Prepared for Waka Kotahi NZ Transport Agency

THE SAFETY IMPACT OF LIGHTING ON A PREVIOUSLY UNLIT SECTION OF SH22

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1 EXECUTIVE SUMMARY

In September 2011 a rural, 100km/h, approximately 7 km-section of SH22 was lit to V3 standard using LED luminaires. This was the first category V installation installed in New Zealand which used LED lighting. Previously there was no route lighting in place, just some intersection flag lights. The LED installation has centrally controlled dimming capability and was dimmed after midnight to a level of V4/V5.

The purpose of this study was to discover any evidence of a positive safety impact associated with the lighting and any impact of the post-midnight dimming.

Analyses were carried out for the following before and after periods:

Eight years before and after the lighting installation
Five years before and after the lighting installation

The comparisons were carried out for all types of crash movements and also after excluding crash movements C and D which are single vehicle crashes involving loss of control, leaving the road and cornering. These C and D types of crashes tend not to be influenced downwards by lighting so may obscure positive changes in other movement categories. C and D movement crashes are also considered separately. as there is a possibility that lighting may sometimes be associated with increases in these crashes, possibly by way of improving the driver perceived road environment enough for some drivers to choose imprudently higher speeds. Only crashes involving injury were included in the analyses.

The conclusions made were that:

- This study suggests an overall beneficial impact on road safety of the LED lighting installed on SH22 in 2011.
- The net impact appears to be the sum of a positive impact on crashes involving more than one vehicle and a smaller, possibly negative, impact on single vehicle C and D type crashes.
- Non C and D type crashes, the group of crashes on which lighting appears to have its main impact, were absent post-midnight in the lit area for 5 years both before and after the change, this may relate to low traffic volumes, where vehicles in close proximity may be a relatively rare occurrence. Lighting may not be required under such conditions.
- This study has been hampered by small numbers of crashes to work with. Similar work involving more stretches of road would add to the precision of the study

2 BACKGROUND

In 2015 In September 2011 a rural, 100km/h, around 7 km-long section of SH22 was lit to V3 standard using LED luminaires. This was the first category V installation installed in New Zealand which used LED lighting. Previously there was no route lighting in place, just some intersection flag lights. The LED installation has centrally controlled dimming capability and was dimmed after midnight to a level of V4/V5. In 2015 a classic before and after crash study was carried out. The study looked at 6 years of crash data, 3 years before the introduction of lighting and 3 years after. The before and after study (Jackett and Frith, 2015). found little evidence of a crash reduction at that stage. It was recommended that further work be done once 5 years data before and after had been gathered. This report provides the results of that further work.

Any results found here will be indicative rather than definitive. The number of crashes involved is unlikely to be enough to achieve statistically significant except in rare cases. However, this does not in any way indicate that the lighting is ineffective, as long as the indications are in the right direction. It is timely here to quote Hauer (1983) who stated:

> *The real-life setting in which research on the effectiveness of safety countermeasures has to be conducted is characterised by relatively small samples and deals with countermeasures the effect of which is typically small. The conventional test of a hypothesis in these circumstances will usually return the answer: The hypothesis no effect" cannot be rejected. The net result of this built-in conservatism is that most real-life countermeasures are branded as "shown not effective". This in turn leads to perpetration of the status-quo and to stagnation.*

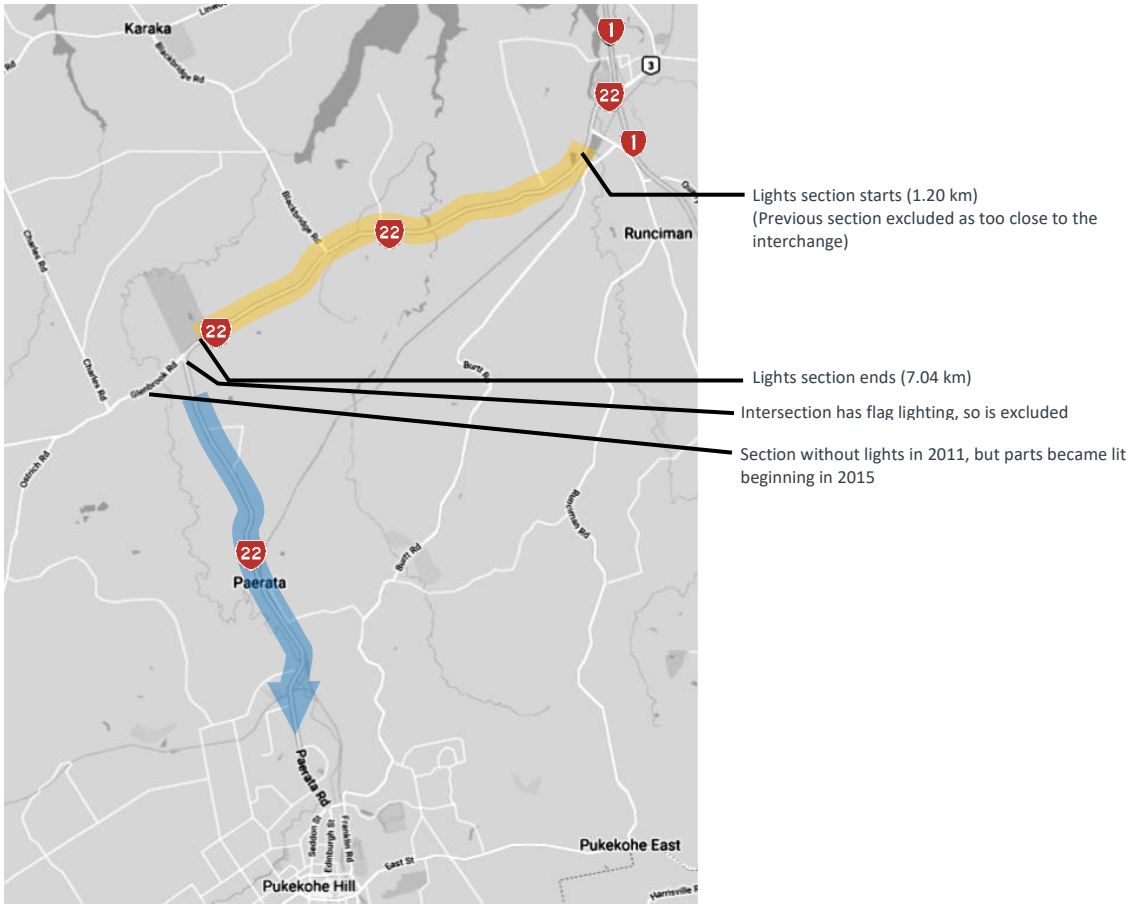
Also, this study relates to a stretch of SH22 where there was no lighting before the LED lighting was installed. Its results have no bearing on the yet unresolved question of whether there is any safety differential between HPS lighting and LED lighting.

3 DATA FOR THIS STUDY

The crashes extracted from CAS on 29/10/2020. They were filtered using a polygon drawn roughly around SH22 and "On state highway". This covers SH22 from the SH1 ramps to Lough Bourne Drive. The Chainage was obtained via mobileroad.org batch conversion. The Easting and Northing from CAS were converted to Route Positions. Where the Route Position came out as a road name, such as BURBERRY RD/0, mobileroad.org was used to find the chainage at the intersection and assigned that value. Crashes on the section before the lights start have been excluded as have crashes within 50m of previously flag-lit intersections. The lit section is of length 6.84km and Figure 1 is a map illustrating the section. The lights are assumed to have become operational on 1/9/2011.

Adjacent to the lights section is another section that was unlit when the lights became operational however this section could not be used as a comparison length as substantial parts of it became lit beginning in 2015.

Figure 1. Map illustrating the lit and unlit sections



4 ANALYSIS PURPOSE AND METHOD

The purpose of this exercise is to discover whether there is any evidence of a positive safety impact associated with the lighting and any impact of the post-midnight dimming. Indicators of change used include:

- Changes in night crashes in the lit section before and after the lights were installed
- Changes in the ratio of the night crash rate per million vehicles, to the day crash rate per million vehicles in the lit section before and after the change.

All analyses relate to the lit section. The ratio of night crashes to day crashes is a commonly used indicator of the impact of lighting, in cases when lighting is installed. In a before and after study setting, its efficacy as an indicator depends on the ratio of the traffic at night and traffic during the day being stable. The data needed to check this is not available currently. The same applies to the similar ratio using rates. Traffic counts used were from 2018 and 2019.

Analyses were carried out for the following before and after periods:

- Eight years before and after the lighting installation
- Five years before and after the lighting installation

The shorter period means a smaller number of crashes to work with and thus less precision. The longer period provides more crashes but a greater chance of extraneous factors muddying the result. The comparisons were carried out for all types of crash movements and also after excluding crash movements C and D which are single vehicle crashes involving loss of control, leaving the road and cornering. The crashes data excluding movements C and D are referred to henceforth as “multi-vehicle crashes”. They do not in this context include pedestrian crashes. These types of crashes tend not to be influenced downwards by lighting (Jackett and Frith, 2015) so may obscure positive changes in other movement categories. C and D movement crashes are also considered separately. This is because as there is a possibility that lighting may sometimes be associated with increases in these crashes, possibly by way of improving the driver perceived road environment enough for some drivers to choose imprudently higher speeds.

5 BEFORE AND AFTER CRASH COMPARISONS

5.1 CRASHES EIGHT YEARS BEFORE AND AFTER INSTALLATION

5.1.1 ALL CRASHES

Table 1 illustrates night crashes before and after installation of the lighting while table 2 looks at the ratio of night crashes to day crashes.

Table 1: Night crashes eight years before and after lighting installed

	Before	After	Change	% change
Injury crashes	14	19	5	36%
High severity crashes	4	3	-1	-25%

Table 1 indicates night injury crashes (being fatal and serious and minor injury crashes) have increased, while high severity crashes (being fatal and serious injury crashes) have decreased by one.

Table 2 looks at the ratio of night crashes to day crashes, eight years before and after installation of the lighting. A higher ratio or an increase in a ratio means night crashes are increasing relative to day crashes.

Table 2: Night to day crash ratio eight years before and after lighting installed

	Before	After	Change	% change
Injury crashes	0.42	0.58	+0.16	36%
High severity crashes	0.36	0.38	+0.02	3%

Table 2 indicates that the night/day crash ratio has remained steady (increasing by only 3 percent) for fatal and serious injury crashes with an increase for all injury crashes. Multi-vehicle crashes

Table 3 illustrates multi-vehicle night crashes before and after the change while table 4 looks at the ratio of multi-vehicle night crashes to day crashes. Table 3 indicates that for all levels of injury in the dark, the number of crashes has decreased or remained steady.

The changes in night injury crashes are quite different for multi-vehicle crashes than indicated in Table 1 for all injury crashes, being single vehicle crashes and multi-vehicle crashes.

Table 3: Multi-vehicle night crashes eight years before and after lighting installed

	Before	After	Change	% change
Injury crashes	8	6	-2	-25%
High severity crashes	3	3	0	0%

The night to day ratio (table 4) has decreased for multi-vehicle injury crashes. This is a substantially greater difference than indicated for all (single vehicle and multi-vehicle) injury crashes in table 2.

Table 4: Multi-vehicle night to day crash ratio eight years before and after lighting installed

	Before	After	Change	% change	Before	After	Change	% change
Injury crashes	0.35	0.23	-0.12	-34%	0.13	0.42	+0.29	233%
High severity crashes	0.30	0.38	+0.08	25%	0.00	0.50	+0.50	-

5.2 CRASHES FIVE YEARS BEFORE AND AFTER INSTALLATION

5.2.1 ALL CRASHES

Table 5 illustrates night crashes five years before and after installation of the lighting while table 6 looks at the ratio of night crashes to day crashes.

Table 5: Night crashes five years before and after lighting installed

	Before	After	Change	% change
Injury crashes	9	8	-1	-11%
High severity crashes	3	1	-2	-67%

Table 5 indicates that for all levels of injury in the dark, the number of crashes has decreased.

Table 6 depicts the night to day crash ratio five years before and after installation of the lighting.

Table 6: Night to day crash ratio five years before and after lighting installed

	Before	After	Change	% change
Injury crashes	0.45	0.36	-0.09	-19%
High severity crashes	0.60	0.14	-0.46	-76%

Table 6 indicates that the night to day ratio has decreased at all levels of severity.

5.2.2 MULTI-VEHICLE CRASHES

Table 7 illustrates night crashes five years before and after installation of the lighting while table 8 looks at the ratio of night crashes to day crashes.

Table 7: Multi-vehicle night crashes five years before and after lighting installed

	Before	After	Change	% change
Injury crashes	7	3	-4	-57%
High severity crashes	3	1	-2	-67%

For injury crashes (table 7) there has been a substantial decrease. However, numbers of crashes are very small so this indication should be treated with caution.

Table 8 indicates the night to day crash ratios.

Table 8: Multi-vehicle night to day crash ratio before and after lighting installed

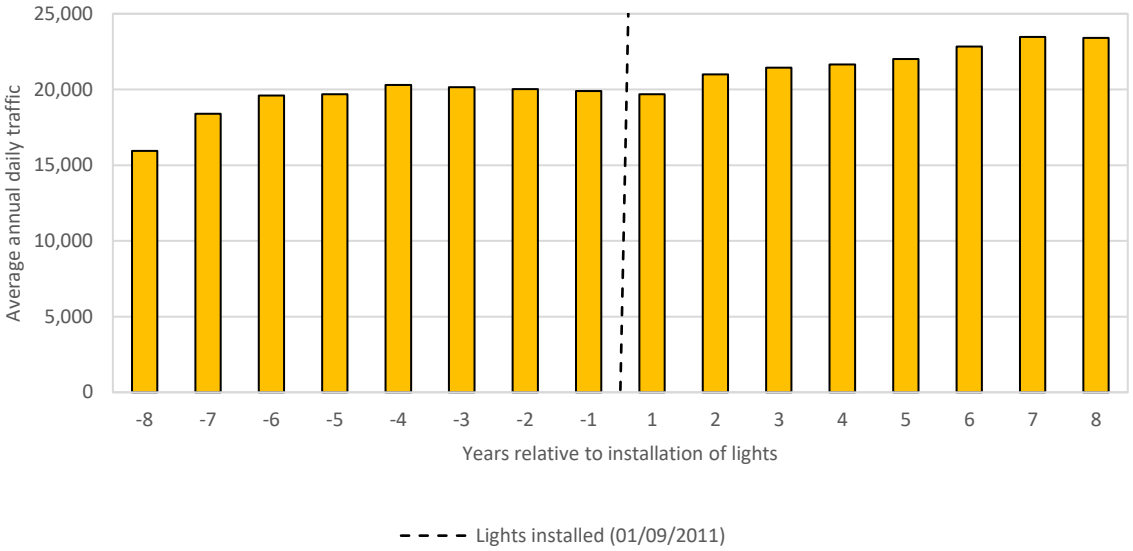
	Before	After	Change	% change
Injury crashes	0.54	0.17	-0.37	-69%
High severity crashes	0.75	0.14	-0.61	-81%

Again, from table 8 there are substantial decreases in the night to day crash ratio.

5.3 CRASH RATE PER 10^6 VEHICLES

Figure 2 looks at the AADT (Average Annual Daily Traffic) on the lit section for 8 years before and after lighting installation. The series of traffic flows is built from extrapolations between available traffic counts.

Figure 2: Traffic flow on lit section of SH22 for eight years before and after the lighting installation



The following section looks at crashes/million vehicles rather than crashes to correct for this changing traffic. It looks at all crashes (figure 3) and multivehicle crashes (figure 4).

For all injury crashes figure 3 indicates that the day crash rate may decrease slightly while it is difficult to discern any change in pattern of night crash rate before-and-after installation of the lighting. In the first two years after installation of the lighting, the night crash rate appears near to the day crash rate. Subsequent to that, the night crash rate generally increases relative to the day crash rate. For multi vehicle crashes (figure 4), there was an obvious decrease in the rate of dark crashes with the day crash rates staying fairly steady.

Figure 3: **All** Injury crashes per million vehicles for lit section

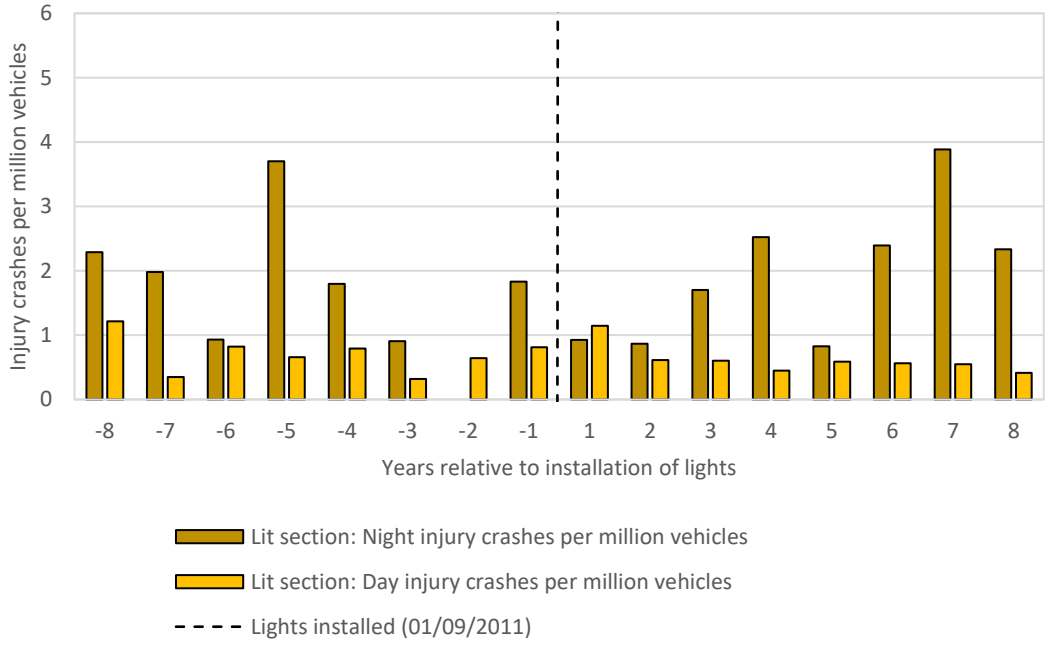
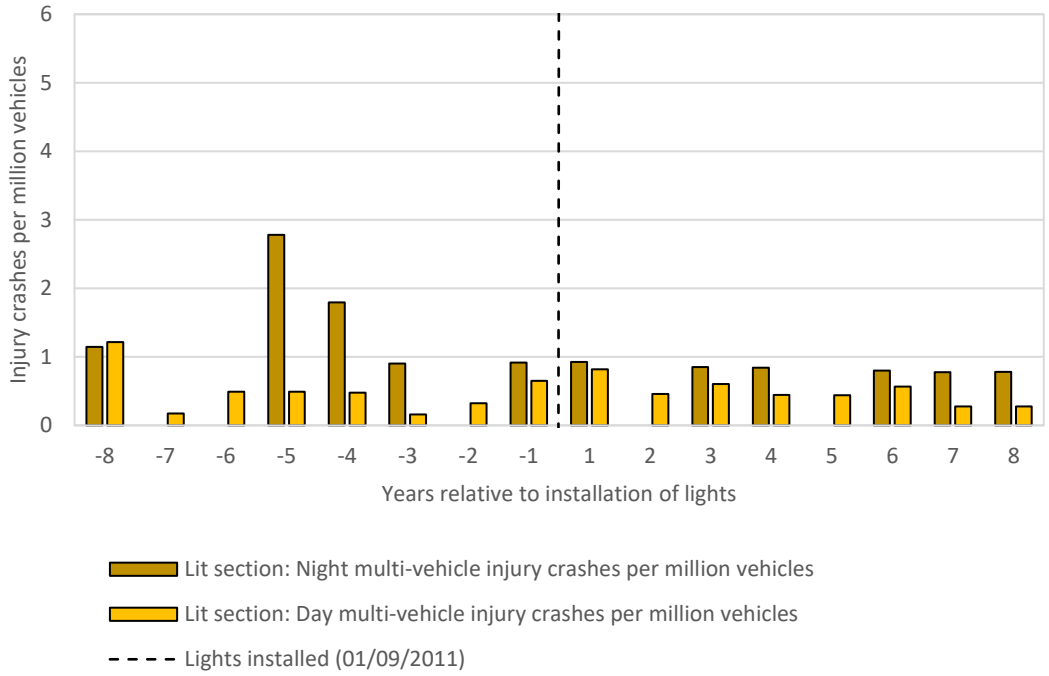


Figure 4: **Multi vehicle** crashes per million vehicles for lit section



Aggregated crash rates were addressed for 5-year before and after periods, to smooth the very lumpy year by year data shown in figures 3 and 4 and aid discernment of change. Eight-year aggregations were not used as it was considered that this was too long a period over which to aggregate the traffic flows. The crash rates per million vehicles over these periods are illustrated in table 9.

Table 9: Before and after injury crashes per 10^6 vehicles for all crashes and multi-vehicle crashes

All crashes	Before	After	% change	Multi-veh, crashes	Before	After	% change
Night	1.6	1.4	-15.9	Night	1.3	0.5	-59.4
Day	0.6	0.7	4.1	Day	0.4	0.5	30.8
Night/Day Ratio	2.5	2.1	-19.2	Night/Day Ratio	.3.3	0.9	-69.0

Table 9 indicates that night multivehicle crash rates decreased by a greater percentage than all night crashes. The changes were 19.2 % for all crashes and 69% for multivehicle crashes.

5.4 SINGLE VEHICLE OFF-ROAD, LOST CONTROL ON STRAIGHT & CORNERING CRASHES (C AND D TYPE).

Multi-vehicle crashes appear to be reduced by lighting more than all crashes when multivehicle crashes are defined as all crashes minus C and D type crashes. This implies that lighting may be associated with increases in C and D type crashes. There is some evidence pointing in this direction from the results of this study. Looking at injury crashes eight years and five years before and after the change results in Table 10.

Table 10 indicates that the lighting introduction coincided with increases in night crashes and decreases in day crashes irrespective of whether 5 years or 8 years were used as the before and after periods. These results indicate, bearing in mind caution associated with small numbers, a possible move to higher night crashes for these crash movements in the presence of lighting. This would be a weak indication by itself, but broadly similar results have been published before (Jackett and Frith, 2015)

Table 10: C and D type injury crashes before and after lighting

	Eight years before and after	
	Before	After
Night	6	13
Day	10	6
Night/Day Ratio	0.60	2.17
	Five years before and after	
	Before	After
Night	2	5
Day	6	3
Night/Day Ratio	0.33	1.67

5.5 NIGHT CRASHES BEFORE AND AFTER MIDNIGHT

The lighting is dimmed after midnight, so it is worthwhile to investigate any impact of this on crashes. The following looks at dark crashes before and after midnight. This is done for 8 years before and after the change and for 5 years before and after the change.

5.5.1 ALL CRASHES EIGHT YEARS BEFORE AND AFTER INSTALLATION

Tables 11 and 12 address injury crashes before and after midnight respectively.

Table 11: Night injury crashes **before midnight** for eight years before and after lighting installed

	Before	After	Change	% change
Injury crashes	7	9	+2	29%
High severity crashes	3	3	0	0%

Table 12: Night injury crashes **after midnight** for eight years before and after lighting installed

	Before	After	Change	% change
Injury crashes	4	10	+6	150%
High severity crashes	1	0	-1	-100%

Table 11 indicates increases in injury crashes before midnight. Table 12 shows mixed results.

5.5.2 MULTI-VEHICLE CRASHES EIGHT YEARS BEFORE AND AFTER INSTALLATION

Tables 13 and 14 address multi-vehicle injury crashes before and after midnight respectively.

Table 13: **Multi-vehicle** night injury crashes **before midnight** for **eight** years before and after lighting installed

	Before	After	Change	% change
Injury crashes	6	5	-1	-17%
High severity crashes	3	3	0	0%

Table 14: **Multi-vehicle** night injury crashes **after midnight** for **eight** years before and after lighting installed

	Before	After	Change	% change
Injury crashes	0	1	+1	-
High severity crashes	0	0	0	-

A decrease of multi-vehicle injury crashes before midnight may be indicated. The numbers are small for multi-vehicle crashes after midnight, which is likely related to lower traffic volumes during this period.

5.5.3 ALL CRASHES FIVE YEARS BEFORE AND AFTER INSTALLATION

Tables 15 and 16 address multi-vehicle injury crashes five years before and after midnight respectively.

Table 15 Night injury crashes **before midnight** for **five** years before and after lighting installed

	Before	After	Change	% change
Injury crashes	5	3	-2	-40%
High severity crashes	3	1	-2	-67%

Table 16: Night injury crashes **after midnight** for **five** years before and after lighting installed

	Before	After	Change	% change
Injury crashes	2	5	0	250%-
High severity crashes	0	0	0	-

5.5.4 MULTI-VEHICLE CRASHES FIVE YEARS BEFORE AND AFTER INSTALLATION

Tables 17 and 18 address multi-vehicle injury crashes five years before and after midnight respectively.

Table 17 **Multi-vehicle** night injury crashes **before midnight** for **five** years before and after lighting installed

	Before	After	Change	% change
Injury crashes	5	3	-2	-40%
High severity crashes	3	1	-2	-67%

Table 18: **Multi-vehicle** night injury crashes **after midnight** for **five** years before and after lighting installed

	Before	After	Change	% change
Injury crashes	0	0	0	-
High severity crashes	0	0	0	-

Comparison of these tables raises the interesting point that after midnight, when traffic volumes are smaller, and there is less chance of vehicles colliding, for the five years before and after period, there were no post-midnight multi-vehicle crashes, leaving post-midnight crashes only single vehicle crashes.

6 DISCUSSION

6.1 BEFORE AND AFTER ANALYSES OF INJURY CRASHES AND CRASH RATES PER 10^6 VEHICLES

Both the crash analyses and crash rate analyses produced results indicating that the lighting improved safety

- Both eight-year comparisons and five-year comparisons indicate crash, and crash rate savings before and after the change.
- The five-year savings were greater than the eight-year savings and the multivehicle crash savings were greater than the all crash savings, on a percentage basis.
- The lower savings on an eight-year basis could be linked to the greater scope for extraneous influences coming into play over the longer before and after periods.
- The higher savings in multivehicle crashes could be related to previous findings that such crashes are most susceptible to improvement from road lighting.
- The higher savings in multivehicle crashes were accompanied by increases in night single vehicle off road and lost control crashes. This could be due to the lighting increasing the tendency of drivers to increase their speeds and could be a subject of further research.

6.2 SINGLE VEHICLE OFF-ROAD, LOST CONTROL ON STRAIGHT & CORNERING CRASHES (C AND D TYPE)

The results indicate that multi-vehicle crashes may be reduced by lighting more than all crashes when multivehicle crashes are defined as all crashes minus C and D crashes.

This implies that lighting may be associated with increases in C and D type crashes. These results indicate, (bearing in mind caution associated with small numbers) a possible move to higher night crashes for these crash movements in the presence of lighting.

6.3 THE IMPACT OF POST-MIDNIGHT DIMMING ON INJURY CRASHES AND INJURY CRASH RATES

The numbers of crashes available for analysis were very small, so normally any conclusions on the direct impact of the dimming on crashes would be very speculative. However, a very interesting observation is that for the 5 years before and after period, post-midnight multi-vehicle crashes in were absent in both the before and after situations, leaving only single vehicle crashes. This brings into question whether there should have been lights on at all in that period as the main target group crashes for lighting were absent, with the crashes present those for which lighting is of doubtful (maybe negative) value.

7 CONCLUSIONS

This study suggests an overall beneficial impact on road safety of the LED lighting installed on SH22 in 2011.

The net positive impact appears to be the sum of a positive impact on multivehicle crashes and a smaller, possibly negative impact on single vehicle C and D type crashes.

Given the absence both before and after the change of multivehicle crashes, the group of non-pedestrian crashes on which lighting appears to have its main impact, in the post-midnight period, it may be worth considering dimming the lights altogether after midnight.

This study looks at a stretch of road with and without LED lighting. It says nothing about whether the LED lights used are more or less effective than HPS lighting of a similar standard. This question could be addressed by carrying out broadly similar work in situations where HPS lights are replaced by LED lights.

This study has been hampered by small numbers of crashes to work with. Similar work involving more stretches of road would add to the precision of the study.

REFERENCES

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