LAND transport safety AUTHORITY

# *Installation of guardrails*

December 2001

## Executive Summary

The Joint Crash Investigation Programme identifies sites suitable for low cost crash reduction treatments and recommends suitable engineering treatments for each site. Since the programme began in 1985, guardrails have been recommended as a safety treatment at a number of sites. This analysis uses data from 63 sites where guardrail installation had been completed.

The primary safety benefit of guardrails is in reducing crash severity. This analysis examines the reduction in the number of crashes which resulted in injury, and in the severity of injury crashes. Crashes in the same local area as the site were used to control for underlying changes in crash patterns. The installation of guardrails was associated with the following reductions in injury crashes[1]. (Estimates marked ** are based on small numbers of injury crashes and should be used with caution).

- All sites: **45%**
- Open road sites: 48%
- **Urban sites: 29%
- Loss of control crashes: 54%
- Other crash types: 28%
- Crashes in daylight: 34%
- Crashes in darkness/ twilight: 61%
- **Fatal crashes: 68%
- Serious injury crashes: 44%
- Minor injury crashes: 44%

The overall saving in social cost achieved by reducing these injury crashes to non-injury crashes, was approximately $99 million[2].

The ratio of fatal and serious injury crashes to minor injury crashes gives an indication of reduction in severity within injury crashes. This ratio decreased by 13% after installation of guardrails, resulting in an estimated *additional* social cost saving of $7.8 million. The total estimated social cost saving at sites where guardrails were installed was $106 million.

1. Quoted reductions do not take regression to the mean into account. See section 8 for discussion.
2. All social costs are in June 2001 prices.

**Table 1: Social cost savings**

| | |
|---|---|
| Migration from injury to non-injury crashes | |
| Open road sites | $ 94.7 m |
| Urban sites | $ 4.0 m |
| Migration from fatal & serious to minor crashes | $ 7.8 m |
| **Total social cost saving** | **$106 m** |

*Note: Totals were calculated before rounding.*

## 1. Introduction

The Joint Crash Investigation Programme was set up in 1985 to undertake a continuous programme of systematic investigation of all roads in New Zealand. Since 1989 the Land Transport Safety Authority (then the Land Transport Division, Ministry of Transport), has progressively developed a monitoring system to gather data on sites investigated under the programme. This analysis uses data on the Crash Reduction Study Monitoring System database, now part of the LTSA's Crash Analysis System, to analyse the effects of specific "actions" or treatments at sites.

This paper looks specifically at the effect of installing guardrails at sites.

## 2. Site selection

The analysis was based on sites where installation of guardrails had been completed, provided the installation of guardrails was considered to be a major or minor component of the safety interventions at the site. Sites where the installation was considered to have little or no effect were excluded from the analysis.

Sixty-three sites met the above criteria. Guardrails were installed on 25 routes, at 27 non-intersection sites and at 11 intersection sites. Guardrail installation was a major component of treatments at 28 of these sites and a minor component at the remaining 35 sites.

At 7 of the studied sites guardrails were installed for reasons other than as part of the crash reduction study.

Table 2 shows the site types and speed zones of sites where guardrails were installed. In this table and elsewhere in this report, "urban" refers to roads or sites with speed limit 70 km/h or less, and "open road" to those in 80-100 km/h speed limit zones. Nearly three quarters of sites where guardrails were installed were on open road sections of State Highways.

**Table 2. Number of sites by speed zone and site type**

| Sites | Open Road | Urban | Total |
|---|---|---|---|
| Intersection | 5 | 6 | 11 |
| Non-intersection | 22 | 5 | 27 |
| Route | 24 | 1 | 25 |
| Total | 51 | 12 | 63 |

**Table 3. Number of sites by speed zone and road classification**

| Sites | Local Rd | State H'way | Total |
|---|---|---|---|
| Urban | 8 | 4 | 12 |
| Open | 5 | 46 | 51 |
| Total | 13 | 50 | 63 |

In addition to the treated sites there were several sites where the installation of guardrails was recommended but has not been implemented. The table below shows the number of years since the recommendations were made.

**Table 4. Sites with guardrails still to be installed.**

| Years since recommendation made | Sites |
|---|---|
| 11 or more | 2 |
| 9 or 10 | 5 |
| 7 or 8 | 5 |
| 5 or 6 | 2 |
| 3 or 4 | 5 |
| Less than 3 | 5 |
| Total | 24 |

(Excludes sites where action was recommended but a decision has been made for them not to be implemented).

## 3. Other works at treated sites

Works other than installation of guardrails were also implemented at treated sites.

The most common actions implemented in addition to the installation of guardrails at the 63 selected sites were:

- Install or move traffic signs (44 sites)
- Install, move or upgrade chevrons (35 sites)
- Upgrade/ reseal carriageway (24 sites)
- Improve edge marker posts (23 sites)
- Install RRPMs (15 sites)

## 4. Crash data

The crash data used in this analysis are from the LTSA's Crash Analysis System, which includes all crashes reported to the LTSA by NZ Police. These results are based on injury crash data up to and including 31 December 2000. Non-injury crashes have lower and more variable reporting rates than injury crashes, and were not used in this analysis.

The average study period before treatment was 5.6 years, and the average post-implementation study period was 5.3 years.

Changes in crash patterns were examined for different site and crash types. Crash types of interest selected for analysis were light conditions (daylight or dark), crash movement type and crash severity. Three levels of crash severity are defined based on the most severe injury to any person involved. A fatal crash is one in which one or more people died as a result of the crash, within 30 days. A crash is defined as serious if any person had injuries requiring hospitalisation, and minor if only less severe injuries were apparent. Selected crash types were examined across all sites.

## 5. Controlling for crash trends

Underlying crash trends within each local area and speed limit zone (urban or open road) were taken into account when calculating reductions at the monitored sites.

Each site was assigned a comparison group of injury crashes in the same local area and urban or open road speed limit category. Where crash numbers permitted controls were drawn from the same Local Authority; in areas with low crash numbers crashes were aggregated across the Local Government Region or in some cases a slightly wider area[3]. Only crashes occurring outside designated monitoring sites were included in the comparison group.

## 6. Analysis method

The number of injury crashes at each site was adjusted for underlying crash trends in the local area, to give an estimated number of injury crashes expected if the improvements had had no effect. The resulting expected number of injury crashes at a site or group of sites was calculated as follows

$$\text{CrashesExpected} = \text{BeforeCrashes} \times \frac{\text{ControlAfter}}{\text{ControlBefore}}$$

where

*CrashesExpected* is the expected number of injury crashes at the site in the 'after' period (ie the period of monitoring after all treatments were implemented), assuming the treatment had no effect;

*BeforeCrashes* is the actual number of injury crashes at the site in the (usually five-year) period before treatment;

*ControlBefore* and *ControlAfter* are the actual number of injury crashes in the control area during the site's 'before' and 'after' periods respectively.

[3] For details see the report 'Overall Results of Crash Reduction Study Monitoring, Feb 2001'.

Actual and expected numbers of 'after' injury crashes were summed across the chosen group of sites and the totals compared to give the crash reduction result as

$$\%\text{Reduction}=\frac{\text{CrashesExpected}-\text{AfterCrashes}}{\text{CrashesExpected}} \times 100$$

## 7. Effect of guardrails on crash severity

The primary role of guardrails is to reduce injury severity in crashes. Among the issues of interest is severity migration from injury to non-injury crashes, and from more serious to less serious injury crashes.

Reporting rates for non-injury crashes are relatively low and vary from time to time and place to place. This analysis therefore examines the reduction in injury crashes only. However, social costs associated with this reduction are calculated on the conservative assumption that no crashes were avoided completely, rather that a number of injury crashes were reduced to non-injury crashes by the presence of guardrails.

The change in severity of injury crashes is estimated here by observing the change in fatal and serious injury crashes as a proportion of all injury crashes (relative to minor injury crashes), before and after the installation of guardrails.

## 8. Regression to the mean

When, as in the Crash Reduction Programme, sites are selected for treatment on the basis of high crash counts, there is likely to be some reduction in crashes in subsequent years even if no works were carried out. This is due to a statistical phenomenon which is referred to as 'regression to the mean'.

The controls described above have been applied to account for underlying crash trends in the local area, but the reductions quoted have not been corrected for possible regression to the mean. Methods for doing this are under investigation. When regression to the mean is taken into account, crash reductions attributable to the programme may be smaller than the changes quoted here.

## 9. Injury Crash Reductions

At sites where guardrails were installed, there were 160 fewer injury crashes on the open road, and 19 fewer in urban areas, after treatment than expected based on the site's history and underlying crash trends. This represents an overall reduction in injury crashes at the treated sites of 45%, and an estimated social cost saving (assuming that the injury crashes were reduced to non-injury crashes) of approximately $99 million (June 2001 prices).

### 9.1 Site type

Injury crash reductions of nearly 50% were achieved on open road sites. There were relatively few urban sites where guardrails had been installed. The results from these sites suggest that crash savings are somewhat lower in urban areas, at around 30%.

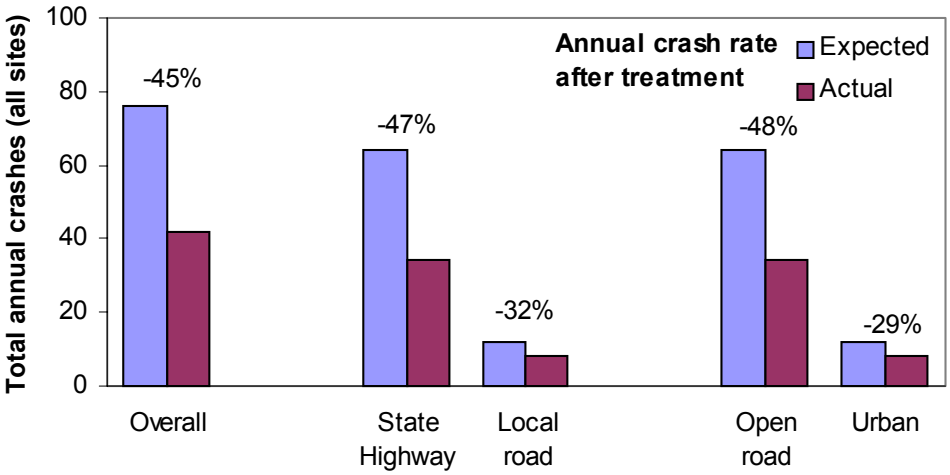
Substantial reductions in injury crashes were achieved at all site types (route, intersection and non-intersection), with the greatest reduction (67%) at non-intersection sites. Eight of these sites were at bridge approaches. At these sites, there was an average reduction in injury crashes of over 60% after installation of guardrails.

Sites where guardrail installation was expected to have a 'major' effect on safety experienced a greater average reduction in injury crashes (51%) than other sites (40%).

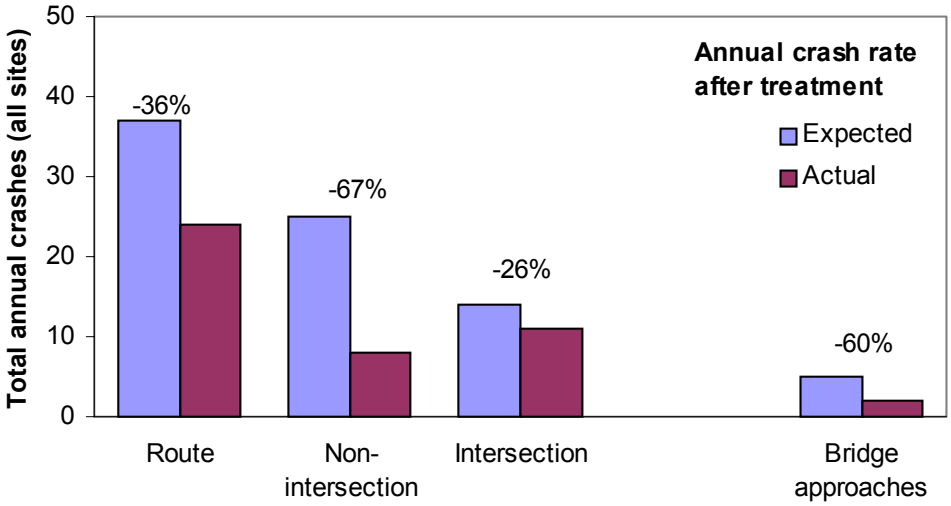
Fig 1 and Table 5 show the change in crash rate and the percentage reduction in crashes for various types of sites.

**Fig 1: Comparison of crash reductions by site type**

a) Crash reductions by road type and speed limit area




b) Crash reductions by site type



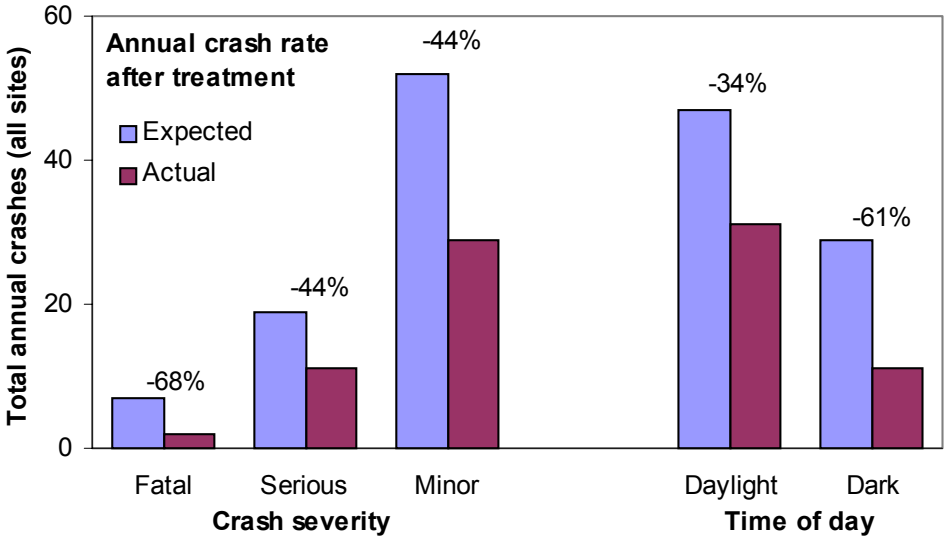

## 9.2 Crash type

Following the installation of guardrails, the number of 'loss of control' type crashes that resulted in injury was halved. Guardrails are also expected to reduce injuries in other types of crash, where a vehicle runs off the road as a result of the crash. This study found a 28% reduction in injury crashes across all other crash types.

There was a reduction of 61% in injury crashes at night (or in twilight) and of 34% in daytime crashes. The greater reduction in nighttime crashes is likely to reflect the higher proportion of loss of control type crashes at this time.

Substantial reductions in injury crashes were observed at all levels of crash severity. Fig 2 and Table 6 show the reduction in various types of crashes experienced at treated sites.

**Fig 2: Crash reductions by crash severity and night/day**




### 9.3 Reduction in severity of injury crashes

As discussed in section 7, *Effect of guardrails on crash severity*, the ratio of fatal and serious injury crashes to minor injury crashes gives an indication of reduction in severity within injury crashes. This ratio decreased by 13% after installation of guardrails, resulting in an estimated social cost saving of $7.8 million (over and above the saving achieved from the reduction in injury crashes).

### 9.4 Total social cost saving

Table 1 (see page 1) shows the total estimated saving in social cost at sites where guardrails have been installed, after controlling for external trends in injury crashes.

The reduction in open road injury crashes (assuming, conservatively, that these were reduced to non-injury crashes) contributed a social cost saving of $94.7 million. A further saving of $4.0 million was contributed by the reduction in injury crashes at urban sites. Severity migration from *fatal and serious* to *minor* injury crashes resulted in a further social cost saving of $7.8 million.

The total estimated social cost saving at sites where guardrails were installed was **$106 million**.

**Table 5. Crash reductions at sites overall and by site type**

| | Number of sites | Expected annual crashes after treatment | Actual annual crashes after treatment | % reduction in injury crashes[4] |
|---|---|---|---|---|
| **All sites** | 63 | 76 | 42 | 45 |
| **Road type** | | | | |
| State highways | 50 | 64 | 34 | 47 |
| Local roads | 13 | 12 | 8 | 32* |
| **Speed limit area** | | | | |
| Open road (all sites) | 51 | 64 | 34 | 48 |
| Open road (State highways only) | 46 | 60 | 31 | 49 |
| Urban roads | 12 | 12 | 8 | 29* |
| **Site type** | | | | |
| Route | 25 | 37 | 24 | 36 |
| Intersection | 11 | 14 | 11 | 26* |
| Non-intersection | 27 | 25 | 8 | 67 |
| Bridge approaches | 8 | 5 | 2 | 60* |
| **Expected safety effect of guardrails** | | | | |
| Major | 28 | 30 | 15 | 51 |
| Minor | 35 | 45 | 27 | 40 |

**Table 6. Crash reductions by crash type**

| | Crashes in study period (sample size) | Expected annual crashes after treatment | Actual annual crashes after treatment | % reduction in injury crashes[4] |
|---|---|---|---|---|
| **Light conditions** | | | | |
| Daylight | 202 | 47 | 31 | 34 |
| Dark/ twilight | 156 | 29 | 11 | 61 |
| **Movement group** | | | | |
| Loss of control | 212 | 49 | 23 | 54 |
| Other crash types | 147 | 27 | 20 | 28 |
| **Crash severity** | | | | |
| Fatal | 35 | 7 | 2 | 68* |
| Serious | 116 | 19 | 11 | 44 |
| Minor | 208 | 52 | 29 | 44 |

*Reductions marked * are based on small numbers of crashes and should be used with caution.*

[4] Percentage reduction includes adjustment for underlying crash trends, as described in section 5.