DO 'SAFE-HIT' POST MEDIANS HAVE A PLACE IN NEW ZEALAND'S SAFE ROADS SYSTEM?

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ABSTRACT

Rural road median treatments can be considered within a 'safety continuum' with standard painted lines and physical barriers being the least and most safe options respectively. In between these extremes, audio tactile profiled (ATP) centrelines, 'wide medians' and possibly flexible posts may be cost-effective options. ATP roadmarkings have already proven to be a cost-effective option for treating a relatively large proportion of New Zealand's rural road network.The purpose of this evaluation was to provide a better understanding of driver behaviour and perceptions, and maintenance issues related to a 'safe-hit' post median treatment at a new passing lane on the Kapiti Coast, in advance of the treatment's longer-term crash reduction effects. The performance of the median treatment was positive with motorists driving slightly further away from the median compared with similar nearby control sites. There was also no increase in speeding (possibly a decrease) and possibly improved merging behaviour at the end of the passing lane. Nearby residents viewed the treatment as a positive safety initiative although some expressed some concern about visibility when turning into or out of properties. This configuration may be a positive road safety option for New Zealand roads in the future, although a longer-term understanding of maintenance issues and crash reduction effects is desirable. The place of this format within a hierarchy of median treatments for New Zealand rural high speed roads remains to be seen.

INTRODUCTION

A unique median treatment that includes the use of plastic 'safe-hit' posts, without the normally associated wire rope, has been installed at a newly constructed passing lane at Peka Peka (SH1) on the Kapiti Coast, which opened on the 24th March 2010. The unique median design includes a 1.5m flush median with audio tactile profiled (ATP) roadmarking on the right-hand edge lines (both directions) with safe-hit posts at 5m centres (Figure 1). This configuration allows wire ropes to be added in the future as funding allows, while hopefully giving an improved level of safety compared with a conventional double yellow painted line road layout. It is anticipated that the proposed trial layout will go some way towards reducing the likelihood of crashes that result from centreline or median crossing.

It will take some time to establish the safety benefits of this configuration, but in the meantime a better understanding of how motorists behave in response to this median treatment is desirable along with a clearer understanding of any usability issues associated with the treatment. Studies have been carried out to evaluate the effects of road marking (Charlton 2006, Godley et al. 2004, Mackie 2009) and design (Charlton et al. In Press, Lewis Evans and Charlton 2006, Elliott et al 2003) on motorist behaviour. However, no formal evaluation of this unique median treatment in New Zealand has yet to be carried out.

The purpose of this evaluation was to provide a better understanding of driver behaviour and perceptions related to the safe-hit post median treatment at Peka Peka, along with maintenance and crash history. Together, this information will help to provide a better understanding of the costs and benefits of this median treatment.

 

Figure 1. Peka Peka passing lane southbound (left) and northbound (right) with safe-hit post median treatment.

The Peka Peka passing lane safe-hit median configuration can be considered within the context of a 'safety continuum' (Figure 2) with painted yellow 'no overtaking' lines only as the least safe median treatment and a median with physical barrier (solid or wire rope) representing the most safe configuration. While wire and solid rope barriers may be the safest treatment for a section of road, in recent years, relatively inexpensive ATP edge and centreline treatments have given some added safety to a larger proportion of the rural road network.

Less safe

Painted yellow lines: Standard median configuration traditionally used in New Zealand.

ATP on (or next to) painted yellow lines: ATP helps to prevent inadvertent lane departures when driver is in control of vehicle but not deliberate departures, or those where the driver is not in control of their vehicle.

Flush median (of varying width) with ATP on right-hand edge lines: In addition to above, the separation provided by the flush median (along with two distinguishable ATP lines) gives added safety via recovery space for deliberate or 'loss of control' departures.

Flush median with ATP on right-hand edge lines plus safe-hit posts (i.e. Peka Peka): In addition to above, the safe-hit posts prevent deliberate central median crossing via a perception of damaged property when hit. The perceptual effects of the safe-hit posts alone are unknown.

Wire rope / solid barrier: In addition to above, the barrier physically prevents central median crossing, providing an inherently safe system for head on/cross centreline crashes.

More safe

Figure 2. Rural road median safety continuum

METHOD

Apart from crash history, no pre-treatment data was available. Therefore a comparison of driver behaviour between the treatment site and nearby untreated sites (with passing lanes) to the North of the newly treated area was carried out. This type of comparison is not as effective as a pre-post comparison of treatment and control sites as there are many other factors that might influence driver behaviour at each of the sites (for example driver frustration at one site compared with another). However, if the data is treated within its limitations and with consideration of confounding variables, useful information may still be determined. Also, comparison with other similar and nearby parts of the route allowed a greater understanding of road user behaviour along an 18 km segment of SH1 between Levin and Paraparaumu. The data collection locations for treated and untreated sites are shown in Table 1. As much as possible the treated and paired untreated sites were matched in terms of their surrounding environment, although the limited number of sites to choose from provided some limits to comprehensive pairing.

Table 1. Descriptions of data collection locations

Site No.	Location (Route Sector)	Geometry / description (passing lanes)	Treated / untreated	Direction (passing lanes)
1	RS 995 +1006	RH Curve – Apex	Untreated	Northbound
2	RS 995 +2000	Straight - Near start	Untreated	Southbound
3	RS 995 +3550	LH Curve – Apex	Untreated	Southbound
4	RS 995 +9130	Straight – Merge	Untreated	Northbound
5	RS 995 +14629	Straight – Mid passing	Untreated	Northbound
6	RS 1012 +882	Straight – Near start	treated	Southbound
7	RS 1012 +1138	Straight – Mid passing	treated	Southbound
8	RS 1012 +1562	RH Curve – Apex	treated	Southbound
9	RS 1012 +1810	Straight - Merge	treated	Southbound

A range of data was collected in order to evaluate the Peka Peka treatment and associated comparison sites. Table 2 describes the measures for the evaluation and the processing that was used following data collection:

Table 2. Data collection variables

Measures	Description and processing
Crash history	A CAS analysis was carried out to determine the crash history for the section of road prior to treatment between 2005–2009 (inclusive). **Processing:** Information reporting only
Maintenance issues	Information about post strikes, number of replaced posts and other related maintenance issues along the installation were obtained from the maintenance contractor. **Processing:** Information reporting only
Speed	Speed was measured using a double tube on the slow lane, fast lane and opposing lane at each data collection site. Speed was measured at three treatment and five comparison sites. **Processing:** Each lane type (slow, fast and opposing) was processed separately and treatment vs comparison sites were analysed for curves and straights. T-tests were used to statistically compare the pairs. Overall treatment site speed was also compared with overall comparison site speeds. Mean and 85^{th} % speeds and a speed frequency histogram were calculated at each site. Only vehicle passes with a headway of at least three seconds were used. Finally, a pictorial representation of the speeds at the three locations and three lane types within the treatment area was produced.
Lane position	Lane position was measured using video. In order to detect statistical differences in lane position a target of 150 vehicles passes (3-second headway only) was established for each lane of each data collection site. This was

	achieved by monitoring the vehicle passes per minute after the start of data collection and then adjusting the data collection duration accordingly so that sufficient vehicle passes were captured without wasting time. At each data collection site a video camera was positioned on a tripod at a location which gave a clear view of the tubes that were also used for collecting speed data. Measurement of the lane width at the location of the tube counters provided calibration information. **Processing:** A digital ruler was created and superimposed over the video recording so that the scale on the ruler and the lane width measurements matched. In order to ensure accuracy, two people agreed on the correct positioning of the ruler prior to any data processing. During data processing the video footage was manually advanced to determine each vehicle's lane position (measured as the distance between the right hand edge of the right front wheel of each vehicle and the inside edge of the centreline (fast lane) or lane line (slow lane)) as it passed over the first tube counter. In addition, vehicles with either their right or left wheels over the right or left lines as they passed over the tubes were tallied. The process was carried out for the slow, fast and opposing lanes for three treatment and three control sites.
Merging	Video was collected at a treated and untreated location (at the end of passing lane) to evaluate merging behaviour. **Processing:** Interactions between vehicles in slow and passing lanes were subjectively categorised as 1 = merging between at least two vehicles occurring but no action taken by the vehicles, 2 = some avoiding action taken by either or both vehicles (evidenced by brake lights, lane deviation slowing or acceleration) or 3 = severe action taken by at least one vehicle (hard braking, obvious crash avoidance behaviour)
Turning	There are no side-roads within the treatment area but incidental turning behaviour was captured by video during the lane keeping video data collection. **Processing:** Information reporting only
Motorist perceptions	A survey of motorist perceptions was distributed (300) via a letter-box drop to residents and businesses on or near the treatment area (from Paraparaumu to Otaki). The survey form content is provided in Appendix A. **Processing:** A Chi square analysis was used for the categorical data (frequencies of chosen categories) and a paired t-test was used to analyse the numerical data (i.e chosen safe speeds). Themes were also reduced from the written comments.
Other matters of interest	Other matters of interest such as the presence of pedestrians and cyclists, occurrence of ATP noise or subjective observations by the researchers were also reported

RESULTS

Crash history

In the ten years between 1999-2009 (inclusive) there were 18 crashes (2 fatal and 9 serious injuries) within the Peka Peka project area. One of the fatal crashes (2001) was a head-on fatigue related crash.

Maintenance Issues

Following project completion damage was relatively minimal with only two posts being replaced in

June 2010. The posts are designed to be pushed over and return to their position when hit so it is not known how many have been hit but not damaged. Scuff marks on some posts indicated that they have been hit and returned to position as designed. An RG17.1 keep left sign at one location was hit (and replaced) numerous times (possibly by turning motorists in and out of properties). At least five signs were replaced during August. It was also noted that the reflective tape on some of the posts has started to peel off. There is a need to better understand the real costs associated with maintenance of these posts.

Speed

Table 3 summarises the speeds measured at slow, single and fast lanes for treated and untreated conditions. In general the safe-hit post median treatment did not result in higher speeds compared with similar un-treated sites (as was feared by the local public). The safe-hit post median treatment may have resulted in overall slightly lower speeds compared with un-treated passing lane sites; however, there are a number of variables that may have affected this so this effect should be treated with caution. Almost all speed differences would be statistically significant due to the large number of data for each condition. Therefore, a better focus is the practical change in speed (sometimes called effect size). However, the speed differences also need to be considered within the context of the variation caused by all sources that might be expected between the treated and untreated sites (such as route factors).

Table 3. Summary of speed measurements for different conditions

Lane type	treatment	Mean Speed (km/hr)	85% Speed (km/hr)
Slow and single lanes	Treated	94	101
	Untreated	95	102
Fast lanes	Treated	103	110
	Untreated	105	113

Lane position

Table 4 compares lane positioning for the conditions where the safe-hit posts are most likely to have the greatest effect on lane positioning. The single lane and fast lane with no interaction conditions (overtaking vehicles) on straights were chosen for this as, in these cases, the vehicles are immediately adjacent to the safe-hit posts, there are no influences from other vehicles and variations in curvature do not exist.

Table 4 Summary of treated vs untreated sites where the effects of the safe-hit posts are likely to have the greatest effect on lane position

Lane type	Treatment	Count	Dist to Centreline (RH edge line)
Straight single lanes	Treated	359	1.11
	Untreated	371	0.84
Straight Fast lanes (no interaction)	Treated	66	0.78
	Untreated	81	0.72

The key lane position findings were as follows:

- The safe-hit post median treatment at Peka Peka resulted in vehicles travelling further from the centre line (right hand edge line) for vehicles travelling immediately adjacent to it. This finding was statistically significant (unpaired t-test, $p<0.01$).

- When vehicles interacted (passing situation on passing lane), at all sites fast lane vehicles travelled closer to the centreline and slow lane vehicles travelled closer to the edgeline. Presumably this was to maximise separation between vehicles while maintaining lane position.

- The right hand curve treatment site (8) had a slightly tighter curvature than the untreated site (1) and it is expected that this difference in curvature had a larger effect than any other variable. Degree of curvature also had a clear effect on lane keeping in the ATP study by Mackie (2009).

- Apart from left-hand curve situations lane departures were rare at all locations and all departures were to the left. ATP edge and centrelines are applied along this route. Previous research (Charlton 2006, Mackie 2009) has shown that ATP lines are effective at reducing inadvertent lane departures.

Merging

Sites 9 (treated) and 4 (untreated) were used to compare merging behaviour (Table 5, Figure 3).

Table 5. Merging behaviour at treated and untreated locations

Site number	No. Merging interactions	No. Level 1 interactions	No. Level 2 interactions	No. Level 3 interactions
9 (treated)	47 (within 49 mins)	35 (74%)	12 (26%)	0
4 (untreated)	36 (within 45 mins)	23 (64%)	13 (36%)	0

Based on this relatively limited analysis the treated (Peka Peka) merging site appeared to have slightly fewer level 2 interactions (some avoiding action taken by either or both vehicles) than the untreated site, but there may be factors that caused this other than the median treatment design such as passing lane length and location (which could affect driver urgency and frustration). Notwithstanding this, the median safe-hit posts may have the effect of forcing drivers to accept their place in the traffic queue earlier by limiting the overall road width available to merging traffic. At untreated sites, although highly risky, the double yellow centreline can easily be crossed during interactions between merging vehicles. This concept is speculation and remains untested.

Figure 3. Examples of Level 2 merging behaviour at Sites 9 (left) and 4 (right). In each example, some action would need to be taken by at least one of the motorists in order to maintain a safe separation between vehicles

Turning

No turning was captured on video during data collection. However, whilst on site, the researchers observed a number of turning activities by residents leaving properties and in particular by rural mail delivery vans. There did not appear to be any issues with turning from the examples we noticed. In all examples, the gaps in the safe-hit post installation appeared to allow turning without any problems. However, some turning issues were raised by residents as discussed later.

Motorist perceptions

Prior to the study anecdotal concerns from some nearby residents were that the new passing lane configuration would cause excessive speeding and also merging problems.

A total of 48 (16%) survey responses were received and processed (survey form given in Appendix A). This was slightly disappointing but not unexpected. However, as seen by the specific results that follow, the relatively clear findings meant that a greater number of participants would not have added significant value to the overall findings, except perhaps giving clarity to some of the subjective issues raised. The key findings of the survey are presented as the questions appeared on the form.

Safety

Figure 6c shows that respondents clearly felt that the treated road section at Peka Peka (with wide median and safe-hit posts, Figure 4b) provides a higher level of safety than the untreated section (Figure 4a). This finding was statistically significant (Chi Square, P<0.01).

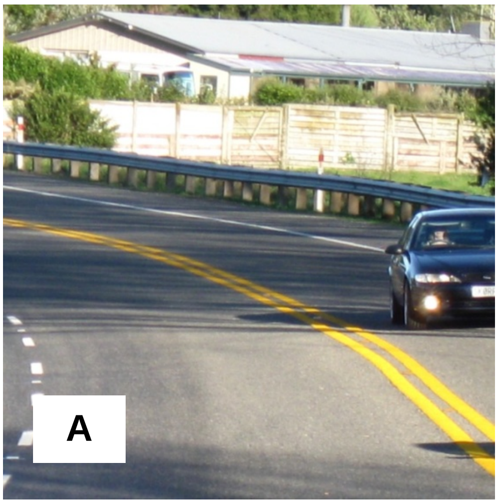

Figure 4a. Untreated site

Figure 5b. Treated site

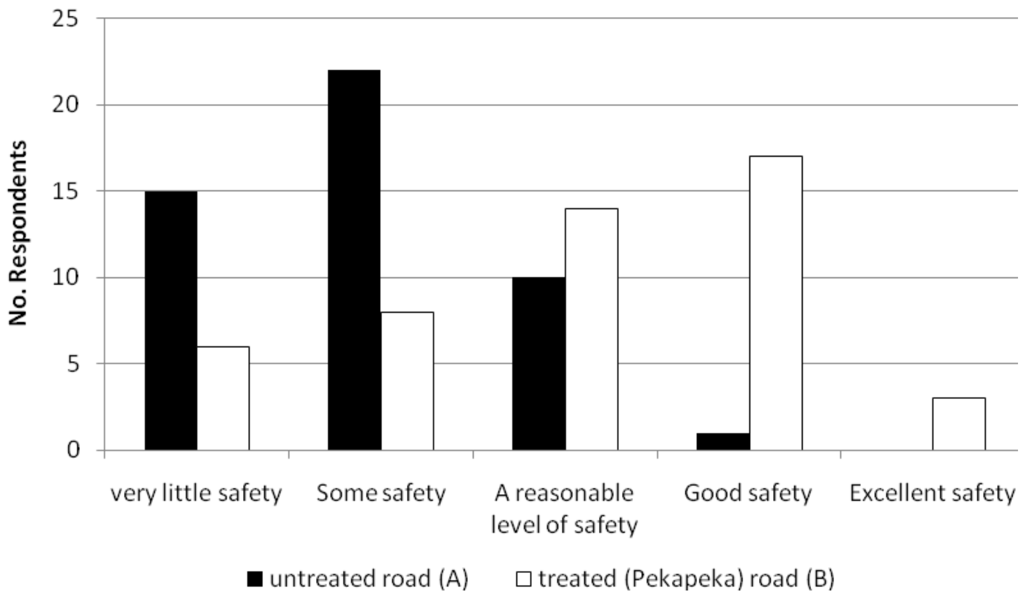

Figure 6c. Responses to survey question 2: Please circle the number that most closely represents the level of safety you feel is provided by the double yellow centrelines (A) / central median (B)?

Speed.
Figure 7 shows that respondents thought that a safe speed to travel along the treated road (B) was higher than for the untreated road (A). This finding was statistically significant (Paired t-test, $P<0.01$). The mean speed that respondents considered safe for the untreated road (A) was 88 km/hr and for the treated road (B) was 94 km/hr.

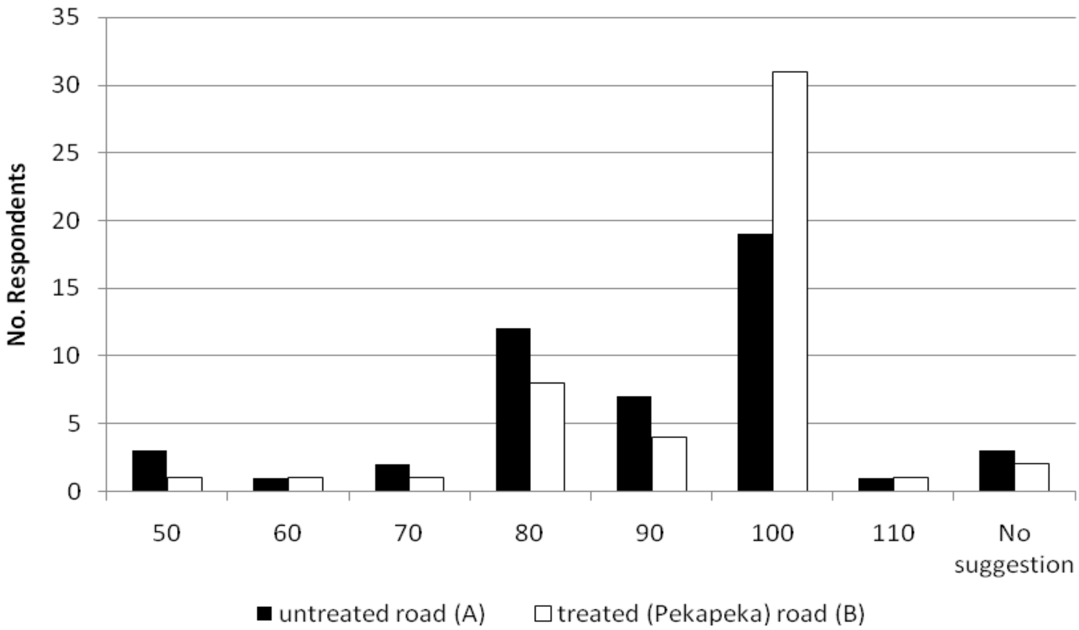

Figure 7. Responses to survey question 3. What do you think is a safe speed (km/hr) to travel along road (A&B)?

Turning and other issues
Nine respondents reported that they had carried out a turning manoeuvre (either into or out of a property or within the road reserve) on the section of road within the treatment area. Four of these respondents reported that visibility is an issue and it can be difficult to see on-coming vehicles through the posts (presumably when looking at a very oblique angle down the road). Two respondents mentioned that vehicle speeds are now higher which makes turning more dangerous; however, the speed data showed that in reality this is not true.

Other themes from respondent's open comments were:

- No physical barrier (9 respondents)
- Generally positive statement (7)
- Turning issues (6), this seemed to be related to merging issues (3) as they are at similar locations.
- Noisy rumble strips (6). This theme seems to be related to respondents who live near the merge (southbound) and left-hand curve (northbound) areas.

Discussion

Overall, the findings of this evaluation were positive for the safe-hit post configuration at Peka Peka:

- To date only two of the safe-hit posts have needed replacing. To some degree the ATP markings may be responsible for this, as anecdotal evidence has shown a decrease in wire rope barrier hits when ATP markings have been installed next to them in the Waikato region. A ‘keep left’ sign has been repeatedly hit (and replaced) and there has been some safe-hit post reflector loss. Overall there has been a relatively modest maintenance requirement but the actual maintenance costs need to be considered as part of a future analysis of benefits and costs.

- The treated area was not associated with higher speeds than surrounding matched, untreated segments of road, and may have resulted in lower speeds in some circumstances. This finding is interesting given the strong feedback from the perceptions survey that higher speeds were considered safe at the Peka Peka site and comments from some respondents who believed that the treatment at Peka Peka has caused excessive speeding. In fact, the findings suggest that the upgraded design at Peka Peka is associated with a much lower mismatch between speed and road design compared with existing surrounding sites where speeds are similar or possibly higher. Certainly, the actual speeds at Peka Peka were very close to the perceived safe speed from the perceptions survey, whereas the actual speeds at untreated sites were much higher than the perceived speed by motorists. This suggests that at untreated sites, motorists are inherently travelling at speeds that they report as being unsafe.
- The safe-hit post median treatment resulted in vehicles travelling further from the centre line (right hand edge line) for vehicles travelling immediately adjacent to it. This may provide added safety through greater separation between opposing vehicles. This does not seem to mean that overtaking vehicles travel closer to slow-lane vehicles, as the lane keeping data showed that in these situations motorists tend to travel slightly closer to the centreline (fast lane) or the edgeline (slow lane). It is possible that the median treatment causes interacting vehicles to travel further to the left during merging, and this may cause an increased number of edgeline crosses, which may in turn cause more ATP noise if it exists at the merging area. However, this theory remains speculative.
- The merging analysis showed that there was a lower proportion of vehicle interactions that required avoiding action during merging at the Peka Peka treatment site compared with a comparison un-treated site. Even if the sites were similar, this is a very different finding to some of the perception survey comments that suggest that the Peka Peka treatment has specifically caused dangerous merging behaviour. Perhaps more likely is the fact that a merging area has been introduced where one previously did not exist and this change has caused a heightened sensitivity amongst those who use it or live close to this section of road. This study found that approximately one quarter to one third of merging actions require some sort of avoiding behaviour by at least one vehicle, which if typical, is of some concern.

There may be some areas that need further consideration:

- All things considered, the safe-hit posts do not represent a physical barrier between opposing directions and therefore do not represent an inherently safe system. However, once more is known about the safety effects of this configuration, a benefit / cost analysis would help to determine the extent that the safe-hit post configuration could be used as an interim lower-cost treatment solution until resources allowed graduation to a wire rope or solid barrier. This concept appears to have been used very successfully for the widespread implementation of ATP roadmarkings, with early indications of very positive BCRs paving the way for their widespread use. Of course the safe-hit post configuration would be relatively more expensive than ATP only treatments, especially when the 1.5m of median space is considered. However, this configuration or something similar could have a place in accelerating the length of New Zealand State Highway that is treated to a higher level of safety than the traditional centreline configuration. Comparisons with other cost effective median solutions (A trial of wide central medians is currently underway by NZTA), including ATP only treatments, should be carried out.
- Referring back to the safety continuum outlined earlier, NZTA is developing a hierarchy of median treatments that are likely to be applicable to high risk roads with crash problems based on various traffic volume levels:
  - o Less than 8000 vehicles per day (VPD) → rumble lines
  - o 8-15,000 VPD →wide central medians (with ATP)

- o Greater than 15,000 VPD → median wire rope barrier

It may be that the safe-hit post configuration has a place within this hierarchy, particularly in combination with wide central median treatments where undesirable cross centreline manoeuvres continue to occur. On the other hand, a 'self explaining roads' approach suggests that fewer and more distinct road categories would yield higher safety benefits and the safe-hit post treatment may introduce an intermediate level of treatment that erodes distinct road categories that are very clear and easy to understand by motorists. The role of safe-hit post median treatments remains to be seen.

- Visibility for those turning right out of properties may be an issue based on comments from the perceptions survey. It seems that when one looks obliquely down the road the safe-hit posts appear very close together, which can obscure oncoming vehicles. This issue should be investigated further in order to assess the level of risk associated with this scenario. Lower post heights may be an alternative solution, which may afford better visibility for turning motorists as well as possibly being more cost effective.
- Specific consideration of motorcyclists needs to be given.

Conclusion

'Safe-hit' posts on a flush median at a new passing lane have shown to be effective in terms of speed, lane positioning, merging and overall public perception, providing a better understanding of driver behaviour and public perceptions of this median treatment. Further analyses of benefits and costs based on safety performance and installation and maintenance costs needs to be considered for their long-term use. Although this treatment sits within a rural high speed road median road safety continuum, the role of this format within a hierarchy of median treatments for New Zealand rural high speed roads remains to be seen.

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APPENDIX A – PERCEPTIONS SURVEY

Road safety questionnaire

The NZ Transport Agency is carrying out road safety work in your area. We would like to know what you think about some of the median installations along State Highway 1 between Peka Peka and Waikanae.
Please answer the following questions.

1. When did you last travel on SH1 between Waikanae and Otaki? Please circle the closest answer.

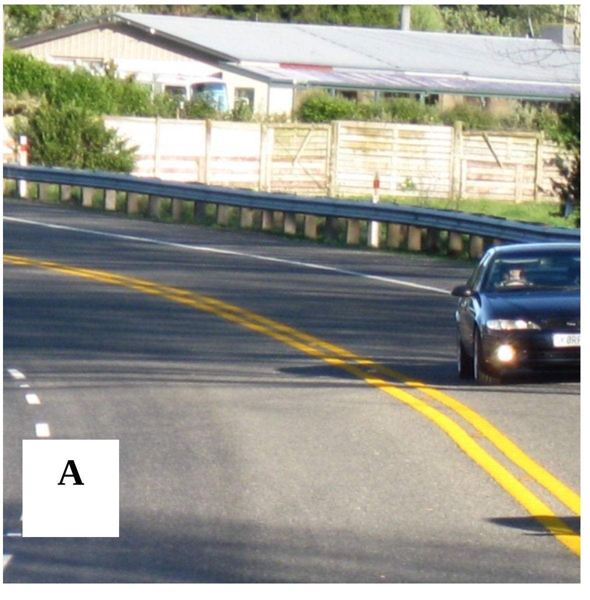
   a. Today

   b. Within the last week

   c. Within the last 2-3 months

   d. More than 2-3 months ago

2. For the following questions, please focus on the centreline/median area. Both pictures are within 100km/h speed areas.



For picture A (left), please circle the number that most closely represents the *level of safety you feel is provided by the double yellow centrelines.*

1. Very little safety

2. Some safety

3. A reasonable level of safety

4. Good safety

5. Excellent safety

Please provide reasons for your answer:
....
....
....

For picture B (left), please circle the number that most closely represents the *level of safety you feel is provided by the central median.*

1. Very little safety
2. Some safety
3. A reasonable level of safety
4. Good safety
5. Excellent safety

Please provide reasons for your answer:

………
………

3. a) What do you think is a safe speed to travel along road A? __________km/h

   b) What do you think is a safe speed to travel along road B? __________km/h

4. Referring to **picture B**, have you ever had to carry out any turning manoeuvre (either into or out of a property or within the road reserve) on the section of road with the plastic posts on the central median?

   Yes / No

   If you circled 'Yes' above, please describe any issues related to the median posts that you have encountered while turning.

   ………
   ………
   ………

5. Do you have any final comments to make about the road layout shown in picture B?

   ………
   ………
   ………

Thank you very much for your contribution to road safety.