ASSESSING THE CRASH RISK IMPLICATIONS OF ROADSIDE HAZARDS

Dr Shane Turner, Associate (Transport), Beca Infrastructure Ltd, Christchurch, NZ
Alan Dixon, Project Manager, Land Transport Safety Authority, Wellington, NZ
Prof Graham Wood, Professor of Statistics, Macquarie University, Sydney, Australia

Abstract

This paper discusses the impact of roadside hazards on the occurrence and severity of rural single vehicle accidents and the important causal variables. The accident prediction models developed so far indicate that the location and type of roadside hazards, the consistency of the horizontal alignment and seal width are important predictor variables. Summary data on the number, location and types of roadside hazards found alongside rural roads in New Zealand is also presented. The roadside hazard predictions are based on a random sample of road sections surveyed throughout New Zealand.

1 Introduction

Roadside hazards are a major factor in many fatal and serious accidents, particularly in rural areas. A significant number of New Zealand rural (50%) and urban (27%) accidents involve at least one roadside hazard/object. A high proportion of accidents involving roadside hazards (85% plus) are single vehicle loss-of-control accidents.

A move towards more forgiving roadside environments, which are clear of roadside hazards, or where motorists are protected from hazards, is expected to reduce the severity of road accidents and significantly lower the road toll. The challenge is how to achieve such an objective when the public road network is over 90,000 km in length. Given the limited funding, central government focus will, at least initially, be on the more strategic and higher volume routes, but there are also opportunities, in combination with other works, such as maintenance, to remove hazards on lower volume roads. There is no doubt that the creation of a forgiving roadside environment, even on the strategic road network, will take many decades to achieve, and that improvement works need to be prioritised to get the maximum reduction in accidents for the money invested.

The first question to address in pursuit of the solution is how many hazards are there out on the road network. Until recently there has been very limited data on the number of roadside hazards on the public road network. This paper discusses recent research undertaken for the Land Transport Safety Authority (Turner, 2004), in which data on roadside hazards has been collected for rural roads and used to estimate the number of hazards by type in various territorial local authorities and nationally. The data collected shows various trends in terms of types of hazards and offset of hazards in different parts of the country.

A number of accident prediction models have been developed for total and individual hazard types and for serious (plus fatal) and all injury accidents. While more research is required to produce better fitting models, as the crash mechanisms are complex, the current models do indicate what factors appear to be important in accidents involving roadside hazards. The models provide some direction on where ‘road retrofit’ funding should be allocated in terms of major factors, such as location of hazards and traffic volume. This can be used in combination with the number of hazards in each region to specify priorities.

2 Accident Trends

An analysis was undertaken of all accidents nationally where a roadside object was specified as a contributing factor in the CAS database from 1998 to 2002. The analysis focused on single-vehicle accidents, as even when objects are a factor in multi-vehicle accidents the severity of the injury is often largely due to vehicle/vehicle interaction, and in most cases it is difficult to identify whether the roadside object did make the injury more severe.

Our analysis found that the same roadside objects tended to appear in most regions. Upright cliff / bank (C) and Ditch (V) were in the top five objects struck in each region. Fence (F), Tree (T), Over bank (E) and Pole (P) all appeared in at least half of the regions. The other roadside object to appear in the top five of any region was Guardrail (G), which appeared in the two major metropolitan areas (Auckland and Wellington) where there are substantial motorway/ expressway networks in place.

Accidents involving roadside objects are often more severe than accidents that do not involve objects. For example between 20% and 28% of reported accidents (injury and non-injury) involving a water body, tree or over bank are fatal or serious, compared with 13% of all single vehicle accidents and 9% of single vehicle accidents that do not involve a roadside object. Table 1 shows each of these statistics for the more commonly struck roadside objects (struck in more than 100 accidents) between 1998 and 2002.

Table 1 - Severity of Single Vehicle Rural Accidents Involving a Roadside Object (1998 to 2002)

Roadside Object	Number Accidents	Fatal	% Fatal	Serious	% Serious	Minor	% Minor	% Injury
B – Bridge	659	35	5%	99	15%	167	25%	45%
C – Cliff / Bank	4337	104	2%	445	10%	1430	33%	45%
E – Over Bank	1996	95	5%	227	11%	548	27%	43%
F – Fence	4946	145	3%	581	12%	1377	28%	43%
G – Guardrail	1705	28	2%	83	5%	338	20%	27%
I – Traffic Island	581	9	2%	27	5%	103	18%	25%
K – Kerb	164	6	4%	18	11%	43	26%	41%
L – Slip / Flood	110	3	3%	1	1%	21	19%	23%
P – Pole	2306	71	3%	264	11%	649	28%	42%
S – Sign	749	16	2%	82	11%	205	27%	40%
T – Tree	2190	113	5%	323	15%	751	34%	54%
V – Ditch	4198	99	2%	446	11%	1143	27%	40%
W – Animal	1155	7	1%	62	5%	151	13%	19%
X – Other	220	7	3%	27	12%	55	25%	40%
Z – Water Body	445	54	12%	69	16%	120	27%	55%
None (Recorded)	4412	53	1%	343	8%	779	18%	27%

Table 1 shows that fences are the most commonly struck roadside object in single-vehicle rural accidents. The severity of accidents involving fences though is only moderate compared to accidents involving Water Bodies (Z), Bridges (B) and Trees (T).

2.1 Roadside Hazard Effect Rating

It is unclear from the accident listing in CAS how much the roadside hazard contributed to the severity of the crash. The only way to identify the ‘effect rating’ or role that various roadside hazard had in accident occurrence and severity is to refer to the original traffic crash reports (TCRs)

A safety specialist reviewed 150 Traffic Crash Reports in an attempt to quantify the contribution of the seven most commonly struck roadside objects to the severity of a selection of rural accidents. This was a subjective exercise, limited by missing and incomplete information in many instances, and by complex accident situations.

The safety specialist reviewed each TCR and made a judgement as to the contribution of the roadside object to the injury severity using a four-tiered scale:

- “All” The object was responsible for the severity of the injuries
- “Major” The object was primarily responsible for the severity of the injury, however there may have been a minor contribution from another object or other source e.g. another vehicle
- “Minor” The object had a minor contribution to the severity of the injury. Other objects or other sources e.g. another vehicle, were the primary contributors
- “Nil” Even though an object was involved in the accident, it did not contribute to the severity of the injury

A simple weight matrix for combinations of levels of accident severity and contribution of roadside object to the severity was developed (Table 2).

Table 2 – Object-Severity Weight Matrix

		Injury Severity		
		Fatal	**Serious**	**Minor**
Roadside Object Contribution	All	9	6	3
	Major	6	4	2
	Minor	3	2	1
	Nil	0	0	0

Average object-severity scores were calculated by totalling the scores for each accident record and dividing by the number of accidents. Table 3 shows the results of the TCR review and object-severity scores.

Table 3 – Object-Severity Scores - TCR Review

Roadside Object	**Number of TCRs Reviewed**	**Average Object-Severity Weight Matrix Score**
P – Pole	25	3.16
C – Cliff/bank	29	3.10
T – Tree	26	2.46

Roadside Object	Number of TCRs Reviewed	Average Object-Severity Weight Matrix Score
V – Ditch	40	2.25
E – Over bank	24	2.17
G – Guardrail	23	1.96
F – Fence	37	1.43

"Pole (P)" and "Cliff / Bank (C)" are the two roadside objects with the highest Object-Severity matrix scores. This means that when a pole or cliff / bank is involved in an accident, the severity of the injury, contribution of the roadside object to the severity, or a combination of the two, will be higher than for other roadside objects.

3 Hazard Identification System

The hazard identification system developed during the roadside hazard study (Turner, 2004) provided a list of potential hazards to observe in the field. The system classifies hazards by type (e.g. concrete pole, tree and bridge end) and potential accident severity (e.g. small tree, medium tree and large trees). For each hazard a number of variables were gathered to allow a risk assessment of the hazard to be completed (this included proximity of hazard to the carriageway, the running distance along the route and how frangible or energy absorbing the hazard was) and also whether the hazard could be removed or relocated or motorists needed protection from the hazard. Hazards were classified into the following continuous and point hazard types.

(a) Continuous Hazards

Continuous hazards include side slopes, drains, railings, fences, hedges, and shoulders. The rating code for a continuous hazard were selected from Table 4.

Table 4 - Continuous Hazards Classification

Hazard	Code	Description
Side slope – down	D1	6:1 & 5:1 – just recoverable side slope (15-20%)
	D2	4:1 & 3:1 – Unrecoverable side slope (20-35%)
	D3	>3:1 – vehicle would overturn (>35%)
	D4	>3:1 with >50m fall or into water (>35%)
Side slope – up, retaining wall	U1	4:1 & 3:1– Unrecoverable side slope (20-35%)
	U2	>1:1 - upright cliff/embankment (>45%)
	U3	>12:1 – upright cliff with jagged rocky face, includes other retaining walls (>45%)
Drain	V1	Traversable, bring vehicle to controlled stop <4:1 slope (<25%)
	V2	>4:1 slope Unrecoverable <1m deep (>25%)
	V3	>1m deep (car trapped)
Guard Rail	G1	W section guard rail – includes W section bridge railing
	G2	Wire rope barrier
	G3	Concrete Barrier – includes concrete bridge parapets
	G4	Other, including bridge railing
Fence	F1	Post and wire – usually rural
	F2	Urban fence – wooden

Hazard	Code	Description
	F3	Public fence – steel, railing type
	F4	Sight railing
	F5	Fence – concrete

(b) Point Hazards

A point hazard includes poles, trees, bridges, roadside furniture, and other. Roadside furniture includes telephone boxes, rural delivery mailbox, power transformers, and the like.

Table 5 - Single Point Hazard Classification

Hazard	Code	Description
Concrete Pole	C1	Vierendeel Pole (windows in pole)
	C2	Round or square concrete lighting pole – lightly reinforced
	C3	Solid Concrete service pole – usually ‘I’ section strongly reinforced
Wooden Pole	P1	Frangible pole (Holes drilled near base – rare)
	P2	Between 100mm & 200mm – lightweight pole
	P3	>200mm – most wooden poles
Steel Pole	H1	Lighting column – Slip or frangible base, includes all fibreglass poles
	H2	Lighting column – ground planted <300mm dia. Most hollow section poles
	H3	Heavy weight steel without slip base >300mm
Tree	T1	50-100mm trunk – include if offset <3m
	T2	100-300mm trunk
	T3	>300mm trunk
Bridge End	B1	Full end treatment – BCT or NC
	B2	Partial treatment e.g. twisted ‘W’ section, fishtail plate
	B3	No treatment – steel/wood rails, solid concrete
	B4	A culvert for traversing a shallow side drain – side road or drive way
	B5	A culvert for traversing a deep side drain, or with a headwall
Sign	S1	<=100mm wood, 60mm steel, or slip base
	S2	>100-150mm wood, 60-120mm steel/aluminium, <=120mm box section support
	S3	Heavy support (>120mm) without slip base
Roadside Furniture	R1	Low impact e.g. sturdy letter box supports
	R2	Medium impact e.g. aluminium telephone box
	R3	High impact e.g. roadside transformer boxes

4 Data Collection

4.1 Sampling Design

The primary purpose of the sampling was to be able to predict with a reasonable level of precision the number of hazards of each type, regionally and nationally on rural roads. A number of sampling designs were considered in the study. The sampling framework was 57 rural territorial authorities. The remaining 17 territorial authorities were either predominately urban (15) or small (Kawerau and Chatham Islands). Rural roads within each TLA were further divided into five strata. This included State Highways and following flow bands 200 to 500, 500 to 1000, 1000 to 2000 and 2000 plus vehicles per day. The following sampling design were considered:

1. Simple random sample of road lengths from each flow category within each of the 57 TLAs.
2. Break down TLAs into 10 clusters based on object struck profiles (or proportion of accidents involving each object or hazard type), and sample one TLA from each cluster.
3. Break down TLAs into 10 clusters and collect data from at least one TLA in each cluster, and more than one TLA from large clusters.
4. Break down TLAs into more than 10 clusters, say 15 or 20 and sample one TLA from each cluster.

The selected sampling design was 3, as it offered the best prospect for gaining nation-wide data efficiently and within the cost constraints of the study. Table 6 shows the TLAs within each cluster.

Table 6 - TLAs in Each Cluster

Cluster	TLA	Cluster	TLA	Cluster	TLA
1	Far North Kaipara Rodney Hauraki	2	Whangarei Wairoa Mackenzie	3	Franklin Western Bay of Plenty Stratford
4	Otorohanga South Waikato Waitomo	5	Thames-Coromandel Taupo Rotorua	7	Matamata-Piako Manawatu
6	Waikato Waipa Gisborne Hastings Central Hawkes Bay South Taranaki Rangitikei Tararua Horowhenua Masterton Waimate Southland Gore	8	Whakatane New Plymouth Wanganui Kapiti Coast South Wairarapa Tasman Marlborough Buller Westland Hurunui Banks Peninsula Waitaki Central Otago Clutha	9	Opotiki Ruapehu Porirua Upper Hutt Kaikoura Grey Queenstown Lakes
				10	Carterton Waimakariri Selwyn Ashburton Timaru

To determine the sample size within each TLA the data collected in the Western Bay of Plenty District pilot study was analysed. An analysis was undertaken of the standard deviation of the length of post and wire fence and number of traffic signs. The size of the area over which an estimate is required increases from a flow category within a region through to the entire country. Sampling costs are proportional to sample size, so the "200" option would cost four times that of the "50" option. Table 7 shows the expected standard error for various samples sizes in the estimate of the length of post and wire fence. Precision improves as the sample size increases and as the data is aggregated.

Table 7 - Sample Size vs. Standard Error for Post and Wire Fence

Sample Size Per TLA	Std Deviation (Flow Category within TLA)	Std Deviation (TLA within Region)	Std Deviation (Region)	Std Deviation (National)
50	±95	±40	±20	±6

100	±70	±30	±15	±4
150	±55	±25	±11	±3.5
200	±50	±20	±9	±3

Table 8 shows the relationship between sample size and margin of error for estimates of number of small signs (code S1) per km. Since the original data exhibited little variation, these values were estimated more easily than Post and Wire Fence (F1).

Table 8 - Sample Size vs. Margin of Error for Number of Small Signs

Sample Size per TLA	Std Deviation (Flow Category within TLA)	Std Deviation (TLA within Region)	Std Deviation (Region)	Std Deviation (National)
50	±0.45	±0.20	±0.09	±0.03
100	±0.32	±0.14	±0.06	±0.02
150	±0.26	±0.12	±0.05	±0.015
200	±0.22	±0.10	±0.04	±0.01

The larger the variation of a continuous variable, the harder it is to estimate. Category F1 (post and wire fence) has a large variation. For a discrete variable, the higher the mean count per km the harder it is to estimate. Thus, the hardest variables to estimate were sought, as the variability in these determined the sample size. The preferred sample size was 100 km of data for each TLA, as this gave a reasonable standard deviation at the regional and national levels, which are the estimates of most interest to the Land Transport Safety Authority. However the cost of a 100km sample in each TLA was prohibitive and hence a 50 km sample size was selected for the main study.

4.2 Sample Size

Roadside hazard data were collected for over 850 km of rural roads, including 414 km of State highways. Using stratified random sampling, 1 km sections were selected in 16 territorial local authorities (TLAs), from Rodney in the north to Southland in the south. For the majority of TLAs, data was collected for 50 such 1 km sections.

Data collected for each 1 km sample section were:

- Road terrain type (level, hilly and mountainous)
- Hazard displacement (or running distance)
- Hazard offsets (from edgeline or edge of seal)
- Curve data (easy > 85 kph, medium 55 – 85 kph, and severe ≤ 45 kph)
- Side slope gradient – beyond the shoulder
- Drainage type
- Number and length of point and continuous hazards
- Mitigation of each roadside hazard (remove, relocate or protect)

Table 9 shows the number of 1 km survey lengths in each TLA for each of the five flow bands.

Table 9 - Surveyed Lengths by Flow Band

TLA	No of 1 km sections surveyed in each Flow Band

	Band 1 (200-500 vpd)	Band 2 (500-1,000 vpd)	Band 3 (1,000-2,000 vpd)	Band 4 (over 2,000 vpd)	Band 5 (State Highway)	Total
Ashburton	18	5	5	0	22	50
Clutha	9	6	5	0	30	50
Grey	15	5	5	0	25	50
Hastings	9	6	3	10	22	50
Horowhenua	8	12	6	2	22	50
Kapiti Coast	7	6	1	0	8	22
Manawatu	14	5	3	8	20	50
Marlborough	9	6	5	2	28	50
New Plymouth	15	4	6	0	25	50
Rodney	7	6	5	7	25	50
Rotorua	12	3	7	5	23	50
Ruapehu	5	2	8	0	35	50
Southland	15	5	5	0	25	50
South Taranaki	10	11	2	0	27	50
South Waikato	11	5	5	0	29	50
Western Bay Of Plenty	18	14	25	11	32	100
Whangarei	10	10	8	6	16	50
Total	**192**	**111**	**104**	**51**	**414**	**872**

In some TLAs there are few district roads carrying >1,000 vehicles per day. Hence there are relatively few sections sampled in flow bands 3 and 4. Almost half of the road sections were on State highways.

5 Study Results

The data collection exercise has produced a large database of roadside hazard data. Summary data has only been produced on some of the trends in the data, and further analysis of the data is proposed. A number of the key trends in the hazard data are given below. The hazard data collected includes all hazards within 9m of either the edgeline where one is marked, or if not marked the edge of seal. It only includes hazards that errant vehicles can hit and therefore does not include objects/hazards that are on top of an embankment, such as a concrete pole, or at the bottom of a cliff.

5.1 Major Hazards Types by Flow Band

There was an expectation that the occurrence of roadside hazards on state highways and higher volume rural roads would be less than on lower volume roads, as such roads are more likely to have been realigned, have an "engineered alignment" or have received some form of 'safety retrofit', be it specifically targeted or as part of maintenance works. **Figure 1** and **Figure 2** shows the average number of discrete and continuous hazards observed in each surveyed TLA for the major hazard types.

Figure 1 - Average Discrete Major Hazards by Type for each Flow

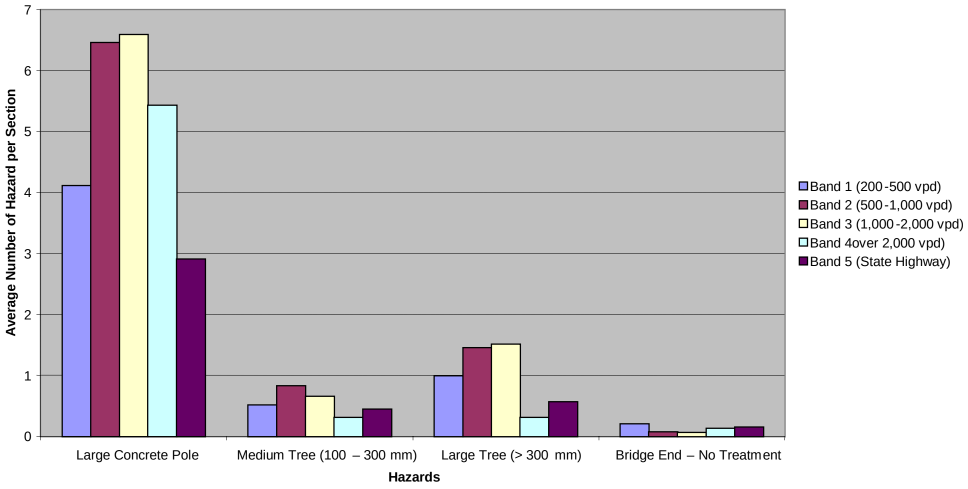
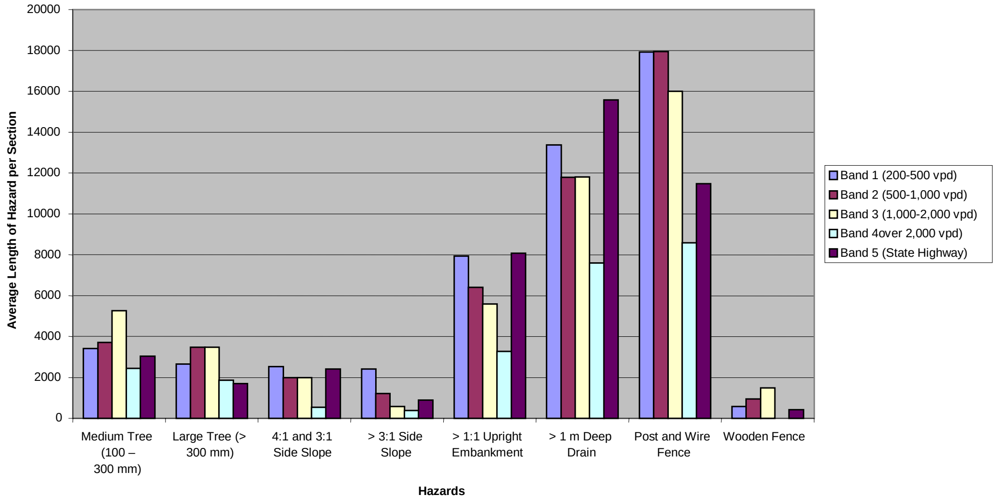


Figure 2 - Average Continuous Major Hazards by Type for each Flow Band



The number of severe discrete hazards per kilometre is typically lower on State Highways than lower volume roads. The number of discrete hazards is also lower on higher volume rural roads (>2000vpd). For continuous hazards there is no overall trend. The length of medium and large tree hazard on state highways and higher volume district roads is lower than the other flow categories. However for deep drains, embankments and side slopes State Highways tend to have a longer average length of hazard per kilometre than most of the district flow categories, while the higher volume district roads have generally a shorter length of hazard.

5.2 Number Hazards in each TLA

New Zealand has a diverse landscape and anecdotal evidence suggests that some roadside hazards are more predominant in different TLAs and regions of the country. This hypothesis is also supported by the different proportions of rural accidents that involve various roadside objects/hazards in different regions of the country. Figures 3 to 5 show the number of large concrete poles and large trees per kilometre and length of large ditches per section (maximum is 2km) in each of the surveyed TLAs. The figures show that there is a large range in the number or these hazards per kilometre observed in the sampled road sections.

Figure 3 - Large Concrete Pole

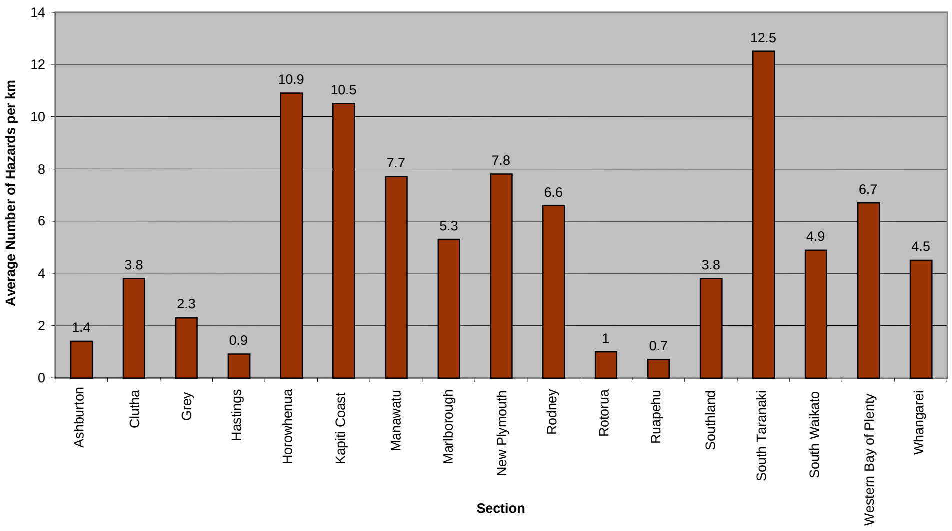


Figure 4 - Large Tree (>300 mm)

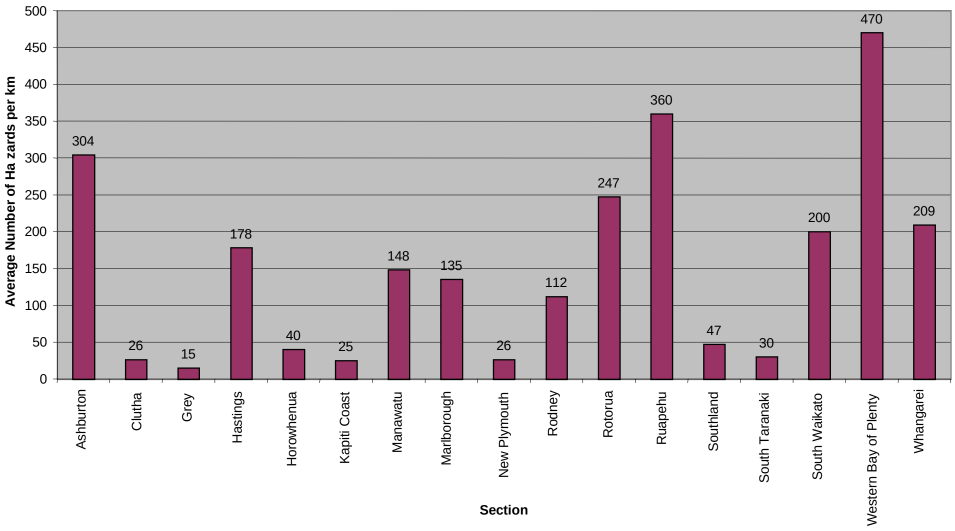
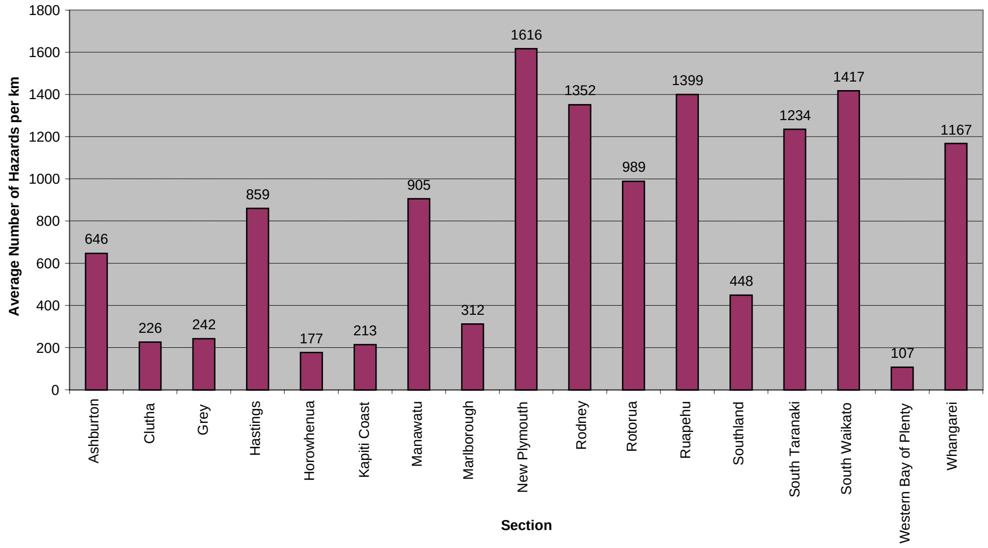


Figure 5 - > 1 m Deep Drain (Continuous)

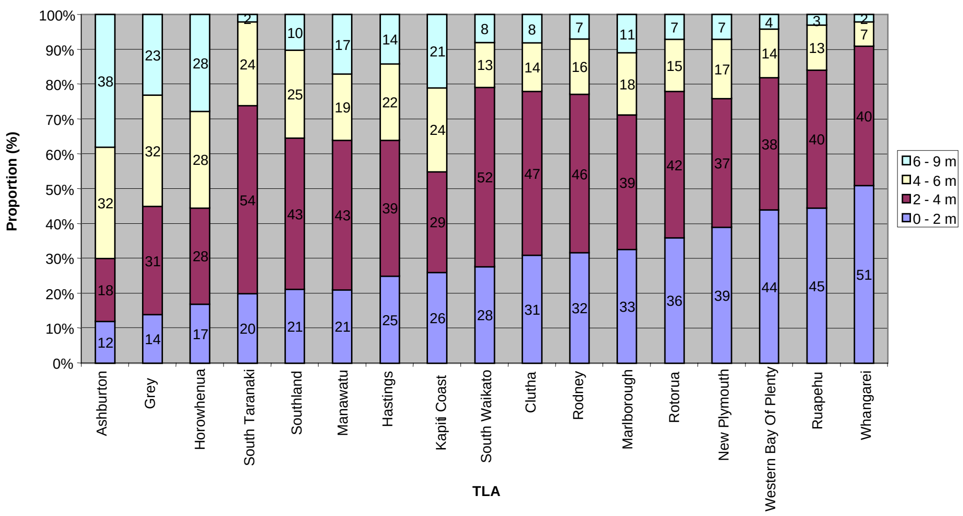


5.3 Hazard Offsets

Figure 6 shows the number of hazards within various offsets from the edge of the sealed carriageway. It should be noted that where roadsides are untraversable, e.g. when the road is in a cutting, roadside hazards behind the untraversable hazard and within 9m of the edge of seal have not been recorded.

Figure 6 shows that there are a large proportion of roadside hazards within 0 to 2 m of the road in Whangarei (51%), Ruapehu (45%) and Western Bay of Plenty (44%). At the other end of the scale, Ashburton, Grey and Horowhenua have the majority of their hazards at least 4m from the edge of the road.

Figure 6 - Proportion of all Hazards within



6 Regional and National Estimates of Severe Roadside Hazards

Table 10 shows the estimated number of roadside hazards on rural roads (with a volume above 200vpd and within the 57 TLAs) for the various TLA clusters and nationally.

Hence it is estimated that there are around 94,000 solid concrete poles alongside (within 9m) New Zealand rural roads (with flows greater than 200vpd). It is also estimated that there are 8500km of upright cliff/embankment and 3000km of unrecoverable sideslope.

This highlights that there are a lot of hazards alongside the rural road network and removal, relocation or protection from such hazards needs to be prioritised, as it will take many decades at current levels of funding to even ‘safety retrofit’ the strategic road network. To assist in prioritising the ‘safety retrofit’ a number of accident prediction models were developed, as outlined in the next section.

7 Accident Prediction Models

Accident prediction models were developed using generalised linear modelling techniques developed by Turner (1995). Models were developed for all roadside hazard accident types combined and disaggregated for each of the main roadside hazard types, (e.g. poles and trees). The best fitting models are presented below. A large number of model forms were considered including various combinations of hazard off-set ranges and for both severe and total hazard types. There is still substantial work required to develop models that explain a significant amount of the variability in the data. We recommend caution when using the models presented below.

7.1 Total Accident Models

Equation 1 presents the accident prediction model for all single vehicle injury accidents in which a roadside hazard of any form (excluding parked vehicles and livestock) has been struck.

$$\mathbf{A_{5T} = 1.01E^{-5} \times Q^{1.083} \times WDH^{0.652} \times ALM^{0.130} \times HVL03^{0.160}} \qquad \textit{(Equation 1)}$$

A_{5T} = Injury accidents in 5 year period per km

Q = 2 way flow (AADT)

WDH = Sealed road width (m)

ALM = Weighted length (m) of serious, moderate and easy curves per km

Weightings:	Serious	=	1
	Moderate	=	0.5
	Easy	=	0.25

HVL03 = Length of Severe hazards within 3m of the edge line or edge of seal per km Hazard Type Accident Models

Table 10 - Prediction of Roadside Hazards by Cluster

	Solid Concrete Pole	**100–300 mm Trees**	**>300 mm Trees**	**Driveway Culvert (no headwall)**	**Low Impact Furniture, e.g. letterboxes**	**Unrecoverable Side Slope**	**Upright Cliff / Embankment**	**4:1 Slip Unrecoverable**	**Post and Wire Fence**	**Urban Fence**
Cluster	**C3**	**T2**	**T3**	**B4**	**R1**	**D2 (km)**	**U2**	**V2**	**F1**	**F2**
	(no.)	**(no.)**	**(no.)**	**(no.)**	**(no.)**	**(km)**	**(km)**	**(km)**	**(km)**	**(km)**
1	15950	35141	10568	15184	8845	274	1375	62	1651	118
2	4123	153	243	87	71	201	660	34	729	28
3	10001	17965	28037	11469	5819	314	1010	100	1430	215
4	5161	586	5973	1994	702	149	567	13	781	35
5	744	4876	9722	4296	969	254	830	4	669	32
6	22875	23673	17924	15289	10638	551	1206	3236	5356	143
7	9105	4436	6820	2908	3372	103	361	282	1212	35
8	23084	24887	13189	17024	11127	697	1467	2468	5012	145
9	1337	8230	9425	6437	1128	332	879	270	813	8
10	2064	12457	27781	6952	2499	151	125	527	2567	26
Total	**94000**	**132000**	**130000**	**82000**	**45000**	**3000 km**	**8500 km**	**7000 km**	**20000 km**	**800 km**

7.2 Models for Major Hazard Types

Hazard Type Accident models estimate the total number of single vehicle accidents in which a specific hazard is struck. The following equations can be used to predict the number of accidents involving each hazard type.

(a) Bridges

$$\mathbf{A_{10\ BRIDGE} = 1.01E^{-5} \text{ x } Q^{-0.424} \text{ x } WDH^{2.586} \text{ x } B2\ 03^{2.119} \text{ x } B3\ 03^{2.790}} \qquad \textit{(Equation 2)}$$

$A_{10\ \mathbf{BRIDGE}}$ = Number of accidents in a 10 year period involving Bridges per km
B2 03 = Number of bridge ends with “Partial” End Treatment (twisted W section or fishtail plate)
B3 03 = Number of bridge ends with no treatment

(b) Ditches

$$\mathbf{A_{10\ DITCH} = 0.52 \text{ x } Q^{0.668} \text{ x } WDH^{-3.202} \text{ x } ALM^{-0.142} \text{ x } HVL03^{0.073} \text{ x } V2\&V3\ 03^{0.293} \text{ x } B4\&B5\ 03^{b6}} \qquad \textit{(Equation 3)}$$

$A_{10\ \mathbf{DITCH}}$ = Number of accidents in a 10 year period involving Ditches per km
V2&V3 03 = Length of ditches <4:1 slope or >1m deep within 3m of the edge line
B4&B5 03 = Number of Culvert Ends within 3m of the edge line

(c) Poles

$$\mathbf{A_{10\ POLES} = 9.34\ E^{-6} \text{ x } Q^{-0.17} \text{ x } ALM^{\ 0.129} \text{ x } POLE\ 09^{0.152}} \qquad \textit{(Equation 4)}$$

$A_{10\ \mathbf{POLES}}$ = Number of accidents in a 10 year period involving Poles per km
POLE 09 = Length of poles within 9m of the edge line – each pole is approximated as 30 m of continuous hazard

(d) Trees

$$\mathbf{A_{10\ TREES} = 0.0102 \text{ x } Q^{1.036} \text{ x } WDH^{-4.569} \text{ x } ALM^{\ 0.100} \text{ x } TREE\ 09^{0.431}} \qquad \textit{(Equation 5)}$$

$A_{10\ \mathbf{TREES}}$ = Number of accidents in a 10 year period involving Trees
TREE 09 = Length of Trees within 9m of the edge line - each discrete tree is approximated as 30 m of continuous hazard (total can exceed 2,000 m)

8 Conclusion and Way Forward

There are a large number of roadside hazards on rural roads in New Zealand. For the first time we can predict the number of hazards and therefore the size of the problem. It is likely that the removal of roadside hazards on strategic roads, even those close to the edge of seal will take many decades (at current funding levels) and that methods to prioritise ‘safety retrofits’ need to be developed to ensure funding is being spent where there is the greatest need.

The accident prediction models developed so far indicate some of the important variables that can contribute to the number of accidents involving roadside hazards. These include the number of severe hazards within 3m of the edge of seal, the traffic volume, the road width and the road alignment. Such variables should be considered in prioritising “safety retrofits”.

However at this stage the models are relatively rough and further work is required to assess the effect of road alignment and gradient on the number of vehicle encroachments into the roadside and how far motorists encroach into the roadside on curves, compared with straights. Further work is also required on the relative hazard weighting to place on the various sub-types within each object type, e.g. small tree versus large tree.

9 References

Turner, S A “Assessing the Crash Risk Implications of Roadside Hazards”, Unpublished Research Report prepared for the Land Transport Safety Authority, June 2004.

Turner, S A “ Estimating Accidents in a Road Network” PhD Thesis, University of Canterbury, School of Engineering, 1995.