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CHRISTCHURCH NEW ZEALAND

ENCI 495 Project Report

The Effects of the Pages Road Cycle Lane on Cyclist Safety and Traffic Flow Operations

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A final year project report submitted in partial

fulfilment of the requirements for the

degree of Bachelor of Engineering

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Executive Summary

The aim of this project was to identify the effects the installation of a cycle lane had on the traffic flow characteristics vehicle speed and vehicle positioning which in turn were used to infer the safety of cyclists using the cycle lane. The analysis of crash history of similar cycle lane sites compared with control sites was used to predict the effects the cycle lane would have on actual cyclist safety. A qualitative opinion survey of residents living near the cycle lane was used to gauge perceived safety.

The cycle lane studied was located on Pages Road, a two-lane, major arterial road with average annual daily traffic flows of between 13,000 and 27,500 vehicles per day in the Christchurch suburb of Bexley.

It was found that mean vehicle speeds decreased by 0.9 km/h for the peak periods and 1.5km/h for off-peak periods. This decrease in vehicle speed corresponds to an increase in inferred cyclist safety. However, vehicle positioning, another method of inferring safety, did not change significantly when cyclists were present after the cycle lane installation.

Crash history data of cycle lane sites compared to control sites indicated that cycle lanes had a detrimental effect on cycle safety as the control sites displayed greater reductions in crash frequency. This was contrary to the vehicle speed result and was largely disregarded in this project due to the nature of the analysis method and selection of control sites. Further, more detailed analysis of crash history would be required to judge the effects of cycle lanes on actual safety.

Residents' opinions indicated no significant change in cyclists' perceptions of safety but motorists perceived an increase in safety. The number of cyclists who feel more comfortable using the footpath or adjacent parking space illustrates a need for more efforts to be made to increase cyclists' perception of safety.

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1.0 Introduction

1.1 Context

Cycling is a mode of transport that benefits the individual user in terms of health and physical fitness, the wider community in terms of lessened environmental impacts due to no carbon emissions and the road provider as cycles cause less traffic congestion than vehicles (Cycling in Canterbury, 2005; Getting There, 2005). With the recent rises in the cost of fuel it is possible that more people will choose to cycle rather than drive a motor vehicle, especially for short trips.

New Zealand's Land Transport Safety Authority (LTSA), which is now part of Land Transport New Zealand, acknowledges that it is important to provide for cyclists on the country's roads and specifies five general route requirements for all cycleways:

- safety
- comfort
- directness
- coherence
- attractiveness

(Cycle Network and Route Planning Guide, 2004). Of these five requirements, safety is arguably the most important and also the most difficult to gauge and provide.

The Christchurch City Council (CCC)'s current cycling strategy was implemented in 2004 with the objectives being to increase cycling in Christchurch, to increase enjoyment of cycling and to improve safety for cyclists (Christchurch Cycling Strategy, 2004). These three objectives are somewhat interdependent as increasing the safety of cyclists may make them feel more comfortable and hence increase their enjoyment, which in turn compels more people to cycle more often (Getting There, 2005).

Cyclists tend to prefer routes that are direct and efficient, in a similar way to motorists. It has been discovered that if one route is greater than 10 percent longer than another 70 percent of cyclists will choose the shortest route, regardless of other factors such as perceived safety or attractiveness (Sign Up For The Bike, 1996).

Hence cycle lanes are often installed along major arterial roads as these offer the most direct and efficient routes between locations.

The Christchurch City Council recognises three classes of cyclist ability:

a) Children, inexperience adults, elderly, disabled
b) Commuter adults
c) Sports cyclists

It is important to provide cycle routes that are safe for all the types of user likely to be present. "Type a" cyclists will often feel more comfortable when separated from the motor traffic flow (Christchurch Cycling Strategy, 2004).

Traditionally installing cycle lanes adjacent to the vehicle lanes has been considered a safer alternative to simply allowing cyclists to use the edge of the vehicle lanes. However, the Christchurch City Council has recently issued a moratorium on any further installation of cycle lanes due to a concern that a recent increase in the city's cycle lanes has not lead to an increase in cyclist safety. The CCC believes that alternatives to on-road cycle lanes should be considered, as well as providing additional amenities to encourage cycle use for example cyclist shower facilities and storage lockers at central destinations (Koorey, 2005a).

There has been much debate over the Council's decision; many of the city's cyclists disagree with the moratorium believing it shows that the Council does not value cycling as a mode of transport. Council research shows that 35% of people living in Christchurch cycle once a month or more often (Market Research Report, 2005). Tim Hughes, the city's senior road safety engineer for the Land Transport Safety Authority states that it has been shown that cycle lanes reduce accidents not only for cyclists but also for pedestrians and motorists (Koorey, 2005a).

In the wake of the Council's cycle lane moratorium determining the effects of cycle lanes on road user safety is a very relevant topic.

1.2 Project Objectives

The aim of this project is to assess the effect of cycle lanes on the traffic flow characteristics of vehicle speed and positioning across the road. It is assumed that these characteristics are related to the safety of cyclists using cycle lanes as when adjacent vehicles travel closer to cyclists or at greater speeds there is more chance of injury to the cyclists (Buckley and Wilke, 2000; Nillson, 2001). Safety of cyclists using the cycle lane will also be assessed by means of qualitative opinion and crash history research into similar cycle lane locations.

This project was undertaken by Megan Fowler, as her Third Professional year Civil Engineering project. She will be referred to in this report as “the student”.

2.0 Literature Review

A significant amount of research has been done on assessing the most appropriate form of cycle facility. New Zealand's Land Transport Safety Authority (LTSA) suggests that these facilities may be either:

- isolated paths
- paths separated by kerbs, islands or nature strips
- marked space on roadways such as cycle lanes and road shoulders
- fully shared mixed road space

(Cycle Network and Route Planning Guide, 2004).

Melbourne's cycle facilities comprise mainly of exclusive cycle lanes (those adjacent to traffic lanes, designated specifically for cyclists); parking and cycle lanes (where separately marked lane widths allow for car parking and cyclist movement, termed "cycle lane next to parking" in New Zealand); and wide kerbside lanes (traffic lanes with additional width to allow for cyclists). A recent study suggested that the width of integrated parking and cycle lanes may hinder their safety and effectiveness; when no cars are parked motorists may be temped to use the lanes as traffic lanes, especially in times of congestion. Wide kerbside lanes were observed to increase the perception of safety for both cyclists and motorists as the additional width made overtaking easier. (Barton and Daff, 2005).

A detailed study was conducted by the United States Department of Transportation Federal Highway Administration (FHWA) concerning the relative merits between wide kerbside lanes and designated bicycle lanes. It was found that accidents were generally related to road user behaviour and site geometry rather than the type of cycle facility. Both types of facility were judged to have improved cycling conditions but bicycle lanes were more likely to increase the amount of cycling compared with wide kerbside lanes. (A Comparative Analysis of Bicycle Lanes, 1999; Bicycle Lanes Versus Wide Curb Lanes, 1999).

As most of Christchurch's cycle facilities were installed after, and required to be in a similar place to, its roads the cycle facilities tend to fall in the "marked space on roadways" category. This is true for the specific cycle lane studied in this project. The Pages Road cycle lane would be considered a parking and bicycle lane, as, although they are distinctly marked, the parking and cycle areas are adjacent. While the scope of this project does not cover wide kerbside lanes the comparative information provided gives some indication of the safety of cycle lanes next to parking.

The Christchurch City Council, under the guidance of Austroads and Transit standards (Guide to Traffic Engineering Practice Part 14, 1999; New Zealand Supplement to Austroads Guide, 2004) states that cycle lanes situated next to parallel parking lanes must be 1.6-2.5m in width to allow clearance between cyclists and opening car doors. The Pages Road cycle lane is 1.8m wide, which is the code's desirable width.

In a study of Manchester Street and Tuam Street, central Christchurch roads with newly installed/widened cycle lanes, it was found that drivers when parking tend to align their vehicles according to markings on the driver's side; hence the cycle lane itself must provide sufficient room for cyclist clearance. (Hughes, 2004).

"Safety" is a difficult concept to define and gauge. As stated by McClintock (2002, p55) "safety is a relative concept. While cycling or walking might feel unsafe, in practice, the environment in which such activities take place, whether on roads or in rural settings, often feels more threatening than it is." Given the nature of safety it is important to consider the parameters used to judge if how the safety of cyclists is affected by the installation of cycle lanes.

Buckley and Wilke, in their paper presented to the New Zealand Cycling Symposium in 2000, suggest that safety has two categories; perceived (that which is experienced by the road user such as speed and separation distances) and actual (that portrayed by the frequency of crashes). In a survey of four major Christchurch roads with newly installed cycle lanes, Tuam Street, Ferry Road, Linwood Avenue and Main Road, it was found that the crash rate for pedestrians and cyclists was almost conclusively reduced after cycle lane installation. (Buckley and Wilke, 2000).

Actual safety is often difficult to effectively measure due to low crash frequencies. Often incidents are not reported, especially those of lower consequence. Also, collision reports involving cyclists tend to be less detailed than reports for vehicle collisions. (Newman, 2002). Therefore, it is important to assess types of cyclist safety rather than just using actual safety in analyses.

A study was undertaken in Sweden on a project similar to the Pages Road cycle lane installation whereby lanes in 14 roads were re-allocated to allow for cycle lanes. The aim of the Swedish project was to increase cycling and increase cyclist safety by reducing the cyclist accident rate. Safety was gauged according to cyclists' opinions and motor vehicle speeds, based on the assumption that speed levels are proportional to risks and consequences of accidents. The study found that the motor vehicle speeds generally did not decrease; for some streets the mean speeds actually increased. However, cyclists considered the streets to be less dangerous. It was suggested that when coupled, these two effects lead to an overall decrease in safety as cyclists feel more comfortable and are therefore less careful in an environment that is in reality more dangerous. (Nillson, 2001).

From an amalgamation of previous CCC studies it has been observed that in Christchurch cycle lanes tend to reduce both cyclist-vehicle and vehicle-vehicle crashes, cause vehicles to drive closer to the left side of the road (when compared with situations of no marked cycle lane present) and have no noticeable effect on vehicle speed. Cycle lanes are identified as the least obvious of all road markings which contribute to a high observed rate of vehicle occupation of cycle lanes. (Newman, 2002).

A qualitative study was conducted in Christchurch to gauge the effects on safety caused by cycle lane installations in Tennyson Street and Lyttleton Street (Tennyson St Lyttleton St Comparative Evaluation, 2004). Data collected was based on the opinions of residents, cyclists, motorists, parents whose children use the cycle lanes, children who use the cycle lanes and school teachers and school board members of nearby schools. All road users perceived significant increases in safety after the cycle lane installations.

There is still much need for further investigation into the effects of cycle lanes on the safety of road users. Based on the previous studies mentioned, it was decided that the safety of the Pages Road cycle lane would be gauged according to the speeds of motor vehicles passing through the site, the distances between cyclists and vehicles, crash analysis of the site and qualitative opinions of those who use the road both as cyclists and motorists.

3.0 Survey Methods

This section of the report details the ways in which the vehicle speeds, vehicle and cyclist positioning, opinions and crash history surveys were undertaken.

3.1 Consideration of Site

The cycle lane studied for this project is located on Pages Road, in the Christchurch suburb of Bexley.

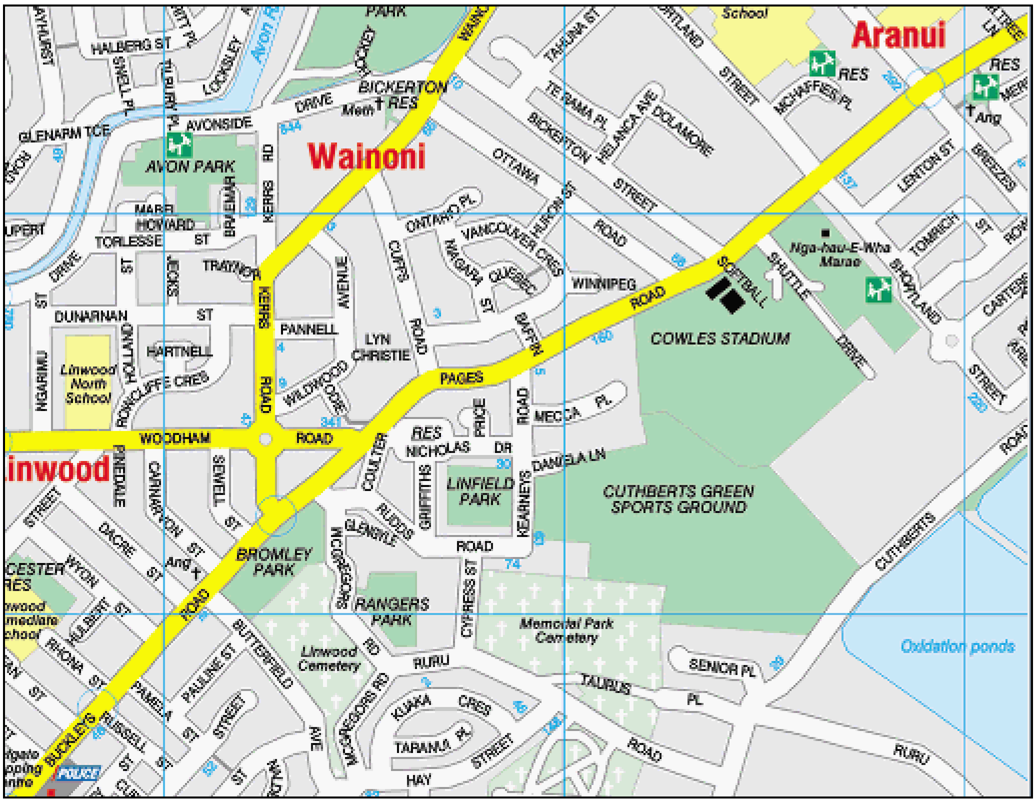

Figure 1 Pages Road Location (Wises Maps, 2005)

Pages Road is a two-lane, major arterial road with average annual daily traffic flows of between 13,000 vehicles per day at its eastern end (New Brighton Road intersection) and 27,500 vehicles per day at its western end (where Pages Road joins Buckleys Road). (Page, 2005).

The cycle lane of interest, located on the eastbound lane, is an extension of one already existing along part of Buckleys and Pages roads. It was installed in June 2005 and was one of the final cycle lanes installed before the commencement of the CCC's cycleway moratorium. The cycle lane was installed in conjunction with the extension of a painted median between traffic lanes that previously existed along some stretches of the road.

The specific site of interest for the purposes of the manually conducted speed and position surves was located on the eastbound lane at 147 Pages Road, between Ottawa Street and Softball Lane. Figure 2 shows the survey site:

Figure 2 Manual Survey Site (Koorey, 2005c)

This location was chosen because it was one of the few stretches of the road that already included a painted median at the centre of the lanes; hence any possible variation due to installing a painted median as well as a cycle lane was eliminated.

The survey site is also situated prior to a left-hand curve in the road. Left-hand curves are often more dangerous for cyclists as vehicles often cut corners when turning and are classified as a low severity-high frequency risk state (Newman, 2002). It was assumed that the location of the site in respect to the road's curve would allow further information about the behaviour of vehicles moving around corners with and without the presence of adjacent cycle lanes.

The figures below show the site's layout before and after the installation of the cycle lanes:

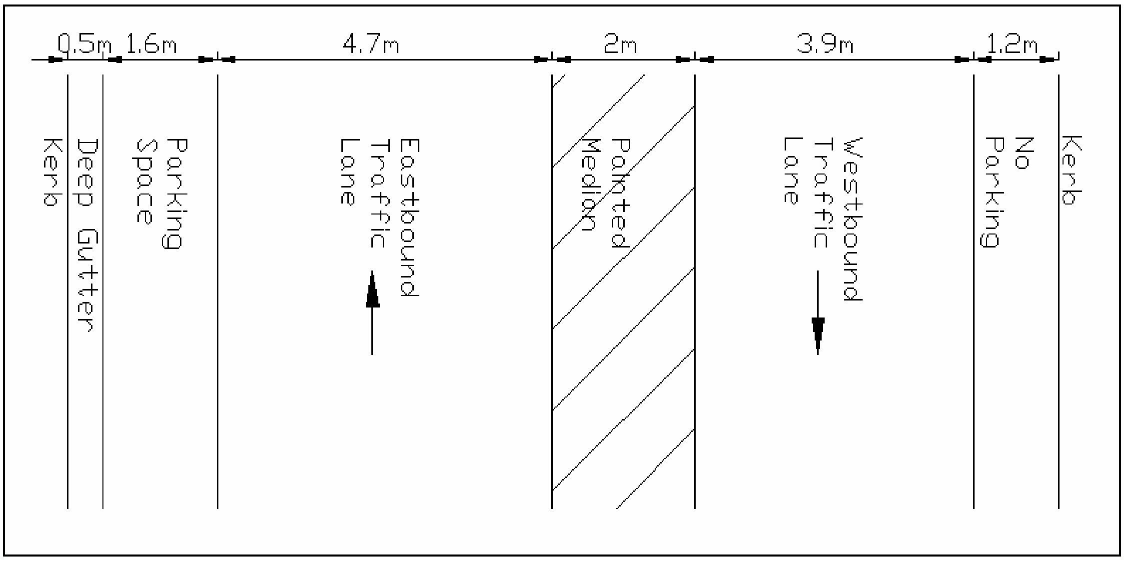

Figure 3 Site Layout Before Cycle Lane Installation

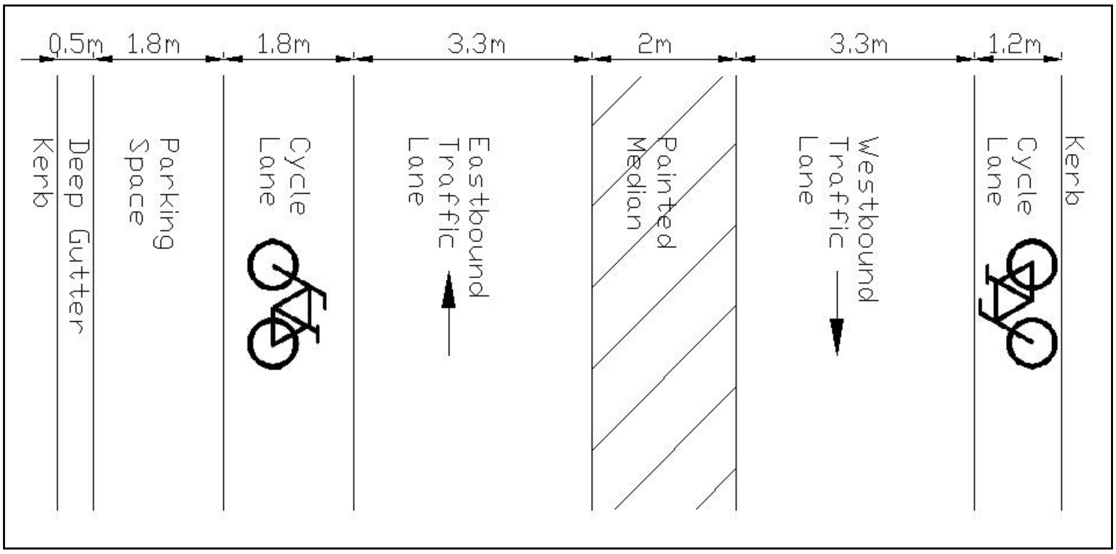

Figure 4 Site Layout After Cycle Lane Installation

As shown in Figure 3 and Figure 4 above the parking areas and bus stops situated adjacent to the eastbound lane have remained relatively unchanged with the cycle lane installation. Previously a narrow no-parking zone bordered the westbound lane by the kerb; this has been converted to a cycle lane.

The location of parking space next to the eastbound cycle lane is of interest, as often cyclists will ride in the parking space rather than the traffic lane when no cycle lane is present. Both before and after the cycle lane installation cyclists' paths were directly next to parked vehicles, which may be dangerous when vehicle occupants open doors in the path of cyclists. This situation is classified as being low severity – low risk as motorists are generally careful before opening doors on the traffic side and cyclists should have enough time to react (Newman, 2002).

Speed data was also obtained from the Christchurch City Council MetroCount system and the New Zealand Police's speed camera records. The MetroCount station was positioned approximately 140m eastwards from the survey site along Pages Road. Speed camera data was obtained from a site approximately 275m eastwards of the survey site on the eastbound lane of Pages Road, the speed camera is shown below in Figure 5**:**

Figure 5 Speed Camera (Koorey, 2005c)

The site is located near Aranui High School, Aranui School and St James School. It was therefore assumed that a large proportion of the cyclists present would be school-aged and classed under type "a" of the council's classification scheme. It was also assumed that there would be a reasonable amount of commuter adults, type "b", heading to and from the central business district each day.

3.2 Vehicle Speeds

Raw vehicle speed data came from three sources: manual surveys, available in Appendix 9.1; MetroCount records, provided by the CCC and available in Appendix 9.2; and speed camera records, available in Appendix 9.3. Summaries of data sets from the three sources are presented in Table 1, Table 2 and Table 3:

Table 1 Vehicle Speed Surveys

Date	Time	Survey Type	Before/After cycle lane	Sample size (veh)
Fri 13 May	2:00 – 4:00pm	Laser Gun	Before	738
Fri 29 July	2:45 – 4:30pm	Laser Gun	After	652
Wed 24 August	8:10 – 9:00am	Laser Detector	After	Unknown

Table 2 MetroCount Data Sets

Period	Before/After cycle lane	Sample size (veh)
11:11 Tuesday 24 May – 11:30 Wednesday 1 June	Before	30668
13:16 Monday 15 August – 10:40 Tuesday 23 August	After	29496

Table 3 Speed Camera Data Sets

Date	Time	Before/After cycle lane	Sample size (veh)
Friday 13 May	6:36-7:21am	Before	151
Friday 3 June	4:57-5:26pm	Before	94
Wednesday 8 June	8:00-8:24am	Before	40
Wednesday 15 June	8:04-9:03am	Before	254
Wednesday 15 June	6:43-7:13pm	Before	83
Wednesday 6 July	5:11-6:10pm	After	171
Thursday 7 July	7:27-8:22am	After	177
Thursday 14 July	6:37-7:07pm	After	93

When assessing the speeds of vehicles passing through the survey sites it was important that only the "free" vehicles were considered. Free vehicles are those travelling at the driver's desired speed, unaffected by surrounding vehicles; hence a measure of what drivers actually consider to be an appropriate speed is obtained. (Koorey, 2004). If all vehicle speeds were considered then, at peak times where flow was slowed due to greater volumes, the average speed measured would decrease; hence factors other than the presence of the cycle lane such as time of day and amount of congestion would affect the survey.

In order to determine which vehicles were free and which were impeded by other traffic a critical headway approach was used. A vehicle’s headway is the length of time between in and the vehicle in front of it. Vehicles with headways greater than critical are considered to be travelling at their desired free speed; if the vehicle in front were travelling at a slower speed the following vehicle, upon reaching the critical headway, would have to decelerate and decrease their speed below desired.

For the surveys the critical headway was assumed to be four seconds, based on previous studies (McLean, 1989). The MetroCount software allowed vehicles with speeds greater than a nominated critical value to be filtered from the database and speed camera values were processed using an Excel spreadsheet to exclude any vehicles with headways.

For the manual surveys the surveyor judged which vehicles where free and measured their speeds with a hand held laser speed measurement device. For the May 13 survey the free speeds, vehicle class (car or heavy) and extra vehicles (those with headway below the critical value) were recorded with a Psion device giving the exact time for each vehicle. For the May 29 survey the same information was recorded by hand in 15-minute time slots.

The August 24 survey involved the use of two laser detectors mounted in concrete filled buckets and placed in the deep gutter of the eastbound lane, five meters apart. The laser devices operated by sending out a beam which, when hitting an object, would be reflected back to the device. The device used the time taken for the beam to be reflected back to calculate the object’s distance. Distances and the times at which they were measured were stored in a file on a laptop computer connected to the lasers.

The lasers' specified maximum range was 14m, but prior testing indicated that this was very weather dependant as high levels of direct sunlight decrease the lasers' range. Each laser was aimed at a target on the opposite side of the road, at a distance of approximately 14 meters. The distance to the target was set as a datum with the intention that the computer programme would only record those distances different to the datum value in order to reduce file size.

As the distance between the lasers was fixed and cars would enter and leave the survey site in the same order it was assumed that vehicle speeds could be calculated by dividing the distance between the two lasers by the time difference between the two lasers for each vehicle.   The laser set up is shown below in Figure 6**:**

Figure 6 Laser Detectors (Koorey, 2005c)

Upon inspection of recorded data it was found that the method of using targets as datums for the two laser devices used in the August 24 survey did not work, possibly due to the presence of sunlight and the distance between the lasers and the targets. As a result continuous distance measurements were recorded rather than individual vehicle movements. This resulted in a very large database of distances, which would have required much filtering to yield meaningful results. To complicate this further distance data was stored by the computer programme in aggregations of distances with the time of recording as the heading for each aggregation, rather than having distance and time of measurement in separate columns.

Due to the student's limited knowledge of database and programming operations it would have taken a long time to process the data sufficiently. Given the large amount of speed data already available from the two other manual surveys, the MetroCount system and the speed camera recordings it was decided not to use the laser detector data. This had mainly been a trial operation to determine the usefulness of the laser devices; from the experience many suggestions for future use were obtained.

3.3 Vehicle and Cyclist Positioning

Five surveys assessing vehicle and cyclist positioning were undertaken, as outlined in Table 4 below, full survey data is given in Appendix 9.4.

Table 4 Vehicle Position Video Surveys

Date	Time	Survey Type	Before/After cycle lane	Sample size (veh, cycles)
Friday 13 May	2:00 – 4:00pm	Video	Before	1852, 15
Thursday 26 May	7:40 – 8:50am	Video	Before	678, 15
Friday 29 July	2:45 – 4:30pm	Video	After	1825, 25
Wednesday 3 August	8:00 – 9:50 am	Video	After	853, 13
Wednesday 24 August	8:10 – 9:00am	Laser Detector	After	Unknown

As for the vehicle speed survey, data from the August 24 laser detector survey was not processed enough to be used at the time of this report. At least two surveys for each of the before and after situations were required due to the low cyclist numbers found in the May 13 survey.

In order to record the vehicle positions, marks were made across a section of the road at 0.5 meter intervals, this is shown in Figure 7 below:

Figure 7 Road Markings (Koorey, 2005c)

These marks were made as inconspicuous as possible to avoid influencing driver behaviour. A video camera was positioned in a vehicle stationed in the parking lane several metres behind the marked site. The presence of side roads and parking restrictions left little option regarding the positioning of the survey vehicle; however it was assumed that the camera would not be obvious to passing traffic as the survey vehicle was facing in the same direction as the traffic flow of interest.

The videos recorded were later played at a slow speed and each individual vehicle was observed. Vehicle and cycle positions, based on the distance of the left rear wheel from the kerb, were recorded in 0.5m categories.

The videos also allowed further investigation of cyclist behaviour. Cyclists were classified according to the basic ability classes of child/inexperienced adult/elderly/disabled, commuter adult and sports cyclist based on their approximate age, attitude and ability displayed. School students were easily classified due to their uniforms and backpacks; sports cyclists were those with no luggage, custom cycle gear and travelling at high speeds.

3.4 Qualitative Opinions

In order to assess public reaction to the cycle lane installation, a survey of residents living along Pages Road was undertaken. Ideally motorists and cyclists passing through the site would have been interviewed but based on the difficulty of approaching motorists and low cycle numbers noticed during surveys the survey sample was taken from people living near the site. It was assumed that residents would be frequent users of the traffic and cycle lanes along Pages Road.

The survey form, shown in Appendix 9.5, was designed to assess frequency of use of different modes of transport, the effect of the cycle lane on motorists opinions about passing cyclists while driving, cyclists perceptions of safety and other issues that may affect how residents react to the cycle lane, such as loss of parking and driveway access issues.

The survey was conducted on Monday 12 September from 2:30 to 4:30pm. The surveyor went to houses between 75 and 322 Pages Road and asked residents to participate in the survey. At houses where no one was present at the time of survey or the residents did not wish to complete the survey immediately the survey form was left with a letter of explanation and return envelope for the resident to complete the survey and return it at a later date. In total 55 survey forms were distributed; seven residents completed the survey during the survey period and 16 forms were returned via mail, giving a survey sample of 23 people.

3.5 Crash History Research

Crash history data was obtained from the Land Transport Safety Authority for 45 intersection sites and 42 mid-block sites for the period 1986 to 2004, as shown in Appendix 9.6. All sites were then classed as either urban (taken as being within the boundaries of Bealey Avenue, Fitzgerald Avenue, Moorhouse Avenue and Deans Avenue) or suburban. Mid-block sites were also classed as either multi-lane or single lane.

For each site, each year containing crash data was correlated with the year of installation, which was renamed "year zero." This allowed data from all sites to be compared regardless of when the cycle lane was installed. Crash frequencies for the years before and after the cycle lanes were installed were calculated. Crashes from the year of installation were disregarded due to the possibility of a novelty effect, which is an initial reaction to change that later dissipates or reduces as road users become used to the new system (Koorey, 2005b). That is, in the year a cycle lane was installed crash frequencies may have increased or decreased significantly as cyclists and motorists adapted to the change.

Other factors such as alcohol and speed restriction campaigns may also have contributed to changes in cyclist crash frequencies in recent years (Cycling in Canterbury, 2005); therefore control sites were required. Crash histories of 97 sites that had not had cycle lanes installed prior to 2004 was also provided by the LTSA. It was assumed that not all of these sites would be appropriate control sites due the selection process used by the CCC when choosing where to install cycle lanes. Generally priority for cycle lane installation is given to areas of high crash rates with high cyclist flows. Most streets without cycle lanes were probably not high priority streets and therefore would not serve as suitable controls.

However, factors other than crash rates also contribute to the choice of where to install cycle lanes. For example Riccarton Road, where anecdotal evidence shows cyclists would appreciate a cycle lane installation but there is much opposition from shop owners who do not wish to lose shop-front parking. Hence it was considered that some of the non-cycle lane streets would serve as accurate control sties.

Sites that did not already have cycle lanes and were identified by the LTSA as having high collision rates (Injury Cycle Collisions, 1999) and minimum cycle volumes greater than 101 cyclists per day (Minimum Daily Cycle Volumes, 2001) were selected as control sites. Three control sites that were similar to Pages road in terms of being single lane, suburban, midblock sites were selected for comparison with similar cycle lane sites to give an estimate of what effect the Pages Road cycle lane would have on crash frequency. The chosen sites were located on parts of Clyde Road, New Brighton Road, Papanui Road, Riccarton Road, Sawyers Arms Road, Springs Road and Stanmore Road that did not have cycle lanes installed before 2004. This data is shown in Appendix 9.7.

In order to compare the control sites with the cycle lane sites the year 2001 was taken as a base year, this was because, as the student's analysis of Appendix 9.6 indicates, most cycle lanes were installed in 2001. Hence for the control sites, the "before" crash data was that of the 1986-2000 period and the "after" crash data was that of the 2001-2004 period. Crash data from the base year was included in the analysis as since no cycle lane was actually installed that year there was no concern over the occurrence of a novelty effect.

In some cases, as well as comparing the cycle lane sites with the selected control sites the crashes for all sites without cycle lanes were also compared. This was to provide an indication of the effect the selection of control sites has on the comparison.

4.0 Survey Results and Analysis

This section of the report details the findings from the surveys and how these results were processed and analysed.

4.1 Vehicle Speeds

4.1.1 Approximation by Normal Distribution

Speed data from the first survey as well as that obtained from the Christchurch City Council MetroCount station situated near the survey site was analysed to determine the likelihood of the data being normally distributed.

As outlined in section 3.2 the critical headway for free vehicles was assumed to be four seconds; all vehicles with headways lower than this were discarded from the data sets. Similarly, all vehicles with speeds less than 40 km/h were assumed to be either accelerating after entering the stream from a nearby driveway or intersection or decelerating to exit the road and were therefore discarded from the sets.

A null hypothesis that each data set was normally distributed with calculated mean and standard deviation was tested using the chi-squared test. Explanations of all statistical tests used in this project are outlined in Appendix 9.8. Four data sets were tested as follows:

Table 5 Probabilities of Normal Distribution of Speed Data sets

Survey Date	Time	Source	Probability of Normal Distribution
Fri 13 May	2:00-4:00pm	Laser Gun Survey	78%
Thur 26 May	8:00-10:00am	CCC MetroCount	68%
Fri 27 May	8:00-10:00am	CCC MetroCount	37%
Fri 27 May	2:00-4:00pm	CCC MetroCount	75%

When assuming a 5% threshold for statistical significance none of these probabilities are below the threshold and hence the null hypothesis that the data sets are normally distributed cannot be rejected. Therefore, for further analysis of the data sets all were assumed to be normally distributed. Separating the heavy vehicles from the cars and increasing the critical headway and speed values may have increased the statistical likelihood of normal approximation. Data from the MetroCount station was also tested in the same way to determine the difference between the Friday afternoon survey period and the Thursday morning survey period. It was determined that the two were statistically similar enough to allow surveying at different times.

4.1.2 Results

Figure 8 and Figure 9 below show the recorded frequencies of vehicle speeds for the before and after laser gun surveys:

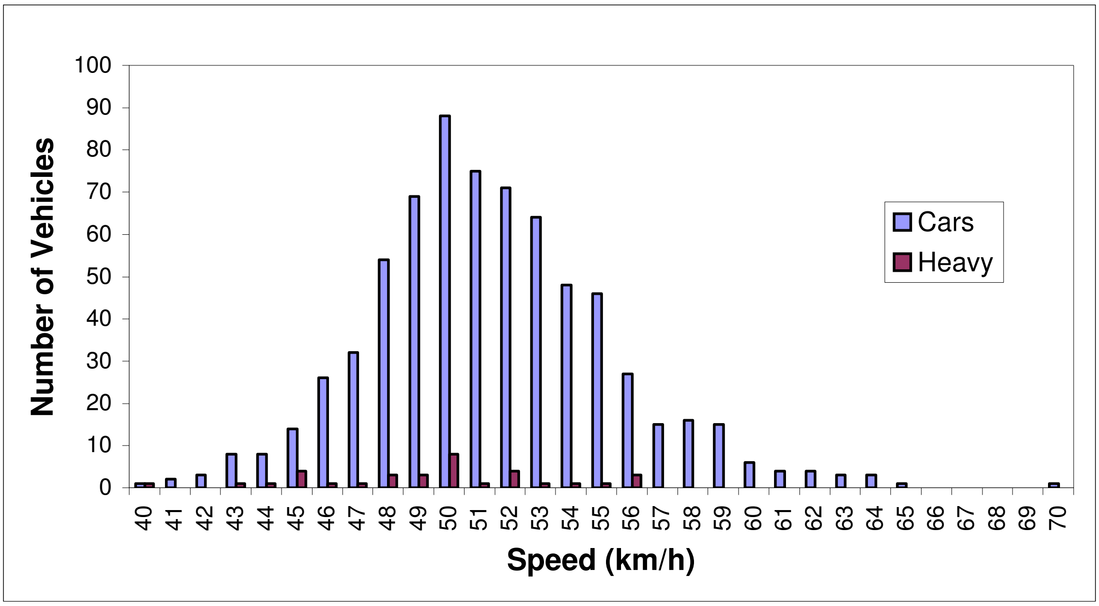

Figure 8 Speed Distribution for Laser Gun Survey, Friday 13 May 2 - 4pm (Before)

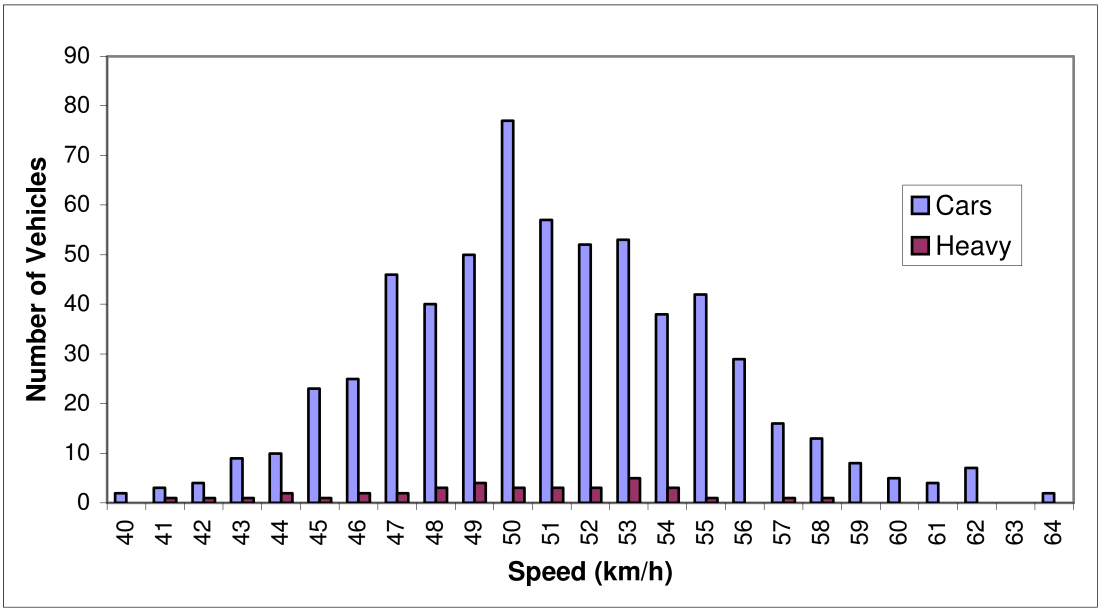

Figure 9 Speed Distribution for Laser Gun Survey Friday 29 July 2:45 – 4:30pm (After)

Table 6 below shows the important statistical parameters for the before and after survey speed data for different vehicle type categories when modelled with a normal distribution:

Table 6 Vehicle Speed Statistics

Vehicle Type	Survey Details	Mean Speed (km/h)	Std. Dev.	85^{th} Percentile	Sample Size
car	27/05/05 (before)	51.46	3.98	55	704
	29/07/05 (after)	51.08	4.13	55	615
heavy	27/05/05 (before)	49.41	3.85	53	34
	29/07/05 (after)	49.76	4.09	53	37
all	27/05/05 (before)	51.36	4.00	55	738
	29/07/05 (after)	51.01	4.14	55	652
all (same time period)	27/05/05 (before)	50.93	3.85	55	510
	29/07/05 (after)	51.05	4.08	55	452

The final entry in Table 6 shows the parameters for all vehicles from both the before and after surveys during a common survey period of 2:45 – 4 pm.

The MetroCount data was processed according to the whole week long samples, peak periods (assumed as 7:00-10:00am and 4:00-6:00pm Monday to Friday) and off-peak periods as shown in Figure 10 and Table 7 below. Note that the outlying speeds greater than 75km/h have been omitted from the figure.

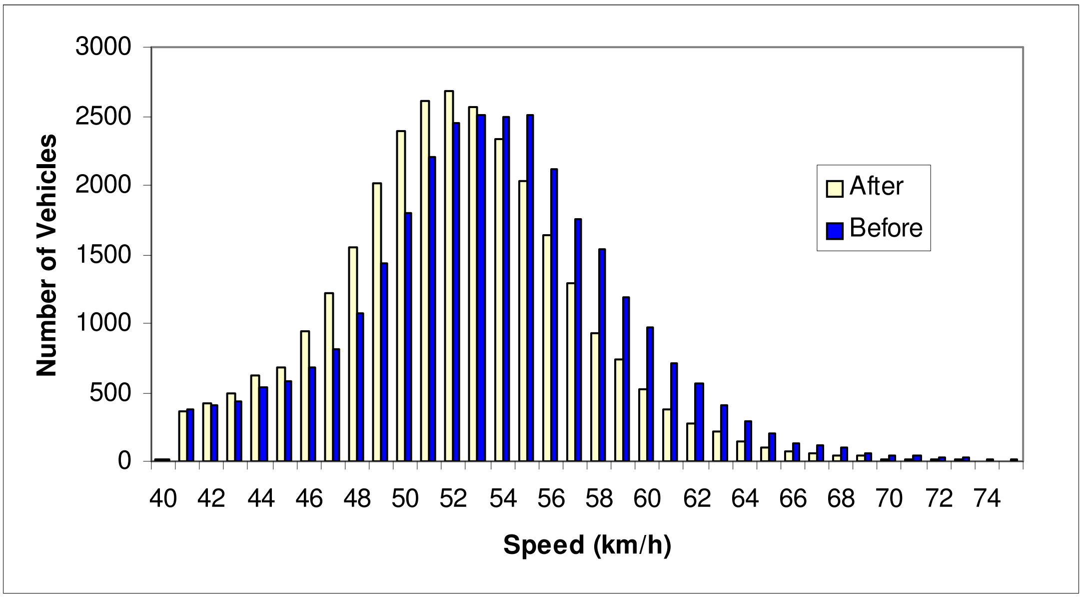

Figure 10 MetroCount Speed Distribution (Before and After)

Table 7 MetroCount Speed Statistics

Period	Before/After	Mean Speed (km/h)	Std. Dev.	85th Percentile	Sample size
All week	before	53.13	5.57	58.3	30668
	after	51.73	5.13	56.2	29496
Peak	before	52.46	5.39	57.2	5587
	after	51.55	4.93	56.2	5934
Off Peak	before	53.28	5.59	58.3	25081
	after	51.77	5.18	56.2	23562

Figure 11 and Table 8 below show the distribution and parameters for the speed camera observations:

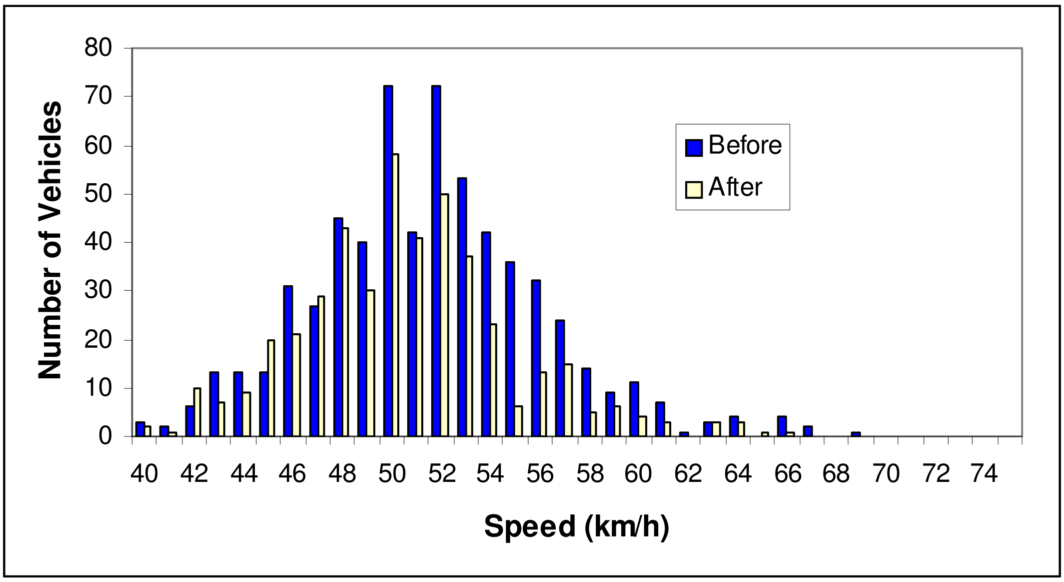

Figure 11 Speed Camera Speed Distribution (Before and After)

Table 8 Speed Camera Statistics

Date	Time	Mean Speed (km/h)	Std. Dev	85th Percentile	Sample Size
Friday 13 May	6:36-7:21am	51.11	4.86	56	151
Friday 3 June	4:57-5:26pm	50.89	3.78	55	94
Wednesday 8 June	8:00-8:24am	51.58	3.49	55	40
Wednesday 15 June	8:04-9:03am	52.25	4.82	57	254
Wednesday 15 June	6:43-7:13pm	51.27	4.83	56	83
Wednesday 6 July	5:11-6:10 pm	51.45	4.79	56.5	171
Thursday 7 July	7:27-8:22am	49.94	3.51	53	177
Thursday 14 July	6:37-7:07pm	49.99	4.55	54	93

The speed camera observations before and after the cycle lane installation did not come from similar periods. Therefore the five data sets from before the installation were aggregated together, as were the three data sets from after the installation. This gave a more general result, with larger sample sizes, as shown in Table 9 below:

Table 9 Lumped Speed Camera Data

	Mean Speed (km/h)	Std. Dev	85th Percentile	Sample Size
Before Installation	51.59	4.63	56	622
After Installation	50.54	4.32	54	441

4.1.3 Comparison of Data Sets

The data sets for each vehicle type before and after the installation of the cycle lane were analysed statistically using the test of two means, further information is shown in Appendix 9.10. Table 10 shows the probability that the null hypothesis of the mean speeds from the manual laser surveys before and after being equal is true:

Table 10 Comparisons of Before and After Laser Gun Survey Speeds,

Vehicle Type	$P(\mu_{before} = \mu_{after})$
car	9%
heavy	72%
all	10%
all (same time period)	65%

When using a 5% statistical threshold none of these are below threshold and hence the null hypothesis cannot be rejected in any case, hence from the survey data it cannot be proven that the speeds changed after the installation of the cycle lane. However, the MetroCount and speed camera data produced statistically significant results as shown in Table 11 below:

Table 11 Comparisons of Before and After MetroCount and Speed Camera Speeds

Source	Period	$P(\mu_{before} = \mu_{after})$
CCC MetroCount	All week	0.00
CCC MetroCount	Peak	0.00
CCC MetroCount	Off Peak	0.00
Speed Camera	Lumped before/after sets	0.02

4.2 Vehicle Positioning

4.2.1 Approximation by Normal Distribution

Vehicle positioning data for each individual survey was analysed according to the chi-squared method in a similar way to the vehicle speed data, as outlined in Appendix 9.8. Due to low cyclist numbers only the vehicle positions when no cyclists were present were analysed.

Table 12 Probabilities of Normal Distribution of Vehicle Position data sets

Survey Date	Time	Probability of Normal Distribution
Fri 13 May	2:00 – 4:00pm	12%
Thurs 26 May	7:40 – 8:50am	16%
Fri 29 July	2:45 – 4:30pm	5.8%
Weds 3 August	8:00 – 9:50 am	4.7%

Of the four surveys, only the survey data from Wednesday 3 August was below the 5% statistical significance threshold for rejecting the null hypothesis that the data was normally distributed.

The nature of the vehicle positioning survey method meant that there was a high degree of variability associated with the data. Data collection was heavily reliant on determining which section of lane each car passed over based on painted marks on the road. It was not always easy for the student to judge from the video recordings each vehicle' exact positioning on the road as the motion of most vehicles was not completely parallel to the direction of view. The collection method also resulted in lumping of data and hence smaller bin sizes could not be determined.

Based on the results from statistical analysis of the four surveys and the nature of the data collection it was assumed that the vehicle position data was normally distributed. The relevant statistical parameters for positions of vehicles when cyclists were or were not present and also cyclist positions are shown below in

Table 13, complete information is given in Appendix 9.11.

Table 13 Vehicle Position Parameters

Category	Survey Details	Mean Distance	Std. Dev.	Number of Vehicles
Vehicles, no cycles present	Fri 13 May, 2:00-4:00pm	4.63	0.46	1828
	Fri 29 July 2:40-4:30pm	4.53	0.38	1781
	Thur 26 May, 7:40-9:16am	4.50	0.45	667
	Wed 3 Aug 8:00-9:50am	4.43	0.32	834
Vehicles, cycles present	Fri 13 May, 2:00-4:00pm	5.02	0.33	24
	Fri 29 July 2:40-4:30pm	5.08	0.30	44
	Thur 26 May, 7:40-9:16am	5.07	0.25	11
	Wed 3 Aug 8:00-9:50am	4.88	0.33	19
Cycles	Fri 13 May, 2:00-4:00pm	1.65	0.71	15
	Fri 29 July 2:40-4:30pm	2.65	0.54	25
	Thur 26 May, 7:40-9:16am	1.42	0.62	15
	Wed 3 Aug 8:00-9:50am	1.52	0.86	13

When data sets were lumped together, depending on whether they represented before or after the cycle lane installation, the relevant statistics became:

Table 14 Lumped Vehicle Position Parameters

Category	Surveys	Mean Distance	Std. Dev	Number of Vehicles
Vehicles, no cycles	Before Total	4.60	0.46	2495
	After Total	4.50	0.36	2615
Vehicles, cycles present	Before Total	5.04	0.30	35
	After Total	5.02	0.32	63
Cycles	Before Total	1.53	0.67	30
	After Total	2.26	0.85	38

4.2.2 Results

The four figures below show the survey results for vehicle positioning. The two before surveys (13 May and 26 May) have been combined, as have the two after (29 July and 3 August) surveys.

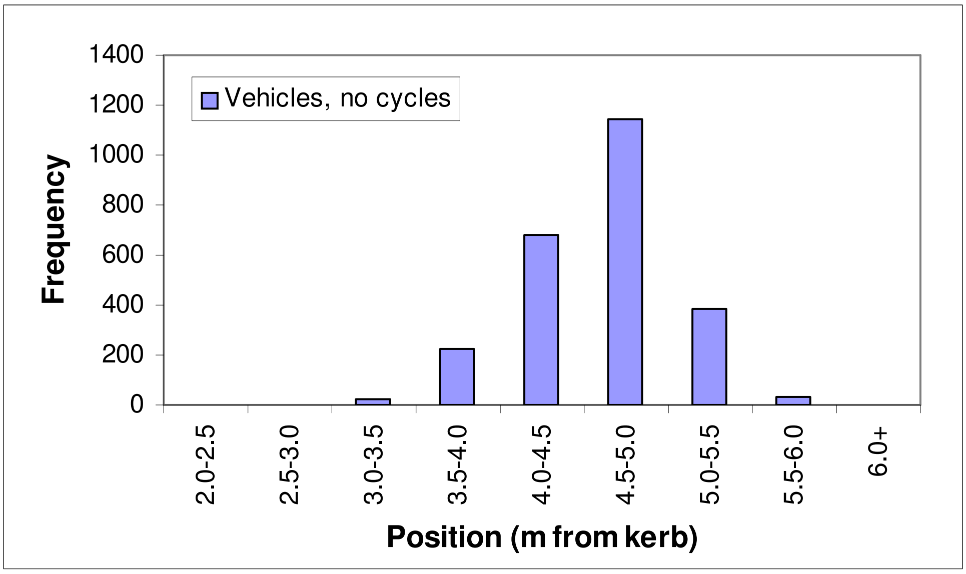

Figure 12 Vehicle Positioning when no Cycles present, before installation of cycle lane

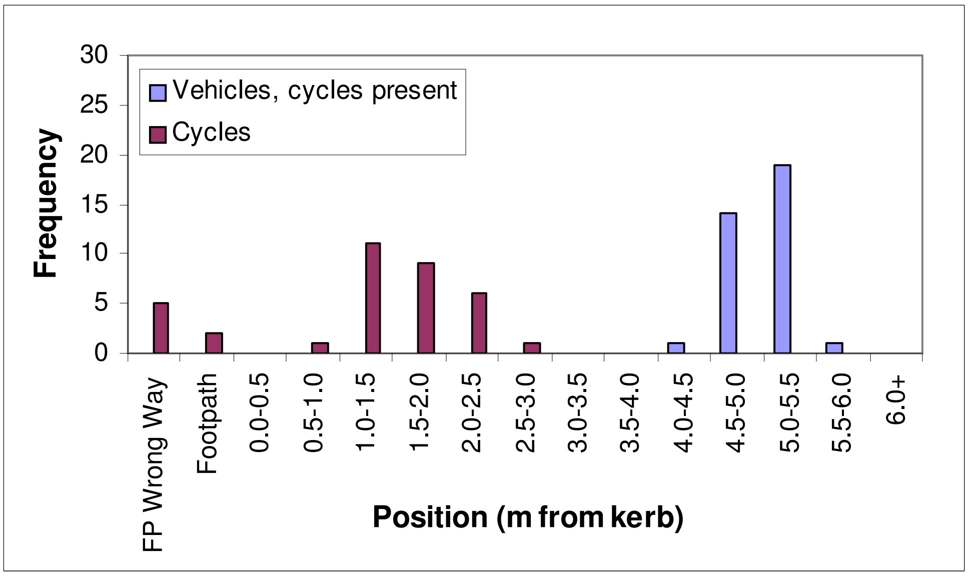

Figure 13 Cycle and Vehicle (when Cycles present) Positioning, before installation of cycle lane

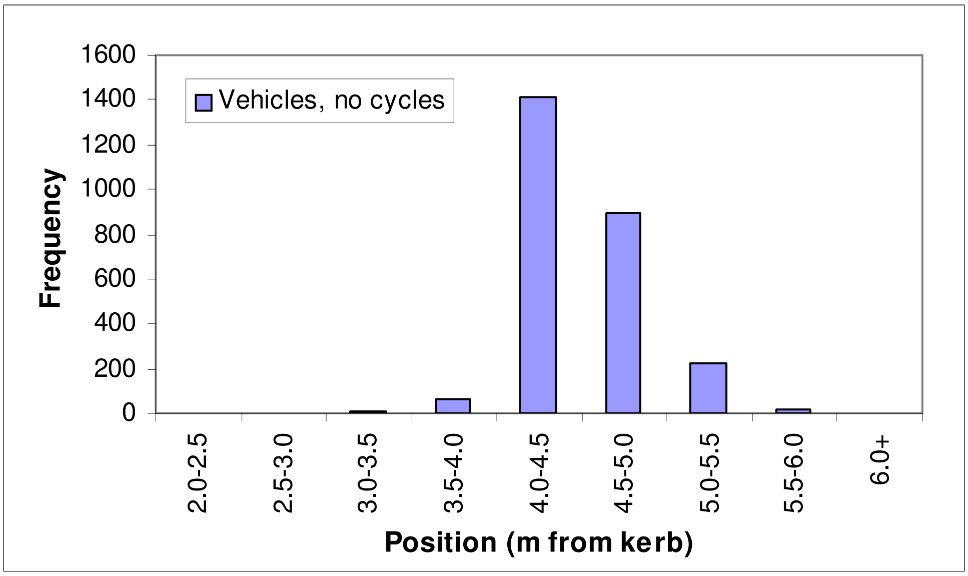

Figure 14 Vehicle Positioning when no Cycles present, after installation of cycle lane

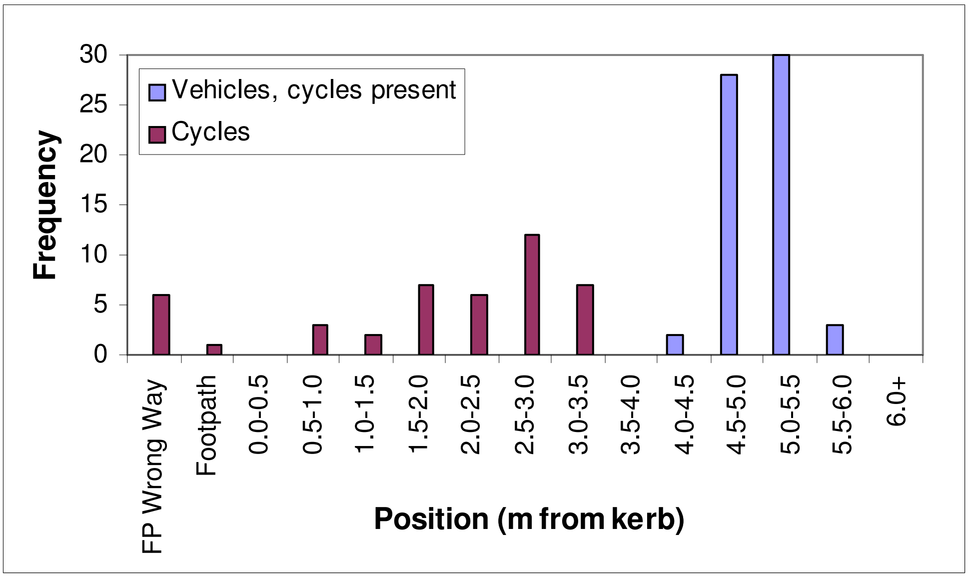

Figure 15 Cycle and Vehicle (when Cycles present) Positioning, after installation of cycle lane

The number of cyclists using the westbound cycle lane, roadside or footpath before and after the cycle lane installation were also recorded as shown in Table 15:

Table 15 Cyclists using Westbound Cycle lane/footpath

	Right Direction	Wrong Direction
Before	38	4
After	34	0

The proportion of eastbound cyclists using all possible eastbound routes (eastbound footpath, parking space, eastbound traffic or cycle lanes or wrong way along the westbound footpath) and cyclist ability levels as judged by the surveyor were recorded as follows:

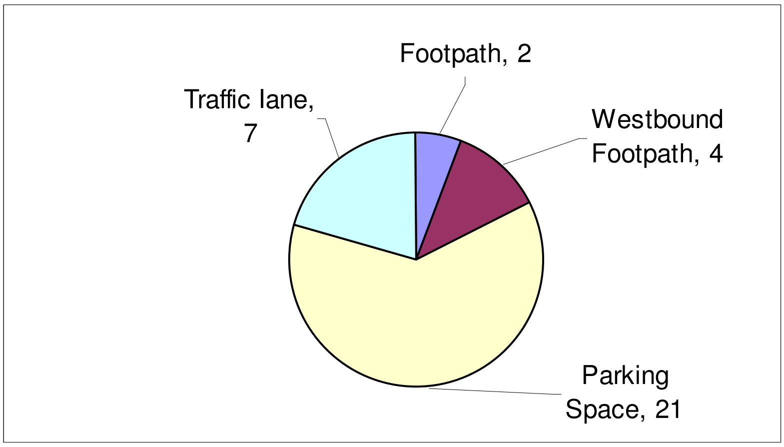

Figure 16 Eastbound Cyclist Routes Before Cycle Lane Installation

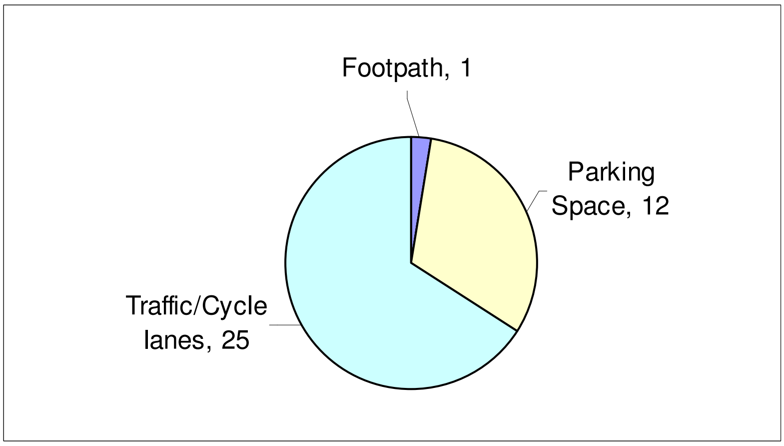

Figure 17 Eastbound Cyclist Routes After Cycle Lane Installation

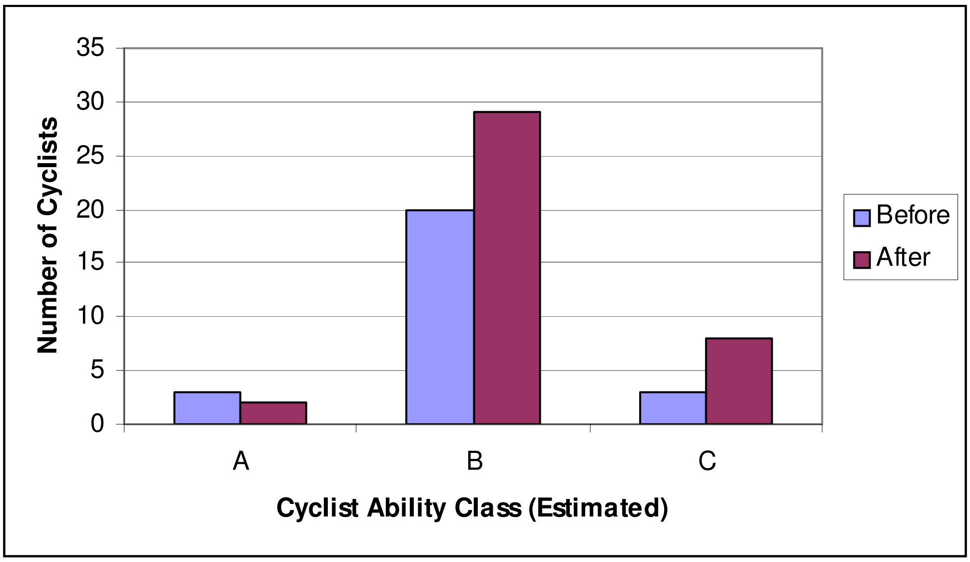

Figure 18 Estimated Cyclist Ability Classes Before and After Cycle Lane Installation

4.2.3 Comparisons between Data Sets

Using the test of two means, before and after data sets for different categories were tested to find the probability that the means before and after were equal, full statistical test results are shown in Appendix 9.12.

Table 16 Comparisons of Before and After Vehicle and Cycle Positions

Category	$P(\mu_{before} = \mu_{after})$
Vehicles, no cycles present	0.0%
Vehicles, cycles present	81%
Cycles	0.0%

During the May 26 survey a car parked in the parking lane directly in front of the survey site and stayed there for the remainder of the survey. The numbers of vehicles to pass through the site were approximately equal before and after the arrival of the parked car; hence another comparison was made to establish the effect of the parked car:

Table 17 Effect of Parked Car on Vehicle Position Parameters

Category	Car Parked	Mean Distance	Std. Dev	Number of Vehicles
Vehicles, no cycles present	No Car	3.92	0.43	371
	Car Parked	4.11	0.46	296
Vehicles, cycles present	No Car	4.58	0.26	6
	Car Parked	4.55	0.27	5

Table 18 Probability of Parked Car Effect

Category	$P(\mu_{no\ car} = \mu_{car\ parked})$
Vehicles, no cycles present	0.0%
Vehicles, cycles present	84%

4.3 Qualitative Opinions

The results for the qualitative survey of Pages Road residents are shown as follows in Figure 19 through to Figure 25 full survey data is shown in Appendix 9.13. For the evaluation residents who cycle at least once a month were considered to be cyclists.

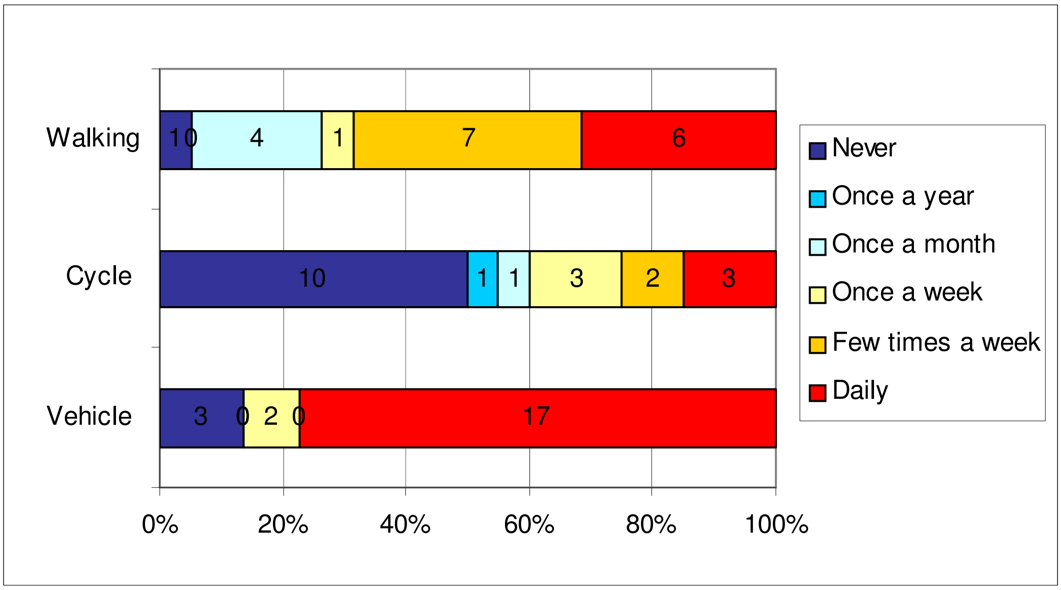

Figure 19 Modes of Transport used by Pages Road Residents

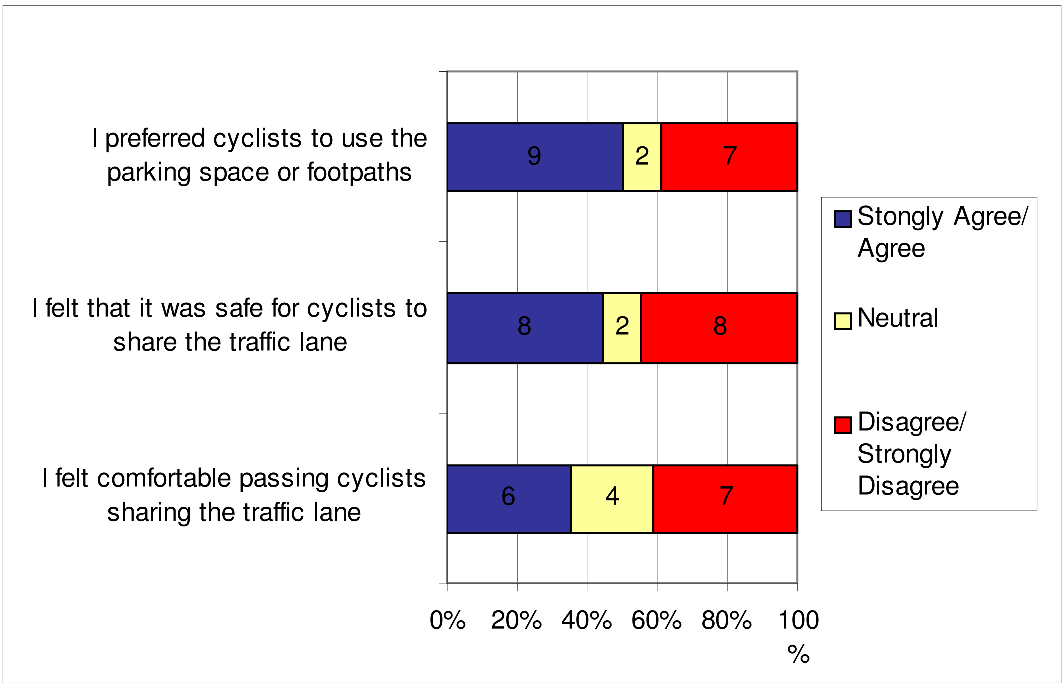

Figure 20 Opinions of Pages Road Residents who Drive (Before Cycle Lane Installation)

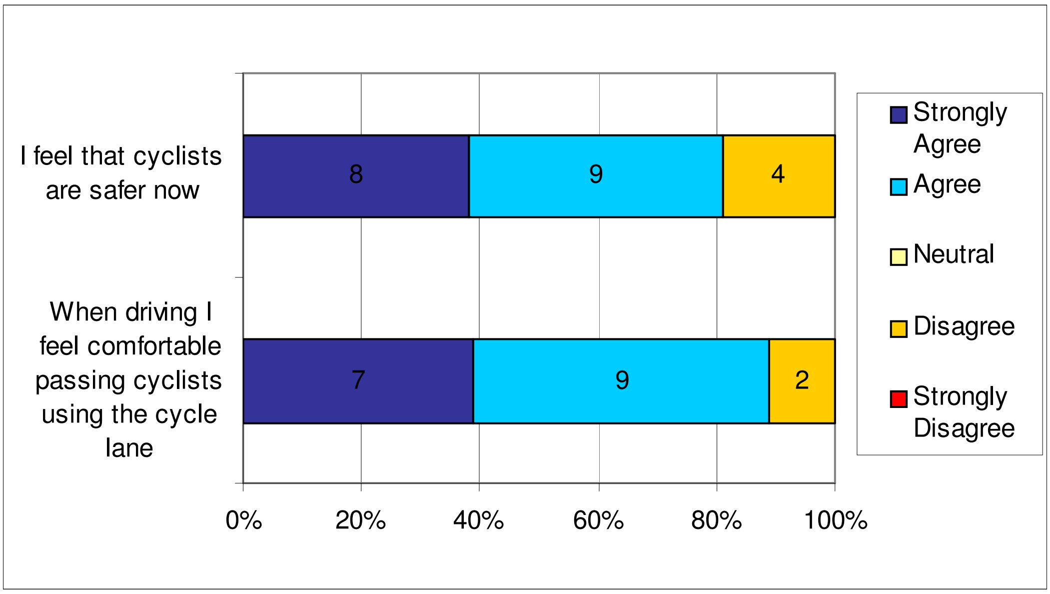

Figure 21 Opinions of Pages Road Residents who Drive (After Cycle Lane Installation)

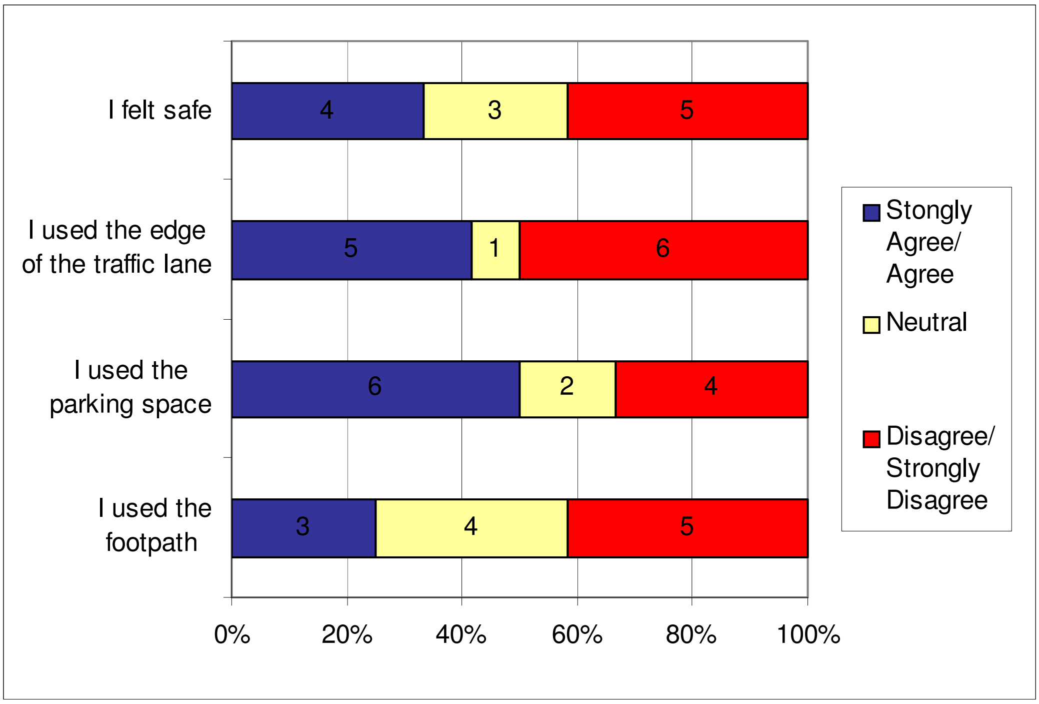

Figure 22 Opinions of Pages Road Residents who Cycle (Before Cycle Lane Installation)

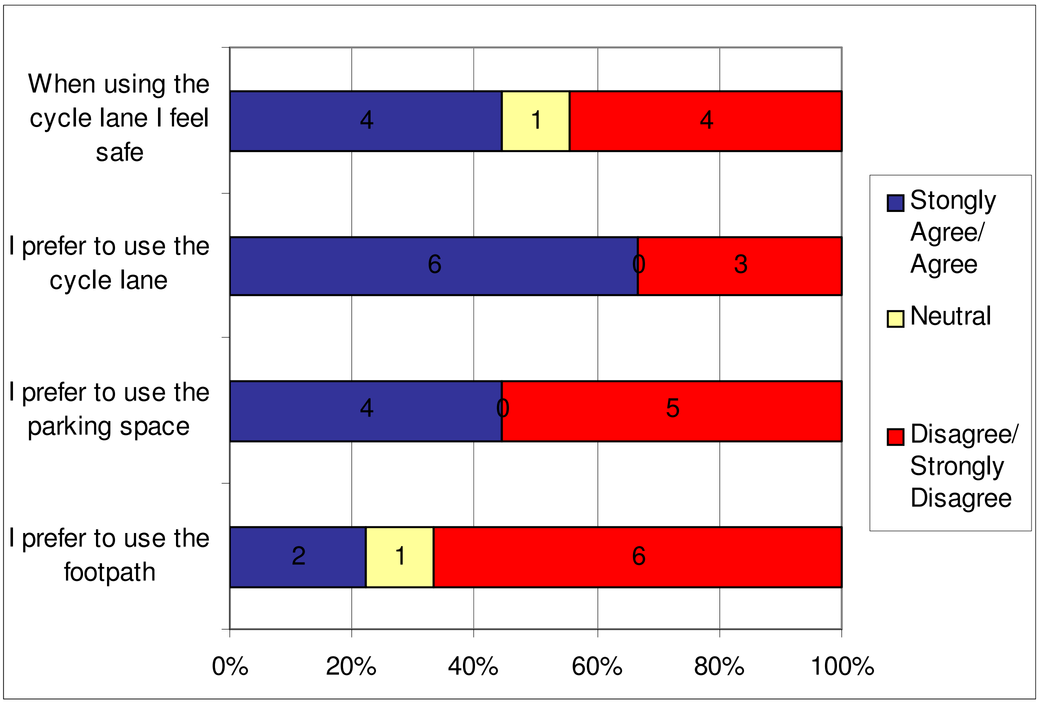

Figure 23 Opinions of Pages Road Residents who Cycle (After Cycle Lane Installation)

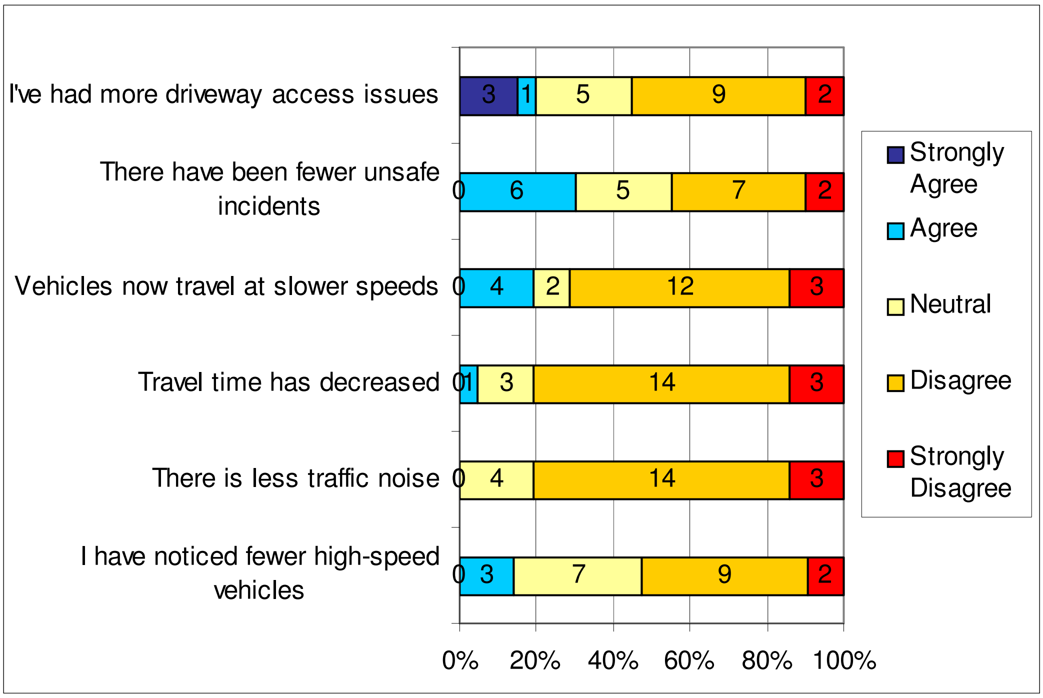

Figure 24 Opinions of Pages Road Residents (After Cycle Lane Installation)

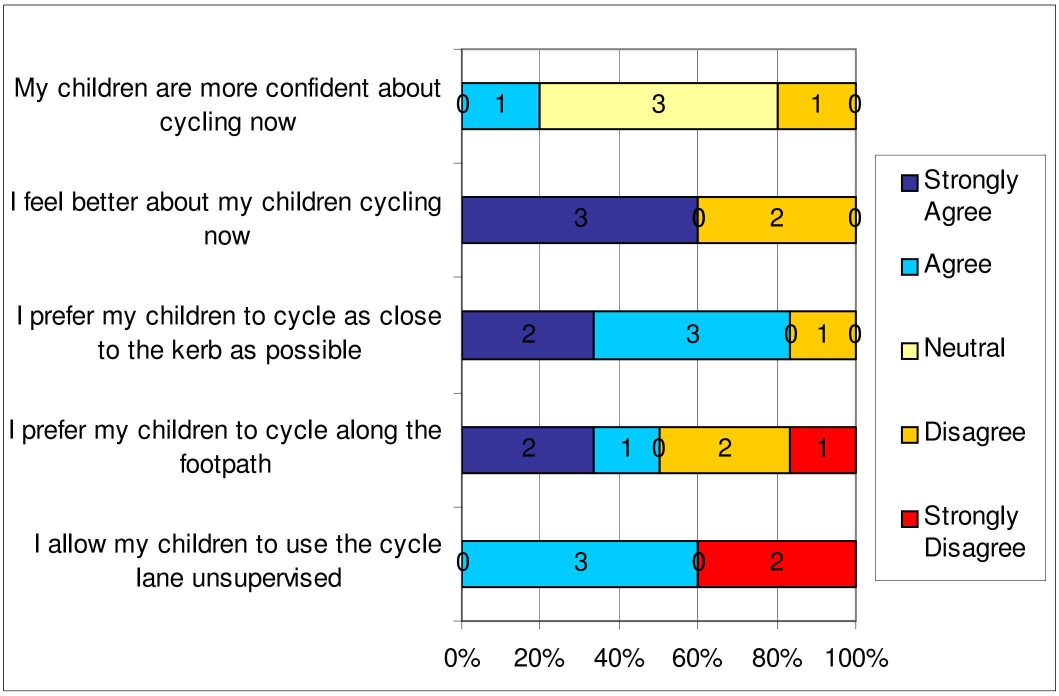

Figure 25 Opinions of Pages Road Residents whose Children Cycle (After)

In addition, residents were given the chance to make any comments related to the installation of the Pages Road cycle lane, these are given in Appendix 9.14. Opinions were generally extreme in nature - either fully supporting or opposing the cycle lane. Some cyclists had positive views of the cycle lane; others felt that it actually impeded their safety due to traffic driving in the cycle lane, cars opening their doors and lack of continuity through the Breezes Road intersection.

4.4 Crash History

4.4.1 Cycle Lane Sites

The following four figures show the trends observed when comparing control sites with sites that had cycle lanes installed in the period 1986-2004. Note that no urban sites were considered suitable as control sites.

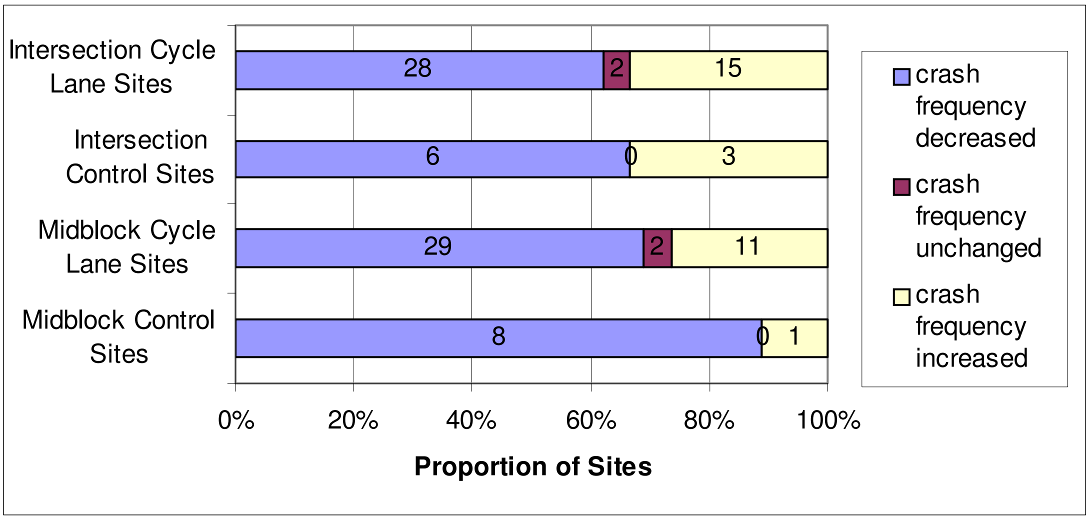

Figure 26 Intersection and Midblock Crash Frequency Changes due to Cycle Lane Installation

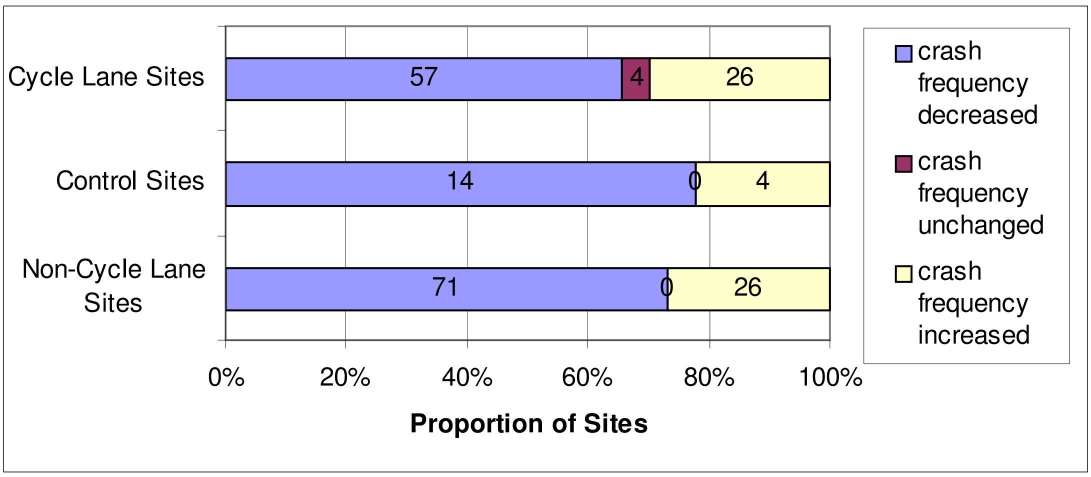

Figure 27 Combined Sites Crash Frequency Changes due to Cycle Lane Installation

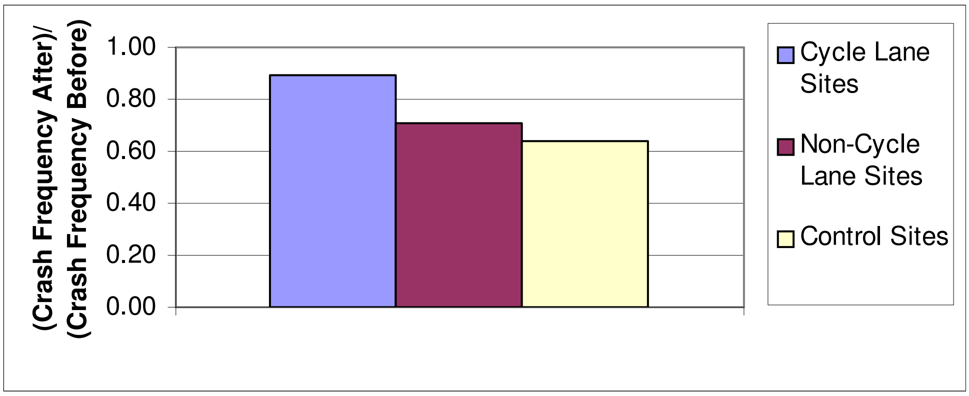

Figure 28 After/Before Crash Frequency Ratio for all Sites Combined

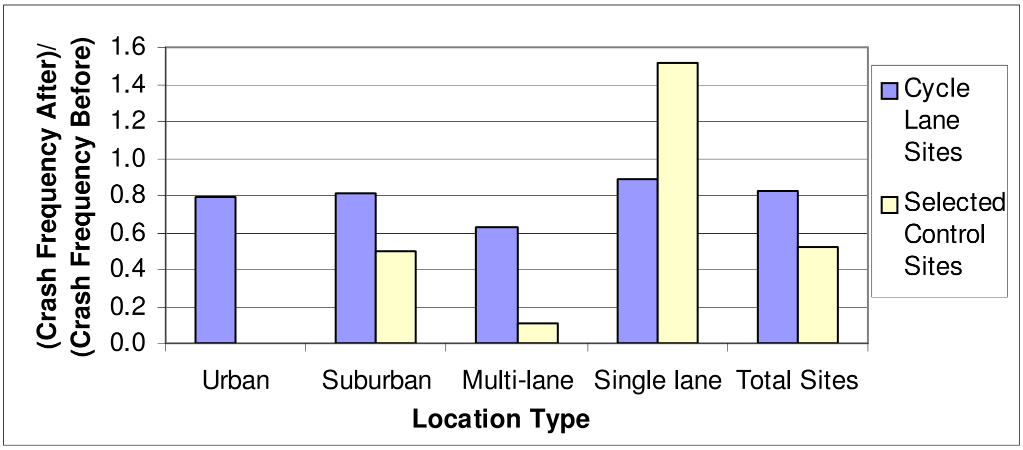

Figure 29 Midblock After/Before Crash Frequency Ratios

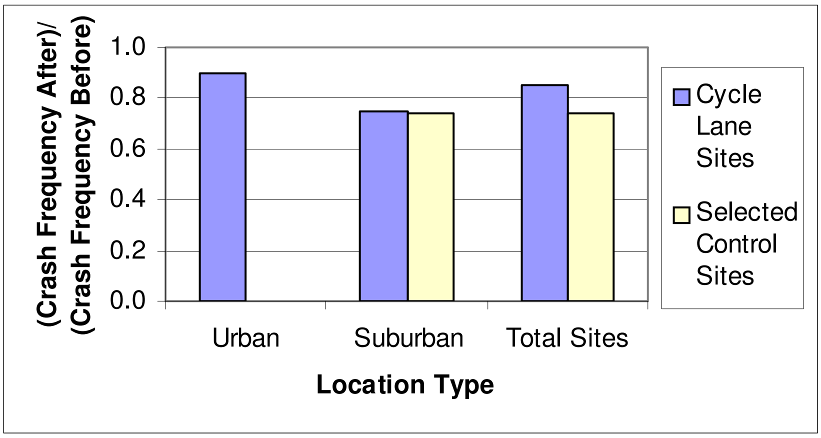

Figure 30 Intersection After/Before Crash Frequency Ratios

4.4.2 Comparisons with sites Similar to Pages Road

In order to predict the effect the Pages Road cycle lane will have on cycle crash frequency suburban, single-lane midblock cycle lane sites were compared with corresponding control sites:

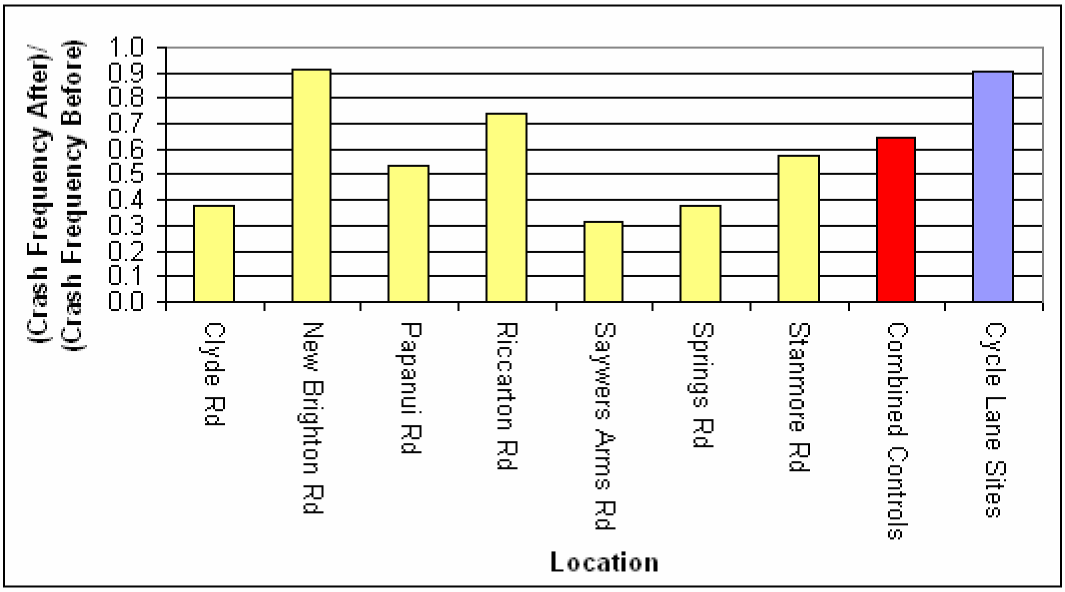

Figure 31 Before/After Crash Frequency Ratios for sites similar to Pages Road

5.0 Discussions

5.1 Vehicle Speeds

Using the test of two means on data from the manual laser gun speed surveys there was no statistical basis to reject the null hypothesis that the mean speeds were equal before and after the cycle lane introduction; in fact, the probability of the null hypothesis being true was high in most cases. Nor was there a common trend displayed for cars and heavy vehicles; the mean speed surveyed for the cars decreased slightly but for the heavy vehicles it increased slightly. These slight differences are probably due to the survey techniques employed; it was difficult to judge exactly which vehicles were free and which were affected by preceding vehicles.

The 85th percentile speeds did not change between the before and after laser gun surveys for either cars or heavy vehicles. The 85th percentile is more sensitive to change (Koorey, 2004) so this result suggests that the cycle lane installation had little, if any, impact on vehicle speed.

From the laser gun survey results it appears that the extreme outlying values decreased after the cycle lane installation; 8 vehicles (1.1%) had speeds greater than 62km/h before the change, compared with 2 vehicles (0.3%) afterwards. Despite the reduction of extreme values and little change in the means, the variabilities for both car and heavy vehicle speeds increased after the cycle lane installation; speeds became more dispersed either side of the mean.

Contrary to the manual speed survey results, statistical evaluation of the MetroCount data suggests that vehicle speeds certainly did change after the cycle lane installation. Speeds appear to have decreased by 0.9 km/h for the peak periods and 1.5km/h for off-peak periods. The overall decrease in mean vehicle speed was 1.4km/h. The inequality between peak and off-peak period speeds suggests that not all speeds used in the analysis were actually free speeds; otherwise it would be expected that the changes for the two periods would be more similar. This indicates that a greater headway time may have been more appropriate.

The 85th percentile speed decreased by 1km/h for peak traffic and 2.1km/h for off-peak traffic after the cycle lane installation. Variability was reduced in both peak and off-peak cases. These changes in speeds may be due to a novelty effect where motorists are initially more cautious than they would normally be. It would be useful to obtain speed data at a later data to assess whether or not the change in speed was permanent.

The mean speeds obtained from the MetroCount data are generally larger than those obtained from the manual survey data. This is probably due to the method used in the manual survey where the student judged vehicle independence. This was a difficult process and probably resulted in the inclusion of vehicles with headways less than four seconds. Also, when using the hand held laser device it was difficult to measure the speeds of certain vehicles, especially when travelling at high speeds, hence some were omitted from the survey. Finally, the MetroCount records contained week-long periods of data before and after the cycle lane installation, a much larger sample size than for the manual surveys. Therefore the MetroCount speed data is probably more accurate than the manual laser gun survey speed data.

Mean speeds obtained from the speed camera data are noticeably lower than those obtained from the MetroCount data. The presence of a speed camera, either as a fixed instalment or as a mobile unit positioned in a parked vehicle, can often be detected by motorists and will result in a decrease of speed. Hence the MetroCount data probably gives a more accurate representation of the true vehicle speed distribution. The speed camera data suggests that vehicle speed has decreased overall by 1km/h, which is consistent with the MetroCount result as most of the speed camera data was obtained from peak period traffic.

The MetroCount and speed camera sample sets contained many more vehicles than the manual speed survey sample and hence will yield more accurate results. However as both the MetroCount station and the speed camera box are positioned in different locations to the survey site other factors may have influenced the speeds obtained from these methods.

The survey site was located prior to a horizontal curve in the road; the MetroCount and speed camera sites were located past the curve, on straight stretches of road. The existence of a curve would possibly have an effect of decreasing vehicle speed but this effect would be present before and after the cycle lane installation so the presence of the curve should not contribute to a change in speed.

As mentioned previously, the Pages Road cycle lane was installed in conjunction with the extension of a painted median strip along the centre of the road. The survey site was chosen in a place that already had a painted median strip hence the only variation made to the site was the cycle lane. The MetroCount, located 140m eastwards from the survey site, was also positioned on the part of the road with a painted median strip prior to the cycle lane installation. The speed camera, located 275m eastwards from the survey site, was positioned on the part of road that did not have a painted median prior to the cycle lane installation. Hence, in terms of changes made, the MetroCount and survey sites were very similar but the speed camera site had another variable, that is the addition of a painted median.

5.2 Vehicle Positioning

The mean distance from the kerb to the left edge of the vehicles' left rear wheels decreased from when no cycle lane was present to after the cycle lane was installed for both the morning and the afternoon surveys. Variability also decreased significantly in both cases which would be expected due to the decrease of the lane width. Before and after data sets were considered statistically independent for both cases.

This result is unexpected for two reasons. Firstly, the geometry of the traffic lane was considerably altered; the distance from the kerb to the traffic lane edge line was increased and the width of the traffic lane was decreased. Hence all parts of the traffic lane that drivers would be inclined to judge their positioning against (i.e. edge of lane or centre of road) were moved rightwards and it is unusual that the mean vehicle position moved leftwards.

Secondly, at least one parked car was present in the parking lane adjacent to the cycle lane for the majority of the August 29 survey. The May 26 survey, where a car was parked for about half of the peak flow period, showed that vehicle positioning significantly increased when a parked car was present. A similar trend may have been expected for the August 29 survey. However, the cycle lane may have been a sufficient buffer to protect people leaving or entering the parked car and to prevent motorists from feeling uneasy about passing a parked car.

The decrease in mean vehicle distance from kerb may have been due to a change in driver perception of safety. The introduction of the cycle lane gave motorists a more clearly defined limitation of where they can and cannot drive. This results in motorists moving closer to the cycle lane, as they believe that they can safely and legally go anywhere up to the cycle lane line. This is especially important leading up to the curve in the road where previously drivers may not have known if they would encounter a cyclist around the corner. With the cycle lane present drivers would feel more comfortable about approaching the corner, trusting that any cyclist around the bend would be safely within the cycle lane.

There was no obvious trend in positioning of vehicles when cyclists were present, nor were changes in variability consistent between the morning and afternoon cases. The null hypothesis that the cycle lane installation did not cause a change in the mean vehicle position could not be rejected statistically.

Mean vehicle distances for the cases where cyclists were present were in all cases higher than those for when cyclists were not present. This shows that motorists gave cyclists extra clearance regardless of the presence of the cycle lane. Therefore, there was less room for change in vehicle position after the cycle lane was installed.

The mean cyclist position increased for both the morning and afternoon survey cases; however there was no basis to prove that the morning before and after survey mean positions were statistically different. Variability decreased between the afternoon surveys but increased between the morning surveys.

Before the introduction of the cycle lane, several cyclists were noticed on the westbound side of the road heading in the east direction. However, no such cases were recorded when the cycle lane was present. This suggests that after the cycle lane installation cyclists were more comfortable to stay on the side of the road corresponding to the direction in which they were heading.

A substantial proportion of cyclists were noticed to have used the footpath before the introduction of the cycle lane; afterwards this proportion was decreased but not eliminated. Such cyclists may have formed a habit they saw no need to change, or still perceived the cycle lane to be too unsafe and hence chose to ride on the footpath. The cyclists riding on the footpath were generally school-aged children.

The proportion of cyclists using the parking space decreased from 61% to 32% after the installation of the cycle lane. This is a substantial decrease but less than anticipated. For a large proportion of survey time there was a car parked just ahead of the survey site; the surveyors vehicle was present several meters before the survey site for all survey durations. This means that many cyclists would choose to enter the parking space even if only for a short distance. These cyclists seemed more comfortable at a greater distance from the traffic, even when the cycle lane was present.

There was an increase in the estimated ability level of the cyclists present in the afternoon surveys; no primary school aged children were present and a higher proportion of sports cyclists was recorded for the survey after the cycle lane installation. The estimated ability level of the cyclists present in the morning surveys decreased; more primary school children and a lower proportion of sports cyclists were recorded after the cycle lane was installed.

As illustrated by the comparison of the manual and MetroCount vehicle speed surveys a larger sample size would increase the accuracy of conclusions made. While the laser detectors were not effectively used in this investigation they could prove to be invaluable in later surveys. A greater understanding of the software requirements and operational techniques associated with the lasers has been gained; with some modifications to the process used the lasers could be used to gain larger, more accurate samples.

5.3 Qualitative Opinions

Figure 19 shows that a reasonable proportion of Pages Road residents cycle; eight of the 20 residents who responded to the cycle use question use the cycle lane at least once a week. Vehicle use is the predominant mode of transport; 19 of the 22 respondents for this question drive a motor vehicle along Rages Road at least once a week. Walking is also popular, the majority of residents walk along Pages Road at least a few times a week. This question is important as it shows that residents can view the road dynamics from a perspective different to that when using the road or cycle lane directly.

As shown in Figure 20, most residents preferred cyclists to use the footpath prior to the cycle lane installation. This attitude may have attributed to the observed trend of many cyclists opting to use the footpath even after the cycle lane was installed. However, a very similar proportion of residents felt that it was safe for cyclists to share the traffic lane before the cycle lane was installed.

Motorists' opinions were equally divided as to whether or not they felt comfortable passing cyclists who shared the traffic lane. Figure 21 shows that motorists felt much safer after the installation of the cycle lane; 16 of the 18 respondents felt comfortable when passing cyclists on the cycle lane, the remaining two respondents were neutral. No respondent indicated that the introduction of the cycle lane had decreased cyclist safety.

Cyclist opinions do not appear to have changed as a result of the cycle lane installation. A wide majority of cyclists prefer to use the cycle lane, but only half of the respondents feel safe when doing so; this is only a slight increase in the proportion of cyclists who felt safe when cycling prior to the cycle lane installation. Two of the eight respondents who answered the section regarding cycling post cycle lane installation still prefer to cycle on the footpath. One of these respondents commented that cars often cut through cyclists' paths, which is unsafe.

Some respondents agreed that they preferred both to ride in the cycle lane and in the parking space; it seems reasonable that situations could arise where the parking space would appear more attractive than the cycle lane. However, it was observed during survey periods, cyclists would often choose to use the parking space rather than the cycle lane even if this meant weaving between parked cars.

Overall, the information provided from cyclists does not display a convincing trend in either cyclists' perceptions of safety or cyclists' choice of positioning on the road. If cyclists do not perceive the cycle lane as safe they will be much less likely to use it; this would render the installation ineffective in its purpose of encouraging cycling and improving cyclists' safety. Education into the benefits and safety of cycle lanes may help encourage cyclists to feel more comfortable about using the cycle lane rather than the footpath or parking space.

Figure 24 shows residents' opinions on other measures of the cycle lane's effectiveness. It was expected that residents may have experienced more difficulty in accessing their properties with the cycle lane present but responses did not support this theory. Contrary to the MetroCount data, which suggested that the mean free speed has decreased by 1.4km/h, residents did not perceive a change in vehicle speed or travel time. Similarly, residents' opinions of traffic noise and high-speed vehicles did not indicate a decrease in speed.

Only five residents with children who use the cycle lane responded. From these responses no definite parental attitude could be distinguished as opinions are quite evenly divided for all questions.

Several similar themes were apparent from the comments made by residents. Many people expressed concern at the number of cyclists who still ride on the footpath. This unsafe practice indicates that many cyclists perceived the cycle lane as being too unsafe.

Concern was raised that the parking space was insufficient for large trucks, which then encroached on the cycle lane and vehicles that parked illegally in the cycle lane.

Residents felt that these occurrences compromised the safety, attractiveness and effectiveness of the cycle lane.

Two residents who had used the cycle lane expressed their wish for it to be extended further, through the Breezes Road intersection and on to New Brighton Road. Prior to the city's cycle lane moratorium the Christchurch City Council had planned to extend the cycle lane through the Breezes Road intersection. However, residents did not seem aware of this.

Many residents were happy with the cycle lane and felt it had improved cyclists' safety. Others were not impressed with it and felt that alternative options should have been considered.

Some residents did not answer all the questions that applied to them, for example four cyclists responded to only one of the three statements about where they prefer to cycle, in this case it was assumed that they disagreed with the remaining statements. Occurrences such as this may have affected the results and suggests that the survey contained some ambiguities. It would have been ideal if all respondents had completed the survey with the surveyor present but many residents preferred to fill in the forms in their own time.

The vast majority of respondents were either in the 40-59 or 60+ year-old age groups; this may possibly indicated that the younger residents felt too busy or uninterested in the survey. While the actual age distribution of Pages Road residents is unknown, it seems unlikely that the age distribution of respondents approximates it well. This may have some bearing on the validity of conclusions drawn from the survey.

Overall, the residents' survey provides some valuable insights into people's opinions and reasons for their behaviour but cannot be taken as a conclusive study of public opinion.

5.4 Crash History Research

From the crash history data where cycle lane sites are compared with control sites it does not appear that cycle lanes have increased cycle safety; in fact, in most cases the control sites appear to have experienced greater reductions in crash frequency. In both midblock and intersection cases a greater proportion of control sites experienced reductions in crash frequency than the corresponding cycle lane sites.

The only case where the control sites had a higher after/before crash frequency ratio than the cycle lane sites was the midblock single-lane situation. This may have been affected by a lack of urban sites considered appropriate controls. Non-cycle lane site may have provided another indication of the affects of the urban/suburban split but time constraints did not allow adequate sorting of the non-cycle lane data into midblock and intersection components, this would have affected the result as midblock and intersection sites have different characteristics and lumping the data would not necessarily allow sufficient comparison.

Overall, sites control sites considered similar to Pages Road had crash frequency reductions sufficiently higher than their corresponding cycle lane sites. Only New Brighton Road had a crash frequency ratio greater than that of the cycle lane sites.

While it appears from the evidence shown that cycle lanes actually have an adverse effect on crash frequency there are several factors worth considering. Firstly, the methodology of this analysis may be flawed. A more appropriate method might be to use the crashes per cyclist rate for each site instead of the crashes per year for each site. This would normalize the data between sites more effectively as, when using the crash frequency method, sites with high cyclist volumes have more potential to decrease in crash rate. Some cyclist counts were provided for intersections around the city however no information was given regarding the number of cyclists on each street hence it was not possible to calculate the accurate average annual daily cyclist counts required for a crashes per cyclist calculation.

Although mainly sites with higher crash frequencies were selected in the analysis the random and infrequent nature of crashes means that one or two crashes may provide the difference between a site decreasing and increasing in crash frequency according to the analysis method used. For this reason the crash frequency ratio graphs may provide a clearer indication of the changes than the proportional sites increased/decreased graphs.

Secondly, the student did not take any additional treatments preformed on the control sites into consideration. While the control sites had not had cycle lanes installed they may have had other safety improvements such as geometric changes, central medians, intersection upgrades or a variety of other remedial works. In a more detailed study it would be advisable to assess each site individually and try to eliminate the effects of other changes made.

Thirdly, as more cycle lanes were installed throughout the city cyclists may have chosen to use those routes instead of the control sites. Hence cyclist volumes would increase on the cycle lane sites and decrease on the control sites. An increase in cyclist volume would ultimately lead to an increase in the number of crashes and conversely. Studying crashes per cyclist count as outlined above would eliminate this effect.

Finally, the CCC carefully investigates prospective cycle lane sites in order to determine which roads would benefit most from having a cycle lane installed and most wisely invest their limited resources. Hence most of the cycle lane sites studied were chosen by the CCC to have cycle lanes due to their unsafe nature. While the sites chosen as controls had similar collision rates they were not necessarily good approximations of what the cycle lane sites would have been like had they not received cycle lanes.

Many of the control sites were taken from stretches of roads that had cycle lanes installed along other stretches. This may have resulted in an increase in safety for the total length of the road as motorists would be more aware of cyclists and would get used to driving with a sufficient gap left available for cyclists thus safety of the non-cycle laned stretches would also improve.

5.5 Combination of Factors

From the results obtained and different methods used it is suggested that Buckley and Wilke's classification of safety as either perceived or actual (Buckley and Wilke, 2000) can be improved. Buckley and Wilke defined perceived safety as being that experienced by the user in terms of vehicle speeds and separation distances. The use of the term "perceived" is perhaps not appropriate here as not all road users infer the same level of safety from changes in these attributes. As indicated by the residents survey road users did not notice any changes in vehicle speeds but the MetroCount data shows that there was a definite decrease. Residents also had many differing opinions based on the same situation.

Given this, it seems that qualitative opinions of road users would better fit the term "perceived safety." The definition of "actual safety" as that observed from crashes is adequate as actual crash incidents are the only definite measures of safety. A third term, "inferred safety," is suggested as safety gauged by indicators such as vehicle speed and vehicle separation distances which have been observed to have a direct relationship with crash rates.

6.0 Conclusions

One indicator, qualitative opinions, was used to gauge the perceived safety of cyclists using the Pages Road cycle lane; one indicator, history of similar sites, was used to gauge the actual safety of road users and two indicators, vehicle speed and vehicle positioning were taken as measures of inferred safety.

Based largely on data provided by the Christchurch City Council's MetroCount system, it was determined that the installation of the Pages Road cycle lane resulted in a 1.4 km/h mean speed decrease for all eastbound traffic. As speed is proportional to accident risk and consequence severity this decrease in motor vehicle speed indicated an increase in the inferred safety of cyclists.

Results from the video recorded vehicle positioning surveys indicated that vehicles moved closer to the kerb after the cycle lane installation when no cyclists were present, but retained the same distance when cyclists were present. It was assumed that the greater the distance between the cyclist and the passing vehicle the greater the safety of the cyclist. Hence, the cycle lane installation had no effect on inferred cyclist safety in terms of vehicle-cyclist separation provided that motorists are aware when cyclists are present. The decreased vehicle distance when no cyclists were present was an indication that motorists felt more comfortable with the cycle lane in place.

Qualitative opinions of Pages Road residents were mixed in their approval of the cycle lane. Motorists agreed that the cycle lane increased cyclists' safety but not all felt comfortable when passing a cyclist using the cycle lane. There was a slight increase in cyclists' perception of safety after the cycle lane installation but half the respondents still did not feel comfortable when using the cycle lane and one quarter still preferred to use the footpath. Based on this evidence, only a slight increase in the perceived safety of cyclists is apparent.

From the crash history of sites with and without cycle lanes recently installed, it appeared that the control sites experienced a greater reduction in crash rate than the cycle lane sites. This observation was probably due to the nature of the information used and would require further investigation to verify.

Therefore, based on qualitative opinions of Pages Road residents, the perceived safety of cyclists using the Pages Road cycle lane was improved slightly. Based on the reduction in vehicle speed and continuity of distance between vehicles and cyclists before and after the cycle lane installation there was an improvement in the inferred safety of cyclists. Based on the comparisons with crash histories of similar sites no improvement in actual safety was apparent.

This study incorporated many different techniques in the analysis of cycle safety and many lessons were learnt about how to improve future studies. The use of the laser detectors but with modified software would result in more accurate data and the possibility of larger sample sizes due to reduced surveying time.

A more in-depth analysis of the crash history of other sites with a better understanding of the requirements of control sites would also be beneficial. More consideration should be taken in eliminating the effects of other treatments and campaigns that affect cyclist crash rates.

It would also be of interest to study responses from a greater sample of cyclists to better measure changes in perceived safety. Ideally surveys would be performed before and after the cycle lane installation from samples of cyclists intercepted while using the cycle lane.

Monitoring the speeds of vehicles over a longer period of time after the cycle lane installation would provide insight into the changing perceptions motorists have of the cycle lane as they grow more accustomed to it. This would identify any novelty effect produced.

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9.0 Appendices

9.1 Manual Survey Vehicle Speed Data

9.2 MetroCount Vehicle Speed Data

9.3 Speed Camera Vehicle Speed Data

9.4 Vehicle Positioning Data

9.5 Resident Survey Form

9.6 Cycle Lane Site Crash History

9.7 Control Site Crash History

9.8 Statistical Test Methods

9.8.1 Goodness of Fit: Chi-Squared Test

In order to determine whether or not the samples could be modelled as normal distributions a goodness of fit test was preformed according to the chi-squared method.

Null hypothesis: that the population is normally distributed with a mean and variance equal to that calculated from the sample data.

Test statistic: $$\sum_{i=1}^{k}\frac{(O_i - E_i)^2}{E_i}$$

Where the Oi values are those observed for each interval. Ei values are those expected to occur in each interval when modelled with a normal distribution. K is the number of intervals.

This was then compared to the critical chi-squared value $\chi^2{}_{(k-r-1),\alpha}$ where the degree of freedom, k-r-1 depends on k, the number of intervals used and r, the number of hypothesised parameters (i.e. 2, the mean and standard deviation for a normal distribution). α is the required level of significance.

These calculations were preformed using Excel, which was also used to give the exact probability of the null hypothesis being true when modelled with a chi-squared distribution.

9.8.2 F Test for Sample Variances

When testing two samples the variances were first tested using the F test to determine whether or not they could be pooled as one population variance.

Null hypothesis: $\sigma_1{}^2 = \sigma_2{}^2$

i.e. that the two populations have the same variance.

Alternative hypothesis: $\sigma_1^2 > \sigma_2^2$

i.e. that the populations have different variances

The F test statistic was calculated by: $F = \frac{s_1^2}{s_2^2}$

where s_1 and s_2 are the variances of the first and second sample respectively.

This was compared to the critical F distribution value from a table of $F_{n_1-1,n_2-1,\alpha}$ where n_1 is the sample size of the first sample, n_2 is the sample size of the second sample and α is the required significance level. If the test statistic was less than the distribution value the null hypothesis could not be rejected and the sample variances were pooled to give a pooled variance of:

$$s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$$

If the null hypothesis could be rejected the individual sample variances were used.

9.8.3 Two Sample Test for Means

When testing the means of two samples after having already tested the variances the student-t distribution was used and a new null hypothesis was established:

Null hypothesis: $\mu_1 = \mu_2$

i.e. that the two populations have the same mean value

The test statistic was calculated by: $\frac{x_1 - x_2}{\sqrt{\frac{s_p^2}{n_1} + \frac{s_p^2}{n_2}}}$ or $\frac{x_1 - x_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$

Where x_1 and x_2 are the sample means, s_1 and s_2 are the sample variances, s_p is the pooled sample variance (if determined appropriate) and n_1 and n_2 are the sample sizes.

The test statistic was compared to the critical student-t distribution value obtained from a table of $t_{n_1+n_2-2,\alpha}$ where n_1 is the sample size of the first sample, n_2 is the sample size of the second sample and α is the required significance level. If the test statistic was less than the distribution value the null hypothesis could not be rejected. Using Excel the exact probability of the null hypothesis being true was calculated using the student-t function.

Results from the Excel spreadsheets used are shown in the following section; sample formulae are included for the first spreadsheet.

9.9 Normal Distribution of Vehicle Speeds

9.10 Test of Means for Vehicle Speeds

9.11 Normal Distribution of Vehicle Positions

9.12 Test of Means for Vehicle Positions

9.13 Resident Survey Answers

9.14 Resident Survey Additional Comments

- It (the cycle lane)'s a mess.
- Cars open doors in front of cyclists.
- Annoyed at loss of parking.
- Think it (the cycle lane) is a good thing – cyclists know where they're allowed to go.
- Have noticed more cyclists recently.
- Hasn't made a difference – traffic still uses cycle lanes.
- Kerbside parking has been removed but cars still park where it used to be.
- The cycle lane stops at the Breezes intersection, which is the busiest and most dangerous part of the road.
- Really like it.
- Trucks park over lane – dangerous.
- Fill in the deep gutters!
- Hope to see more cycle lane down Pages Road to Brighton.
- Pages Road is a very busy and fast road, cycling at any time is dangerous, the cycle lane was a positive step but vehicle speeds are still a big issue.
- I disagreed with the cycle way when first mooted. I still think the same way. The proper solution would have been the original plans for road widening.
- I don't feel very safe sitting on the median strip waiting to turn into my drive.
- Being new to the South Island I am amazed at the number of people who cycle on the footpath – even though there is a cycle lane!
- My daughter walks or buses to school.
- People of all ages still prefer to cycle on footpaths, very dangerous driving out of properties. It would be safer all round if they would use cycle lanes.
- I still see lots of folk riding on the footpath.
- Thank you for cycle lanes.
- Speed signs are better, I look for them. Some places I hate going 50, long roads. Some places safe to drive 50.
- South NZ roads are getting better. Safer.
- It is better with the cycle lane, safer for children especially.
- The median strip in the middle slows the traffic too.

- It's easier to get into our driveway.
- The installation of cycle lanes has increased road usage by pushing vehicles closer to back opposing lanes by cycle lanes encroaching into the carriage way. The islands also decrease the amount of road space.
- I think it is a great idea to at least make drivers aware of cyclists on the road.
- Hopefully more people will now cycle.
- I live where the two vehicle lanes merge into a single lane, and have been aware of more vehicles having to brake - due to excessive speed and aggression?
- Improve safety for cyclists but no parking lane on other side is a disadvantage.
- Cars have no thought for the cyclist on the new lane. They cut you of all the time. I feel safer on the footpath. The Give-Ways need to be looked at.
- I do no mind the cycle lane but not in that it removes the parking space, our people park on the grass.
- Definitely better and safer for all road users.

9.15 Time Log

Date	Description	Duration (hrs)
13 May	Survey #1	2.5
17 May	Survey #1 data processing	1.0
26 May	Survey #2	2.0
29 June	Video data collection	4.0
11 July	Speed data processing	1.0
12 July	Video data collection Research – Swedish study	3.5 1.0
14 July	Video data collection Position data processing	2.0 1.5
15 July	Project briefing	1.0
18 July	Research and direction meeting	1.0
20 July	Research – CCC moratorium	1.0
21 July	MetroCount data stats Research – related papers	4.0 1.0
22 July	Research – cycling strategies	3.0
26 July	Research – library books	1.5
28 July	Meeting and survey prep MetroCount data	1.0 4.0
29 July	Research – Cycle Planning Book Survey #3	1.0 3.0
1 August	Survey #3 speed stats	1.5
2 August	Survey #3 speed stats Survey #3 video analysis	1.0 3.5
3 August	Survey #4 Survey #4 video analysis	2.5 3.0
4 August	Survey #4 video analysis Vehicle position statistics	3.0 3.0
5 August	Meeting, statistics, photos	1.5
8 August	Video data – cyclist age and ability	3.0

10 August	Analysis of videoed cyclists	3.0
11 August	Report writing of findings	2.0
12 August	Report and meeting	2.0
23 August	Laser survey prep Statistics	1.5 2.5
24 August	Laser survey and data analysis	4.0
1 September	Report	7.0