linear growth ☐

Geometric ☐

Other ☐

Not sure ☐

Using standard growth rate tables ☐

Using more complicated growth modelling ☐

4. Is any allowance made for **limiting** your **traffic growth** calculation when the road network **capacity is exceeded**? OR: When a road/area has reached its full capacity, do you make allowances for this in your calculations of traffic growth?

Yes ☐

No ☐

Briefly, what method do you use? OR: How do you do this?

Flat cut off ☐

Decreasing growth rate ☐

5. Do you vary growth rates by **vehicle type**? OR: Do you calculate different growth rates for different vehicles?

Yes ☐

No ☐

If so, what vehicles do you take into consideration? OR: What categories do you use?
(tick more than one box if necessary)

Light/Heavy ☐
Passenger cars ☐
Light commercial vehicles ☐
Medium commercial vehicles ☐
Heavy commercial vehicles-Type 1 ☐
Heavy commercial vehicles-Type 2 ☐
Buses ☐

6. Do you calculate **different rates of traffic growth** for different areas/road types?

Yes ☐
No ☐

If so what groupings do you use?

Urban arterial ☐
Urban other ☐
Rural Strategic ☐
Rural other ☐
Other

____

____

7. Do you take into account **expected population growth**? OR: Do you use a demographic model as the basis for determining traffic growth?

Yes ☐
No ☐

8. What other **variables** do you factor into your **calculations**? If they do not mention these first three please ask about them, and detail in spaces provided.

   Time of the day and variations in traffic flow

   Effects of peak spreading

   Changes in road capacity (if they answered Yes in Q4 – ask them about changes in capacity other than exceeded/full capacity)

9. What are other **key factors** you consider in your **calculations** that have a bearing upon traffic growth?

Demographics ☐

Age ☐

Ethnic groups ☐

Others

____

____

Tourism ☐

Land prices ☐

Urban sprawl ☐

Population growth ☐

Population migration ☐

National Economy ☐

Regional Economy ☐

Induced Traffic due to improvements in other roads nearby ☐

Weather/season ☐

Roading improvements other than capacity ☐

Changes in vehicle ownership ☐

Vehicle operating costs ☐

Freight movements ☐

Number of junctions along a given route/road ☐

Type of development, or land use ☐

Development Pressure/Zoning ☐

Other

10. Do you use information from the Transfund **Project Evaluation Manual** to help forecast traffic growth? (you may have an idea of this from the answer they gave in Q3)

Yes ☐

No ☐

In what way do you use the PEM? (Tick the sections of the PEM that they use)

Traffic composition ☐

Vehicle occupancy and travel purpose ☐

Traffic Volumes ☐

Traffic Growth rates ☐

Future traffic volumes ☐

Travel times and speeds ☐

Appendix A11 ☐

11. Are the results of traffic growth predictions used in any plan processes?

Yes ☐

No ☐

Don't know ☐

12. Do you have any other further comments?

A.2 Detailed Results from Local Practice Survey

Regional Authorities

Methods used most often in order (8 respondents):

Modelling	(4)	50%
Historical data	(2)	25%
Historical data with linear extrapolation	(1)	13%
Historical data with geometric extrapolation	(1)	13%

Factors used most often in order (8 respondents):

Tourism	(4)	50%
Different areas/roads	(4)	50%
Demographics	(4)	50%
Freight movements	(3)	38%
Type of land use	(3)	38%
Weather/season	(3)	38%
Population migration	(2)	25%
Regional Economy	(2)	25%
Vehicle type	(2)	25%
Changes in road capacity	(2)	25%
National economy	(2)	25%
Induced traffic	(2)	25%
Population growth	(1)	13%
Vehicle operating costs	(1)	13%
Number of junctions	(1)	13%
Exceeded Capacity	(1)	13%
Time of day	(1)	13%
Peak spreading	(1)	13%
Urban sprawl	(1)	13%
Roading Improvements	(1)	13%
Vehicle ownership	(1)	13%
Land Prices	(0)	0%
Development pressure	(0)	0%

38% of respondents use the Project Evaluation Manual

City Authorities

Methods used most often in order (10 respondents):

Historical data	(7)	70%
Modelling	(6)	60%
Historical data with linear extrapolation	(4)	40%
Use of PEM Growth rate tables	(4)	40%
Traffic counts	(3)	30%
Historical data with geometric extrapolation	(1)	10%
Common sense	(1)	10%

Factors used most often in order (10 respondents):

Different areas/roads	(8)	80%
Population growth	(8)	80%
Type of land use	(8)	80%
Regional Economy	(7)	70%
Demographics	(7)	70%
Urban sprawl	(7)	70%
Population migration	(7)	70%
Induced traffic	(7)	70%
Roading Improvements	(7)	70%
Development pressure	(7)	70%
National economy	(6)	60%
Freight movements	(6)	60%
Weather/season	(6)	60%
Vehicle ownership	(6)	60%
Peak spreading	(5)	50%
Exceeded Capacity	(5)	50%
Changes in road capacity	(5)	50%
Vehicle operating costs	(5)	50%
Time of day	(5)	50%
Number of junctions	(4)	40%
Vehicle type	(3)	30%
Tourism	(3)	30%
Land Prices	(0)	0%

80% of respondents use the Project Evaluation Manual

District Authorities

Methods used most often in order (23 respondents):

Historical data	(18)	78%
Traffic counts	(8)	35%
Use of PEM Growth rate tables	(7)	30%
Historical data with linear extrapolation	(5)	22%
Modelling	(1)	4%
Historical data with geometric extrapolation	(1)	4%
Best fit	(1)	4%
Common Sense	(1)	4%

Most often used factors in order (23 respondents):

Tourism	(17)	74%
Type of land use	(13)	57%
Different areas/roads	(12)	52%
Population Growth	(11)	48%
Freight movements	(11)	48%
Weather/Season	(10)	44%
Vehicle Type	(10)	44%
Induced Traffic	(8)	35%
Demographics	(8)	35%
cont'd		
Roading Improvements	(7)	30%

Regional Economy	(7)	30%
Development pressure	(4)	17%
Changes in road capacity	(4)	17%
Time of day	(4)	17%
Urban sprawl	(3)	13%
Vehicle ownership	(3)	13%
Population migration	(3)	13%
Peak spreading	(3)	13%
Vehicle operating costs	(3)	13%
Number of junctions	(3)	13%
Exceeded capacity	(2)	13%
National Economy	(2)	9%
Land prices	(1)	4%

74% of respondents use the Project Evaluation Manual

Total*

Methods used most often in order (42 respondents):

Historical data	(28)	67%
Traffic counts	(11)	26%
Historical Data with Linear extrapolation	(11)	26%
Modelling	(11)	26%
Use of PEM Growth rate tables	(11)	26%

Most often used factors in order (42 respondents):

Different areas/roads	(24)	59%
Tourism	(24)	59%
Type of land use	(24)	59%
Freight movements	(20)	48%
Population Growth	(20)	48%
Weather/Season	(19)	45%
Demographics	(19)	45%
Induced Traffic	(17)	41%
Vehicle Type	(16)	38%
Regional Economy	(16)	38%
Roading Improvements	(15)	36%
Population migration	(12)	29%
Changes in road capacity	(11)	26%
Urban sprawl	(11)	26%
Development pressure	(11)	26%
National Economy	(10)	24%
Time of day	(10)	24%
Vehicle ownership	(10)	24%
Peak spreading	(9)	21%
Vehicle operating costs	(9)	21%
cont'd		
Exceeded capacity	(9)	21%

* Total also included one Transit NZ office, one Unitary authority, and one Consultant (for Southland DC)

Number of junctions	(8)	19%
Land prices	(1)	2%

67% of respondents use the Project Evaluation Manual.

The following are brief notes based on the responses received. For more detailed information, contact the authors.

Regional Authorities

High Growth areas

- *Auckland*

Do modelling.
Look at most factors, but not vehicles, land prices, economy, season.
They use the general principles from the PEM.

- *Bay of Plenty*

They do not do calculations they get information from TNZ or from the district authority.

Stable growth areas

- *Waikato*

They do calculate traffic growth quite frequently. They use historical data with linear and geometric extrapolation. They do not take too many factors into consideration.

- *Northland*

Do not consider traffic growth. They leave it up to the District councils

Low or Declining Growth areas

- *West Coast*

Use historical growth. They look at demographics, tourism, economy (nat and reg), weather and season, freight movements and type of land use. They do not use the PEM.

- *Taranaki*

Do not do calculations
The District Councils do these.

- *Hawkes Bay*

Use consultants, and TLAs do most of calculations

City Authorities

Most larger cities use models.
On specific projects, consultants calculated traffic growth.
All do not differentiate vehicles to a great degree. If they do, they usually look at Light vs Heavy or differentiate between type 1 and type 2 heavy vehicles.
In most of the cities, most of the factors in the survey are used to help predict traffic growth. Although some of these factors are calculated indirectly.

<u>High Growth areas</u>
- *Auckland Region*
Councils involved: Auckland City, Manukau City, North Shore City, Waitakere City

- All use models
- Use historical data and linear extrapolation only very occasionally.
- Usually they subcontract out to consultants (Gabites Porter or Becas)
- They have two regional models: the regional planning model and regional traffic model. These two models interact with one another. Each council uses a "sub-regional model".
- The model is not maintained (Manukau). Although Waitakere mention that it is updated.

- *Auckland City*
When doing their own calculations they consider area/road capacity, and calculate using historical growth, and flat cut off for exceeded capacity. They do use information from the PEM.

- *Manukau City*
They do calculations for specific projects
Also think it would be a good idea to look at Fuel consumption.
Do not use the PEM.

- *North Shore*
Always subcontract

- *Waitakere City*
They use growth matrices, traffic counts, and default values in the PEM.
Waitakere update the model when improvements to road are made.

- *Hamilton*
Do use a model.
Also yes historical data with linear extrapolation, and educated guesses.
Most factors are looked at, however some are indirectly considered.

<u>Stable Growth areas</u>
- *Palmerston North*
Do not use a model
Do not do many calculations.
However when they do they take quite a few factors into consideration.

<u>Low or decreasing Growth areas</u>

- *Dunedin*

They use a model and use historical data with Linear extrapolation when necessary.
They look at most factors except land prices
Do not differentiate vehicles to a great extent

- *Napier*

Do not use a model or calculate do calculations that frequently.
Do not consider Tourism, land prices, population migration, and land use.
Do not differentiate vehicle type.

- *Invercargill*

do not do traffic growth prediction at all.

District Authorities

<u>High Growth areas</u>

- *Franklin*

Use historical data with linear extrapolation, traffic counts and growth rate tables.
Look at different areas/roads.

- *Thames/Coromandel*

Use historical data. They look at 3 groups of vehicles (light, heavy 1 and heavy 2), different areas/roas, tourism, weather season, time of day, traffic due to other roads.

- *Queenstown Lakes*

No traffic growth predictions done.
When they do they use historical data. They would look at demographics, tourism and population growth.

<u>Stable growth areas</u>

- *Whangarei*

Do calculations often
Use historical data with linear/best fit.
Look at a lot of different vehicle types, different areas/roads, tourism, weather, season.

- *Rotorua*

Use traffic counts and tables
They look at heavy and light behicles, different roads/areas, demographics, changes in road capacity, tourism, population growth, traffic due to other roads, roading improvements, freight movements and land use (However these factors are only considered for specific projects)

- *Opotiki*
Use historical data with linear and geometric extrapolation, and growth rate tables.
They differentiate heavy vehicles, and look at different roads/areas, demographics, tourism, population growth, weather/season and land use. Multiple land use is an issue here because of Maori population.

- *Marlborough*
(also unitary authority)
Make predictions every 3 years when reviewing Regional LTS
Take into account potential heavy traffic growth, e.g. forestry, ferry terminal
Consider population growth, tourism, regional economy, induced traffic, weather/season, freight movements (minor), land use

- *Tasman*
Consider all but population changes, demographics, national economy or changes in vehicle ownership

- *Hurunui*
They use historical data.
They look at demographics, population growth and type of land use.

<u>Low or declining growth areas</u>
- *Gore*
Overall reduction in population so no great need for TGP
Do not usually do calculations.
Traffic counts are done for B/C ratios.
They do look at Tourism, pop migration, regional economy, season, weather, type of land use as factors of traffic growth prediction.

- *Rangitikei*
Use historical data and PEM tables
They only look at land use and freight movements

- *Gisborne*
Do not do traffic counts very often.

- *Central Otago*
Use historical growth, traffic counters
They look at different roads/areas, tourism, population migration, regional economy, weather/season, roading improvements, freight movements and land use

- *Matamata - Piako*
Use historical data and common sense, traffic counts and growth tables.
Look at different areas, population growth, regional economy, traffic due to other roads, weather and season, and freight movements.

- *Timaru*
Use traffic counts, historical and land use growth.
Look in detail at vehicle type, freight movements, land use, and different types of roads/areas.

- *Clutha*
They do a lot of traffic growth prediction calculations.
They use historical data and growth rate tables.
They look at light vehicles and different heavy vehicles (approx 3 categories)
Also look at areas/roads, tourism, roading improvements, freight movements

- *New Plymouth*
They use historical data and traffic counts
They look at different areas/roads, changes in road capacity, tourism, weather/season, vehicle ownership and type of land use.

- *Mackenzie*
Use traffic counts and historical data
Do not look at any factors

- *Kawerau*
Use traffic counters
But do not do anything else as traffic is decreasing in this area

- *Southland*
Use standard growth rate tables.
Consider tourism, roading improvements, land use.
Forests coming onstream and a large number of Dairy conversions of sheep farms

Points that may be necessary to consider.
"school holiday situation" in Auckland (mentioned by Waitakere) causes problems with Transit's traditional methods of traffic growth prediction.

Using fuel consumption as a prediction measure.

Waikato Regional Council say that there is a difference in quality between each region and that there should be a set routine.

Areas that state (without prompting) they would like some sort of system:
- Franklin District
- Timaru District
- Waikato Region

Other related factors:
- Seal extensions
- Traffic Counts for projects - B/C ratios
- Commercial vehicles and damage to roads
- Tourist vehicles (esp. 4WD vehicles) damaging unsealed roads

A.3 Sampled Road Sites

Note: ADTs are for 1998-99

District	Street	Type	ADT - 5days	ADT -7days
Palmerston North	Broadway Rd 550	Commercial	12035	
Palmerston North	Cuba 1200	Commercial	7509	
Palmerston North	Limbrick 100	Residential	2533	
Palmerston North	Slacks 930	Residential	1784	
Tasman	Tabbot St	Commercial	2388	
Tasman	Queens Street	Commercial	8161	
Tasman	Wensley Rd	Residential	1939	
Tasman	Hill Street	Residential	600	
Thames/Coromandel	Purangi Rd	Rural	158	
Thames/Coromandel	the 309 Road	Rural	151	
Thames/Coromandel	Port Rd	Commercial	2286	
Thames/Coromandel	Hetherington Rd	Residential	2877	
Timaru	Mere Mere St	Quiet/Urban	355	359
Timaru	Church St	Busy/Urban	8373	7219
Timaru	Milford Clandeboye Rd	busy/Rural	1137	1052
Timaru	Fraser Rd	quiet/Rural	31	30
Southland	Main Street Otautau	Urban arterial		1116
Southland	Church St			298
Southland	Dunlop St			619
Southland	Gorge Rd			912
Central Otago	Barry Ave	Urban/sealed		2000
Central Otago	Springvale Rd	Rural Strategic		339
Central Otago	Earnscleugh Rd	Sealed Rural		808
South Waikato	Tapapa Te Poi Rd - Okoroire Rd Sth			512
South Waikato	Tapapa Te Poi Rd - Okoroire Rd Nth			198
South Waikato	Okoroire Rd - Tapapa Te Poi Rd - W			500
South Waikato	Old Taupo - Kinleith Rd- South			77
South Waikato	Kinleith Rd - Old Taupo Rd - East			165
South Waikato	Kinleith Rd - Old Taupo Rd - North			896
South Waikato	Waotu Rd - Arapuni Rd - South			316
South Waikato	Arapuni Rd - Waotu Rd - West			582
South Waikato	Arapuni Rd - Waotu Rd - East			848
Whangarei	Waiatawa Rd	Urban arterial	16070	15253
Whangarei	Maungakarema Rd	Rural collector	1294	1209
Tauranga	Vale St		5775	5364
Tauranga	Cameron Rd		15004	13783
Tauranga	Maunganui road		24508	22043
Rotorua	Ranolf St	Urban arterial		8897
Rotorua	Luke Rd	Urban arterial		14914
Rotorua	Broadlands Rd	Rural arterial		1172
Hurunui	Lawcocks Rd			707
Hurunui	Amberley Beach Rd			600
Hurunui	Dalmeny Rd			64
Hurunui	Glenmark Dr			144
Hurunui				62
Hurunui	Leslie Hills Rd			64
Hurunui	Pyramid Valley Rd			158
Hurunui	Mt Cass Rd			30
Hurunui	Medbury Rd			93
Hurunui	Mays Rd			58
Hurunui	Maskells Rd			42
Kapiti Coast	Kapiti Road	Urban		12000
Kapiti Coast	Otaki Gorge Rd	Rural		887

A.4 Summaries of Various Regressions

(Analysis conducted using the Splus2000 statistical package)

Palmerston North - 1st Regression

padt - Site adt
preg - vehicle registrations
prty - road type
pyear - year of count
ppop - regional population
pfte - numbers (regional) in full time employment
pdwe - number of dwellings
pagr - numbers in agriculture
pret - numbers in wholesale or retail

Call: glm(formula = padt ~ preg + prty + pyear + ppop + pfte + pdwe + pagr + pret, family = gaussian, na.action = na.omit)

Coefficients: (5 not defined because of singularities)

	Value	**Std. Error**	**t value**
(Intercept)	-23662.82	21149.36	-1.1188
preg	-26.26	16.09	-1.6321
prty	-5881.27	455.97	-12.8983
pyear	1046.79	617.71	1.6946
ppop	NA	NA	NA
pfte	NA	NA	NA
pdwe	NA	NA	NA
pagr	NA	NA	NA
pret	NA	NA	NA

Palmerston North - 2nd Regression

Call: glm(formula = padt ~ preg + prty + pyear + ppop + pdwe, family = gaussian, na.action = na.omit)

Coefficients: (1 not defined because of singularities)

	Value	**Std. Error**	**t value**
(Intercept)	258613.80	294366.70	0.8785
preg	244.31	276.42	0.8838
prty	-6683.36	1158.62	-5.7684
pyear	-7027.28	8516.12	-0.8252
ppop	-0.66	0.59	-1.1020
pdwe	NA	NA	NA

Palmerston North - 3rd Regression

Call: glm(formula = padt ~ preg + prty + pyear + pret, family = gaussian, na.action = na.omit)

Coefficients: (1 not defined because of singularities)

	Value	Std. Error	t value
(Intercept)	-23662.82	21149.36	-1.1188
preg	-26.26	16.09	-1.6321
prty	-5881.27	455.97	-12.8983
pyear	1046.79	617.71	1.6946
pret	NA	NA	NA

Palmerston North - 4th Regression
summary(preg4)

Call: glm(formula = padt ~ preg + prty + pyear + pfte + pagr, family = gaussian, na.action = na.omit)

Coefficients: (2 not defined because of singularities)

	Value	Std. Error	t value
(Intercept)	-23662.82	21149.36	-1.1188
preg	-26.26	16.09	-1.6321
prty	-5881.27	455.97	-12.8983
pyear	1046.79	617.71	1.6946
pfte	NA	NA	NA
pagr	NA	NA	NA

South Waikato - 1st Regression

wadt	- Site adt	wreg	- vehicle registrations
wyear	- year of count	wpop	- regional population
wfte	- numbers (regional) in full time employment		
wdwe	- number of dwellings	wagr	- numbers in agriculture
wret	- numbers in wholesale or retail		

Call: glm(formula = wadt ~ wreg + wyear + wpop + wfte + wdwe + wagr + wret, family = gaussian, na.action = na.omit)

Coefficients: (3 not defined because of singularities)

	Value	Std. Error	t value
(Intercept)	-6414.661	14604.36	-0.4392
wreg	0.267	17.17	0.0155
wyear	76.556	531.94	0.1439
wpop	-0.010	0.017	-0.5999
wfte	0.026	0.046	0.5713
wdwe	NA	NA	NA
wagr	NA	NA	NA
wret	NA	NA	NA

South Waikato - 2nd Regression

Call: glm(formula = wadt ~ wreg + wyear + wpop + wdwe, family = gaussian, na.action = na.omit)

Coefficients:

	Value	Std. Error	t value
(Intercept)	3661.109	17306.83	0.2115
wreg	-4.092	19.71	-0.2076
wyear	76.556	531.94	0.1439
wpop	-0.057	0.095	-0.5971
wdwe	0.160	0.280	0.5713

South Waikato - 3rd Regression

Call: glm(formula = wadt ~ wreg + wyear + wret, family = gaussian, na.action = na.omit)

Coefficients:

	Value	Std. Error	t value
(Intercept)	-4606.438	8767.42	-0.5254
wreg	-1.434	7.63	-0.1878
wyear	93.724	279.33	0.3355
wret	0.010	0.016	0.6458

South Waikato - 4th Regression

Call: glm(formula = wadt ~ wreg + wyear + wfte + wagr, family = gaussian, na.action = na.omit)

Coefficients:

	Value	Std. Error	t value
(Intercept)	-3239.889	15974.59	-0.2028
wreg	-1.826	15.85	-0.1152
wyear	76.556	531.94	0.1439
wfte	0.006	0.030	0.2057
wagr	0.021	0.036	0.5999

A.5 Recommended Glossary of Terms

ADT — Average Daily Traffic. This is the raw average obtained from a traffic count survey of a fixed period. Generally this should not be used directly for project evaluation. The ADT needs to be adjusted for seasonal and daily variations to produce a reliable Annual Average Daily Traffic (AADT).

Arithmetic Growth — A linear increase in traffic volumes, i.e.

$$Vol_N = Vol_0 + N \times K$$

where Vol_N = Volume in the Nth year
Vol_0 = Initial volume
K = Increase in volume per year

Alternatively,

$$Vol_N = Vol_0 \times (1 + G \times N)$$

where G = % Growth rate/year (= K/Vol_0)

This is the standard method for calculating growth rates for Transfund Project Evaluations.

Diverted Traffic — Existing traffic that shifts to or from alternative routes. This may be because of capacity constraints or because of changes in relative travel costs. For a complex roading network, a transportation model may be required to assess this.

Generated Traffic — New trips not previously made by the existing mode (or at all). A transportation model may be able to identify any change in modal split. However variable trip matrix techniques will be needed to assess any other new traffic.

Geometric Growth — An exponential increase in traffic volumes, i.e.

$$Vol_N = Vol_0 \times (1 + G)^N$$

where Vol_N = Volume in the Nth year
Vol_0 = Initial volume
G = % Growth rate/year (= $Vol_1/Vol_0 - 1$)

Growth rates for Transfund Project Evaluations should ***not*** be calculated in this manner.

Induced Traffic — See *Generated Traffic*.

Intermittent Traffic — Traffic that will not occur over the full lifetime of a project. Examples may include traffic from forestry lots with short-term demand at logging time, and traffic generated by a major construction project.

Normal Traffic Growth	Increases in volumes due to overall local or national trends. For example, population growth, Gross National Product (GNP) and vehicle ownership levels are likely to affect traffic growth. This usually has the best correlation with historical traffic growth.
Peak Spreading	An increase in the peak period duration, caused by traffic growth being constrained by capacity. As a result some trips are taken earlier or later.
Suppressed Traffic	Trips that are not currently undertaken, either because of capacity constraints or travel costs. They are desired trips however, and road improvement projects may cause these trips to be undertaken.