



**MONASH** University  
Accident Research Centre

**EVALUATION OF PERCEPTUAL  
COUNTERMEASURES FOR  
MOTORCYCLISTS STAGES 1&2  
FINAL REPORT**

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**Title and sub-title:**

Evaluation of Perceptual Countermeasures for Motorcyclists Stages 1&2 – Final Report

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**Abstract:**

This project evaluated the effects of two types of perceptual countermeasure treatments on motorcycle speed and lane position along a popular recreational motorcycle riding route in Victoria; peripheral transverse lines on approach to a single curve and through a series of curves and ascending guideposts on approach to a single curve and through a series of curves. A controlled before after design was used to compare speed and lane position before treatment installation with two periods after treatment installation; one short-term period (five weeks post installation) and one long-term period (five months post installation).

Overall, the treatments produced significant net speed reductions in the short-term but were not effective in maintaining the reductions in the long-term. Peripheral transverse lines installed on approach to a single curve and enhanced guideposts installed throughout a series of curves were associated with significant average long-term speed reductions of 1.34 km/h and 1.49 km/h respectively. The peripheral transverse lines treatment was also associated with a small but significant 85<sup>th</sup> percentile speed reduction of 0.53 km/h. However, an assessment about whether these treatments are inherently effective in the long-term must be considered in light of: 1) the small size of the long-term mean speed reductions; 2) the long-term net 85<sup>th</sup> percentile speed increase of 4.27 km/h found at Treatment Site 4, and 3) the lack of evidence to demonstrate a reduction in the proportion of riders travelling over 75 km/h at Treatment Sites 1 and 4 in both the short- and the long-term. In general, the impact of the treatments on motorcycle speed are indicative of a 'novelty' effect rather than an enduring and more permanent characteristic of the treatments in changing rider speed perception.

Changes to lane position adopted by motorcyclists when negotiating the curves were evident in the short-term for the peripheral transverse lines treatment and the enhanced guideposts treatment installed on approach to a single curve. In the long-term, these changes were maintained for the enhanced guideposts treatment only.

As this study is the first of its kind to be conducted with motorcyclists, a follow-up trial and evaluation would provide a stronger justification for any future decision to implement the most effective treatments along high speed leisure riding routes. However, the results obtained in this study are unlikely to deliver substantial savings in severe trauma for, arguably, the most vulnerable road user group within the road-transport system. Consideration should be given to reducing substantially the posted speed limits on high speed leisure riding routes in order to gain the magnitude of speed reduction needed to make a substantial contribution to reducing severe trauma sustained by motorcyclists.

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**Key Words:**

Motorcycle, perceptual countermeasures, injury

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# Preface

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# Contents

<b>EXECUTIVE SUMMARY .....</b>	<b>VIII</b>
<b>1.0 INTRODUCTION .....</b>	<b>13</b>
1.1 BACKGROUND .....	13
1.2 AIM OF THE PROJECT .....	13
1.3 PROJECT COMPONENTS AND STRUCTURE.....	14
<b>2.0 METHOD .....</b>	<b>17</b>
2.1 EXPERIMENTAL DESIGN .....	17
2.2 SELECTION OF THE TREATMENTS .....	17
2.3 SELECTION OF THE TREATMENT AND CONTROL SITES.....	18
2.3.1 Route selection .....	18
2.3.2 Site selection.....	20
2.3.3 Treatment and site details.....	21
2.4 DATA COLLECTION .....	29
2.4.1 Speed measurements .....	29
2.4.2 Lateral lane position .....	31
2.4.3 Data collection dates.....	33
2.4.4 Site inspections.....	34
2.5 DATA ANALYSIS.....	34
<b>3.0 RESULTS.....</b>	<b>36</b>
3.1 Sampling characteristics.....	36
3.2 Mean speed.....	38
3.3 85 <sup>th</sup> percentile speed .....	43
3.4 Proportion of motorcyclists travelling above 75 km/h .....	48
3.5 Proportion of vehicles travelling in the left, centre or right side of approach lane.....	53
<b>4.0 DISCUSSION .....</b>	<b>57</b>
4.1 Overview .....	57
4.2 Short-term speed changes.....	58
4.3 Short-term lane position changes .....	59
4.4 Long-term speed changes.....	59
4.5 Long-term lane position changes.....	61
4.7 Study limitations and suggestions for further research.....	62
<b>5.0 CONCLUSIONS AND RECOMMENDATIONS.....</b>	<b>64</b>
<b>6.0 REFERENCES .....</b>	<b>67</b>

## Figures

FIGURE 2.1 FREQUENCY OF MOTORCYCLE CASUALTY CRASHES IN SELECTED REGIONS .....	19
FIGURE 2.2 FREQUENCY OF LOSS OF CONTROL (LOC) MOTORCYCLE CRASHES ALONG ROUTES WITHIN THE YARRA RANGES .....	20
FIGURE 2.3A CONTROL SITE.....	22
FIGURE 2.3B CONTROL SITE .....	23
FIGURE 2.4 TREATMENT SITE1 – PERIPHERAL TRANSVERSE LINES – SINGLE CURVE .....	24
FIGURE 2.5 PAVEMENT MARKINGS USED FOR PERIPHERAL TRANSVERSE LINES TREATMENTS .....	24

FIGURE 2.6 SPECIFICATIONS FOR PERIPHERAL TRANSVERSE LINES TREATMENT .....	25
FIGURE 2.7 TREATMENT SITE 2 - CURVE ENHANCEMENT THROUGH GUIDEPOSTS – SINGLE CURVE .....	26
FIGURE 2.8 SPECIFICATIONS FOR CURVE ENHANCEMENT THROUGH GUIDEPOSTS TREATMENT .....	27
FIGURE 2.9 TREATMENT SITE 3 - CURVE ENHANCEMENT THROUGH GUIDEPOSTS – SERIES OF CURVES.....	28
FIGURE 2.10 TREATMENT SITE 4 - CURVE ENHANCEMENT THROUGH GUIDEPOSTS – SERIES OF CURVES.....	29
FIGURE 2.11 PHOTO OF PROJECTED VIDEO FOOTAGE AND DIVISIONS OF TRAFFIC LANE INTO THREE CATEGORIES ...	33
FIGURE 3.1 MEAN SPEED AT TREATMENT SITE 1 (PERIPHERAL TRANSVERSE LINES – SINGLE CURVE) AND CONTROL SITE FOR EACH PERIOD .....	39
FIGURE 3.2 MEAN SPEED AT TREATMENT SITE 2 (CURVE ENHANCEMENT THROUGH GUIDEPOSTS – SINGLE CURVE) AND CONTROL SITE FOR EACH PERIOD .....	39
FIGURE 3.3 MEAN SPEED AT TREATMENT SITE 3 (PERIPHERAL TRANSVERSE LINES – SERIES OF CURVES) AND CONTROL SITE FOR EACH PERIOD .....	40
FIGURE 3.4 MEAN SPEED AT TREATMENT SITE 4 (CURVE ENHANCEMENT THROUGH GUIDEPOSTS – SERIES OF CURVES) AND CONTROL SITE FOR EACH PERIOD .....	40
FIGURE 3.5 MEAN SPEED AT THE CONTROL SITE AND ALL TREATMENT SITES FOR EACH PERIOD.....	41
FIGURE 3.6 85 <sup>TH</sup> PERCENTILE SPEED AT TREATMENT SITE 1 (PERIPHERAL TRANSVERSE LINES – SINGLE CURVE) AND CONTROL SITE FOR EACH PERIOD .....	44
FIGURE 3.7 85 <sup>TH</sup> PERCENTILE SPEED AT TREATMENT SITE 2 (CURVE ENHANCEMENT THROUGH GUIDEPOSTS – SINGLE CURVE) AND CONTROL SITE FOR EACH PERIOD .....	44
FIGURE 3.8 85 <sup>TH</sup> PERCENTILE SPEED AT TREATMENT SITE 3 (PERIPHERAL TRANSVERSE LINES – SERIES OF CURVES) AND CONTROL SITE FOR EACH PERIOD.....	45
FIGURE 3.9 85 <sup>TH</sup> PERCENTILE SPEED AT TREATMENT SITE 4 (CURVE ENHANCEMENT THROUGH GUIDEPOSTS – SERIES OF CURVES) AND CONTROL SITE FOR EACH PERIOD.....	45
FIGURE 3.10 85 <sup>TH</sup> PERCENTILE SPEED AT THE CONTROL SITE AND ALL TREATMENT SITES FOR EACH PERIOD.....	46
FIGURE 3.11 PERCENTAGE OF RIDERS EXCEEDING 75 KM/H AT TREATMENT SITE 1 (PERIPHERAL TRANSVERSE LINES – SINGLE CURVE) AND CONTROL SITE FOR EACH PERIOD .....	50
FIGURE 3.12 PERCENTAGE OF RIDERS EXCEEDING 75 KM/H AT TREATMENT SITE 2 (CURVE ENHANCEMENT THROUGH GUIDEPOSTS – SINGLE CURVE) AND CONTROL SITE FOR EACH PERIOD.....	50
FIGURE 3.13 PERCENTAGE OF RIDERS EXCEEDING 75 KM/H AT TREATMENT SITE 3 (PERIPHERAL TRANSVERSE LINES – SERIES OF CURVES) AND CONTROL SITE FOR EACH PERIOD .....	51
FIGURE 3.14 PERCENTAGE OF RIDERS EXCEEDING 75 KM/H AT TREATMENT SITE 4 (CURVE ENHANCEMENT THROUGH GUIDEPOSTS – SERIES OF CURVES) AND CONTROL SITE FOR EACH PERIOD.....	51
FIGURE 3.15 PERCENTAGE OF RIDERS EXCEEDING 75 KM/H AT THE CONTROL SITE AND ALL TREATMENT SITES FOR EACH PERIOD.....	52

## Tables

TABLE 2.1 DATA COLLECTION DATES AT EACH SITE AND COLLECTION PERIOD .....	33
TABLE 3.1 NUMBER OF SPEEDS MEASURED AT THE CONTROL AND TREATMENT SITES.....	36
TABLE 3.2 NUMBER OF RIDER SPEEDS MEASURED AT THE CONTROL AND TREATMENT SITES .....	37
TABLE 3.3 NUMBER OF RIDER LANE POSITIONS EXAMINED AT THE CONTROL AND TREATMENT SITES.....	37
TABLE 3.4 MEAN SPEED (KM/H $\pm$ S.E) FOR THE CONTROL AND TREATMENT SITES FOR BEFORE, FIRST AFTER AND SECOND AFTER COLLECTION PERIODS.....	38
TABLE 3.5 SUMMARY OF THE EFFECTS OF PERCEPTUAL COUNTERMEASURES ON MEAN SPEED ADJUSTED FOR THE PERCENTAGE CHANGE AT THE CONTROL SITE FOR EACH TIME PERIOD.....	42
TABLE 3.6 COMPARISON OF MEAN SPEEDS OBSERVED (KM/H) AND MEAN SPEEDS EXPECTED (KM/H) WHEN ADJUSTED FOR THE PERCENTAGE CHANGE AT THE CONTROL SITE FOR EACH TIME PERIOD.....	42
TABLE 3.7 85 <sup>TH</sup> PERCENTILE SPEED (KM/H) FOR THE CONTROL AND TREATMENT SITES FOR BEFORE, FIRST AFTER AND SECOND AFTER COLLECTION PERIODS .....	43
TABLE 3.8 SUMMARY OF THE EFFECTS OF PERCEPTUAL COUNTERMEASURES ON 85 <sup>TH</sup> PERCENTILE SPEED ADJUSTED FOR THE PERCENTAGE CHANGE AT THE CONTROL SITE FOR EACH TIME PERIOD.....	47
TABLE 3.9 COMPARISON OF 85 <sup>TH</sup> PERCENTILE SPEEDS OBSERVED (KM/H) AND 85 <sup>TH</sup> PERCENTILE SPEEDS EXPECTED (KM/H) WHEN ADJUSTED FOR THE PERCENTAGE CHANGE AT THE CONTROL SITE FOR EACH TIME PERIOD .....	47
TABLE 3.10 NUMBER AND PERCENTAGE OF RIDERS TRAVELLING ABOVE 75 KM/H.....	48
TABLE 3.11 NUMBER OF RIDERS AT EACH SITE EXCEEDING 75 KM/H BEFORE AND AFTER TREATMENT INSTALLATION.....	49
TABLE 3.12 PERCENTAGE OF RIDERS AT EACH SITE EXCEEDING 75 KM/H BEFORE AND AFTER TREATMENT INSTALLATION.....	49

TABLE 3.13	SUMMARY OF THE EFFECTS OF PERCEPTUAL COUNTERMEASURES ON PERCENTAGE OF RIDERS EXCEEDING 75 KM/H ADJUSTED FOR THE CHANGE AT THE CONTROL SITE FOR EACH TIME PERIOD.....	52
TABLE 3.14	COMPARISON OF OBSERVED AND EXPECTED PERCENTAGE OF RIDERS EXCEEDING 75 KM/H WHEN ADJUSTED FOR THE PERCENTAGE CHANGE AT THE CONTROL SITE FOR EACH TIME PERIOD .....	53
TABLE 3.15	NUMBER AND PERCENTAGE OF RIDERS AT EACH SITE TRAVELLING IN THE LEFT SIDE OF THE APPROACH LANE .....	53
TABLE 3.16	NUMBER AND PERCENTAGE OF RIDERS AT EACH SITE TRAVELLING IN THE CENTRE OF THE APPROACH LANE .....	54
TABLE 3.17	NUMBER AND PERCENTAGE OF RIDERS AT EACH SITE TRAVELLING IN THE RIGHT SIDE OF THE APPROACH LANE .....	54
TABLE 3.18	PERCENTAGE OF RIDERS TRAVELLING IN THE LEFT SIDE OF THE LANE WHEN ADJUSTED FOR THE CHANGE AT THE CONTROL SITE FOR EACH TIME PERIOD .....	54
TABLE 3.19	PERCENTAGE OF RIDERS TRAVELLING IN THE CENTRE OF THE LANE WHEN ADJUSTED FOR THE CHANGE AT THE CONTROL SITE FOR EACH TIME PERIOD .....	55
TABLE 3.20	PERCENTAGE OF RIDERS TRAVELLING IN THE RIGHT SIDE OF THE LANE WHEN ADJUSTED FOR THE CHANGE AT THE CONTROL SITE FOR EACH TIME PERIOD .....	55

# EXECUTIVE SUMMARY

This project comprised an on-road trial and evaluation to assess the behavioural effects of perceptual countermeasures (PCMs) on the safety of motorcyclists. Perceptual countermeasures are relatively low cost additions or modifications to the road or roadside environment designed to change the way the driving/riding environment is perceived by road users. They typically consist of simple treatments such as guideposts or line markings that change the perception of how fast a driver/rider is travelling.

Five key tasks were undertaken for the evaluation:

- 1 A literature review to identify the most suitable PCMs with the greatest potential to improve the safety of motorcyclists;
- 2 Development of specifications for PCMs to be implemented on road;
- 3 Identification of appropriate locations for the installation and trial of the selected PCMs and control/comparison locations;
- 4 Evaluation of the effect of the selected PCMs on key behavioural measures affecting the safety of motorcyclists including speed and lane positioning; and
- 5 Development of recommendations for the use of PCMs for preventing motorcycle injury crashes.

## Perceptual countermeasure treatments and study design

Two types of perceptual countermeasure treatments were installed along a popular recreational riding route in Victoria with a high number of motorcycle serious casualty crashes: peripheral transverse lines on approach to a single curve and through a series of curves and ascending guideposts on approach to a single curve and through a series of curves. A controlled before-after design was used to compare speed and lane position before treatment installation with two periods after treatment installation; one short-term period (five weeks post installation) and one long-term period (five months post installation). The purpose of the 'First After' period following treatment installation was to examine whether the treatments had any short-term effect on changing rider speed and lane position. The 'Second After' period following treatment installation assessed the extent to which any change in speed and lane position identified in the First After period was a consequence of a 'novelty effect' or a more permanent and enduring characteristic of the treatments in changing rider speed and lane position perception.

A generalised linear model with contrasts was used to determine whether any speed change between the before and after periods at the treatment sites differed from any speed change at the control site over the same periods. The difference between the two changes provides an estimate of the 'net' change in speed that can be attributed to an effect of the treatment and was calculated for both short-term and long-term periods. This technique was used to examine net changes in mean speed; 85th percentile speed; and the proportion of riders exceeding 75 km/h. A similar model was used to analyse lane position changes, but the results were not analysed using inferential testing due to small numbers.

## Results

### *Absolute speed changes*

An examination of the absolute changes in speed across each time period showed that motorcycle speeds were substantially higher at the control site than at the treatment sites for all indicators (mean and 85<sup>th</sup> percentile speed and the proportion of riders exceeding 75 km/h). Overall, there was an



increase in speed at all sites in the short-term and substantial speed reductions at all sites from the short-term to the long-term period following treatment installation. Speeds at all sites in the long-term were lower than those measured prior to treatment installation (Before Period).

The difference in weather conditions across data collection periods may account for some of the speed changes at the sites. Data collection prior to treatment installation was conducted during winter conditions whereas data collection post treatment installation was conducted in warm to hot weather. It is possible that leisure riders take more risks (and hence increase their speed) during warmer months when the roads are less slick, visibility is better, and weather conditions are more conducive to riding. However the results showed that there was a greater increase in speed at the control site compared to most of the treatment sites in the short-term. This result would support the hypothesis that the treatments were effective in preventing a short-term net increase in speed that might otherwise have occurred at the sites without the treatments.

An unanticipated limitation of this study was the conduct of a police enforcement blitz targeting speeding motorcyclists along the treatment route during the long-term data collection period. The enforcement blitz almost certainly explains the substantial long-term speed reductions found at all sites.

#### *Net speed changes*

Overall, the treatments produced significant net speed reductions in the short-term (from Before to First After) but were not effective in maintaining these reductions in the long-term (from Before to Second After). Peripheral transverse lines installed on approach to a single curve and enhanced guideposts installed throughout a series of curves were associated with significant average long-term speed reductions of 1.34 km/h and 1.49 km/h respectively. The peripheral transverse lines treatment was also associated with a small but significant 85<sup>th</sup> percentile speed reduction of 0.53 km/h. However, an assessment about whether these treatments are inherently effective in the long-term must be considered in light of: 1) the small size of the long-term mean speed reductions; 2) the long-term net 85<sup>th</sup> percentile speed increase of 4.27 km/h found at Treatment Site 4, and 3) the lack of evidence to demonstrate a reduction in the proportion of riders travelling over 75 km/h at Treatment Sites 1 and 4 in both the short- and the long-term. Peripheral transverse lines installed throughout a series of curves was associated with net speed increases across all time periods and is therefore unlikely to lead to any significant improvements in motorcycle safety.

In general, the impact of the treatments on motorcycle speed reported in this study are indicative of a ‘novelty’ effect rather than an enduring and more permanent characteristic of the treatments in changing rider speed perception.

#### *Lane position changes*

While the treatments used in this study were not designed to elicit specific lane position changes, lane position was compared before and after treatment installation to determine any potentially safe or adverse consequences as a result of the treatments. Riders were categorised into “left”, “centre” or “right” side positions within the approach lane and comparisons were made between the proportions of riders in each category across the three time periods.

The results indicated large short-term reductions (around 30%) in the proportions of riders utilising the right side of the lane for both the Peripheral Transverse Lines treatment (Treatment Site 1) and the Guide Post treatment (Treatment Site 2). In the longer term, this effect was maintained at Treatment Site 2 (84% before treatment and 45% after treatment) but appeared to wear off at Treatment Site 1 (68% before treatment and 67% after treatment).

The lane position results at Treatment Site 1 appear to be indicative of a ‘novelty’ effect with motorcyclists generally utilising the full width of the traffic lane in both the short and the long-term despite physical modifications to the road surface. The long-term results at Treatment Site 2,

however, suggest a more enduring effect on lane position. Since the aim of the guideposts treatment was to produce the illusion of a tighter curve, it is possible that riders approached the curve more cautiously, expecting a smaller radius. Lower approach speeds allow the rider to proceed through the curve closer to the centre of the lane resulting in a more conservative use of the traffic lane. This interpretation is consistent with the long term absolute speed reductions recorded at this site. The long-term shift away from the right side of the lane may also confer a safety advantage in lowering the risk for head-on crashes. However, as there is little empirical evidence to demonstrate a relationship between speed and lane position, these conclusions should be treated with caution.

## **Recommendations**

On the basis of these results, the following recommendations might be worthy of consideration:

- In accordance with the design specifications discussed in Section 4.7 of this report, consider a further trial/s of the treatments most effective in producing long-term net speed reductions (peripheral transverse lines treatment installed on approach to a single curve and guideposts treatment installed throughout a series of curves) along high-speed leisure riding routes. As this study is the first of its kind to be conducted with motorcyclists, a follow-up trial and evaluation would provide a stronger justification for any future decision to implement the treatments along high speed leisure riding routes.
- It is possible that variables such as rider age and experience, motorcycle size and type; familiarity with the motorcycle; and rider speed choice interact to modify lane position choice. To assess this possibility, a future study could examine the relationship between the above mentioned variables and lane position choice by means of a short road side survey of a sample of riders travelling through the sites.
- Consider a trial and evaluation of ‘Where You Look Is Where You Go’ (WYLIWYG) – the only PCM treatment that has been designed specifically for reducing motorcycle crashes on curves. This treatment was designed in the United Kingdom and implemented at a single site in Buckinghamshire. While no formal evaluation had been undertaken at the time the literature review was being prepared for this report, anecdotal evidence indicated no crashes had occurred at the site since installation of the treatment.

While it is important to be open to new possibilities for managing the critical role played by rider (and driver) travel speed choice in determining rider crash and injury risk, it is also important to maintain a balanced perspective on the contribution that innovative measures can make to motorcyclist safety. The trial route used in this study, like many other roads that attract high levels of riding (and, commonly, motorcyclist crashes) is currently zoned 100 km/h. The results obtained in this study, are unlikely to deliver substantial savings in severe trauma for, arguably, the most vulnerable road user group within the road-transport system. It is therefore recommended that consideration be given to reducing substantially the posted speed limits on such roads in order to gain the magnitude of speed reduction needed to make a substantial contribution to reducing severe trauma sustained by motorcyclists. It will be argued that many riders will not comply with a new, lower posted speed limit. However, there remains a responsibility to advise those riders and drivers who are willing to comply as to what is an appropriate speed for roads of the type studied in this evaluation. Over time, compliance levels can be raised by a well-targeted combination of enforcement and public education.





## **1.0 INTRODUCTION**

### **1.1 BACKGROUND**

Motorcyclists are over-represented in fatal and serious injury crash statistics particularly in high speed zones. Victorian motorcycle crash data has shown an increase in the number of motorcyclists killed along tourist routes which are popular among recreational riders and typically embody high risk factors such as speed, challenging road geometry and low roadside safety.

While enforcement, education/publicity and engineering programs have assisted in reducing motorcycle trauma, supplementary measures to reduce the incidence of unsafe riding behaviours, particularly at hazardous locations, are now being sought (Macaulay, Gunatillake, Tziotis et al., 2004).

Perceptual countermeasures (PCMs) are relatively low cost additions or modifications to the road or roadside environment that have been effective in reducing speed among car drivers (Fildes & Jarvis, 1994). PCMs are designed to change the way the driving/riding environment is perceived by road users. They typically consist of simple treatments such as guideposts or line markings that change the perception of how fast a driver/rider is travelling.

Much of the research on PCMs has been evaluated in terms of their effects on the safety of car drivers. There has been very little research on the effects of PCMs on motorcyclists, and very few PCMs have been designed specifically for improving motorcycle safety. It is thought that delineation is particularly important for motorcyclists, particularly in choosing lane position and speed on entry into curves. Because of the influence visual delineation of the roadway has on both rider speed and lateral lane position, PCMs may be more effective for preventing motorcycle crashes than car crashes. While PCMs have the potential to improve motorcycle safety, they must be applied with caution given the very high vulnerability of motorcyclists to road based hazards and their greater likelihood of injury in the event of a crash.

This project involved an on-road trial and evaluation to assess the behavioural effects of selected perceptual countermeasures (which have been successful in reducing speeds among car drivers) on the safety of motorcyclists.

### **1.2 AIM OF THE PROJECT**

The overall aims of this project are to:

- 1 Identify the most suitable PCMs with the greatest potential to improve the safety of motorcyclists;
- 2 Develop specifications for PCMs to be implemented as part of the evaluation;
- 3 Identify appropriate locations for the installations and trial of the selected PCMs and control/comparison locations;
- 4 Evaluate the effect of the selected PCMs on key behavioural measures affecting the safety of motorcyclists such as speed, lane positioning and braking; and

- 5 Develop recommendations for the use of PCMs for preventing motorcycle injury crashes.

### 1.3 PROJECT COMPONENTS AND STRUCTURE

The first stage of the project comprised a literature review and consultation with expert motorcyclists to establish the current state of knowledge on PCMs for motorcyclists (Mulvihill, Candappa, Corben & Lenné, 2007). Given that few PCMs have been designed specifically for motorcyclists, an assessment was also made about the extent to which PCMs designed for car drivers could be applied effectively to the motorcycling context. Of the treatment options identified in the literature review, the following were considered potential candidates for the on-road evaluation and were therefore examined in detail in the Stage 1 report:

- Where You Look Is Where You Go (WYLIWYG) motorcycle curve treatment;
- Cross-Hatched Median;
- Peripheral transverse lines;
- Reflector posts (ascending in height and placed at diverging lateral positions as they approach the middle of the curve);

The literature review identified only one PCM for motorcyclists - **Where You Look Is Where You Go (WYLIWYG)** (James, 2005). WYLIWYG is a treatment used in Buckinghamshire, UK, designed to reduce the number of crashes on curves. The treatment is intended to provide a more optimal path to guide the motorcyclist through a curve by directing the gaze to the vanishing point of the curve. While no formal evaluation had been undertaken at the time of the literature review, anecdotal evidence indicated no crashes had occurred at the site since installation of the treatment. As this was the only treatment designed specifically for motorcyclists, consultation was made with Buckinghamshire to determine feasibility for reproducing it in Victoria. Specifications for the treatment, however, were not readily available, and the negotiations required to obtain them were deemed to exceed project timelines and budget. However, this treatment appears to be very promising, and a separate project is recommended as follow-up.

The **cross-hatched median** treatment, intended to reduce head-on crashes, comprises cross-hatched linemarking over the centre of the road to create a visual median, thereby increasing the distance between vehicles travelling in opposing directions (Godley, Fildes, Triggs & Brown, 1999). This treatment was not deemed feasible for the current project due to the narrow lane widths and shoulders of the selected sites and the potential for increased risk of run-off-road crashes for both car drivers and motorcyclists.

**Peripheral transverse lines** appear to be the best treatment for reducing speeds on approach to curves and other hazards for motorcyclists (as well as for car drivers). It comprises line marking in the form of short bars placed on either side of the road lane to create the illusion of faster travel speed than in reality. Recommendations based on national and international research (e.g., Godley, 1999; Godley et al. 1999) show that peripheral transverse lines are effective for a number of reasons: 1) they are very easy to install and maintain; 2) they are least likely to interfere with the wheel path of a motorcycle (and indeed a car as well) and thus do not provide a slick surface under wet conditions on a road segment that may potentially already have safety concerns; and 3) since only a very

small amount of pavement marking material is required, the treatment is very cost effective.

**The Curve Enhancement Guide Posts** (Godley, 1999; Godley et al., 1999) consisting of frangible guide posts ascending in height and placed at diverging lateral positions as they approach the middle of the curve has been demonstrated in the literature to be effective in reducing speeds for car drivers. This treatment is likely to reduce run-off-road crashes on curves and may potentially reduce head-on collisions by preventing loss of control crashes where the rider moves into the path of an oncoming vehicle. Due to the roadside width restrictions of the selected treatment sites (See Chapter 2), it was agreed that the treatment would be installed without the lateral displacement of the posts. The effect of this modification on the motorcyclist's perception of the treatment, however, is not known.

On the basis of the Stage 1 review, the following treatments were selected for the on-road trial and evaluation:

- Peripheral transverse lines;
- Reflector posts (ascending in height as they approach the middle of the curve).

Specifications for the development of the two PCM treatments were prepared and appropriate locations for their installation and evaluation were identified (Candappa, Mulvihill, 2007). These tasks are described in more detail in Chapter 2 of this report.

The second stage of this research was an on-road trial and evaluation of the selected PCMs on key behavioural measures affecting the safety of motorcyclists including speed and lane position.

This report summarises the Stage 1 methodological components of the project and details the outcomes of the Stage 2 on-road evaluation. Recommendations for the use of PCMs for preventing motorcycle injury crashes are then presented.





## 2.0 METHOD

### 2.1 EXPERIMENTAL DESIGN

This study used a controlled before-and-after design incorporating two after periods, one short-term and one longer-term. This evaluation is known as a quasi-experimental design as it follows the format of a fully randomised treatment-control method but differs in that the treatment sites are not chosen at random (Elvik, 2002). In this study, the design attempts to determine the effect of an intervention (selected PCM treatments) on the dependent variables motorcycle speed and lane position by comparing the dependent variables at both the treatment and control sites before and after the PCMs are implemented at the treatment sites. Changes in the dependent variables at the treatment sites after installation of perceptual countermeasures were compared to changes in the dependent variables at the control site over the same time frame. This design attempts to control for the effect of factors apart from perceptual countermeasures that may affect the dependent variables (such as weather, traffic density, and road safety campaigns and police presence) (Stephan, Lenné & Corben, 2007).

The purpose of the First After period was to examine whether the treatments had any short-term effect on changing rider speed and lane position. The Second After period assessed the extent to which any change observed in the First After period is a consequence of a ‘novelty effect’ or to a more permanent and enduring characteristic of the treatment. If behaviour changes when measured at the First After period but returns to its pre-treatment state in the Second After period, it is likely that riders have adapted to the treatments over time and that the benefits observed will only be short-term. If the treatments are creating a change in rider perception as intended, any benefits observed in the First After period are likely to be maintained when measured in the Second After period.

Five key tasks were undertaken for the evaluation:

- Selection of the treatments
- Selection of the treatment and control sites
- Site observations and data collection
- Data analysis

### 2.2 SELECTION OF THE TREATMENTS

On the basis of the literature review and an assessment of motorcyclists’ specific safety needs (see Mulvihill, Candappa, Lenné et al., 2007, for a detailed review), the treatments considered appropriate for trial in Stage 2 were Peripheral Transverse Lines and Curve Enhancement through Guide Posts.

The **Peripheral Transverse Line Treatment** involves linemarking in the form of short transverse bars placed on either side of the road lane to create an illusion of travelling faster than in reality.

Recommendations based on national and international research (e.g., Godley, 1999; Godley et al., 1999) show that peripheral transverse lines are effective for a number of reasons: 1) they are very easy to install and maintain; 2) they are least likely to interfere with the wheel path of a motorcycle (and indeed a car as well) and thus do not provide a slick surface under wet conditions on a road segment that may potentially already have

safety concerns; and 3) since only a very small amount of pavement marking material is required, the treatment is very cost effective

The **Curve Enhancement Guide Post Treatment** involves the placing of frangible guide posts along the side of the road in an ascending/descending height configuration. The original treatment configuration also includes lateral displacement of the guideposts in a semicircle. Due to the roadside width restrictions of the selected treatment sites, it was agreed that the treatment will be installed without the lateral displacement of the posts.

Reflector posts ascending in height and placed at diverging lateral positions as they approach the middle of the curve have been demonstrated in the literature to be effective in reducing speeds for car drivers (Godley, 1999; Godley et al., 1999), and it is likely that their effect will be similar for motorcyclists. This treatment is likely to reduce run-off-road crashes on curves and may potentially reduce head-on collisions by preventing loss of control crashes where the rider moves into the path of an oncoming vehicle rather than running off the road.

## **2.3 SELECTION OF THE TREATMENT AND CONTROL SITES**

Following the selection of appropriate PCMs for motorcyclists, the process of route selection for implementation and evaluation of the selected PCMs was conducted. An appropriate route was defined as one that had a motorcycle crash problem and adequate motorcyclist volumes. A route that attracts recreational riding as opposed to commuter travel was also deemed preferable for two reasons: 1) 'free speed' is more likely in higher speed, recreational riding routes where there is very little congestion; and 2) the higher speeds more typical of this type of riding are likely to result in more discernable speed changes effected by the treatments should they have an effect. It was also hypothesised that should there be a detectable effect on recreational rider behaviour, success in changing commuter rider behaviour would be likely. Site selection criteria along the route also included environments conducive to data collection needs.

### **2.3.1 Route selection**

Ideally, trial routes are selected on the basis of their crash history and traffic volumes. However, route-based motorcyclist volume data were not available for this trial. In the absence of these data, trial routes were selected primarily on the prevalence of crashes along selected lengths, with crash numbers used as a surrogate indication of motorcyclist activity. As noted above, the known popularity of routes for recreational riding was also a consideration.

Thirteen regions in Victoria known for their relatively high levels of recreational riding were provided by VicRoads for crash analysis. Using VicRoads' CrashStats (CRASHSTATS, Road Crash Statistics Victoria, 2004 Edition © VicRoads 1995-2004), a list of all crashes involving a motorcyclist or pillion passenger, of all levels of injury severity, was compiled for the period 01/01/2001 to 01/01/2006. Yarra Ranges had the highest proportion of the 74 fatal crashes and 1,325 serious injury crashes involving a motorcyclist or pillion rider over this period (See Figure 2.1). Further crash analysis was then conducted on the routes within this region.

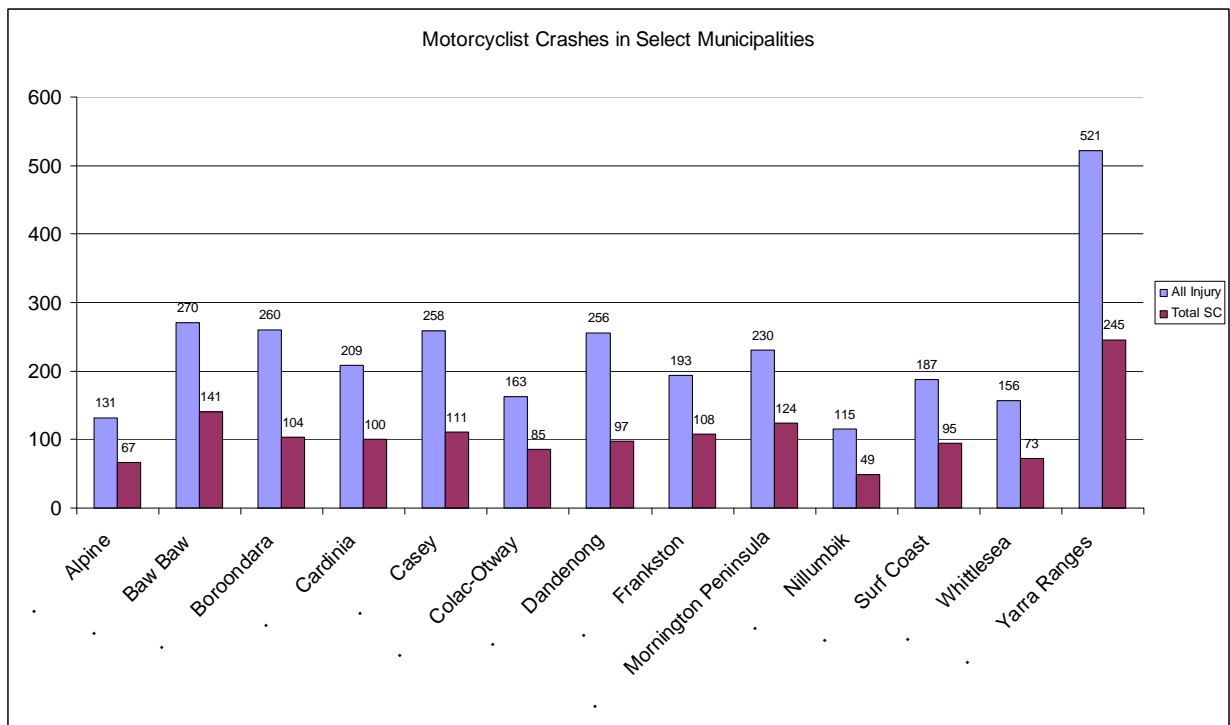


Figure 2.1 Frequency of motorcycle casualty crashes in selected regions

A list of all crashes involving motorcyclists, moped, and motor scooters in the Yarra Ranges region was extracted from CrashStats for the five-year period from 01/01/2001. The highest number of crashes occurred on Warburton-Woods Point Road (43 crashes) followed by Maroondah Hwy (32) and Mt Dandenong Tourist Road (20) (See Figure 2.2). Warburton-Woods Point Road was therefore selected for implementation and evaluation of the chosen PCMs. While the next highest crash route, Maroondah Highway, was likely to produce larger volumes of motorcyclists than Warburton-Woods Point Road, Warburton-Woods Point Road was chosen for its greater use as a recreational riding route compared to Maroondah Highway.

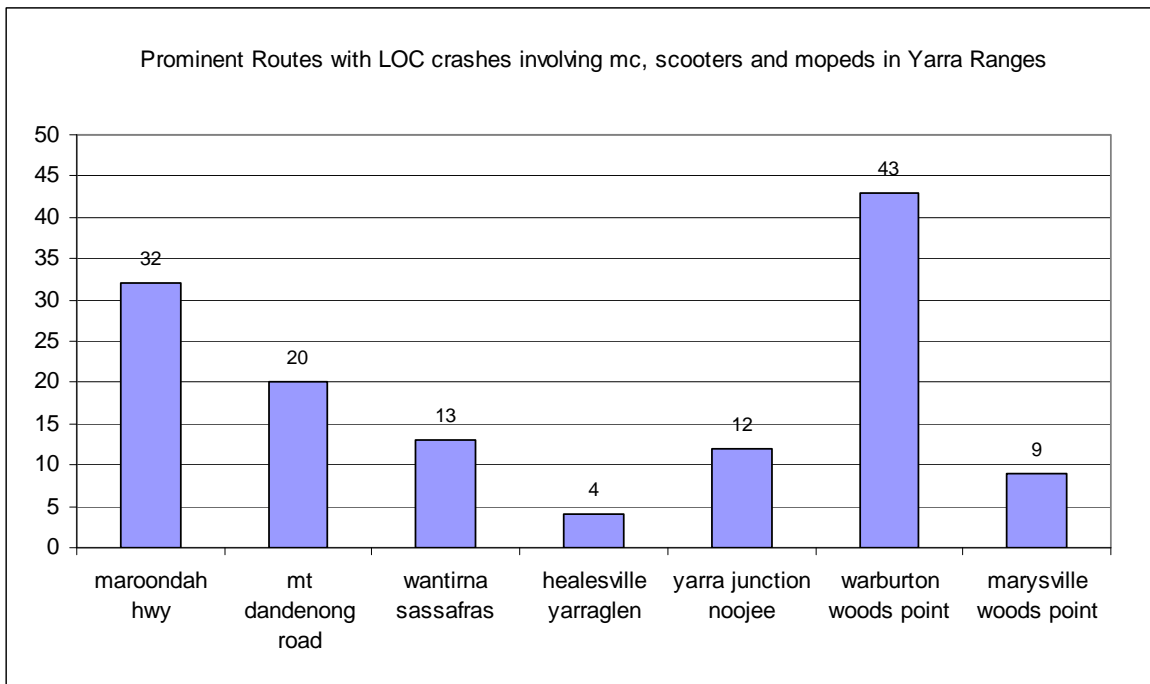


Figure 2.2 Frequency of loss of Control (LOC) motorcycle crashes along routes within the Yarra Ranges

### 2.3.2 Site selection

A total of four visits were undertaken to assess the route along Warburton Woods Point Road for suitable data collection sites. A VicRoads representative and the contractor for data collection (ARRBTR) attended on one of these occasions.

Five suitable sites within the route were selected: a control site; two sites for implementation of the peripheral transverse lines treatment and two sites for implementation of the curve enhancement through guideposts treatment. Given the highly curvilinear nature of more than half of the route along Warburton Woods Point Road, one of the sites for each treatment type was on a single curve where the road geometry on the approach and departure to the curve was relatively straight and the other was on a series of curves along a curvilinear section of road. Typically, perceptual countermeasures are installed on approach to a hazard (such as an individual curve) in an attempt to reduce speed by the time the hazard is reached. However, one of the general aims of evaluating these measures was to gauge the potential for their use along routes that are popular with leisure riding. As such routes generally involve tightly curved road sections, it was important to understand the performance of the countermeasures not just at isolated curves but also over an entire section of road that involved ‘S-bends’. Therefore, each treatment was implemented through a series of curves as well as at an individual curve.

Several criteria were used in the selection of appropriate treatment and control sites:

- Although there are alternating sections of 80 and 100 km/h speed zones along Warburton-Woods Point Road in the section between Donna Buang Road and Cumberville Junction, only sites in the 100 km/h sections were considered. This decision was based on the assumption that speed choice may be more amenable to change in higher speed zones;

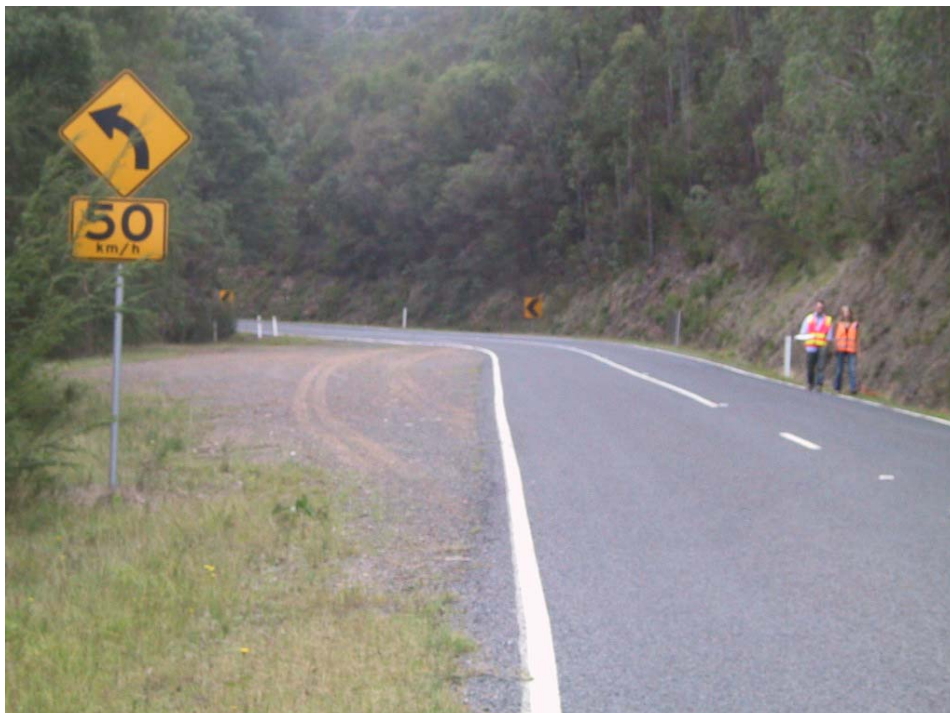
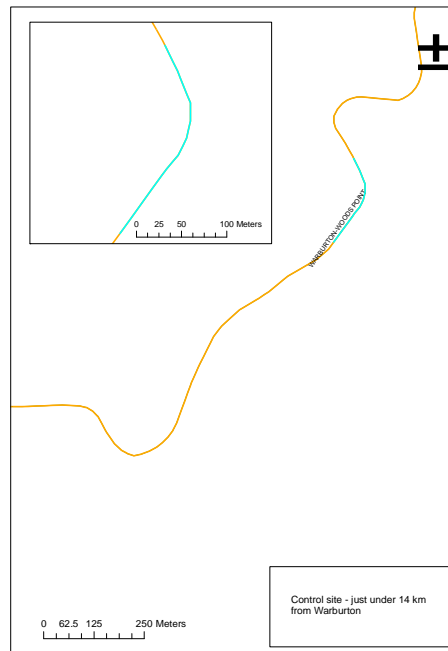
- The sites were to be on bends – an analysis of the crashes in Yarra Ranges indicated that motorcycle crashes were relatively more common on bends (61%) than on straights (39%). It is also logical and intuitive that negotiating a bend poses a greater risk of a crash and appropriate choice of speed is more crucial while negotiating a bend than a straight section. Therefore, constraining the study to the more critical aspect of the road geometry is more likely to address the key safety problems;
- The sites were to be on left turn bends – Warburton-Woods Point Road is a C class, tourist road, and constitutes left- and right-hand bends of varying severity. Given the left-hand drive conditions on Victoria roads, left-hand bends tend to have 2 m smaller radii than their right-hand counterparts (assuming a general lane width of around 2 m) and therefore can produce a more heightened level of risk and may be more sensitive to rider speed choice than right-hand bends. Selecting either left or right also maintains uniformity through the sites;
- To ensure selection of bends that posed some level of heightened risk of a run-off-road crash, only curves that were preceded by advisory speed signs - and so had already been identified as requiring reduced speed for safe negotiation - were selected. Sites that had advisory speed signs applicable over several kilometres were also considered;
- The control site was required to match the treatment sites in terms of geometric, geographical and traffic characteristics as closely as possible. The chosen single curve control site was suitable for controlling geographical and traffic characteristics but somewhat less suitable for controlling geometric characteristics for the series of curve sites (See Section 4.7);
- It was important to choose a control site that preceded the treatment sites so that behaviour at the control site would not be influenced by prior exposure to the treatments during the after data collection periods;
- Selection of the sites within the one route was important to minimise potential inconsistencies in traffic characteristics, geographical and road geometry characteristics, weather conditions and police presence that may occur across different routes. Comparing the effectiveness of different treatments within a single route is also likely to be more valid than comparing treatments across several routes. Should the treatments be effective in reducing motorcycle speeds, it was also deemed important to maximise any safety benefits along Warburton Woods Point Road where motorcycle serious casualties are currently higher than along any other route in the Yarra Ranges. However, the treatment sites were spaced as far apart as possible within the route to minimise the possibility of expectancy effects at Treatment Sites 2, 3 and 4 following treatment installation;
- All sites required a minimum of at least an 80 metre straight stretch of road prior to the curve to maximise the number of speed measurements; to ensure adequate sight distance for the rider through the curve and to adequately detect any effect of the treatment.

### **2.3.3 Treatment and site details**

The five sites along Warburton Woods Point Road were chosen in a 100 km/h zone; on left hand bends (or commencing on left-hand bends for the series treatments) and were preceded by an advisory speed limit sign.

### ***Control site***

The control site was located 14 km from Warburton and was preceded by a 50 km/h advisory speed limit sign.



*Figure 2.3a* Control site



Figure 2.3b Control site

***Treatment Site 1 – Single curve – Peripheral transverse lines***

Treatment Site 1 was located 29 km from Warburton and was preceded by a 45 km/h advisory speed limit sign.

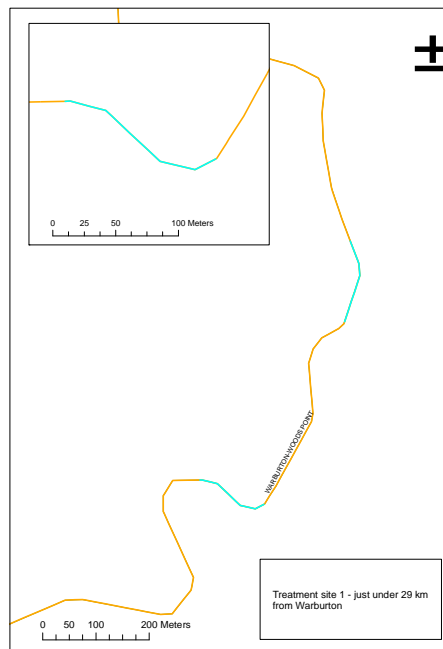






Figure 2.4 Treatment Site1 – Peripheral Transverse Lines – Single Curve



Figure 2.5 Pavement markings used for peripheral transverse lines treatments

The details of the peripheral transverse lines treatment on approach to a single curve are described below:



- The treatment was implemented only on the Woodspoint bound lane (left-hand lane in Figure 2.4);
- The length of the treatment was 83 metres. The start of the treatment was 90 metres from a road marker at the start of the curve. The treatment ended 7 metres from this same marker;
- Transverse lines bordered the roadside and centre line of the left lane (Figure 2.4);
- Each transverse line was 500 mm wide and 500 mm long (square); the lane width was 2.8 metres leaving 1.8 metres of ‘untreated’ road;
- Each transverse line was placed 3500 mm apart from each other (from the edge of one line to the beginning of the next);
- Linemarking contractors were instructed to use yellow paint that minimised risk of slippage for all road users (especially motorcyclists) and one that increased durability as the treatment effect depended on the visibility of the treatment.

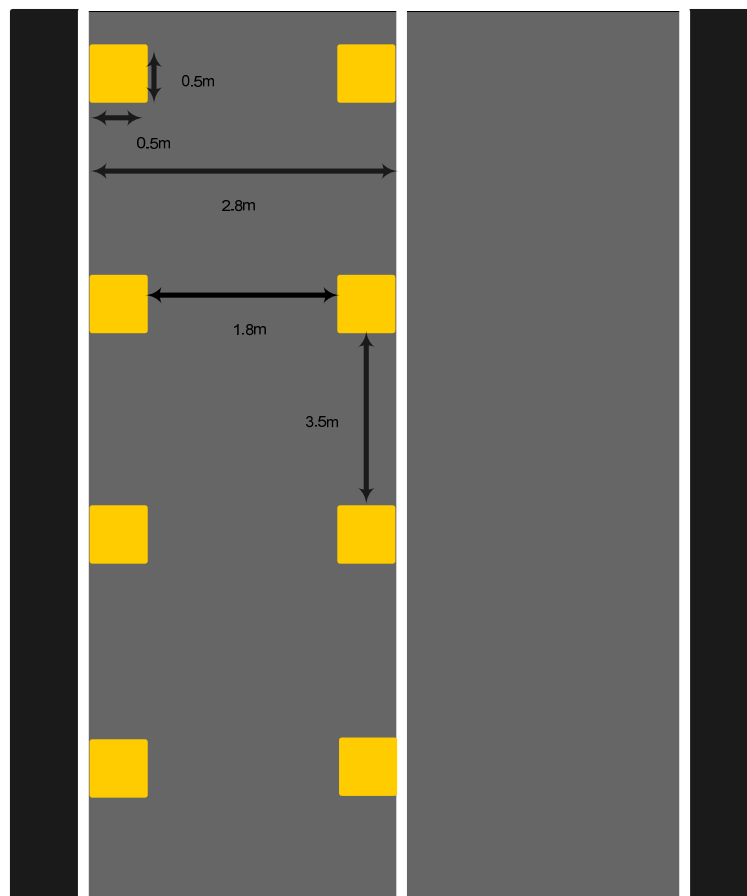


Figure 2.6 Specifications for peripheral transverse lines treatment

### ***Treatment Site 2 – Single curve – Curve enhancement through guideposts***

Treatment Site 2 was located 29.7 km from Warburton and was preceded by a 50 km/h advisory speed limit zone.

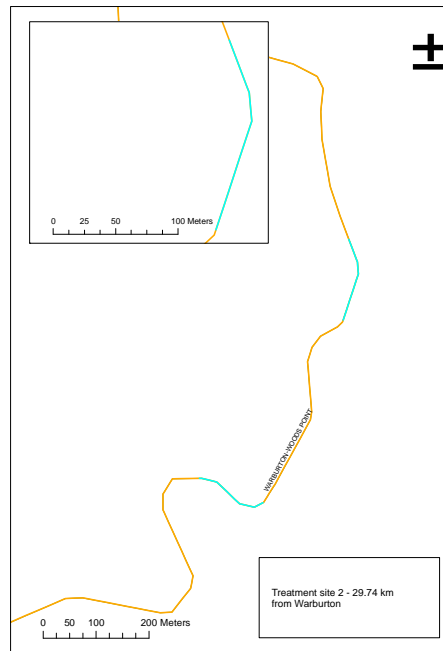
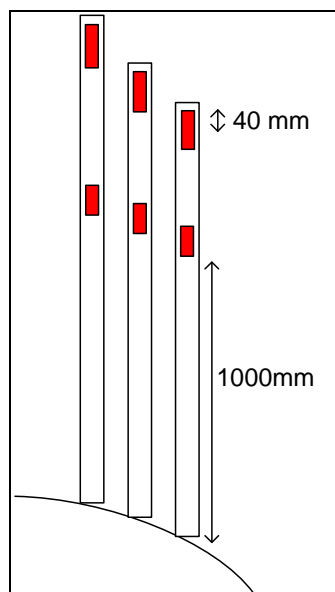


Figure 2.7 Treatment Site 2 - Curve Enhancement through Guideposts – Single Curve



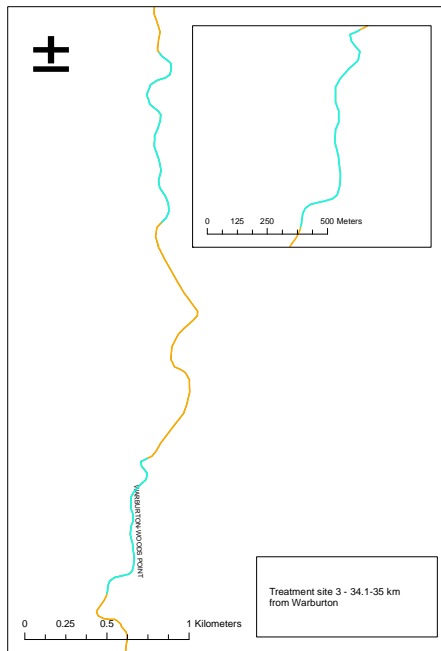
*Figure 2.8 Specifications for curve enhancement through guideposts treatment*

The details of the curve enhancement through guideposts treatment on approach to a single curve are described below:

- The treatment was implemented only on the Woodspoint bound lane (left-hand lane in Figure 2.7) and only the outer curve was treated as per previous studies;
- The start/finish of the treatment coincided with the start/finish of the curve
- The entire treatment length was 140 m;
- Flexible guideposts 500 mm in height were installed at the start of the treatment segment increasing in increments to 1500 mm at the centre of the treatment segment and then reducing in height back to 500 mm at the end of the treatment segment;
- Guideposts over 1000 mm in height had the standard reflective marker at approximately 1000 mm in addition to a square reflective marker 40 mm from the top of the guidepost.
- Guideposts were standard tubular flexible posts painted white with the standard red reflectors placed for oncoming traffic and white reflectors for opposing traffic;
- To maintain consistency, all existing square guideposts that were on the opposite side to treatment side (i.e., inner curve) but within the treatment length were replaced by the tubular guideposts to remove any impact of having a combination of guidepost designs in the study area. No other modifications were made to these posts. Guideposts within a range of 50 m prior to the start of the treatment and 50 m after the treatment were replaced by the tubular posts to maintain consistency;
- The guidepost's position from the end of the lane was not changed, i.e., if the offset was 1.05 m from the edge of the lane, the treatment post was installed at approximately the same location;
- Guideposts on the outer (treatment end) curve were spaced at half the standard spacings. Guideposts were placed 10 m apart with a height increase of approximately 140 mm between posts.

***Treatment Site 3 – Series of curves – Peripheral transverse lines***

Treatment Site 3 was located 34.1-35 km from Warburton and was preceded by a 50 km/h advisory speed limit sign.



*Figure 2.9 Treatment Site 3 - Curve enhancement through guideposts – Series of Curves*



The specifications for this treatment were essentially the same as those reported for Treatment Site 1 – Peripheral transverse lines – Single Curve with the exception that the treatment was installed over a 900 metre series of curves, including through the curves.

***Treatment Site 4 – Series of curves – Curve enhancement through guideposts***

Treatment Site 4 was located 37 km from Warburton and was preceded by a 50 km/h advisory speed limit sign.



*Figure 2.10 Treatment Site 4 - Curve enhancement through guideposts – Series of Curves*

The specifications for this treatment were essentially the same as those reported for Treatment Site 2 – Curve enhancement through guideposts – Single Curve with the exception that the treatment was installed over a 1,035 metre series of curves.

## **2.4 DATA COLLECTION**

### **2.4.1 Speed measurements**

Speed is the biggest predictor of crash outcome. This is particularly the case for motorcyclists who not only have the potential to reach higher speeds than other vehicles, but are also highly vulnerable in the event of a crash, given the lack of protection through the body of a vehicle and vehicle related safety features.

## **Control and Treatment Sites 1 and 2**

The primary aim of perceptual countermeasures is to reduce vehicle speeds on approach to a hazard. Therefore, speeds were measured at each site (excluding the series sites) on approach to the curve. As discussed in Section 2.3.2 'Site Selection', the sites were required to have at least an 80 metre straight stretch of road prior to the curve to maximise the number of speed measurements; to ensure adequate sight distance for the rider through the curve and to adequately detect any effect of the treatment.

Several methods for measuring speed were considered for the project including pneumatic tubes, laser guns and permanent radar fixtures on the sides of the road. Key considerations in selecting an appropriate measuring device included minimising any influential effects of speed monitoring on the rider behaviour; maximising the potential to obtain several data points at the one site; and minimising costs (whilst permanent fixtures located at several points on approach to the curve are potentially an effective covert option; this method is not cost effective particularly for a temporary study). As a result covert methods of speed measurement were favoured. This excluded pneumatic tubes, leaving laser guns as the suitable option. Laser guns allow several data points for each rider, while enabling the measuring device to be concealed to some extent. The road geometry of the selected route was such that little roadside width was available in many cases to conceal a parked vehicle (in which the speed gun operator was generally positioned), although attempts were made to minimise effects. However, as this potential extraneous factor would impact rider speed equally both before and after treatment installation; it was unlikely to bias the results.

A Laser Technology International 20-20 speed gun was used to record motorcycle speeds. When aimed at a vehicle, the laser gun automatically takes two to three spot speed and distance measurements per second. Speed was measured in kilometres per hour and the distance reading provides a measure of the distance between the laser gun and the motorcyclist. The laser can only record one motorcycle at a time so it was not possible to measure the speeds of more than one motorcyclist travelling through a site simultaneously or in close proximity.

The laser has a limited range of approximately one kilometre over which speed and distance can be taken and typically cannot measure objects within a range of less than 20-30 metres. Depending on site distance and the available space to park the ARRB vehicle at each site, most readings could be taken from inside the vehicle (or next to the passenger door).

The data from the laser gun were transmitted via an RS-232 connection (a serial port) to a computer running ARRB's own software, which then recorded each reading and a time stamp.

## **Treatment Sites 3 and 4**

It was not possible to measure speeds through the series of curve treatments using the laser gun because of the curvilinear, alignment of the route and the presence of dense vegetation lining the roadsides. An average speed per rider was therefore calculated by recording the time taken to ride through the treatment and dividing it by the length (km) of the treatment. A two-person team, one at the start of the treatment and the other at the end of the treatment, measured time using a hand held stopwatch and pen and paper. Speeds were measured over a distance of 900 metres at Treatment Site 3 (Peripheral Lines) and 1,035

metres at Treatment Site 4 (Guideposts). Both distances corresponded approximately to the length of the treatments.

#### **2.4.2 Lateral lane position**

Lane position was analysed qualitatively to determine any changes in rider behaviour when negotiating a left hand bend. While the treatments were not explicitly intended to modify lane position, it was important to examine any positive effects such as a potential shift away from the centre line and also to examine any adverse effects of the treatments on rider behaviour.

As outlined in the Stage 1 literature review, lane position data has been collected in a limited number of studies examining the effect of perceptual countermeasures on car driver safety. No empirical studies have examined the effect of perceptual countermeasures on motorcycle lane position when negotiating curves.

It was necessary to determine typical lane trajectory for curve negotiation before an assessment could be made about the effect of the treatments on motorcyclist lane position as used in this study. The primary source of information for this task was consultation with expert police motorcycle rider trainers and experienced rider trainers at VicRoads. This information was also supplemented by a description of some recommendations for safe cornering techniques as set out in the US Motorcycle Safety Foundation's second edition of 'Motorcycling Excellence' (US Motorcycle Safety Foundation, 2006). While any one of a number of reputable published sources could have been used to substantiate the information derived from VicRoads, this reference was chosen for its clarity and excellent reputation.

Based on these sources of advice, a motorcyclist considers and selects the appropriate position in which to negotiate the curve on approach to the curve. For a left hand bend, a rider would move from the position generally adopted when riding through straight sections of road (the centre of the lane) to the outer right side of the lane. From this point the rider heads to the apex of the curve, the inner radius, and then moves out again to the outer edge of the lane. This allows the widest trajectory to be taken within the confines of the road geometry reducing bend radius, maximising available traction, reducing the angle of lean and the amount of time spent at maximum lean.

While this is the general theory for safe curve negotiation, factors such as rider experience, weather, road condition, motorcycle features and the rider's propensity for risk taking can modify the effect on the actual trajectory and the speed at which the rider moves through the curve. Entry speed in turn can affect the lane position taken. It can be said that lower entry speed allows for safer curve negotiation as it requires less lean, and therefore less potential to overbalance, allows more wheel traction, and provides opportunity for corrective measures. This suggests that the lower the entry speed the smaller the proportion of lane that needs to be utilised to remain upright.

Lane position data was captured for each rider passing through the control site, Treatment Site 1 and Treatment Site 2, using a JVC standard definition, digital video recorder owned by ARRB Transport Research. As perceptual countermeasures aim to influence rider behaviour on the approach to a curve, the video was stationed at a suitable vantage point prior to the curve. In most cases, the video was run off a power supply or an ARRB car's batteries. As such, the location of the video depended on the available space to park the vehicle, taking into account site distance and conspicuity to passing riders. It was not

possible to measure lane position through the series of curves treatments because the video, stationed in one position, could only capture footage of riders within sight distance. Motorcycle speed and lane position data were collected for traffic moving in a northerly direction so that riders travelled through the control site before the treatment sites. Consequently, behaviour at the control site would not be influenced by prior exposure to the treatments.

Continuous video recording took place at each site and data collection period during the hours of observation.

Analysis and interpretation of lane position data were then derived from the video recordings at a later time.

Lane position was analysed by projecting the video footage on to a screen and comparing proportions of riders in the left, centre and right sides of the approach lane in the three treatment periods for the Control Site and Treatment Sites 1 (Peripheral Lines) and 2 (Guide Posts). The aim was to identify a location that would capture any change in rider lane position as a result of the implemented treatments. This was done by identifying the point at which the majority of riders begin to position themselves in order to negotiate the upcoming bend. As discussed above, there is no one location at which all riders will commence bend negotiation: factors such as approach speeds, motorcycle type, rider experience and site familiarity, weather conditions, and rider attitude are some of the influences that determine the distance at which riders position themselves to ride through a curve. Similarly, it is not possible to select a point of comparison at the exact same distance for each of the control and treatment sites as each curve is likely to elicit slightly different negotiation techniques. The selected point at which lane position was compared therefore is a general location likely to highlight any changes. The specific point was based on advice from motorcycle riders, including a police officer and was also influenced by practical issues such as video angle and zoom to ensure an appropriate balance between ideal location and accurate data analysis.

At the selected points and using the projected video footage, the travel lane was divided into three equal parts - left, centre and right (see Figure 2.11). As each motorcyclist passed this point, the position adopted within the lane – left, centre or right, was recorded. Lane position was recorded at the exact point at which the bottom of the motorcycle tyre intersected with the overlaid “grid”. Where the tyre fell in between the centre and left or right side, the position was recorded as being in the centre. Motorcyclists who intentionally moved into the oncoming traffic lane to overtake were not included in the analysis. Win DVD software was used to slow down the footage where necessary for greater accuracy.

Motorcyclists travelling in groups were included in the analysis. Group travel appeared to be quite popular and so inclusion of rider behaviour both individually and as a group was considered important. Samples of group versus individual rider behaviour did not suggest a bias towards one particular lane position and so, for the purpose of this analysis, was not expected to heavily influence lane position proportions.





Figure 2.11 Photo of projected video footage and divisions of traffic lane into three categories

### 2.4.3 Data collection dates

All data were collected between May 2007 and April 2008. Data were collected over five weekends between 10:00am and 4:00pm on Saturday and Sunday at each collection period (Before, First After and Second After) and for each site (Control and Treatment). ‘Before’ data were collected in May, June and September 2007 and the treatments were installed on October 17, 2007.

There was a five week ‘settling in’ period between treatment installation and commencement of the First After data collection to allow frequent users of the sites to adjust to the modified conditions without impacting the after data. The Second After data collection phase took place in March and April 2008, approximately five months after installation of the treatments. Table 2.1 shows the dates on which data was collected at each site and collection period.

**Table 2.1 Data collection dates at each site and collection period**

	Control	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Before	1 & 2 <sup>nd</sup> September 2007	15 <sup>th</sup> 2007 & 16 <sup>th</sup> September 2007	26 <sup>th</sup> & 27 <sup>th</sup> May 2007	9 <sup>th</sup> & 10 <sup>th</sup> June 2007	22 <sup>nd</sup> & 23 <sup>rd</sup> September 2007
First After	24 <sup>th</sup> & 25 <sup>th</sup> November 2007	1&2 <sup>nd</sup> December 2007	12&13 <sup>th</sup> January 2008	17 <sup>th</sup> November & 16 <sup>th</sup> December	24 <sup>th</sup> & 25 <sup>th</sup> November 2007
Second After	March 8 & 9 <sup>th</sup> 2008	15 <sup>th</sup> & 16 <sup>th</sup> March 2008	5 <sup>th</sup> & 6 <sup>th</sup> April 2008	5 <sup>th</sup> & 6 <sup>th</sup> April 2008	19 <sup>th</sup> & 20 <sup>th</sup> April 2008

#### **2.4.4 Site inspections**

Five site inspections were conducted over the study period to ensure the treatments had not worn or become damaged. The condition of the treatments remained satisfactory throughout the duration of the study period.

### **2.5 DATA ANALYSIS**

A generalised linear model with contrasts was used to determine whether any speed change between the before and after periods at the treatment sites differed from any speed change at the control site. The difference between the two changes provides an estimate of the 'net' change in speed that can be attributed to an effect of the treatment and was calculated for both short-term and long-term periods. If the perceptual countermeasures were affecting travel speeds, a reduction in speeds on the treatment sites relative to the control site would be expected over the periods of interest. This technique was used to examine changes in mean speed; 85th percentile speed; and the proportion of riders exceeding 75 km/h.

As noted in Section 2.3.2 above all sites were preceded by an advisory speed limit sign of 45-50 km/h despite an 80-100 km/h speed limit through most of the route. The advisory speed limit provides an indication of the speed at which a vehicle can travel safely, all else being equal. It was of interest in this study to assess whether the treatments had any effect on reducing the proportion of riders exceeding the advisory speed limit. However, discussions with police motorcycle riders identified that, as most riders travelling through the site tend to be leisure riders, it is unlikely that they would adhere to the advisory speed limit. A ride through the sites by one of the police motorcyclists identified that an experienced motorcyclist could travel through each treated site safely at a speed of not more than 75 km/h. Therefore, the proportion of motorcyclists travelling above 75 km/h was calculated for each site in the before and after periods. Logistic regression was used to compare how the relative odds of exceeding 75 km/h on the treatment sites in the after periods changed relative to the before period, adjusted for the change at the control site.

The proportion of motorcyclists travelling in the left, centre or right hand side of the approach lane was calculated for each site and time period.

Data were screened for outliers and checked for normality. This preliminary analysis identified that the data were slightly skewed. A logarithmic transformation was therefore performed to provide a better fit to the data for the analysis.



## 3.0 RESULTS

### 3.1 Sampling characteristics

4,412 motorcycle speeds were measured across all sites and time periods for a total of 1,318 riders. At the Control Site and Treatment Sites 1 and 2, 3,809 motorcycle spot speeds were recorded with the laser gun for a total of 715 riders (mean number of records per rider = 5.33). A total of 603 average speed measurements were recorded for as many riders at Treatment Sites 3 and 4. Table 3.1 shows the total number of speed measurements collected at each site and time period. Table 3.2 shows the total number of riders measured at each site and time period.

Fifteen spot speeds were excluded due to a laser malfunction or because the rider slowed down to enquire about the study. Six riders were excluded from the study because they noticed the researcher/s prior to entering the measurement area or were held up by slow moving traffic. As the sites are located along a popular leisure-riding route, a number of riders traversed the sites in groups of two or more. The laser can only record speeds for one rider at a time and so a set of speed measurements for riders travelling in close proximity to each other could only be taken for one of the riders in the group.

**Table 3.1** Number of speeds measured at the control and treatment sites

	Before	First After	Second After	Total
<b>Control</b>				
Saturday	196	42	100	338
Sunday	417	311	346	1,074
<b>Total</b>	<b>613</b>	<b>353</b>	<b>446</b>	<b>1,412</b>
<b>Treatment 1</b>				
Saturday	39	180	100	319
Sunday	411	221	213	845
<b>Total</b>	<b>450</b>	<b>401</b>	<b>313</b>	<b>1,164</b>
<b>Treatment 2</b>				
Saturday	161	152	37	350
Sunday	279	405	199	883
<b>Total</b>	<b>440</b>	<b>557</b>	<b>236</b>	<b>1,233</b>
<b>Treatment 3</b>				
Saturday	11	25	9	45
Sunday	55	28	59	142
<b>Total</b>	<b>66</b>	<b>53</b>	<b>68</b>	<b>187</b>
<b>Treatment 4</b>				
Saturday	17	54	64	135
Sunday	83	81	117	281
<b>Total</b>	<b>100</b>	<b>135</b>	<b>181</b>	<b>416</b>
				<b>4,412</b>

Table 3.1 shows a much higher number of speed measurements on Sunday than on Saturday. This reflects the higher number of motorcyclists riding on that day (See Table 3.2).

**Table 3.2** Number of rider speeds measured at the control and treatment sites

	Before	First After	Second After	Total
<b>Control</b>				
Saturday	32	16	20	68
Sunday	51	51	60	162
<b>Total</b>	<b>83</b>	<b>67</b>	<b>80</b>	<b>230</b>
<b>Treatment 1</b>				
Saturday	6	33	22	61
Sunday	66	39	40	145
<b>Total</b>	<b>72</b>	<b>72</b>	<b>62</b>	<b>206</b>
<b>Treatment 2</b>				
Saturday	41	36	7	84
Sunday	64	88	43	195
<b>Total</b>	<b>105</b>	<b>124</b>	<b>50</b>	<b>279</b>
<b>Treatment 3</b>				
Saturday	11	25	9	45
Sunday	55	28	59	142
<b>Total</b>	<b>66</b>	<b>53</b>	<b>68</b>	<b>187</b>
<b>Treatment 4</b>				
Saturday	17	54	64	135
Sunday	83	81	117	281
<b>Total</b>	<b>100</b>	<b>135</b>	<b>181</b>	<b>416</b>
	<b>426</b>	<b>451</b>	<b>441</b>	<b>1,318</b>

Table 3.2 shows that weekend riding is much more popular on Sunday than on Saturday with just over 70 percent of the 1,318 riders choosing to ride on Sundays. This pattern was consistent across all 15 weekends.

Lane position of a total of 1,026 motorcyclists was analysed qualitatively to determine any changes in rider behaviour when negotiating the left hand bend at the Control site and Treatment Sites 1 and 2. Table 3.3 presents the total number of rider lane positions examined for each site and time period.

**Table 3.3** Number of rider lane positions examined at the control and treatment sites

	Before			First After			Second After		
	Left	Centre	Right	Left	Centre	Right	Left	Centre	Right
Control	1	53	36	3	83	60	7	101	57
Treatment 1	0	29	62	0	57	30	0	38	62
Treatment 2	0	20	109	0	51	102	0	39	26

### 3.2 Mean speed

Table 3.4 presents mean motorcycle speeds and standard deviations at each site prior to installation of the treatments (the Before period) and afterwards (First After and Second After). A comparison of mean treatment and control site speeds at each time period is also presented separately in Figures 3.1 to 3.5 below.

**Table 3.4 Mean speed (km/h  $\pm$  S.E) for the control and treatment sites for Before, First After and Second After collection periods**

	Before	First After	Speed $\Delta$	Second After	Speed $\Delta$ (Before to Second After)
Control	73.74 (+ 1.14)	77.76 (+ 1.37)	+ 4.02	68.62 (+ 0.98)	- 5.12
Treatment 1	62.07 (+ 0.91)	62.18 (+ 1.05)	+ 0.11	56.42 (+ 1.15)	- 5.65
Treatment 2	65.29 (+ 0.97)	67.08 (+ 0.89)	+ 1.79	61.97 (+ 1.26)	- 3.32
Treatment 3	66.31(+ 1.36)	70.72 (+ 1.32)	+ 4.41	65.51 (+ 1.62)	- 0.8
Treatment 4	70.14 (+ 1.01)	70.28 (+ 0.87)	+ 0.14	63.78 (+ 0.95)	- 6.36

Table 3.4 shows that the mean motorcycle speeds were substantially higher at the control site than at the treatment sites across each time period. Mean speed increased at all sites from the before to First After period, particularly at the Control site and at Treatment Site 3. At all sites, mean speed dropped substantially between the First and Second After periods and was lower in the Second After period than in the Before period.

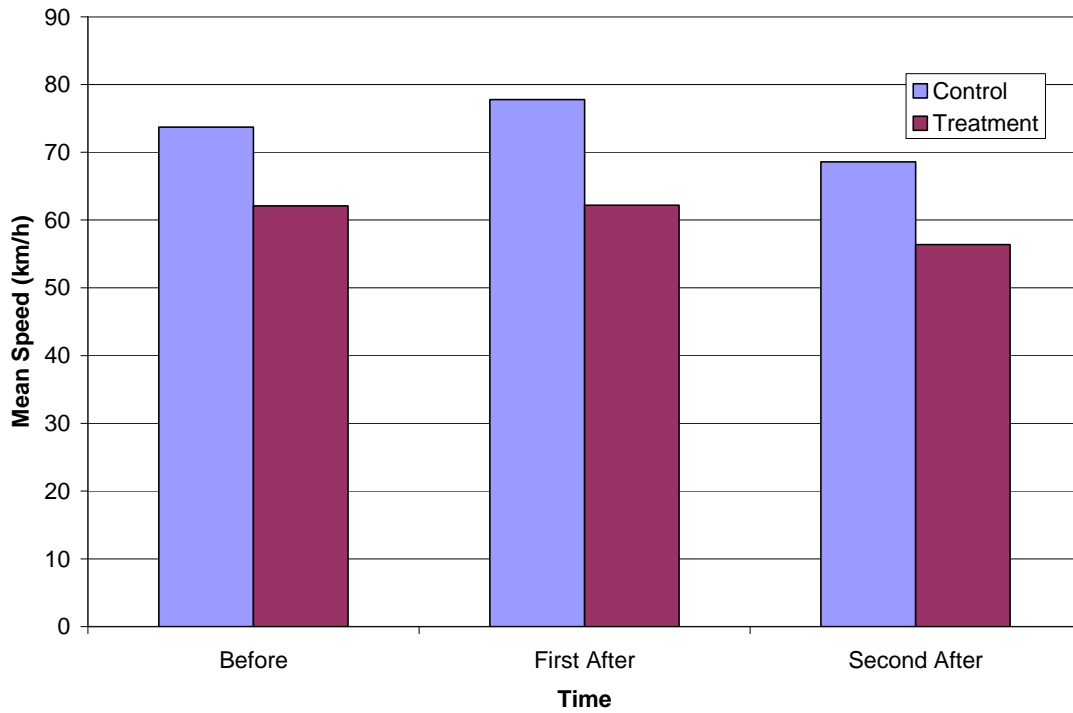


Figure 3.1 Mean speed at Treatment Site 1 (Peripheral Transverse Lines – Single Curve) and Control site for each period

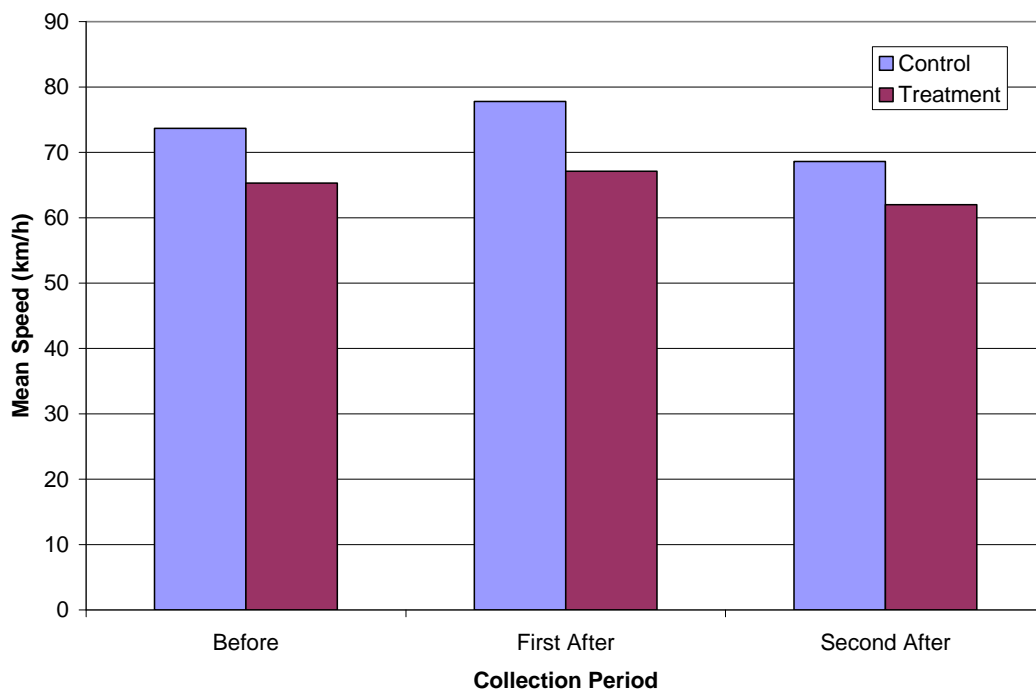


Figure 3.2 Mean speed at Treatment Site 2 (Curve Enhancement through Guideposts – Single Curve) and Control site for each period

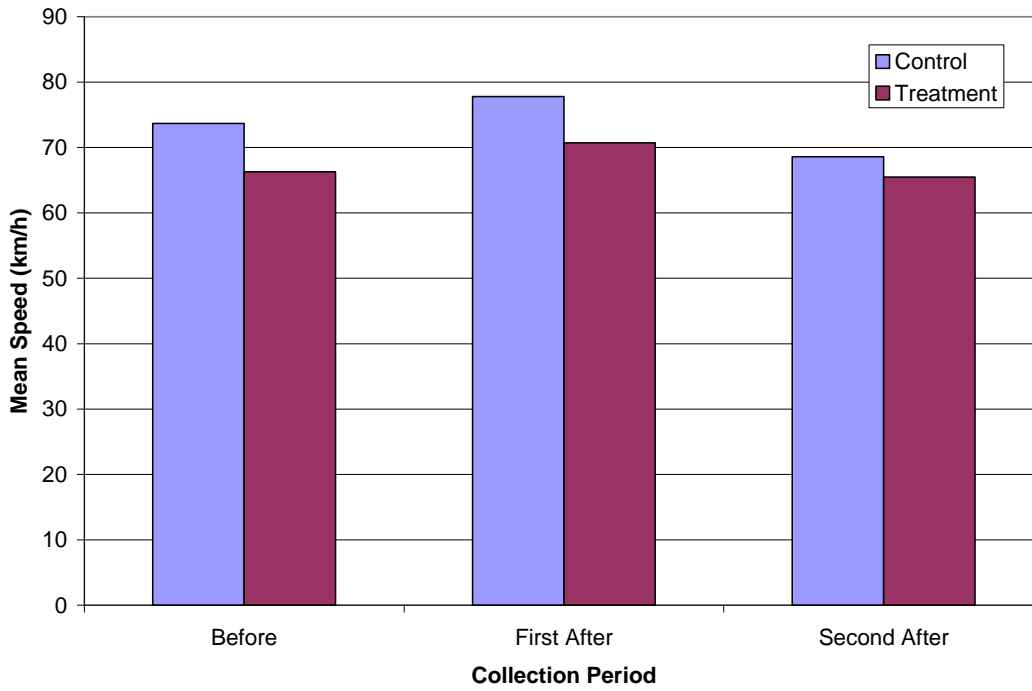


Figure 3.3 Mean speed at Treatment Site 3 (Peripheral Transverse Lines – Series of curves) and Control site for each period

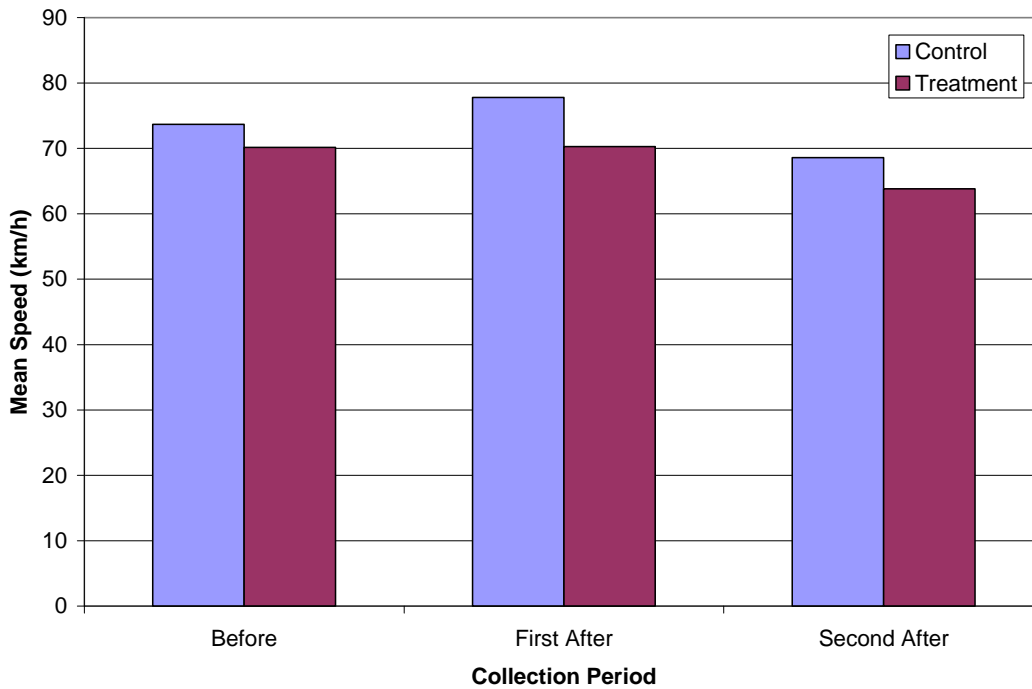


Figure 3.4 Mean speed at Treatment Site 4 (Curve Enhancement through Guideposts – Series of Curves) and Control site for each period



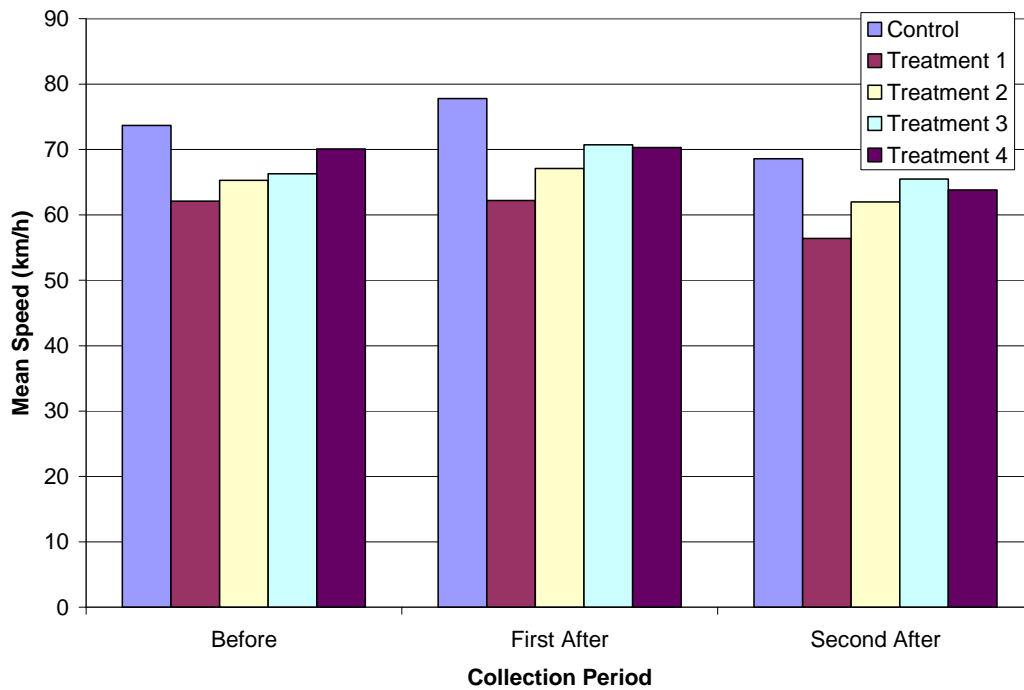


Figure 3.5 Mean speed at the Control site and all treatment sites for each period

Table 3.5 shows the percentage changes in mean speed between the before and after periods at the treatment sites adjusted for the percentage changes at the control site. Subtracting the percentage change over time at the control site from the percentage change over time at each treatment site provides an indication of the net change due to the effect of the treatment, or, the effect of the treatment over and above that obtained due to extraneous factors (i.e. at the control site). Table 3.6 shows the observed mean speeds at each treatment site and the mean speeds that would be expected at those sites if no treatments had been installed. The expected mean speeds (columns in bold type) are derived by: 1) calculating the percentage change in mean speed at the control site, 2) calculating the percentage change in mean speed at the treatment site, 3) subtracting the difference between the two, 4) adding the change in mean speed (if a reduction) or by subtracting the change in mean speed (if an increase) to the mean speed obtained in the First After period. These figures essentially show what the mean speeds would have been if speed at each treatment site had increased/decreased by the same proportional amount as at the control site across each time period.

As an example, the mean speed at Treatment Site 1 in the First After period was 62.18 km/h (Table 3.6). The change in mean speed from the Before period to the First After period at the control site was 5.45% (or 4.02 km/h) increase (Table 3.5). The change in mean speed from the Before period to the First After period at Treatment Site 1 was 0.18% (or a 0.11 km/h increase) (Table 3.5). Subtracting the percentage change over time at the Control Site from the percentage change over time at the treatment site provides the net percentage change due to the effect of the treatment, or the effect of the treatment over and above that obtained due to extraneous factors (i.e. at the control site). Thus,  $0.18\% - 5.45\% = -5.27\%$  (Table 3.5). The treatment at Site 1 thus prevented a 5.27% increase in mean speed between the Before and First After period, or a 3.27 km/h increase in mean speed from 62.07 km/h to 65.34 km/h over this period (Table 3.6).

**Table 3.5 Summary of the effects of perceptual countermeasures on mean speed adjusted for the percentage change at the control site for each time period**

	Net speed change at the treatment sites (km/h) relative to the control site (95% CI)		
	Before to First After	Before to Second After	First After to Second After
Treatment 1	-3.27 (-3.61, 2.74)	-1.34 (-1.75, -0.90)	1.55
Treatment 2	-1.77 (-2.15, -1.34)	1.21 (0.81, 1.67)	2.77
Treatment 3	0.80 (0.35, 1.27)	3.80 (3.47, 4.32)	3.10
Treatment 4	-3.68 (-4, -3.16)	-1.49 (-1.85, -1.08)	1.76

All changes were significant at the 0.001 level of significance

**Table 3.6 Comparison of mean speeds observed (km/h) and mean speeds expected (km/h) when adjusted for the percentage change at the control site for each time period**

Time period	Before	First After	First After (adjusted for control)	Second After	Second After (adjusted for control) (From Before Period)	Second After (adjusted for control) (From First After Period)
Treatment 1	62.07	62.18	<b>65.34</b>	56.42	<b>63.41</b>	<b>60.63</b>
Treatment 2	65.29	67.08	<b>67.06</b>	61.97	<b>64.08</b>	<b>64.31</b>
Treatment 3	66.31	70.72	<b>65.51</b>	65.51	<b>62.51</b>	<b>67.62</b>
Treatment 4	70.14	70.28	<b>73.82</b>	63.78	<b>71.63</b>	<b>68.52</b>

Table 3.5 shows a significant net reduction in mean speed between the Before and First After periods at all sites except Treatment Site 3. The largest mean speed reduction of 3.68 km/h occurred at Treatment Site 4 ( $\chi^2$  317.06,  $df$  1,  $p < 0.000$ ), followed by Treatment Site 1 (3.27 km/h) ( $\chi^2$  220.59,  $df$  1,  $p < 0.000$ ), and Treatment Site 2 (1.77 km/h) ( $\chi^2$  78.42,  $df$  1,

$p < 0.000$ ). A significant increase of 0.80 km/h was evident at Treatment Site 3 ( $\chi^2$  10.81,  $df$  1,  $p > 0.001$ ).

Significant net reductions in mean speed from the Before to Second After period occurred at Treatment Sites 1 (1.34 km/h) ( $\chi^2$  40.68,  $df$  1,  $p < 0.001$ ) and 4 (1.49 km/h) ( $\chi^2$  64.61,  $df$  1,  $p < 0.001$ ). A significant net increase in mean speed occurred at Treatment Sites 2 (1.21 km/h) ( $\chi^2$  31.41,  $df$  1,  $p < 0.001$ ) and 3 (3.80 km/h) ( $\chi^2$  303.77,  $df$  1,  $p < 0.001$ ) over the same period.

There was a significant net increase in mean speed at all treatment sites between the First After and Second After period. The largest net increase occurred at Treatment Site 3 (3.10 km/h), followed by Treatment Sites 2 (2.77 km/h), 4 (1.76 km/h) and 1 (1.55 km/h).

### 3.3 85<sup>th</sup> percentile speed

Table 3.7 presents 85<sup>th</sup> percentile mean motorcycle speeds at each site prior to installation of the treatments (Before period) and afterwards (First After and Second After). A comparison of 85<sup>th</sup> percentile speeds at the control and treatment sites at each time period is also presented separately in Figures 3.6 to 3.10.

**Table 3.7 85<sup>th</sup> percentile speed (km/h) for the control and treatment sites for Before, First After and Second After collection periods**

	Before	First After	Speed Before-First After	$\Delta$	Second After	Speed Before-Second After	$\Delta$
Control	84.54	89.05	+ 5.33%		76.54	- 9.46%	
Treatment 1	71.51	72.00	+ 0.69%		64.21	- 10.21%	
Treatment 2	75.72	78.52	+ 3.7%		72.16	- 4.70%	
Treatment 3	77.01	80.36	+ 4.35%		76.60	- 0.53%	
Treatment 4	79.51	81.23	+ 2.16%		76.26	- 4.19%	

Table 3.7 shows that the 85<sup>th</sup> percentile motorcycle speeds were, in general, substantially higher at the control site than at the treatment sites across each time period. The 85<sup>th</sup> percentile motorcycle speeds increased at all sites from the Before to First After period, particularly at the Control site. At all sites, the 85<sup>th</sup> percentile speed dropped substantially between the First and Second After periods and was lower in the Second After period than in the Before period.

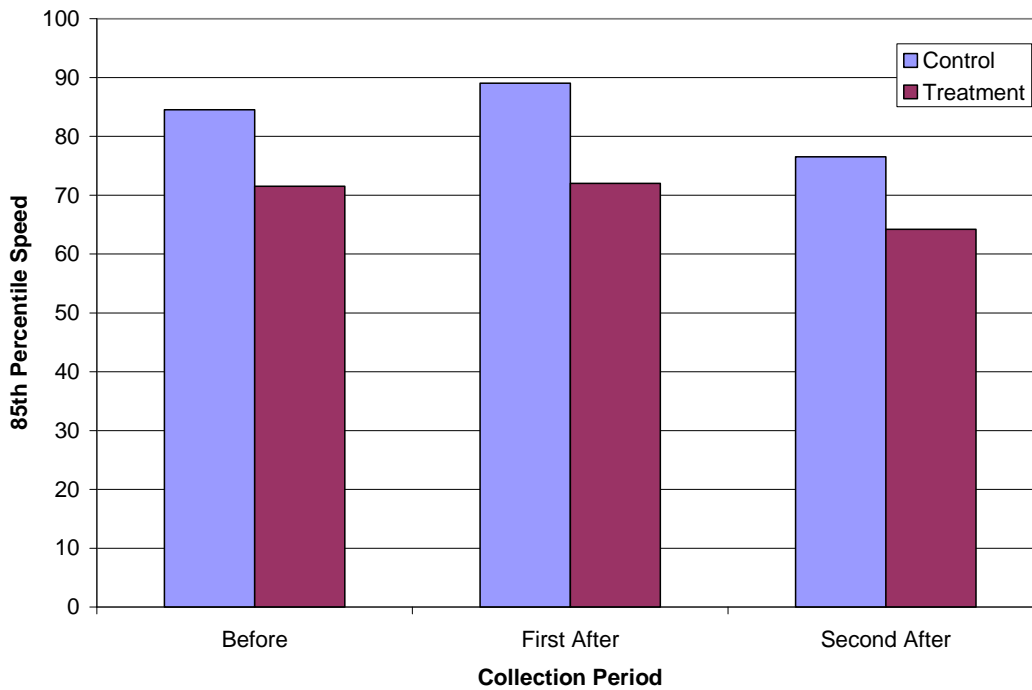


Figure 3.6 85<sup>th</sup> percentile speed at Treatment Site 1 (Peripheral Transverse Lines – Single Curve) and Control site for each period

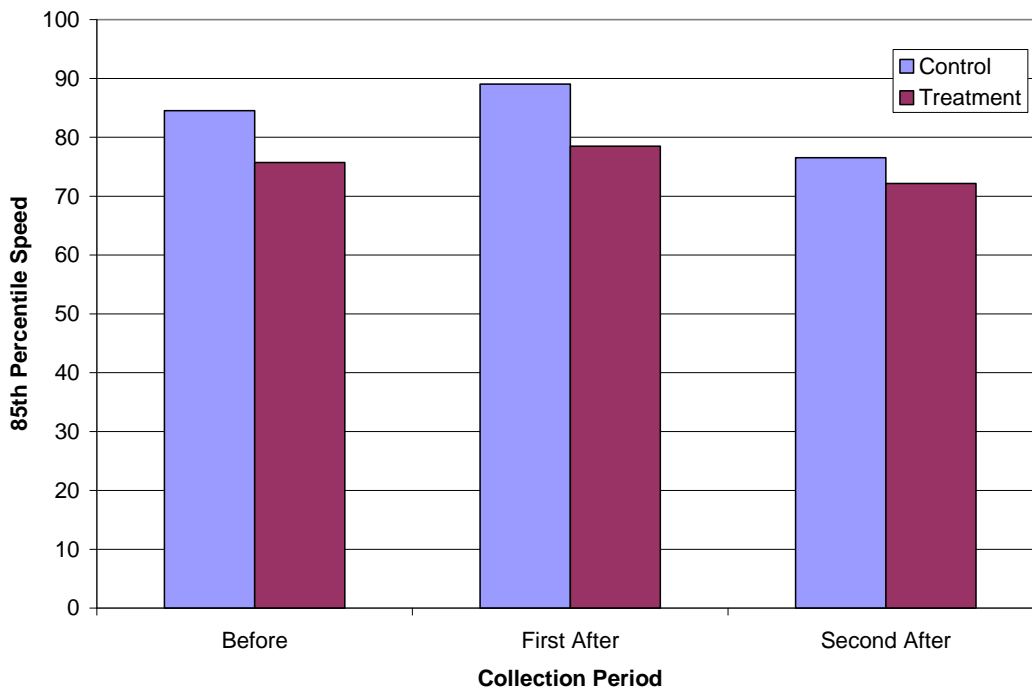


Figure 3.7 85<sup>th</sup> percentile speed at Treatment Site 2 (Curve Enhancement through Guideposts – Single Curve) and Control site for each period

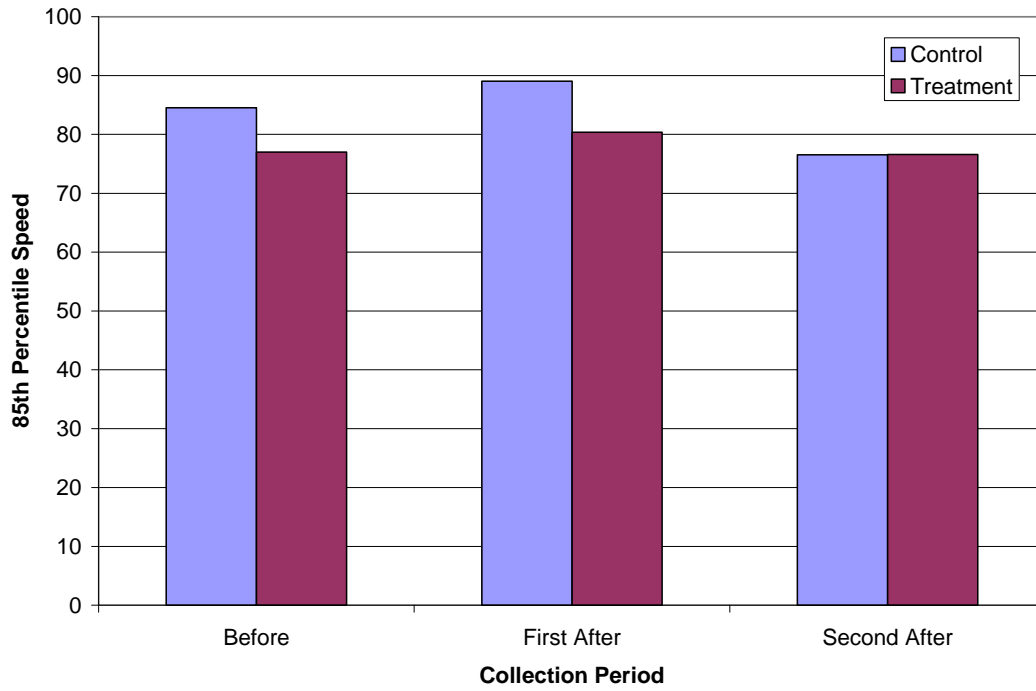


Figure 3.8 85<sup>th</sup> percentile speed at Treatment Site 3 (Peripheral Transverse Lines – Series of curves) and Control site for each period

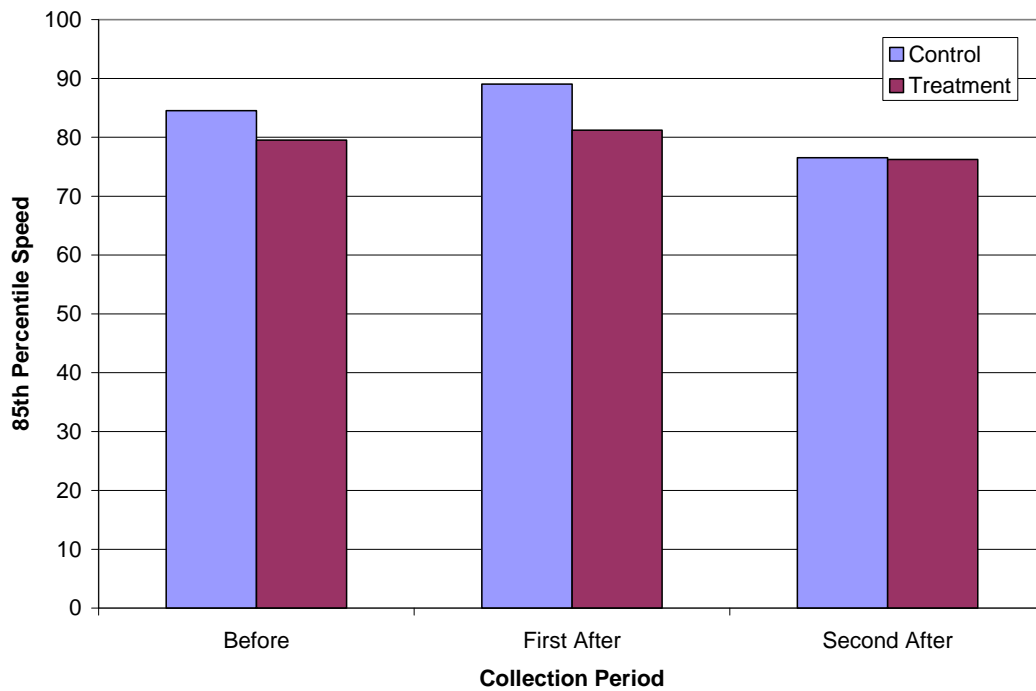


Figure 3.9 85<sup>th</sup> percentile speed at Treatment Site 4 (Curve Enhancement through Guideposts – Series of Curves) and Control site for each period

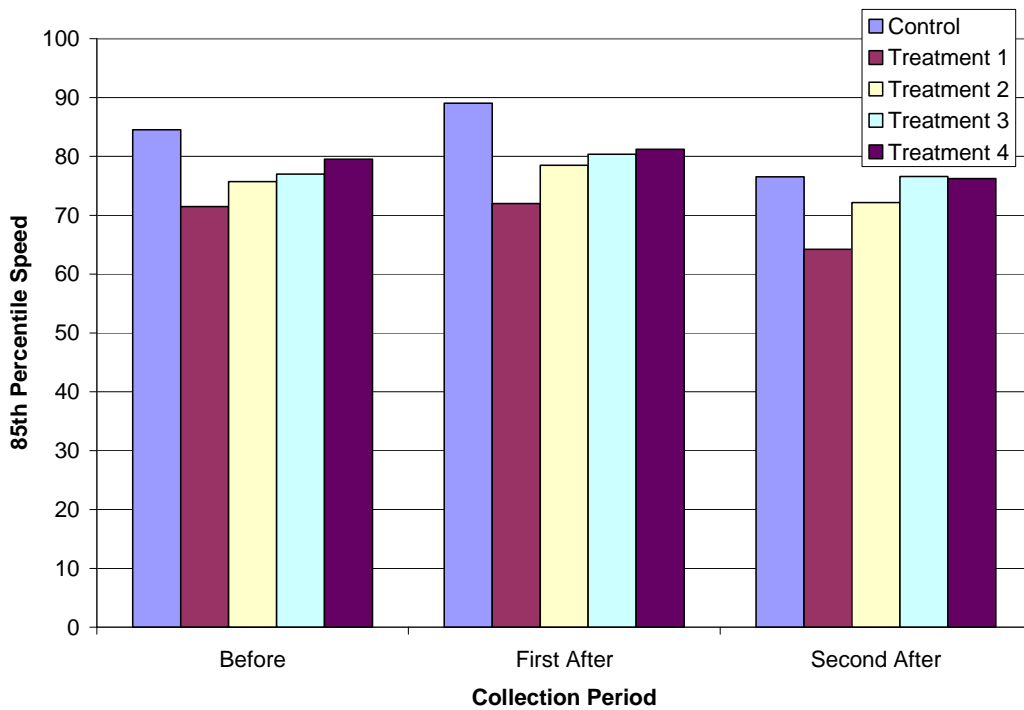


Figure 3.10 *85<sup>th</sup> percentile speed at the Control site and all treatment sites for each period*

Table 3.8 shows the percentage changes in 85<sup>th</sup> percentile speed between the before and after periods at the treatment sites adjusted for the percentage change at the control site. Based on the results in Table 3.8, Table 3.9 shows the observed 85<sup>th</sup> percentile speeds at each treatment site and the percentage change in mean speeds that might be expected at those sites if no treatments had been installed.

**Table 3.8 Summary of the effects of perceptual countermeasures on 85<sup>th</sup> percentile speed adjusted for the percentage change at the control site for each time period**

	Net speed change at the treatment sites (km/h) relative to the control site (95% CI)		
	Before to First After	Before to Second After	First After to Second After
Treatment 1	-3.32 (-3.67, 2.8)	-0.53 (-0.96, -1.28) (p=0.011)	2.32
Treatment 2	-1.24 (-1.65, -0.86)	3.61 (3.25, 4.11)	4.67
Treatment 3	-0.76 (-1.21, 0.24) (p=0.002)	6.88 (6.75, 7.66)	7.53
Treatment 4	-2.52 (-2.85, -2.11)	4.27 (4.04, 4.8)	6.44

\* All changes were significant at the 0.001 level apart from those in italics, where the associated probability is indicated.

**Table 3.9 Comparison of 85<sup>th</sup> percentile speeds observed (km/h) and 85<sup>th</sup> percentile speeds expected (km/h) when adjusted for the percentage change at the control site for each time period**

Time period	Before	First After	First After (adjusted for control)	Second After	Second After (adjusted for control) (From Before Period)	Second After (adjusted for control) (From First After Period)
Treatment 1	71.51	72.00	<b>74.83</b>	64.21	<b>72.04</b>	<b>69.68</b>
Treatment 2	75.72	78.52	<b>76.96</b>	72.16	<b>72.11</b>	<b>73.85</b>
Treatment 3	77.01	80.36	<b>77.77</b>	76.60	<b>70.13</b>	<b>72.83</b>
Treatment 4	79.51	81.23	<b>82.03</b>	76.26	<b>75.24</b>	<b>74.79</b>

Table 3.8 shows a significant net reduction in 85<sup>th</sup> percentile speed between the Before and First After periods at all sites. The largest reduction of 3.32 km/h occurred at Treatment Site 1 ( $\chi^2$  227.38, *df* 1,  $p$ <0.001), followed by Treatment Site 4 (2.52 km/h) ( $\chi^2$  149.00, *df* 1,  $p$ <0.001), Treatment Site 2 (1.24 km/h) ( $\chi^2$  37.53, *df* 1,  $p$ <0.001) and Treatment Site 3 (0.76 km/h) ( $\chi^2$  9.75, *df* 1,  $p$ <0.002).

Significant net increases in 85<sup>th</sup> percentile speed between the Before and Second After period occurred at all sites except Treatment Site 1. The largest increase of 6.88 km/h occurred at Treatment Site 3 ( $\chi^2$  996.53, *df* 1,  $p$ <0.001), followed by Treatment Site 4

(4.27 km/h) ( $\chi^2$  523.77, *df* 1,  $p < 0.001$ ), and Treatment Site 2 (3.61 km/h) ( $\chi^2$  281.83, *df* 1,  $p < 0.001$ ). The treatment at Site 1 produced a small but significant 85<sup>th</sup> percentile speed reduction of 0.53 km/h ( $\chi^2$  6.54, *df* 1,  $p < 0.01$ ).

There was a significant net increase in 85<sup>th</sup> percentile speed at all treatment sites between the First After and Second After period. The largest net increase occurred at Treatment Site 3 (7.53 km/h), followed by Treatment Sites 4 (6.44 km/h), 2 (4.67 km/h) and 1 (2.32 km/h).

### 3.4 Proportion of motorcyclists travelling above 75 km/h

Table 3.10 shows that almost 23 percent (302) of the 1,218 riders exceeded 75 km/h pooled across all sites and time periods. Tables 3.11 and 3.12 present the number and percentage of motorcyclists travelling above 75 km/h at each site prior to installation of the treatments (Before period) and afterwards (First After and Second After). A comparison of the proportion of riders exceeding 75 km/h at the control and treatment sites at each time period is also presented separately in Figures 3.11 to 3.15.

**Table 3.10 Number and percentage of riders travelling above 75 km/h**

	Frequency	Percent
0-75 km/h	1,016	77.1
75.1 and over	302	22.9
Total	1,218	100.0



**Table 3.11** Number of riders at each site exceeding 75 km/h before and after treatment installation

	Before	First After	Second After
Control	38	38	18
Treatment 1	6	3	3
Treatment 2	17	25	3
Treatment 3	12	19	14
Treatment 4	33	45	28
Total	106	130	66

**Table 3.12** Percentage of riders at each site exceeding 75 km/h before and after treatment installation

	Before	First After	Second After
Control	45.8	56.7	22.5
Treatment 1	8.3	4.2	4.8
Treatment 2	16.2	20.2	6.0
Treatment 3	18.2	35.8	20.6
Treatment 4	33.0	33.3	15.5

Table 3.12 shows that the percentage of riders exceeding 75 km/h at each site was substantially higher at the control site than at the treatment sites across each time period. The percentage of riders exceeding 75 km/h increased at all sites from the Before to First After period, except at Treatment Site 1. At all sites except Treatment Site 1 the percentage of riders at each site exceeding 75 km/h dropped substantially between the First and Second After periods. The percentage of riders exceeding 75 km/h was lower in the Second After period than in the Before period at all sites except Treatment Site 3.

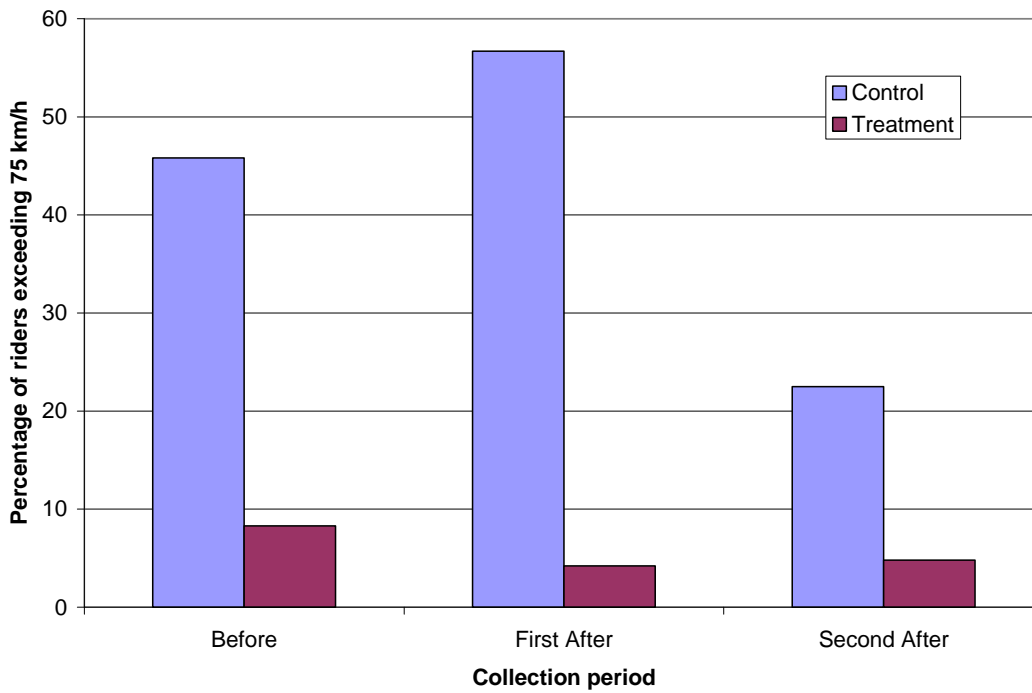


Figure 3.11 Percentage of riders exceeding 75 km/h at Treatment Site 1 (Peripheral Transverse Lines – Single Curve) and Control site for each period

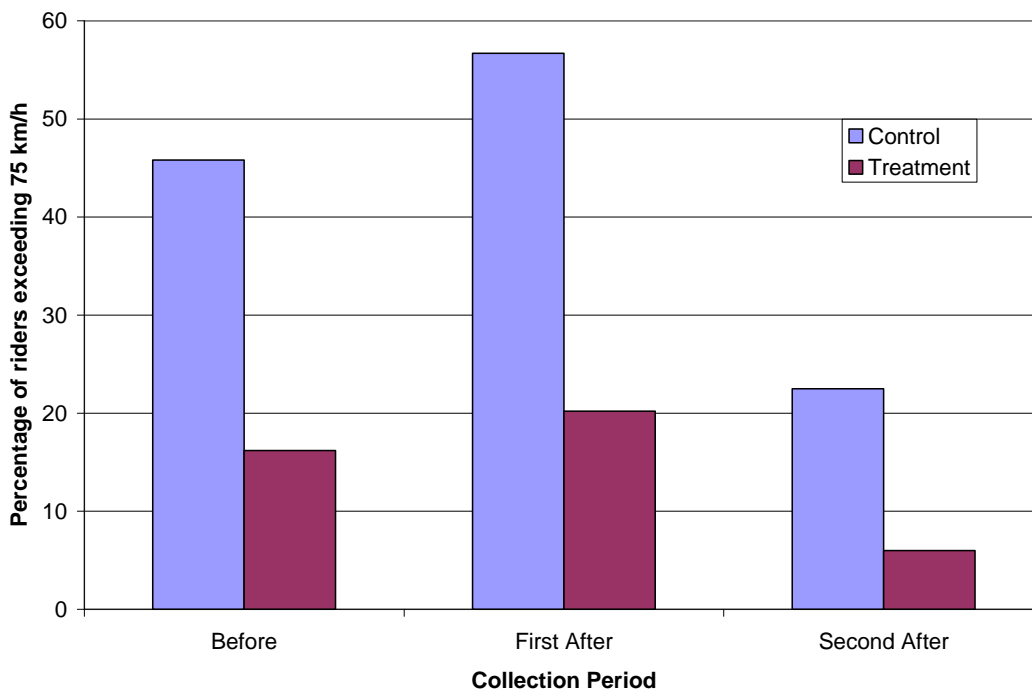


Figure 3.12 Percentage of riders exceeding 75 km/h at Treatment Site 2 (Curve Enhancement through Guideposts – Single Curve) and Control site for each period

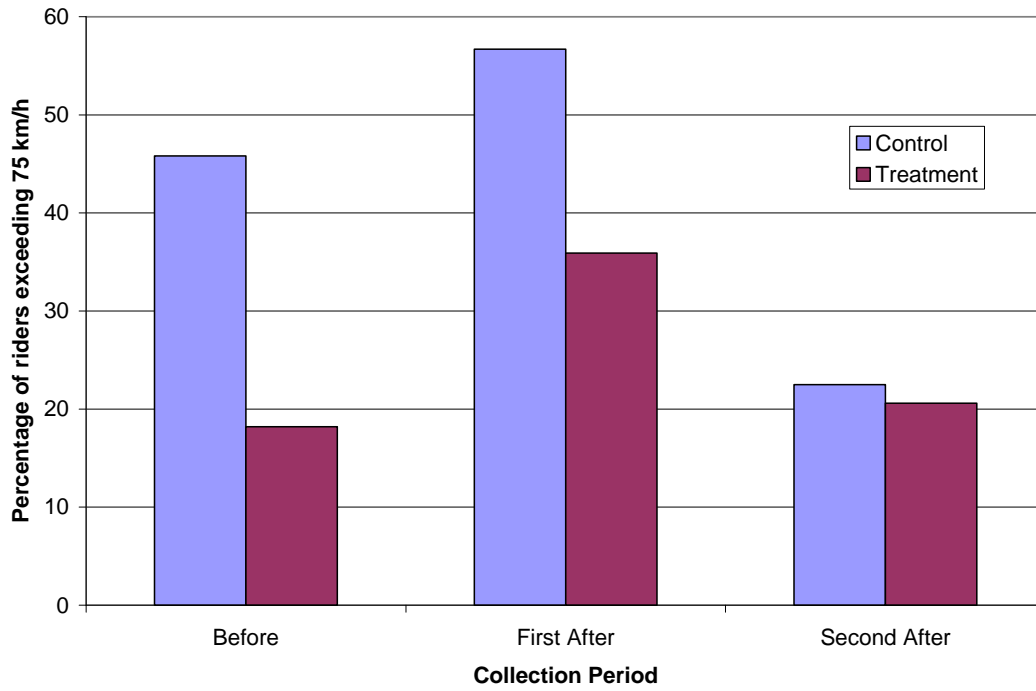


Figure 3.13 Percentage of riders exceeding 75 km/h at Treatment Site 3 (Peripheral Transverse Lines – Series of curves) and Control site for each period

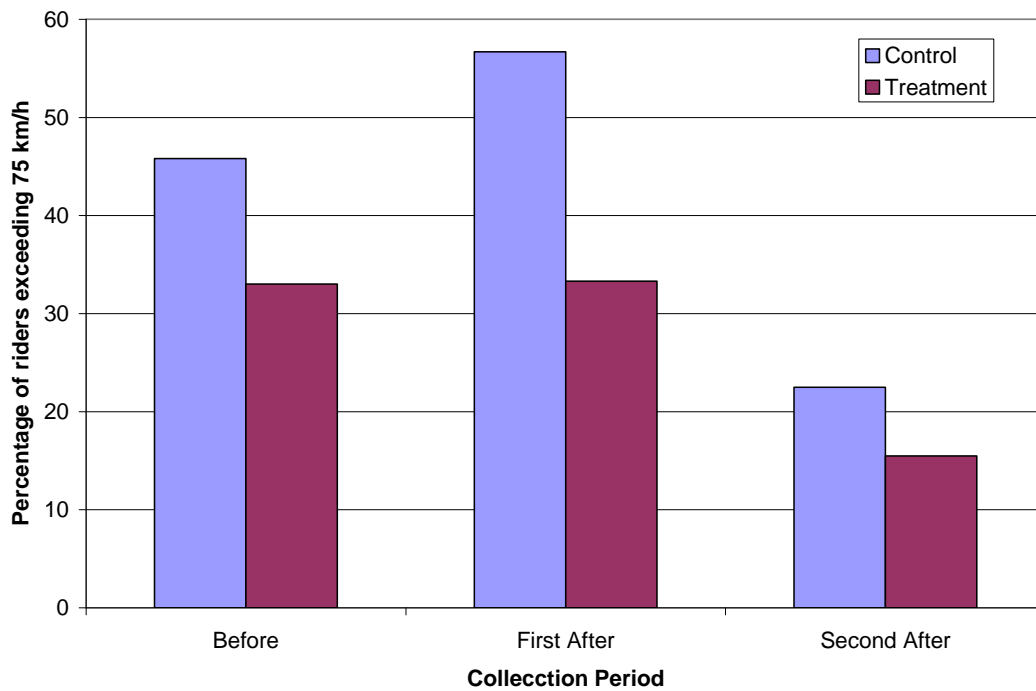


Figure 3.14 Percentage of riders exceeding 75 km/h at Treatment Site 4 (Curve Enhancement through Guideposts – Series of Curves) and Control site for each period

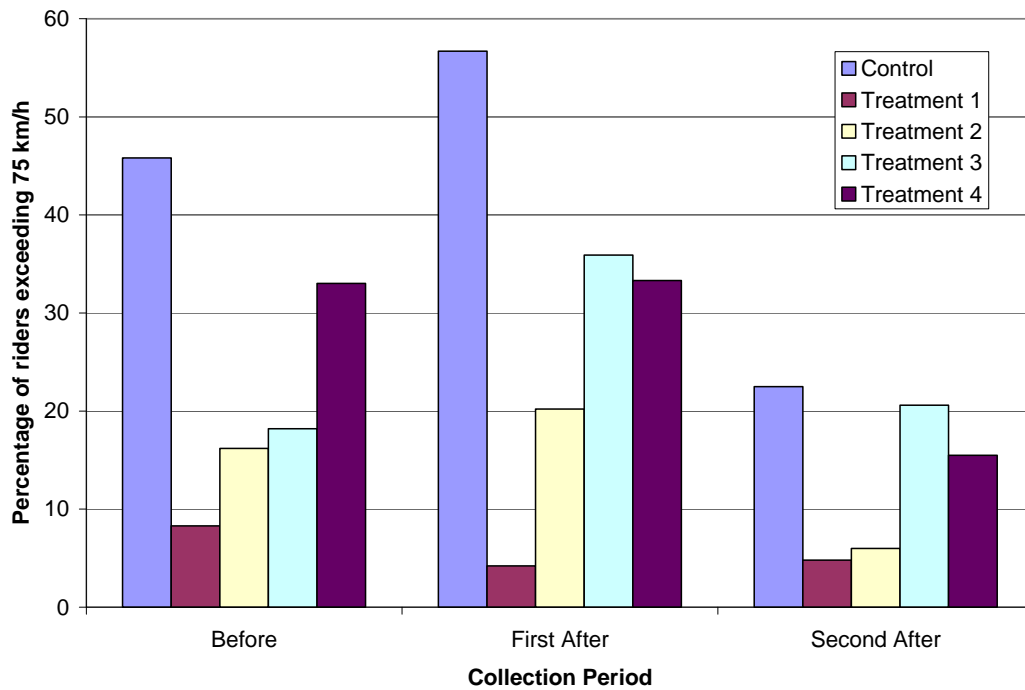


Figure 3.15 Percentage of riders exceeding 75 km/h at the Control site and all treatment sites for each period

A logistic regression analysis was used to compare how the relative odds of exceeding 75 km/h at the treatment sites in the after periods changed relative to the before period, compared with the control site. The net change in the proportion of vehicles travelling over 75 km/h at the treatment sites, relative to the control site is shown in Table 3.13.

**Table 3.13 Summary of the effects of perceptual countermeasures on percentage of riders exceeding 75 km/h adjusted for the change at the control site for each time period**

	Net percentage change at the treatment sites relative to the control site (95% confidence interval)		
	Before to First After	Before to Second After	First After to Second After
Treatment 1	-59.6 (-90, 91)	18.2 (-72, 390)	77.8
Treatment 2	0.5 (-47, 91)	-24.6 (-79, 169)	-25.1
Treatment 3	59.2 (-21, 221)	130.4 (0, 432)	71.2
Treatment 4	-18.5 (-50, 32)	-4.6 (-50, 82)	13.9

\*All effects were non-significant (at 0.05%)

Table 3.13 shows that the treatments produced a non-significant net reduction in the proportion of riders exceeding 75 km/h at Treatment Site 1 (59.6%) (OR = 0.404, 95% CI = 0.101-1.609,  $p > 0.05$ ) and Treatment Site 4 (18.5%) (OR = 0.815, 95% CI = 0.503-1.322,  $p > 0.05$ ) from the Before to First After period. The treatments at Sites 2 and 3

produced a non-significant net increase of 0.5% (OR = 1.005, 95% CI = 0.530 – 1.908,  $p > 0.05$ ) and 59.2% (OR = 1.592, 95% CI = 0.790 – 3.206,  $p > 0.05$ ) respectively in the proportion of riders exceeding 75 km/h over this period.

Non-significant net increases in the proportion of riders exceeding 75 km/h occurred between the Before and Second After period at Treatment Sites 1 (18.2%) (OR = 1.182, 95% CI = 0.285 – 4.904),  $p > 0.05$ ) and 3 (130.4%) (OR = 2.304, 95% CI = 0.998 – 5.319,  $p < 0.05$ ). Non-significant net reductions in the proportion of riders exceeding 75 km/h were evident at Treatment Sites 2 (24.6%) (OR = 0.754, 95% CI = 0.212 – 2.686,  $p > 0.05$ ) and 4 (4.6%) (OR = 0.954, 95 % CI = 0.501 – 1.815,  $p > 0.05$ ) over this period.

There was a non-significant net increase in the proportion of riders exceeding 75 km/h between the First and Second After periods at Treatment Sites 1 (77.8%); 3 (71.2%) and 4 (13.9%). A non-significant net reduction in the proportion of riders exceeding 75 km/h was evident at Treatment Site 2 (25.1%).

**Table 3.14 Comparison of observed and expected percentage of riders exceeding 75 km/h when adjusted for the percentage change at the control site for each time period**

Time period	Before	First After	First After (adjusted for control)	Second After	Second After (adjusted for control) (From Before Period)	Second After (adjusted for control) (From First After Period)
Treatment 1	8.3	4.2	<b>6.7</b>	4.8	<b>3.9</b>	<b>1.07</b>
Treatment 2	16.2	20.2	<b>20.1</b>	6.0	<b>7.5</b>	<b>7.5</b>
Treatment 3	18.2	35.8	<b>14.6</b>	20.6	<b>0</b>	<b>5.9</b>
Treatment 4	33.0	33.3	<b>39.7</b>	15.5	<b>16.2</b>	<b>13.4</b>

### 3.5 Proportion of vehicles travelling in the left, centre or right side of approach lane

Tables 3.15 – 3.17 show the proportions of riders positioning themselves in the left, centre and right sides of the lane prior to negotiating the curve.

**Table 3.15 Number and percentage of riders at each site travelling in the left side of the approach lane**

	Before (No.)	Before (%)	First After (No.)	First After (%)	No. $\Delta$ Before-First After	Second After (No.)	Second After (%)
Control	1	1	3	2	+2	7	4
Treatment 1	0	0	0	0	0	0	0
Treatment 2	0	0	0	0	0	0	0

**Table 3.16 Number and percentage of riders at each site travelling in the centre of the approach lane**

	Before (No.)	Before (%)	First After (No.)	First After (%)	No. $\Delta$ Before- First After	Second After (No.)	Second After (%)
Control	53	59	83	57	+30	101	61
Treatment 1	29	32	57	66	+28	38	38
Treatment 2	20	16	51	33	+31	39	60

**Table 3.17 Number and percentage of riders at each site travelling in the right side of the approach lane**

	Before (No.)	Before (%)	First After (No.)	First After (%)	No. $\Delta$ Before- First After	Second After (No.)	Second After (%)
Control	36	40	60	41	+24	57	35
Treatment 1	62	68	30	34	-32	62	62
Treatment 2	109	84	102	67	-7	26	40

Tables 3.15 – 3.17 show that few or no riders selected the left lane position when approaching a left hand bend at both the control and treatment sites. At the control site, a larger proportion of riders selected the centre of the lane on approach to the curve than the right side. This remained reasonably constant in both the before and after time periods. In contrast, around two thirds of the riders selected the right side of the lane on approach to both Treatment Sites 1 and 2 in the Before period. For Treatment Site 1 – Peripheral Lines, this was reduced to a third in the First After period, and then increased again to levels similar to that prior to treatment installation. At Treatment Site 2 – Guide Posts - however, the proportion in the right side of the lane reduced even further to around half that of the Before period.

Tables 3.18 – 3.20 below show the percentage changes in the proportion of riders travelling in the left, centre and right side of the approach lane between the before and after periods at the treatment sites adjusted for the percentage change at the control site.

**Table 3.18 Percentage of riders travelling in the left side of the lane when adjusted for the change at the control site for each time period**

Time period	Before	First After	First After (adjusted for control)	Second After	Second After (adjusted for control)
Treatment 1	0	0	1	0	3
Treatment 2	0	0	1	0	3

**Table 3.19 Percentage of riders travelling in the centre of the lane when adjusted for the change at the control site for each time period**

Time period	Before	First After	First After (adjusted for control)	Second After	Second After (adjusted for control)
Treatment 1	32	66	68	38	42
Treatment 2	16	33	35	60	58

**Table 3.20 Percentage of riders travelling in the right side of the lane when adjusted for the change at the control site for each time period**

Time period	Before	First After	First After (adjusted for control)	Second After	Second After (adjusted for control)
Treatment 1	68	34	33	62	67
Treatment 2	84	67	66	40	45

Table 3.18 indicates that there were no riders in the left side of the lane for both treatment sites and time periods. The change at the control site suggests that there should be a slight increase in the proportion of riders in the left side of the lane following treatment implementation. It could be argued that the treatments have prevented an unsafe or unorthodox position to be adopted. However, given the small numbers in question, this conclusion should be treated with caution.

Table 3.19 indicates that the proportion of riders in the centre of the lane at Treatment Site 1 – Peripheral Lines, increased by a third in the First After period (from 32% to 68%). The increase in the proportion of riders positioning themselves in the centre of the lane was not as pronounced in the Second After period (42%). Treatment Site 2 – Guide Posts had a larger proportion of riders in the centre of the lane after treatment compared to before. This increased to 58% of riders travelling in the centre of the lane in the Second After period.

Table 3.20 indicates that the proportion of riders travelling in the right side of the traffic lane at Treatment Site 1 – Peripheral Lines, fell from 68% to 33% in the First After Period and then increased in the Second After period to about the same proportion (67%) as prior to treatment installation. Treatment Site 2 – Guide Posts, experienced nearly a 40% reduction in the proportion of riders in the right side of the lane in the Second After period when compared to the Before period. This was a further reduction from the First After period where the proportion was around 66%.

Although not reported here, the results also indicated that the proportion of riders straying over the centre line in the before period was generally greater than in the after periods at both the control and treatment sites.



## 4.0 DISCUSSION

### 4.1 Overview

This project evaluated the effects of two types of perceptual countermeasure treatments on motorcycle speed and lane position along a popular recreational motorcycle riding route in Victoria; peripheral transverse lines on approach to a single curve and through a series of curves and ascending guideposts on approach to a single curve and through a series of curves. A before after design was used to compare speed and lane position before treatment installation with two periods after treatment installation: one short-term period (five weeks post installation) and one long-term period (five months post installation).

With the exception of Treatment Site 1, the results showed that motorcycle speeds were substantially higher at the control site than at the treatment sites across each time period for all parameters (mean speed, 85<sup>th</sup> percentile speed, and the proportion of riders exceeding 75 km/h). Overall, there was an increase in mean and 85<sup>th</sup> percentile speeds at all sites in the short-term, particularly at the Control Site and Treatment Site 3 – Peripheral Transverse Lines – Series of Curves. At all sites except Treatment Site 1 the percentage of riders exceeding 75 km/h dropped substantially between the First and Second After periods. For all parameters except the proportion of riders exceeding 75 km/h, speeds in the long term were lower than prior to treatment installation (Before Period) and there were also substantial reductions at all sites from the First After to the Second After period. At all sites except Treatment Site 1 the percentage of riders at each site exceeding 75 km/h dropped substantially between the First and Second After periods. The percentage of riders exceeding 75 km/h was lower in the Second After period than in the Before period at all sites except Treatment Site 3.

Notwithstanding these results, the true effect of the treatments can only be derived by subtracting the percentage change at the control site from the percentage change at each of the treatment sites over the periods of interest. This result provides an indication of the net effect, or the effect of the treatment over and above the effect of any extraneous variables as measured by the control site. Extraneous variables are factors other than the treatment that can have a transient effect on motorcycle speed including weather, police presence, traffic volumes, road category, and road geometry. Without the use of a control, it is impossible to determine if changes observed at the treatment sites are due to the perceptual countermeasure treatments or to other extraneous variables that also changed over time.

An analysis of the net change in speed parameters over the periods of interest showed that the treatments were generally effective in reducing (or preventing an increase in) speeds in the short-term but not in maintaining these reductions in the long-term. A significant long term reduction in average speed was found for Treatment Sites 1 and 4 only, with Treatment site 1 also producing a small but significant reduction in the 85<sup>th</sup> percentile speed over this period.

With respect to lane position on approach to the curve, the results showed that a short term shift in the proportion of riders travelling in the right side to the centre of the approach lane was not maintained in the long-term for Treatment Site 1. With respect to Treatment Site 2 – Guide Posts, however, there appeared to be a longer term shift in lane position, with the proportion of riders travelling in the right side of the lane nearly halving from the Before Period to the Second After period.

The short and long-term speed and lane position changes at the sites and possible explanations for the results are described below in terms of: a) the absolute change in speed at all sites; b) the net change in speed and lane position at the treatment sites and c) the impact of the treatments on motorcycle speed and lane position.

## **4.2 Short-term speed changes**

### ***Absolute speed changes at all sites***

The results showed that motorcycle speeds were substantially higher at the control site than at the treatment sites in the short-term (i.e. five weeks post treatment installation) for all speed parameters. Overall, there was an increase in mean and 85<sup>th</sup> percentile speeds at all sites, particularly at the Control Site (mean speed from 73.7 km/h to 77.8 km/h; 85<sup>th</sup> percentile speed from 84.54km/h to 89.05km/h) and Treatment Site 3 – Peripheral Transverse Lines – Series of Curves (mean speed from 66.3 km/h to 70.7 km/h; 85<sup>th</sup> percentile speed from 77.01 km/h to 80.36 km/h). Relatively smaller increases were found at the other sites. The percentage of riders exceeding 75 km/h increased at all sites except Treatment site 1 (Peripheral Transverse Lines – Single Curve) which fell from 8.3% to 4.2%. The most substantial increase occurred at the Control Site (from 45.8% to 56.7%)

It is likely that seasonal weather differences before and after treatment installation could account for the increase in speeds recorded at all sites in the short-term. In the current study, much of the data collection in the Before Period took place in the winter months of May and June. The weather on each of these weekends was cold and, in some cases, there was fog in the morning and potential for the roads to be slick. The short-term data collection period following treatment installation was carried out from mid November to mid January when the weather was much warmer. It is possible that leisure riders increase their speeds and so take more risks during warmer months when the roads are less slick and weather conditions are more conducive to riding. The difference in weather conditions between the Before and First After data collection periods may explain the increase in speed at each of the sites in the short-term. However, as noted above, the increase in speed was greater at the Control Site than at the treatment sites (with the exception of Treatment Site 3). The greater increase in speed at the control site compared to most of the other sites would support the hypothesis that the treatments were effective in preventing a net increase in speed that might otherwise have occurred at the sites without the treatments. This is described further in the next section.

### ***Net speed changes at the treatment sites***

Treatment Site 1 – Peripheral Transverse Lines – Single Curve was most effective in reducing speed in the short-term and had the lowest baseline speed of the five sites examined. Despite little change in mean speed in the short-term (from 62.1 to 62.2 km/h), this treatment was effective in preventing a 3.27 km/h increase in mean speed and a 3.32 km/h increase in 85<sup>th</sup> percentile speed that might otherwise have occurred at the site without the treatment.

A reduction of a similar magnitude occurred at Treatment Site 4 – Guideposts – Series of Curves (average speed: 3.68 km/h and 85<sup>th</sup> percentile speed: 2.52 km/h). A 1.77 km/h reduction in mean speed and a 1.24 km/h reduction in 85<sup>th</sup> percentile speed were observed at Treatment Site 2 – Guideposts – Single Curve. The Peripheral Transverse Lines treatment at Site 3 – Series of Curves was not effective in reducing mean speed in the short-term, although it did produce a 0.76 km/h reduction in the 85<sup>th</sup> percentile speed.

Short-term net reductions in the proportion of riders exceeding 75 km/h occurred at all sites except Treatment site 3, although none of the effects were significant. The failure of these results to reach statistical significance is most likely due to the very small sample size for this speed parameter; only 23 percent (302 riders) of the total sample exceeded 75 km/h across all sites and collection periods. Breaking this figure down into single sites and collection periods for the analysis reduced the sample size even further, particularly at Treatment Site 1 (See Table 3.11 for raw numbers).

#### **4.3 Short-term lane position changes**

The results indicated that lane position at Treatment Sites 1 (Peripheral Transverse Lines) and 2 (Guide Posts) was modified substantially in the short-term. While no riders were observed in the left side of the approach lane at both treatment sites for all time periods, there was a large proportion travelling in the right side of the lane before treatment. These proportions fell at both sites in the First After period, from 68% to 33% (Treatment Site 1 – Peripheral Lines) and from 84% to 66% (Treatment Site 2 – Guide Posts). Riders travelling in the centre of the lane increased proportionately at both sites (although the total does not add to 100% due to adjustments made for the change at the Control site).

With respect to Treatment Site 1 – Peripheral Transverse Lines, the findings indicate that riders were travelling more often in the centre of the lane when approaching the left hand bend. With respect to Treatment Site 2 – Guide Posts, the results suggest that a greater proportion of riders approached the bend in the centre of the lane during the First After period (33%) than prior to treatment (16%).

#### **4.4 Long-term speed changes**

The Second After period of data collection was carried out five months post treatment installation and assessed the extent to which any change observed in the First After period was a consequence of a ‘novelty effect’ or to a more permanent and enduring characteristic of the treatments. If behaviour changes when measured at the First After period but returns to its pre-treatment state in the Second After period, it is likely that riders have adapted to the treatments over time and that the benefits observed will only be short-term. If, however, the treatments are creating a change in rider perception as intended, any benefits observed in the First After period are likely to be maintained when measured in the Second After period.

##### ***Absolute speed changes at all sites***

The results of this study showed that there were substantial long-term speed reductions at all sites following treatment installation. This effect was largest between the First and Second After period of data collection, but speeds were still substantially lower in the Second After period than before treatment installation. The largest average speed reduction between the Before and Second After periods occurred at the Control Site (6.36 km/h (9.1%)) whilst the largest 85<sup>th</sup> percentile speed reduction of 7.3 km/h occurred at Treatment Site 2 (10.2%).

The results could partly be explained by seasonal weather changes between the short and long-term data collection periods. As described earlier, warm weather is likely to encourage higher travel speeds among riders than when the roads are less likely to be slick and the weather is warmer. The First After data collection was carried out during generally warmer weather (mid November to mid January) than the Second After period (mid March

to end of April). It is possible that the reduction in speed observed in the long-term was due, in part, to increased caution on the part of riders compared to when riding in warmer weather. However, the long-term reductions in speed were relatively much greater than the short-term increases in speed to be explained entirely by seasonal differences across the data collection periods. If seasonal differences were the only variable explaining the change, speeds should have been higher than or at least as low as those recorded prior to treatment installation. This was clearly not the case.

Consultation with VicRoads and the Warburton Police identified that that an enforcement blitz targeting speeding motorcyclists was conducted along Warburton Woods Point Road during the long-term data collection period. The enforcement blitz almost certainly explains the substantial long-term speed reductions found at all sites. Two enforcement operations were carried out over this period: 'Operation Titan' in the Reefton Spur along Warburton Woods Point Road towards Cambarville Junction, and 'Operation Surreptitious' along the Black Spur.

Operation Titan was conducted along an 800 metre straight stretch of road approximately 38 kilometres from Warburton and 5 kilometres from the top of the Cambarville junction leading to Marysville. The commencement of the enforcement blitz was located approximately one kilometre north of the end point of Treatment Site 4 – Guideposts – Series of Curves. The blitz involved the police taking overt laser gun measures of motorcycle speeds for riders travelling in both directions. A marked police car was parked by the side of the road and speeding riders were intercepted by the police who stepped out on to the road to pull the rider over.

The blitz was conducted on the same weekends that data was being collected for Treatment Sites 2 and 3 (April 5<sup>th</sup> and 6<sup>th</sup>) and Treatment Site 4 (April 20<sup>th</sup>). However, its effect on motorcycle speeds is likely to have impacted all sites equally, despite the fact that riders travelling in a northerly direction would have passed all five sites before they reached the location of the blitz. There are several possible reasons for this assumption. The first is that riders travelling in the opposite direction probably created a general deterrence effect by forewarning oncoming riders about the police presence. The second is that, given the very curvilinear terrain along Woods Point Road, it is likely that forewarned riders reduced their speeds along the entire route because it is often not possible to see more than about 50 metres ahead to anticipate where the police might be waiting. Finally, although the blitz was not conducted on the weekends that data were collected at the Control Site and at Treatment Site 1, speed reductions of a similar magnitude to the other sites or greater were also found at these two sites. Again, a general deterrence effect is likely to account for these results. The police blitz along Woods Point Road commenced in mid February 2008 and was undertaken on at least one day of each of the three weekends prior to data collection at the Control Site (March 8 and 9) and Treatment Site 1 (March 15 and 16). It is likely that local or regular riders also travelled more cautiously on these weekends due to an expectation that the police could be out on site 'because they were last weekend'. Discussions with Warburton Police revealed that the blitz was widely publicised so it is possible that riders unfamiliar with the route were also informed.

While the enforcement blitz almost certainly explains the much lower mean and 85<sup>th</sup> percentile speeds recorded at all sites during the long-term data collection period, unless the net speed changes at the treatment sites are examined (i.e., taking into account the change at the control site), it is not possible to determine how much of the reduction, if any, was due to treatment effects. These effects are discussed in the next section.

### ***Net speed changes at the treatment sites***

Analysis of the long-term net changes in speed (Before to Second After) showed that the treatments were not effective in maintaining the net speed reductions produced in the short-term, with only small significant reductions in average speed at Treatment Sites 1 (1.34 km/h) and 4 (1.49 km/h) and a small significant reduction in the 85<sup>th</sup> percentile speed at Treatment Site 1 (0.53 km/h).

Significant average speed increases were recorded at Treatment sites 2 (1.21 km/h) and 3 (3.80 km/h) over this period. Significant and substantial 85<sup>th</sup> percentile speed increases were observed at Treatment Sites 3 (6.88 km/h), 4 (4.27), and 2 (3.61 km/h). Long-term net increases in the proportion of riders exceeding 75 km/h occurred at all sites except Treatment site 2, although none of the effects were significant.

These long-term results show that the treatments were generally not effective in maintaining the net speed reductions produced in the short-term and suggest the outcomes were indicative of a ‘novelty’ effect rather than an enduring and more permanent characteristic of the treatments in changing rider speed perception.

#### **4.5 Long-term lane position changes**

The results indicate that lane position at Treatment Site 1 – Peripheral Transverse Lines showed little change in the Second After period when compared to the Before period. About two thirds of the riders approached the curve in the right side of the lane both before treatment (68%), and after treatment (67%). These results may suggest that the short-term lane position changes recorded at this site are more likely due to a novelty effect rather than a more enduring characteristic of the treatments in changing lane position behaviour. In other words, the lower proportion of ‘centre lane’ riders in the short term compared to the longer-term is perhaps indicative of riders avoiding contact with the paint (due to a perception that it might be slippery) during a period when they are less familiar with the treatment.

With respect to Treatment Site 2 – Guide Posts, however, there does appear to be a longer term shift in lane position as a result of the treatment, with proportions in the right side of the lane nearly halving from 84% in the Before Period to 45% in the Second After period.

The long-term lane position changes recorded at Treatment Site 2 could suggest a more permanent and enduring characteristic of the treatment in changing rider lane position choice rather than a short-term novelty effect. Since the aim of the guideposts treatment was to produce the illusion of a tighter curve, it is possible that riders approached the curve more cautiously, expecting a smaller radius. Lower approach speeds allow the rider to proceed through the curve closer to the centre of the lane resulting in a more conservative use of the traffic lane. This interpretation is consistent with the long term absolute speed reductions recorded at this site. The description of curve negotiation in Section 2.4.2, suggests that the greater the requirement to use the full extremities of the lane width, the higher the approach speeds. The long-term shift away from the right side of the lane may also confer a safety advantage in lowering the risk for head-on crashes.

Overall, the long-term reduction in the proportion of riders travelling in the right side of the lane together with the absolute speed reductions recorded at Treatment Site 2 – Guideposts, suggest an overall safer outcome at this site.

However, these conclusions should be treated with caution because little is known about the relationship between speed and lane position. The current study showed that riders were more likely to adopt a 'safer' lane position at Treatment Sites 1 and 2 in the short despite an increase in the absolute speed from the Before period. In the long-term, however, riders were more likely to adopt a safer lane position at Treatment Site 2, consistent with the absolute speed reduction recorded at this site. The results at Treatment Site 2 would support the hypothesis that the lower the travel speed, the less surface area is required to safely negotiate the curve and the more likely the rider is to keep to the centre of the lane. According to this line of reasoning, it is likely that speed itself dictates the lane position adopted when negotiating a curve. Irrespective of lane position, however, speed is the single most important predictor of crash risk and crash outcome. A safe lane position is unlikely to confer a substantial risk reduction if a rider loses control whilst speeding or travelling at a speed that is unsafe for the prevailing conditions. While it is acknowledged that poor choice of lane position may itself cause a loss of control under certain circumstances, the outcome is less likely to be severe if the rider is travelling at a safe speed than if he/she is speeding or travelling at a speed that is unsafe for the prevailing conditions.

#### **4.7 Study limitations and suggestions for further research**

An important and unanticipated limitation of this study was the conduct of a police enforcement blitz along Warburton Woods Point during the long-term data collection period. The blitz almost certainly explains the much lower speed parameters recorded at all sites during this period compared to the earlier data collection periods. However, assuming that enforcement affected each of the sites equally, the use of a control site enabled an assessment of whether the treatments were having an impact on speeds over and above that of enforcement (or other extraneous factors). Without the use of a control, it would not be possible to determine whether the reductions observed at the treatment sites were due to the perceptual countermeasure treatments or to other extraneous variables like enforcement that also changed over time.

It would be informative to run another round of data collection during the warmer months to examine the effect of the treatments in isolation from the effect of enforcement. This would provide a better indication of the absolute speeds since the speeds obtained in this study were likely to be much lower than they would be without enforcement. However, the use of a control site has still enabled us to partial out, for each site, the proportion of speed change *attributable to the treatments*. Should another round of data collection be conducted, it would not necessarily modify the *proportional amounts* by which the *treatments* are likely to affect speed, all else being equal.

Each of the collection periods in this study had to be conducted over a minimum of five weekends (one weekend per site) due to the limited availability of resources. On several occasions, data collection had to be postponed (or repeated) due to inclement weather; low motorcycle volumes or equipment malfunction. As such, data collection was extended beyond the five week period and prior to treatment installation; it had to be split across two seasons due to inclement weather and the anticipation of low motorcycle volumes with the onset of winter. While staggering the data collection periods is a potential limitation of the current study, an examination of weather patterns on the test weekends showed that the conditions were well matched across sites despite the change in season during the first collection period (See Table 2.1). Ideally, for each collection period, speeds at each site would be measured at exactly the same time (ideally over one weekend) to minimise potential variations in weather conditions, traffic volumes and possibly even rider types.

This approach approximates a within-subjects design in which the same riders are measured at all sites within the one collection period (assuming they all travel through the entire route) and reduces the random variability that occurs in studies, such as the current one, utilising between subjects designs. It would also be preferable to collect data only during the warmer months when motorcycle volumes are highest.

The importance of adhering to several critical design criteria in the current study limited the choice of suitable control sites along Woods Point Road (See Section 2.3.2 for a description of the site selection criteria). Whilst all of the design criteria were met, it was not possible to match all sites in terms of exact geometric characteristics. This task proved more difficult than anticipated given the curvilinear road geometry; the minimal site distance through most curves, and the limited shoulder space available to take safe and where possible, unobtrusive speed measures. In the current study, the control site was similar to the treatment sites in terms of weather conditions, traffic volumes, police presence and geographical characteristics. The use of a control site on the same route as the treatment sites is considered effective in maintaining consistency across the sites and is a strength of the current study design. However the control site was preceded by fewer curves and a longer and straighter stretch of road on approach to the curve than the treatment sites. These differences are likely to account for the higher absolute speeds found at the Control Site compared to the treatment sites across all data collection periods, particularly prior to treatment installation. Negotiating a series of sharp curves, all within close proximity, is likely to induce more cautious riding and hence lower speeds than when negotiating a single curve preceded by several kilometres of relatively straight sections of road. The control site used in this study was not closely matched to sites 3 and 4 in which the treatments were installed over a series of curves rather than a single curve only. Unless any speed change over time at the control site was different to any speed change over time at the treatment sites as a result of variations in site specific characteristics (for which there is no evidence in the current study), the use of a single curve control site is unlikely to have impacted the results reported here. However, in any future research, a series of curves control site would provide a better match for the series of curves treatments in terms of geometric road characteristics.

## 5.0 CONCLUSIONS AND RECOMMENDATIONS

Overall, the results of this study show that the treatments were generally effective in significantly reducing net speeds in the short-term (from Before to First After) but not in maintaining these reductions in the long-term (Before to Second After).

The peripheral transverse lines treatment installed on approach to a single curve (Treatment Site 1) and the guideposts treatment installed throughout a series of curves (Treatment Site 4) were the most effective treatments in reducing net speeds overall. However, an assessment about whether these treatments are inherently effective in the long-term must be considered in light of: 1) the small size of the long-term mean speed reductions (1.34 km/h for Treatment Site 1 and 1.49 km/h for Treatment Site 4); 2) the long-term net 85<sup>th</sup> percentile speed increase (4.27 km/h) found at Treatment Site 4 and 3) the lack of evidence to demonstrate a reduction in the proportion of riders travelling over 75 km/h at Treatment Sites 1 and 4 in both the short and the long-term. Peripheral transverse lines installed throughout a series of curves (Treatment Site 3) was associated with significant long term mean and 85<sup>th</sup> percentile net speed increases (3.80 km/h and 6.88 km/h respectively) and is therefore unlikely to lead to any future improvements in motorcycle safety.

In general, the impact of the treatments on motorcycle speed reported in this study are indicative of a ‘novelty’ effect rather than an enduring and more permanent characteristic of the treatments in changing rider speed perception.

In terms of lane position, the results suggest that Treatment Site 1 – Peripheral Transverse Lines is unlikely to have a long-term effect on the lane position adopted by motorcyclists when negotiating a curve. While the short-term results indicate a large reduction in the proportion of motorcyclists travelling in the right side of the lane after treatment, this effect appeared to wear off, with the right side of the lane being utilised in the same proportions as before treatment. The findings suggest that lane position behaviour at Treatment Site 1 was indicative of a ‘novelty’ effect, with motorcyclists utilising the full width of the traffic lane in the Second After period, despite physical modifications to the road surface.

Treatment Site 2 – Guide Posts seemed to have a more enduring effect on rider lane position, with the proportion of riders travelling in the right side of the lane nearly halving from before to after treatment installation. Since the aim of the guideposts treatment was to create the illusion of a tighter curve, it is possible that riders approached the curve more cautiously, expecting a smaller radius. This interpretation is consistent with the long term absolute speed reductions recorded at this site. Overall, the long-term reduction in the proportion of riders travelling in the right side of the lane (where head on collisions are more likely) together with the absolute speed reductions recorded at Treatment Site 2 – Guideposts, suggest an overall safe outcome at this site. However, as there is little empirical evidence to demonstrate a relationship between speed and lane position, these conclusions should be treated with caution.

On the basis of these results, the following recommendations might be worthy of consideration:

- In accordance with the design specifications discussed in Section 4.7 of this report, consider a further trial/s of the treatments most effective in producing long-term net speed reductions (peripheral transverse lines treatment installed on approach to a single curve and guideposts treatment installed throughout a series of curves) along



high-speed leisure riding routes. As this study is the first of its kind to be conducted with motorcyclists, a follow-up trial and evaluation would provide a stronger justification for any future decision to implement the treatments along high speed leisure riding routes.

- It is possible that variables such as rider age and experience, motorcycle size and type; familiarity with the motorcycle; and rider speed choice interact to modify lane position choice. To assess this possibility, a future study could examine the relationship between the above mentioned variables and lane position choice by means of a short road side survey of a sample of riders travelling through the sites.
- Consider a trial and evaluation of ‘Where You Look Is Where You Go’ (WYLIWYG) – the only PCM treatment that has been designed specifically for reducing motorcycle crashes on curves. This treatment was designed in the UK and implemented at a single site in Buckinghamshire. While no formal evaluation had been undertaken at the time the literature review was being prepared for this project, anecdotal evidence indicated no crashes had occurred at the site since installation of the treatment.

Finally, while it is important to be open to new possibilities for managing the critical role played by rider (and driver) travel speed choice in determining rider crash and injury risk, it is also important to maintain a balanced perspective on the contribution that innovative measures can make to motorcyclist safety. This study has sought to assess the effectiveness of speed perceptual countermeasures on rider speed choice (as well as lateral positioning within lanes) along roads of a type that are clearly characteristically hazardous for riders. The trial route used in this study, like many other roads that attract high levels of riding (and, commonly, motorcyclist crashes) is currently zoned 100 km/h.

This evaluation has found that speed perceptual countermeasures for riders have the potential to reduce mean speeds by around 1-2 km/h at the trial locations. This statistically reliable finding, while beneficial in safety terms, is unlikely to deliver substantial savings in severe trauma for, arguably, the most vulnerable road user group within the road-transport system. It is therefore recommended that consideration be given to reducing substantially the posted speed limits on such roads in order to gain the magnitude of speed reduction needed to make a substantial contribution to reducing severe trauma sustained by motorcyclists. It will be argued that many riders will not comply with a new, lower posted speed limit. However, there remains a responsibility to advise those riders and drivers who are willing to comply as to what is an appropriate speed for roads of the type studied in this evaluation. Over time, compliance levels can be raised by a well-targeted combination of enforcement and public education.



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