ACCIDENT TRENDS IN NEW ZEALAND

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Transit New Zealand Research Report No. 47

ISBN 0-478-10504-5
ISSN 1170-9405

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Kennaird. A. 1995. Accident trends in New Zealand.
Transit New Zealand Research Report No. 47. 67pp.

Keywords: accidents, analysis, cost, project evaluation, road improvements, safety, traffic

AN IMPORTANT NOTE FOR THE READER

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EXECUTIVE SUMMARY

Trends in Road Accidents

When evaluating improvements for a road site or a route using the procedures in the 1991 Transit New Zealand Project Evaluation Manual, the assumption is made that the only reduction in accidents will be those resulting from the road improvements. In fact accidents are as likely to be reduced by a number of other road safety programmes including enforcement, education, improvements in vehicles, reduced use of vehicles, and possibly from road maintenance of a general nature.

Past trends in road accidents in New Zealand are analysed and an assessment is made of likely future trends based on road safety plans and programmes available in 1994. The contribution that road improvements make to accident reduction is estimated and this estimate is used to determine underlying trends in road accidents resulting from other road safety improvement programmes other than road improvements.

Recommendations

Recommendations are made for adjustments to the process of evaluating accident savings in New Zealand resulting from road improvements that allow for the underlying trends in New Zealand road accidents, as follows:

Changes to the 1991 Transit New Zealand Project Evaluation Manual procedures and values:

- The prediction year for accident analysis in project evaluation be "time zero", as defined in the Project Evaluation Manual (e.g. for projects prepared for the 1995/96 National Land Transport Programme, accident estimates would be done for 1995).

- Average annual accident numbers calculated from a five-year accident history at a road site be multiplied by the accident trend adjustment factors to give the "do minimum" number of accidents at the site for the prediction year.

- Consideration be given to requiring motorcycle accidents to be analysed separately if more than two such accidents are recorded at the site of proposed road improvements.

- The AADT (average annual daily traffic) used in the accident analysis be estimated for "time zero".

- The typical number of accidents for the site of proposed road improvements be calculated using the typical accident rate and the site traffic exposure at "time zero".

- Equivalent arithmetic growth rates be used in discounting accident reduction benefits.

- The constants in the typical accident rate formulae in Appendix A6 of the Project Evaluation Manual be changed so that they can:
    - be used with traffic exposures at "time zero", and
    - predict accidents per year at "time zero".

- The adjustment factors presented in the report should be re-calculated at intervals of two to three years to allow for changes in accident and traffic volume trends.

Changes to Accident Analysis

- Any analysis of the effectiveness of road safety measures should make allowance for general trends in accidents, either by using the adjustment factors presented in the report or by using control sites.

- More attention should be given to recording any road improvements so that changes in site characteristics can be allowed for in the evaluation of further safety improvements and/or effectiveness of treatments, and so that a more accurate estimate can be made of the contribution that road improvements make to overall accident reductions.

- Consideration should be given to extending the purpose of the Land Transport Safety Authority Accident Investigation database to record all site-specific (or route-specific) road improvements.

ABSTRACT

Recommendations are presented for adjustments to the procedures used by Transit New Zealand for determining accident savings from road improvements for project evaluation. The adjustments allow for general trends in New Zealand road accidents arising from those road safety programmes other than road improvements.

1. INTRODUCTION

1.1 Background

The Transit New Zealand project evaluation process requires an assessment of accident cost savings for all proposed road improvements in New Zealand. To assist this process, detailed information is provided in the 1991 Transit New Zealand Project Evaluation Manual (PEM) on the cost of the different types of accidents, accident rates for typical road situations, and guidance on estimating the expected accident reduction resulting from proposed road improvements. The effect of road improvements on accident reduction is the least well defined because it is site-specific. The assessed accident reduction can have a critical effect on the benefits, and hence ranking, of proposed road improvements.

The number of accidents at a particular road site can change for reasons other than a change to the physical road environment. Changes to road rules, education, enforcement, vehicle design, and even general maintenance on the road, can produce a general change in accidents. Changes in the number or type of vehicles using the road can also change accident occurrence. Accident reduction benefits will be inaccurate unless the general change in accidents is allowed for in analysing accident rates for specific sites and in determining the effect of road improvements. The underlying trend in accidents can be determined by identifying and excluding from overall accident numbers the reduction resulting from improvements to the roading system.

1.2 Objectives

The objectives of this study were to determine the nature and extent of double counting of accident savings for improvements carried out on roads in New Zealand; and to propose a method to eliminate this double counting in future project evaluations prepared for consideration by Transit New Zealand.

1.3 Study Method

This study was undertaken in five major stages:

1. Review current procedures for evaluating accident savings resulting from road improvements and identify areas of possible double counting;
2. Identify safety projects, programmes and other measures that are significant in producing national trends in accidents;
3. Analyse past accident trends and predict future trends;
4. Quantify double counting of accident savings;
5. Recommend changes to accident evaluation methods to eliminate double counting.

2. EVALUATION OF ACCIDENT REDUCTION BENEFITS

2.1 Procedures in 1994

The procedures for the evaluation of accident reduction benefits from road improvements carried out in New Zealand are set out in the *Project Evaluation Manual, Volume I: Simplified Procedures, and Volume II: Full Procedures* (PEM, Transit New Zealand 1991). These manuals have been updated in September 1992 and September 1993. The detailed description of the method is given in Appendix A6 of Volume II. The calculation of accident costs involves three stages:

1. **Analysing and comparing accident records** including any supplementary information on the incidence of accidents, at a site with typical accident rates;

2. **Determining remedial measures** and assessing the numbers, categories and severity of accidents that will be eliminated by these measures;

3. **Calculating the accident costs** using the numbers of past and predicted future accidents, and the unit costs of individual categories of accidents.

2.2 Analysis Methods

Two analysis methods are provided in the Transit New Zealand Project Evaluation Manual:

1. **Accident rate analysis** compares the accident rate of the existing facility with an accident rate applicable to the facility after it has been changed by the proposed road improvements;

2. **Accident-by-accident analysis** estimates accident reduction for the site by determining which of the past accidents are likely to be eliminated or have reduced severity as a result of the proposed road improvements.

Accident rate analysis is used where the proposed road improvements will produce a fundamental change in the existing road facility and/or there will be major changes in the traffic flows. Typical accident rates applicable to the modified facility are needed for this type of analysis.

Accident-by-accident analysis can be used if the proposed road improvements produce no fundamental change in the road facility or traffic flows. This analysis requires clear patterns of accidents at the site of the proposed road improvements and documented accident reduction effects of road improvements.

If the conditions for neither accident rate analysis nor accident-by-accident analysis are fully met, then both analyses are tried with the lesser result used. In such a situation, the accident reduction resulting from the proposed road improvements is limited to 30% of the past number of accidents unless a second expert opinion is obtained.

2.3 Factors Used in Analysis

The analysis takes into account the following factors:

(a) Posted speed limit for the site – accident severity proportions, under-reporting rates, accident costs and typical accident rates are different for each speed limit category.

(b) Traffic exposure – accidents are proportional to the number of vehicles at the site (number of 100 million vehicle kilometres travelled per year for mid-block sections of road; and the square of the number of million vehicles entering the intersection per year for intersections).

(c) Years of reported accident history – the most recent five calendar years of accident history are used, or a lesser period if a major change has been made to the site that has changed the accident incidence. If the road has less than 1000 vpd (vehicles per day), the latest 10 years can be reviewed to check for accident problems not revealed by data from the latest five years.

(d) Number of reported accidents – the past average annual number of accidents is the principal piece of data used for an accident analysis. (An accident analysis is only undertaken where the site of proposed road improvements has an accident history of either: (i) four or more non-injury accidents; (ii) one injury and three or more non-injury accidents; or (iii) two or more injury accidents.)

(e) Classifications of the vehicle movement and type – the classification of reported accidents by the vehicle movement and vehicle type involved in the accident can be used in an accident-by-accident analysis to more accurately identify the number of accidents that may be reduced by a proposed road improvement and the benefits associated with the accident reduction.

(f) Accident severity – the four levels of severity (fatal, serious, minor and non-injury) for accidents can be used with typical ratios of severity for the different road types in an accident-by-accident analysis to more accurately analyse accident reductions. (An aggregation into injury and non-injury is used where five or less injury accidents are affected by the proposed improvement.)

(g) Reporting rate – not all accidents at a site are reported and therefore adjustment factors need to be applied to convert the number of reported injury and non-injury accidents to a total estimated number of accidents for an accident-by-accident analysis.

(h) Accident costs – standard unit costs per accident for each speed limit, severity, movement, and type of vehicle category, are used to cost the estimated number of accidents associated with each scenario.

(i) Typical accident rates – typical rates of reported injury accidents (proportional to traffic exposure) are given for urban intersections, urban arterials and collectors (mid-block), and 100 km/h two lane roads (by terrain type, e.g. flat, rolling, hilly), based on the average accident history of selected sites over a five year period. They are used in accident rate analysis to estimate the accident reduction from the proposed road improvements.

(j) Road improvement effectiveness – typical percentage reductions in accidents resulting from road improvements are given in the publication *Accident Investigation Procedures* (Transit New Zealand, Ministry of Transport Land Transport Division 1991), for accident-by-accident analysis.

(k) Effect of speed – for speeds above 50 km/h both the number of injuries per reported accident, and the ratio of fatal plus serious injuries to other injuries, increase linearly with speed. To allow for this effect on projects which increase the overall speed of traffic by 5 km/h or more, correction factors are applied to the unit accident costs.

2.4 Causes of Possible Double Counting

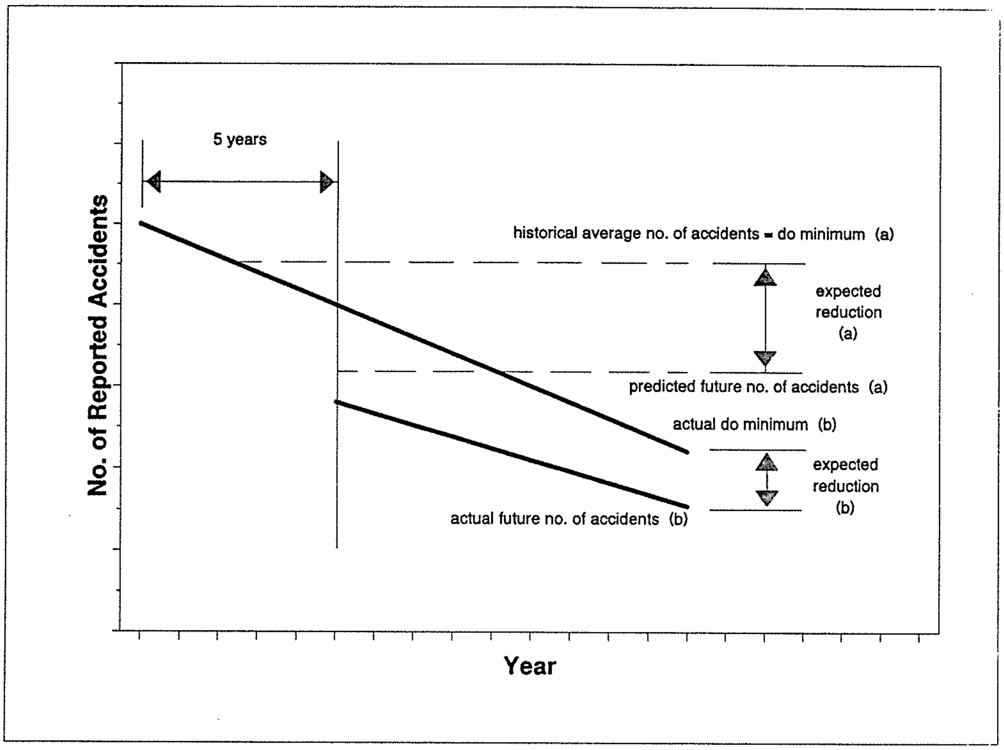
The use of the reported accident history (average annual number of accidents over a five-year period) in the analysis to define the "do minimum" situation, is a potential cause of double counting. The past average annual number of accidents for the site, corrected if appropriate for severity rates and reporting rate, is assumed to continue under the "do minimum" option. Taking the average over five years is used to minimise the "regression to the mean" effect, which is the tendency of a random variable to fluctuate about its true mean if measured in short time periods. However using a five year average does not make allowance for the general trend in accidents at the site that will occur even if no improvements are made. By ignoring the underlying general trend this process will not give an accurate prediction of future accidents at the site, neither for the "do minimum" option nor for the option involving road improvements. This is illustrated in Figure 2.1.

The benefit/cost ratio for a proposed road improvement only uses the difference between the accident costs for the "do minimum" and the accident costs for the improvement option, i.e. it is only the expected accident reduction that counts in the benefit/cost ratio. Thus inaccurate determination of the "do minimum" situation is likely to lead to an over-optimistic estimate of the expected accident reduction, especially if the expected accident reduction is determined as a percentage of the "do minimum" number of accidents. Inaccurate determination of the "do minimum" situation could also lead to an inaccurate assessment of the effectiveness of a road improvement.

Other sources of double counting are possible in the determination of the expected accident reduction for both accident-by-accident analysis and accident rate analysis. In accident-by-accident analysis, the accident reduction effects of road improvements are determined from analysis of the change in reported accidents at sites where similar road improvements have been applied.

In general the average annual number of accidents for a period of five years before the road improvement was made is compared to the average for a similar period after making the road improvement, and the road improvement is credited with all of the change. Again this approach does not allow for a general trend in accidents resulting from other measures, during the 10- to 12-year period involved, and as a result the expected reduction is likely to be wrong.

Figure 2.1 Accident prediction using five year accident history.

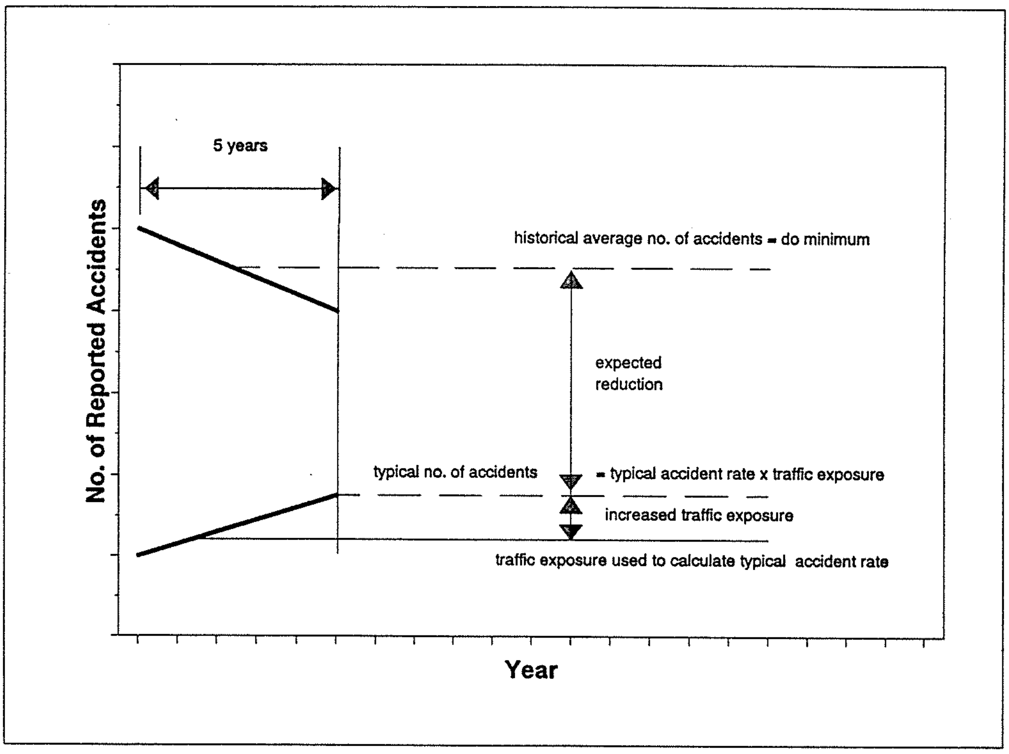


Similarly, typical accident rates used in accident rate analysis have been derived by taking a five year average of reported accident history for all sites on a particular type of road. A five-year period between 1985 and 1991 was used in deriving the typical accident rates given in the Transit New Zealand Project Evaluation Manual. Typical accident rates are all expressed as a proportion of traffic exposure (exposure squared for intersections) using traffic exposures that applied at the time of the analysis. These typical accident rates are then applied to future years with no allowance for a general trend in accidents.

When typical accident rates are used in an accident rate analysis for a proposed road improvement, current traffic exposures are used. With increasing traffic volumes this gives a prediction of increasing accidents which is against the recent general trend in number of accidents. Accident rate analysis does not do a year-by-year forward prediction of accidents but rather uses the difference between the past number of accidents for the existing facility and the number of accidents determined from the typical accident rate appropriate to the improved facility. The use of up-to-date traffic exposure for the predicted number of accidents with no adjustment for traffic exposure effect will tend to make the expected accident reduction smaller than it should be (Figure 2.2).

A further cause of double counting of accident reduction benefits results from the method of discounting to obtain total benefits for a 25-year analysis period. In the 1991 Project Evaluation Manual, annual accident benefits are discounted using a discount factor which takes into account traffic growth at the road site. Use of such a discount factor infers that accidents at the site will increase in the future in direct proportion to the traffic volume. This is unlikely to be the case, and a more accurate method of discounting accident benefits is required.

Figure 2.2 Accident prediction using a typical accident rate.



3. ROAD SAFETY PLANS AND PROGRAMMES USED IN NEW ZEALAND

3.1 National Road Safety Plan

The National Road Safety Plan (Officials' Committee on Road Safety 1991) established a framework for road safety and set both long and short term goals and targets for road safety in New Zealand. This plan has been endorsed by all central government departments and agencies.

The plan identifies themes for establishment of road safety programmes as follows:

- safer people,
- safer roads,
- safer vehicles,
- safer systems.

Within each theme, target areas have been selected for detailed attention and these have been set out in the National Road Safety Plan.

The long-term goal of the plan, targeted to the year 2001, is to achieve at least an equivalent level of road safety as the safest countries in the world (Norway, Sweden, USA). This goal requires annual road deaths to be reduced to approximately 350 in the year 2001 from the 600 deaths that occurred in 1993 – an annual reduction of slightly over 6%, and a similar percentage reduction in other road safety measures. The New Zealand Minister of Transport has requested the Officials' Committee on Road Safety and the Land Transport Safety Authority (LTSA) to review these targets and to propose how they can be achieved. This review will be included in an update of the plan currently under preparation.

Annual reports have been published on progress compared with the plan (Officials' Committee on Road Safety 1992, 1994). These list major initiatives that have been undertaken and the focus for the forthcoming year. No quantitative information is provided on the effect of the various programmes on accident reduction. However trends in the following road user behaviour measures are reported (Appendix 1):

- proportion of dead drivers with blood alcohol over the legal limit;
- driving speeds (urban and rural);
- seat belt use (front and back seats);
- child restraint use (front and back seats);
- bicycle helmet use.

3.2 Safety (Administration) Programme

The annual Safety (Administration) Programme (LTSA 1994), prepared by the LTSA for the Secretary for Transport under Section 28 of the Transit New Zealand Act 1989, detail road safety projects to be delivered by the New Zealand Police, the LTSA, and territorial local authorities within each local authority area. The programme covers:

- enforcement;
- safety education and information;
- community projects;
- administration of the land transport fund;
- safety regulation and monitoring.

The programme builds on the National Road Safety Plan and uses the same road safety targets and road user behaviour measures plus some additional measures. Police operational hours devoted to road safety under the Safety (Administration) Programme are shown in Table 3.1.

Table 3.1 Police hours allocated to road safety.

Year	Total Police Hours	Annual Change
1990-91	1,552,691[1]	
1991-92	1,553,250[1]	+0.04%
1992-93	1,618,550	+4.20%
1993-94	1,799,170	+11.16%
1994-95	1,770,680	−1.58%

[1] Includes 57,250 hours on heavy vehicle enforcement and 183,000 hours of New Zealand Police time not covered by the programme in these years.

The Safety (Administration) Programme does not cover all safety regulation and monitoring activities carried out by the LTSA. These activities are described in more detail in the Authority's business plan and have had a reasonably constant level of resource input over the period covered by Table 3.1.

3.3 National Land Transport Programme

Transit New Zealand is required by Section 29 of the Transit New Zealand Act 1989 to produce a National Land Transport Programme (NLTP) each year for approval by the Minister of Transport. This programme details expenditure for maintenance and construction (improvement) works on state highways and local roads, as well as expenditure on public transport. Safety works are shown as separate outputs. These are works where more than 50% of the benefits come from accident reduction. Transit New Zealand expenditure allocated to safety works is shown in Table 3.2. The total amount of expenditure on safety works on local roads is approximately double that shown in Table 3.2 because Transit New Zealand financial assistance to local authorities is on average 50%.

Safety maintenance expenditure shown in Table 3.2 is mostly to maintain driver guidance lines and markings and therefore is maintaining the current level of road safety rather than improving it. The table shows that a fairly constant level of road work has been aimed at maintaining or improving road safety since 1990. Before this, under the former National Roads Board (now Transit New Zealand), a lower level of construction work was aimed specifically at improving road safety.

Table 3.2 Transit New Zealand expenditure ($ million) on road safety works.

Year	Local roads maintenance[2]	Local roads minor projects[2]	Local roads construction[2]	State highways maintenance	State highways minor projects	State highways construction
1990-91	21.70	3.68	4.55	22.28	4.54	14.72
1991-92	22.31	3.54	6.58	20.87	4.07	25.82
1992-93	23.37	4.33	6.83	20.08	3.92	28.40
1993-94	23.79	4.48	6.02	20.23	4.00	50.52
1994-95[1]	25.30	4.60	7.40	20.40	4.00	54.60

[1] Transit New Zealand recommended programme.
[2] 50% financial assistance from Transit New Zealand to local authorities.

3.4 Effect of Programmes

Because of the large number of interacting activities that influence road safety (including changes in general attitudes in society), the effect of each activity cannot easily be quantified. Some activities can be evaluated by comparing locations that have been subject to the activity with control locations with similar characteristics that have not been subject to the activity. This evaluation can consist of "before and after" measurements at a single location or set of locations, or measurements at the same time at different locations with and without the activity.

Overseas literature documents different studies on the effectiveness of road safety activities, but care is needed in translating them to New Zealand situations. Some "before and after" studies have been conducted in New Zealand on road improvements such as lighting (Jackett 1993a), and reflective raised pavement markers (Beca et al. 1991). Studies are underway on the effectiveness of compulsory breath testing and speed cameras. The effectiveness of road improvements at accident blackspots is also being monitored on a "before and after" basis.

For 1993-94 Transit New Zealand has estimated that the construction expenditure shown in Table 3.2 will save 86 accidents (fatal or injury) on local roads and 60 such accidents on state highways. The estimated accident savings were calculated from the benefits claimed for safety construction works excluding minor projects. This calculation was used only in 1993-94 by Transit New Zealand and, because the actual accident savings achieved are difficult to determine for comparison with the estimated accident savings, it has not been used further.

The LTSA maintains a database for those Accident Investigation (AI) studies which follow the procedures in the Transit New Zealand/Land Transport 1991 manual "Accident Investigation Procedures". Accident Investigation studies are aimed to find low cost road improvements for accident blackspots, routes and areas. Some AI studies undertaken by Auckland, Wellington and Christchurch Cities have not been included in this database. Figures 3.1 to 3.4 show reported accidents at AI sites from the LTSA database.

For the analysis of AI sites, sites were grouped by the year in which road improvements were completed. For some sites road improvements occurred over several years, so, for each group of AI sites, the number of sites that had road improvement work started is shown for each year in Figures 3.1 to 3.4. For each group of AI sites, the number of accidents reported at these sites are shown divided by the number of accidents reported at all non-AI sites (AI/Others). The predicted accident situation if road improvements had not been made is shown as a dotted line and is based on the profile of accidents at non-AI sites and the AI/Other ratio applying before beginning the road improvements at the particular group of AI sites.

For each group of AI sites, the number and percent of accidents saved each year after completion of the road improvements are shown. Road improvements have reduced accidents at the AI sites by an average of approximately 30% after allowing for the general trend in accidents obtained from non-AI sites. At the end of 1993, 1014 fully implemented AI sites were recorded in the database. These accounted for an average of 1482 reported accidents per year before road improvements were made.

To the end of 1993, road improvements at AI sites recorded in the database have thus saved a total of 445 accidents per year (3.7% of all reported accidents). In addition, approximately another one-third as many accidents have been saved from AI road improvements that are not entered in the database. AI site road improvements have been carried out from 1987 (and from 1989 for local authority AI road improvements not in the database). Table 3.3 shows the number of sites with road improvement work completed each year and the estimated associated number of accidents saved per year.

Table 3.4 shows the estimated annual reduction in accidents from road improvements at AI sites plus accidents saved from construction works at other sites. The reduction in numbers of accidents saved from construction works in 1993 are the Transit New Zealand estimate and for years other than 1993 the numbers are rough estimates based on knowledge of the types of work undertaken in those years. Analysis of the AI sites in the database shows that 60% are in 50 km/h speed limit areas, 5% are in 70 km/h or Limited Speed Zone (LSZ) areas, and 35% are in open road speed limit areas (80+ km/h). Construction works at other sites have similar proportions within each speed limit category. Table 3.4 also shows the total accidents saved from all road improvements distributed by speed limit category.

Table 3.3 Number of accidents saved as a result of road improvements at Accident Investigation sites.

Year	No. of LTSA-recorded AI sites implemented in year	Estimated no. of accidents saved in year from LTSA recorded AI Sites	Estimated no. of accidents saved from additional local authority AI sites
1987	42	50	-
1988	135	80	-
1989	225	100	28
1990	172	65	30
1991	135	50	30
1992	150	50	30
1993	155	50	30
Total	**1014**	**445**	**148**

Table 3.4 Estimated reduction in accidents (number of accidents per year) from road improvements.

Year	AI sites	Construction sites	All road improvements	50 km/h areas	70 km/h and LSZ areas	80+ km/h areas
1981-85	-	75	75	45	4	26
1986	-	80	80	48	4	28
1987	50	50	100	60	5	35
1988	80	60	140	84	7	49
1989	128	70	198	119	10	69
1990	95	80	175	105	9	61
1991	80	100	180	108	9	63
1992	80	120	200	120	10	70
1993	80	146	226	136	11	79

Figure 3.1 Reported accidents at LTSA-recorded Accident Investigation sites with road improvements completed in 1988.

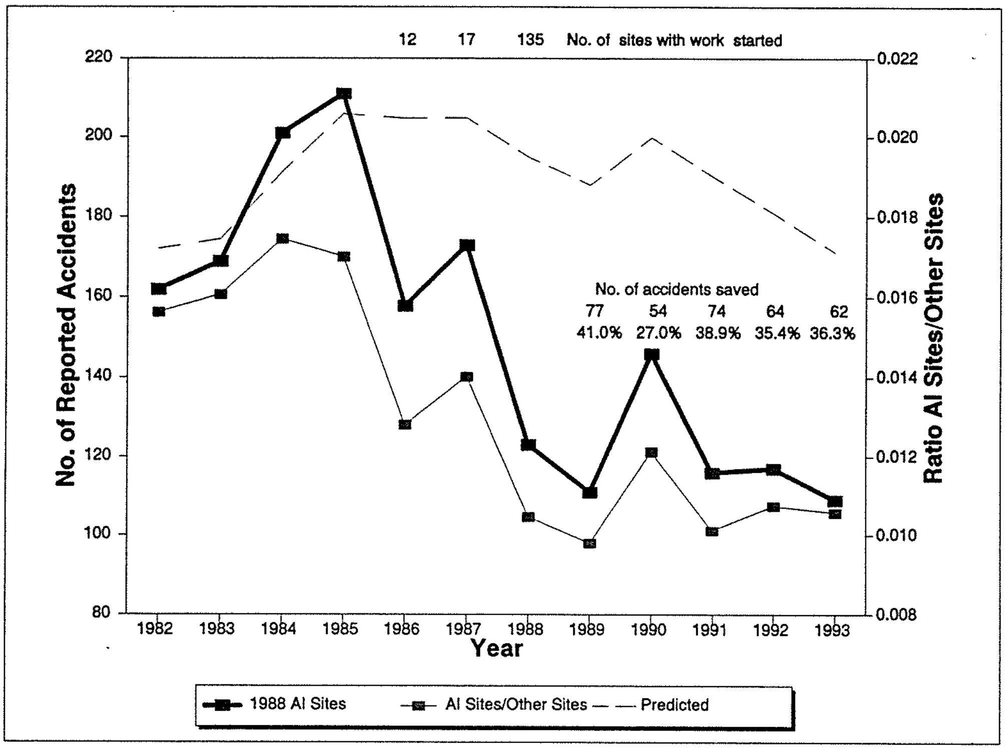


Figure 3.2 Reported accidents at LTSA-recorded Accident Investigation sites with road improvements completed in 1989.

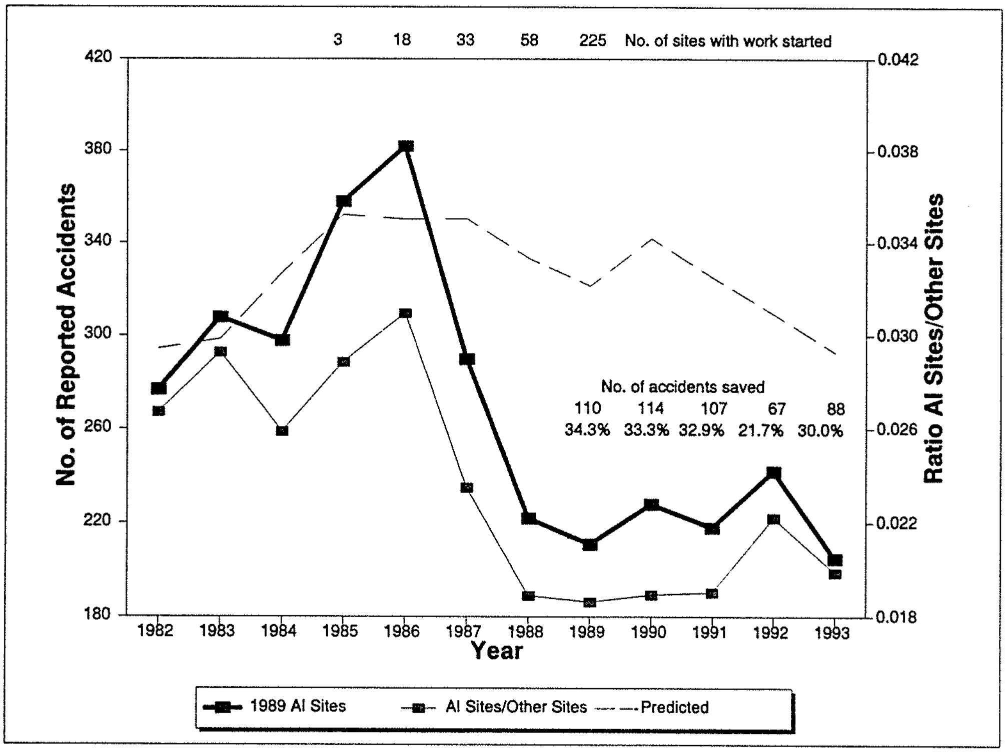


Figure 3.3 Reported accidents at LTSA-recorded Accident Investigation sites with road improvements completed in 1990.

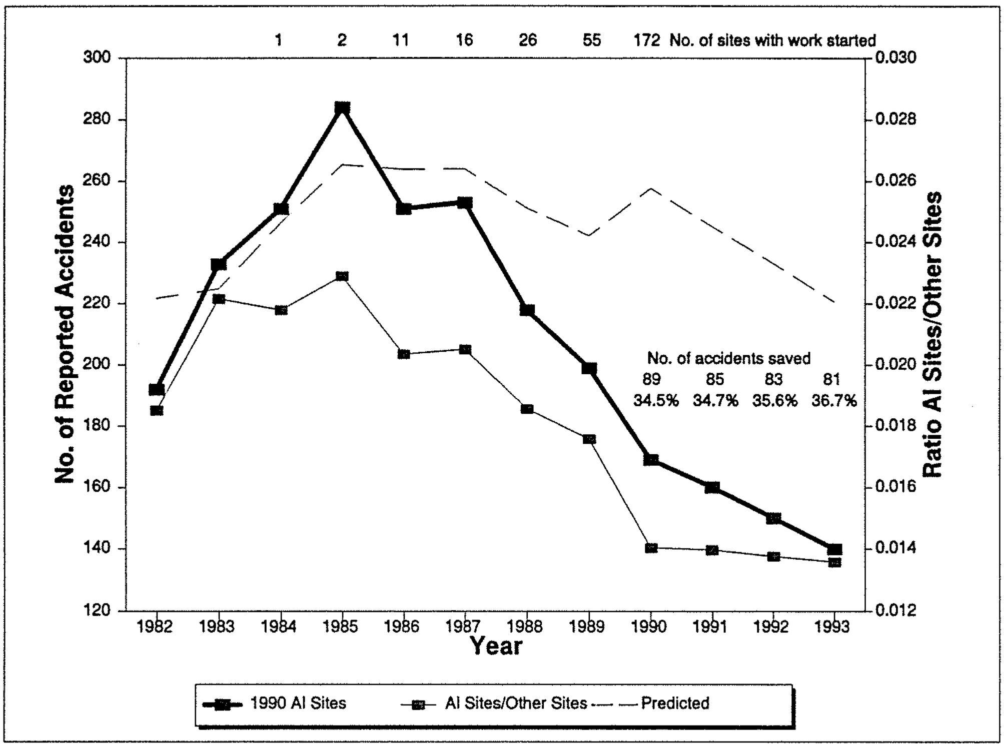
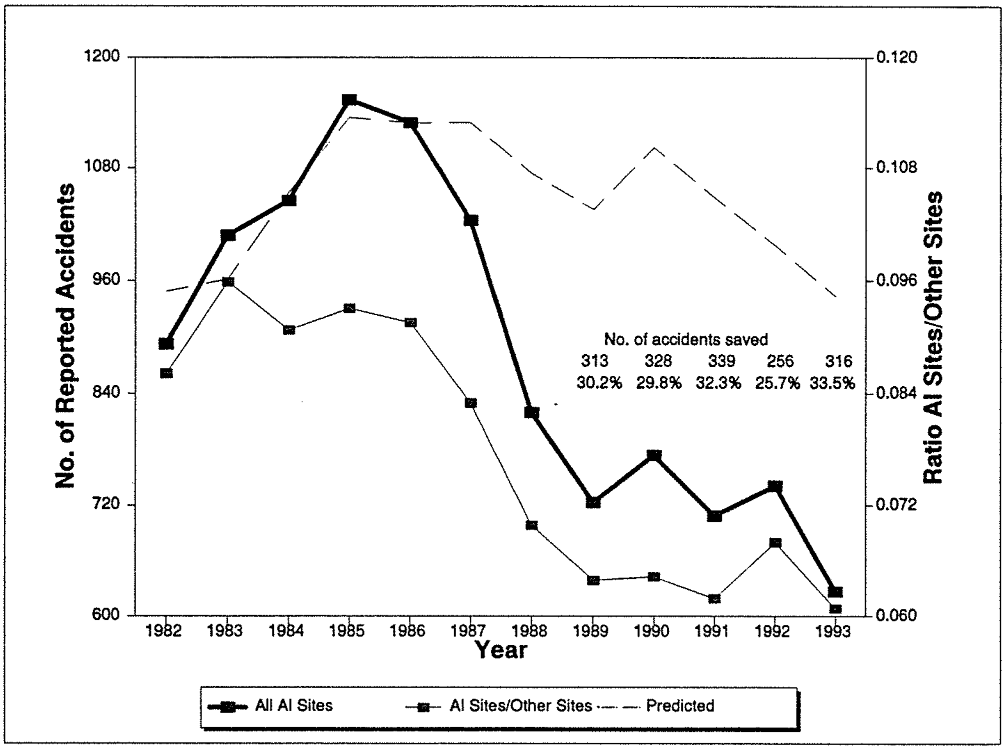


Figure 3.4 Reported accidents at all LTSA-recorded Accident Investigation sites with road improvements completed.



Legislation implemented to improve road safety is listed in Appendix 2. An estimate of the effect on fatalities of known road safety activities prepared for the LTSA in 1994 is given in Appendix 3. This estimate indicates that fatalities could reduce by 180, from the 1993 level of 600, by the year 2001 even after allowing for increased traffic growth. This is less than the target currently set in the National Road Safety Plan and is an accident reduction of approximately 4.5% per year. It is possible that additional programmes will be developed to give a reduction nearer to the National Road Safety Plan target of an annual accident reduction of slightly over 6% (see Section 3.1).

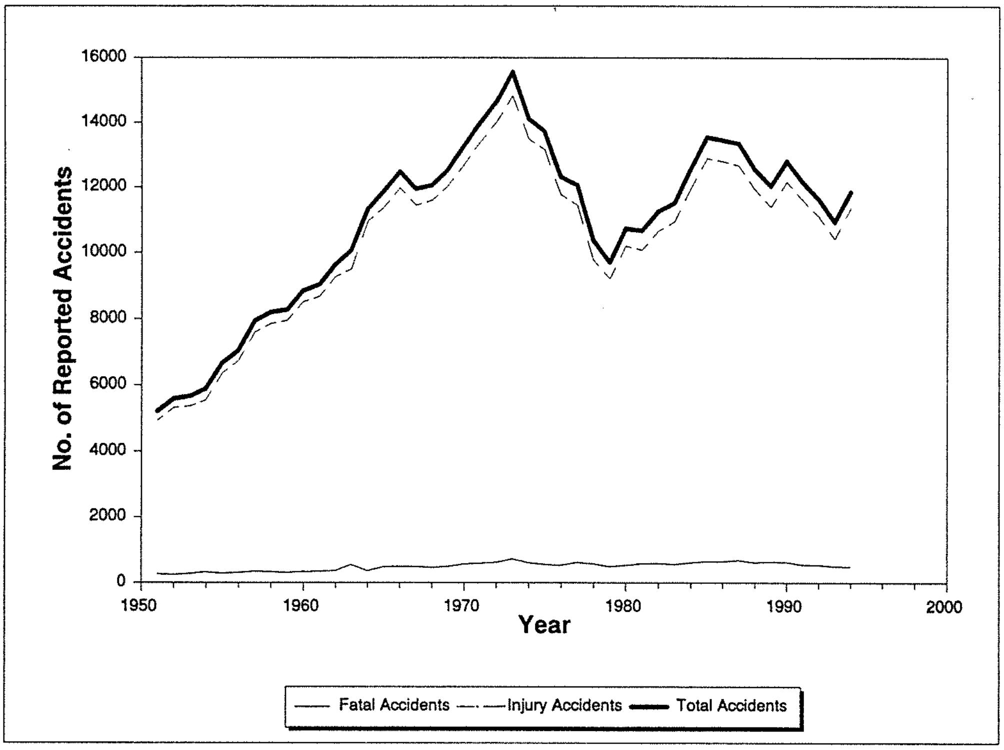
4. ACCIDENT TRENDS IN NEW ZEALAND

4.1 Past Trends and Traffic Volume Influences

Information from the LTSA's Traffic Accident System database and *Annual Statistical Statements on Motor Vehicle Accidents* (LTSA 1993) have been used to investigate past accident trends. A quantitative analysis approach rather than a statistical time series or regression approach has been used to analyse past accident trends and predict future trends. For most aspects of accident analysis the number of records in the Traffic Accident System database is insufficient for a time series analysis.

Figure 4.1 shows reported fatal plus injury accident numbers for each year since 1951. The figure shows a number of distinct trends. The number of accidents generally increased each year up to 1973, decreased each year from 1974 to 1979, increased again each year from 1980 to 1985, and have generally decreased each year from 1986 to 1994.

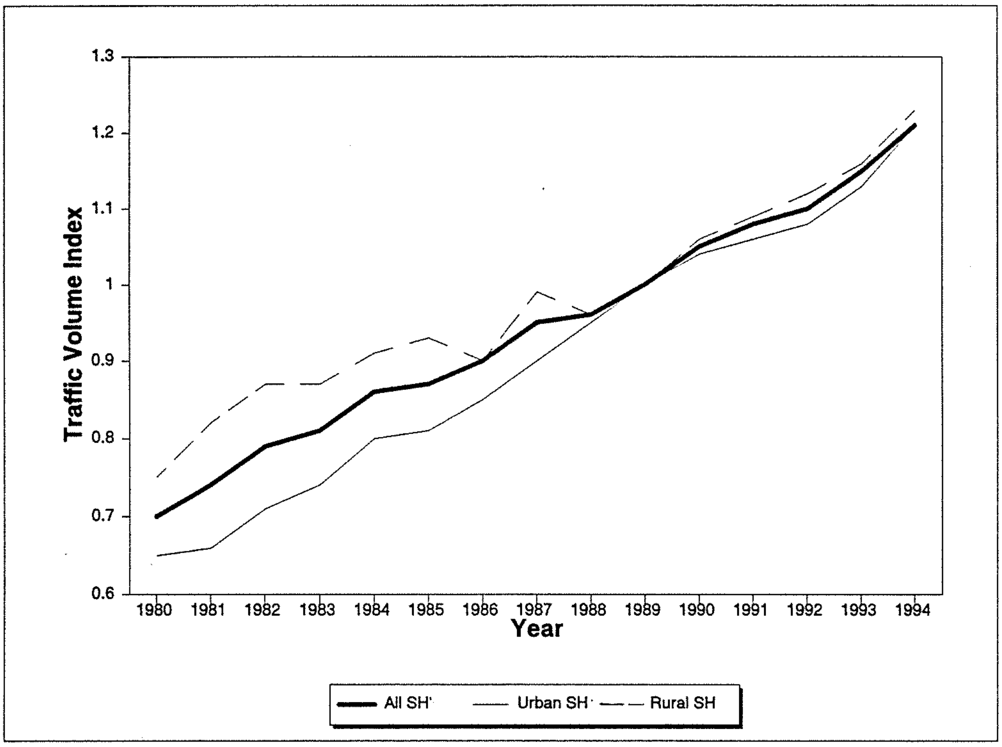
Figure 4.1 Numbers of fatal and injury accidents per year.



Trends in the period from 1980 to 1994 are of most relevance to evaluation of road improvements because data from within this period are used with the 1991 Transit New Zealand Project Evaluation Manual to determine accident savings resulting from road improvements.

As the number of accidents at a particular road site is taken as being proportional to traffic volumes (see Section 2.3), changes in traffic volumes will have a major influence on accident trends. The only reliable series of traffic volume measurements is that for the state highway traffic volume index, which is based on 50 representative count sites on the state highway system. The state highway traffic volume index is shown in Figure 4.2. The index[1] uses 1989 traffic volumes as a base.

Figure 4.2 State highway traffic volumes for 1980-94.



The publication *A Guide on Estimating AADT and Traffic Growth* (Transit New Zealand 1994) recommends that the calculation of traffic growth is based on the average annual change in traffic volume over a 5-year period expressed as a percentage of the volume for the latest year in the period, also that the average annual change in traffic volume should be determined by a linear fit to the annual traffic volumes. The linear fit should also be used to extrapolate traffic volumes. State highway traffic volume growth for 1994 determined by this approach is 3.24% from the urban index, 3.48% from the rural index, and 3.27% from the combined index.

The state highway traffic volume record is not necessarily representative of changes in traffic volumes on local roads. An estimate of traffic growth at June 1994 is included in the National Traffic Database commissioned by Transit New Zealand (Works Consultancy Services 1994). This database contains information about road type and traffic for every

[1] The device of indexing time series values to a particular date is used throughout this report. This consists of dividing all values in a particular time series by the value for that time series at the index date. The result is to bring different time series on to a common scale so that trends can be compared.

section of public road in New Zealand. This information has been used to give 1994 average traffic growth rates (weighted by road section length) for each road type in each local authority area and for state highways in each Transit New Zealand region. These traffic growth rates are summarised by local authority region in Table 4.1. The 1994 average traffic growth rate for all state highways from this analysis is 3.16%, and the average for all roads (including state highways) is 2.5%.

Table 4.1 1994 average traffic growth rates (%).

Transit New Zealand Region	Road Category					
	Urban Arterial	Urban Fringe	Urban Other	Rural Strategic	Rural Other	All Roads
Northland	2.86	-	2.41	1.79	2.35	2.28
Auckland	7.09	2.86	2.86	3.70	3.82	3.64
Waikato	3.52	3.27	2.52	3.53	2.42	2.69
Bay of Plenty	1.38	6.58	4.90	3.51	3.71	3.86
Gisborne	2.68	-	2.68	2.68	2.68	2.68
Hawke's Bay	2.47	2.80	2.26	2.93	3.38	3.13
Taranaki	1.68	-	0.28	0.29	–0.23	–0.07
Manawatu-Wanganui	2.00	-	1.60	2.30	1.88	1.86
Wellington	2.75	2.31	3.12	2.85	3.45	3.16
Nelson-Marlborough	3.14	2.51	2.20	2.76	2.17	2.25
Canterbury	2.63	8.78	2.73	2.32	2.67	2.71
West Coast	-	-	3.00	12.02	3.61	5.75
Otago	2.15	-	1.35	3.40	1.62	1.83
Southland	1.02	-	1.17	1.09	1.15	1.15
All Regions	**3.88**	**4.75**	**2.49**	**3.27**	**2.25**	**2.50**

The increases in traffic volumes identified above could have been expected to have resulted in a similar increase in the number of accidents. This did occur from 1980 to 1985, but from 1986 to 1994 a reduction in accidents has occurred while traffic volumes have continued to grow. This means that since 1986 accident reduction activities have not only cancelled out the effect of increased traffic volumes, but they have also reversed the trend. Figure 4.3 shows the total number of reported accidents (fatal plus injury) each year from 1980 to 1994. The dotted lines are linear fits for the years 1980 to 1985 and 1986 to 1994.

Based on the linear fit lines in Figure 4.3, the annual change in the total number of reported accidents for the period 1980 to 1985 was an increase of approximately 5%, and for 1986 to 1994 the annual change was a decrease of approximately 2% (Figure 4.4). The annual decrease for the latter period would have been nearer 5% if the fluctuations in 1990 and 1994 had not occurred.

Figure 4.3 Reported accidents and accidents adjusted for traffic growth for the period 1980-94.

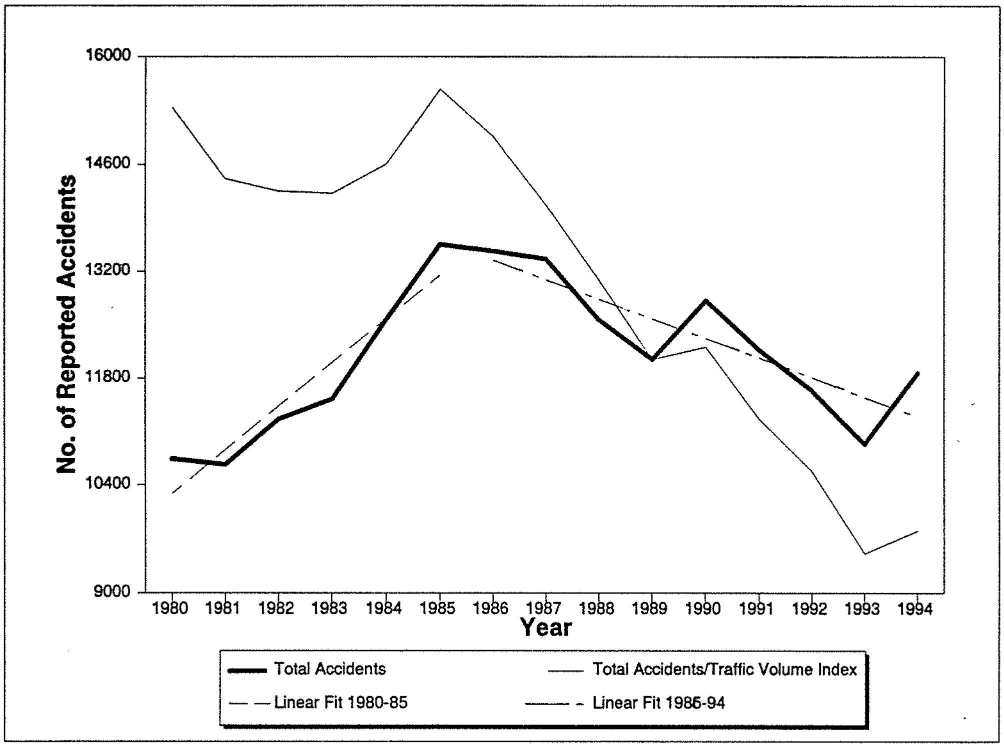
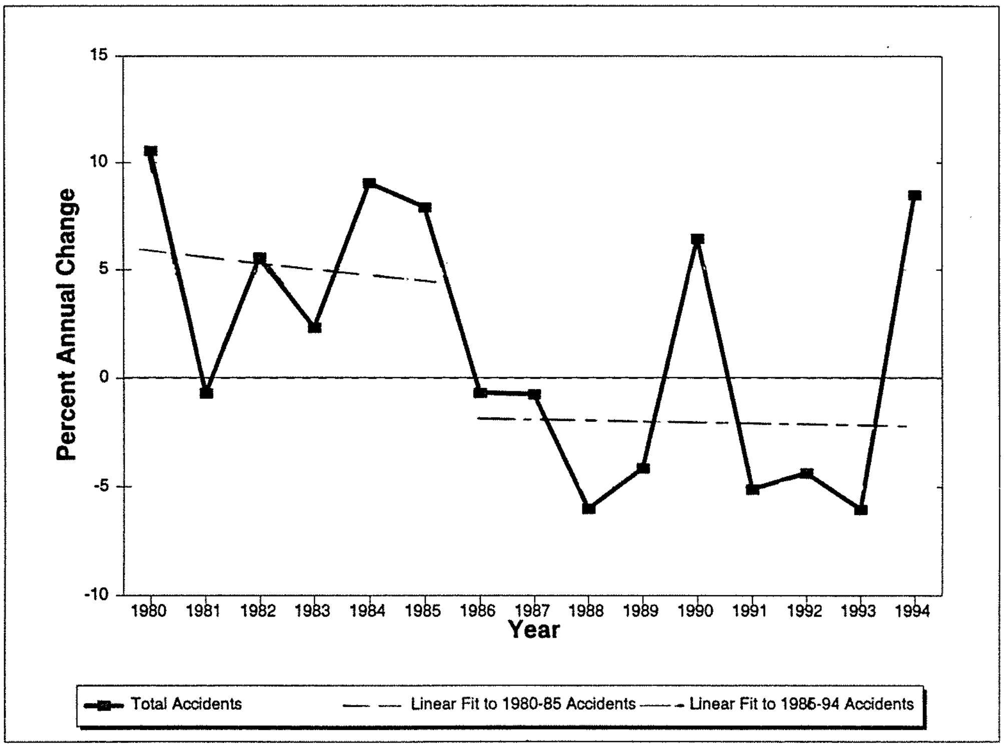


Figure 4.4 Percent annual change in number of reported accidents for the period 1980–94.

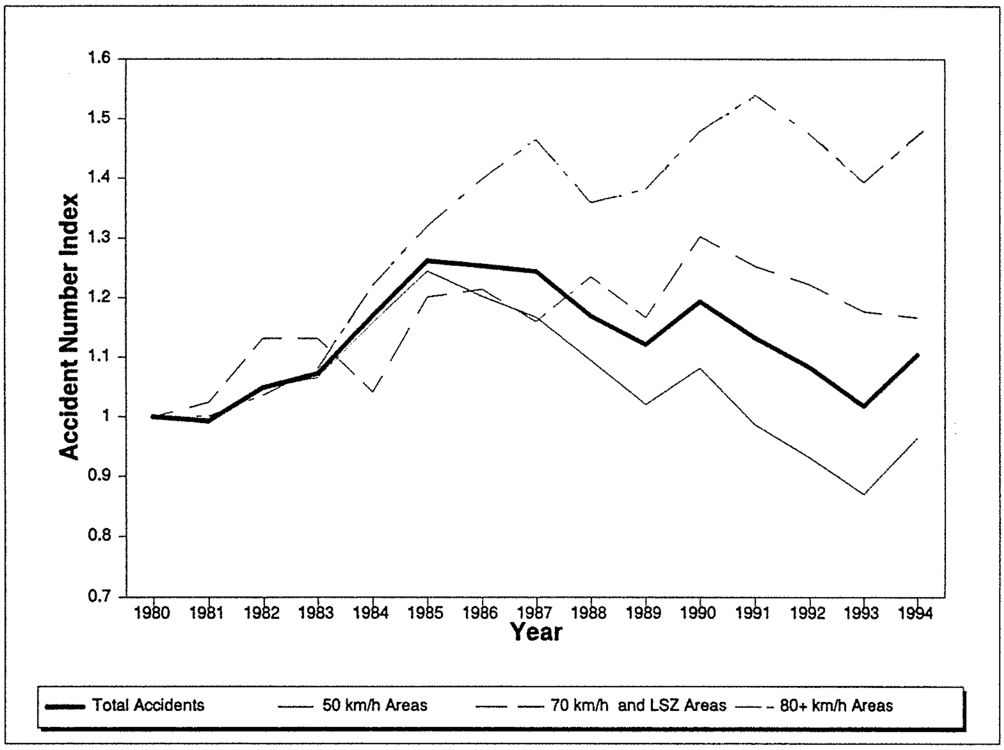


4.2 Type of Site

As accident analysis for project evaluation is always site-specific, accident trends should also be determined according to the type of site at which the accidents occurred. A first disaggregation of site type is by the posted speed limit. Figure 4.5 shows the number of reported fatal plus injury accidents disaggregated by the posted speed limit for the area in which the accident occurred, and indexed to 1980 values. This figure shows that for the period from 1980 to 1985, the trend in total accidents was similar for all posted speed limits. However since 1985 the indexed number of accidents in 50 km/h areas decreased at a rate greater than the national average, and accidents on the open road (includes 80 km/h areas) increased. In 1993, 60% of reported accidents occurred in 50 km/h areas, 5% in 70 km/h or LSZ areas, and 35% on the open road.

A further disaggregation of site type is by intersection versus mid-block. For this analysis intersection accidents are only those accidents coded as occurring at an intersection. Including accidents coded as occurring within 50 metres of an intersection did not significantly change the trends. Accidents occurring at intersections compared with those occurring on mid-block sections of road are shown in Figures 4.6 and 4.7 for 50 km/h areas and open road (80+ km/h) areas respectively.

Figure 4.5 Fatal plus injury accidents disaggregated by posted speed limit.



For 50 km/h areas, the indexed number of accidents shows the same trend for accidents occurring at intersections as that for accidents occurring on mid-block sections of road. (Approximately half of all accidents in 50 km/h areas occurred at intersections.) For open road (80+ km/h) speed limit areas, intersection accidents account for approximately 17% of all accidents and since 1981 have increased at a higher rate than other accidents.

Figure 4.6 Accidents disaggregated as occurring at intersections and mid-block sections of roads with 50 km/h speed limits.

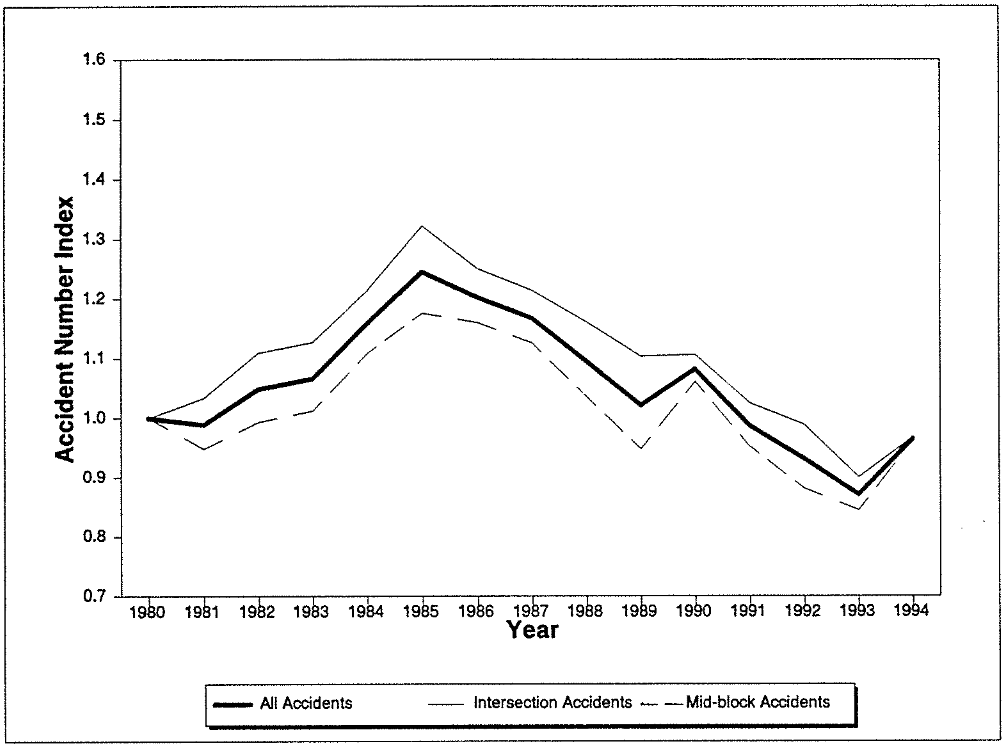
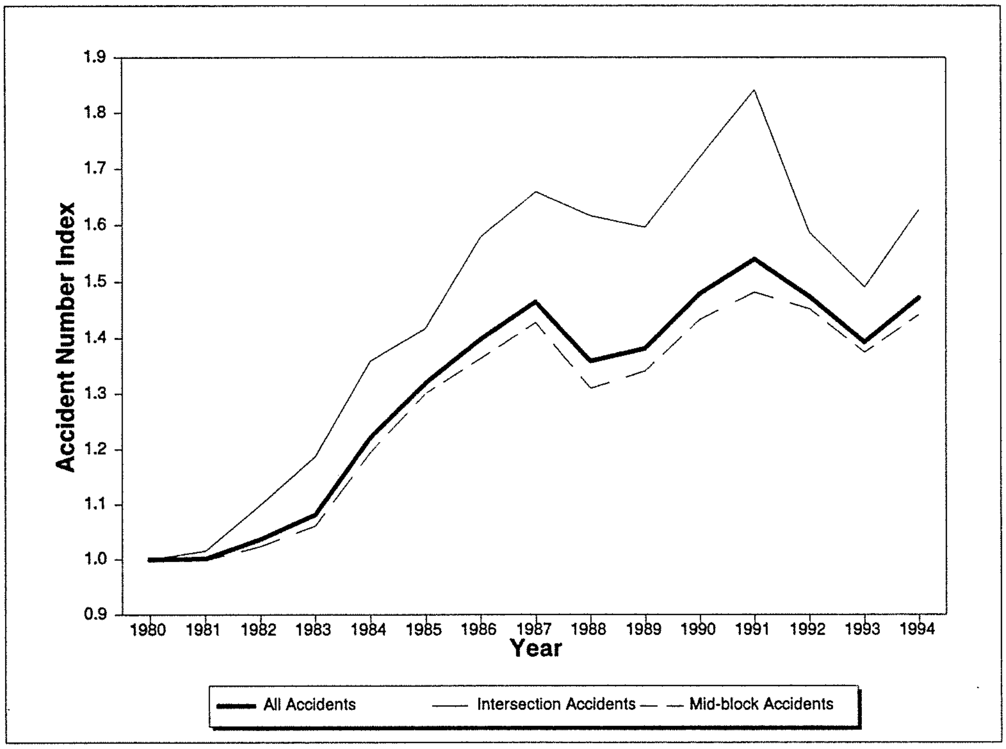


Figure 4.7 Accidents dissaggregated as occurring at intersections and mid-block sections of roads with open road (80+ km/h) speed limits.



4.3 Type of Vehicle Movement

The type of vehicle movement involved in an accident is important for accident-by-accident analysis at a site. The number of reported fatal plus injury accidents disaggregated by the type of vehicle movement and indexed to 1980 values are shown in Figures 4.8a and 4.8b. This shows that a larger than average reduction has occurred in overtaking accidents, accidents involving hitting an object, and accidents involving a pedestrian. Rear-end-crossing movements and crossing-turning movements increased more than average in the period up to 1985.

Accident trends by type of vehicle movement are given for 50 km/h speed limit areas in Figures 4.9a and 4.9b, and for open road (80+ km/h) speed limit areas in Figures 4.10a and 4.10b.

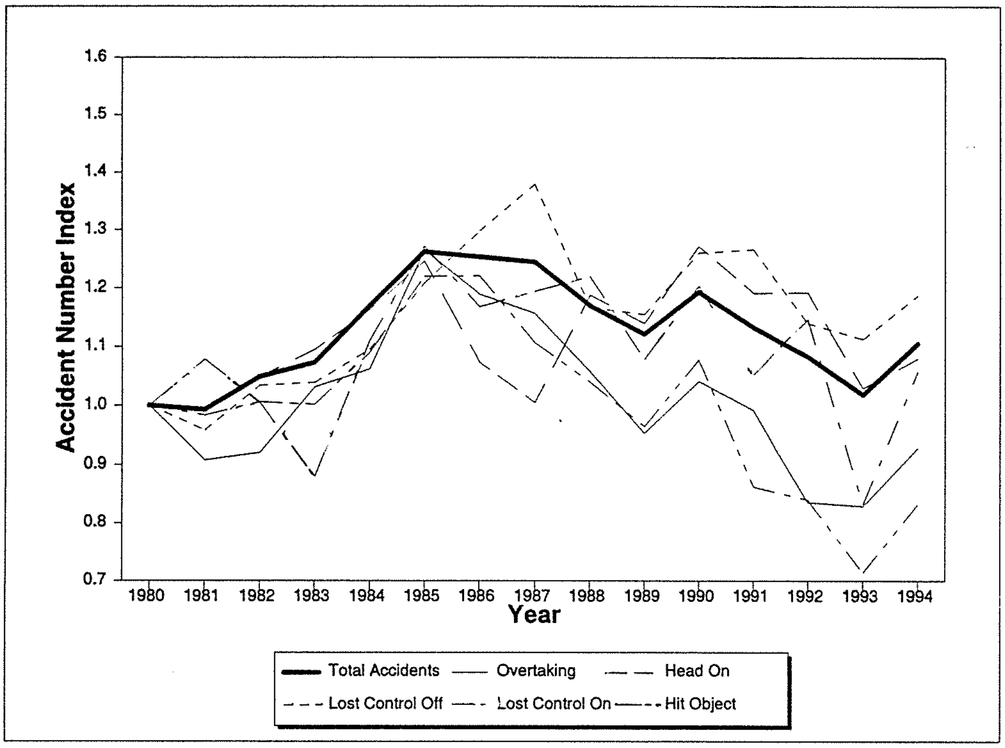
The numbers and percent of accidents for each type of vehicle movement for 1993 are shown in Table 4.2.

Table 4.2 1993 accidents disaggregated by type of vehicle movement.

Type of Vehicle Movement	Number of Accidents	%
Overtaking	403	3.7
Head On	931	8.5
Lost Control Off Road	3,193	29.2
Lost Control On Road	159	1.5
Hit Object	478	4.4
Rear End Slow Vehicle	404	3.7
Rear End Crossing	373	3.4
Rear End Queuing	508	4.6
Crossing Direct	908	8.3
Crossing Turning	2,542	23.2
Pedestrian	931	8.5
Miscellaneous	105	1.0
Total	**10,935**	**100.0**

Figure 4.8 Fatal plus injury accidents disaggregated by type of vehicle movement.

a. Overtaking, Head on, Lost control off road, Lost control on road, Hit object



b. Rear end; Rear end slow vehicle; Rear end crossing; Crossing direct; Crossing turning; Pedestrian

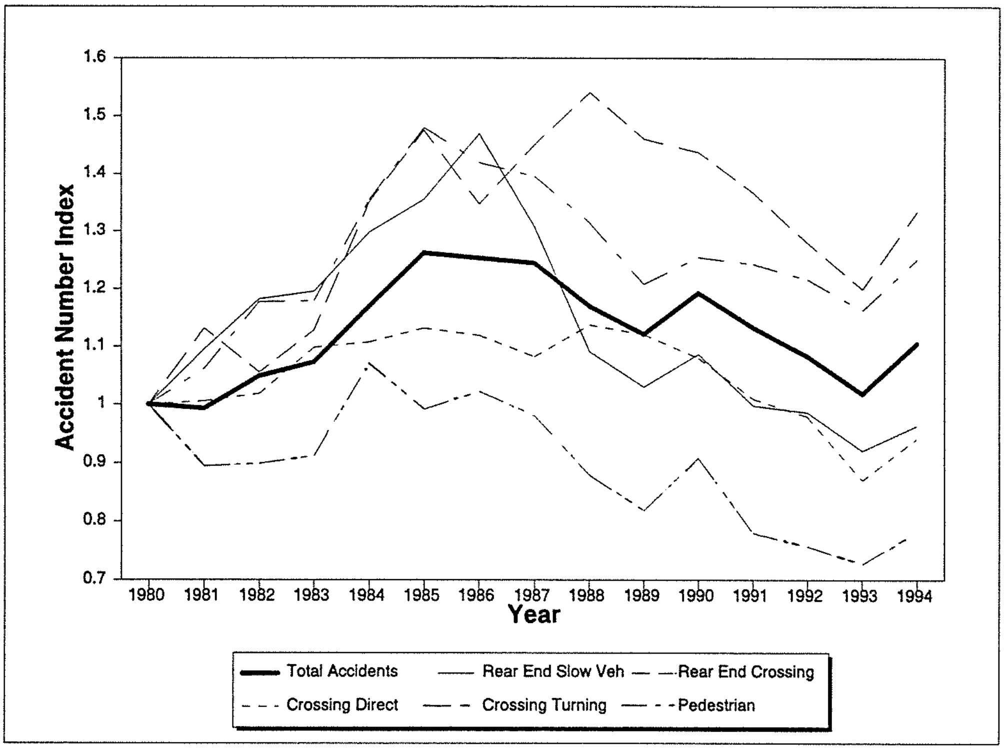
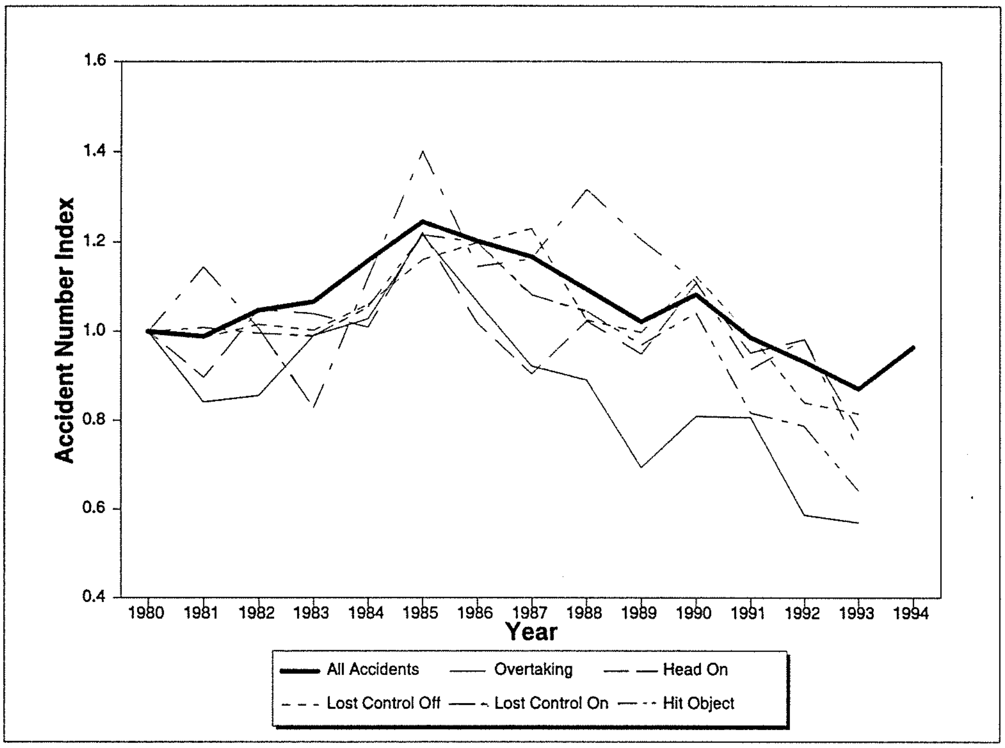


Figure 4.9 Accidents in 50 km/h speed limit areas disaggregated by type of vehicle movement.

a. Overtaking, Head on, Lost control off road, Lost control on road, Hit object



b. Rear end; Rear end slow vehicle; Rear end crossing; Crossing direct; Crossing turning; Pedestrian

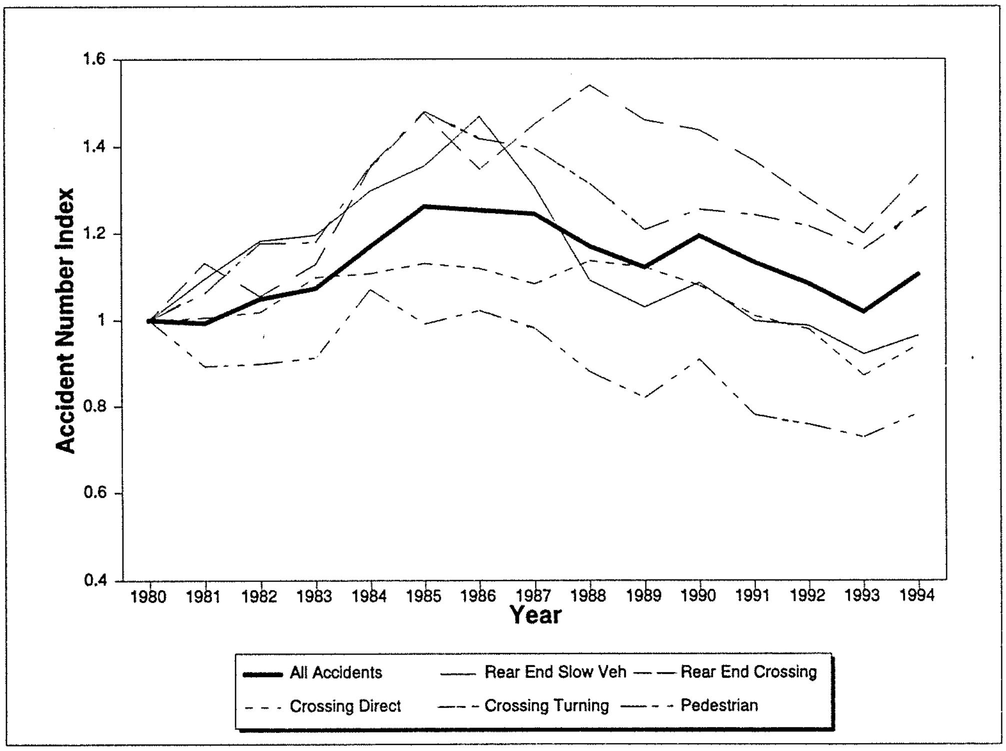
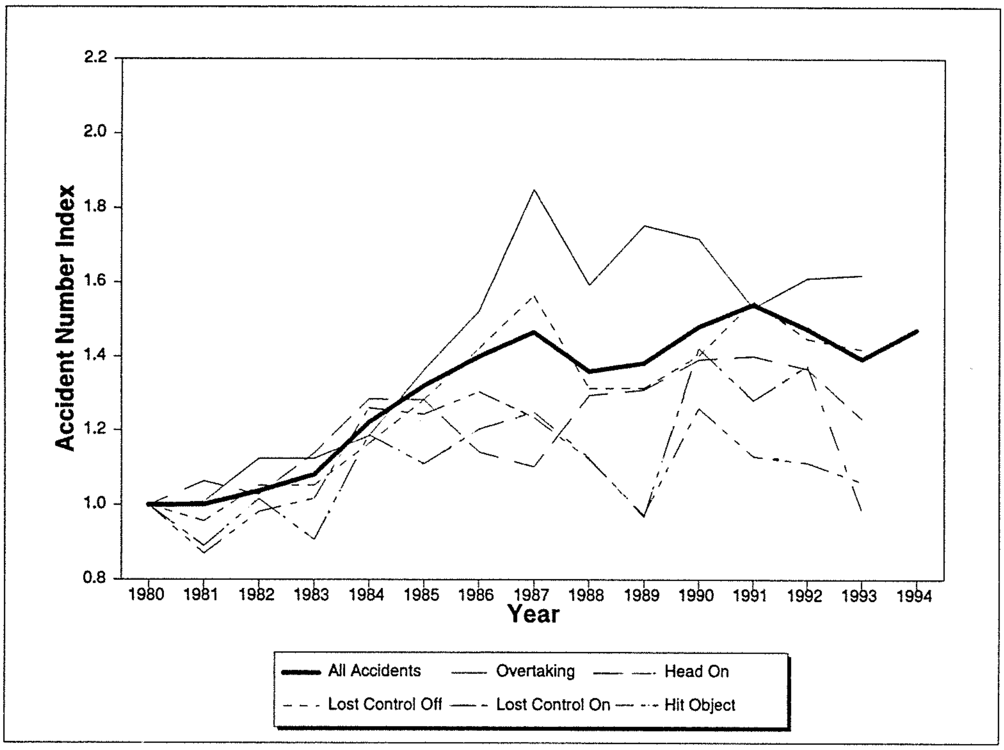
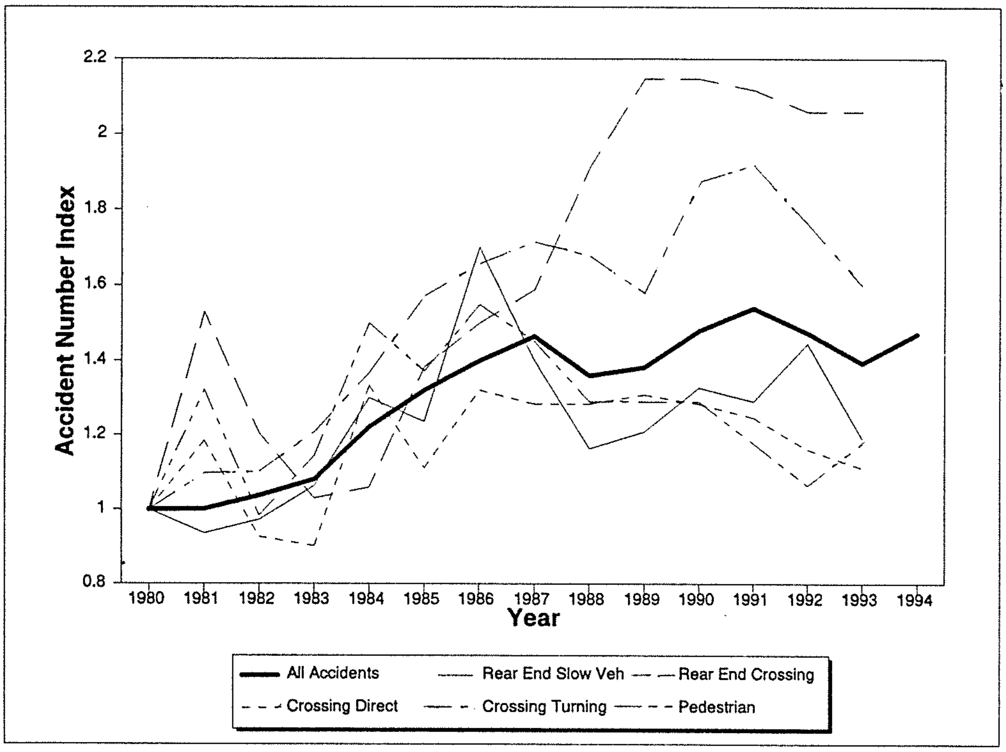


Figure 4.10 Accidents in open road (80+ km/h) speed limit areas disaggregated by type of vehicle movement.

a. Overtaking, Head on, Lost control off road, Lost control on road, Hit object



b. Rear end; Rear end slow vehicle; Rear end crossing; Crossing direct; Crossing turning; Pedestrian



4.4 Type of Vehicle

Vehicle types involved in accidents can be identified as: truck; bus; car; van; motorcycle; and bicycle. The involvement of a pedestrian in an accident is also coded on the accident record as a type of vehicle. Accident involvement of the various vehicle types is shown in Figures 4.11, 4.12 and 4.13. (Note that, in any one accident, more than one vehicle type may be involved.)

In 50 km/h speed limit areas (Figure 4.12), accidents involving pedestrians decreased and bicycle accidents increased more than the average trend between 1980 and 1982, but since then have followed the general trend. The type of vehicle that stands out as being significantly different is motorcycles. Accidents with this type of vehicle followed the general trend until 1985 and then reduced at a very steep rate.

For open road (80+ km/h speed limit) areas, involvement of truck/bus and car/van vehicle types have followed the general trend (Figure 4.13). In fact the car/van type dictates the trend because these are by far the predominant vehicle type involved in accidents. The annual number of accidents involving pedestrians and the annual number involving bicycles have fluctuated widely. These vehicle types are however a relatively small percentage (1.4% and 1.0% respectively) of open road accidents. Again the trend that stands out is that for motorcycles, which have been involved in significantly fewer accidents since 1987.

Figure 4.11 Involvement of vehicles and pedestrians in all accidents.

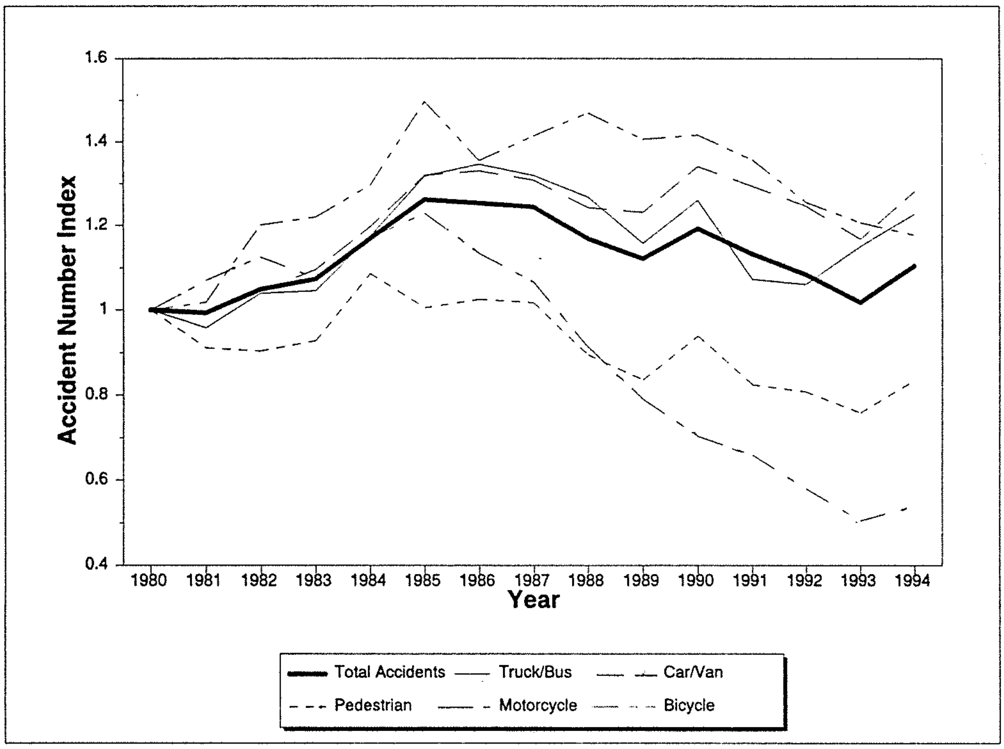


Figure 4.12 Involvement of vehicles and pedestrians in accidents in 50 km/h speed limit areas.

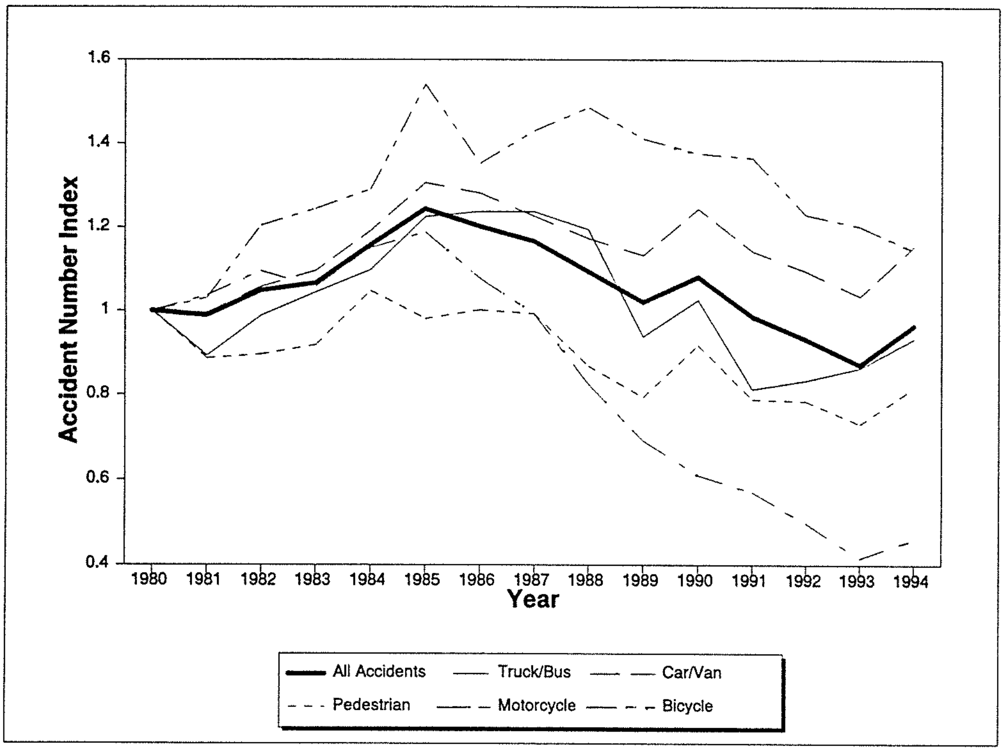
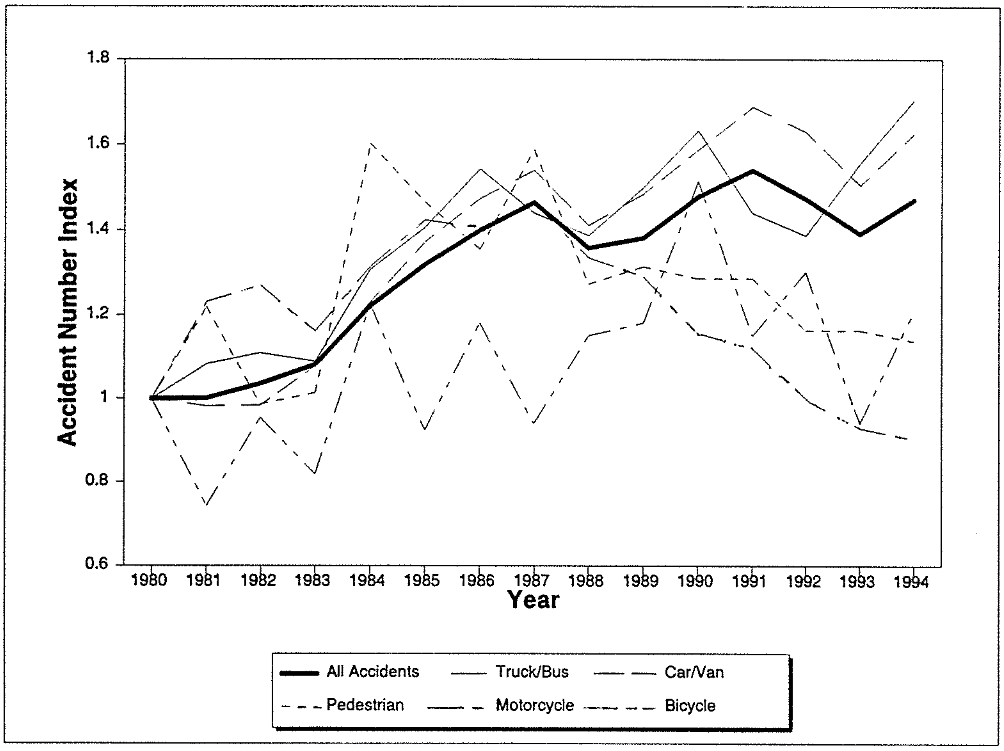


Figure 4.13 Involvement of vehicles and pedestrians in accidents in open road (80+ km/h speed limit) areas.

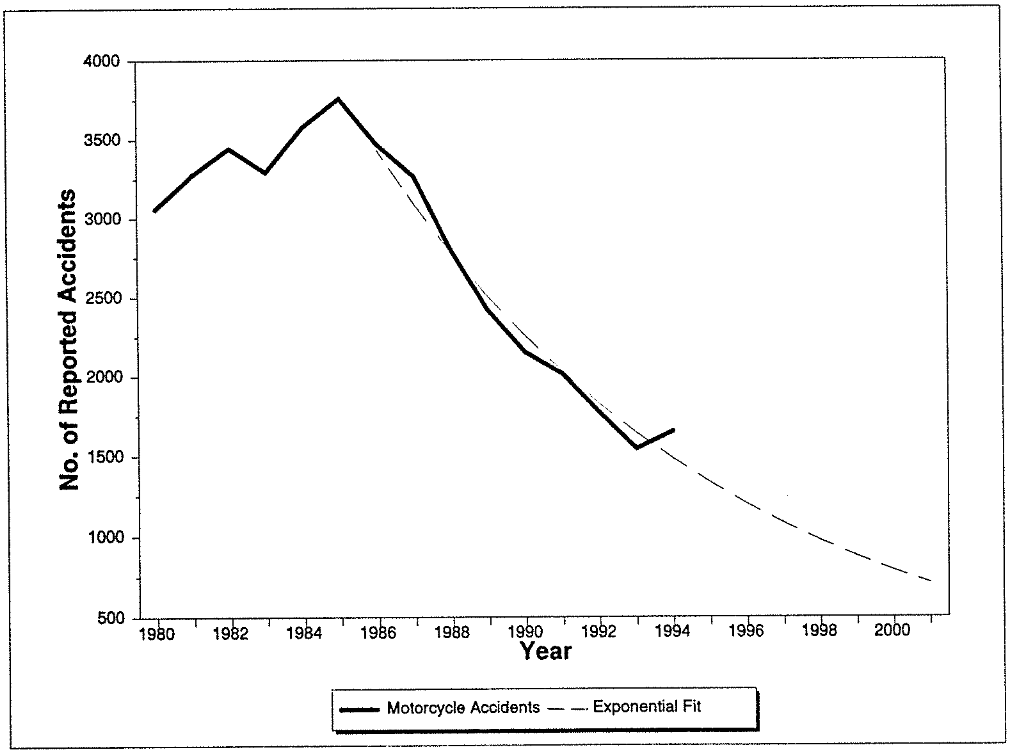


Overall, motorcycle accidents have decreased at an average rate of 10.5% per year since 1985 (Figure 4.14). This reduction has had a major effect on the overall trend in accidents. In 1985 motorcycles were involved in 15.2% of all accidents and by 1993 this had dropped to 7.8%. This trend is likely to continue unless there is a marked change in the relative cost of owning motorcycles and cars. However the rate of decrease is likely to flatten as the number of reported motorcycle accidents approaches zero. An exponential fit as shown in Figure 4.14 has therefore been used to extrapolate the trend in motorcycle accidents. The proportion of vehicle types involved in accidents for 1993 is shown in Table 4.3.

Table 4.3 Vehicle and pedestrian involvement in road accidents in 1993.

Vehicle Type	Number of Vehicles	%
Truck/Bus	969	4.9
Car/Van	15,344	77.5
Pedestrian	1,021	5.1
Motorcycle	1,544	7.8
Bicycle	921	4.7
Total	**19,799**	**100.0**

Figure 4.14 Trend in motorcycle accidents.



4.5 Prediction of Future Trends

To correctly determine the "do minimum" situation at a road site, an assessment of the accident situation in the future needs to be made, at least at the point in time when the improvement project would be undertaken, so that general changes in accidents are allowed for.

Past trends show that the accident numbers for future years are inherently difficult to predict with any accuracy. Forward programmes identified in Section 3 of this report should produce a continued downward trend in accident numbers at least until the year 2001, although traffic volumes, and hence traffic exposure, are likely to continue to increase over this period.

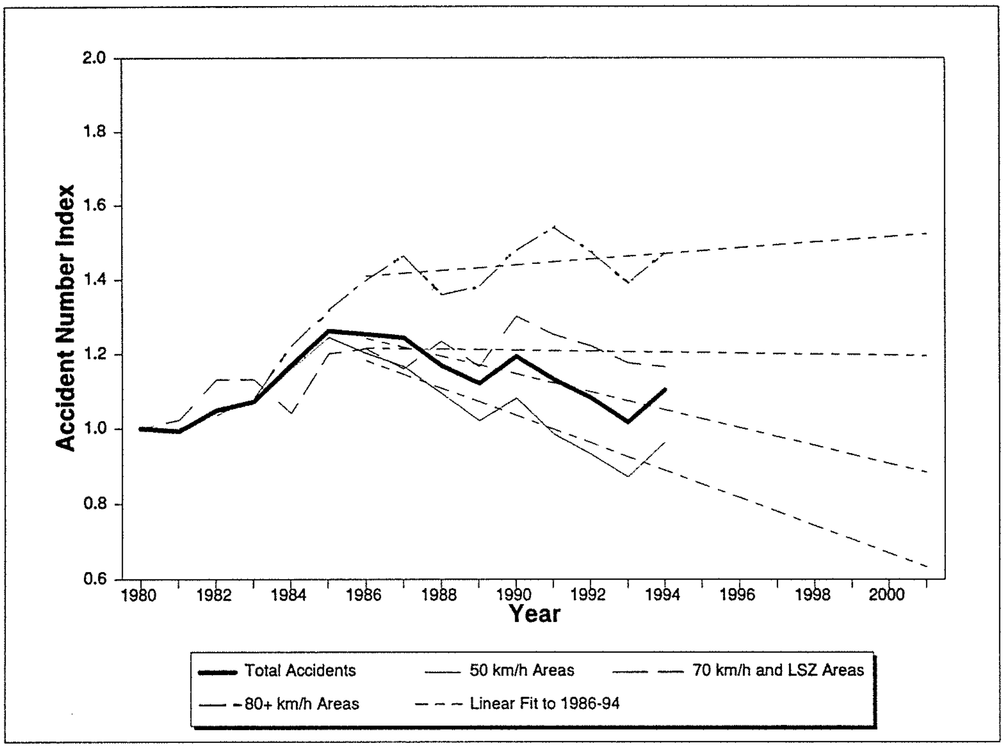
Other researchers have investigated the use of macroscopic models to predict road safety trends (e.g. Beca et al. 1995, Scott et al. 1987), but these have proved to be of little use in predicting trends in the short term.

One approach to predicting future accident numbers is to take the trend from the most recent (say 5-year) period as the best indicator of what is likely to happen in the short term future. This approach can give markedly wrong answers if there are significant changes in the programmes affecting road safety, major changes in the economy, or changes in other measures that affect road safety, as is evident from looking at past trends in the number of reported accidents (Figure 4.1). The 5-year trends immediately before 1973, 1979 and 1985 are not good predictors of accident numbers in the following years.

Notwithstanding the difficulties identified above, extrapolation of accident trends from the major turning point of 1986 is considered to be realistic given the improved road safety management structures and focus that have been put in place since then (e.g. formation of Transit New Zealand, introduction of the Safety Administration Programme and the National Land Transport Programme, introduction of the National Road Safety Plan, and the formation of the LTSA), and the accident reduction targets that were established in 1991. Such extrapolations are shown in Figure 4.15 for the three speed limit areas.

The linear fit for all accidents gives an annual reduction in accidents of 2.3%, which is significantly below the 6% per annum reduction required to achieve the accident reductions targeted for the year 2001, and the annual reduction of 4.5% which presently known road safety programmes should achieve.

Figure 4.15 Extrapolation of road accident trends to the year 2001 for the three speed limit areas.



5. QUANTIFYING DOUBLE COUNTING OF ACCIDENTS

5.1 Typical Accident Rates

Typical accident rates are given in Transit New Zealand Project Evaluation Manual for:

- urban intersections;
- urban arterials and collectors (mid-block);
- 100 km/h roads (mid-block);
- 100 km/h roads (curves).

These typical accident rates are used in accident rate analysis to compare with the past accident rate for a site and hence to calculate the accident reduction. The typical rates are also used in accident-by-accident analysis as a check on the degree of change in accident numbers that may be attributed to a change in traffic volume.

Typical urban intersection accident rates are based on an analysis of reported accidents for the 5-year period 1987-91 and traffic volumes from computer-based traffic models calibrated to 1986 traffic counts but adjusted to 1989 values (Gabites Porter 1990). The typical urban intersection accident rate is given as:

Accidents per year = a X^2,
where X is the annual traffic volume in millions of vehicles.

The typical mid-block accident rates for urban arterials and collectors are based on an analysis of reported accidents at a selection of typical road sections throughout the country (Jackett 1993b), using accidents for the period 1987-91. For this analysis the traffic volumes used were those applicable to the mid-point of the analysis period, i.e. 1989 (M. Jackett pers. comm. 1994). The mid-block accident rates for 100 km/h roads were obtained from reported accidents for the period 1985-89 with 1988 traffic volumes. Typical mid-block accident rates are given as:

Accident per year per kilometre = a X,
where X is the annual traffic volume in hundred million vehicles.

5.2 Adjustment for Traffic Exposure

The number of accidents from a typical accident rate formula can be taken as correct at the mid-point of the accident record used in determining the rates (accident base year) and for traffic volumes as at the year used in the analysis (traffic volume base year). However typical accident rate formulae are currently used in project evaluation with more recent traffic volumes to give a prediction of likely accidents at a site after some road improvements have been made. Because traffic volumes have significantly increased since the traffic volume base year and are predicted to continue to increase, but accidents have decreased and are predicted to continue to decrease, the use of current or future traffic volumes in the accident rate formulae will give an over-estimate of the likely number of accidents.

To correct for the different dates involved, first the traffic volume to be used in the project evaluation should be scaled back to the value applicable to the traffic volume base year for use in the formula. This can be achieved simply by changing the constant in the formula so that future traffic volumes can be used, as follows:

If $X_{future} = b\ X_{base}$,

then

Intersection accidents per year = $(a/b^2)\ X_{future}^2$, and

Mid-block accidents per year = $(a/b)\ X_{future}$.

Factor "b" is determined from changes in traffic volumes between the traffic volume base date and the date at which accident analysis is done. Traffic volume adjustment factors, based on a linear annual change in traffic volume calculated as 2.5% in 1994, are given in Table 5.1 for a range of base and future years.

Table 5.1 Adjustment factors for national average traffic volume increases.

Traffic Volume Base Year	Future Year			
	1995	**1996**	**1997**	**1998**
1986	1.28	1.31	1.34	1.38
1987	1.24	1.27	1.30	1.33
1988	1.21	1.24	1.26	1.29
1989	1.17	1.20	1.23	1.26
1990	1.14	1.17	1.19	1.22
1991	1.11	1.14	1.16	1.19
1992	1.08	1.11	1.13	1.16
1993	1.05	1.08	1.10	1.13
1994	1.03	1.05	1.08	1.10

5.3 Adjustment for Accident Trends

Accident-by-accident analysis involves identifying accidents that are likely to be reduced by a proposed road improvement. Current procedures use the average of the most recent five calendar years of accident history to determine the "do minimum" accident occurrence for the site. Accidents from this record are then reviewed to identify those that could be reduced. When there is a significant general downward trend in accidents, exclusive of road improvements, the number of accidents occurring at the site at the time of the road improvement will be somewhat less than the past average (3 – 4% per 1% per year of general downward trend). This should be allowed for before deciding the proportion of accidents that can be reduced, otherwise it is likely that the expected reduction will be overly optimistic.

Similarly for accident rate analysis, typical accident rates, determined from the average of five calendar years of accident history, should be adjusted for the general trend in accidents before being applied to a road site under investigation for improvement. A typical accident rate (or average accident rate) for a certain type of site can be taken as correct at the mid-point of the period used to determine the rate. The typical accident rate then needs to be projected forward allowing for the general trend in accidents (exclusive of road improvements).

One possibility for the forward projection (analysis year for accidents) is to use the third year after the road improvements are completed. This is the mid-point of a 5-year "after" period which would be used for any analysis of effectiveness. For calculation of accident reduction benefits it would also be necessary to determine the accident rate or number of accidents at "time zero" as defined in the Project Evaluation Manual. To keep calculation as simple as possible, it is best to do the accident analysis at "time zero".

The general trend in accidents for use in predicting the "do minimum" situation can be obtained from the trends shown in Figure 4.15 adjusted for the contribution to accident reduction made by the road improvements given in Table 3.4. Figure 5.1 shows the adjusted accident trends. Annual accident savings from Table 3.4 are added cumulatively to the accident numbers in Figure 4.15 to produce Figure 5.1.

Because accidents are usually analysed in 5-year periods, adjustment factors for general accident trends can be calculated by comparing 5-year averages of reported and extrapolated accidents.

From Section 4 it is clear that corrections for past accident trends should be specific to the type of site characterised by the posted speed limit, because of the significantly different trends between urban and rural areas. Further disaggregation into intersection and mid-block is not necessary because both sets of accidents follow the general trend for each speed limit category.

Figure 5.1 Accident trends adjusted to exclude the contribution from road improvements.

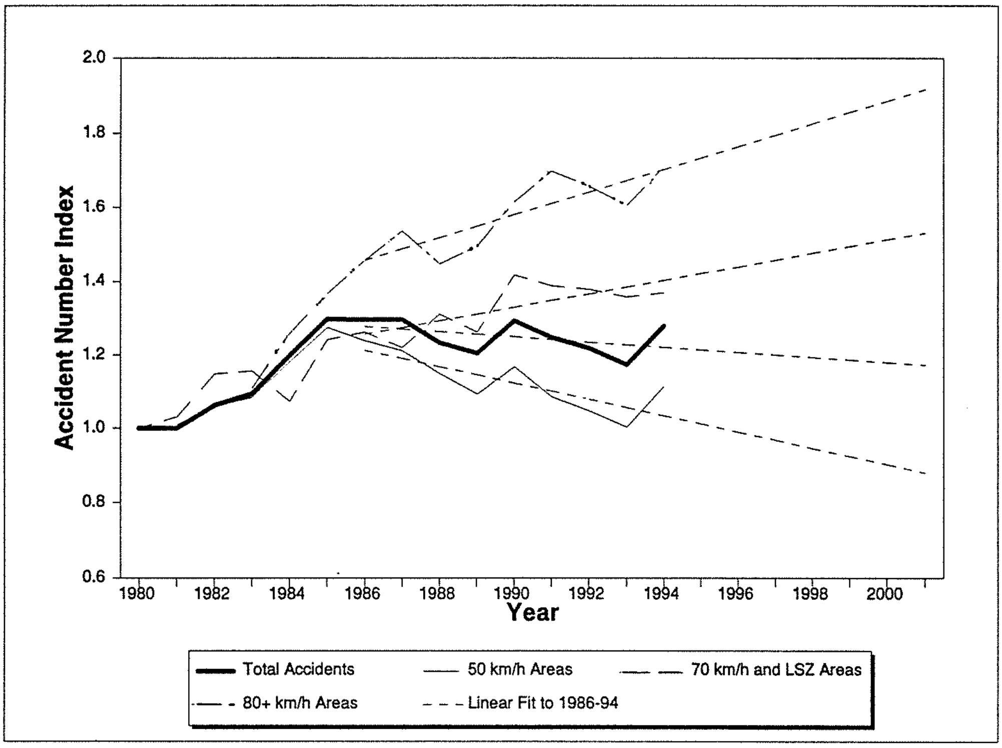
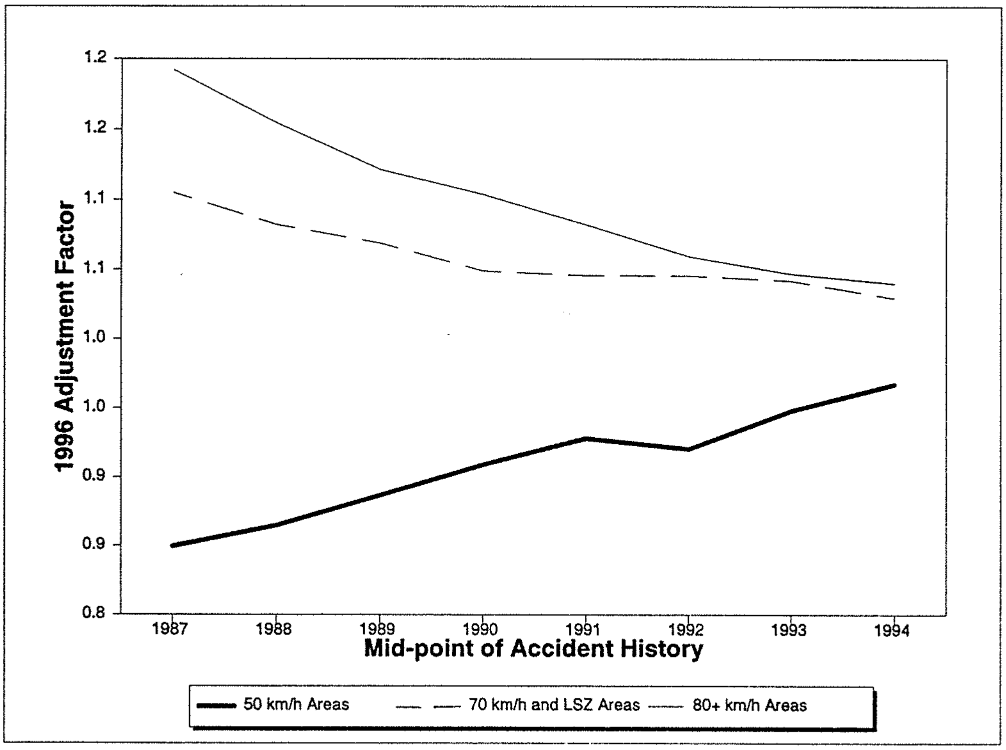


Figure 5.2 1996 national average accident trend adjustment factors for the three posted speed limit categories (all vehicle types combined).



Factors to adjust past accident numbers and accident rates to 1996 values are shown in Figure 5.2 for the posted speed limit categories used in the Project Evaluation Manual. These factors exclude the effect of road improvements, but include the effect of traffic growth. They are national average accident trend adjustment factors. Figure 5.2 shows that the factors for 70 km/h and LSZ areas are essentially the same as for the open road (80+ km/h speed limit) areas.

Figures 4.9a and 4.9b and 4.10a and 4.10b indicate that some of the vehicle movement types have different trends. Because of these different trends, different adjustments for accident trends could be made to each of the movement categories recorded at a site. However the more significant movement categories of "lost control off road" and "crossing turning" have, in general, followed the average trend. Different adjustments for movement categories will therefore only produce a moderate redistribution of accidents between the categories recorded at a site. Considering the assumptions that have to be made in determining the adjustments, this could give a spurious accuracy and is not recommended.

It is clear from Figures 4.12 and 4.13 that the trend in motorcycle accidents is for a much greater reduction than for accidents in general, but that the trend in accidents for other vehicle types and for pedestrians follow the general trend. A separate adjustment could therefore be made to any motorcycle accidents recorded at a site. National average accident trend adjustment factors for urban (50 km/h speed limit) areas and rural (70+ km/h speed limit and LSZ) areas disaggregated into "motorcycles" and "other vehicles" are given in Appendix 4 (Tables A4.1 to A4.3). These accident trend adjustment factors are applicable to accident information where traffic growth is equal to the national average or is unknown, e.g. for adjusting typical accident rates.

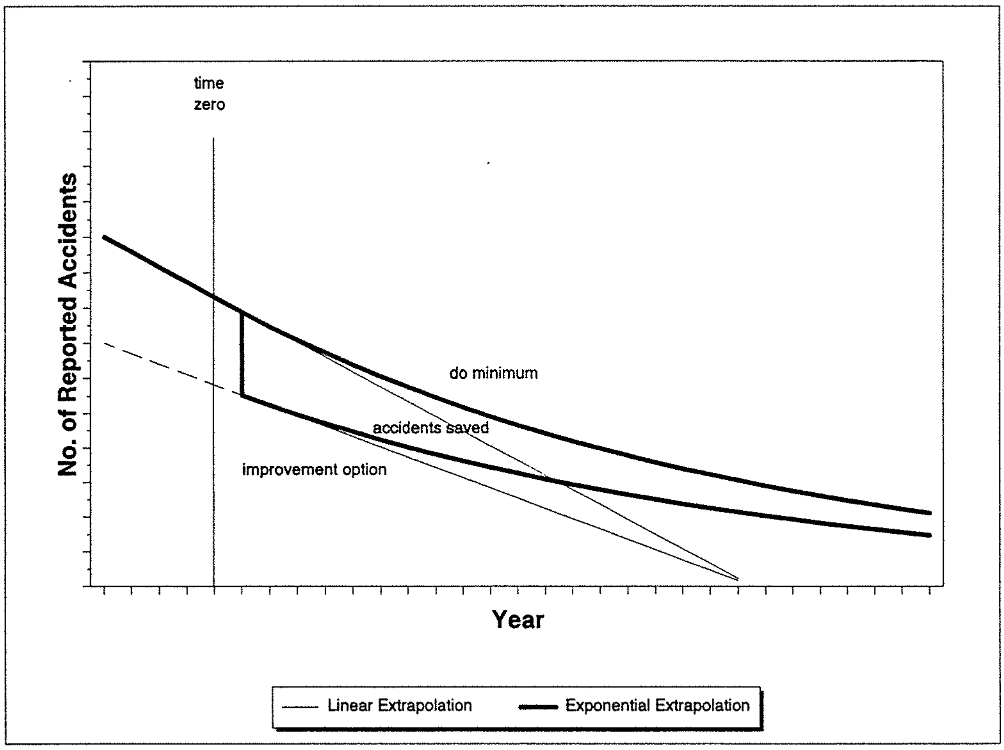
Accident trend adjustment factors for use at a particular road site must also allow for the actual traffic growth at the site. The factors given in Tables A4.1 to A4.3 in Appendix 4 include the effect of national average traffic growth. The traffic growth effect can be removed from the accident trend adjustment factors by dividing them by the traffic growth adjustment factors given in Table 5.1. Tables A4.4 to A4.6 of Appendix 4 are accident trend adjustment factors excluding the effects of both road improvements and traffic growth. The accident trend adjustment factor for use at a particular site is then the appropriate factor from Tables A4.4 to A4.6 multiplied by the ratio of the traffic volume at the analysis time ("time zero") to the traffic volume at the mid-point of the accident history.

For most accident analysis, "time zero" will be four years ahead of the mid-point of the accident history, e.g. accident analysis undertaken in mid to late 1995 will use accident records for the period 1990-94 (mid-point 1 July 1992) and "time zero" will be 1 July 1996. This relationship allows the number of accident trend adjustment factors to be simplified. Factors to adjust average annual accident numbers for a road site for the period 1990-94, to give predicted annual accident numbers for 1996, are given in Table 5.2.

Table 5.2 1996 accident trend adjustment factors for road sites.

Speed Limit	Vehicle Type	Site Traffic Growth Rate							
		0%	1%	2%	3%	4%	5%	6%	7%
50 km/h	All vehicles	0.83	0.86	0.90	0.93	0.96	0.99	1.03	1.06
	Motorcycles	0.63	0.66	0.68	0.71	0.73	0.76	0.78	0.81
	Other Vehicles	0.85	0.88	0.91	0.95	0.98	1.02	1.05	1.08
70+ km/h and above	All vehicles	0.95	0.98	1.02	1.06	1.10	1.14	1.17	1.21
	Motorcycles	0.75	0.78	0.81	0.84	0.87	0.90	0.93	0.96
	Other vehicles	0.95	0.99	1.03	1.07	1.11	1.15	1.18	1.22

Figure 5.3 Extrapolation of accident trends for calculation of accident reduction benefits.



5.4 Calculation of Accident Reduction Benefits

Accident reduction benefits resulting from road improvements are calculated as the difference between the accident costs of the "do minimum" and the accident costs of the improvement option. Accident costs are calculated over a 25-year analysis period commencing at the completion of the improvement work, and are discounted to "time zero". Many road safety improvements are completed within a year, so for these projects the analysis period is 26 years from "time zero" with benefits commencing at the end of the first year.

While it is reasonable to use linear extrapolation of accident trends over the short period up to "time zero", it would be unreasonable to expect such a trend to continue over a further 26 years, especially if the trend is a significant annual reduction or increase in accidents. An exponential trend asymptoting to zero change should be used for discounting accident reduction benefits. This is illustrated in Figure 5.3.

The present value of the time stream of accident costs resulting from the exponential extrapolations shown in Figure 5.3 can be obtained by using an equivalent arithmetic growth rate in the discount calculation using the arithmetic growth present worth, given in the Project Evaluation Manual. The equivalent arithmetic growth rate is dependent only on the accident trend adjustment factor, because this factor dictates the shape of the exponential curve. The equivalent arithmetic growth rates are given in Table 5.3.

Table 5.3 Equivalent arithmetic growth rates for use in discounting accident costs.

Accident Trend Adjustment Factor	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3
Arithmetic Growth Rate for Accidents	–7.6%	–6.2%	–4.4%	–2.4%	0.0%	+2.6%	+5.5%	+8.6%

6. RECOMMENDATIONS

In consequence of the results obtained in this study, recommendations are made for adjustments to the process of evaluating accident savings in New Zealand resulting from road improvements that allow for the underlying trends in New Zealand road accidents, as follows:

6.1 Changes to 1991 Transit New Zealand Project Evaluation Manual

The following changes are recommended to the procedures and values in the Project Evaluation Manual:

- The prediction year for accident analysis in project evaluation be "time zero", as defined in the Project Evaluation Manual (e.g. for projects prepared for the 1995/96 National Land Transport Programme, accident estimates would be done for 1995).

- Average annual accident numbers calculated from a 5-year accident history at a road site be multiplied by the accident trend adjustment factors given in Table 5.2 of this report to give the "do minimum" number of accidents at the site for the prediction year.

- Consideration be given to requiring motorcycle accidents to be analysed separately if more than two such accidents are recorded at the site of proposed road improvements.

- The AADT (average annual daily traffic) used in the accident analysis be estimated for "time zero".

- The typical number of accidents for the site of proposed road improvements be calculated using the typical accident rate and the site traffic exposure at "time zero".

- The equivalent arithmetic growth rates given in Table 5.3 of this report be used in discounting accident reduction benefits.

- The constants in the typical accident rate formulae in Appendix A6 of the Project Evaluation Manual be changed so that they can:
  – be used with traffic exposures at "time zero" (factor from Table 5.1 of this report); and
  – predict accidents per year at "time zero" (factor from Table 5.2 of this report).

- The adjustment factors presented in this report should be re-calculated at intervals of two to three years to allow for changes in accident and traffic volume trends.

6.2 Changes to Accident Analysis

The following changes are recommended to the procedures for carrying out accident analysis:

- Any analysis of the effectiveness of road safety measures should make allowance for general trends in accidents, either by using the adjustment factors presented in this report or by using control sites.

- More attention should be given to recording any road improvements so that changes in site characteristics can be allowed for in the evaluation of further safety improvements and/or effectiveness of treatments, and so that a more accurate estimate can be made of the contribution that road improvements make to overall accident reductions.

- Consideration should be given to extending the purpose of the LTSA Accident Investigation database to record all site-specific (or route-specific) road improvements.

7. REFERENCES

Beca Carter Hollings and Ferner. 1991. The effectiveness of reflective raised pavement markers at reducing accidents. Draft report to Transit New Zealand.

Beca Carter Hollings and Ferner. 1995. Macroscopic models relating traffic volumes and fatalities. *Transit New Zealand Research Report No.* 48. 35pp.

Gabites Porter Ltd. 1990. System wide accident analysis, Stage II. Draft report to Transit New Zealand.

Jackett, M. 1993a. Road lighting to prevent accidents. Report to the New Zealand Traffic Institute.

Jackett, M. 1993b. Accident Rates on Urban Routes – 1992 Update. *The Institution of Professional Engineers New Zealand Transactions 20(1/CE).*

Land Transport Safety Authority (LTSA). 1993. *Annual Statistical Statement on Motor Vehicle Accidents.*

Land Transport Safety Authority (LTSA). 1994. *Safety (Administration) Programme.* LTSA for the Secretary for Transport, NZ Government.

Officials' Committee on Road Safety. 1991. *National Road Safety Plan.* Land Transport Division, Ministry of Transport. 91pp.

Officials' Committee on Road Safety. 1992. *National Road Safety Plan, Report on the First Year.* Land Transport Division, Ministry of Transport. 12pp.

Officials' Committee on Road Safety. 1994. *National Road Safety Plan, Report on the Second Year.* Land Transport Safety Authority. 12pp.

Scott, G., Pittams, G., Darby, N. 1987. Regression models of New Zealand road casualty data: Results of a preliminary investigation. Internal report, Transport Research Section, Economics Division, Ministry of Transport.

Transit New Zealand. 1991. *Project Evaluation Manual,* Volumes I and II.

Transit New Zealand, Ministry of Transport Land Transport Division. 1991. *Accident Investigation Procedures.*

Transit New Zealand. 1994. *A guide on estimating AADT and traffic growth.*

Works Consultancy Services. 1994. National Traffic Database. Report to Transit New Zealand.

APPENDIX 1
TRENDS IN ROAD USER BEHAVIOUR

TRENDS IN ROAD USER BEHAVIOUR

The following figures show trends in road user behaviour, together with the targets for 1994 and 2001 given in the 1994/95 Safety (Administration) Programme (LTSA 1994).

Figure A1.1 Open road speeds.

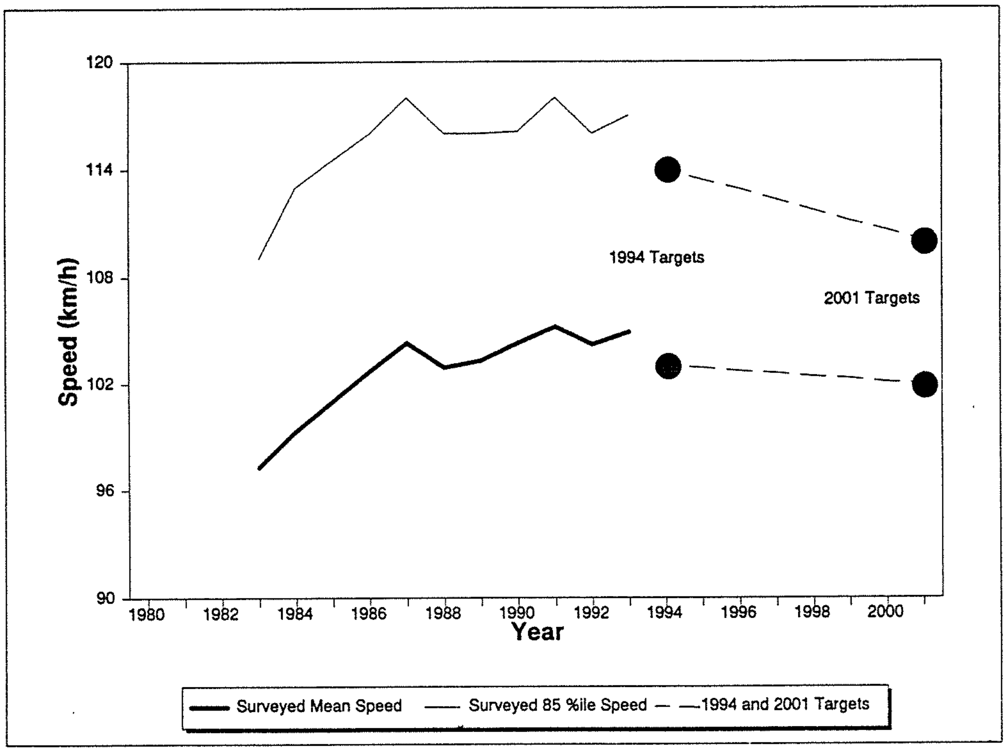


Figure A1.2 Number of dead drivers whose blood alcohol levels were over the legal limit.

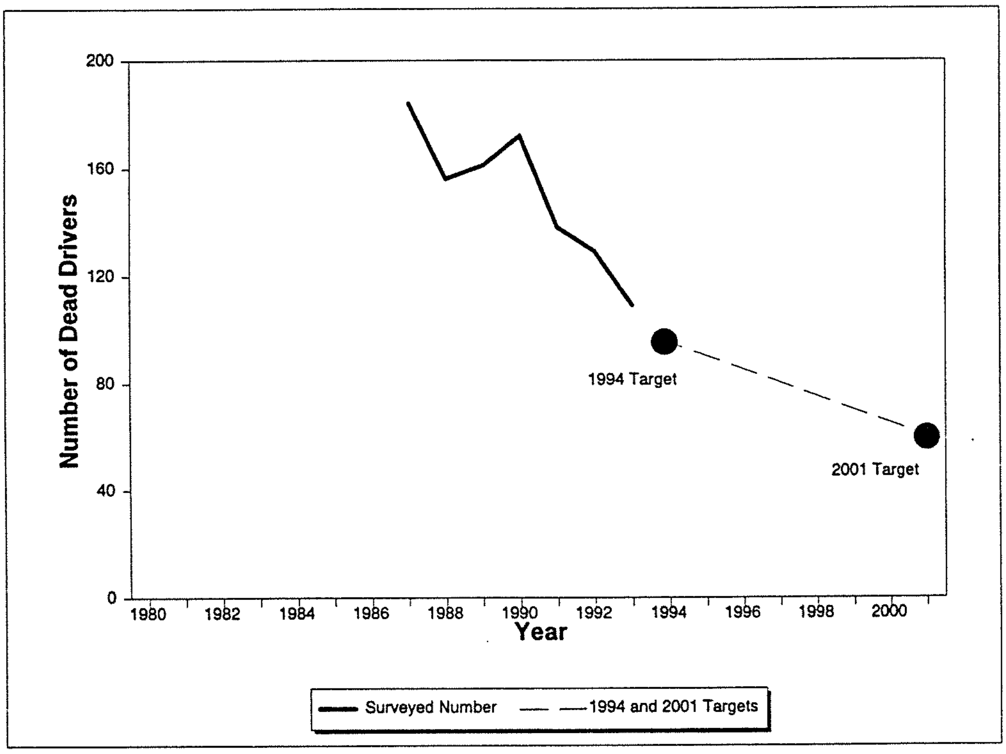


Figure A1.3 Seat belt use by adults (15 years and older) in front seats of motor vehicles.

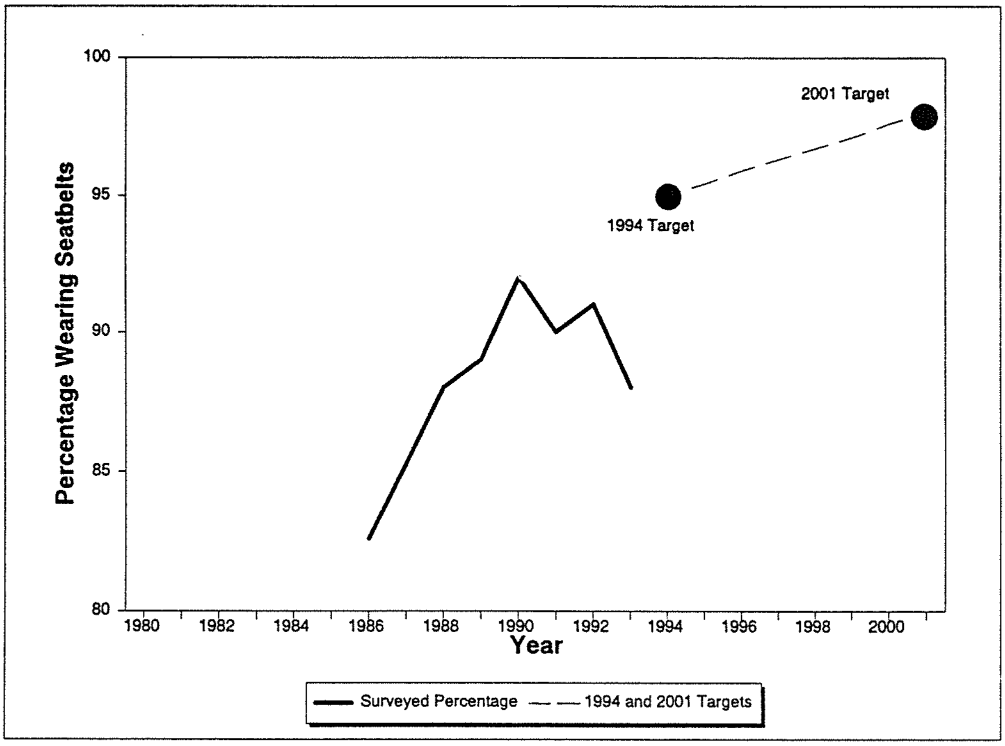


Figure A1.4 Seat belt use by adults in rear seats of motor vehicles.

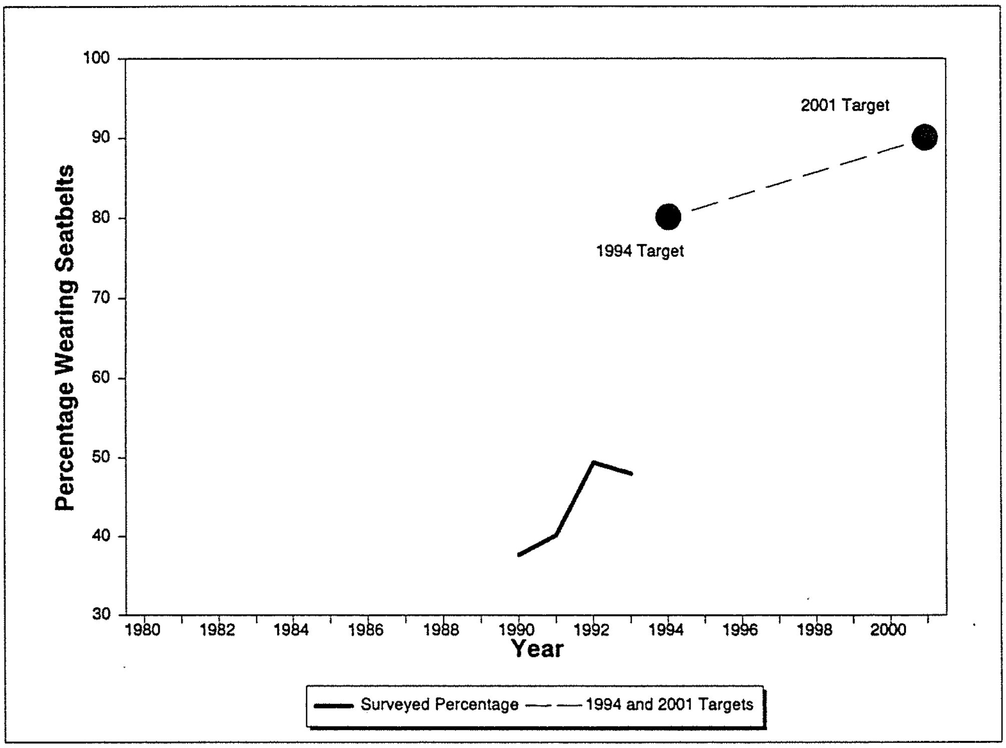


Figure A1.5 Helmet use by bicyclists.

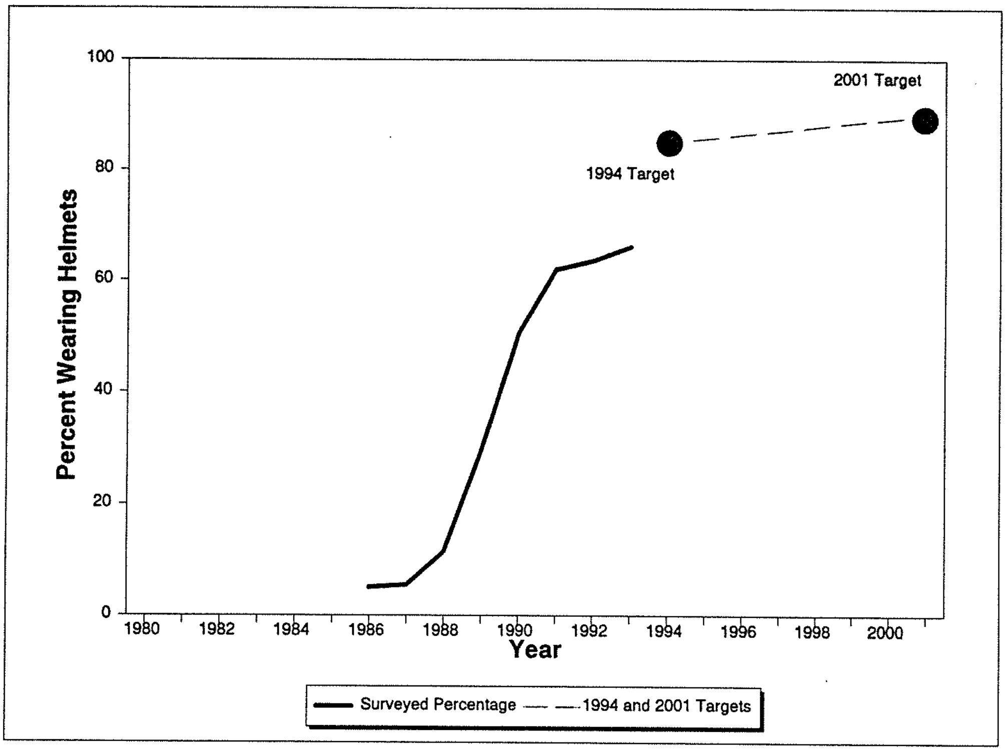


Figure A1.6 Number of bicyclists plus pedestrians admitted to hospital.

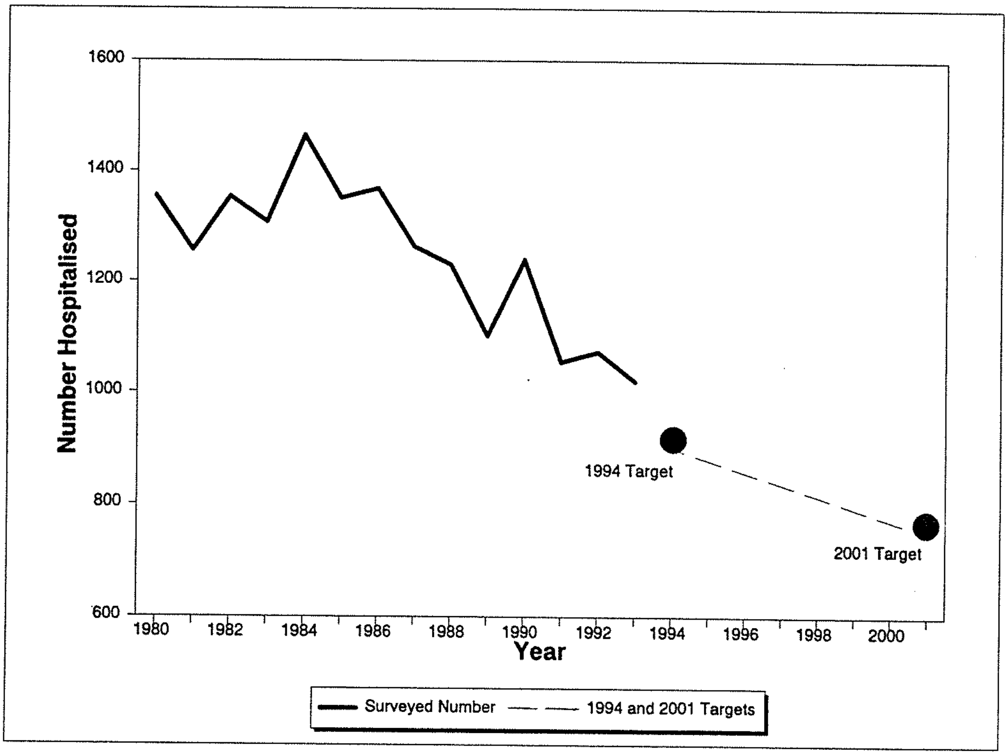


Figure A1.7 Restraint use by children (0-14 years) in motor vehicles.

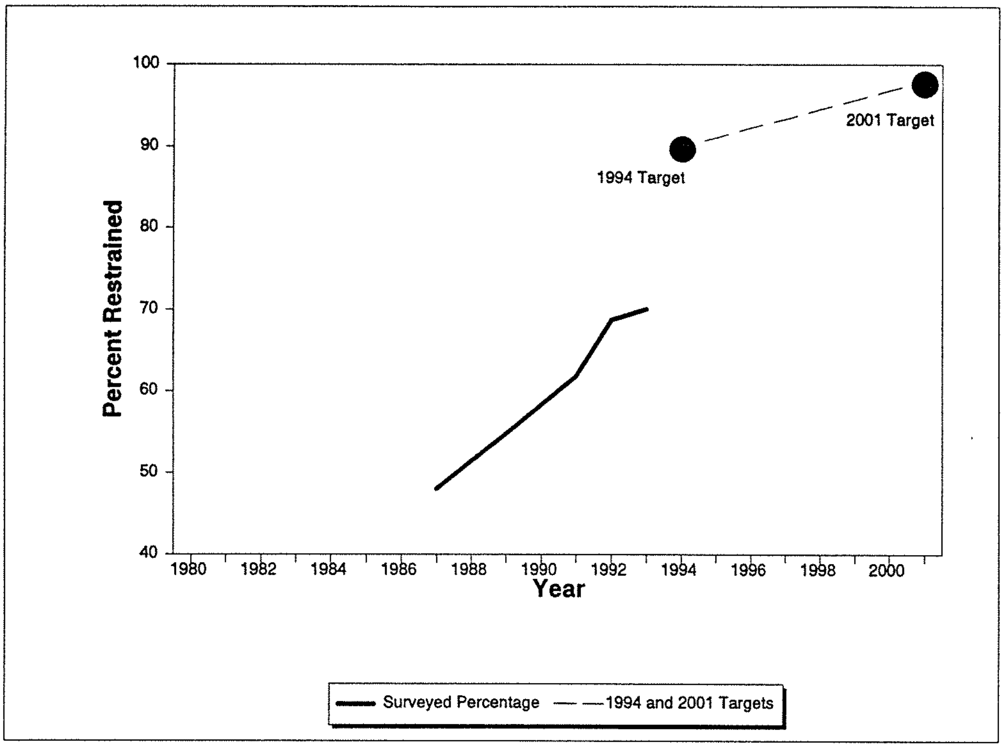
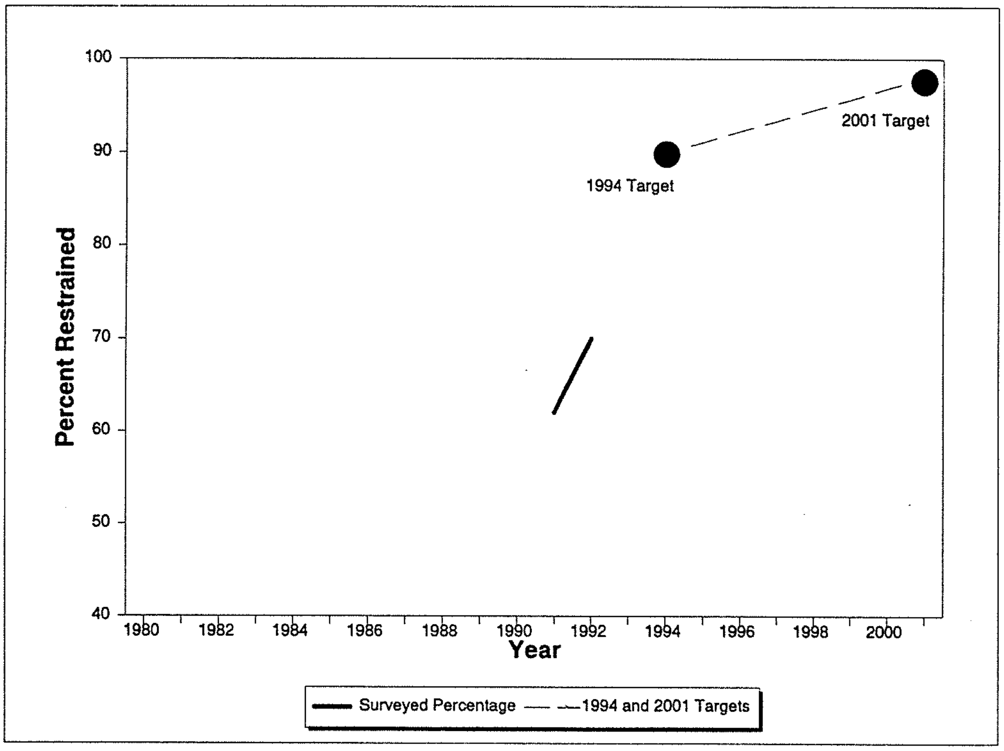


Figure A1.8 Restraint use by children (under 5 years) in motor vehicles.



APPENDIX 2
NEW ZEALAND ROAD SAFETY LEGISLATION

NEW ZEALAND ROAD SAFETY LEGISLATION

A brief listing of road safety legislation introduced in New Zealand since 1965 follows.

1965	(1)	All new motor cars, station wagons and light trucks must be fitted with safety belts.
1967	(1)	Introduction of the demerit points system.
	(2)	Driving at an 'unreasonably slow speed' became a traffic offence.
1969	(1)	Introduction of breath and blood alcohol tests.
	(2)	Introduction of parking infringement system.
	(3)	Minimum tread depth for pneumatic tyres prescribed.
1971	(1)	Speeding Infringement System introduced.
1972	(1)	Compulsory testing for blood alcohol of accident victims at hospitals.
	(2)	Compulsory fining and wearing of safety belts for certain drivers and front seat passengers 15 years and over in light vehicles registered since 1965.
1973	(1)	Safety helmets compulsory for motor cyclists and pillion riders at all speeds. Previously (from 1956) they had been compulsory only if travelling in excess of 30 mph (50 km/h).
	(2)	Maximum open road speed limit reduced from 55 mph to 50 mph (80 km/h) as part of fuel conservation measures. Effective from 4 December 1973.
1975	(1)	Seat belt requirements (see 1972 above) extended to motor vehicles registered on or after 1 January 1955.
	(2)	Change over to metric speed limits and road signs.
1977	(1)	New traffic regulations (Traffic Regulations 1976) came into effect bringing major changes to give way rules, intersections and pedestrian crossings.
1978	(1)	Introduction of evidential breath testing. Lowering of permissible blood alcohol level from 100 milligrams of alcohol per 100 millilitres of blood to 80 milligrams per 100 millilitres. Tougher criteria for issue of limited licences to disqualified drivers.
1979	(1)	Age for compulsory seat belt use in motor vehicles lowered to children 8 years old.
1980	(1)	Introduction of traffic infringement systems to speed up processing of minor traffic offences plus notices of prosecution servable on roads.
1981	(1)	Traffic Regulations 1976 heavily amended to provide legal framework for safe installation and inspection of alternative fuel systems in motor vehicles.
1983	(1)	The Transport Amendment Act (No. 2) 1983. Introduced to provide an orderly phase-out of the 150-km rail protection by allowing shippers, upon payment of a long distance haulage fee, to use road transport in circumstances in which they were previously required to use rail. Effective from 1 November 1983.
	(2)	Transport Amendment Act (No. 3) 1983 allows the Court to make an order requiring a person, convicted twice or more in a five-year period of specific alcohol or drug related traffic offences, to attend an Assessment Centre and for disqualification from holding or obtaining a driver's licence until the Secretary for Transport makes an order removing that disqualification. Effective from 1 December 1983.

1984 (1) Regulations governing the approval and use of child restraints introduced.

1985 (1) The open road speed limit was increased from 80 km/h to 100 km/h for all vehicles except heavy motor vehicles (speed limit now 90 km/h), articulated vehicles (90 km/h) and vehicles towing trailers (80 km/h). Effective from 1 July 1985.

1986 (1) Staggered relicensing of motor vehicles and provision for lifetime drivers' licences introduced.

(2) Strict liability for carriage of insecure loads came into effect (1 February).

1987 (1) Increased powers of arrest for traffic officers, new driving hours and logbook requirements for professional drivers, graduated licensing system and increased penalties for unlicensed driving introduced (1 August).

1988 (1) Lowering the legal breath alcohol level from 500 mgA to 400 mgA and the removal of the traffic enforcement officers' right to require a blood sample in certain circumstances. Increased maximum monetary penalty for serious traffic offences and an increase in the level of infringement fees payable for a number of offences. Introduction of community based sentences as a substitute for disqualification. Increased powers for traffic enforcement officers dealing with offenders who fail to stop.

(2) Introduction of class C roads and the removal of the class II road classification. Revised maximum weights for heavy motor vehicles.

1989 (1) Introduction of the Transit New Zealand Act 1989 establishing Transit New Zealand, the Safety (Administration) Programme and the National Land Transport Programme.

(2) Introduction of the Transport Services Licensing Act 1989.

(3) Introduction of a new schedule of infringement fees to cover a wide range of minor offences and road user charges infringements. Increased fees for speeding infringements.

(4) Traffic enforcement officers given power of entry onto private property for the purposes of undertaking drink driving offence procedures.

(5) Assumption of national traffic enforcement control by the Ministry of Transport.

(6) Introduction of new regulations governing the transport of hazardous substances.

1990 (1) Amendment to the Transport Act to validate the breath test notice in its existing form.

(2) Introduction of the Transport (Vehicle Standards) Regulations 1990.

1991 (1) A change in the driver licence regulations to allow the introduction of the "scratch" driver licence testing forms.

1992 (1) The merger of the Traffic Safety Service Branch of the Ministry of Transport with the New Zealand Police was implemented 1 July.

(2) Amendments made to the Transport Act to allow for compulsory breath testing, reduced alcohol limits for under 20 year olds, extended owner liability regime and reduced driving hours regime, to be brought in during 1993.

(3) Amendments made to the Transport Services Licensing Act to allow for area knowledge for taxi drivers, the licensing of rail services, 5 year ID cards and tighter controls over taxi organisations, to be implemented during 1993.

(4) Amendments made to the Transport (Vehicle and Driver Registration and Licensing) Act to implement the new Motor Vehicle Registration system in 1994.

(5) Railway Safety and Corridor Management Act 1992 to come in to force during 1993.

(6) Amendments made to the Transport Accident Investigation Commission Act to include rail accidents.

(7) Amendments made to the Local Government Act to simplify procedures for removing abandoned vehicles.

(8) Amendments made to the Road User Charges Act to implement a new Road User Charges system over 1993.

1993 (1) Introduction of the Land Transport Act 1993 establishing the Land Transport Safety Authority.

(2) Changes to demerit points, including making points apply from offence date and providing for a uniform 3-months suspension period.

(3) Commencement of Compulsory Breath Testing (CBT).

(4) Lowered youth alcohol limits (30mg for under 20 year olds).

(5) Rationalisation of driving hours and logbook.

(6) Introduction of a Railways Safety regime.

(7) New stationary vehicle offences introduced to enable parking wardens to more effectively deal with registration and licensing offences.

(8) Introduction of Area Knowledge tests for taxi drivers.

(9) Owner liability for Speed Cameras. Speed Cameras become operational on 15 October.

(10) Graduated demerit points for speeding, from 10 - 50 points for specified excess speeds.

(11) Introduction of Vehicle Identification Number (VIN) system for vehicle identification purposes.

1994 (1) Compulsory bicycle helmets (from 1 January 1994).

(2) Compulsory child restraints for 0 - 2 year olds (from 1 April 1994) and 3 - 5 year olds (from 1 April 1995)

APPENDIX 3
ESTIMATE OF FUTURE REDUCTION IN FATALITIES IN NEW ZEALAND

Source: Land Transport Safety Authority

ESTIMATE OF FUTURE REDUCTION IN FATALITIES IN NEW ZEALAND

An analysis of the savings that could result from programmes and developments planned for the years 1994 to 2001 has been prepared by the Land Transport Safety Authority (LTSA) and is given below. Although the overall impact of the various current programmes and possible future projects cannot be accurately forecast, an assessment has been made of the savings for the years 1994 and 2001, i.e. immediate and long term. The degree to which economic, vehicle and population growth offset the estimated savings is difficult to estimate although a guesstimate is included below.

	1994 Saving	2001 Saving
Bicycle helmets An estimate was made in the proposals for the regulation introduced for compulsory bicycle helmet wearing that all bicyclists would achieve a 90% wearing rate and save 6 lives per year. (A considerable reduction in serious head injuries will also result.)	-6	-6
Rail crossing accidents In 1993, an unusually high number of people were killed in rail crossing accidents. The figure is normally around 10 (average 8½ for the last 4 years), so regression back to the mean would give 9 lives saved. Road crashes have a 'randomness' about trends so regression to the mean here is likely to be balanced by an increase elsewhere in the system with a net gain of zero. Work being done in rail safety may give a longer term saving of 30% of the normal number of rail deaths.	0	-3
Seat belt wearing Wearing rates in New Zealand are 90% for front seat adults, 48% for rear seat adults, and 70% for children, but they are known to be much lower among those who are killed in road accidents. About 160 of the vehicle occupants who were killed each year did not wear a seatbelt and the typical estimate of the officers attending the accidents is that some 50 would have been saved if they had worn them. If a 95% seatbelt wearing rate could be achieved in 1994 (the 1994/95 Safety Administration Programme target rate), then the savings would be less than half the 50 lives mentioned above (say 20) because the vehicle occupants that are hardest to influence are likely to be those that contribute most to the road toll. If the year 2001 target of 98% wearing of seat belts is reached, and the most obvious means is through strict enforcement of the existing laws, plus attendant publicity and education, an additional 20 lives are likely to be saved.	-20	-40
Motorcyclists In recent years a reduction in the number of motorcycle deaths has occurred, whether through increased availability of cheaper cars to people who would otherwise own a bike, increased ACC levies, or improved training and education. However, this trend seems to have levelled off, and with no projects aimed at reducing motorcycle casualties, no savings are likely in 1994. However licensing of 15 and 16 year olds is continuing to decrease which, combined with new initiatives that may come out of an ACC study on motorcycle accidents, may reduce the percentage of deaths involving motorcycles. If the percentage was reduced to that of New South Wales (8% of deaths rather than our 13.5%), it would give a long-term saving of 48 lives.	0	-36
Vehicle safety features The requirements for safety equipment for new vehicles in New Zealand have been subjected to some public and media criticism. Rules relating to airbags, front and side impact standards, and anti-roll fuel valves, among others, are being studied with a view to implementation in 1994. Any new requirements are likely to apply only to new vehicles, which currently are involved in about 30 vehicle occupant fatalities each year. Very optimistically, 5 - 10% of such fatalities might be saved by these mandatory safety features. By 2001, about 100 vehicle occupants would be affected by safety features giving a total saving of about 8 lives.	-2	-8

	1994 Saving	2001 Saving
Compulsory Breath Testing/Alcohol Compulsory Breath Testing (CBT) came into effect in April 1993. In Victoria the equivalent Random Breath Testing (RBT) was attributed with contributing about 30% of the decrease in the number of road deaths between 1989 and 1992, or a 15% drop in road deaths over that period. As New Zealand probably had a higher level of alcohol enforcement before the introduction of CBT than Victoria, New Zealand could expect perhaps a 10% decrease in road deaths. The New Zealand road toll dropped in December 1992 when alcohol enforcement activity was increased and the road toll continued at the lower rate all through 1993. If most of the 7% drop in road deaths in 1993 is assumed to result from alcohol enforcement, then another 5% gain may be made to match the reduction in accidents recorded in Victoria. It can be assumed that half of this saving occurs immediately (in 1994) and half in the longer term (2001). In the long term other alcohol countermeasures are aimed at achieving the goal to bring the percentage of fatalities caused by intoxication down to 25% of the total. At the current road toll that would be a total saving of about 60 lives.	-18	-60
Speed cameras In Victoria speed cameras are attributed with the same total saving in lives as RBT, or a saving of about 15% of the road toll. Since they were only introduced in New Zealand in 1994, most of the saving that could be attributed to them will occur in 1994 and later years. The programme is being introduced gradually as equipment becomes available. so New Zealand could expect a third of the savings in 1994 and the rest over the next two years.	-30	-90
Open road speeds The road toll on open roads in New Zealand varies according to changes in the speed limits, which is a well known phenomenon seen in several countries which have experimented with changes in their speed limits. A reduction in the New Zealand open road speed limit from 100 km/h to 90 km/h would give about a 10% reduction in the total number of New Zealand's fatalities on such roads, which was about 440 in 1993. Accident savings from reduction in open road speeds is clearly a more long-term prospect and depends on a change in speed limit policy.	0	-40
Fleet modernisation The gradual improvement in the vehicle fleet as new models arrive and older cars head for the graveyard should have an effect on casualty levels. This effect is difficult to estimate. It is likely to have a similar effect to the introduction of standards for vehicle safety features.	-2	-8
Raising the minimum driving age Raising the driving age to either 16 or 17 years has been estimated to save about 5 or 15 deaths respectively.	0	-15
Blackspots Road improvements that have already been made to accident blackspots are estimated to have saved approximately 20 lives a year. If the blackspot scheme is enhanced and extended a similar potential for savings in the future may be expected.	0	-20
Road improvements Dutch research shows that the accident rate per km travelled on motorways (with no opposing traffic or at grade intersections) is about 1/4 that of rural roads with opposing traffic and intersections. Similarly, residential "calmed areas" have a fatality rate about 1/4 that of normal residential streets. Wider road shoulders has also been shown to reduce fatalities. The effect of these roading improvements will depend to what degree roading money is available to upgrade the system. However it is estimated that 10 lives a year could be saved in the long term from road improvements.	0	-10

	1994 Saving	2001 Saving
Economic, vehicle and population growth As New Zealand's economy improves, an associated rise in the road toll will occur, reflecting the increase in discretionary spending through driving. Such a rise and fall in the road toll has been seen in New Zealand in the past as the economy has risen and fallen. It is difficult to estimate the number of fatalities that relate to a change in the economy. Growth in both vehicles and population will also tend to offset the other estimated gains. If the deaths per vehicle stayed at the 1994 level then the growth in vehicles would produce 75 extra deaths by 2001. An extra 25 deaths related to economic growth has been allowed to give a total loss of 100.	+20	+100
Arithmetic total	-58	-236
Adjusted total Note that several of the measures listed above will apply to the same target groups, so the individual savings do not sum up. For instance seatbelts are worn less by intoxicated victims than other casualties, and some motorcyclists will be alcohol-affected. (The CBT and Speed camera savings are based on the Victorian experience where they were treated separately.)	-40?	-180?

If all the programmes above were to be undertaken and the estimates of the likely savings are correct, then 560 deaths will occur in 1994 and 420 deaths in 2001. If, on the other hand say, seat belt wearing stays at 90% for 1994 and rises to only 95% by 2001, no change is made to the open road speed limit, motorcycling regains popularity, and speed cameras have only half the desired effect, then the road toll will be 595 and about 560 in 1994 and 2001 respectively.

APPENDIX 4
ADJUSTMENT FACTORS FOR ACCIDENT TRENDS

ADJUSTMENT FACTORS FOR ACCIDENT TRENDS

The following tables give numerical factors to be used to adjust numbers of accidents obtained from past accident records, to give predicted accident numbers.

Table A4.1 Accident trend adjustment factors to adjust past accident numbers to 1996 values for sites with national average traffic growth.

Period of Accident History	Urban (50 km/h speed limit)			Rural (70+ km/h speed limit)		
	All Vehicles	Motorcycles	Other Vehicles	All Vehicles	Motorcycles	Other Vehicles
1985-89	0.85	0.40	0.92	1.10	0.57	1.18
1986-90	0.86	0.45	0.93	1.08	0.62	1.14
1987-91	0.89	0.51	0.94	1.07	0.69	1.11
1988-92	0.91	0.58	0.95	1.05	0.76	1.08
1989-93	0.93	0.65	0.96	1.05	0.82	1.07
1990-94	0.92	0.70	0.94	1.05	0.83	1.06
1991-95	0.95	0.76	0.96	1.04	0.88	1.06

Table A4.2 Accident trend adjustment factors to adjust past accident numbers to 1997 values for sites with national average traffic growth.

Period of Accident History	Urban (50 km/h speed limit)			Rural (70+ km/h speed limit)		
	All Vehicles	Motorcycles	Other Vehicles	All Vehicles	Motorcycles	Other Vehicles
1985-89	0.81	0.35	0.89	1.14	0.51	1.23
1986-90	0.83	0.40	0.89	1.11	0.55	1.18
1987-91	0.85	0.45	0.90	1.10	0.62	1.15
1988-92	0.87	0.51	0.91	1.08	0.68	1.12
1989-93	0.89	0.57	0.92	1.07	0.73	1.11
1990-94	0.88	0.61	0.91	1.07	0.74	1.10
1991-95	0.91	0.67	0.93	1.07	0.78	1.09

Table A4.3 Accident trend adjustment factors to adjust past accident numbers to 1998 values for sites with national average traffic growth.

Period of Accident History	Urban (50 km/h speed limit)			Rural (70+ km/h speed limit)		
	All Vehicles	Motorcycles	Other Vehicles	All Vehicles	Motorcycles	Other Vehicles
1985-89	0.80	0.32	0.88	1.15	0.47	1.25
1986-90	0.81	0.36	0.88	1.13	0.52	1.20
1987-91	0.83	0.41	0.89	1.11	0.58	1.17
1988-92	0.85	0.46	0.90	1.09	0.63	1.14
1989-93	0.87	0.52	0.91	1.09	0.69	1.12
1990-94	0.86	0.56	0.89	1.09	0.69	1.12
1991-95	0.89	0.61	0.91	1.08	0.74	1.11

Table A4.4 Factors to adjust past accident numbers to 1996 values for sites with zero traffic growth and no road improvements.

Period of Accident History	Urban (50 km/h speed limit)			Rural (70+ km/h speed limit)		
	All Vehicles	Motorcycles	Other Vehicles	All Vehicles	Motorcycles	Other Vehicles
1985-89	0.67	0.31	0.72	0.87	0.45	0.93
1986-90	0.69	0.36	0.75	0.87	0.50	0.92
1987-91	0.74	0.43	0.78	0.89	0.58	0.93
1988-92	0.78	0.50	0.81	0.90	0.65	0.92
1989-93	0.82	0.57	0.84	0.92	0.72	0.94
1990-94	0.83	0.63	0.85	0.95	0.75	0.95
1991-95	0.88	0.70	0.89	0.96	0.81	0.98

Table A4.5 Factors to adjust past accident numbers to 1997 values for sites with zero traffic growth and no road improvements.

Period of Accident History	Urban (50 km/h speed limit)			Rural (70+ km/h speed limit)		
	All Vehicles	Motorcycles	Other Vehicles	All Vehicles	Motorcycles	Other Vehicles
1985-89	0.62	0.27	0.68	0.88	0.39	0.95
1986-90	0.66	0.32	0.71	0.88	0.44	0.94
1987-91	0.69	0.37	0.73	0.89	0.50	0.93
1988-92	0.73	0.43	0.76	0.91	0.57	0.94
1989-93	0.77	0.49	0.79	0.92	0.63	0.96
1990-94	0.78	0.54	0.81	0.95	0.65	0.97
1991-95	0.83	0.61	0.85	0.97	0.71	0.99

Table A4.6 Factors to adjust past accident numbers to 1998 values for sites with zero traffic growth and no road improvements.

Period of Accident History	**Urban (50 km/h speed limit)**			**Rural (70+ km/h speed limit)**		
	All Vehicles	**Motorcycles**	**Other Vehicles**	**All Vehicles**	**Motorcycles**	**Other Vehicles**
1985-89	0.60	0.24	0.66	0.86	0.35	0.94
1986-90	0.63	0.28	0.68	0.88	0.40	0.93
1987-91	0.66	0.33	0.71	0.88	0.46	0.93
1988-92	0.70	0.38	0.74	0.89	0.52	0.93
1989-93	0.73	0.44	0.76	0.92	0.58	0.94
1990-94	0.74	0.48	0.77	0.94	0.59	0.97
1991-95	0.79	0.54	0.81	0.96	0.65	0.98