Transport Research Laboratory

Assessment of TfL's experimental scheme to allow motorcycles onto with-flow bus lanes on the TLRN

by I.York, S.Ball, O.Anjum, D.Webster

PPR495

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FINAL PROJECT REPORT

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Assessment of TfL's experimental scheme to allow motorcycles onto with-flow bus lanes on the TLRN

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Prepared for:	**Project Record:**	**Powered Two Wheelers in Bus Lanes**
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Contents

1 Introduction

1.1 This Document

This report presents the results for the study, "Assessment of London's Motorcycles in Bus Lanes Scheme". The scope of the results in this document is the 56 trial sites and an overall assessment of the effect on the whole of the TLRN (Transport for London Road Network). The study was commissioned by Transport for London and ran from September 2008 to May 2010.

1.2 Issues

Road space is a finite resource with limited capacity for the users. Providing priority to one, or more, users is achieved at the potential expense of other non-priority users. Priority is provided to improve either the journey times, or the safety of the permitted users. However, clearly, the number of priority users must be limited; otherwise their overall benefits will be eroded.

Buses have been provided with various forms of priority for many years to improve their journey times and reliability. One of the main forms of priority is bus lanes. These exclude all non-priority vehicles (generally) from the left hand lane of the carriageway which permits buses to pass traffic queues at downstream junctions and therefore reduces their delay. In reality bus lanes do not extend to the downstream junctions stop line, as this would have a highly adverse effect on junction capacity and cause delay to other road users, and there can be issues with left turning non-priority traffic. Instead, the bus lane is "set back" from the junction and the buses re-join the traffic queues close to the junction.

Few bus lanes are for the exclusive use of buses. Generally, taxis and cycles are also permitted to use them, and other forms of shared-use lanes have also been implemented. Cyclists, in particular, have been permitted access to segregate them from the main traffic flow, reducing their interactions with traffic, with the purpose of improving their safety.

Permitting motorcycles into bus lanes could provide them with a journey time advantage and assist flows by removing them from the non-priority lanes. In addition, motorcycles have a relatively poor safety record.

In 2007 there were 4,222 motorcycle casualties, equating to approximately 15% of all road collisions in London, and a total of 1,208 of these collisions resulted in a death or serious injury. However, motorcycles represented a much smaller component of the traffic flow than 15%. Although traffic flows and their composition vary depending with the area of London surveyed and through seasonal variation. Available estimates indicate that motorcycles only represent 1.2% to 1.4%[1]. This implies their collision rates are much higher than the overall average for all modes.

The safety of all road users is a major concern for TfL. In 2006 the Mayor announced targets for 2010 of a 50% decrease in road users being killed or seriously injured, and a 40% reduction in the number of motorcyclists killed or seriously injured. Therefore, schemes that can improve motorcyclists' safety have been considered and allowing them use of a bus lane could reduce their interaction with other vehicles and therefore may improve their safety.

In addition to meeting casualty reduction targets, there are financial benefits to reducing the number of collisions. A collision tends to close a lane, or even a road, for at least 15 minutes and can affect flows for up to a day; therefore disrupting traffic. These costs combined with others, including medical costs, can represent a large overall cost to the community. For example, in 2005 the total cost to the community of all road collisions in Greater London was estimated to be almost £1.9 billion (at June 2006 prices)[1]. Therefore, proportionately (according to the 2002 data with RPI applied from national statistics annual figures) in 2009 motorcycle collisions cost authorities within Greater London approximately £0.44 billion.

1.3 Background on the Study

TfL conducted a trial scheme which permitted motorcycles to use three bus lanes on the A13, A23 and A41 in 2002. Also, Westminster City Council separately allowed motorcycles to use eight of their bus lanes in 2005, which was monitored by TRL, and other small scale studies of schemes elsewhere in the UK have also been conducted. The smaller sample sizes involved in the past studies resulted in there

[1] Collisions and casualties on London's roads 2007 (Oct 2008), TfL

being no statistically robust conclusions. Overall, there appeared to be no major concerns, although certain motorcycle behaviours (for example lane discipline), and certain site characteristics (for example high flows and side roads) were identified that were potentially of concern. The Mayor announced his intention to permit motorcycles into bus lanes on the complete Transport for London Route Network (TLRN), which constitutes approximately 580 kilometres of road with 478 bus lanes, from January 2009.

1.4 Objective of the Study

TfL's stated objectives for this study are:

1. To facilitate the safe, efficient and effective movement of motorcyclists, without an adverse effect on other traffic;
2. To fully assess the impact on all traffic, in particular cyclists, which will facilitate an informed decision about whether to permanently allow motorcyclists to use bus lanes;
3. To fully consider and respond to representations made by road user representatives, groups representing people with disabilities, statutory and other key stakeholders and members of the public.

TRL were commissioned by TfL to design and conduct an independent experimental trial which would allow for rigorous assessment and produce evidence based recommendations to meet objectives 1 and 2 as stated above, See Figure 1.

Primary 1	Assess changes casualty/collision rates on the 28 trial and control routes.
Primary 2	Assess changes in casualty/collision numbers on all TLRN bus routes in the study.
Secondary 3	Assess effect on cycle usage
Secondary 4	Assess motorcycle usage
Secondary 5	Assess the effect on bus journey times

Figure 1: TfL's Trial Evaluation Criteria

TRL was initially commissioned to deliver analysis on the five evaluation criteria as set out in Fig.1. A sixth criterion (Secondary 6) was part of the original criteria set, but is not within the remit of this report. The subject of Secondary 6 was Attitudinal Surveys.

A further evaluation measure (Secondary 7) was subsequently added following consultation with stakeholders. The subject of which was a Conflict Analysis which is included in this report.

2 Methodology and Information Analysed

2.1 Objective Led Methodology

TRL's methodology for data capture was objective led, tailored to provide a robust understanding of any changes in the five evaluation criteria, as shown in Figure 2.

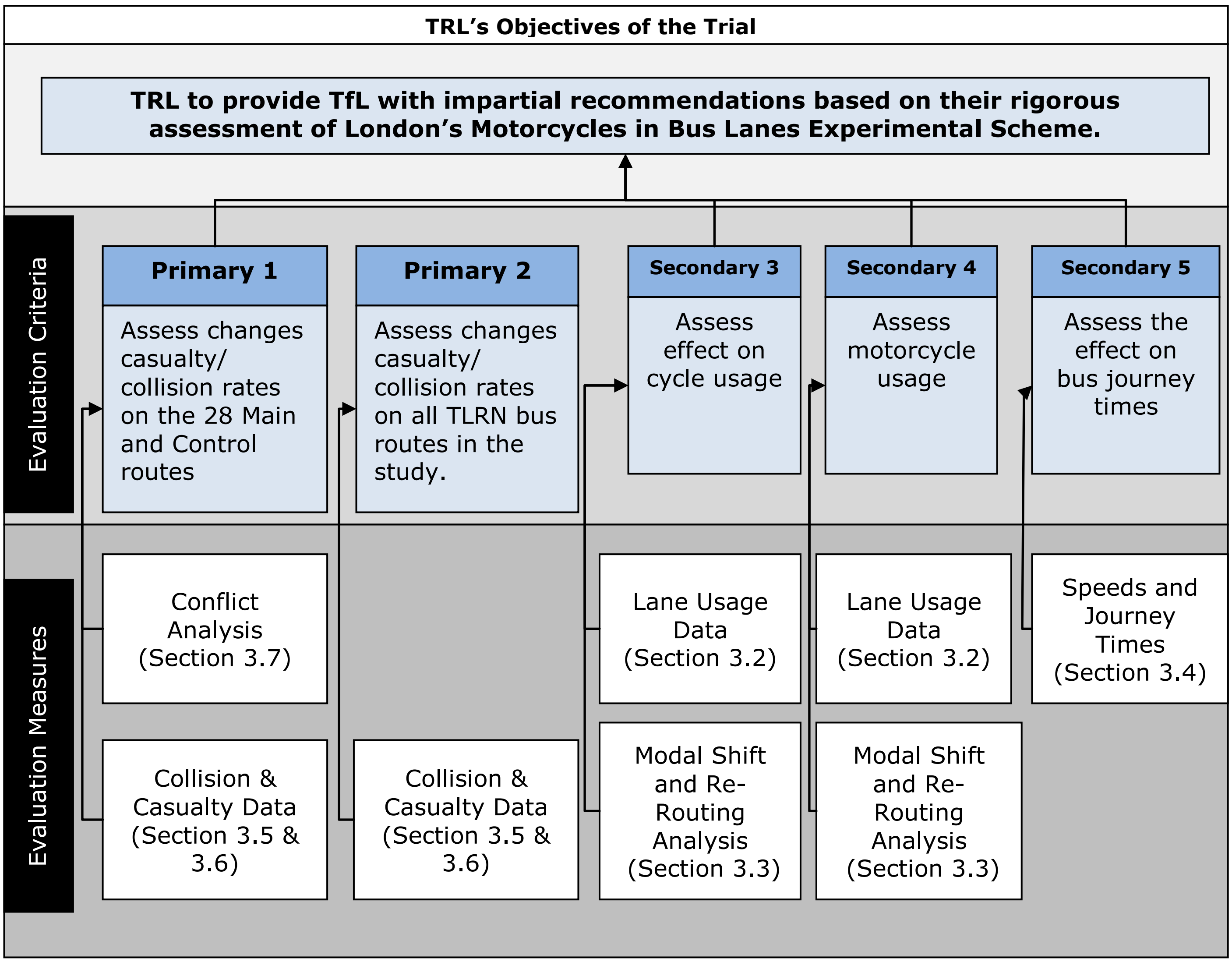


Figure 2: Objective Led Methodology

2.2 Methodology Overview

The methodology used to assess the effect of permitting motorcycles into the bus lanes on TfL's road network involved on-street Before and After surveys being carried out at 60 sites across London, and involved two main survey techniques, video survey and automatic traffic counters (ATC). The Before surveys were carried out in Autumn 2008 and captured the behaviour of road users prior to motorcyclists being granted permission to use the bus lanes in operational hours, see Section 3.2.1. The surveys were then repeated 12 months later, on comparable days, in order to examine any changes in site use and behaviour.

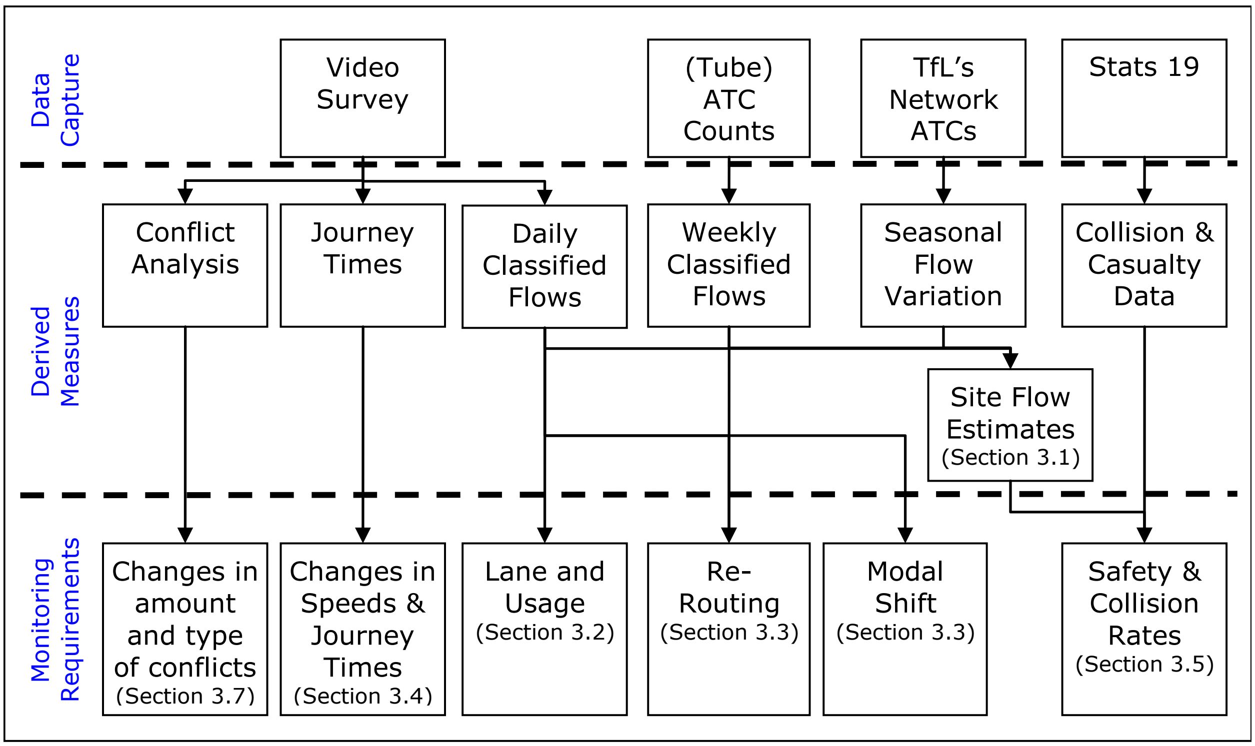


Figure 3: Data Capture and Measures

Figure 3 shows how the data collected during the on-street surveys was used to produce statistically robust results combined with data supplied by TfL on collisions within the network and seasonal flows of motorcycles and cycles.

The following data was collected during the trial on each survey site:

- Automatic Traffic Count;
- Classified Vehicle Count (including use of the footway);
- Journey Times;

- Conflicts between motorcycles, or cycles, and other road users.

The study required 56 sites in order to be statistically significant at the 90% level. Data was collected for 60 sites, so that there was some contingency for dropping sites in the event of data collection failures, e.g. road works. A total of 68 sites were initially considered for inclusion. Upon conducting the site visit, some sites did not meet the required site criteria and were therefore rejected. For the 56 sites that were used in the study, the original numbering of 1-68 remained to avoid confusion.

Survey data has been collected for 56 sites (see Table 1). Each site has been assigned a number between 1 and 68. Sites numbered between 1 and 34 are all Main survey sites and sites numbered between 35 and 68 are Control sites. Each Main site has been paired with a Control site. For easy reference, each pair has been assigned a pair identifier of between A-AB. The pairing of sites is described in Section 2.3. The Main and Control site pairs are used in all the analysis, with the exception of the conflict data, which was only conducted for the Main sites, as described in Table 1. For full site details see Appendix A.

Information Analysed	Site Numbers	Pairs	Main Sites		Control Sites		Total Sites
			Sites	Site No	Sites	Site No	
Automatic Traffic Count	Sites 1-68	Pairs A-AB	28	Sites 1-34	28	Sites 35-68	56
Classified Vehicle Count	Sites 1-68	Pairs A-AB	28	Sites 1-34	28	Sites 35-68	56
Journey Times	Sites 1-68	Pairs A-AB	28	Sites 1-34	28	Sites 35-68	56
Conflicts	Sites 1-68	NA	28	Sites 1-34	NA	NA	28
STATS 19 Accident Data	Sites 1-68	Pairs A-AB	28	Sites 1-34	28	Sites 35-68	56

Table 1: Site Numbers and Data Collected

There is no data for the following 12 rejected sites.

Intentional Missing Data	
Main	Control
13	47
18	52
24	58
29	63
32	66
34	68

Table 2: Site Data Intentionally Not Included

Sites 13, 18, 24, 34, 47, 52, 58, 68 were initially considered for inclusion in the study, but were rejected, because they did not meet the required site criteria.

Sites 29, 32, 63 and 66 did meet the criteria, but were rejected due to emergency road works, or other events, affecting traffic flows during the Before or After survey.

The following sections describe how the survey sites were selected, the data collected on each site, and techniques used in more detail, and how the data was initially processed to gain information on site conditions.

2.3 Site Surveys Performed

2.3.1 Site Selection Strategy

The sampling strategy utilised within this project aimed to ensure at least a 90% confidence in the results based upon calculations from previous studies. Where greater confidence in results has been achieved (e.g. a 95% confidence), the results are reported to the high confidence level. Sites on the borough road network were used for comparison (Control sites) to assist in explaining any trends in migration and trip generation, and to provide a basis for any network changes that occurred between the Before and After surveys. A sample size of 56 sites was used in this study, consisting of 28 Main sites and 28 Control sites. This sample size was derived from the observed variances in collision rates obtained in the previous Westminster study, and it was therefore the best estimate available to calculate the sample size required to achieve statistical validity without needing to survey an excessive number of sites.

2.3.2 Approach to Site Selection

Information was obtained from TfL on all bus lanes affected by the implementation of the scheme on the TLRN: 478 bus lanes, of which 461 were with-flow bus lanes. A total of 30 (Main) sites were randomly selected from those available excluding abnormal sites, i.e. those:

- In Westminster (as motorcycles had previously been allowed in eight of their bus lanes);
- On the three previous trial sites A13, A23 and A41 (see Section 1.3);

- In unique situations (where no control could be allocated), e.g. on a bridge or on the approach to Blackwall Tunnel.

Also the following types of bus lane in the database were excluded:

- Contra-flow bus lanes (17 bus lanes);
- Bus lanes not permitting cycle access (48 bus lanes);
- Bus lanes that were adjacent to each other.

Half the Main sites selected included long bus lanes and half short bus lanes: where a long bus lane was at least 200m in length. These were paired with 30 other Control sites, chosen to satisfy the following criteria:

- It was not on a road that contains a bus lane affected by the scheme;
- Within 2 miles of the Main site;
- On a similar classification of road: i.e. pairing of A roads. If same classification was not available a road of lesser classification was selected, but towards the "higher end" of the classification, for example an A road may have been paired with a wide B road;
- In approximately the same direction (parallel) to the Main site.

The site selection was confirmed initially using web-based information gathering. This initial desk-based check of the site was performed using the web sites of:

- maps.google.co.uk/maps;
- itouchmap.com/latlong.html;
- 192.com/maps/journeyplanner;
- maps.live.com.

These provide aerial views of the sites and approximate positions of bus stops. These multiple sources were implemented to maximise the probability that a site visit would result in a suitable site for inclusion in the study.

If the site was a potential candidate for inclusion in the study then a site visit was conducted to ensure that conditions on each site would permit the collection of all required data, see Section 2.3.4. If a site was rejected, then it was randomly replaced from the list of all remaining sites within the database that were in the same length classification. This process was repeated until 30 suitable Main site, and Control site, pairs had been located for inclusion in the Before survey.

The replacement site was initially accepted, provided it could be located on the available maps and was not on an adjacent link to a chosen site. The above process of checking the replacement site on the web and then via a site visit was again undertaken. Should this process have rejected the replacement site, a further replacement site was chosen, and so on, until all sites were located.

The Before survey therefore included 60 sites (30 Main and 30 Control). This approach was taken in order that 2 Main sites and Control sites could be removed from the final sites analysed. This allowed for unexpected occurrences that affected the results at two sites, for example emergency road works causing abnormal journey times.

2.3.3 Details of Site Types

The sites were categorised into those with short (less than 200m in length) and long (greater than 200m in length) bus lanes.

If a site failed to meet the required criteria (See Section 2.3.4) then it was replaced. A statistical software package (SPSS) was used to generate a random site from those that had not already been selected and was restricted to the same type as the one being replaced: i.e. according to whether it was a:

- short bus lane;
- long bus lane.

This was required to maintain the sub-sample sizes in the design.

2.3.4 Site Selection Criteria

Section 2.3.2 discussed the filtering technique for initial consideration of a site, whereas this section lists the specific criteria that were assessed during the site visit.

The site selection requirements were driven by the data to be extracted from the video surveys, see Section 2.4.2. The ideal Main site permitted the installation of two cameras with:

- Downstream camera showing second timing point on carriageway;
- Second timing point close (approx 5 to 10 metres) to end of bus lane;
- Camera field of view showing end of bus lane and complete timing point across carriageway (in direction being studied);
- Upstream camera showing first timing point on carriageway, and footway;
- First timing point 250 metres upstream of second timing point;
- Camera field of view showing 5 to 10 metres before first timing point and complete timing point across carriageway and footway (in direction being studied).

The ideal Control site permitted the installation of two cameras with:

- Downstream camera showing second timing point on carriageway;
- Second timing point not nearer than approx 30 metres from a major junction;
- Camera field of view showing 5 to 10 metres before chosen second timing point and complete timing point across carriageway (in direction being studied);
- Upstream camera showing first timing point on carriageway, and footway;
- First timing point 250 metres upstream of second timing point;
- Camera field of view showing 5 to 10 metres before first timing point and complete timing point across carriageway and footway (in direction being studied);

The Main and Control were required not to have:

- A bus stop between the two timing points;
- A major turning movement occurring between the timing points; greater than approximately 5%;
- A pedestrian crossing between the timing points;
- Other factor affecting speeds or flows between the timing points;
- Any road works on OR near the road being studied.

Further, the control sites were not required to have a bus lane.

Sites with a pedestrian crossing between the timing points were excluded from the study, because this would have resulted in the measured journey times being highly influenced by the crossing, and any effect of permitting motorcycles into bus lanes would have been masked (i.e. confounded) by this source of journey time variation. However, pedestrian crossings were included in the larger area used for observing the effect of the scheme on collisions, as they were potentially a location of motorcycle and pedestrian interaction.

See Figure 7 for an overview of the camera positions and fields of view. Some deviations from the optimal selection criteria were required, and the permitted variations are discussed in Appendix I.

2.3.5 Selected and Rejected Sites

The processes in the previous sections were applied, including random sampling, web-based initial site checks and site visits. This resulted in a final selection of thirty sites for study, of which one was excluded following the Before survey and one was excluded following the After survey, owing to unexpected confounding factors affecting site conditions. The final selection of sites is shown in Figure 4 below. These were selected according to the process contained in the previous section.

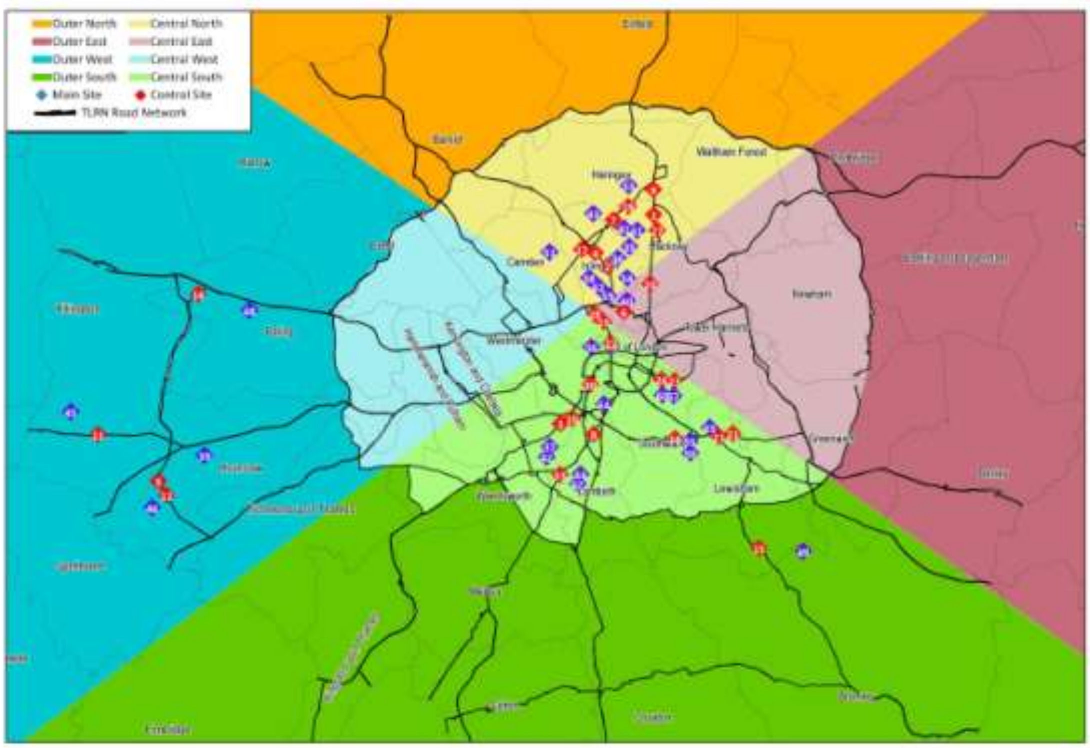


Figure 4: Map of TLRN Bus Lanes and the Sites Selected

In obtaining these selected sites, many others were randomly selected and then rejected after a site visit. The locations of the rejected sites are shown in Figure 5.

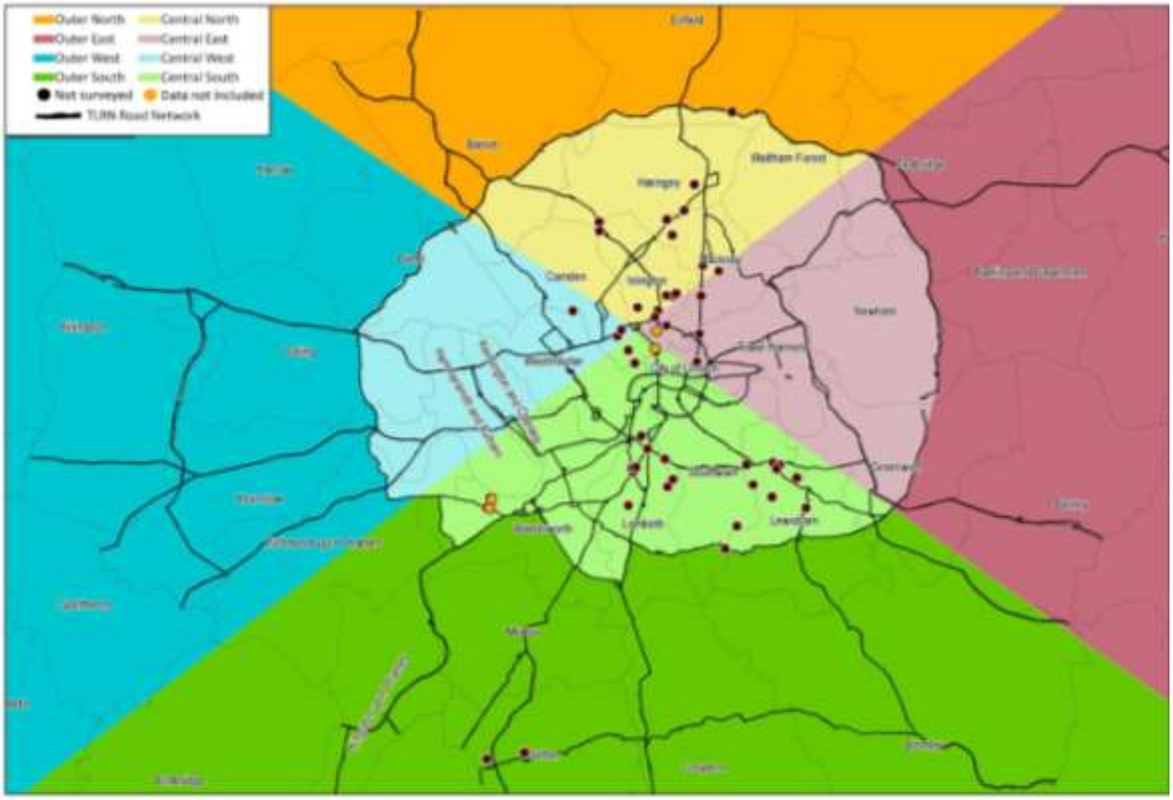


Figure 5: Map of the Sites Rejected from the Study

On initial inspection of the sites selected it would appear that there is a propensity of sites in a central north/south corridor. This also holds to a reasonable extent on those sites that were selected and rejected. However, the selection process was based upon a random sample of the sites available, with no restriction placed upon the geographical location of the sites chosen. Supporting evidence that this was achieved is contained in Table 3.

Available and Selected Sites for Surveys						
Borough	Total number of bus lanes	Number of bus lanes selected	Total length of bus lanes (m)	Length of bus lanes selected (m)	Percentage of lanes selected	Percentage of bus lane length selected
Barking & Dagenham	4	0	750	0	0.0%	0.0%
Brent	1	0	364	0	0.0%	0.0%
Bromley	1	0	410	0	0.0%	0.0%
Camden	27	0	6,910	0	0.0%	0.0%
City of London	16	1	2,308	163	6.3%	7.1%
Croydon	11	0	2,515	0	0.0%	0.0%
Ealing	2	1	1,375	176	50.0%	12.8%
Enfield	5	0	1,665	0	0.0%	0.0%
Greenwich	10	0	2,209	0	0.0%	0.0%
Hackney	40	5	9,165	888	12.5%	9.7%
Haringey	19	1	4,842	173	5.3%	3.6%
Hillingdon	6	1	2,765	194	16.7%	7.0%
Hounslow	5	2	1,058	355	40.0%	33.5%
Islington	40	7	10,508	1,173	17.5%	11.2%
Kensington & Chelsea	1	0	243	0	0.0%	0.0%
Kingston-Upon-Thames	0	0	0	0		
Lambeth	79	3	17,799	520	3.8%	2.9%
Lewisham	33	3	8,825	474	9.1%	5.4%
Merton	5	0	1,572	0	0.0%	0.0%
Newham	2	0	245	0	0.0%	0.0%
Southwark	43	3	8,497	463	7.0%	5.5%
Sutton	5	0	381	0	0.0%	0.0%
Tower Hamlets	37	0	11,308	0	0.0%	0.0%
Wandsworth	34	3	7,688	587	8.8%	7.6%
Westminster	30	0	8,009	0	0.0%	0.0%
Total	**456**	**30**	**111,410**	**5,164**	**6.6%**	**4.6%**

Table 3: Available and Selected Sites

The table shows the type of distribution that would generally occur when selecting sites irrespective of location. Generally, a larger number of bus lanes were selected in boroughs that had the greatest number of bus lanes available to survey. This is also displayed in Figure 6 below.

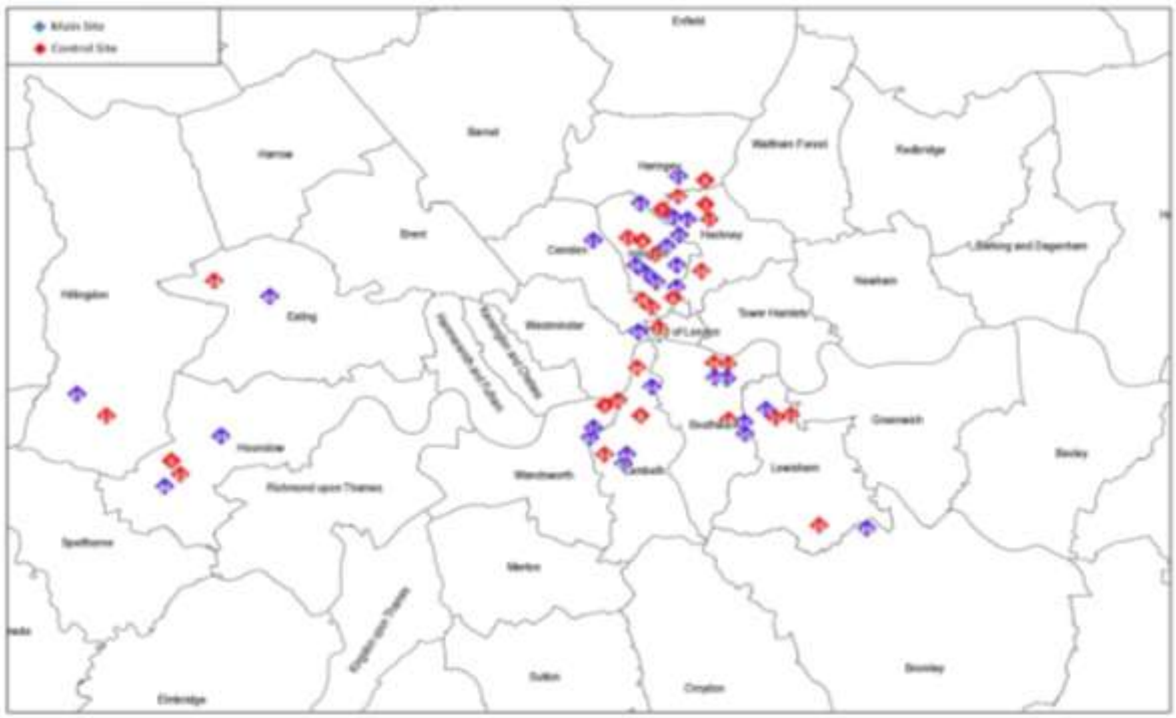


Figure 6: Borough Map of Main and Control Sites

For example, consider the lack of sites in the East of London: Greenwich, Bexley, Newham, Barking & Dagenham, Waltham Forest and Redbridge. There were only 16 bus lanes that could have been selected in these London Boroughs out of 456 bus lane sections available: i.e. 4% of the bus lanes and 6% of all bus lanes were selected as survey sites, that is, the probability of selecting one of these bus lanes was very low.

2.4 Data Sources

2.4.1 Video and ATC Configurations

Video analysis provides a high quality method of understanding and investigating the conditions on a section of carriageway, as it permits multiple playbacks of the situations in order to gather in-depth information. This technique was therefore used within the project to investigate journey times of vehicles (between two defined timing points on the link being investigated), the interactions of the motorcyclists and cyclists with other road users, lane usage, and detailed classified flows to compare to longer term ATC data.

At each survey site cameras recorded traffic for twelve hours a day (0700 to 1900) over two weekdays, both before and after the scheme's implementation date. Further, the same weekdays were surveyed both in the Before and After surveys at each site in order to reduce the effect of any day-by-day variations in flows on the sites.

Two video cameras were positioned on one link (of up to three lanes). The video cameras were set between 150 and 250 metres apart, such that (where possible) no bus stops were between them. The upstream camera recorded the rear of vehicles and the downstream camera recorded their fronts, as shown in the following figure. The ideal setup is shown in Figure 7, however some minor adjustments were made to this layout where site conditions did not permit its exact implementation; although the underlying design principles were maintained.

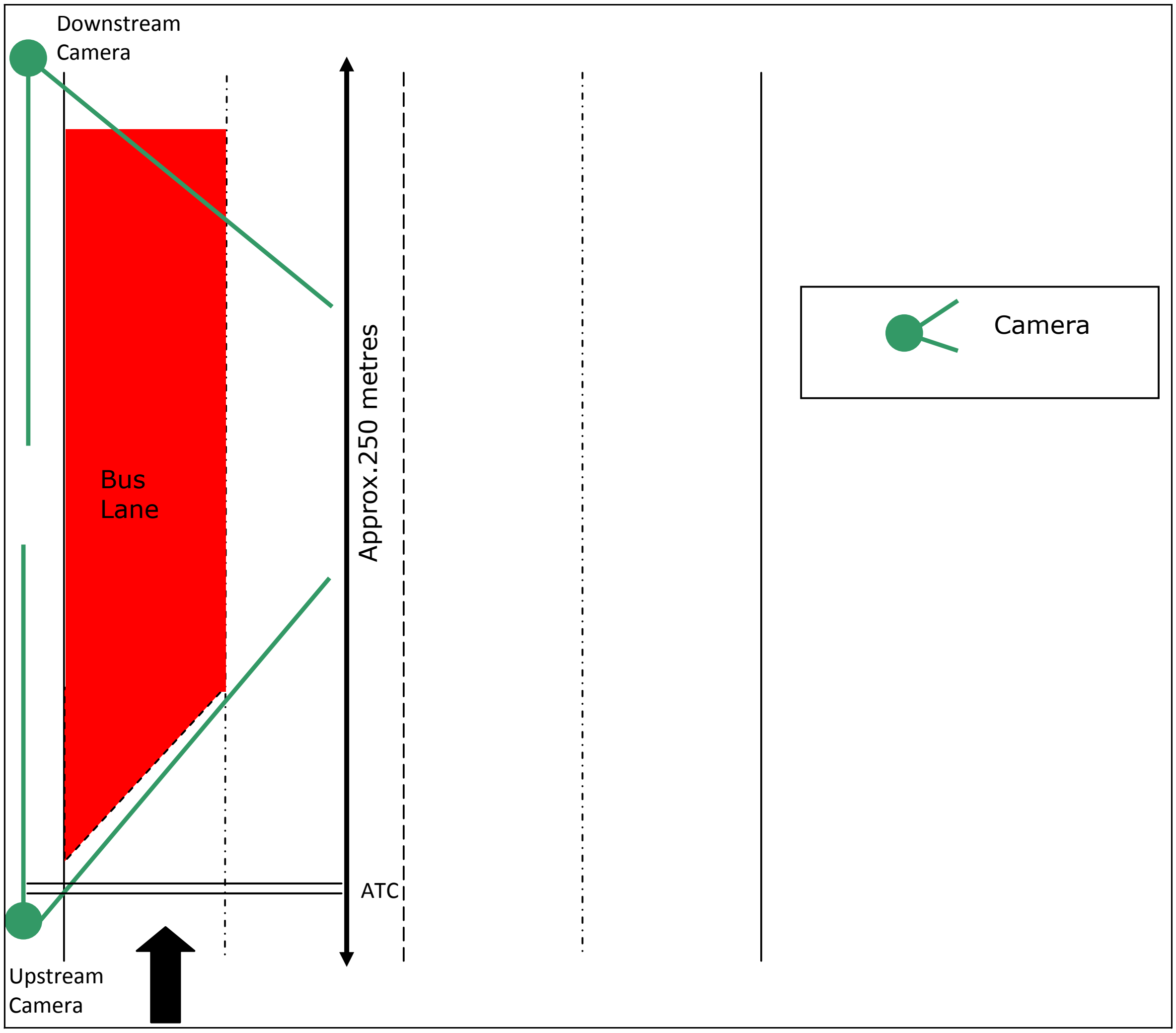


Figure 7: Camera Positions and Fields of View

In addition, Temporary (Tube) Automatic Traffic Counters (ATCs) were positioned on each identified traffic link for one week before and after the changes were introduced. The ATC was positioned close to the upstream camera so that the recorded flows from both data sources were directly comparable, and the ATC recorded data during the two days of the video survey.

2.4.2 Video Data Collection

Video data was available between 0700 and 1900 for each of the 28 Main and Control sites. The following information was extracted from the videos (for the entire twelve hour period):

- Classified count of vehicles passing the first (upstream) camera. The classification will be according to:
  - vehicle type (cycle/motorcycle/car or light goods/heavy goods/bus) and;
  - lane (pavement/bus lane/other traffic lane).

In addition, the journey times of a sample of cars, motorcycles and buses was collected according to:

- Journey time of the vehicles was measured between two marked points on the carriageway 250 metres apart where possible and a minimum of 150 metres apart;
- Journey times were collected over six hours: 0730 to 0930, 1200 to 1400 and 1600 to 1800;
- In each hour the journey time was collected for:
  - 100 cars;
  - 50 motorcycles;
  - 50 buses.

In addition, on the Main sites, 50 motorcycles and 50 cycles were observed and the following recorded:

- Conflicts between motorcycles and other road users;
- Conflicts between cycles and other road users;

The conflict information included:

- Which lane the vehicle (motorcycle or cycle) used;
- Position in the lane;
- Whether a conflict occurred, and if one did:
  - The lane it occurred in;
  - The distance it occurred at;
  - The manoeuvre being made by the vehicle;
  - The extent of braking used by the vehicle;

- The extent of swerving by the vehicle;
- The overall level of conflict;
- The type of other vehicle/pedestrian involved;
- The manoeuvre being made by the other vehicle/pedestrian involved;
- The extent of braking used by the other vehicle/pedestrian involved;
- The extent of swerving used by the other vehicle/pedestrian involved.

2.4.3 Other Data Sources

Other data used within this analysis was provided by TfL:

- ACCSTATS database - to understand the effect on collisions at the sites
- Motorcycle and cycle flow counts over several years - to examine the seasonal variation in flows at the sites

Collision rates were investigated using data from TfL's ACCSTATS database, which is a STATS19 database containing details of all reported personal injury collisions occurring within the greater London area. TRL analysed data on all collisions occurring both ten months before the motorcycles were permitted into the bus lanes and ten months after they were permitted access: January to October 2008 and January to October 2009.

TfL also provided information on motorcycle and cycle flow counts that had been collected within London over the past few years. These were analysed by TRL to assess the seasonal variations in these flows and provide an estimate of the yearly (and 10 month) flows of motorcycles and cycles on each of the studied sites.

2.4.4 Missing Data

Previous sections describe the information collected from each site using video cameras and ATCs. Where possible all the required data was collected by these techniques. Further, the survey was re-scheduled and the survey day replaced when an equipment failure was located, or an occurrence on site, that affected a significant proportion of the data. However, on some occasions a small amount data was affected, or other issues arose during analysis. These have been collated and are contained in Appendix G.

In addition to these incidents, it was found during the analysis that the bus lane operational hours on one site (Site 33) had changed between the two surveys. In the Before survey the operational hours were at least 0700 to 1900, but the operational hours in the After survey were 0700 to 1000. This has affected the analysis of this site and care needs to be taken when interpreting results from it.

It was necessary to combine the information from the data sources in order to estimate the annual flows of vehicles on the sites and the TLRN network. The processes that were undertaken, assumptions that were made and the patching techniques employed are discussed in Appendix J.

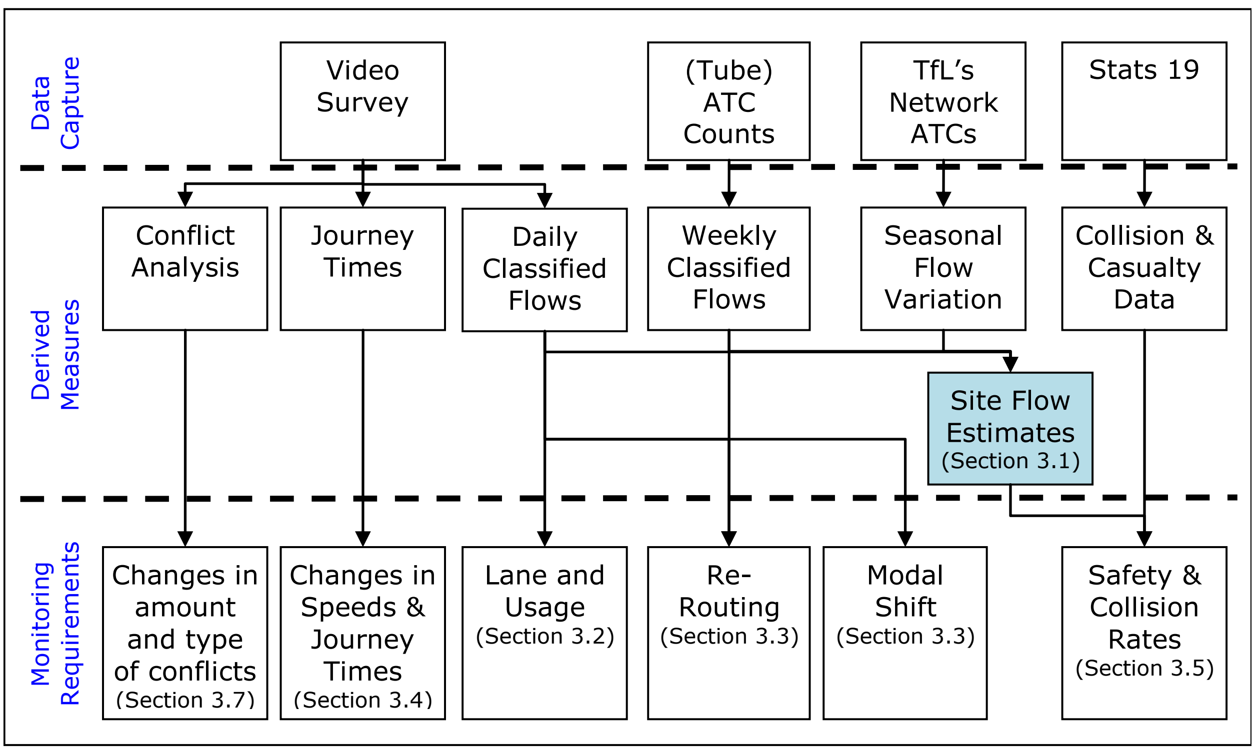
3 Effects on Studied Bus Lanes and Control Routes

Data in this report has been displayed in charts and tables using a standardised format as shown in Figure 8.

Site Category	Before Survey	After Survey	Comparative Data
Main Sites			
Control Sites			

Figure 8: Key to Standardised Formatting

3.1 Traffic Flows on Studied Sites



Traffic flows affect journey times (and therefore speeds), which in turn can affect driver (or rider) behaviour and consequently conflicts and collisions. Variations in flows between the surveys were minimised by performing the surveys at the same time of the year and on the same weekdays. However, this cannot take into account any general changes in flow either on the network, within the area, or even in the corridor being surveyed. Flow changes can result from a number of underlying causes, including economic variations, fuel costs, or the introduction of a new trip attractor (for example, a supermarket).

Traffic flows are available from two main data sources, the video surveys which give detailed and accurate classified vehicle counts over twelve hours on two weekdays, and ATC (tube) counters that were positioned on each of the sites for one week. This study has aimed to use the strengths, and account for the weakness of both these data sources, by combining the information available. This is discussed further in Appendix J.

Considering the video counts in isolation, these provide information on the flows of different types of vehicles over a comparable twelve hour period and information on the lane these vehicles used.

3.1.1 Changes in Flows – Video Surveys

The video surveys were conducted over twelve hours on two weekdays. The weekdays remained the same for the Before and After surveys on each site and the surveys were conducted at the same time of the year, therefore minimising any seasonal effects on flow.

It was therefore possible to estimate the average hourly flow on each site and directly compare the flows from the two surveys. As a standard procedure, the classified flows have been converted into PCU (Passenger Car Unit) flows using the conversion scale shown in Table 4.

PCU Conversion Rate	
Mode	**PCU Value**
Cycle	0.3
Motorcycle	0.75
Car/LGV	1.0
HGV	2.0
Bus	3.0

Table 4: PCU Conversion Rate

Percentage Change in Flow by Site Pairs							
Site Pair	Site Type	Site Number	Percentage Change in Flow	Site Pair	Site Type	Site Number	Percentage Change in Flow
A	Main	1	11.5%	O	Main	16	-2.7%
	Control	35	6.8%		Control	50	2.4%
B	Main	2	4.2%	P	Main	17	-9.3%
	Control	36	3.2%		Control	51	0.5%
C	Main	3	0.2%	Q	Main	19	0.0%
	Control	37	-6.8%		Control	53	7.1%
D	Main	4	1.4%	R	Main	20	5.4%
	Control	38	-8.7%		Control	54	0.3%
E	Main	5	-3.7%	S	Main	21	-6.3%
	Control	39	1.5%		Control	55	-19.7%
F	Main	6	-8.3%	T	Main	22	-5.6%
	Control	40	-6.0%		Control	56	-0.6%
G	Main	7	-2.2%	U	Main	23	-7.6%
	Control	41	-1.2%		Control	57	1.5%
H	Main	8	1.2%	V	Main	25	1.4%
	Control	42	-0.3%		Control	59	-0.5%
I	Main	9	-4.8%	W	Main	26	-1.9%
	Control	43	-4.6%		Control	60	8.4%
J	Main	10	3.4%	X	Main	27	3.8%
	Control	44	-5.1%		Control	61	-4.3%
K	Main	11	-14.4%	Y	Main	28	14.9%
	Control	45	-2.9%		Control	62	4.8%
L	Main	12	-4.4%	Z	Main	30	-0.8%
	Control	46	6.7%		Control	64	-7.3%
M	Main	14	1.0%	AA	Main	31	-1.2%
	Control	48	4.5%		Control	65	-0.3%
N	Main	15	-2.5%	AB	Main	33	-1.9%
	Control	49	-0.7%		Control	67	-4.3%

Table 5: Percentage Change in Flow by Site Pairs

The changes in flows were highly variable ranging from -20 to 15% on the sites studied. On the 28 Main sites, the flow significantly increased (at the 95% confidence level) on 5 and significantly decreased on 9 sites. Overall, there was an average small decrease in flows of approximately 1% on the Main sites, and a similar decrease on Control sites.

The differences between individual sites and their Controls are shown in Table 5.

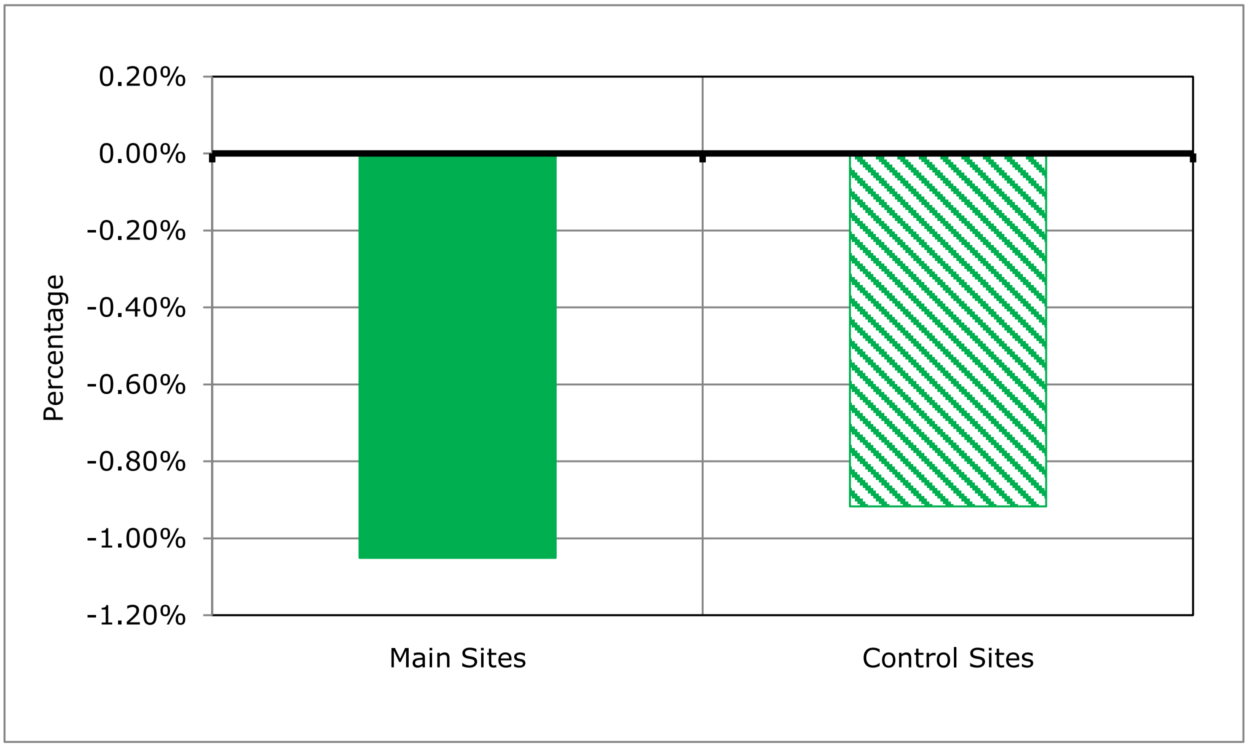


Figure 9: Average Change in PCU flows from Before Survey

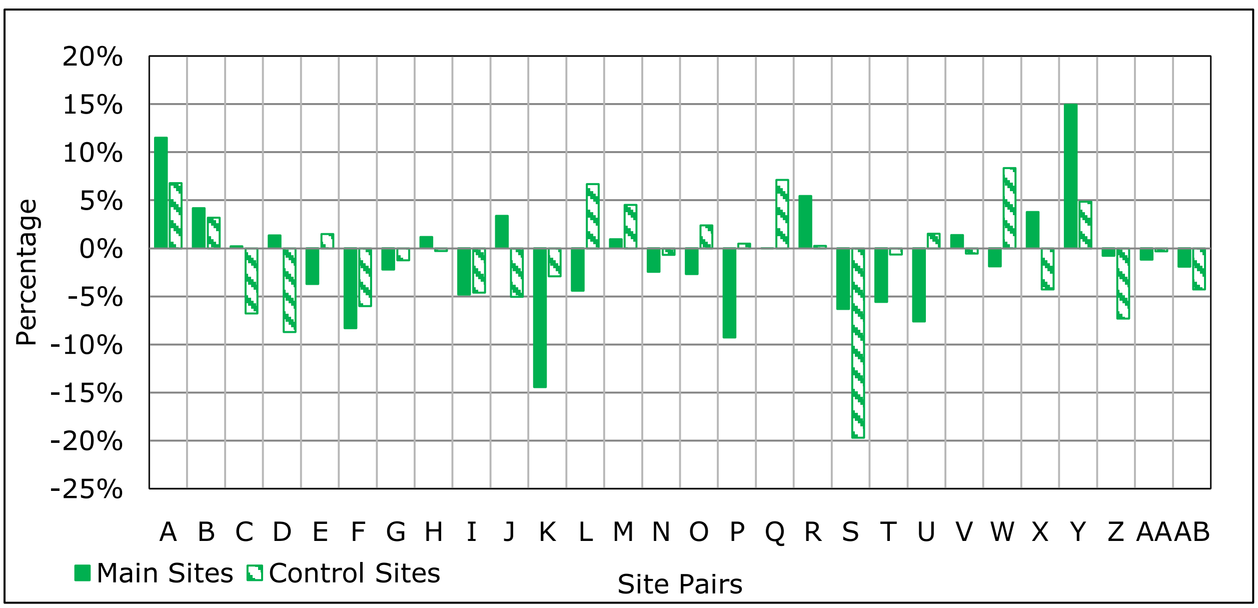


Figure 10: Change in PCU flows from Before Survey by Site Pair

The direction of the percentage change in flows was the same for 16 of the 28 site pairs, and they were generally in the same direction when changes were large. That is, it would appear that flow changes on the Main sites are generally mirrored, i.e.

controlled, by the Control sites and therefore generally represent a change in traffic flow in the area of the site surveyed.

Overall, there appears to be a small decrease in flows between the surveys. This is consistent with expectation, given the change in economic conditions within the UK. The difference would not be expected to unduly affect speeds and site conditions, except under a limited range of circumstances. However, clearly, consideration needs to be given to individual sites where large flow changes were observed.

A link (section of carriageway) has a theoretical maximum capacity of 1725 PCUs per lane[2]. It is therefore possible to assess the percentage of the available capacity in use by vehicles. This has been calculated for each site in the morning peak, off-peak and evening peak and averaged, see Figure 11.

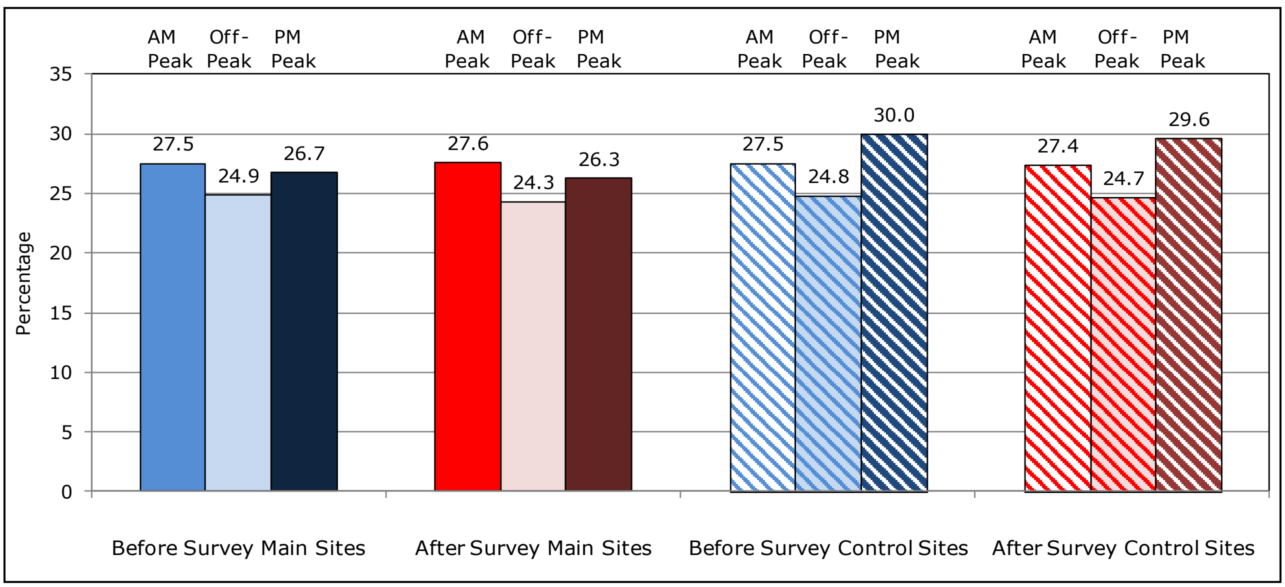


Figure 11: Average Percentage of Link Capacity Used

The values include the capacity of the bus lane (if present) and therefore appear low compared to typical urban conditions. Taking this into account by using the classified flows by lane, the percentage of non-priority lane capacity used ranged from 24% on Site 1 in the morning peak to 72% on Site 15 in the morning peak. On average across all Main sites with lane classifications, the percentage of non-priority capacity used was calculated and is shown in Table 6.

[2] COBA -www.dft.gov.uk/pgr/economics/software/coba11usermanual

Average Percentage of Non-Priority Link Capacity Used				
	Before	**After**	**Difference in Percentages**	**Percentage Reduction**
AM Peak	45.7%	43.6%	2.1%	4.6%
Off-Peak	40.1%	38.6%	1.5%	3.7%
PM Peak	42.6%	40.6%	2.0%	4.7%

Table 6: Average Percentage of Non-Priority Link Capacity Used on Main Sites

Therefore across these sites the flows had decreased, which equates to a change of between 3.7 and 4.7% in the capacity used.

The previous discussion considers overall changes across all Main sites. Information was collected on the classified flow for each site in quarter of an hour periods. This level of detail has not been presented for each site. However, as an example, the overall PCU flow in Before and After surveys for Site 6 and its Control Site 40 are shown in Figure 12 and Figure 13.

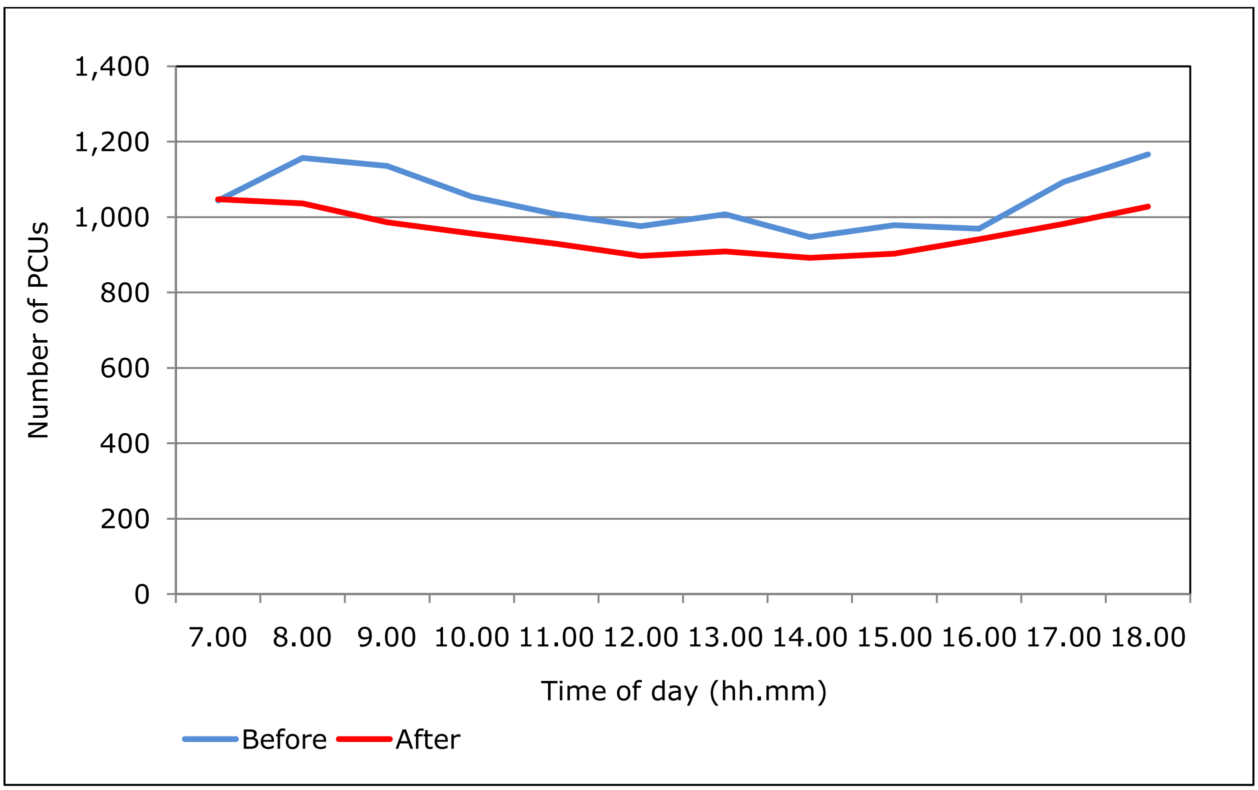


Figure 12: Example of Change in PCU flow: Main Site 6

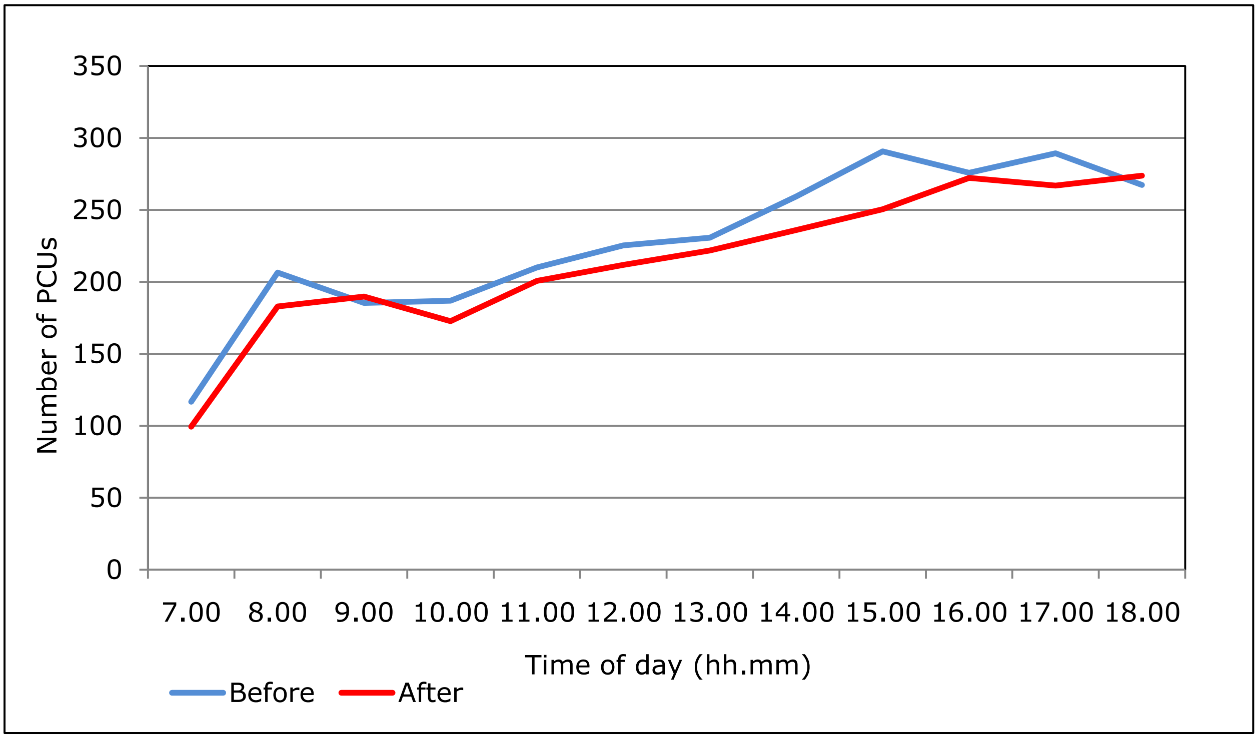


Figure 13: Example of Change in PCU flow: Control Site 40

These two figures show that the change in flows on both the Main and Control sites have decreased throughout the day.

3.1.2 Scaling to Weekly and 10-monthly Flows

In order to determine the collision rates for the 10-month STATS19 period, the video counts were scaled to weekly flows (Appendix J, Section 2) and then factored up to 10-monthly flows (Appendix J, Section A.1.1.1J.2.4). Due care was taken to ensure this modelling approach was as robust as possible. However, variation in the flows was unavoidably introduced at different stages of the process.

1. The average video flows (07:00-19:00) presented in Section 3.3 include cycles on the pavement, but these were removed for the STATS19 data, because it would be inappropriate to include them.
2. Variation for the different days of the week was modelled using a combination of the ATC axle count data and video data proportions.

3. Variation throughout the night (19:00-07:00) was modelled by applying undercounting percentages to the ATC classified data.
4. The month of the video survey was taken as the baseline and the seasonal factors were applied for motorcycle and cycle flows. The Before and After surveys were not always conducted in the same month, e.g. due to road works, and so on occasion this affected which month was taken as the baseline.

The tables below present the hourly, weekly and 10-monthly flows, averaged over all sites. The amounts do not factor up uniformly as the modelling process used to facilitate the factoring uses different expansion factors on different survey sites and this weighting process affects the percentage changes. These flows do not include cycles on the footpath.

		Cycles	Motorcycle	Cars	LGVs	HGVs	Buses	All
Main	Before	45.3	50.2	496.3	171.3	23.2	30.6	825.1
	After	50.9	51.2	491.2	158.2	25.6	30.9	815.0
	Increase	12.6	2.0	-1.0	-7.7	10.5	0.8	-1.2
Control	Before	25.7	18.5	312.1	90.1	8.4	14.5	474.0
	After	28.6	17.7	309.9	83.7	10.6	14.8	469.5
	Increase	11.5	-4.7	-0.7	-7.1	25.8	2.2	-1.0

Table 7: Average Hourly Video Flows

NOTE: In Section 3.3, the increase for motorcycle flows on the Main and Control sites was noted as 2.4% and -4.5%, respectively. These figures were derived by first computing the increase for each site and then taking the average across all sites. In the table above, the average flows were computed across all sites first and then the increase was computed; this accounts for the minor discrepancy. A sensitivity analysis was conducted and was found that both approaches yielded the same results.

		Cycles	Motorcycle	Cars	LGVs	HGVs	Buses	All
Main	Before	4570	5077	65774	18123	2464	3836	99845
	After	4970	5125	64331	17028	2667	3776	97898
	Increase	8.8%	0.9%	-2.2%	-6.0%	8.3%	-1.6%	-2.0%
Control	Before	2541	1991	38206	8866	830	1831	54265
	After	2983	1981	37169	8601	1013	1846	53595
	Increase	17.4%	-0.5%	-2.7%	-3.0%	22.1%	0.9%	-1.2%

Table 8: Average Modelled Weekly Flows

		Cycles	Motor-cycle	Cars	LGVs	HGVs	Buses	All
Main	Before	242678	259319	1666283	459117	62422	97188	2787008
	After	266355	266456	1629722	431379	67575	95651	2757137
	Increase	9.8%	2.8%	-2.2%	-6.0%	8.3%	-1.6%	-1.1%
Control	Before	134615	101324	967897	224610	21021	46374	1495840
	After	160756	102661	941626	217892	25669	46776	1495380
	Increase	19.4%	1.3%	-2.7%	-3.0%	22.1%	0.9%	0.0%

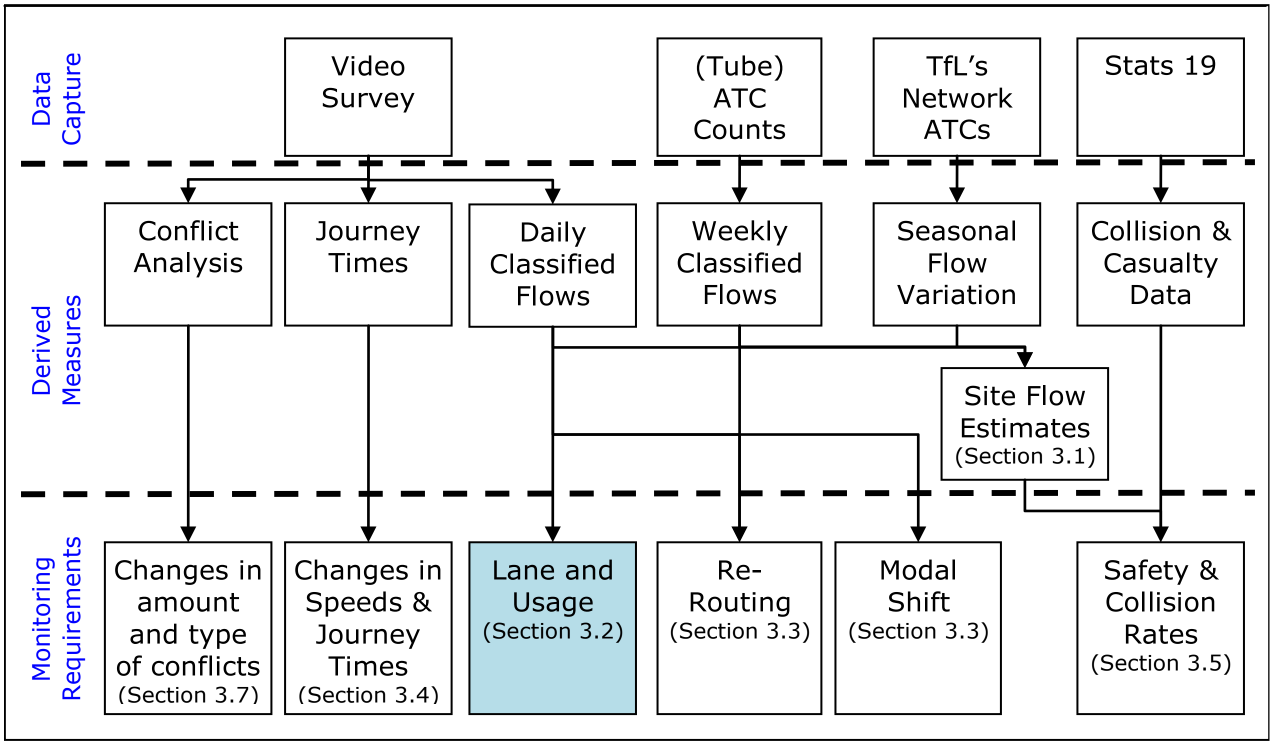
Table 9: Average Modelled 10-monthly Flows

3.1.3 Conclusions

Conclusions - Changes in Flows

- The change in traffic flow (PCU/hr) varied from -20 to +15% on the Main sites. Overall, there was a small decrease of approximately 1% on the Main sites and a similar decrease in flows on the Control sites.

3.2 Bus Lane Usage



One potential effect of permitting motorcycles access to bus lanes is that they discourage others (particularly cyclists) from using them. The video surveys collected classified counts of vehicles according to the lane they used.

3.2.1 Bus Lane Operational Hours

This study considers the effect of motorcycles being permitted access into bus lanes on the TLRN throughout the day. However, motorcyclists and all other road users, could legally use the bus lanes outside of operational hours in both the Before and the After survey. Although, it is possible that motorcylists' behaviour was influenced outside of operational hours by them not being able to use the lanes at some times during the day, potentially through uncertainty over when they were permitted to use the lanes.

The actual operational hours of the bus lanes studied, together with the percentage of the video survey hours that were within the operational hours are summarised in Table 10.

Site Number	Operational Days - Start	Operational Days - End	Operational Hours - Start	Operational Hours - End	Operational Hours – Start	Operational Hours - End	Video Survey Hours	Number of operational hours surveyed	Percentage of surveyed hours in operational hours
1	Mon	Sun	07:00:00	19:00:00			12	12	100%
2	Mon	Sat	07:00:00	19:00:00			12	12	100%
3	Mon	Sun	07:00:00	19:00:00			12	12	100%
4	Mon	Sun	07:00:00	19:00:00			12	12	100%
5	Mon	Sun	00:00:00	23:59:59			12	12	100%
6	Mon	Sat	07:00:00	19:00:00			12	12	100%
7	Mon	Sun	07:00:00	19:00:00			12	12	100%
8	Mon	Sat	07:00:00	10:00:00	16:00:00	19:00:00	12	6	50%
9	Mon	Sun	07:00:00	19:00:00			12	12	100%
10	Mon	Sun	07:00:00	19:00:00			12	12	100%
11	Mon	Sun	00:00:00	23:59:59			12	12	100%
12	Mon	Sat	07:00:00	19:00:00			12	12	100%
14	Mon	Fri	07:00:00	10:00:00	16:00:00	19:00:00	12	6	50%
15	Mon	Fri	07:00:00	10:00:00			12	3	25%
16	Mon	Fri	07:00:00	10:00:00	16:00:00	19:00:00	12	6	50%
17	Mon	Sun	07:00:00	19:00:00			12	12	100%
19	Mon	Sun	00:00:00	23:59:59			12	12	100%
20	Mon	Sun	07:00:00	19:00:00			12	12	100%
21	Mon	Fri	16:00:00	19:00:00			12	3	25%
22	Mon	Sat	07:00:00	19:00:00			12	12	100%
23	Mon	Sun	00:00:00	23:59:59			12	12	100%
25	Mon	Sat	07:00:00	19:00:00			12	12	100%
26	Mon	Sun	00:00:00	23:59:59			12	12	100%
27	Mon	Sun	07:00:00	19:00:00			12	12	100%
28	Mon	Sat	07:00:00	19:00:00			12	12	100%
29	Mon	Sun	07:00:00	19:00:00			12	12	100%
30	Mon	Sat	07:00:00	10:00:00	16:00:00	19:00:00	12	6	50%
31	Mon	Sat	07:00:00	10:00:00	16:00:00	19:00:00	12	6	50%
33*	Mon	Sun	07:00:00	10:00:00	10:00:00	23:59:59	12	12	100%
Overall							348	300	86%

*Operational Hours of Bus Lanes changed between the Before and After Survey

Table 10: Operational hours of bus lanes

Most (86%) of the hours recorded in the video surveys were during the operational hours of the bus lanes. Therefore the overall results of lane usage, speeds and conflict analysis pertain generally to the effect of motorcycles being permitted access to the lanes during operational hours.

In contrast, the collision data analysis contained information for 24 hours a day, 7 days a week, and therefore where necessary, the analysis has been split into the effect in and outside of operational hours.

3.2.2 Bus Lane Usage

All vehicles using the study sites within two twelve hour periods (0700 to 1900) were recorded according to the lane they occupied at the first timing point. On the Main sites this was whether the vehicles were in the left hand (bus) lane, or in the other non-priority lanes. On the Control sites this was whether they were in the left hand lane, or any other lane: there were only five Control routes with two lanes, and on four of these one was a bus lane. Control sites have therefore been excluded from the lane usage analysis in this section.

The average percentage use of the left hand (or bus lane) is shown in Figure 14 for three of the main modes being considered, motorcycles, cycles and buses for the Main sites.

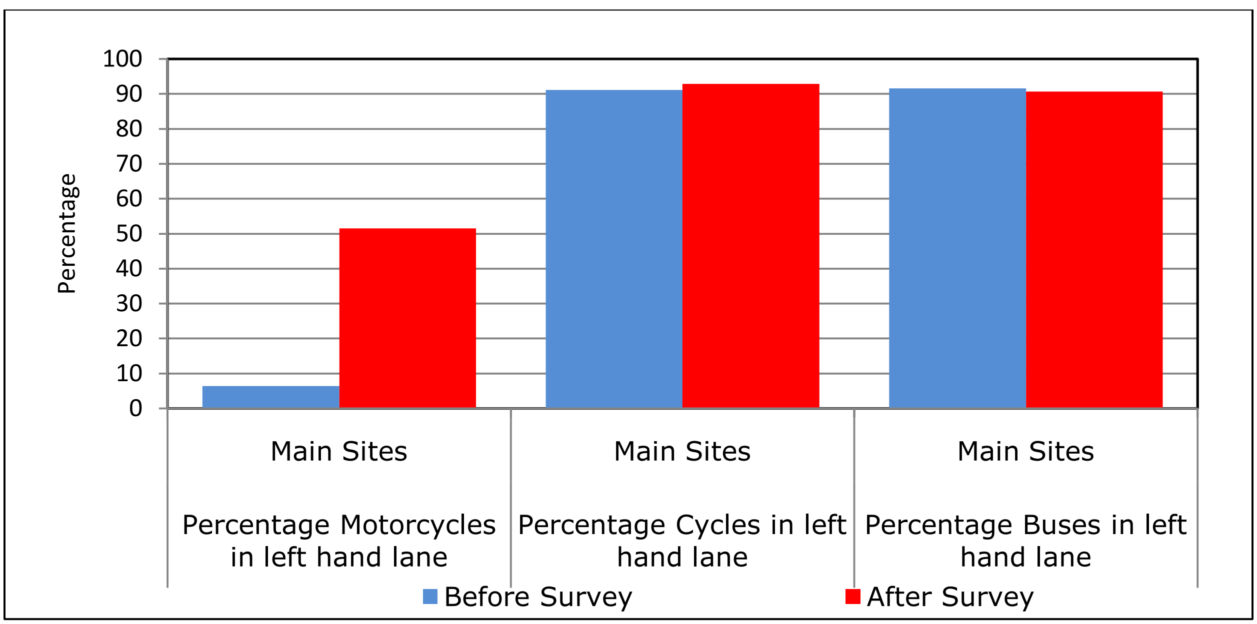


Figure 14: Bus Lane (Left Lane) Usage by Mode for Main sites

On the Main sites, bus lane usage was approximately 90% for both buses and cycles in both the Before and After Surveys. The main difference in lane usage was from motorcyclists, who increased their usage of the bus lane from 6% to 51% on average across all the sites. Also, 6% and 53% of motorcyclists were observed to use the bus lanes during operational hours in the before and after surveys respectively. That is, 6% of motorcyclists were observed to illegally use the bus lanes in the Before survey, and 51% utilised the bus lane after they were permitted access. The percentage changes on individual sites and their respective Control sites are shown in Table 11.

	Percentage motorcycles in left hand lane		Percentage cycles in left hand lane		Percentage buses in left hand lane	
Site Number	**Before**	**After**	**Before**	**After**	**Before**	**After**
1	0.0	36.6	92.3	93.3	98.1	91.4
2	0.3	68.0	99.3	98.6	93.0	95.7
3	1.3	63.4	95.9	97.3	94.3	92.4
4	1.6	42.4	96.3	97.7	91.3	99.7
5	17.0	80.5	95.7	97.8	99.8	99.4
6	0.3	57.0	93.2	95.7	96.3	98.4
7	6.4	72.1	98.5	96.0	100.0	93.7
8	3.1	27.1	92.1	90.6	95.6	88.0
9	9.0	48.8	85.0	88.7	71.0	63.8
10	7.3	67.9	97.4	96.3	96.3	95.0
11	1.2	31.9	71.9	84.1	95.3	93.1
12	0.0	50.8	80.1	82.0	98.9	92.6
14	28.1	80.0	51.2	55.3	99.2	100.0
15	9.3	57.4	90.2	97.2	94.5	91.3
16						
17	0.2	41.9	93.8	94.4	96.8	97.2
19	0.6	43.2	92.4	95.3	44.0	46.1
20						
21						
22	6.5	33.0	96.7	97.6	92.2	94.0
23	7.2	36.5	97.6	99.1	98.5	98.6
25						
26	10.5	57.0	96.0	96.0	100.0	99.3
27	0.5	60.3	90.5	91.7	81.5	85.0
28						
30	2.3	32.7	99.4	99.2	95.9	90.4
31	35.3	43.1	92.8	93.1	74.6	81.5
33*	0.0	52.1	97.4	97.9	98.4	99.3

*Site 33 - Operational hours of bus lane changed between the Before and After study

Table 11: Percentage of Bus Lane Usage by Mode of Transport

The individual changes in bus lane usage by motorcyclists according to site are shown in Figure 15.

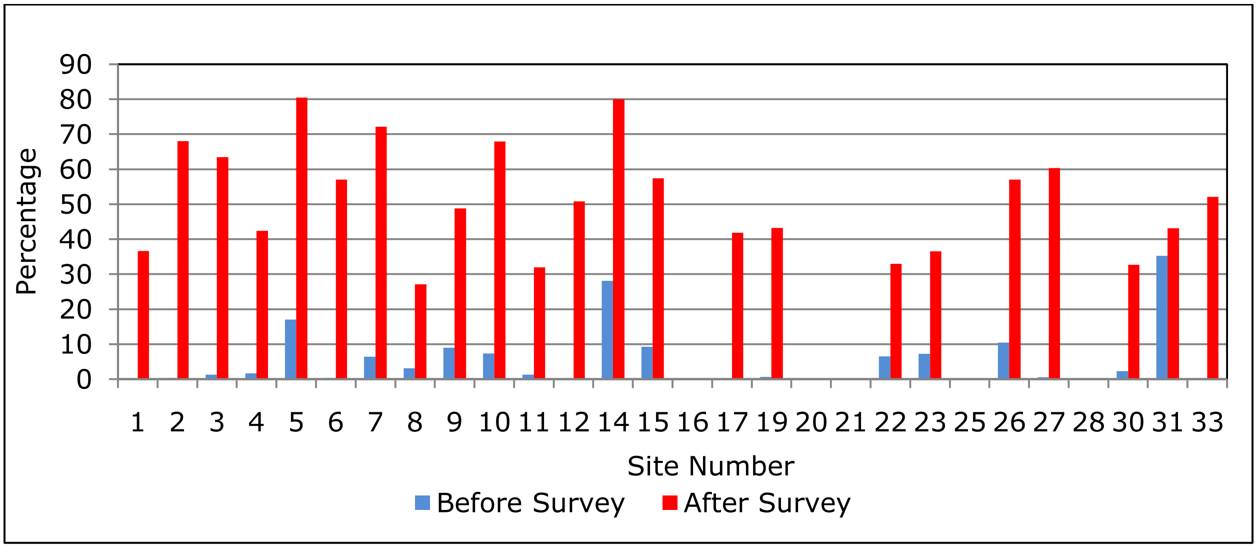


Figure 15: Percentage of Motorcycles in Bus Lane

The percentage of motorcycles using the bus lane increased on all Main sites, where lane information was available: on Sites 16, 20, 21, 25 and 28 the lane classification could not be ascertained. The requirement to identify which lane was used was prescribed after filming had begun, and so some cameras were not positioned in a way to record this data.

There has been the expected increase in bus lane usage by motorcycles. In the before situation, motorcycles should not have used the bus lane, and the level of illegal use was generally low and varied between 0% and 35%, with an average of 6%. After they were permitted access, the percentage varied between 27% and 80%, with an average of 51%. The percentage of motorcycles using the bus lane increased on all Main sites and was significant at the 95% confidence level.

The above values are motorcycle bus lane usage averaged across the sites. It is also possible to examine the average bus lane usage for all motorcycles on the sites studied. For example, consider if 50 motorcycles were observed on Site A, and 100 on Site B, and 25 and 75 used the bus lanes respectively. The bus lane usage averaged across the sites is 100*(25/50 + 75/100)/2 = 62.5%, whereas the average bus lane usage for all motorcycles on the sites studied is 100*(25+75)/(50+100) = 66.7%. The average bus lane usage for all motorcycles on the sites is shown in Table 12.

	Before	After
Average number of motorcycles using the bus lane	2.7	25.4
Average number of motorcycles observed per hour	50.7	51.9
Percentage of motorcycles using the bus lane	5.4%	48.9%

Table 12: Overall Change in the Number of Motorcycles using Bus Lanes on Main Sites

3.2.3 Cycling on the Footway

In theory, the majority of cyclists should not use the pavement (or footway). However, in reality, it is known that some do cycle on it. An increase in use of the footway by cyclists is also a potential effect of permitting motorcycles into bus lanes. That is, cyclists could decide to not use the bus lane, and in particular decide to use the pavement in preference to the bus lane. The average use of the pavement before and after motorcycles were permitted access is shown in Figure 16.

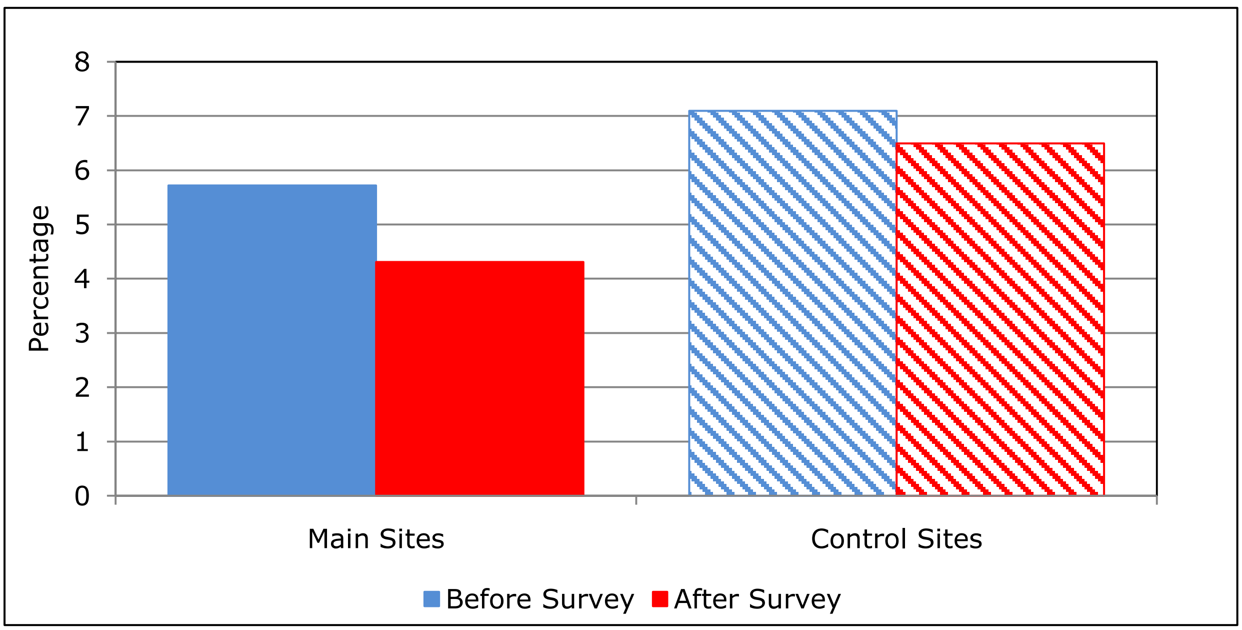


Figure 16: Percentage of Cycles on Pavement

The percentage of cyclists on the pavement decreased slightly on average between the two surveys, but only by between 1 and 2 percent. The change in cycling on the pavement on individual sites is shown in Figure 17.

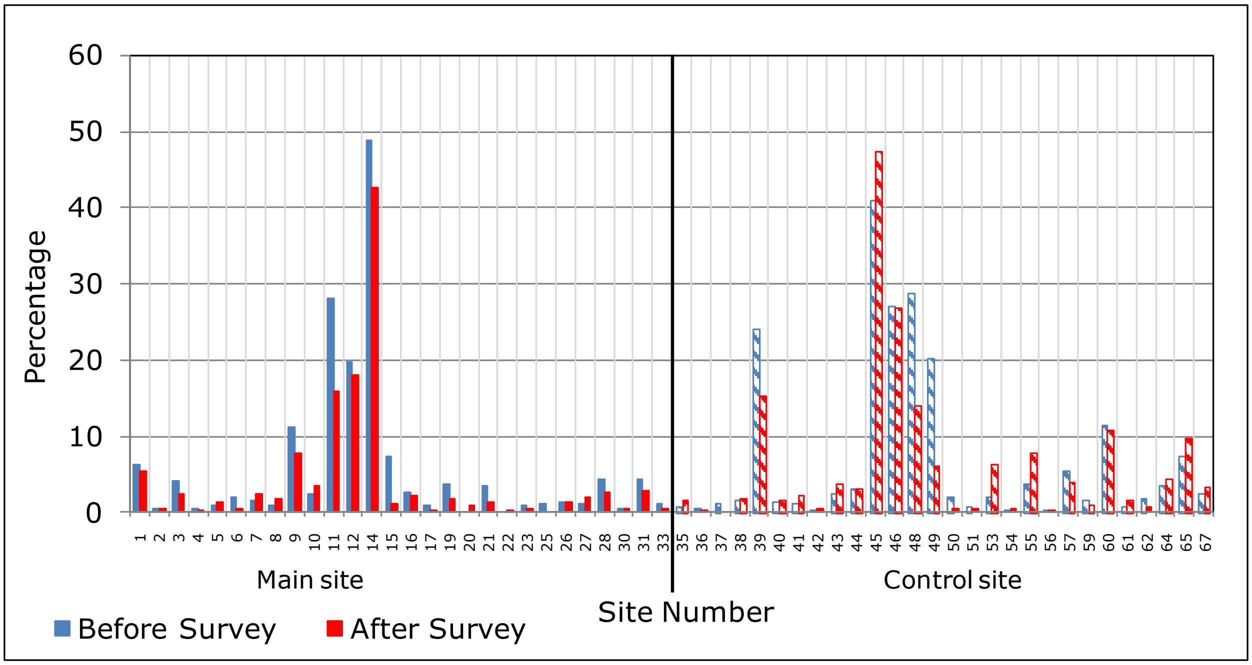


Figure 17: Percentage of Cycles on Pavement by Site

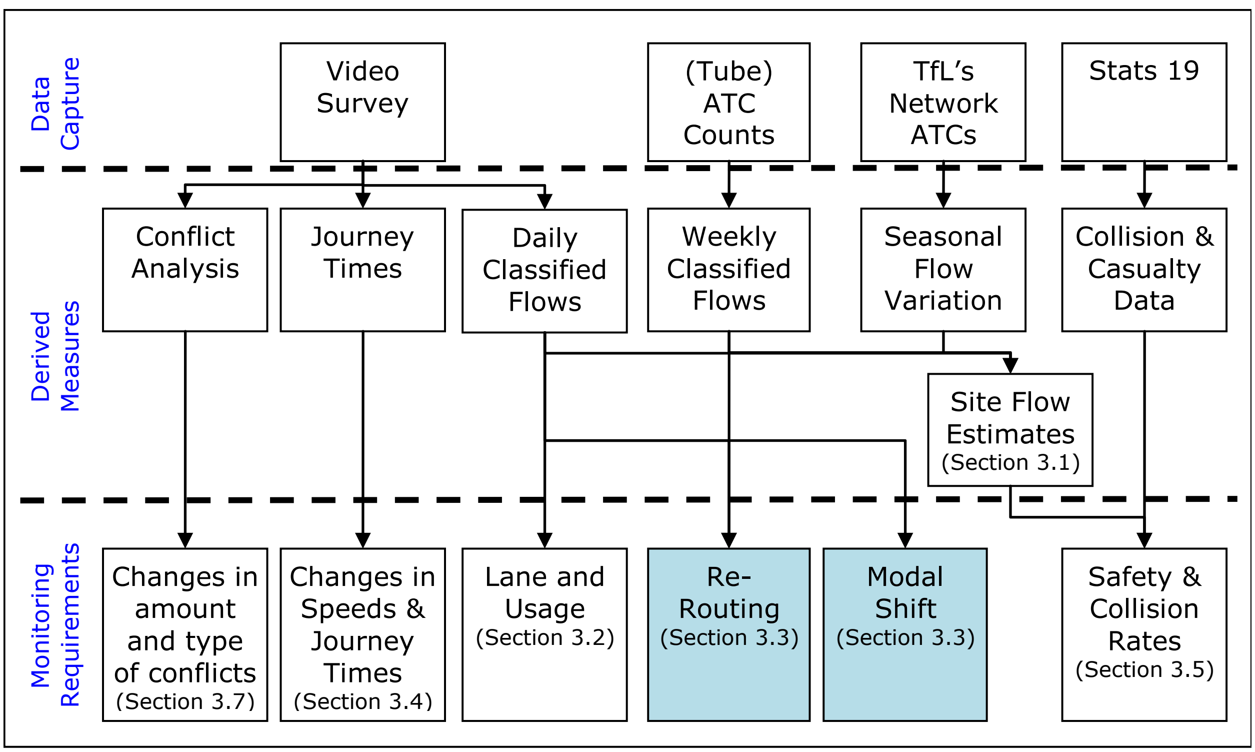
Overall, there was a slight reduction in the use of the footway by cyclists after the scheme was introduced. However, the average reduction on the Main sites was from 6% to 4% of cyclists and therefore represents small numbers of cyclists. Therefore, although there was a consistent reduction in cycling on the footway on Main sites, the change was only significant (at the 95% confidence level) on 6 of the 28 Main sites.

3.2.4 Conclusions

Conclusions - Bus Lane Usage

- Illegal use by motorcycles (Before survey) varied from 0% to 35%.
- Percentage of motorcycles using the bus lanes increased on all sites in the After survey: varying between 27% to 80%, with an average of 51%.
- Motorcycles using the bus lane did not adversely affect the percentage of cyclists using it.
- The percentage of cyclists using the footway slightly reduced in the After survey.

3.3 Changes in Modes and Routes



Motorcycles were permitted access to bus lanes on the 28 Main sites and conditions on the 28 Control sites remained unchanged. In addition, each of the 28 Control sites was specifically chosen to be parallel to one of the Main sites. The Control sites therefore provide a basis for understanding changes on the network and whether any re-routing from the TLRN onto other alternative routes, or vice versa occurred between the two surveys. Possible changes include motorcycles altering their route to gain the new priority on the TLRN. Alternatively, it is possible that the cyclist may decide to stop using the bus lanes on the TLRN owing to the presence of the motorcycles; this could be either through changing routes, or by using other lanes (or the footway) on the same route. The video classified counts for two days permitted examination of the vehicle using each site in both the Before and After surveys.

Analysis has been performed for the motorcycles in isolation as they are one of the key modes affected by the scheme's introduction. The changes in their average hourly flows (between 07:00 and 19:00) over the two video survey days are shown in Figure 18.

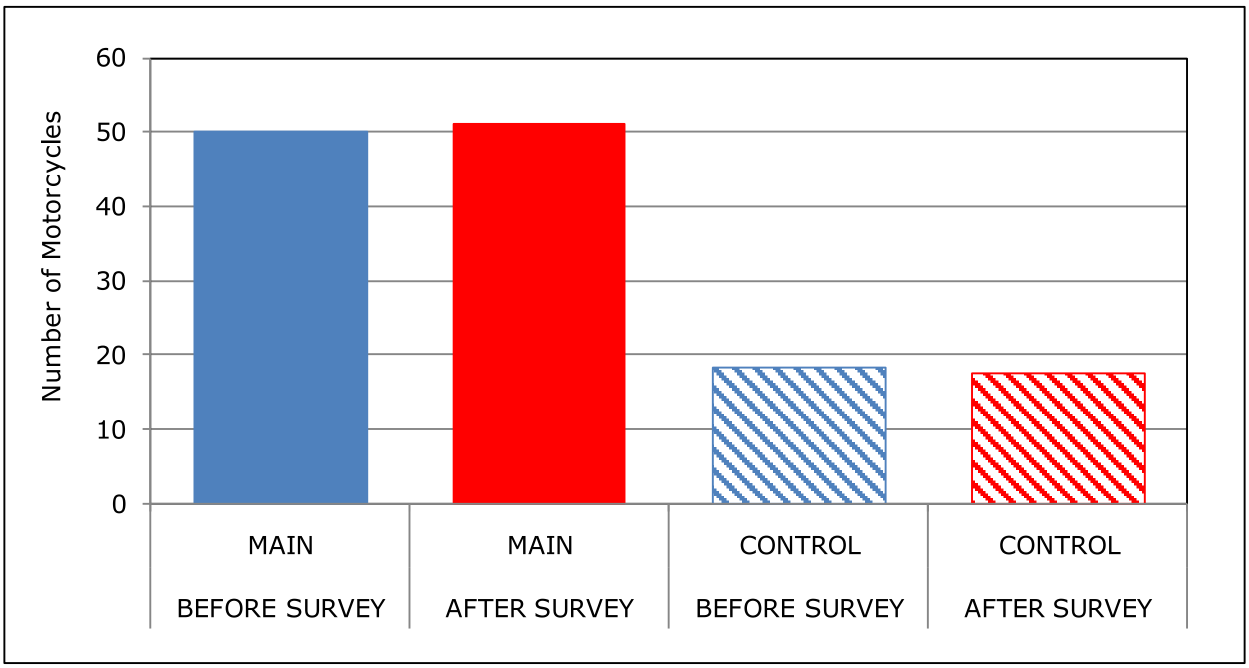


Figure 18: Average Number of Motorcycles per Hour (07:00-19:00), Averaged Across All Sites

There was a small overall increase in the number of motorcycles on the Main sites from 50 to 51 per hour. The average percentage change across all Main sites was 2.4%, whilst there was an average decrease of 4.7% on the Control sites. However, these results may be slightly confounded. Some of the sites were surveyed in the After survey during November, whilst they were surveyed in September, or October, in the Before survey. Evidence has emerged that motorcycle flows may vary after October, although there was insufficient data to investigate this trend.

Therefore to eliminate any such influence, the percentage change has been calculated for sites unaffected by such a seasonal change. Across these Main sites there was a 4.1% increase in motorcycle flows in the After survey, whilst across the Control sites there was a 2.0% decrease in flows.

This evidence implies that the motorcycle flows on the Main sites has increased, whilst there has been a smaller decrease on the Control sites. It would therefore appear probable that there has been some migration onto the Main sites, but this was only of the order of 1.0 to 1.5 motorcycles per hour on average. Overall, the change in the relative flows (ratio of the flows on a site against its Control site) increased significantly at the 95% confidence level. An ANOVA model also indicated the same trends within the data; however, this was not significant probably owing to it considering all sites against all Control sites and not considering individual pairs.

It should be borne in mind that the changes were highly site specific. The maximum increase was on Site 26, from 49 to 60 motorcycles per hour (22%). However, there were decreases on some sites, with a 7% decrease (136 to 127 motorcycles per hour) on Site 22.

Cyclists were the other main mode that may have been expected to be affected by the scheme's introduction. Previously they shared the bus lanes with buses and taxis. However, motorcyclists were also permitted access after the scheme's introduction. This additional flow in the priority lane could influence the cyclists' decisions on routes, or on whether they used the bus lane. The observed total cycle flows on the Main, and Control, routes within the two surveys are shown in Figure 19.

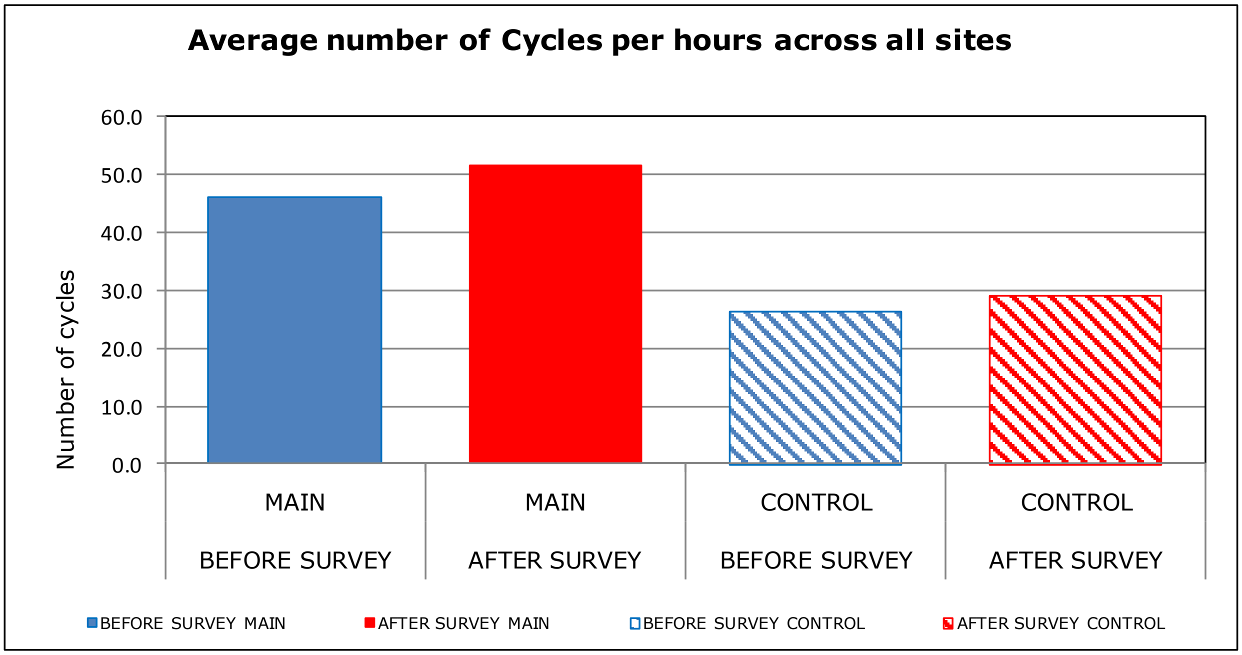


Figure 19: Average Number of Cycles per Hour Across All Sites

The number of cycles increased on both the Main and Control routes: by 16% on the Main and 13% on the Control routes. This implies that there was an overall increase in cycle usage on the network, but that it was unaffected by allowing motorcycles into the bus lanes on the Main sites. Overall, the change in the relative flows (ratio of the flows on a site against its Control site) did not change significantly. It should also be borne in mind that these changes, although appearing large, only represent a small change in the proportion of the traffic using the link. So, the change from 46 to 52 cycles per hour on average on the Main site represents a 0.8% increase in the percentage of flow on the studied links.

The conditions on individual links varied, with average hourly cycle flows ranging between 2 and 116, and average hourly motorcycle flows ranging between 7 and 136. However, these are relatively low flows, so the probability of the cycles generally noting a large increase in bus lane usage is low and it does not appear to have affected their use of the routes or their behaviour.

Bus flows are determined by their schedules, and therefore would not be generally expected to alter between the two surveys, and the flows of buses on the sites have remained constant in line with that expectation (see Table 20).

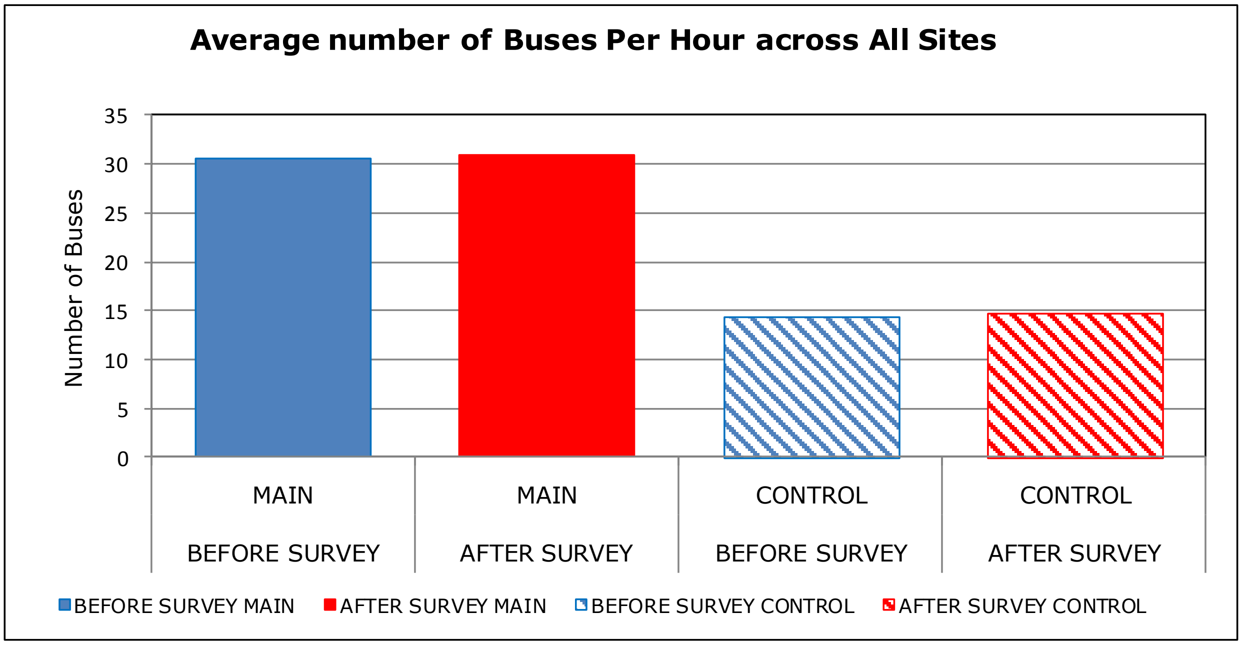


Figure 20: Average Number of Buses per Hour Across All Sites

The average composition of traffic on the Main sites and the Control sites is shown in Figure 20 to Figure 23.

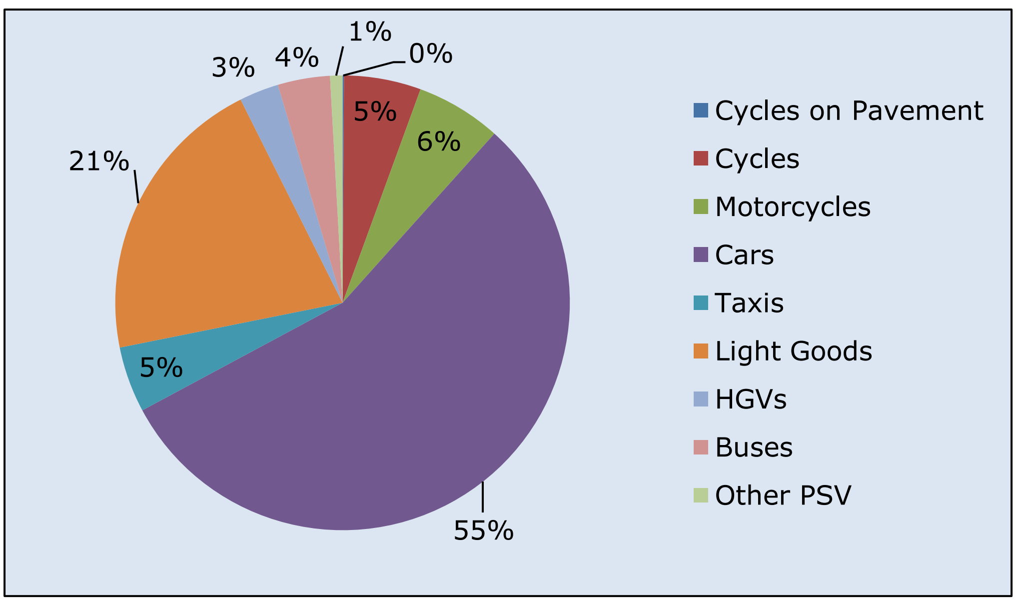


Figure 20: Composition of Traffic Mode for Main Sites (Before Survey)

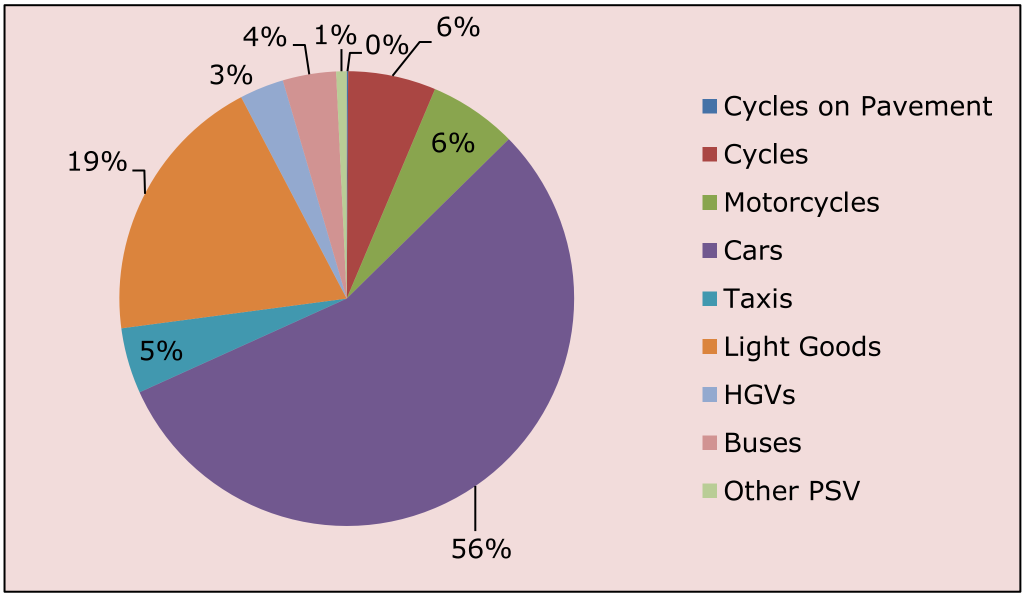


Figure 21: Composition of Traffic Mode for Main Sites (After Survey)

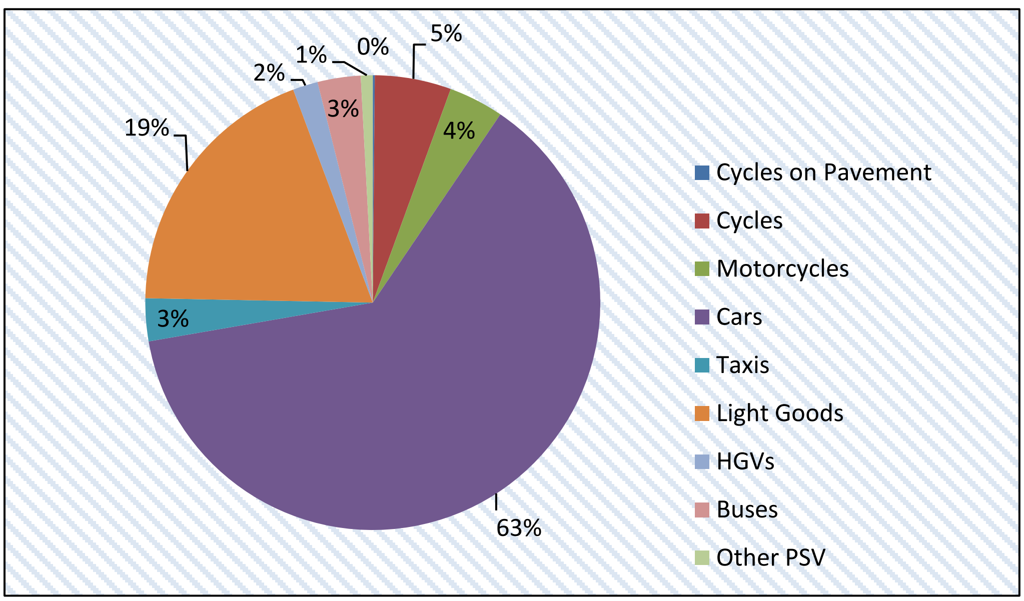


Figure 22: Composition of Traffic Mode for Control Sites (Before Survey)

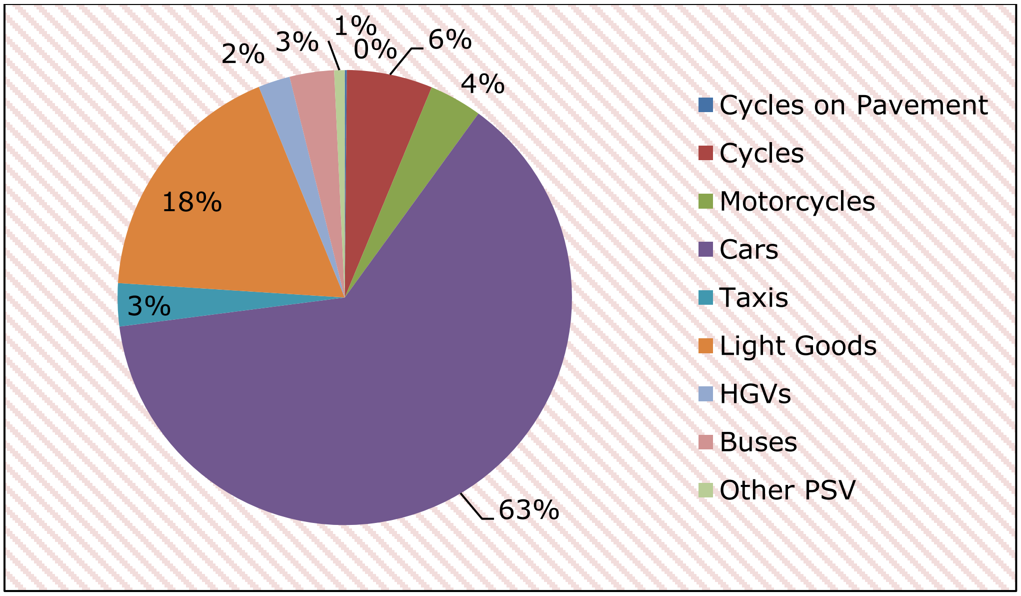


Figure 23: Composition of Traffic Mode for Control Sites (After Survey)

The average composition of the traffic on both the Main sites and the Control sites has remained constant between the two surveys. That is, the relative use by different modes has generally not altered.

The weekly traffic composition for one example site (Site 8) is shown in Figure 24 and Figure 25.

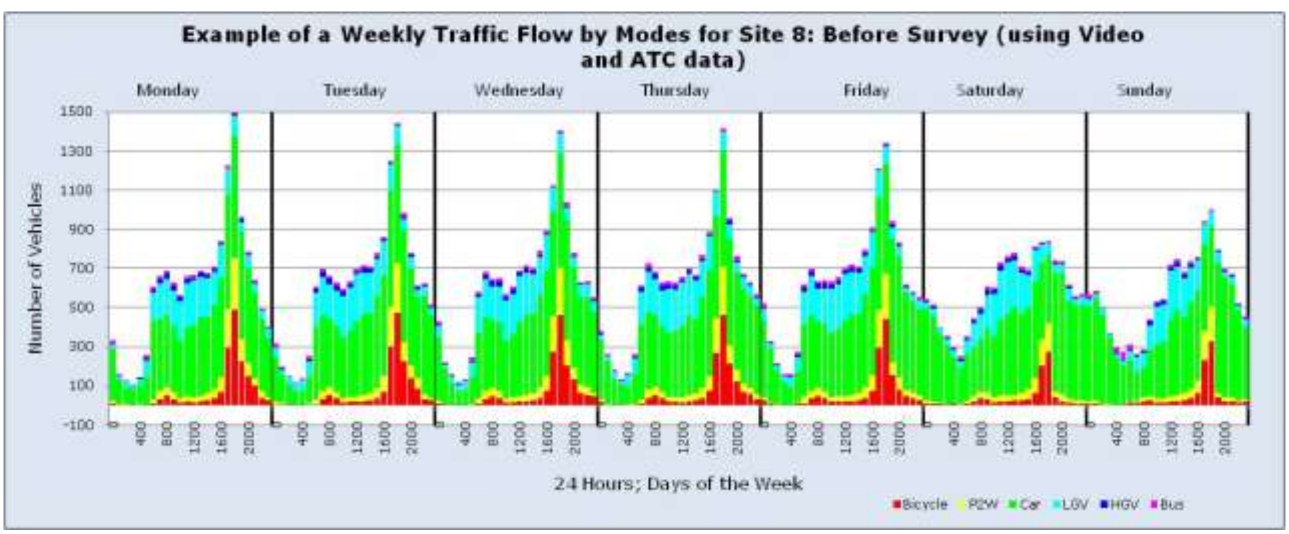


Figure 24: Example of Weekly Traffic Flow by Modes for Site 8: Before Survey (using Video and ATC data)

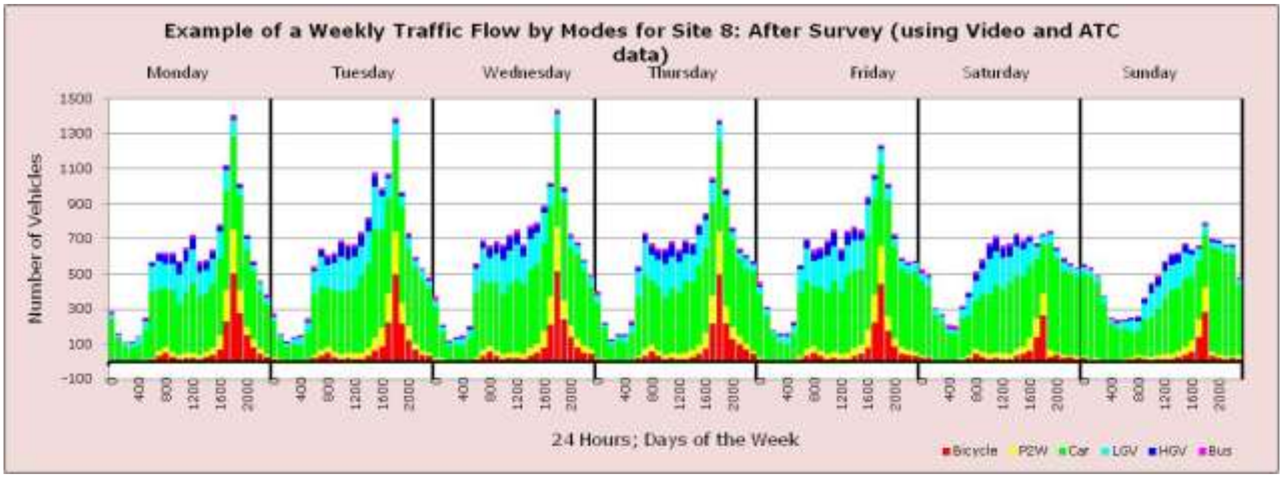


Figure 25: Example of Weekly Traffic Flow by Modes for Site 8: After Survey (Using Video and ATC data)

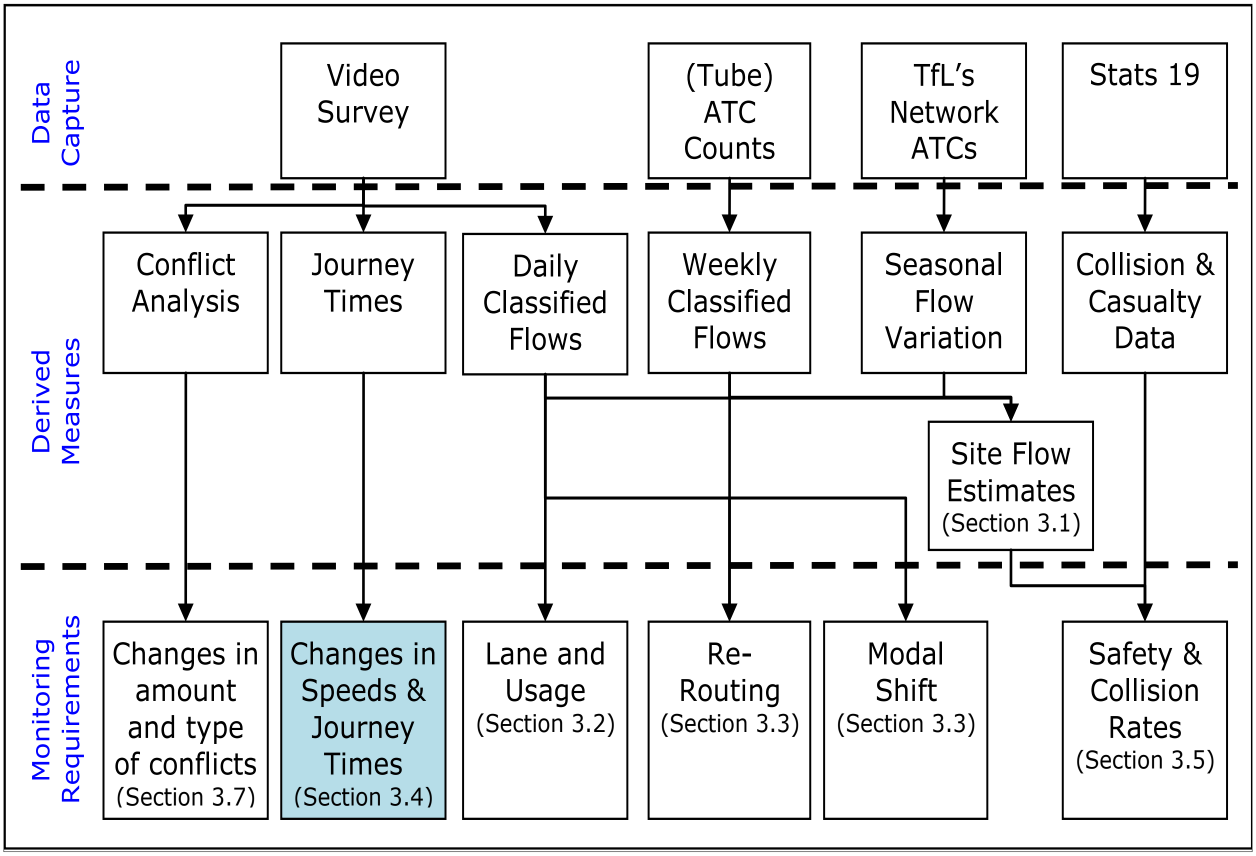
In agreement with the average trends across all sites, the flows and their composition have remained fairly consistent between the two surveys on this site.

3.3.1 Conclusions

Conclusions - Changes in Modes and Routes

- There was a small (4%) increase in the number of motorcycles using the Main routes after they were permitted access to the bus lanes, and a corresponding 2% decrease on the Control sites.
- The slight (implied) migration of motorcycles onto the Main routes was statistically significant.
- The number of cyclists increased by 16% on the Main Routes and 13% on the Control Routes.
- The modal share remained fairly constant on both the Main and the Control routes, with the variation generally being 1% or less.

3.4 Speeds and Journey Times on Studied Sites



Journey times and vehicle speeds of motorcycles, buses and cars on the sites are considered in this section, and the influence of the implementation of the scheme is explored.

Journey time and speed data was extracted from the video surveys for motorcycles, buses and cars. For these three modes the time the vehicle passed the upstream and downstream timing points was recorded to get journey times. This was done on both video days for up to 50 motorcycles, up to 50 buses and up to 100 cars per hour in each of the following periods:

- 07:30 to 08:30 and 08:30 to 09:30
- 12:00 to 13:00 and 13:00 to 14:00
- 16:00 to 17:00 and 17:00 to 18:00.

The distance between the upstream and downstream timing points ranged from approximately 130 to 250 metres. Each journey time observation was divided by the respective video section length to give the speed for that vehicle.

In this chapter the analysis is broken down for Main and Control sites and by lane, i.e. bus lane or non-priority lane. The speeds are also compared to the speed limit of each site.

3.4.1 Average Vehicle Speed

The average of the speed observations was taken for each of the three modes across the Main sites and Control sites in the Before and After survey. This is shown in Figure 26 and Table 13.

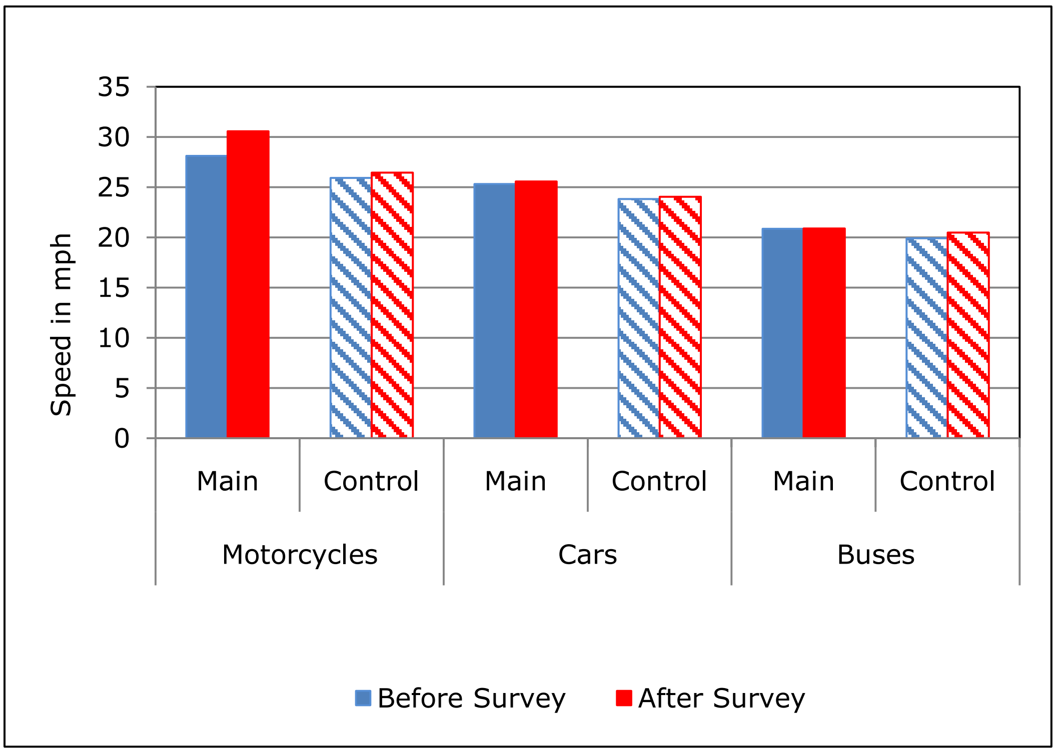


Figure 26: Average Vehicle Speed (mph)

	Motorcycles		Cars		Buses	
	Main	Control	Main	Control	Main	Control
Before (mph)	28.1	25.9	25.3	23.8	20.9	19.9
After (mph)	30.6	26.4	25.6	24.0	20.9	20.5
Increase (mph)	2.5	0.5	0.2	0.2	0.0	0.6
Increase (%)	8.8%	2.0%	0.9%	0.9%	0.1%	2.8%

Table 13: Average Vehicle Speed (mph)

This shows that the largest change since implementation has been an increase in average motorcycle speeds on the Main sites of 2.5 mph from 28.1 mph to 30.6 mph. This represents an increase of 8.8%. There has also been a smaller increase on the Control sites of 0.5 mph (a 2.0% increase) for motorcycles. A statistical comparative test that allowed for the underlying variation in the Control sites was undertaken. The test showed that the increase in speed in the Main sites relative to the Control sites was a significant increase at the 95% confidence level. That is, the speed on the main sites had increased significantly more than the speed on the control sites. This is also supported by the speeds increasing significantly on 18 Main sites, but only on 12 Control sites.

There was a small increase of 0.2 mph in car speeds in both the Main and Control sites. This was found to be not statistically significant. As discussed in 3.1, there has been a reduction in PCU flow of approximately 1% in the After survey compared to the Before survey. This may in part explain the small (and generally non-significant) increase in speeds on the Control sites for all three modes, as well as for the cars on the Main sites. Furthermore, the change in lane usage by motorcycles also represents an average reduction of 2.6% in PCU flow in the non-priority lanes, and this could have increased car speeds.

The car speeds represent those of non-priority traffic. A statistical test was performed to assess whether the changes in motorcycle speeds were in line with changes in general traffic speeds, or differed from them. That is, whether the motorcyclists had gained a journey time advantage allowing for any other changes (for example in flows) on the sites. This showed that the change in motorcycle speeds on the Control sites was not significantly different (even at the 90% confidence level) to changes in general traffic speeds. However, changes in motorcycle speeds on the Main sites were significantly different at the 95% confidence level. So, motorcycles had gained a journey time advantage, over general traffic flows, on the Main sites only.

For buses there has been a negligible increase in average speed on the Main sites of 0.1% up to 20.9 mph and an increase of 2.8% on the Control sites up to 20.5 mph. A statistical test was conducted on the Main sites relative to the Control sites and there was found to be no statistically significant change in bus speeds. All 28 Main sites have bus lanes, whereas only 4 of the Control sites have bus lanes. Therefore buses on the Main sites are relatively unaffected by changes in overall traffic flows, but are affected on most Control sites. Therefore the observed reduction in flow may explain why there was an increase in bus speeds on the Control sites, but not the Main sites.

Figure 14 showed that on the Main sites, 6% of motorcyclists were observed to illegally use the bus lanes in the Before survey, and 51% utilised the bus lane after they were permitted access. Table 13 suggests that there has been a significant increase in motorcycle speeds. This has been broken down further according to lane usage to investigate whether the increase in speed is predominantly in the bus lane.

Figure 27 shows the average vehicle speeds in the bus lane and non-priority lanes on the Main sites. This is not presented for the Control sites, because only 4 Control sites had bus lanes. It was also not possible to distinguish lane usage on Sites 16, 20, 21, 25 and 28, and so the data from these sites was excluded.

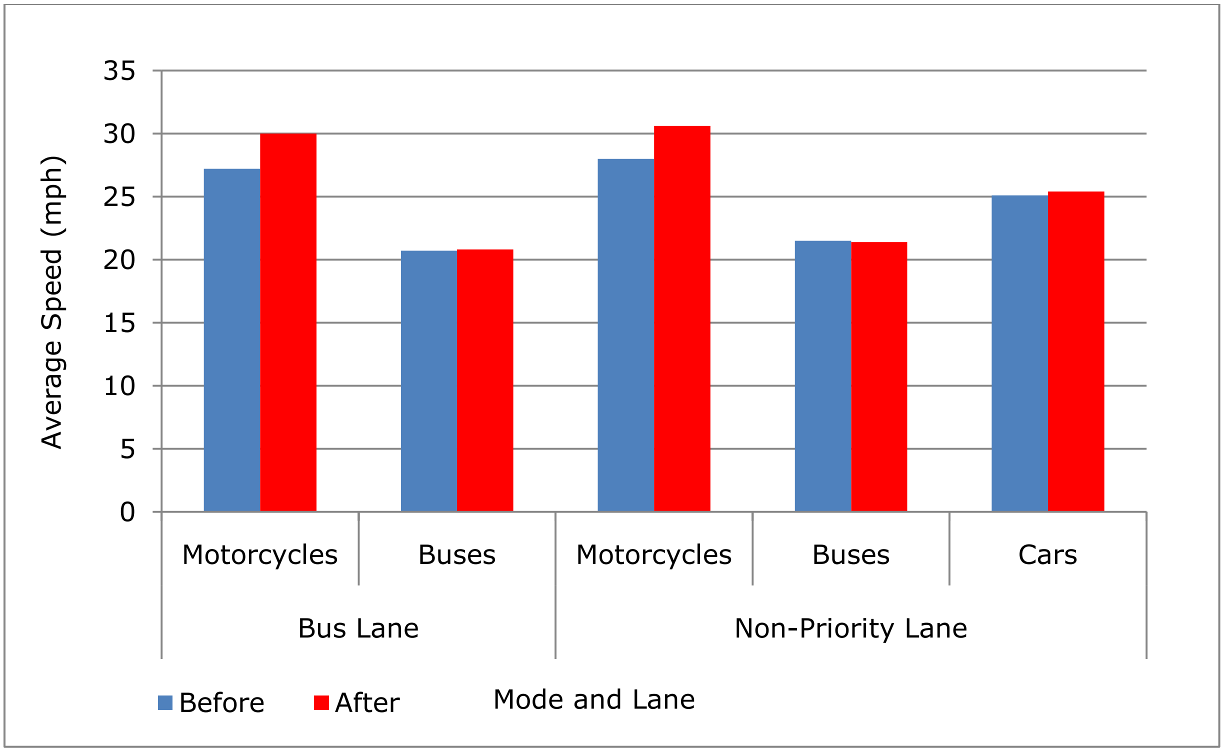


Figure 27: Average Vehicle Speed by Lane Used on the Main Sites

		Speed		Sample	
		Before	**After**	**Before**	**After**
Bus Lane	Motorcycles	27.2	30.0	504	4906
	Buses	20.7	20.8	6685	6855
Non-Priority Lane	Motorcycles	28.0	30.6	7469	3951
	Buses	21.5	21.4	700	832
	Cars	25.1	25.4	23221	23708

Table 14: Average Vehicle Speed by Lane Used on the Main Sites

Motorcycle speeds were on average slightly faster in the non-priority lane compared to the bus lane in both surveys. A possible explanation for this is that motorcycles are using the non-priority lane when traffic is flowing freely and are only using the bus lane under congested conditions to bypass traffic queues. Motorcycle speeds had increased in both the bus lane and the non-priority lane by 2.8 mph and 2.6mph, respectively. There is weak evidence of this lane choice behaviour in the data. A regression analysis of the speed data categorised by lane implied that that the percentage of motorcycles using the bus lane increased by approximately 4% for each 1mph reduction in average non-priority vehicle speed, although it should be noted that the variation in this data was large.

There has been no significant change in average bus speeds since implementation. The average bus speeds using the non-priority lane were slightly higher than in the bus lane, as with the motorcycle speeds.

3.4.2 Speed Limit Compliance

This section investigates the effect the scheme has had on speed limit compliance, in particular for motorcycles. Figure 28 shows the percentage of vehicles travelling above the speed limit for the three modes, in the Before and After survey and for the Main and Control sites.

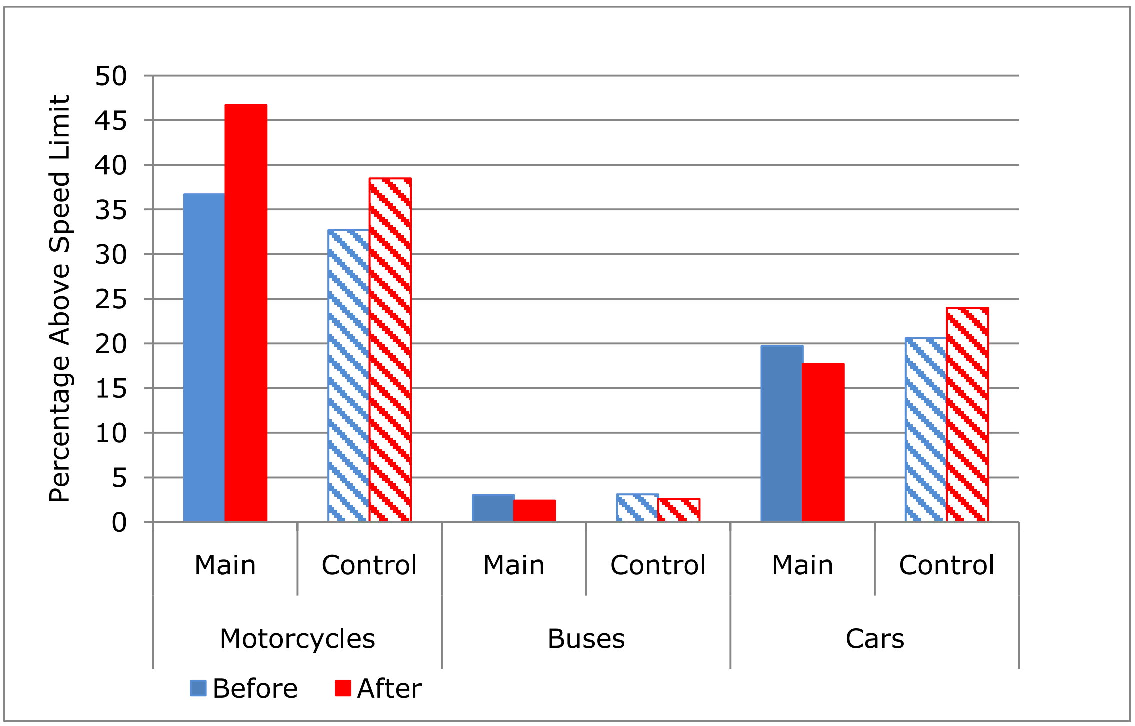


Figure 28: Percentage of Vehicles Travelling Above Speed Limit (All Sites)

There has been an increase in the percentage of motorcycles above the speed limit on both the Main and Control sites. In the After survey on the Main sites, 47% of motorcycles were filmed exceeding the speed limit between the two timing points. The increase in percentage of motorcycles exceeding the speed limit was 6% on the Control sites and 10% on the Main sites. Although this initially appears similar, a statistical analysis shows that the percentage increase on the Main sites was greater than that on the Control sites (at the 95% confidence level).

Table 15 shows the number of Main and Control sites with speed limits of 20, 30 and 50 mph. The speed limits on both the Main and the Control sites were not stipulated in the site selection process. The purpose of site selection was to obtain a range of sites selected randomly from across the network, with the Control site being a potential alternative parallel route.

	Speed Limit			
	20	**30**	**50**	**Total**
Main Site	0	27	1	**28**
Control Site	4	24	0	**28**
Total	**4**	**51**	**1**	**56**

Table 15: Number of Sites with Different Speed Limits

Figures 30, 31 and Table 16 display speeds in 5mph bands. The higher value of any band and the lower value of the proceeding band display the same value for simplicity (i.e. 30-35, 35-40 etc). The actual range is inclusive of the lower figure and exclusive of the higher figure (i.e. 35mph exactly would fall into the 35-40 category).

The distribution of speeds is shown below for motorcycles on the Main sites. Results are presented only for sites with speed limits of 30 mph, which represent 91% of all sites. Summary tables for all individual sites are presented in Appendix D.

Figure 29 shows the distribution of motorcycle speeds on the Main sites. This is not broken down by lane, as in the previous section.

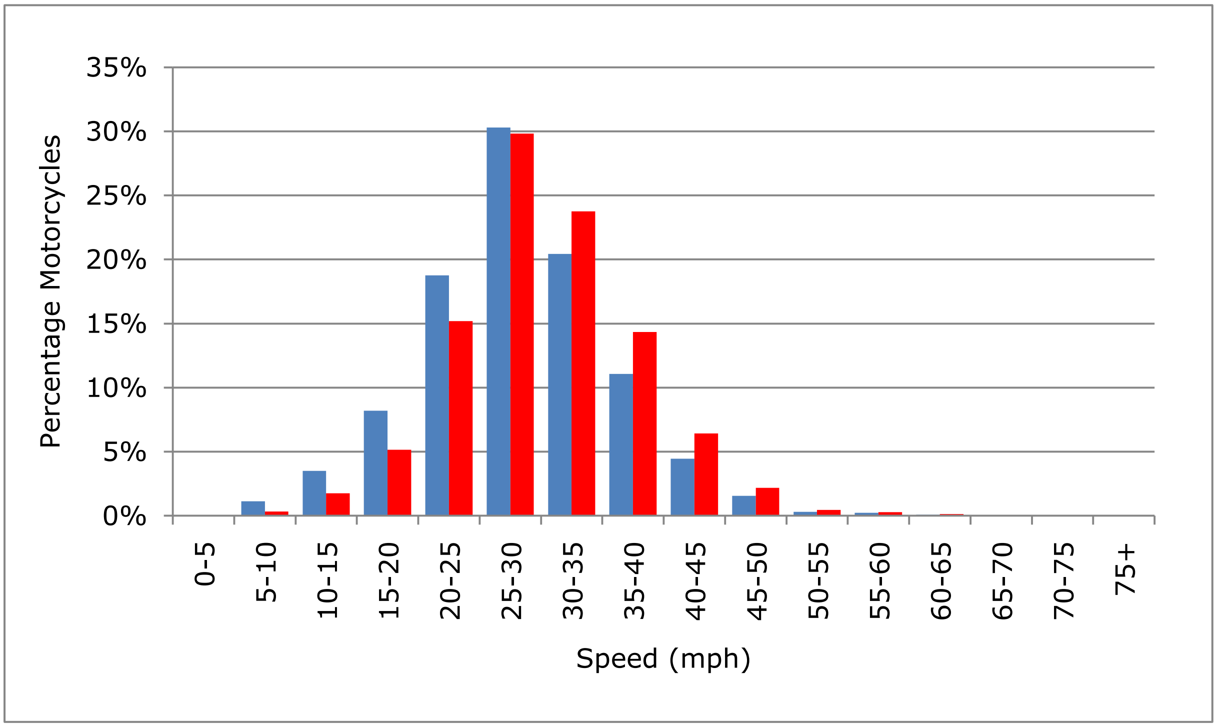


Figure 29: Distribution of Motorcycle Speeds on Main Sites with 30 mph Speed Limit (mph)

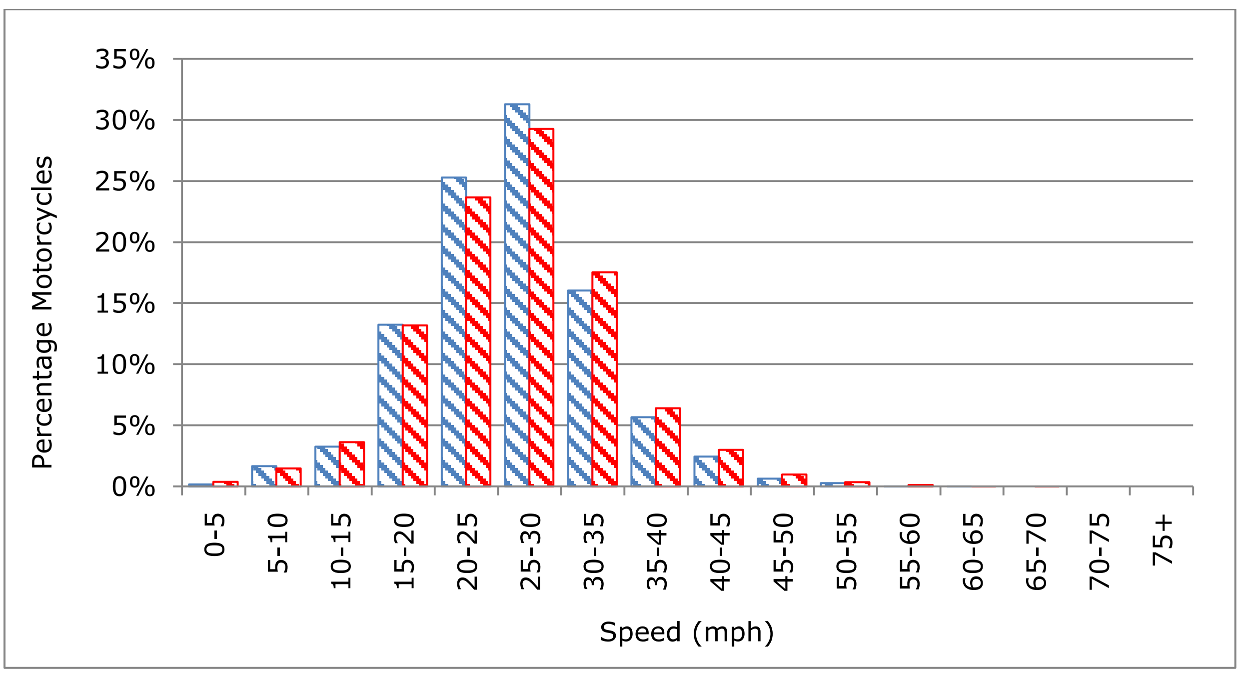


Figure 30: Distribution of Motorcycle Speeds on Control Sites with 30 mph Speed Limit (mph)

	Before		After	
Speed	Main	Control	Main	Control
0-5	0.0%	0.2%	0.0%	0.4%
5-10	1.1%	1.7%	0.3%	1.5%
10-15	3.5%	3.2%	1.8%	3.6%
15-20	8.2%	13.2%	5.1%	13.2%
20-25	18.8%	25.3%	15.2%	23.7%
25-30	30.3%	31.3%	29.8%	29.3%
30-35	20.4%	16.1%	23.8%	17.5%
35-40	11.1%	5.7%	14.3%	6.4%
40-45	4.4%	2.4%	6.4%	3.0%
45-50	1.5%	0.6%	2.2%	1.0%
50-55	0.3%	0.3%	0.4%	0.3%
55-60	0.2%	0.0%	0.3%	0.1%
60-65	0.1%	0.0%	0.1%	0.0%
65-70	0.0%	0.0%	0.0%	0.0%
70-75	0.0%	0.0%	0.1%	0.0%
75+	0.0%	0.0%	0.0%	0.0%
Total	100%	100%	100%	100%

Table 16: Distribution of Motorcycle Speeds on Main Sites (mph)

For the 25 Main sites with speed limits of 30 mph, there were increases in the percentage of motorcycles in the following speed bands:

- the 30-35 mph band (20.4% to 23.8%);
- the 35-40 mph band (11.1% to 14.3%);
- the 40-45 mph band (4.4% to 6.4%)
- the 45-50 mph band (1.5% to 2.2%).

The observed changes in both average motorcycle speeds and percentage of motorcycle speeds above the speed limit are consistent. Both had increased on the Control sites, and this could have been related to a slight reduction in the traffic flows across the network. However, they had both increased to a greater degree on the Main sites, and the available evidence implies that this is through the motorcycles being able to utilise the bus lane, particularly when the non-priority lanes are congested.

3.4.3 Journey Times

Vehicle journey times are highly site dependent as they are directly related to the distance between the timing points. The average journey times for the three modes for the Main and Control sites are shown in Figure 31, although the interpretation of these values is difficult owing to the non-uniformity in timing point distance across the sites.

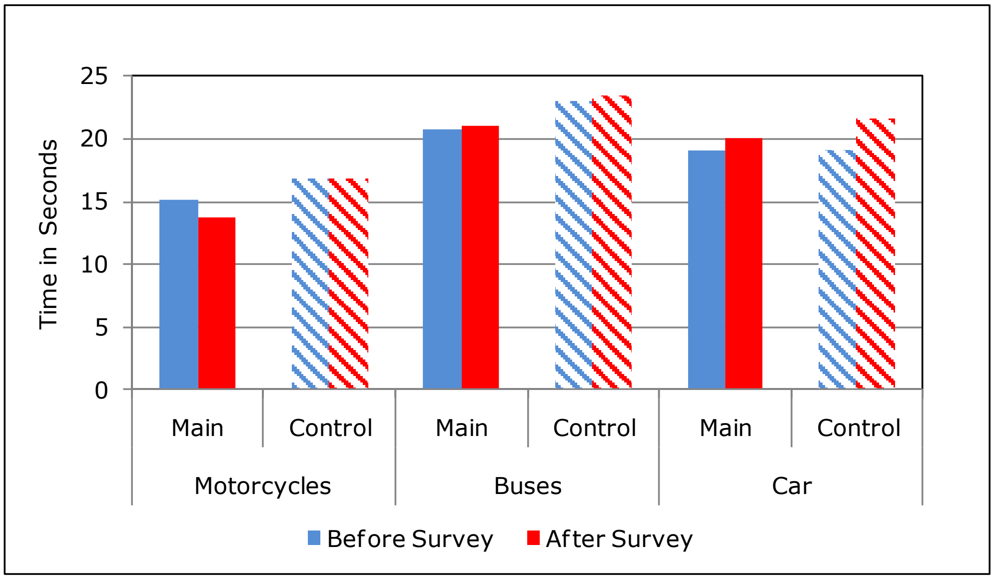


Figure 31: Journey Time for all 30 mph Sites at All Times

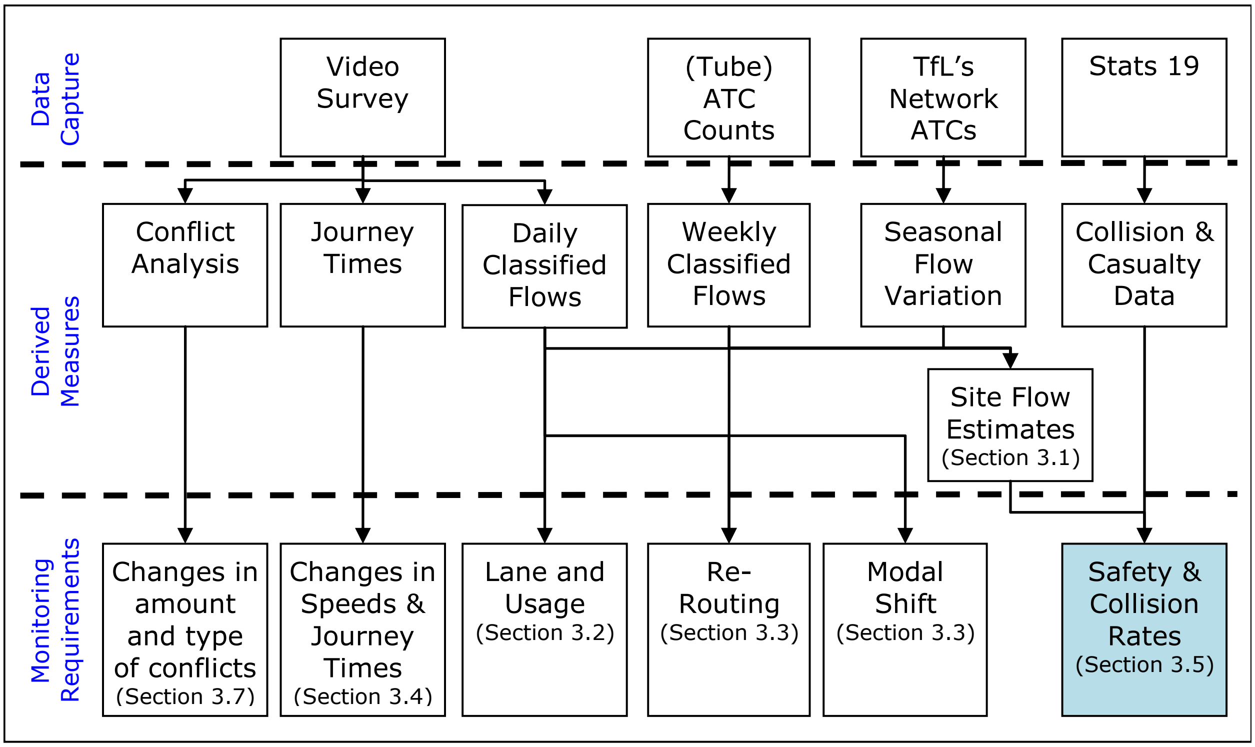
The same trends in journey times and speeds are seen, with the journey time of motorcycles decreasing (speed increasing), and the journey times of buses and cars only marginally changing. The individual journey times of these modes for each site are in Appendix D.

3.4.4 Conclusions

Conclusions - Speeds and Journey Times on Studied Sites

- Bus speeds were unaffected by permitting motorcycles access to the bus lanes.
- Non-priority traffic speeds remained reasonably constant on the Main and Control sites.
- Motorcycle speeds increased after they were permitted access to the bus lanes.
- There was an increase in the percentage of motorcycles exceeding the speed limit.

3.5 Collision Rates on Studied Sites



Three approaches are used to assess the effect of permitting motorcycles to use bus lanes. The first considers the overall effect on the collision rates; that is the number of collisions according to the flow of traffic, i.e. collisions per million vehicles. The second looks at the number of collisions in more detail and explores the underlying reasons that resulted in the collisions, and finally the conflicts between vehicles are examined to assess the interactions between road users.

DfT collate information on all personal injury collisions reported to the police occurring on the public highway within the UK. This data is also separately held by TfL for greater London on their ACCSTATS database. TfL supplied TRL with data from this database for all reported collisions on each of the Main and Control (56) sites that involved a motorcycle, cycle or pedestrian. At the time of analysis, ten months of data after the scheme was implemented was available. Therefore the analysis in this report is based upon a comparison of collisions between January and October 2008 (before motorcycles were permitted access) and between January and October 2009.

TRL have further processed this data to separately isolate the collisions involving vehicles travelling in the direction of travel of the bus lane being studied on each site.

Ten months of collision data provided a sound basis for understanding any main effects of the scheme on safety. However, such quantities of data are considered relatively small for basing robust safety conclusions owing to the high degree of variability in this type of data. Consequently, a conflict analysis was conducted to support the collision analysis and aimed to ensure that any collision trends are in agreement with observed behavioural changes on the survey sites.

Collision rates provide the best measure of whether the overall safety of road users has been affected by allowing motorcycles into bus lanes. It takes into consideration any underlying changes in flows on the network, as for example, if the number of collisions doubled but so did the flows, then overall safety is unaffected. It also compensates for any general underlying trends in collisions. That is, if the collision rate changes to the same extent on the roads allowing motorcycle access and on roads not allowing motorcycles access (the Control sites), then the change in collisions would not be expected to be attributable to the scheme.

Two types of collision rate analysis have been performed. The first examines the collision rates on the 28 Main survey sites and compares them to changes on the 28 Control sites. The second considers the collision rate on the whole of the TLRN network with bus lanes compared to trends on the remainder of the London road network (the Control).

3.5.1 Motorcycle Collision Rates

An analysis was performed to ascertain any changes in the collision rate of motorcyclists, and whether it was attributable to other changes in network flows. Therefore the number of motorcyclists involved in collisions who were travelling in the direction under consideration was divided by the estimated 10-month flows of motorcycles on the studied sites (see Appendix J section 2.4). This forms the collision rate for motorcyclists using the sites studied. These rates have been calculated for the Before and After studies, using the control routes for comparison.

	Main Sites		Control Sites	
	Motorcyclists involved in collisions	Estimated 10 month motorcycle flow	Motorcyclists involved in collisions	Estimated 10 month motorcycle flow
Before	30	7260943	16	2837072
After	41	7460778	8	2874515
% Change		**2.75%**		**1.32%**

Table 17 : Summary of Collisions over All Sites (Using Non-filtered Data)

Rates Per Million	Main Sites	Control Sites	Main vs Control
	Motorcyclists involved in collisions	Motorcyclists involved in collisions	
Before	4.132	5.640	**136.5%**
After	5.495	2.783	**50.6%**
Rate change	**133.0%**	**49.3%**	

Table 18 : Summary of Collision Rates over All Sites (Using Non-filtered Data)

The rate at which motorcyclists were involved in collisions on the Main sites increased by 33.0% and decreased by 50.7% on the Control sites. This suggests that overall the main sites had a higher collision risk for motorcycles due to the use of bus lanes.

Although the number of collisions across the sites were quite small (as data was only available for 10 months), the percentage change in the collisions was large. This combined with the percentage change in flows being small, implied that the collision rate had increased. The statistical significance of this change was explored using the Hauer[3] approach. The test is used when collision data needs to be combined from a number of trial sites that have undergone a similar change (i.e. the introduction of motorcycles into the bus lane) and where a control for the sites can be established. The full details from the result of fitting the model are shown in Table 19.

[3] Hauer E , (1997) *Observational before-after studies in road safety*, Pergamon Press, ISBN 0-08-043 053 8

Data	Survey	Treatment	Control	
	Before	30	16	
	After	41	8	
Model Fitting	Step	Model Details		Explanation
	Step 1	Lambda	41.000	Actual number observed
		ratio c	0.464	Change observed in control sites allowing for flow differences
		Pi	14.317	Expected number of collisions, allowing for change in control sites and in flow differences
	Step 2	var lambda	41.000	
		var pi	45.267	
	Step 3	Delta	26.68	Increase in collisions from expected
		Theta	2.346	Proportion more than expected
		1-theta	134.6%	Fitted percentage increase
	Step 4	SD (delta)	9.288	Standard deviation of difference
		SD (theta)	1.162	Standard deviation of increase
Summary	prob(delta =0)		<0.01	Delta= Increase in number of collisions

Table 19: Results of the Hauer approach

The model developed using the Hauer approach is shown in Table 19 and measures the change on the Main sites, assuming that any changes on the Control sites are from other underlying changes across the network. The statistical tests associated with the Hauer approach consider if the relative change between the Main and Control sites could occur within natural variation, or whether it is the result of the changes made on the Main sites: i.e. permitting motorcycles into the bus lanes. The developed model indicated that there was a 134.6% (relative) increase (see 1-theta) in motorcycle collisions due to their use of bus lanes, i.e. relative to the Control sites. The difference between the observed and expected number of collisions for the main sites after motorcycles were permitted access to the bus lanes was statistically significant (at the 95% confidence level, see prob(delta=<0.01)). This implies that the difference in the rate of collisions involving motorcyclists was statistically significant. However, some caution needs to be taken in interpreting these results as the sample sizes were relatively small, and therefore small changes in absolute numbers results in large percentage changes. If there had been four more motorcycle collisions in the control sites after period, i.e. 12 instead of 8, then the difference would not have been statistically significant (at the 95% level).

An alternative site-based model was also tested. This was not judged to be as appropriate as the Hauer approach model presented above due to considerable variability between sites. However, its general conclusions were in agreement with the Hauer approach model. Details of the alternative model are included in Appendix F.

3.5.2 Cycle Collision Rates

A similar analysis to the one performed for motorcycles was undertaken to test whether there were any changes in rate of collisions in cyclists, that may be as a result of permitting motorcycles into bus lanes. This approach accounted for any underlying changes on the network by using the changes on the Control sites. Therefore the number of cyclists involved in collisions who were travelling in the direction under consideration was divided by the estimated 10-month flows of cycles on the studied sites (see Appendix J, Section A.1.1.1J.2.4). This forms the collision rate for cyclists using the sites that have been studied. These rates have been calculated for the Before and After studies, using the control routes for comparison.

	Main Sites		**Control Sites**	
	Cyclists involved in collisions	Estimated 10 month Cycle flow	Cyclists involved in collisions	Estimated 10 month Cycle flow
Before	7	6794974	14	3769218
After	21	7457936	16	4501181
% Change		**9.76%**		**19.42%**

Table 20 : Summary of Collisions over All Sites (Using Non-filtered Data)

Rates Per Million	**Main Sites**	**Control Sites**	Main vs Control
	Cyclists involved in collisions	Cyclists involved in collisions	
Before	1.030	3.714	**360.6%**
After	2.816	3.555	**126.2%**
Rate change	**273.3%**	**95.7%**	

Table 21 : Summary of Collision Rates over All Sites (Using Non-filtered Data)

The rate at which cyclists were involved in collisions on the Main sites increased by 173.3% and decreased by 4.3% on the Control sites. This suggests that overall the main sites had a higher collision risk for cycles.

There was a large percentage increase in cycles involved in collisions, however, the numbers involved were small and therefore it should be treated with caution. Furthermore, this analysis does not isolate the underlying cause for any change in safety on the sites.

The statistical significance of this change was again explored using the Hauer approach. The full details from the result of fitting the model are shown in Table 22.

Data	Survey	Treatment	Control	
	Before	7	14	
	After	21	16	
Model Fitting	Step	Model Details		Explanation
	Step 1	lambda	21.000	Actual
		ratio c	0.893	Allowing for flow differences
		Pi	6.862	Expected, allowing for flow differences
		var		
	Step 2	lambda	21.000	
		var pi	13.035	
	Step 3	delta	14.14	Increase in collisions from expected
		theta	2.397	Proportion more than expected
		1-theta	139.7%	Fitted percentage increase
	Step 4	SD (delta)	5.834	Standard deviation of difference
		SD (theta)	1.365	Standard deviation of increase
Summary	prob(delta=0)		<0.02	Statistically significant

Table 22: Results of the Hauer approach

The model developed using the Hauer approach is shown in Table 22 and measures the change on the Main sites, assuming that any changes on the Control sites are from other underlying changes across the network. The developed model indicated that there was a 140% (relative) increase (see 1-theta) in cycle collisions relative to the Control sites. The difference between the expected and observed numbers of collisions was statistically significant (at the 95% confidence level, see prob(delta<0.02)). This implies that the difference in the rate of collisions involving cyclists was statistically significant.

3.5.3 Pedestrian Collision Rates

A similar analysis to that contained in the previous sections for motorcycles and cycles was performed to test whether there were any changes in collision rates of vehicles travelling in the direction being considered that involved a pedestrian. This approach accounted for any underlying changes on the network by using the changes on the Control sites.

The number of pedestrians involved in such collisions was divided by the estimated 10-month flows of all traffic on each site (see Appendix J Section 2.4). This forms the collision rate for pedestrians using the sites that have been studied. These rates have been calculated for the Before and After studies, using the control routes for comparison.

	Main Sites		Control Sites	
	Pedestrians involved in collisions	Estimated 10 month flow (all vehicles)	Pedestrians involved in collisions	Estimated 10 month flow (all vehicles)
Before	25	78036222	8	41883531
After	23	77199839	12	41870646
% Change		**-1.07%**		**-0.03%**

Table 23 : Summary of Collisions over All Sites (Using Non-filtered Data)

Rates Per Million	Main Sites	Control Sites	Main vs Control
	Pedestrians involved in collisions	Pedestrians involved in collisions	
Before	0.320	0.191	**59.6%**
After	0.298	0.287	**96.2%**
Rate change	**93.0%**	**150.0%**	

Table 24 : Summary of Collision Rates over All Sites (Using Non-filtered

The rate at which pedestrians were involved in collisions on the Main sites decreased by 7.0% and increased by 50.0% on the Control sites. This suggests that overall the main sites had a lower collision risk for pedestrians. The statistical significance of this change was again explored using the Hauer approach. The full details from the result of fitting the model are shown in Table 25.

Data	Survey	Treatment	Control	
	Before	25	8	
	After	23	12	
Model Fitting	Step	Model Details		Explanation
	Step 1	lambda	23.000	Actual
		ratio c	1.334	Allowing for flow differences
		pi	32.986	Expected, allowing for flow differences
	Step 2	var lambda	23.000	
		var pi	270.209	
	Step 3	delta	9.99	Increase in collisions from expected
		theta	0.559	Proportion more than expected
		1-theta	44.4%	Fitted percentage increase
	Step 4	SD (delta)	17.123	Standard deviation of difference
		SD (theta)	0.302	Standard deviation of increase
Summary	prob(delta=0)		>0.10	NOT statistically significant

Table 25: Results of the Hauer approach

The model developed using the Hauer approach is shown in Table 25 and measures the change on the Main sites, assuming that any changes on the Control sites are from other underlying changes across the network. The developed model indicated that there was a 44% (relative) decrease (see 1-theta) in pedestrian collisions relative to the Control sites. However, the difference between the expected and observed number of collisions was not statistically significant.

3.5.4 Conclusions

Conclusions - Collision Rates on Studied Sites

The analysis implied:

- Collision rates involving motorcycles significantly increased (at the 95% confidence level) on the Main sites, although some caution is needed as the sample size is relatively small.
- Collision rates involving cycles significantly increased (at the 95% confidence level) on the Main sites, although, again, caution should be applied as the sample size is relatively small.
- Collision rates involving pedestrians did not significantly change.

3.6 Detailed Examination of Collisions

Collision rates show whether a change has occurred on the Main (test) sites, relative to any changes on the Control sites, which represent changes on the network as a whole.

The collision rates do not provide the whole story. They only indicate that a change has occurred. However, the STATS19 and ACCSTATS databases contain detailed information on each collision that occurs. This includes which vehicles were involved, where the collision was relative to junctions, any manoeuvres being performed by the vehicles involved and the severity of the injuries of the road users involved in the collision. These collected variables are in the form of pre-defined categories which the attending police officer selected. In addition, there are text fields on the form that permit the officer to comment on the circumstances behind the collision and allow the identification of the person(s) at fault.

This information has been analysed in depth to isolate the trends and underlying behavioural changes that are associated with any variation in collisions and rates. The number of motorcycles and cycles involved in collisions, travelling in the direction of interest, over all the sites is shown in Figure 32.

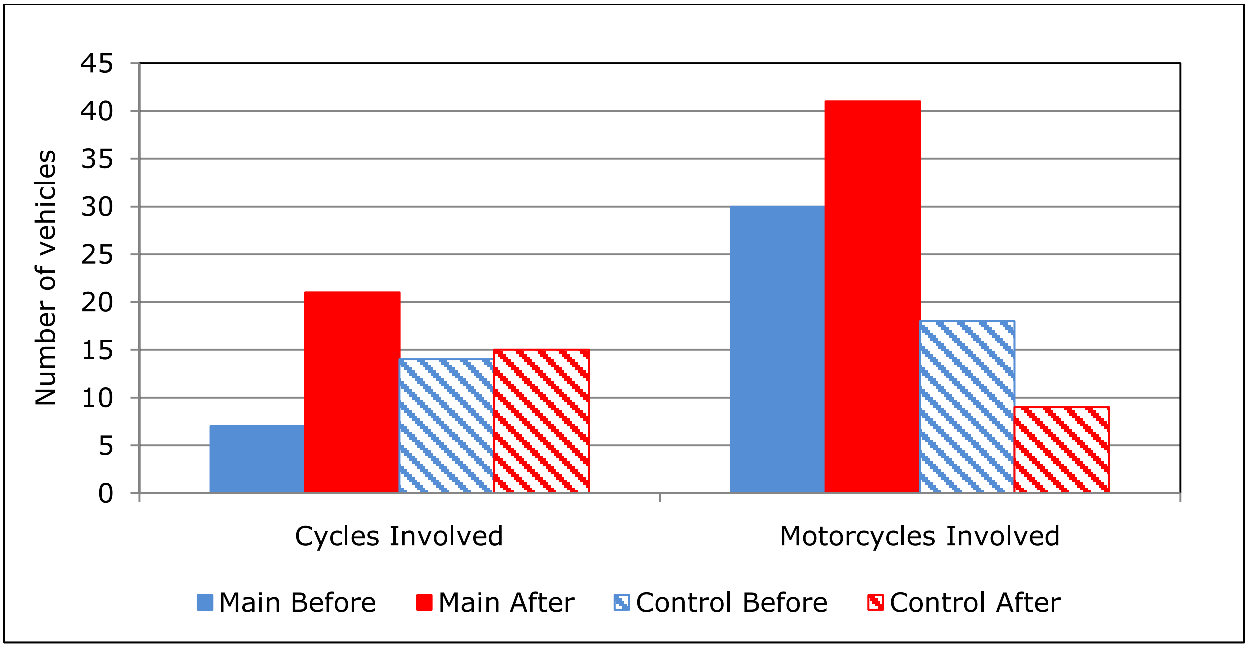


Figure 32: Number of Vehicles Involved: Travelling in Direction of Interest

The number of motorcycles involved in collisions had increased from 30 to 41 (31%) and the number of cycles involved had tripled on the Main sites from 7 to 21. In comparison, the number of motorcycles involved in collisions on the Control sites had reduced, and the number involving cyclists had only altered to a minimal extent from 14 to 16 (i.e. a 14% increase). However, care is needed when interpreting these initial figures as they do not attribute reasons for the changes, nor do they take account of any other traffic flow (or other) changes that could have occurred between the two time periods studied.

3.6.1 Motorcycle Collisions

This section considers the collisions involving a motorcycle travelling in the direction of interest on studied sites. The number of collisions had increased, and the collision rate had significantly increased, and the reasons underlying this are now investigated. One effect that needed consideration was whether there were any initial issues when the scheme was introduced, that is during a settling in period whilst motorcycles and other road users adapt their behaviour. The number of motorcycles involved in collisions according to the month of the year is shown in Figure 33.

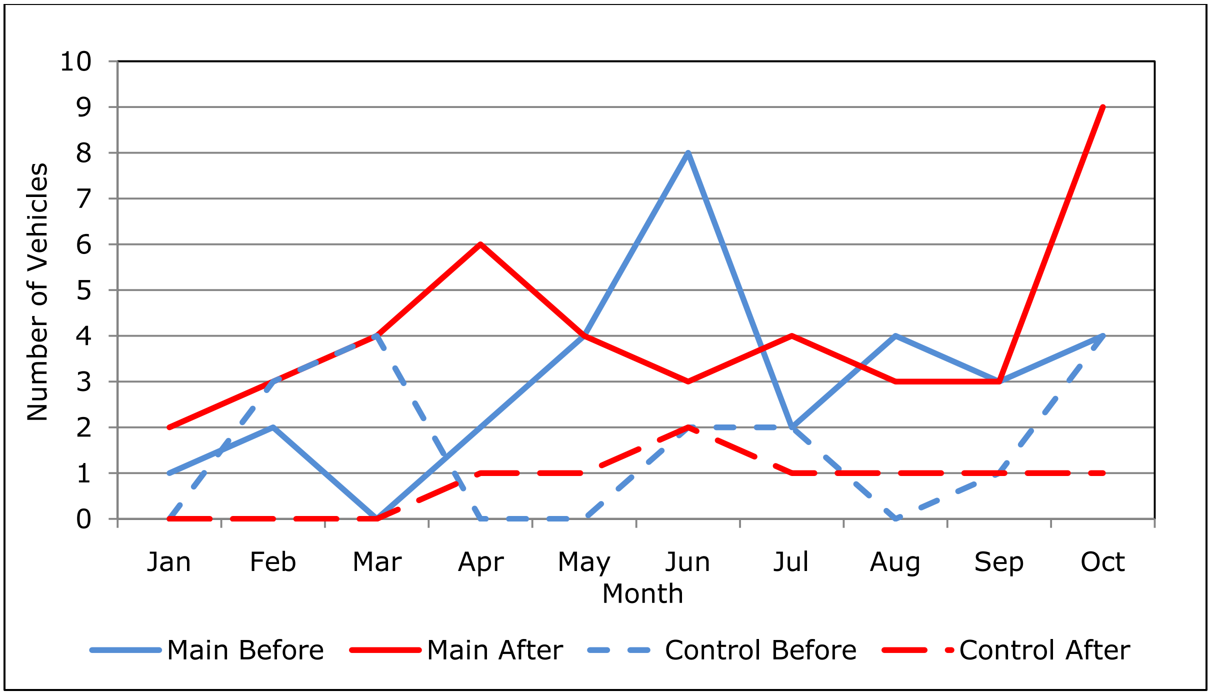


Figure 33: Number of Motorcycles Involved In Collisions Each Month

There is no evidence that the settling in period had an undue effect on collisions on the sites studied. Motorcyclists were first permitted access to bus lanes in January 2009 with no mitigating activity (such as speed enforcement or road safety awareness campaigns) implemented to support the introduction of the measure. There is no evidence of an increase in collisions between January and March, a three month settling in period.

For completeness the number of collisions within bus lane operating hours was also calculated, but Site 33 was excluded as its operating hours had altered between the two surveys. On the remaining sites the number of collisions during bus lane operating hours had increased from 24 in the before study to 29 in the after study (a 21% increase). It is not possible to isolate whether the increase on the main sites in non-operational hours was associated with motorcycles being permitted access to the bus lane. However, it is possible that permitting motorcycles to use the bus lanes during operating hours changed their behaviour at all times of the day.

The question therefore needs to be explored as to the circumstances underlying the increase in motorcyclists involved in collisions on the Main sites. The database provides detailed information on each collision; this includes the location of the collision, the time and day of the collision, the vehicles involved, the manoeuvres they were making before the collision and the severity of the injuries to those involved. Considering those collisions involving a motorcycle travelling in the direction being studied, the other vehicles involved in collisions with motorcyclists travelling in the direction of interest are summarised in Figure 34.

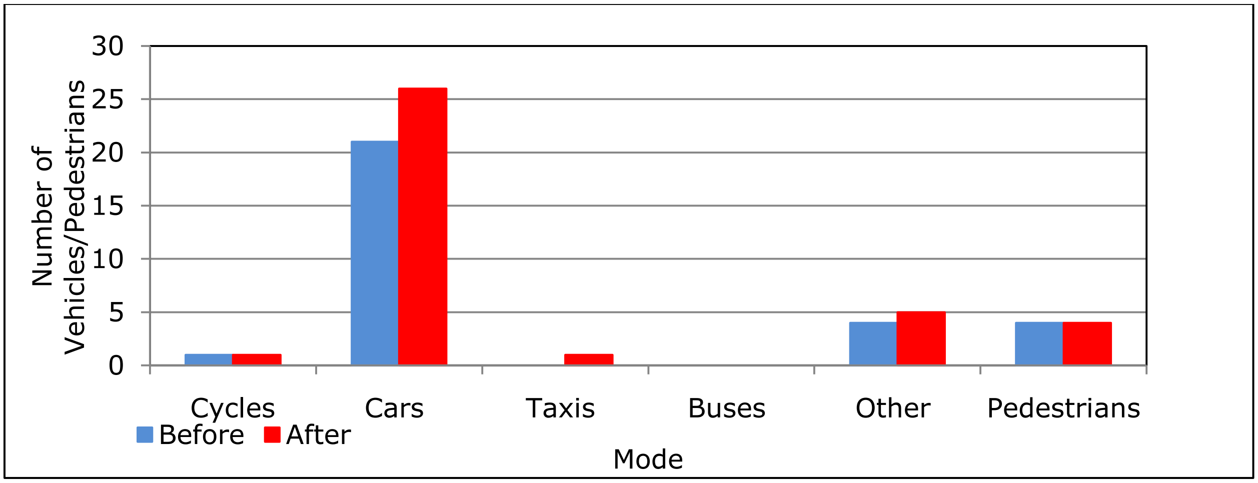


Figure 34: Other Vehicles and Pedestrians in Collisions, involving Motorcycles Travelling in Direction of Interest

Most of these collisions were between motorcycles and cars, and the observed increase in motorcycle collisions was with this mode, which represents approximately 55% of the total vehicle flow on these sites. The manoeuvres being performed before the collision by the vehicles involved are summarised in Figure 35.

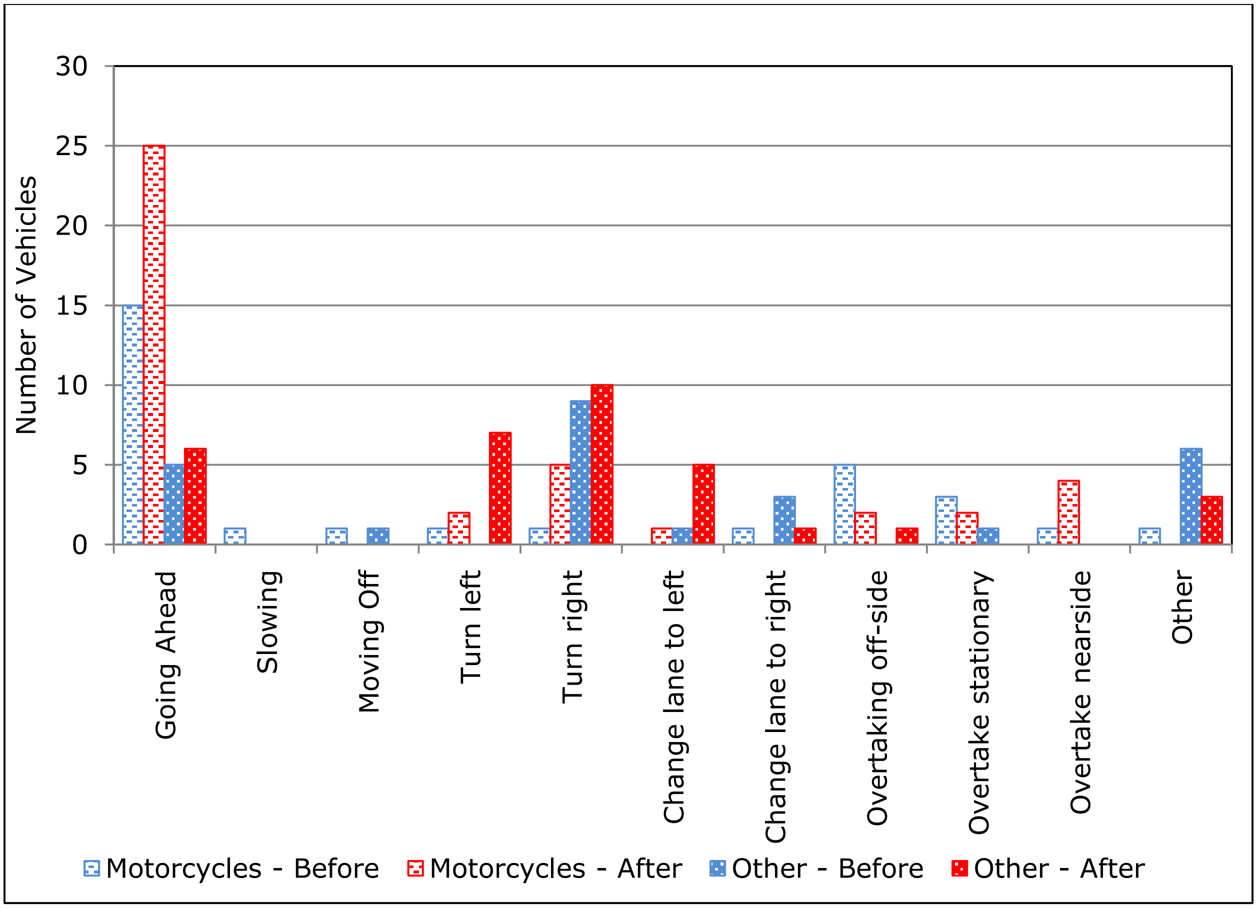


Figure 35: Number of Vehicles According to Motorcycle Manoeuvre in Collisions: Involving Motorcycles Travelling in Direction of Interest

The largest increase amongst the motorcyclists involved was when they were travelling straight ahead on the road. There was also a smaller increase for motorcyclists turning right or overtaking on the nearside, whilst there were slight decreases in the number of collisions involving motorcyclists overtaking on the off-side, or overtaking stationary vehicles.

The manoeuvres being performed by other vehicles involved in these collisions are also shown in Figure 35. The increases appear to be associated with them turning left or changing lane to the left. This is possibly owing to the car drivers not seeing (or expecting) a fast moving vehicle on their nearside. For example see sites 14 and 16 (Appendix C) for collisions involving cars turning left in to a side road. The locations of the collisions involving motorcycles travelling in the direction under consideration are summarised in Figure 36. Full details on the distribution of the collisions can be found in the Appendix.

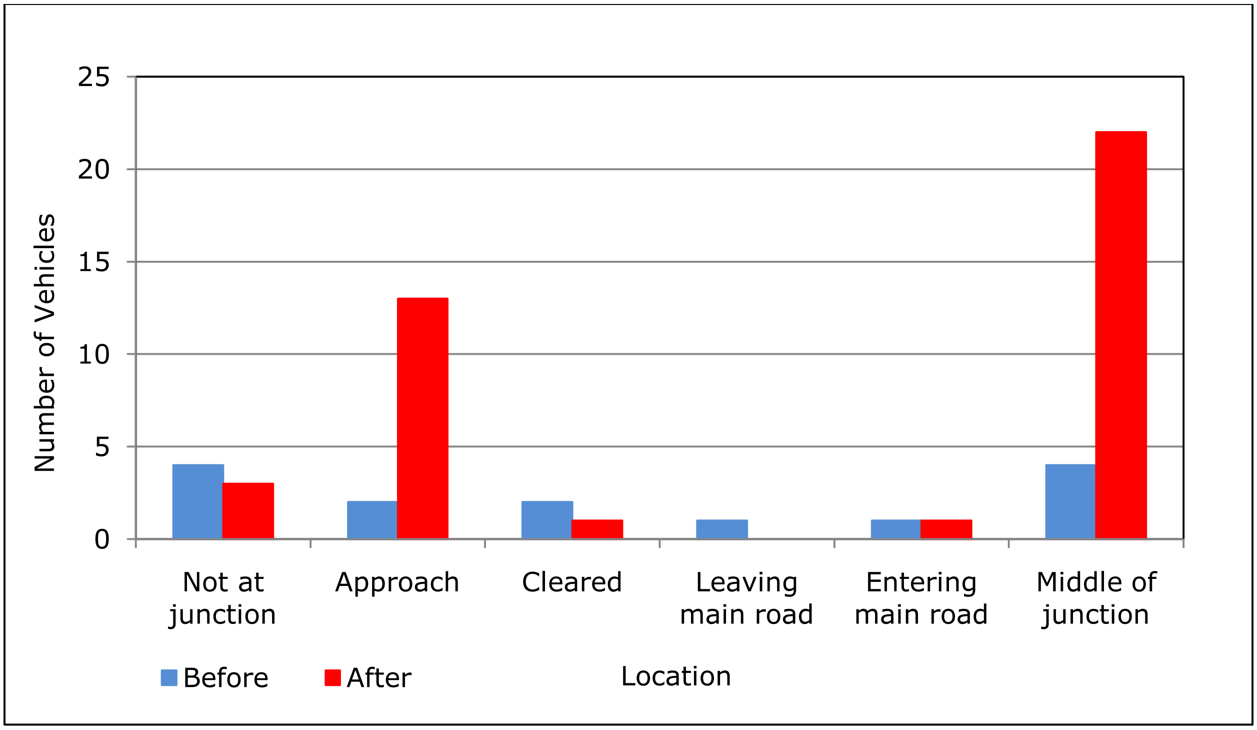


Figure 36: Location of Vehicles in Collisions: Involving Motorcycles Travelling in Direction of Interest

The increase in the motorcycle collisions occurred in the middle of junctions. Also, the associated manoeuvres tended to be where the motorcyclist was continuing straight on and a car turned left. Therefore, the implication is that there has been an increase in motorcycle collisions with cars that were either turning into, or out of, side roads. The maximum severity of the casualty injuries in the collisions is shown in Figure 37.

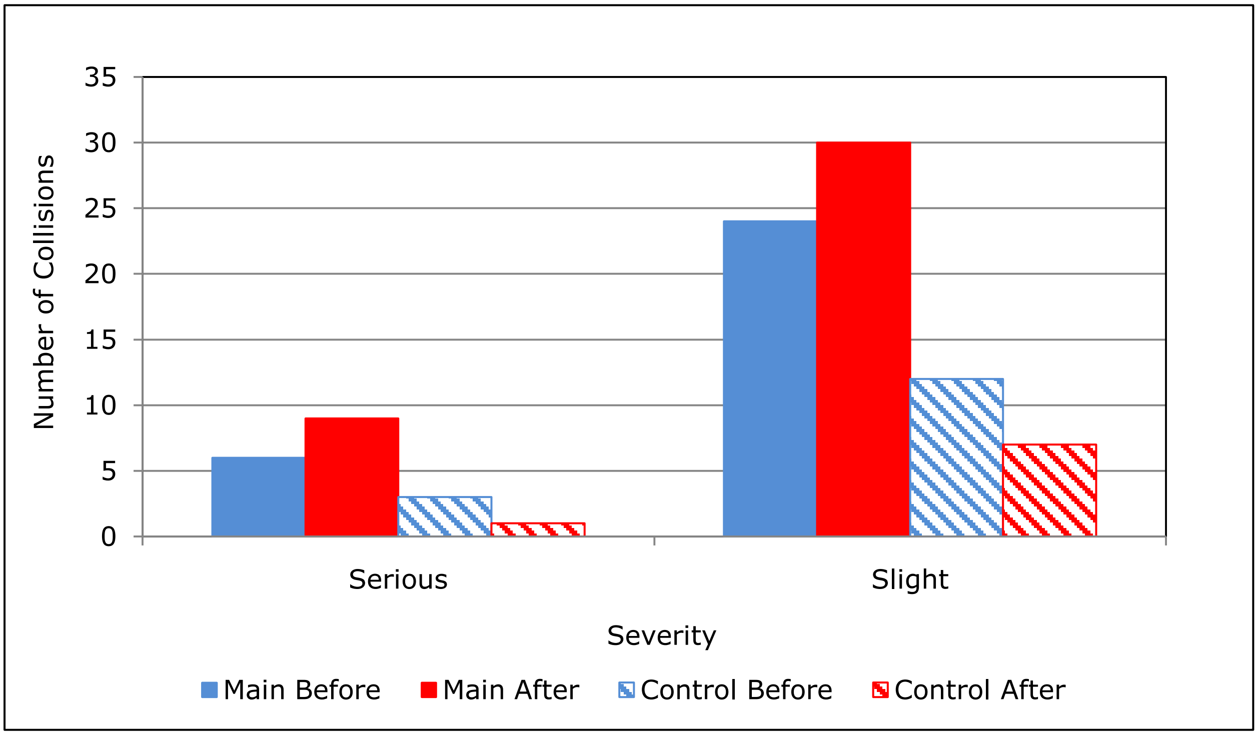


Figure 37: Severity of Casualties in Collisions: Involving Motorcycles Travelling in Direction of Interest

There were some changes to the maximum severity of injuries occurring in these collisions involving motorcycles travelling in the direction of interest. Whilst the number of collisions (and hence casualties) of different severities are quite small, they indicate a 25% increase in collisions with slight injuries, but a 50% increase in collisions with serious injuries. However, no fatalities occurred in either the before, or after, period on these sites, and the relative difference between the percentage seriously injured in the two survey periods was not significant as the numbers involved in the sample are small, so the results should be treated with caution.

The above analysis considers the individual components of a collision that are collected at the scene by the police. These appear to be consistent and indicate the underlying causal effects for the increase in collisions involving motorcycles on the Main sites travelling in the directions under consideration. It is possible to explore these collisions from a different perspective. The collision record includes a text description of the collision that attributes the collision to the vehicle “at fault” and a coded variable describing the factors that resulted in the collision. These assessments must be treated with some caution as they are the personal opinions of the officer attending and do not represent a legal allocation of fault for the collision, however, they provide a useful insight into the underlying causal effects.

These have been separately analysed and the results of this analysis is in Figure 38 and Figure 39.

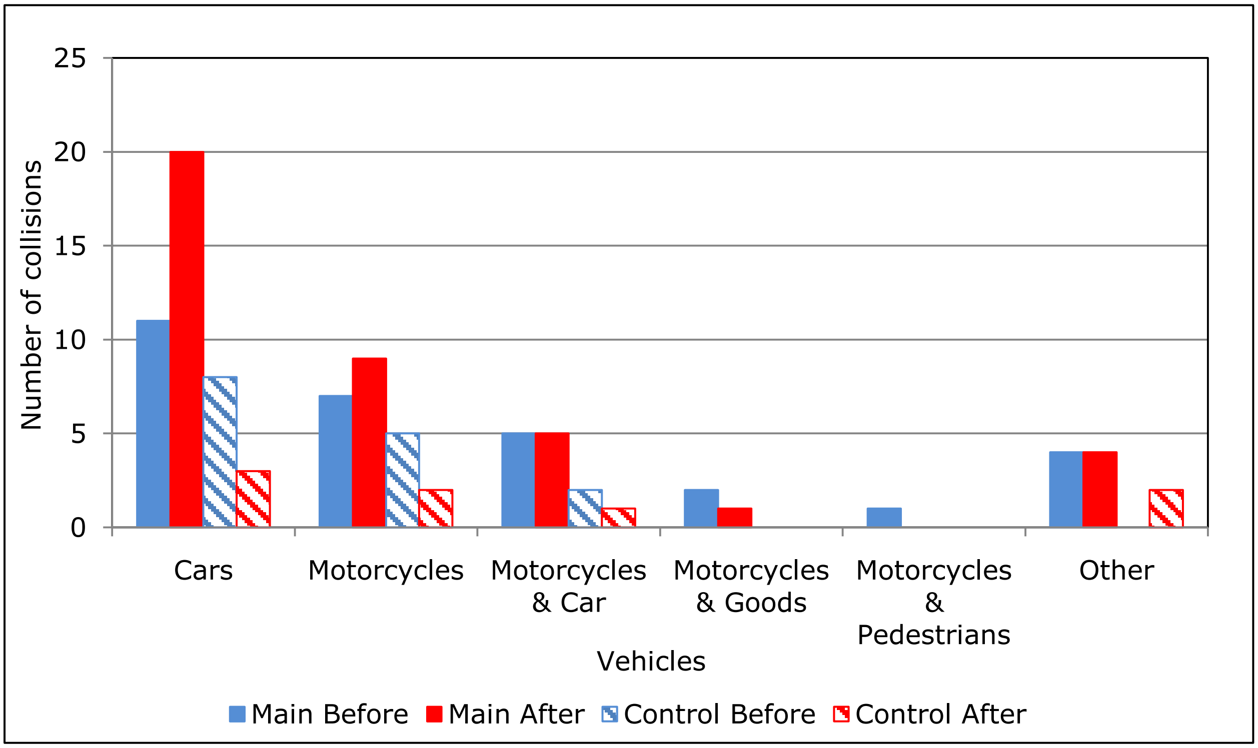


Figure 38: Vehicles Considered at Fault: Involving Motorcycles Travelling in Direction of Interest

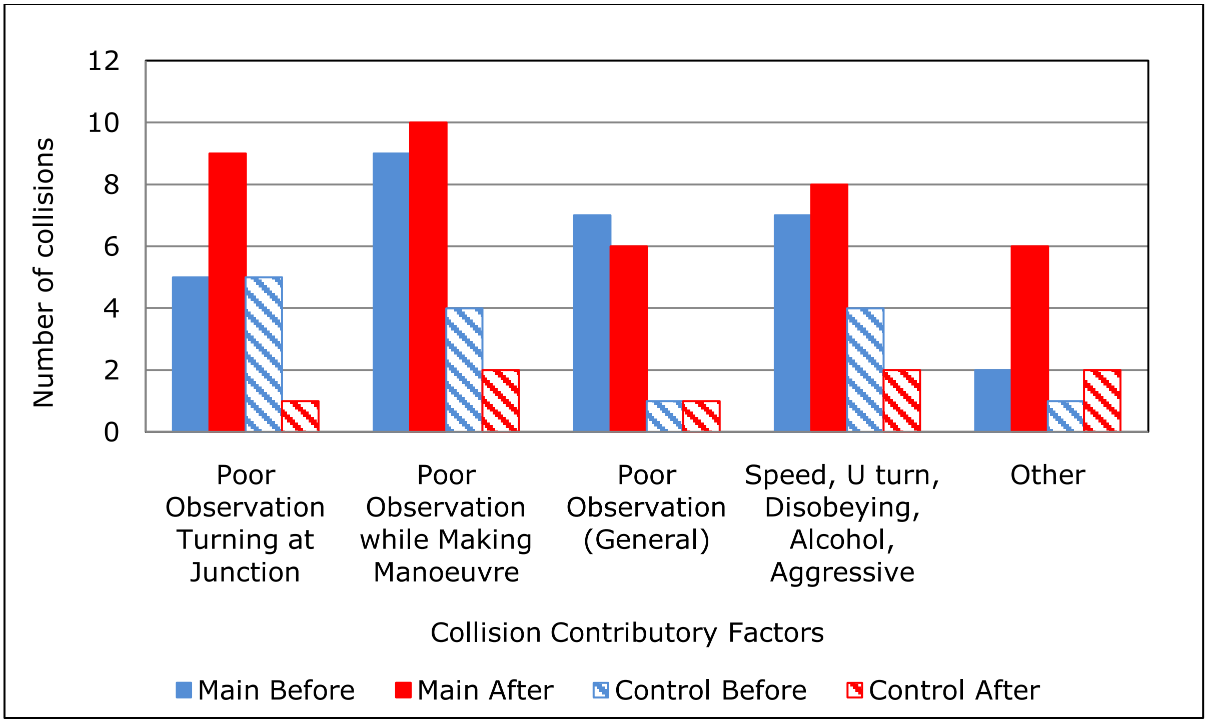


Figure 39: Attributed Cause Of Collisions: Involving Motorcycles Travelling in Direction of Interest

This analysis is consistent with the results in the main analysis. The increase in the collisions involving motorcycles (in the direction of travel being considered) was generally attributed to cars and to poor observation turning at junctions.

3.6.2 Cycle Collisions

Collisions involving cycles travelling in the direction under consideration were also analysed in depth. The collision rate analysis indicated that there was a significant increase in cyclists involved in collisions, although the numbers were small. This analysis aims to investigate whether permitting motorcycles into bus lanes either directly or indirectly affected the safety of cyclists. It is feasible that motorcyclists and cyclists would interact in the bus lane (directly affecting safety), alternatively the cyclists could decide to use another lane (or the footway) and therefore their safety could be indirectly affected. The other vehicles involved in these cycle collisions are shown in Figure 40.

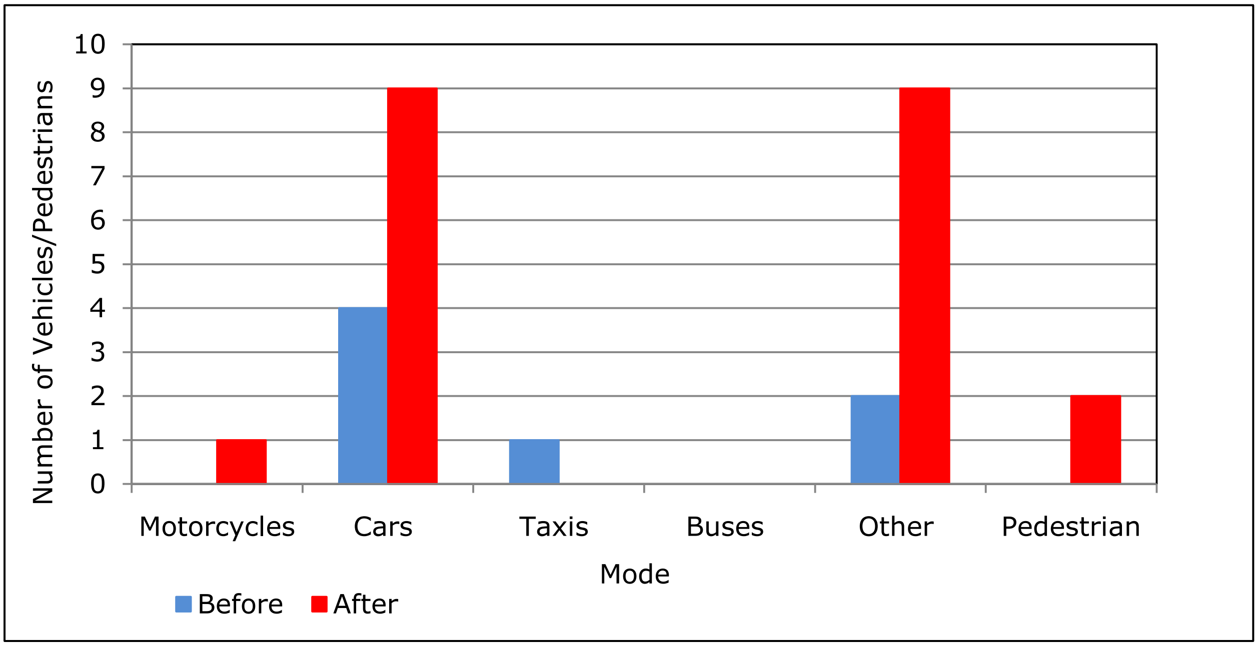


Figure 40: Other Vehicles and Pedestrians in Collisions: Involving Cycles Travelling in Direction of Interest

Only one motorcycle was involved in a collision with a cycle travelling in the direction under consideration. Although this was in the After survey period, it would appear unlikely that motorcycles have directly resulted in a safety issue for cyclists. Cyclist collisions with cars and other vehicles were the ones that had increased. The manoeuvres being made by the vehicles involved in these collisions are shown in Figure 41.

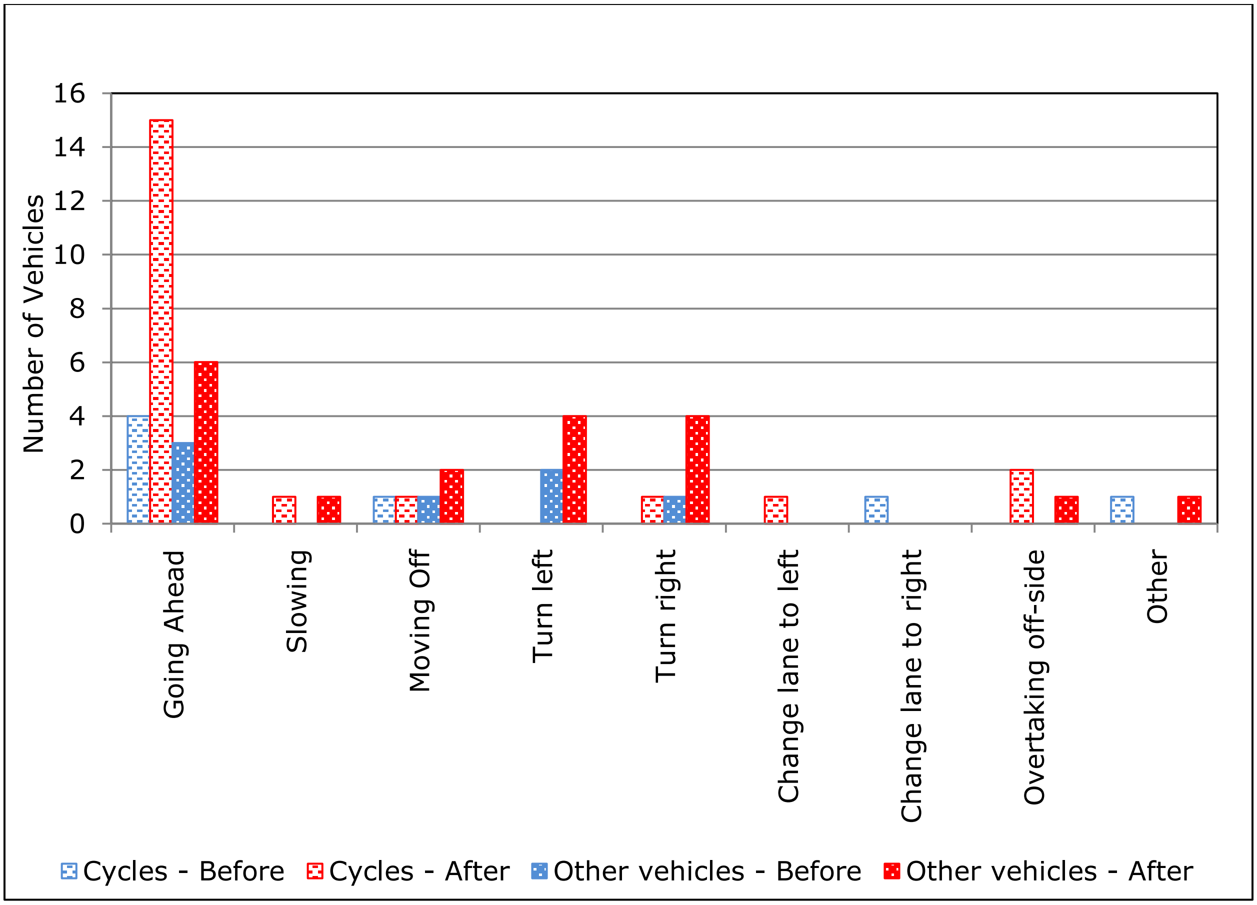


Figure 41: Number of Vehicles According to Manoeuvre in Collisions: Involving Cycles Travelling in Direction of Interest

The increase in collisions with cyclists travelling in the direction under consideration tended to be associated with the cyclists mainly going straight ahead, but there were also increases in collisions when they were turning left and right. Therefore no clear interaction between the cyclists and cars seems to have resulted in this increase in collisions. There was some evidence (Section 3.2.1) that the number of cyclists using the footway had decreased and therefore more were in traffic lanes. However, no reason can be suggested for this change in behaviour and it is not possible to associate it with the increase in collisions. Similarly, given the vehicles and manoeuvres involved it seems unlikely that permitting motorcycles into the bus has resulted in this increase.

The number of collisions within bus lane operating hours was also calculated, but Site 33 was excluded as its operating hours had altered between the two surveys. On the remaining sites the number of collisions during bus lane operating hours had increased from 6 in the before study to 14 in the after study (a 133% increase).

Again, it was not possible to isolate whether, or not, the increases inside and outside of bus lane operating hours were through an overall change in behaviour or if they had differing underlying causes.

As with the motorcycle collisions, it is possible to explore them using the text description of the collision that attributes the collision to the vehicle "at fault" and the coded factor(s) variable. These assessments must be treated with some caution as they are the personal opinions of the officer attending and do not represent a legal allocation of fault for the collision, however, they provide a useful insight into the underlying causal effects. These have been separately analysed and the results of this analysis is in Figure 42 and Figure 43.

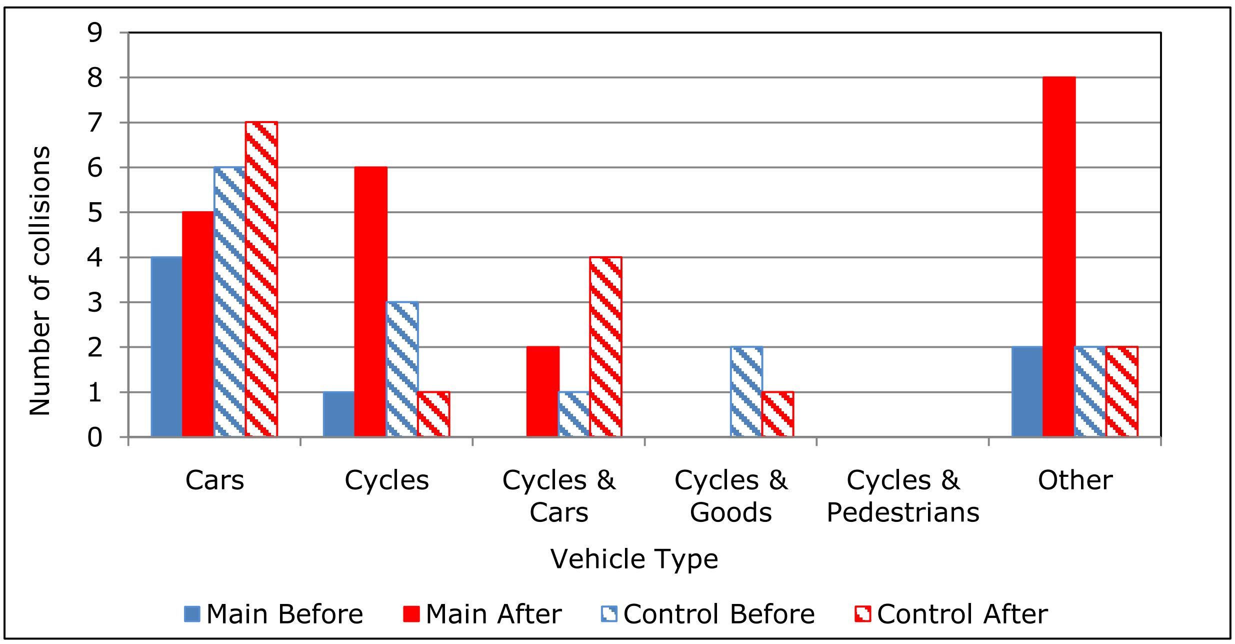


Figure 42: Vehicles Considered At Fault: Involving Cycles Travelling in Direction of Interest

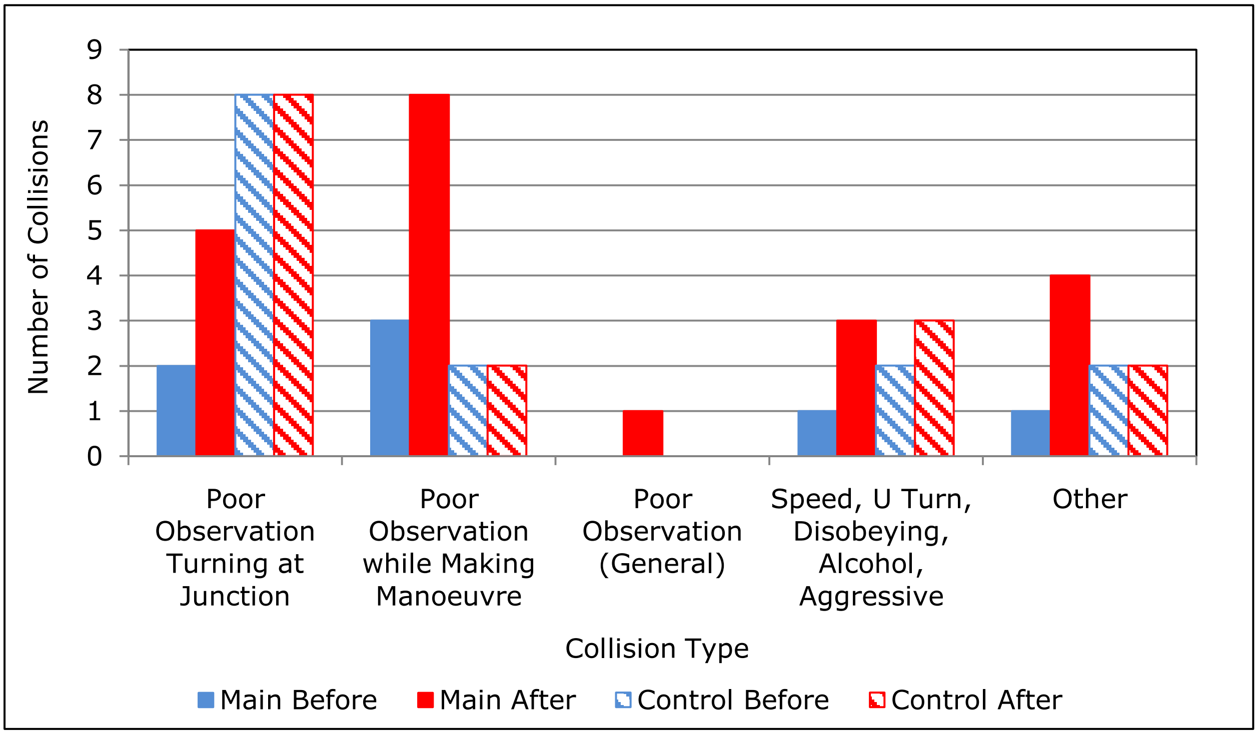


Figure 43: Attributed Cause Of Collisions: Involving Cycles Travelling in Direction of Interest

On the Main sites the increase amongst vehicles considered at fault are mainly the cyclists and the other vehicles. The other vehicles in the Before period were bus and goods vehicles. The other vehicles in the After period were goods vehicles, buses, pedestrians and in one case a motorcycle. There were also two motorcyclists considered at fault on the Control sites; one in the Before and the other in the After period.

The main causal effects attributed for the increase in collisions was poor observations (either at a junction or whilst making a manoeuvre). Therefore, combining the two sets of analysis, the relatively small absolute (although large percentage) increase in collisions appears to be associated with cars, with the cyclists often judged at fault. The cause was generally through poor observation by cyclists and car drivers (see Figure 43) with the cyclists travelling straight on. It therefore seems unlikely that the increase in collisions involving cyclists was caused by the motorcyclists using the bus lane.

3.6.3 Pedestrian Collisions

Pedestrian involvement in collisions is recorded differently to vehicle involvement. Whereas details of the vehicles are separately collected for each one involved in the collision, pedestrian involvement is recorded as a simple yes or no answer in the overall details of the collision. To understand the effect of motorcycles being permitted into the bus lanes on pedestrian safety, all collisions involving vehicles travelling in the direction of the bus lane studied were selected and those also involving a pedestrian were then examined in more detail. The number of collisions involving pedestrians is shown in Figure 44.

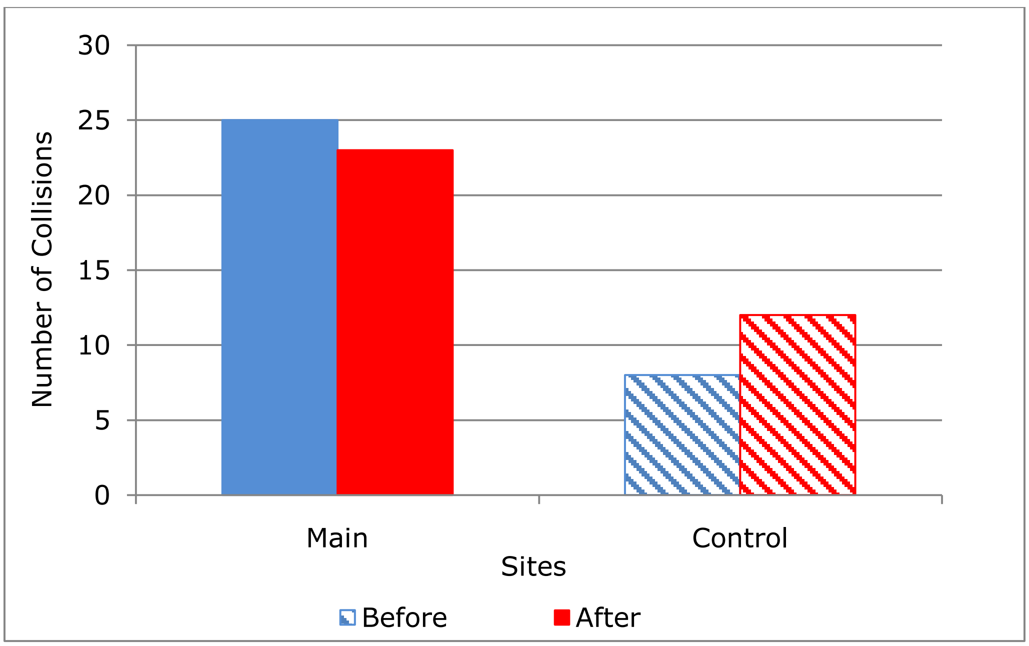


Figure 44: Number Of Collisions: Involving Pedestrians and a Vehicle Travelling in Direction of Interest

Section 3.5.3 showed that the collision rates had not changed significantly, and it can be seen that there was only a marginal change in the pedestrians involved in collision on the sites studied. In addition, the vehicles involved in these collisions are shown in Figure 45, note that more than one vehicle can be involved in a collision with a pedestrian.

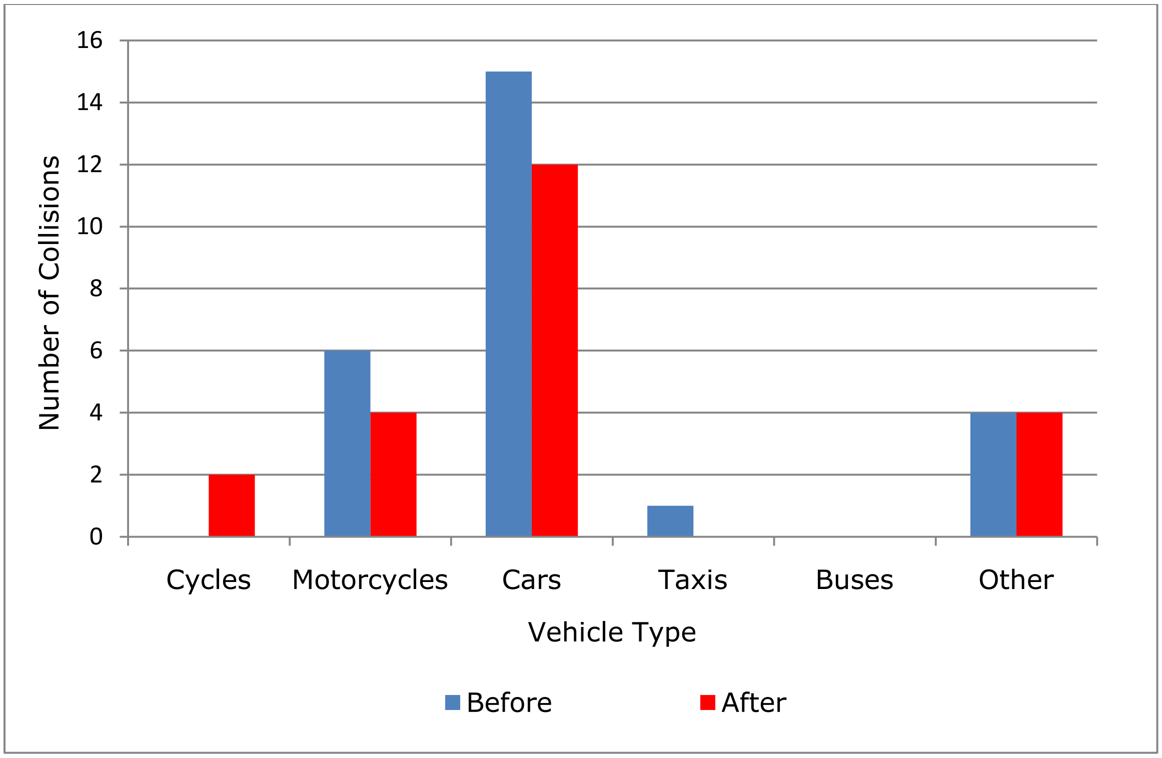


Figure 45: Number Of Collisions: Involving Pedestrians and Vehicles Travelling in Direction of Interest

The number of collisions involving a pedestrian and a motorcycle was small, and overall it is clear there was no major change in pedestrian safety on the sites.

As with the motorcycle and cycle collisions, it is possible to explore pedestrian collisions using the text description that attributes the collision to the vehicle "at fault" and the coded factor(s) variable. These assessments must be treated with some caution as they are the personal opinions of the officer attending and do not represent a legal allocation of fault for the collision, however, they provide a useful insight into the underlying causal effects. These have been separately analysed and the results of this analysis is in Figure 46 and Figure 47.

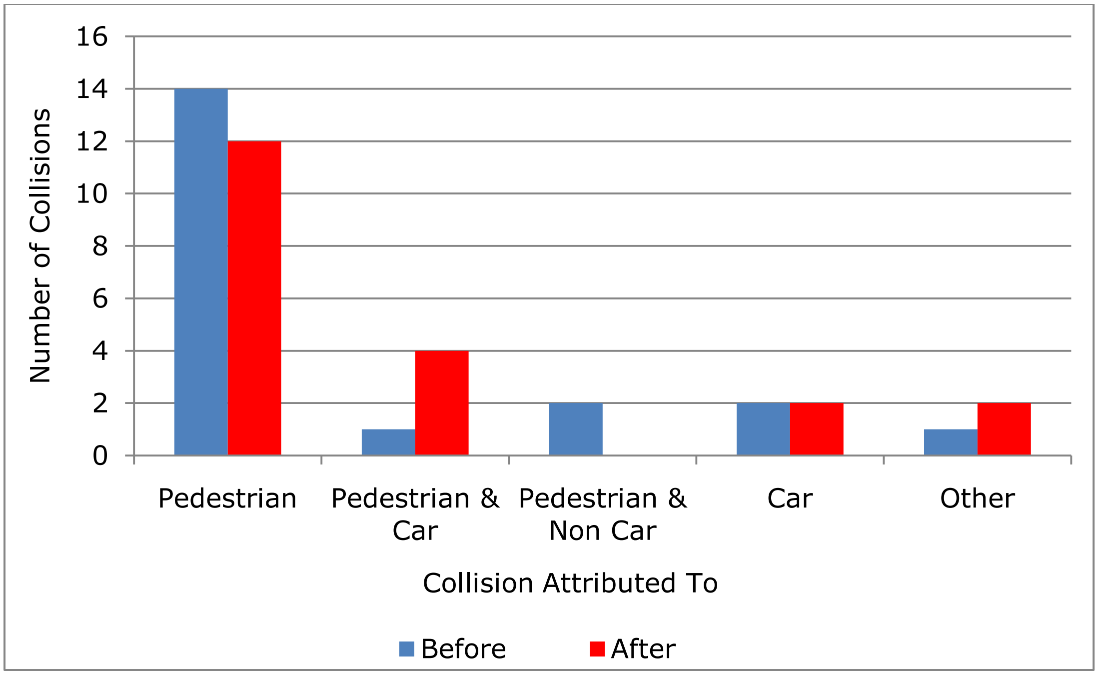


Figure 46: Person Considered at Fault: Collisions Involving Pedestrians and a Vehicle Travelling in Direction of Interest

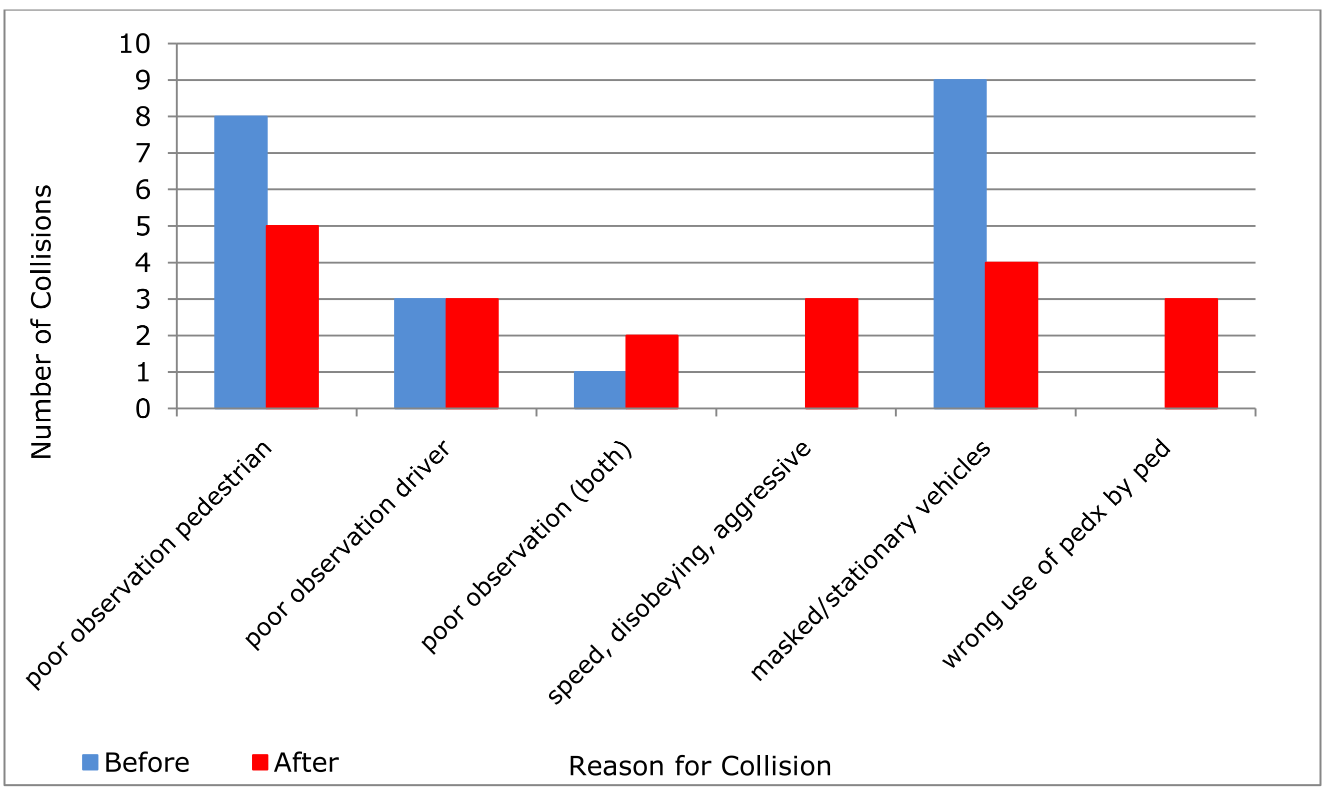


Figure 47: Attributed Cause Of Collisions: Involving Pedestrians and a Vehicle Travelling in Direction of Interest

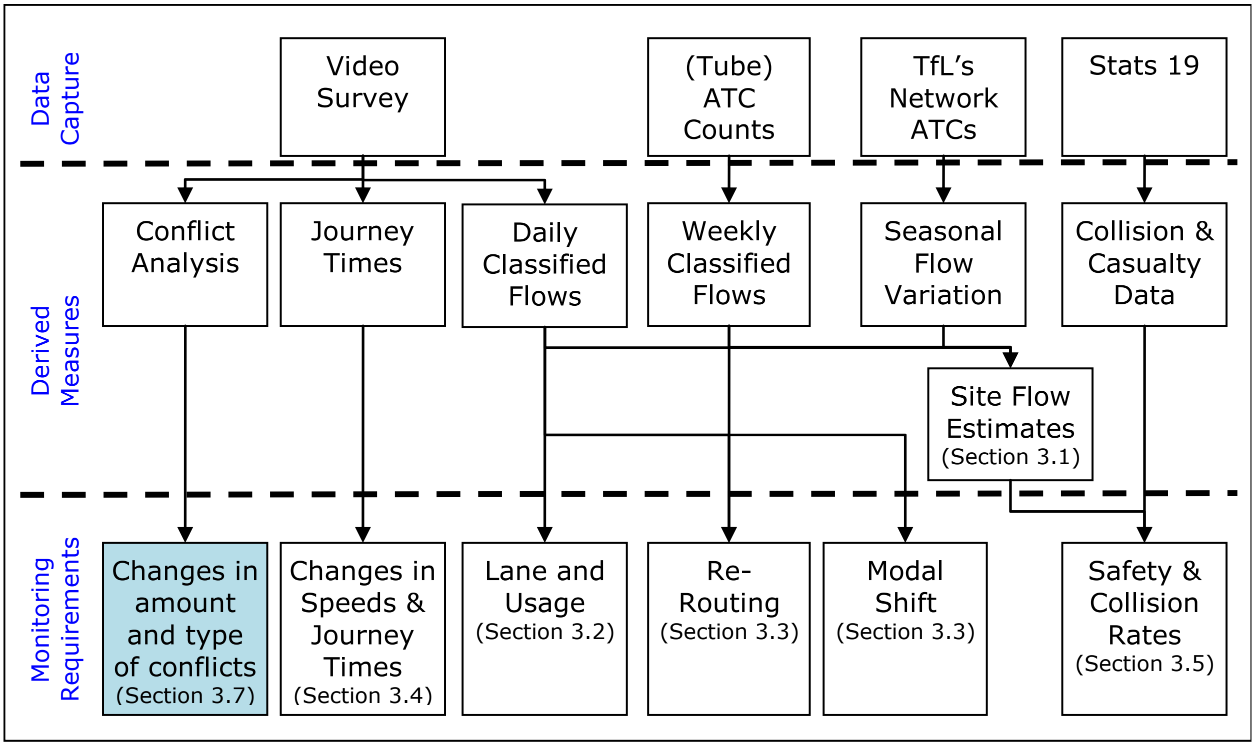
Most collisions involving pedestrians were through the pedestrian not being observant and therefore placing themselves into conflict with a vehicle. All aspects of this analysis show that there was no evidence of pedestrian safety being affected by motorcycles being permitted access to the bus lanes.

3.6.4 Conclusions

Conclusions - Detailed Examination of Collisions

- The increase in motorcycle collisions did not appear to be a result of a settling down period for the scheme.
- The increase in motorcycle collisions generally involved cars turning left into and out of side roads.
- The severity level of the motorcycle collisions had increased with a 25% increase in slight injury and a 50% increase in serious injury collisions, although the numbers involved in the sample are small and should be treated with caution.
- The increase in cycle collisions could be partially explained by the increase in cycle flows.
- It appeared that the change in cycle collisions was not a result of motorcyclists being permitted access to the bus lane.

3.7 Conflicts Involving Motorcycles or Cycles



One of the main considerations when introducing any road scheme is its effect on safety and this is of particular relevance to permitting motorcycles into bus lanes. There are two main considerations within this analysis. Firstly, these are the effect the scheme has on the safety of motorcyclists and secondly, the effect on other vulnerable road users, in particular cyclists. Permitting motorcyclists into the bus lane should remove them from the main traffic flow and could therefore reduce their interaction with other road users. However, this study has shown in Section 3.4 that they utilise their priority to gain a journey time advantage. It is also possible that a fast moving and inconspicuous vehicle in a lane that is traditionally used for slower moving traffic (buses and cycles) could be unobserved by other road users bringing them into conflict with them. For example, cyclists could now interact with a new priority user and this may affect their safety.

This section examines how observed motorcycles and cycles moved through the study sites and whether they conflicted with other road users whilst observed. A conflict occurs when two road users attempt to use the same road space, and this results in one or both reacting by moving out of the way of the other road user (swerving), or by slowing (or accelerating) to prevent the same road space being used.

Conflicts are not collisions between road users; rather they can be the precursor of a collision. A collision can only occur if two road users actually use the same road space. Collisions are a rare occurrence and conflicts can show the movements and interactions between road users that can result in them.

A conflict analysis has been performed to assess any changes in behaviour of road users and their effect on conflicts. The results of this analysis consider the effect on the number, type and severity of the conflicts. These are then compared and contrasted to the results of the collision analysis in Section 3.6.

It should be noted that the collision analysis was included in the study brief after video filming had begun. The video placement was primarily chosen based on the timing points for the journey time analysis. As a result some camera views were not optimum for the conflict analysis.

It should also be noted that due to the short video data collection periods and the small conflict zones, the numbers of conflicts are generally quite small. As such, the conflict analysis is intended as supporting information to the more robust STATS19 collision analysis.

3.7.1 Conflict Methods and Definition

A conflict analysis was performed on the two days of video data collected for flow and journey time analysis for all the 28 Main sites. This analysis did not include the Control sites as the conditions had not changed on those sites and therefore the types of conflicts would not be expected to alter.

A conflict zone was defined in the cameras field of view: where possible the conflict zone was 75, or 100 metres in length and was split into 25 sub-zones. This approach was taken in order to permit the investigation of where any observed conflicts occurred in relation to the road layout being studied. For example, it would permit the identification of conflicts being associated with the start of a bus lane, or the presence of a side road.

The method was to select up to 50 motorcycles and up to 50 cycles each hour (depending on the available flows). Each of these selected road users (object vehicle) were monitored through the conflict zone. Any conflicts between these vehicles and other road users were recorded, including information on:

- Severity of conflict
- Extent of braking used by object vehicle
- Extent of swerving used by object vehicle
- Lane of object vehicle
- Position in lane of object vehicle
- Manoeuvre of object vehicle
- Type of other road user
- Lane of other road user
- Position in lane of other road user
- Manoeuvre of other road user
- Braking of other road user
- Swerving of other road user
- Queuing

Three measures of severity were recorded. The extent of braking and swerving was noted which was classified as none, slight or heavy. Also, the overall severity of the conflict was judged by the observer on a qualitative scale from 1 to 5 with the following definitions:

- 1 – “Precaution”
- 2 – “Controlled”
- 3 – “Rapid / Near-miss”
- 4 – “Emergency / Very-near”
- 5 – “Accident”

For each of the 28 Main sites (Sites 1 to 33) the following time periods sampled for the morning peak, off-peak and evening peak, were analysed on both video days:

- 07:30 to 08:30; 08:30 to 09:30
- 12:00 to 13:00; 13:00 to 14:00
- 16:00 to 17:00; 17:00 to 18:00

3.7.2 Examples of Conflicts of Higher-level Severity

The screenshot captures below illustrate some of the Severity Level 2 and 3 observed conflicts involving motorcycles using the bus lane.

Figure 48: Severity Level 2 – Motorcycle Brakes to Manoeuvre Around Car (Site 27, After Survey)

Figure 48 shows a conflict between a motorcycle and car in the After survey. The car pulled out from the side-road and waited to join the traffic queue, blocking entry to the bus lane. The motorcycle braked then weaved past into the bus lane in a controlled manner.

Figure 49: Severity Level 2 – Motorcycle Brakes to Manoeuvre Around Car and Wait for Cyclist (Site 27, After Survey)

Figure 49 shows another conflict on Site 27, also in the After survey. A car was waiting to join the traffic queue and was blocking the entrance to the bus lane. The motorcycle had to brake, and waited for the cyclist to pass. The motorcycle then entered the bus lane in a controlled manner.

Figure 50: Severity Level 2 - Motorcycle Cuts in Front of Car to Enter Bus Lane (Site 30, After Survey)

Figure 50 shows a conflict between a motorcycle and a car. The motorcycle overtook the car near the bollards then weaved in front of it to gain access to the bus lane.

Figure 51: Severity Level 3 - Car Pulls Out in front of Motorcycle (Site 31, After Survey)

Figure 51 shows a screen capture from the only Severity Level 3 (or higher) conflict involving a motorcycle. The car had just pulled out of the side-road on the left and was accelerating up to speed. The motorcycle was travelling reasonably fast and had to brake quite hard. Further downstream on the 2nd camera, the same car turned right, at which point the motorcycle entered the bus lane to undertake it.

3.7.3 Distinction between Conflict and "Passing Vehicle"

The definition of conflict is when two road users manoeuvre, or change speed, owing to trying to use the same road space. For larger vehicles this is a clear definition. However, some motorcycles and cycles were observed on some sites to use the opposite side of the road to overtake traffic queues. These were noted as a 'potential conflict' in the data extraction. Close inspection of these manoeuvres showed that although the motorcyclists were potentially conflicting with on-coming traffic, these were not true conflicts and should be eliminated from the main analysis. It was possible to identify these based upon the manoeuvre, lane and lane position and they were considered separately to the rest of the analysis.

Motorcycles and cycles were also observed filtering through traffic and these interactions were retained as low-severity conflicts.

All sampled motorcycles and cycles were observed from the start of the conflict zone through to its end. The maximum number observed of each mode was 50 in any hour, and they were observed for 6 hours on each of two survey days for all 28 sites. Consequently, the total number of observations possible was 16,800 (50 x 6 x 2 x 28).

Table 26 shows the total number of these "passing vehicle" observations as well as other observations.

	Motorcycles		**Cycles**	
Type	**Before**	**After**	**Before**	**After**
"Conflicts"	311	125	32	7
Passing Vehicles	540	235	1	0
Other Observations	10,385	11,313	9,768	10,391
Total Observations	11,236	11,673	9,801	10,398

Table 26: Passing Vehicles and Other Observations

There was a large reduction from 540 to 235 of observations where the motorcycle used the opposite side of the road to overtake vehicles between the two surveys. This reduction across all sites in this type of manoeuvre was 57%, which is in approximate agreement with the increased use in bus lane use by motorcycles that rose from 6 to 51%. It would appear that motorcyclists switched from overtaking on the outside of traffic queues in the Before survey to undertaking using the bus lane in the After survey.

Site 7 in particular experienced a major reduction in this behaviour, with a reduction from 206 to 3 observations.

3.7.4 Overall Number of Conflicts

Table 27 shows the number of conflicts of all severities.

	Motorcycles		Cycles	
Type	**Before**	**After**	**Before**	**After**
Conflict	311	125	32	7
Total Observations	11,236	11,673	9,801	10,398

Table 27: Conflicts of All Severities

The total number of conflicts with motorcyclists fell by 60% between the two surveys, and the number with cyclists fell by 78%. The reduction in conflicts with motorcyclists was significant (at the 95% confidence level) on 17 out of the 28 sites, although there was a significant increase on 2 sites. This does not necessarily mean that motorcyclists are safer on these sites. This can only be determined by investigating the severity of the conflicts, see Section 3.7.5.

This analysis implies that the high percentage of motorcyclists deciding to use the bus lane when permitted to do so resulted in them interacting less with the general traffic flow. These changes could be a result of fewer avoidance actions, but could also be a result of less low speed manoeuvres in the After study through motorcyclists not filtering close to traffic queues.

3.7.5 Change in Severity of Conflicts

The previous sections have identified that motorcyclists interacted less with traffic after they were permitted into the bus lanes. This is in line with expectation as they are segregated from the majority of the traffic when they use the priority lane. This, however, does not directly translate into the motorcyclists being safer in the After study. The severity of the conflicts is of most importance in interpreting safety. The severity was scored on a qualitative scale from 1 to 5 with the following definitions:

- 1 – “Precaution”
- 2 – “Controlled”
- 3 – “Rapid / Near-miss”
- 4 – “Emergency / Very-near”

- 5 – “Accident”

In particular, precautionary manoeuvres only indicate a very low-level interaction that could be expected as a natural consequence of motorcycles standard behaviour of overtaking and filtering through traffic. The most importance should be attributed to conflicts scored as higher severity, as these are associated with avoidance actions. Table 28 below shows the number of conflicts of each severity level observed across all sites.

Severity	**Motorcycles**		**Cycles**		**Total**
	Before	**After**	**Before**	**After**	
1	307	116	32	3	**458**
2	4	8	0	1	**13**
3	0	1	0	0	**1**
4	0	0	0	3	**3**
5	0	0	0	0	**0**
Total Conflicts	**311**	**125**	**32**	**7**	**475**
Total Observations	11,236	11,673	9,801	10,398	43,108

Table 28: Conflicts According to Severity

For motorcycles and pedal cycles, there was a decrease in the overall number of conflicts. Overall, for motorcycles, the reduction was from 311 to 124 with the split being a reduction from 307 to 116 for level 1 and an increase from 4 to 8 for level 2. The cycle conflicts fell from 32 to 3 for level 1, although 1 conflict at level 2 was seen in the after survey.

Motorcycle conflicts in bands 3 and above showed an increase from 0 to 1 in severity level 3, and there were no conflicts for motorcycles in either the before or after periods for levels 4 and 5.

For pedal cycles the only conflicts registered in bands 3 and above were in the after survey and these were 3 conflicts at severity level 4.

Significance tests were performed on the changes in conflicts of different severity levels across all Main sites surveyed, see Table 29 and Table 30.

Severity Level	Before		After		Z Statistic	Significant at 95%
	Number of conflicts	Total Observations	Number of conflicts	Total Observations		
1	307	11,236	116	11,673	9.77	Y
2	4	11,236	8	11,673	-1.09	N
3	0	11,236	1	11,673	-0.98	N

Table 29: Statistical testing of motorcycle conflicts

Severity Level	Before		After		Z Statistic	Significant at 95%/90%
	Number of conflicts	Total Observations	Number of conflicts	Total Observations		
1	32	9,801	3	10,398	5.08	Y/Y
2	0	9,801	1	10,398	-0.97	N/N
3	0	9,801	0	10,398	N/A	N/N
4	0	9,801	3	10,398	-1.68	N/Y

Table 30: Statistical testing of cycle conflicts

These tests show that the decrease in Level 1 conflicts involving motorcycles or cycles was significant at the 95% level. The increase in Level 2, 3 and 4 conflicts involving motorcycles was not significant, but the increase in Level 4 conflicts (from 0 to 3) involving cycles was significant at the 90% level although none of these involved an interaction with a motorcycle, as discussed in Section 3.7.7.

3.7.6 Circumstances of Conflicts – Motorcycles or Cycles

Previous sections have established that there was a significant reduction in the number of precautionary conflicts, but there was a (generally non-significant) negligible increase in conflicts of higher severity when each severity level is looked at in isolation or aggregated. This section considers the circumstances underlying the changes. Firstly, the location of the conflicts is considered in Table 31; that is whether it occurred in the bus lane, or in one of the non-priority lanes.

Severity Level	Lane	Motorcycles		Cycles		Total
		Before	After	Before	After	
1	Bus Lane	19	39	25	2	**85**
	Non-priority	288	77	7	1	**373**
2	Bus Lane	0	3	0	1	**4**
	Non-priority	4	5	0	0	**9**
3	Non-priority	0	1	0	0	**1**
4	Bus Lane	0	0	0	3	**3**
	Total	**311**	**125**	**32**	**7**	**475**

Table 31: Conflicts According to Lane

The aggregated number of precautionary and controlled conflicts involving a motorcycle in the non-priority lanes reduced from 292 and 82, but increased from 19 to 42 in the bus lanes, the reductions should be attributed to the severity level 1 conflicts in the non-priority lane. There was a slight (and not statistically significant) increase in conflicts in the bus lane for motorcycles for both severity levels 1 and 2.

This is again consistent with the motorcyclists switching from using the non-priority lanes to using the bus lane.

Next the lane position of the motorcyclists and cyclists is considered, see Table 32.

Severity	Lane and Position	Motorcycles		Cycles	
		Before	After	Before	After
1	Bus Lane, Left	0	3	2	0
	Bus Lane, Middle	2	2	0	1
	Bus Lane, Right	14	33	20	1
	Bus Lane, Varying	3	1	3	0
	Non-Priority Lane, Left	203	53	1	0
	Non-Priority Lane, Middle	45	3	0	0
	Non-Priority Lane, Right	28	20	4	1
	Non-Priority Lane, Varying	12	1	2	0
2	Bus Lane, Middle	0	2	0	0
	Bus Lane, Right	0	0	0	1
	Bus Lane, Varying	0	1	0	0
	Non-Priority Lane, Middle	0	1	0	0
	Non-Priority Lane, Right	4	4	0	0
3	Non-Priority Lane , Right	0	1	0	0
4	Bus Lane, Left	0	0	0	2
	Bus Lane, Middle	0	0	0	1
	Total	**311**	**125**	**32**	**7**

Table 32: Conflicts According to Lane Position

The largest decrease in precautionary (Severity Level 1) conflicts involving a motorcycle was for those in the left hand lane of the non-priority lane: reducing from 203 to 53 after they were permitted access to the bus lane. This could indicate that fewer motorcycles were filtering through the traffic on the inside, instead they entered the bus lane. It is not possible to establish whether the lane position was a contributory factor in higher level conflicts owing to the low numbers of such conflicts that occurred.

Another potential contributory factor underlying changes in conflicts is potentially the manoeuvres of the vehicles involved. Table 33 shows the conflicts of the motorcyclists and cyclists by manoeuvre they were making.

Severity	Manoeuvre	Motorcycles		Cycles	
		Before	After	Before	After
1	None	8	3	4	1
	Changing lanes left	91	40	3	1
	Changing lanes right	18	15	4	1
	Passing stationary vehicle	54	33	19	0
	Passing moving vehicle	132	25	2	0
	Turning right into side road	3	0	0	0
	Other	1	0	0	0
2	None	0	1	0	0
	Changing lanes left	0	1	0	0
	Changing lanes right	0	1	0	1
	Passing stationary vehicle	2	4	0	0
	Passing moving vehicle	2	1	0	0
3	None	0	1	0	0
4	None	0	0	0	3
	Total	**311**	**125**	**32**	**7**

Table 33: Manoeuvre at time of conflict

The most conflicts occurred through motorcyclists passing either moving, or stationary, traffic. The decreases (or increases) in conflicts of different severities were mainly associated with such manoeuvres although, to a lesser extent, they were also associated with changing lanes.

In addition to the overall level of the conflict, information was also collected on the level of braking or swerving utilised during each conflict, see Table 34 and Table 35.

Severity	Braking	Motorcycles		Cycles	
		Before	After	Before	After
1	None	78	9	25	2
	Slight Braking	225	94	6	1
	Heavy Braking	4	11	1	0
	Slight Acceleration	0	2	0	0
2	Slight Braking	4	2	0	1
	Heavy Braking	0	5	0	0
	Slight Acceleration	0	1	0	0
3	Heavy Braking	0	1	0	0
4	Heavy Braking	0	0	0	3
	Total	**311**	**125**	**32**	**7**

Table 34: Motorcycles, or cycles, braking at time of conflict

Severity	Swerving	Motorcycles		Cycles	
		Before	After	Before	After
1	No Swerving	30	3	2	1
	Slight Swerving	257	92	26	1
	Heavy Swerving	20	21	4	1
2	No Swerving	0	1	0	0
	Slight Swerving	3	1	0	0
	Heavy Swerving	1	6	0	1
3	Slight Swerving	0	1	0	0
4	Heavy Swerving	0	0	0	3
	Total	**311**	**125**	**32**	**7**

Table 35: Motorcycles, or cycles, swerving at time of conflict

This analysis supports the view that it is the level of severity that changed slightly between the two surveys. The number of motorcycle conflicts involving slight braking and/or slight swerving reduced: from 229 to 96, and from 260 to 94 respectively. However, the number of motorcycle conflicts involving heavy braking and/or heavy swerving increased: from 4 to 17, and from 21 to 27 respectively.

For motorcycle conflicts of all severity levels: the increase in heavy braking was significant at the 95% Level; the decrease in slight braking was significant at the 95% Level; and the increase in slight acceleration was significant at the 90% Level. For cycles, there was no significant change in braking or acceleration.

For conflicts of all severity levels: the decrease in slight swerving was significant at the 95% Level for both motorcycles and cycles; and there was no significant change in heavy swerving. However, for conflicts of Severity Level 2, the increase in heavy swerving was significant at the 90% Level for motorcycles.

3.7.7 Circumstances of Conflicts – Other Road User

The previous section considered the lane position and the manoeuvre being made by each of the motorcycles and cycles involved in a conflict. This section considers similar information for the other road user involved in the conflict.

Other road users were classified into: Pedestrian; Cycle; Motorcycle; Car; Taxi; LGV; HGV; Bus; and Other PSV. Table 36 below summarises the other vehicles involved in the conflict.

Severity	**Other Vehicle Type**	**Motorcycles**		**Cycles**		**Total**
		Before	**After**	**Before**	**After**	
1	Pedestrians	1	0	1	0	**2**
	Cycles	1	0	0	0	**1**
	Motorcycles	7	1	0	0	**8**
	Cars	194	52	14	0	**260**
	Taxis	13	11	2	0	**26**
	LGVs	75	31	11	2	**119**
	HGVs	13	6	3	0	**22**
	Buses	3	15	1	1	**20**
2	Cars	3	5	0	0	**8**
	LGVs	1	2	0	0	**3**
	HGVs	0	1	0	1	**2**
3	Cars	0	1	0	0	**1**
4	Cars	0	0	0	2	**2**
	Taxis	0	0	0	1	**1**
	Total	**311**	**125**	**32**	**7**	**475**

Table 36: Other vehicles involved in the conflicts

Most conflicts involved either a car or a light goods vehicle. In particular, 7 out of 8 of the motorcycle conflicts at severity level 2 were with such vehicles. And the only level 3 conflict was with a car. For Severity Level 1 "Precautionary" conflicts there has been a reduction between motorcycles and cars, LGVs and other motorcycles, but an increase between motorcycles and buses, significant at the 95% Level. This trend is as expected, because the motorcycles would inevitably interact more with the buses when using the bus lane, albeit smaller numbers compared to interactions with cars due to the lower bus flows. These low-level interactions may include actions such as letting the bus pull out of a bus stop.

The other element to understanding the type of conflicts involved is the manoeuvre being conducted by the other road user. See Table 37.

Severity	**Other Vehicle Manoeuvre**	**Motorcycle**				**Cycle**			
		Before		**After**		**Before**		**After**	
		Bus Lane	Non-Priority	Bus Lane	Non-Priority	Bus Lane	Non-Priority	Bus Lane	Non-Priority
1	None	19	261	38	74	23	5	0	1
	Changing lanes left	0	0	0	0	1	0	0	0
	Changing lanes right	0	2	0	0	0	0	1	0
	Passing stationary vehicle	0	0	0	1	0	0	0	0
	Passing moving vehicle	0	1	0	0	0	1	0	0
	Turning left into side road	***0***	***0***	***0***	***2***	***1***	***0***	***1***	***0***
	Turning right into side road	0	21	0	0	0	0	0	0
	Turning left out of side road	***0***	***0***	***1***	***0***	***0***	***0***	***0***	***0***
	Other	0	3	0	0	0	1	0	0
2	None	0	4	1	3	0	0	0	0
	Turning left into side road	***0***	***0***	***0***	***1***	***0***	***0***	***1***	***0***
	Turning right into side road	0	0	0	1	0	0	0	0
	Turning left out of side road	***0***	***0***	***2***	***0***	***0***	***0***	***0***	***0***
3	***Turning left out of side road***	***0***	***0***	***0***	***1***	***0***	***0***	***0***	***0***
4	None	0	0	0	0	0	0	1	0
	Turning right into side road	0	0	0	0	0	0	2	0
	Total	**19**	**292**	**42**	**83**	**25**	**7**	**6**	**1**

Table 37: Other vehicles manoeuvres involved in the conflicts

Most of the potential conflicts (Severity Level 1) were with other road users that were simply going ahead. This again emphasises that the motorcycles and cycles were generally over-taking or under-taking the road users in this type of conflict. The only notable reduction in potential conflicts was amongst those involving the other road user in the non-priority lane turning right into a side road: decreasing from 21 to 0. That is, permitting motorcycles access to the bus lane appears to have reduced the extent to which they are overtaking on the outside of the traffic queues and therefore reduces the extent to which they have low-level conflicts with right turning traffic.

Examining the four additional motorcycle conflicts of Severity Level 2 and the one additional conflict at Severity Level 3, there was no difference in the number that involved motorcycles where the other road user was not making any manoeuvre. The difference in these higher severity conflicts appear to be associated with the other road user turning left either into, or out of, a side road: these are highlighted in bold italics.

The manoeuvres underlying the changes in the number of collisions are in agreement with the alterations in behaviour seen in the conflict analysis. Many motorcyclists have altered from filtering through traffic either on the outside of traffic, or between queues, to using the bus lane. It would also appear that they have made this alteration to gain a journey time advantage. The collision data implies that this has resulted in them being more likely to be involved in a collision, and those collisions are with cars turning left, possibly owing to the car drivers not seeing (or expecting) a fast moving vehicle on their nearside.

Although these are small numbers, this suggests that since implementation of the scheme, motorcycles have been involved in higher-level conflicts. These are generally with cars and light goods vehicles, with the motorcycle passing a queue of traffic and the other road user making a left turn.

Of the three incidents (that involved four conflicts with cycles) at Severity Level 2 or above, none involved an interaction with a motorcycle. The three incidents are briefly described below:

- Level 2 (Site 8, After) – A truck was reversing slowly out of a drive; the cycle didn’t wait and manoeuvred out of the bus lane, around the truck to overtake in a controlled manner.
- Level 4 (Site 27, After) – A car turned left out of the side road and had to wait to join the traffic queue, and as a result partially blocked the entrance to the bus lane. As a taxi came into view of the camera, a cyclist tried to undertake it. The taxi didn’t see the cyclist and manoeuvred around the waiting car into the bus lane. The cyclist had to brake to an emergency stop to avoid a collision.

- Level 4 (Site 1, After) – In a somewhat rare incident, a vehicle towing another vehicle turned right from the other side of road across the path of two cyclists. Neither cyclist saw the towing rope until very late and both had to brake very sharply.

The nature of the high-level severity conflicts involving cycles indicates no safety disbenefit due to the implementation of the scheme, because none of them involved any interaction with motorcycles.

3.7.8 Factoring up the Conflicts to 10-monthly Figures

The conflicts discussed above are relatively small numbers. It should be re-iterated that conflict data was analysed on the Main sites for up to 50 motorcycles and up to 50 cycles per hour, only during the peak periods. Also due to the field of view on the cameras, the conflict zone ranged from 35 to 149 metres across the sites.

In order to make the conflict data comparable to the STATS19 collision data, the conflict zones have been scaled up to the same size as the STATS19 zones and the conflict rates were multiplied by the 10-monthly motorcycle and cycle flows. Table 38 shows the estimated 10-month total for conflicts on the Main sites. Table 38 shows the estimated 10-month total for conflicts on the Main sites.

	Severity	Motorcycle		Cycle	
		Before	After	Before	After
Survey Total	1	307	116	32	3
	2	4	8	0	1
	3	0	1	0	0
	4	0	0	0	3
Estimated 10-month Total	1	1,171,825	372,511	113,202	7,957
	2	24,581	38,208	0	3,238
	3	0	3,728	0	0
	4	0	0	0	6,254

Table 38: Estimated 10-month Total Conflicts on the Main sites

The estimated number of Severity Level 2, "Controlled" motorcycle conflicts increase from approximately 25,000 to 38,000 over the 10-month period. There was only 1 observation of a Severity Level 3 "Rapid/Near Miss" motorcycle conflict in the After survey. However, once factored up, this represents 3,700 near miss conflicts across the 26 sites in the 10-month period.

3.7.9 Conclusions

Conclusions - Conflicts Involving Motorcycles or Cycles

- The number of level 1 conflicts involving motorcycles, decreased after they were permitted access to the bus lane probably as a result of the motorcyclists being segregated from the main traffic flow. However, these were unlikely to have safety implications.
- There was a small increase (from 4 to 8) in the number of level 2 conflicts after motorcycles were permitted access to the bus lane. The number of conflicts in severity level 3 were too few (four in total) to enable robust comparison, although more conflicts were seen in the After survey.
- In general increases in bus lane conflicts were as a result of more cars turning left into, or out of, side roads (albeit this conclusion is based on small numbers).

4 Effects on TLRN Network

The study examined twenty-eight Main sites and their Control sites in detail. It was possible to isolate the vehicles travelling in the direction of the bus lane on these sites and consider the movements they were making before the collision in this context. Comparing this with the conflict analysis that was also performed provided an in-depth insight into the underlying causal effects of the collision trends observed. In addition, traffic flow and composition, information was collected on each of these sites. This permitted a robust estimation of the 10 month classified flows on these sites, and therefore the associated trends in collision rates.

This previous analysis provides the most accurate and detailed understanding of collision trends resulting from permitting motorcycles into bus lanes. However, it is also informative to examine the collisions on the whole of the affected network. This has the advantage of showing overall trends and is based on improved sample sizes, however, the estimated flows are less accurate and detail information cannot be extracted to the same extent as for the Main sites.

A method was developed between TRL and TfL that captured all collisions on TLRN network (road) links with a bus lane: Network Sites. These were then compared (to Network Control Sites) to collisions occurring in London, but elsewhere on the road network. The Network Control consequently consisted of all Borough roads and any links on the TLRN without a bus lane.

One further complication had to be accounted for within the analysis. Motorcycles had previously been permitted into bus lanes within Westminster. Therefore the effect on relative safety in Westminster would be expected to be different from other roads in the London network. For this reason, all collisions in Westminster have been excluded from the analysis.

4.1 Defining the TLRN Bus Lanes

Data is extracted from the ACCSTATS database for a defined GIS (Geographic Information System) area. This is effectively a polygon overlaid on a London road map. The polygon was defined by using the information in the database on the outside (right-side) white line that delineates the bus lane. The width of the polygon was set to incorporate the road width, as well as accounting for positional inaccuracies in the collision records. It was also defined to include a distance both before and after the defined bus lane to ensure that any collisions involving vehicles moving into and out of the lane were captured. The rules that were developed to define the bus lane areas, and prevent double-counting collisions were:

1. If there were less than 100m between bus lanes starting and ending, then they were amalgamated into one lane. This had the advantage of avoiding double counting owing to the overlap of the start and end of lanes, it also avoided sections of bus lanes being dealt with as separate bus lanes. However, it did result in junctions being included within the statistical analysis.
2. A 50m distance around the bus lane line was used to define the bus lane. This covered all sized bus lanes, all lanes in the direction of travel, and a reasonable distance either side of the carriageway. This allowed collisions marked close to the carriageway, but not on it, to be captured. However, it had the disadvantage of capturing some accidents on side roads, although this was constant between the surveys.
3. Where bus lanes are in each direction they were amalgamated into one bus lane, to prevent double counting from overlap of defined bus lanes.
4. The maximum distances of amalgamated bus lanes were used. For example, suppose the bus lane in one direction started 20m before the point where the bus lane in the other direction ended. Then the bus lane in the other direction was extended by 20 metres and therefore included 20m after its end.
5. Where two bus lanes of different operating hours are amalgamated, the longest hours were used. For example, if one was 0700 to 1600 and the other 1200 to 1900, then the hours 0700 to 1900 would be used for the amalgamated bus lane.
6. The distance before and after the bus lane included in the analysis was 20m. Thus for short setbacks this could extend into a junction.

4.1.1 Conclusions

Conclusions - Defining the TLRN Bus Lanes

- A series of rules were developed between TRL and TfL to correctly capture collisions occurring between vehicles (and pedestrians) on the approach, within and leaving all bus lanes on the TLRN.

4.2 Network Flows

Collision rates require the estimation of the vehicle flows on the TLRN network. The overall approach to get these was broken down into three steps:

1. Estimate Before and After 10-monthly average link flows for each London Borough for both TLRN and non-TLRN
2. Multiply these estimates by the relevant road lengths in each borough to get vehicle-km
3. Scale the TLRN and non-TLRN vehicle-km estimates by TfL estimates.

Step 1 - Flow estimates for the period January to October were available for 28 Main sites. These 28 sites were situated across 11 different London boroughs. For each of these 11 London boroughs, the average flows were computed and applied to all roads in that borough. For the 22 remaining London boroughs, a model was designed to estimate relative flows by weighting according to the distance from the centre of each borough. A sensitivity analysis was performed to assess the "best" function of distance for this purpose, and the flows were weighted according to the distance squared. A similar approach was taken for the 28 Control sites.

Step 2 - The flows were converted into vehicle-kilometres using the lengths of the road network supplied by TfL. The road lengths were for the whole of the TLRN. Therefore, the available data did not indicate the length of roads in the TLRN without a bus lane; it was assumed that all had bus lanes within this analysis.

Step 3 - The calculated vehicle-kilometres were finally scaled using TfL's estimate of overall network flows. A similar process was used to estimate flows on the non-TLRN network using the estimated flow on the Network Control Sites. However, road lengths were only available for Borough's "roads of interest", i.e. generally those with bus routes. Therefore, the non-TLRN road length estimate did not include all roads, whilst the ACCSTATS data was for all roads within London. However, the majority of collisions would be expected to be on the main roads within the network, and therefore the collisions were effectively associated with the "roads of interest".

4.2.1 Conclusions

Conclusions - Network Flows

- Network flows were modelled by extrapolating the modelled flows on the 28 sites to forming an average flow in each London Borough.

4.3 Collision Rates on the Network

The number of collisions on the Network Sites, and for the remaining road network (Network Control Sites), was extracted from the ACCSTATS database for each London borough, see Section 4.1. These have been divided by an estimate of the vehicle-kilometres by mode, see Section 4.2, with collisions and roads in Westminster excluded. The resulting collision rates for motorcycles, cycles and pedestrians have been compared between the before and after 10-month periods, accounting for any trends on the Network Control (i.e. Borough roads and TLRN roads without bus lanes). This analysis was conducted using the Hauer approach, the results of which can be seen in the following sections.

4.3.1 Motorcycle Collision Rates

An analysis was performed to investigate whether any changes in the motorcyclist collision rate had occurred on the Network Sites, and whether it was attributable to other changes in network flows. The results of the Hauer approach are shown in Table 39.

		All Boroughs (excl Westminster)
Increase in rate per veh-km	Main	9.2%
	Control	-3.0%
Collisions	Observed	555.0
	Expected	492.6
	Difference	62.4
	Standard error of difference	35.8
Statistical significance		<0.10
% increase relative to control		12.3%

Table 39 : Summary of Motorcycle Collisions Rates over Network

The rate at which motorcyclists were involved in collisions on the Network Sites increased by 9.2% and decreased by 3.0% on the Network Control sites. This suggests that overall the Network Sites had a higher collision risk for motorcycles due to the use of bus lanes. The difference between the expected and observed collisions, having taken into account changes in the control sites and flows, was significant at the 90% confidence level. Therefore, although the fitted increase in collisions on the TLRN Network with bus lanes (Network Sites) had increased by a lesser extent than the fitted increase on the Main sites studied in detail, the conclusion that permitting motorcycles into bus lanes appears to have increased the collision rate of motorcyclists was found in both analyses.

4.3.2 Cycle Collision Rates

A similar analysis was performed to investigate whether any changes in the cyclist collision rate had occurred on the Network Sites, and whether it was attributable to other changes in network flows. The results of the Hauer approach are shown in Table 40.

		All Boroughs (excl Westminster)
Increase in rate per veh-km	Main	-5.8%
	Control	-14.3%
Collisions	Observed	361.0
	Expected	328.1
	Difference	32.9
	Standard error of difference	28.4
Statistical significance		>0.10
% increase relative to control		9.6%

Table 40 : Summary of Cycle Collision Rates over Network

The rate at which cyclists were involved in collisions on the Network Sites decreased by 5.8% and decreased by 14.3% on the Network Control sites, therefore there was a relative increase of 9.6% on the Network Sites. However, the difference between the expected and observed collisions was not statistically significant and the change in rate was less than the 140% increase observed on the Main sites. Overall, there is some evidence that the cycle collision rate had increased, however, the sample size on the Main Sites was small and the degree of any change is uncertain.

4.3.3 Pedestrian Collision Rates

An analysis was performed to investigate whether any changes in the pedestrian collision rate had occurred on the Network Sites, using the overall flow in all vehicles. The results of the Hauer approach are shown in Table 41.

		All Boroughs (excl Westminster)
Increase in rate per veh-km	Main	6.0%
	Control	-3.1%
Collisions	Observed	357.0
	Expected	326.2
	Difference	30.8
	Standard error of difference	27.6
Statistical significance		>0.10
% increase relative to control		9.0%

Table 41 : Summary of Pedestrian Collision Rates over Network

The rate at which pedestrians were involved in collisions on the Network Sites increased by 6.0% and decreased by 3.1% on the Network Control sites, therefore there was a relative increase of 9.0% on the Network Sites.

However, the difference between the expected and observed collisions was not statistically significant and the change in rate was in the opposite direction to the non-significant decrease observed on the Main sites. Therefore, overall, there was no evidence for a significant change in pedestrian collision rates.

4.3.4 Conclusions

Conclusions - Collision Rates on the Network

- The relative change in collision rates on the TLRN roads with a bus lane compared and other lanes appears to imply that permitting motorcycles access to bus lanes:
    - increased motorcyclists' chance of having a collision.
    - did not affect cyclists' chance of having a collision
    - did not affect pedestrians' chance of having a collision

4.4 Collisions on the Network

Previous sections have examined the collision rates of motorcycles, cycles and pedestrians. These have shown that permitting motorcycles into the bus lanes has affected collisions. In particular it has increased the percentage of motorcycles and cycles involved in collisions. This section considers the collision information without taking into account the flows. This permits a more detailed analysis of when the collisions occurred and the vehicles involved in the collisions.

It should be noted that there is a slight difference in interpreting the collision information for vehicles and for pedestrians. Information is recorded for all vehicles involved in each collision, so the number of vehicles involved in collisions can be calculated. However, the database only contains data on whether a pedestrian was involved in a collision. Therefore in the collision discussion, the number of pedestrians refers to the number of collisions involving pedestrians.

4.4.1 Collisions Involving Vulnerable Users

The overall number of motorcycles and cycles involved in collisions, and the number of collisions involving a pedestrian, are shown in Figure 53 for the Network Sites (TLRN) and the Network Control Sites. Also, the percentage change in these measures between the Before and After periods is shown in Figure 53.

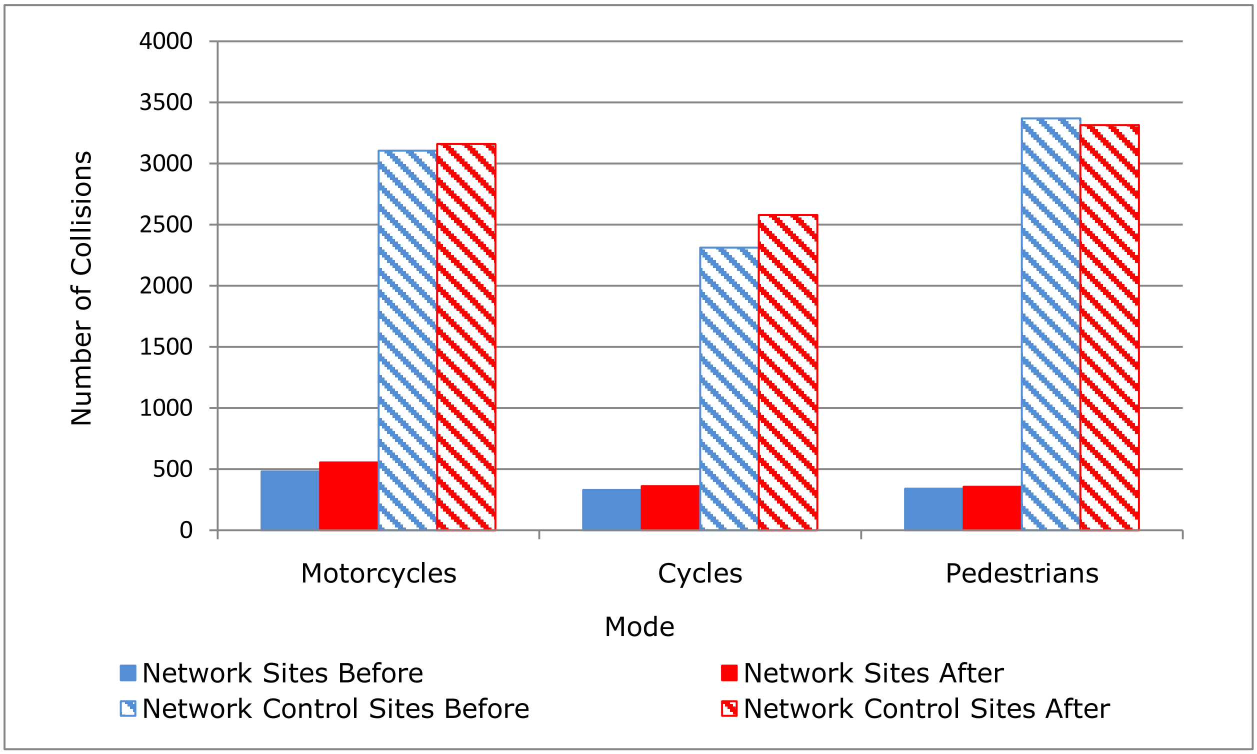


Figure 52: Number of Collisions Involving Vulnerable Users

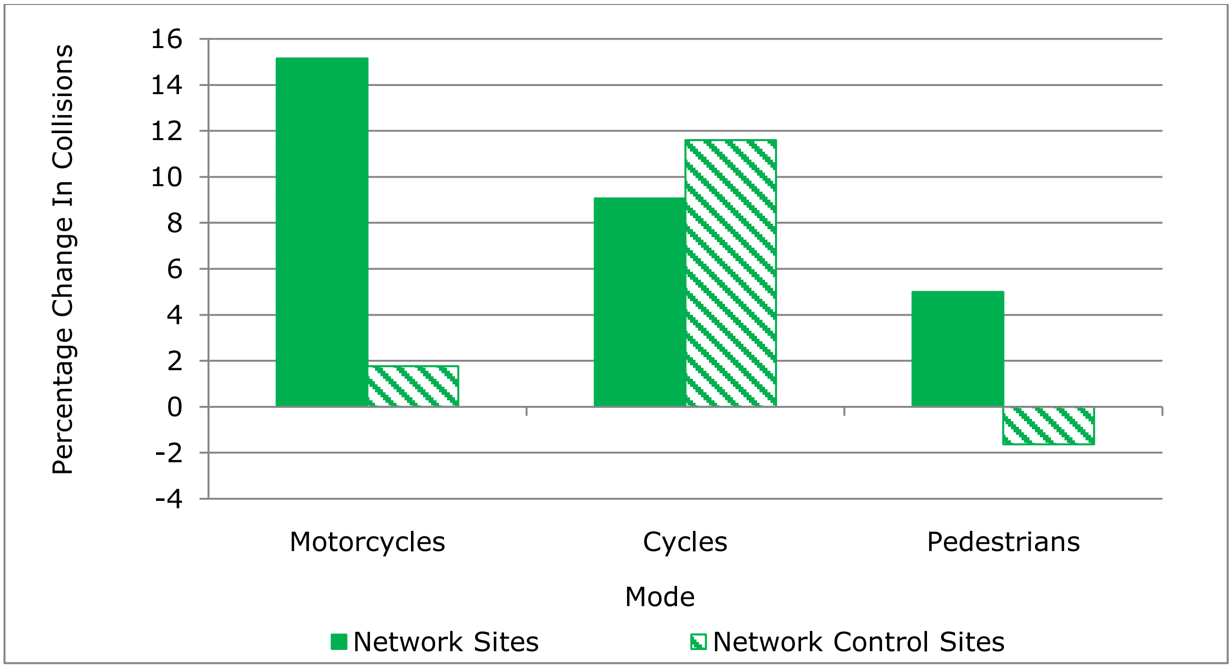


Figure 53: Percentage Change in Collisions Involving Vulnerable Users

The absolute increase in number of motorcycle involved in collisions on the network was similar on both the Network Sites and the Network Control Sites. However, in percentage terms there was a large increase in collisions involving motorcycles on the Network Sites (15%), which was not seen on the Network Control Sites.

The number of cycles involved in collisions had increased on both the Network Sites and the Network Control Sites and, although this represented a relative collision rate change of 9.6%, it was not significant. Similarly, the number of collisions involving pedestrians had increased on the Network Sites, but the relative collision rate change was not significant.

The distribution of the collisions involving motorcycles on London's road network is shown in Figure 54. This shows that the location of the collisions on the TLRN (Network Sites) has not been greatly affected, only the number of motorcyclists involved in the collisions.

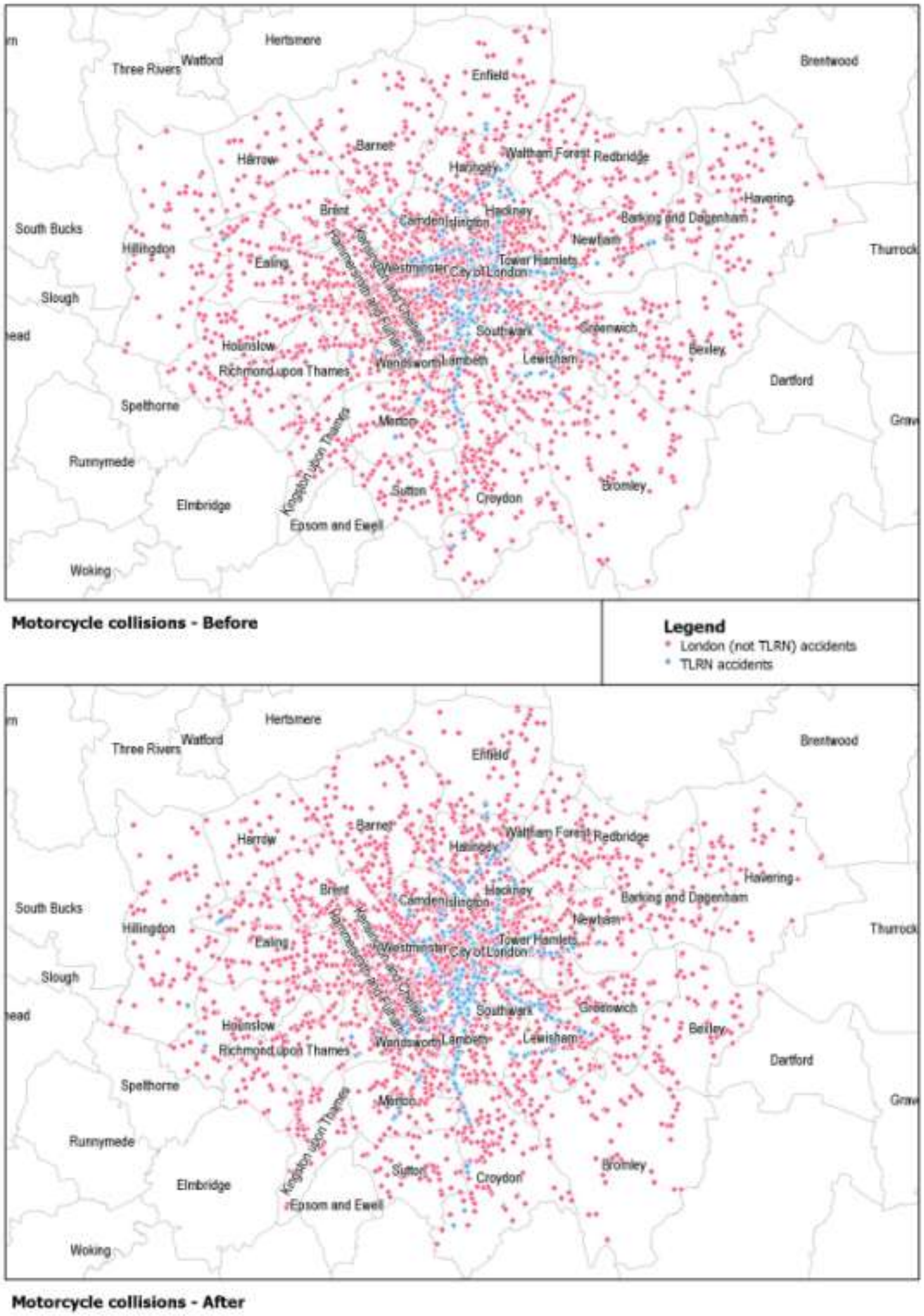


Figure 54: Spatial Distribution of Motorcycle Collisions

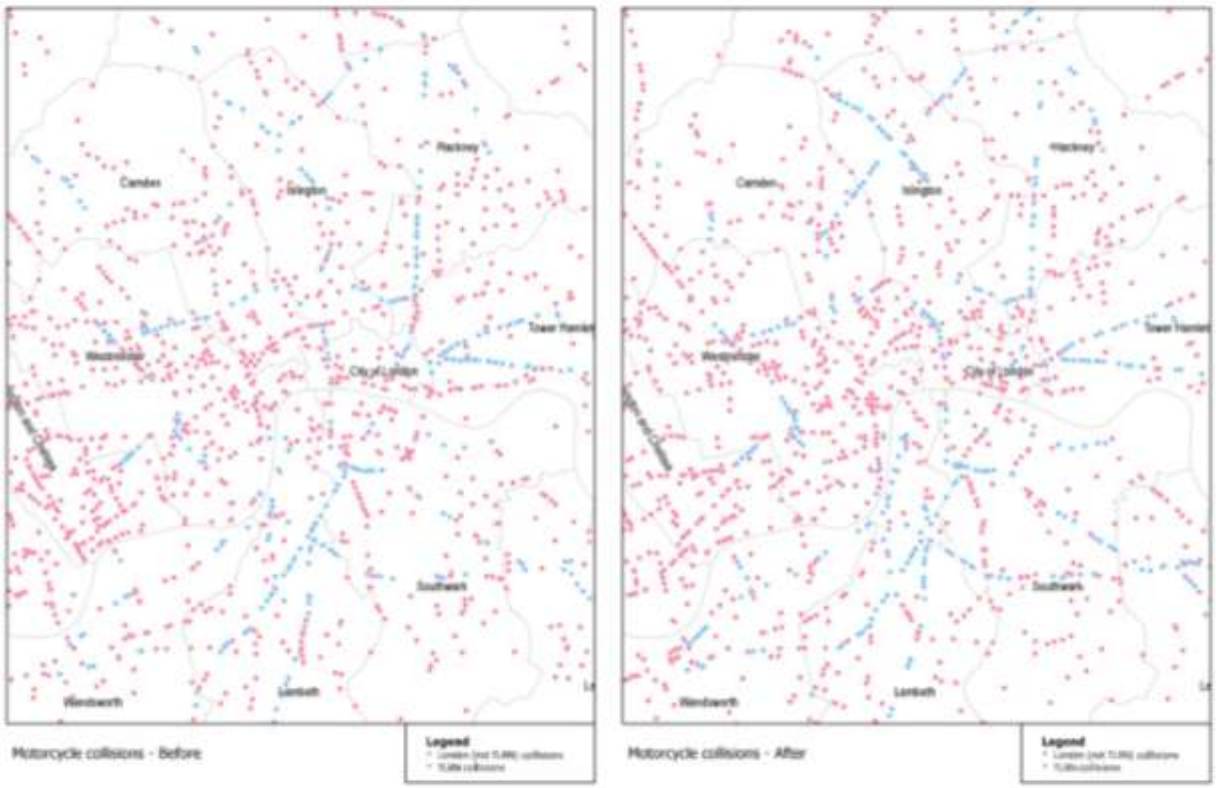


Figure 55: Spatial Distribution of Motorcycle Collisions (Inner London)

4.4.2 Collisions Involving Vulnerable Users in Operating Hours

Overall numbers of motorcycles involved in collisions appear to have been adversely affected by allowing them into the bus lanes on the TLRN. Their introduction into the bus lanes did not have any consistent effect on the safety of cyclists and pedestrians. In the case of pedestrians there was no significant effect, and the safety of cyclists appeared not have been affected on the TLRN (Main Network Sites), but there was evidence it had been adversely affected on the twenty-eight Main Sites although this increase appears not to have been as a result of motorcyclists being permitted to use the bus lane.

Although allowing them into the bus lane increased the extent to which they used them in operating hours, the effect outside of operational hours was variable. For example, whilst the percentage using the bus lane during operational hours increased greatly on Sites 14 and 15, the percentage using the lanes outside of operational hours increased by 8% and 25% respectively. On some sites their behaviour changed outside operational hours after they were permitted access, and on others it did not. This may have been through uncertainty as to whether they were permitted to use the bus lane in the before survey, in other cases they may not have considered there was an advantage in using the bus lane, or other reasons.

Further evidence of whether motorcycles being permitted access to bus lanes affect safety may be found by examining the number of collisions occurring within the operating hours of the bus lanes, where there had been an observed increase in bus lane use on nearly all surveyed sites. The number of collisions in the Before and After period, and the change in the in the number of collisions are shown in Figure 56 and Figure 57 respectively.

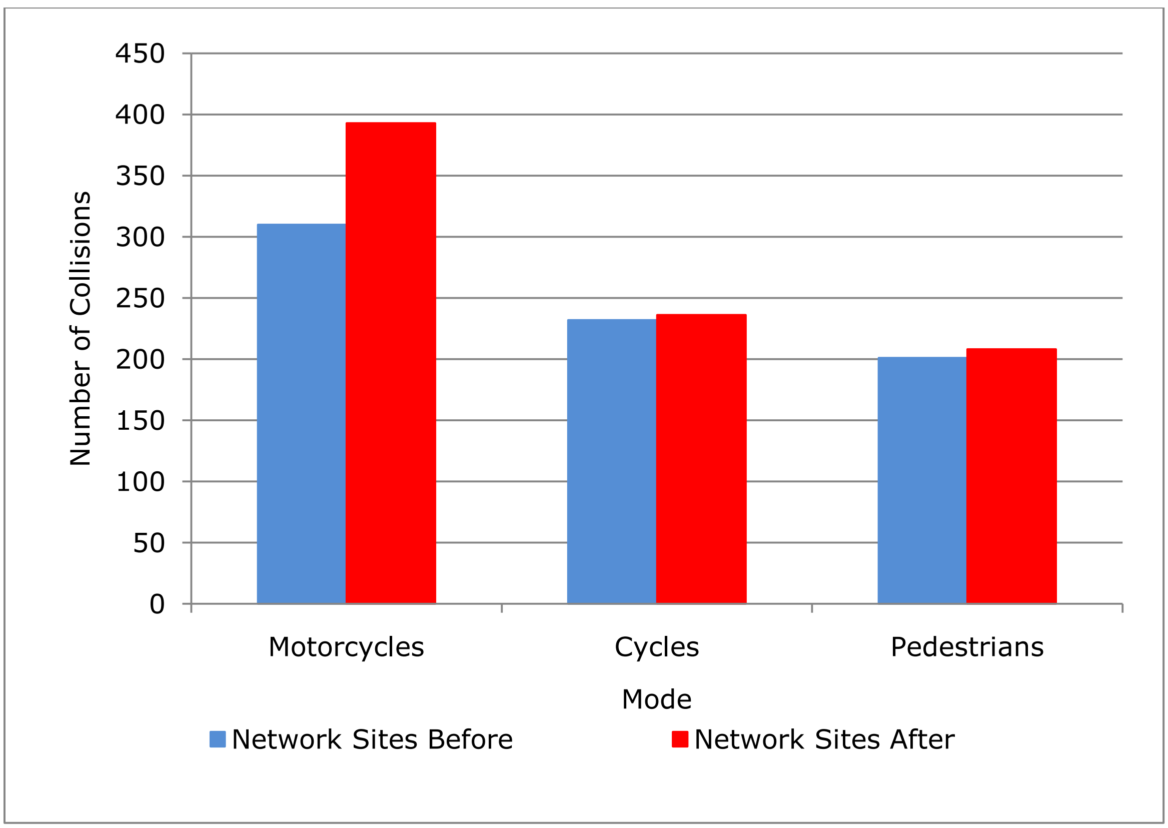


Figure 56: Number of Collisions Involving Vulnerable Users – Operating Hours

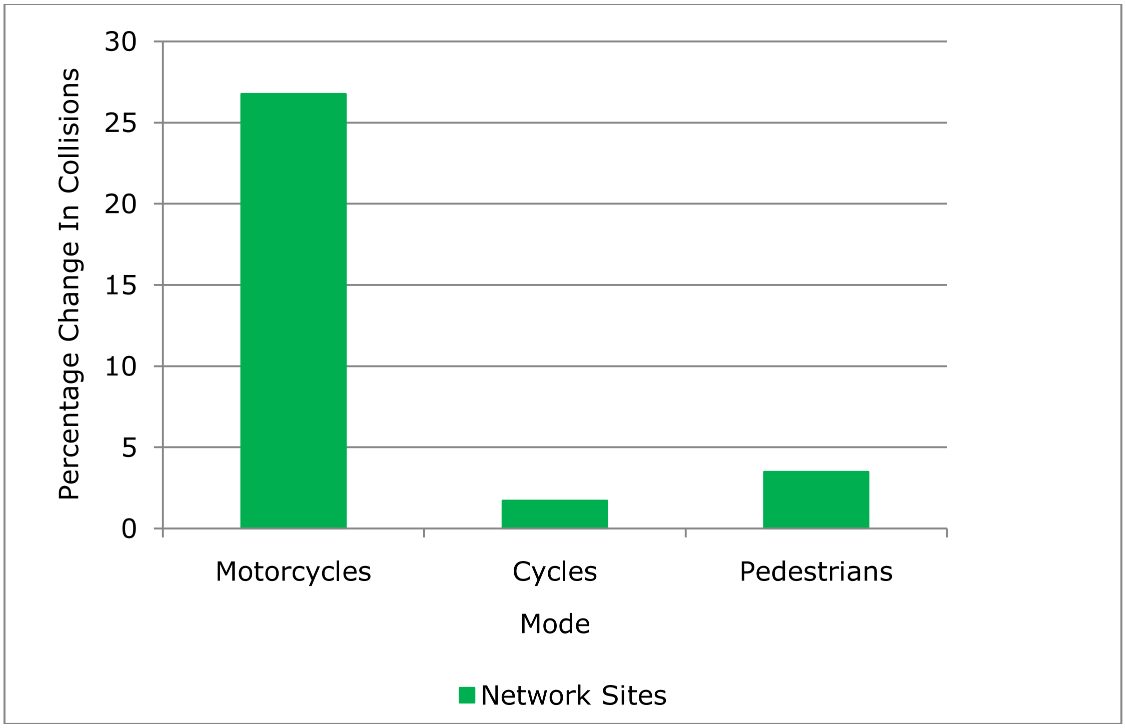


Figure 57: Percentage Change in Collisions Involving Vulnerable Users – Operating Hours

The percentage change in cycle and pedestrian collisions within operational hours was less than that over all hours, implying that any potential changes in safety were mainly outside of operational hours. It would be difficult to attribute such changes to the presence of motorcycles in bus lanes owing to the wide variation in changes in their lane usage outside of operational hours. Further, over all hours there was no significant change in the safety of these users on the road network. It would appear their safety has not been affected to a significant degree.

A different picture emerges with respect to the safety of motorcyclists on the network. The percentage increase in motorcyclists involved in collisions in operational hours was 27% compare to 15% overall. Therefore, motorcycle safety appears to have particularly been adversely affected in operational hours when they were observed to have generally increased their use of the bus lanes. Also, the change in percentage over all hours on the Network Sites was statistically significant (at the 90% confidence level) as was the increase on the twenty-eight Main Sites.

4.4.3 Collisions Involving a Motorcycle

The main effect of permitting motorcycles into bus lanes has been that the number of them involved in collisions has increased. These collisions have therefore been examined in more detail to consider which other vehicles were involved in the collisions, see Figure 59 and Figure 60.

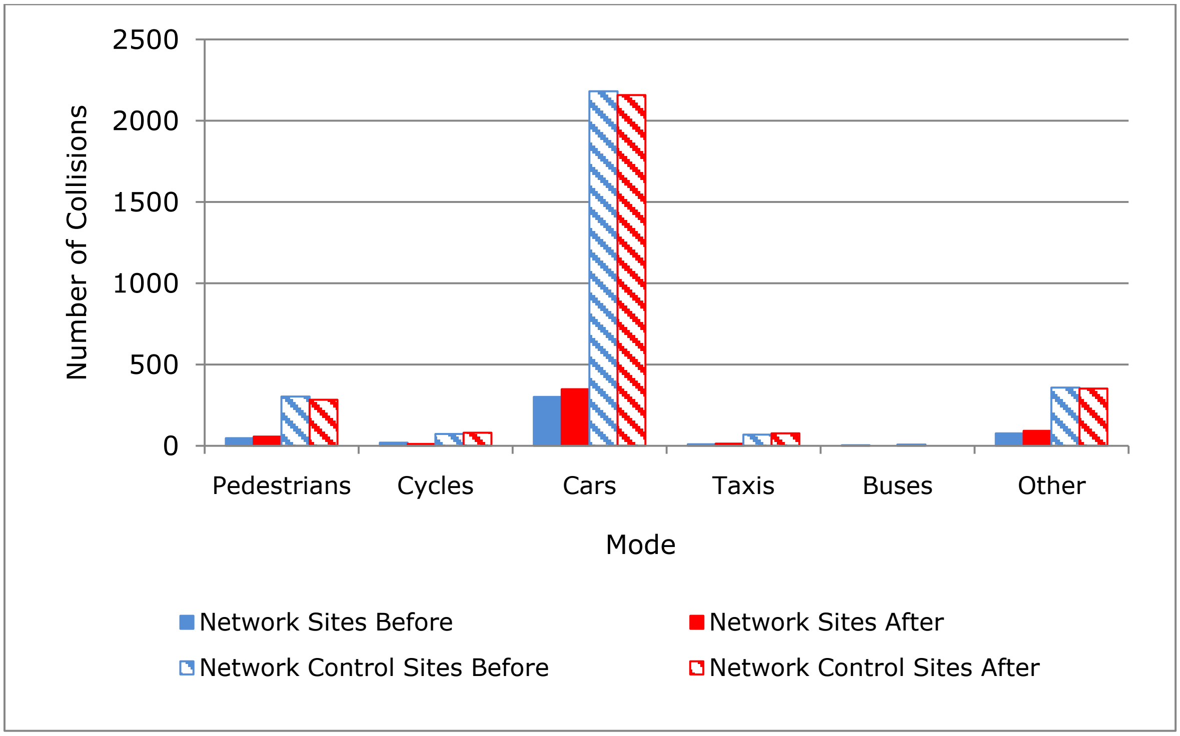


Figure 58: Change in Collisions Involving Motorcycles – out of operating hours

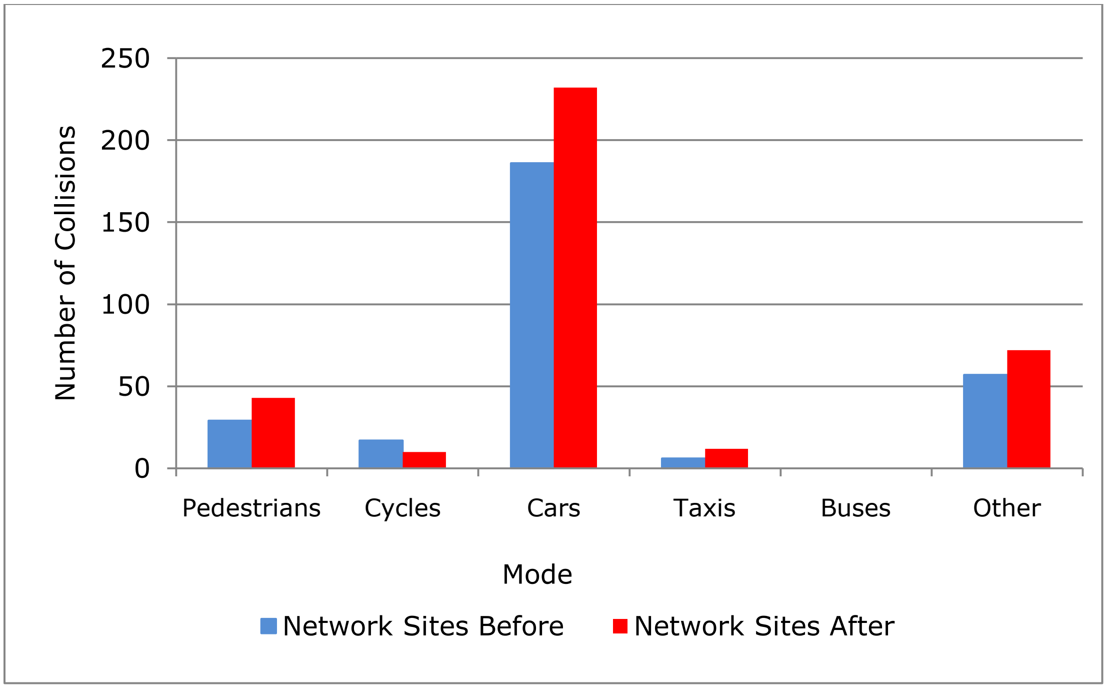


Figure 59: Change in Collisions Involving Motorcycles – During operating Hours

Most motorcycle collisions were with cars and these had increased by 16% over all hours and by 25% during operating hours. This is consistent with the findings on the twenty-eight Main Sites where collisions with cars had increased, particularly where the cars were turning left into, or out of a side road.

It is also important to note that the results from the analysis of pedestrian collisions on the 418 routes show significant variation with those of the 28 paired Main and Control sites. The pedestrian collisions involving a motorcycle on the 418 TLRN routes increased from 47 to 57 (21%) over all hours, and from 29 to 43 (48%) during operating hours. However, the number injured was not particularly large considering they were over the whole of the TLRN with bus lanes.

In contrast, the 28 Main and Control sites showed a reduction in the number of pedestrian collisions from 25 to 23 (8%), and a collision rate reduction of 44% (see section 3.5.3). While of note, the numbers were small, and this study is not able to identify the causes for these differing outcomes.

4.4.4 Casualties In Collisions

In addition to examining changes in the number of collisions, the number of casualties according to mode of travel has been analysed. The percentage change for each mode and for each severity of injury is shown in Figure 61 for all hours and in Figure 62 for operational hours.

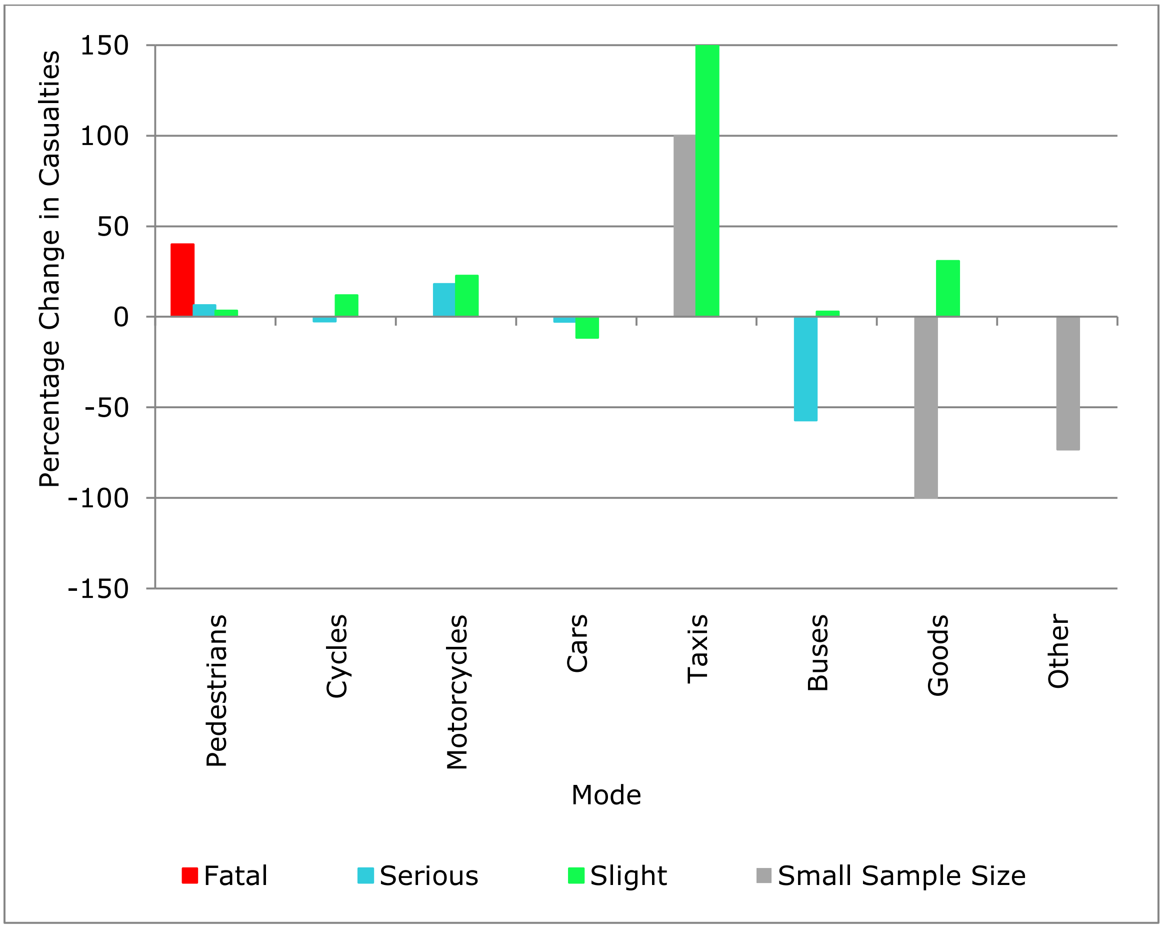


Figure 60: Percentage Change in Casualties – all hours

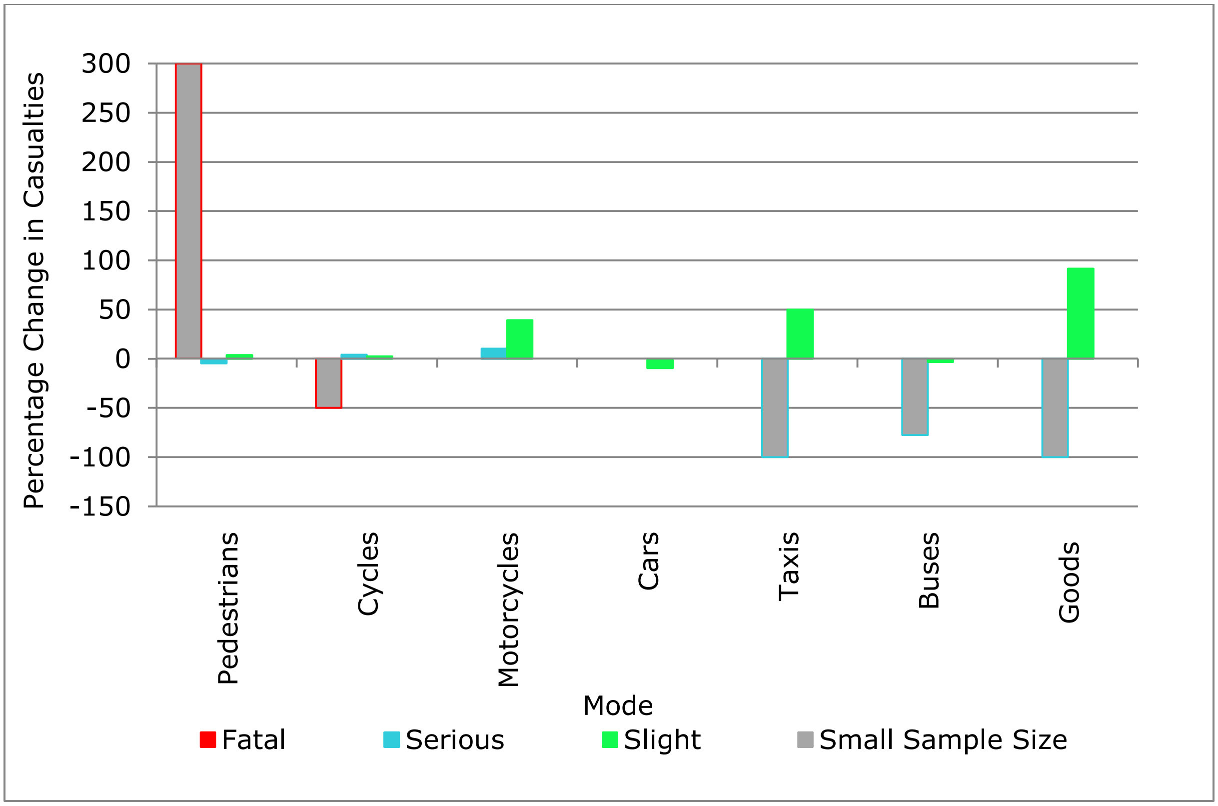


Figure 61: Percentage Change in Casualties – Operating Hours

Care needs to be taken when interpreting these Figures. The percentage changes where there were small sample sizes (less than 4) have been coloured in grey and should be treated with caution. In terms of the other casualties, the main increase was in motorcyclists, particularly in operating hours. There was also an increase in cyclist casualties, but these occurred outside bus lane operating hours.

4.4.5 Casualties in Motorcycle Collisions

The main change in collisions has occurred amongst those involving motorcyclists, therefore these are now considered further in this section. The other vehicles involved with the motorcycles in these collisions are shown in Figure 63 for all hours and in Figure 63 for bus lane operating hours.

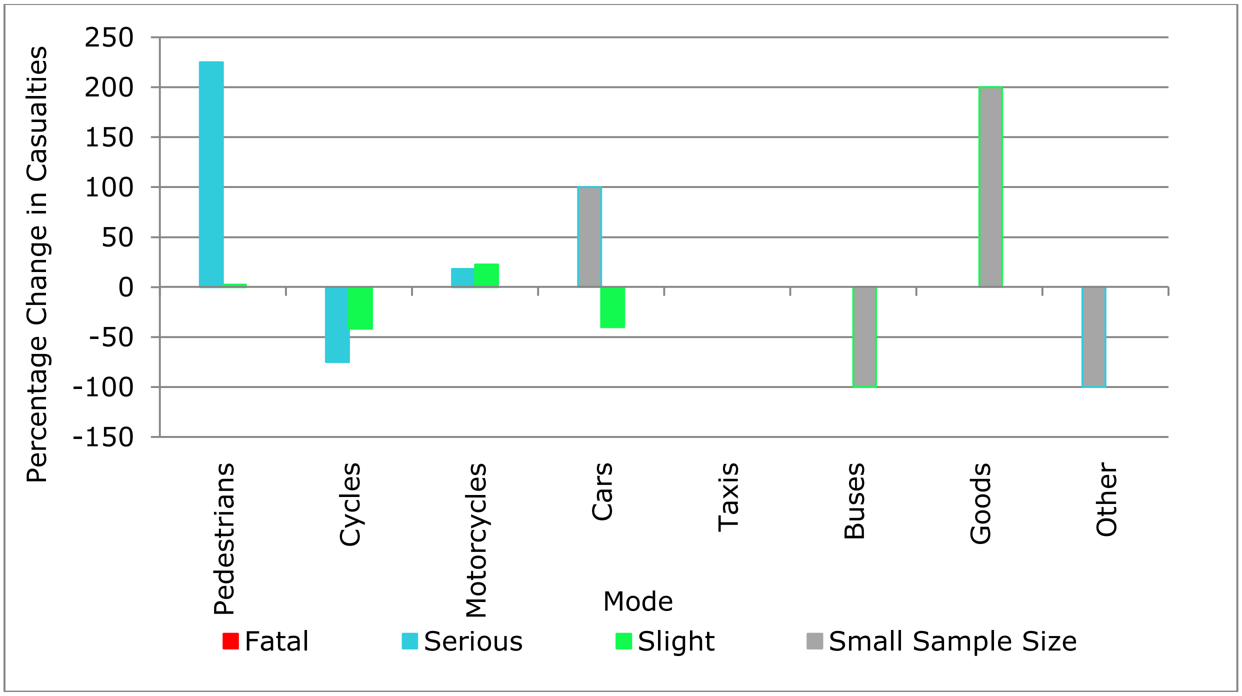


Figure 62: Percentage Change in Casualties in Collisions Involving a Motorcycle – all hours

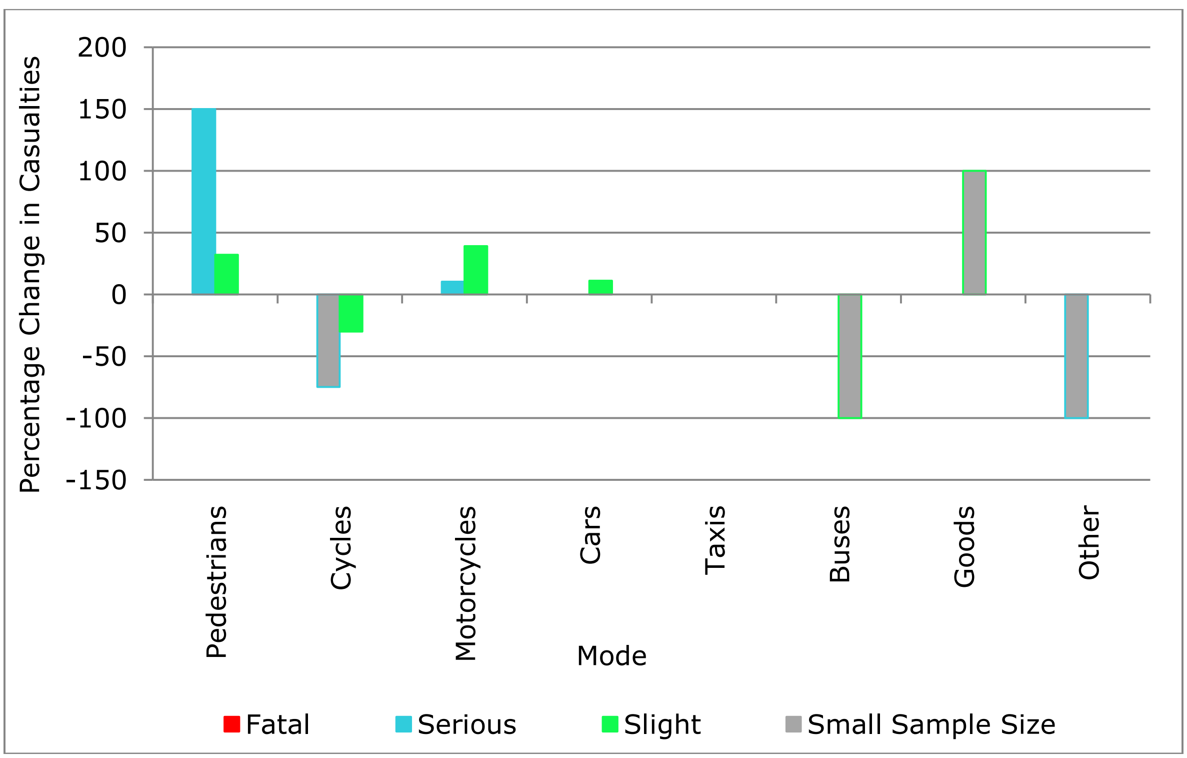


Figure 63: Percentage Change in Casualties in Collisions Involving a Motorcycle – Operating Hours

In collisions involving motorcycles the vast majority of casualties were motorcyclists:

- 73% in the before survey over all hours
- 75% in the after survey over all hours
- 83% in the before survey over bus lane operating hours
- 85% in the after survey over bus lane operating hours

Therefore the main concern is for motorcyclist safety, although the largest increases were in slight injuries. Another issue to note was the increase in pedestrian collisions with motorcycles, however, the number injured was not particularly large considering they were over the whole of the TLRN with bus lanes: the number of pedestrians seriously injured in a collision with a motorcycle was 4 in the before period and 13 in the after period over all hours, and was 4 in the before period and 10 in the after period during bus lane operating hours.

4.4.6 Conclusions

Conclusions - Collisions on the Network

- There was a large percentage increase in collisions involving motorcycles on the Network Sites, which was not seen on the Network Control Sites and their safety appears to have particularly been adversely affected in operational hours
- In collisions involving motorcycles the vast majority of casualties were motorcyclists, between 73% and 85% depending on time of day and survey.
- The percentage change in cycle and pedestrian collisions within operational hours was less than that over all hours, implying that any potential changes in safety were mainly outside of operational hours

5 Conclusions

Motorcycles were permitted access to bus lanes in London on the TLRN in January 2009. TRL have monitored the effect of permitting this access with the express objective of meeting the following key evaluation criteria (see Figure 64) and to assess the following monitoring areas.

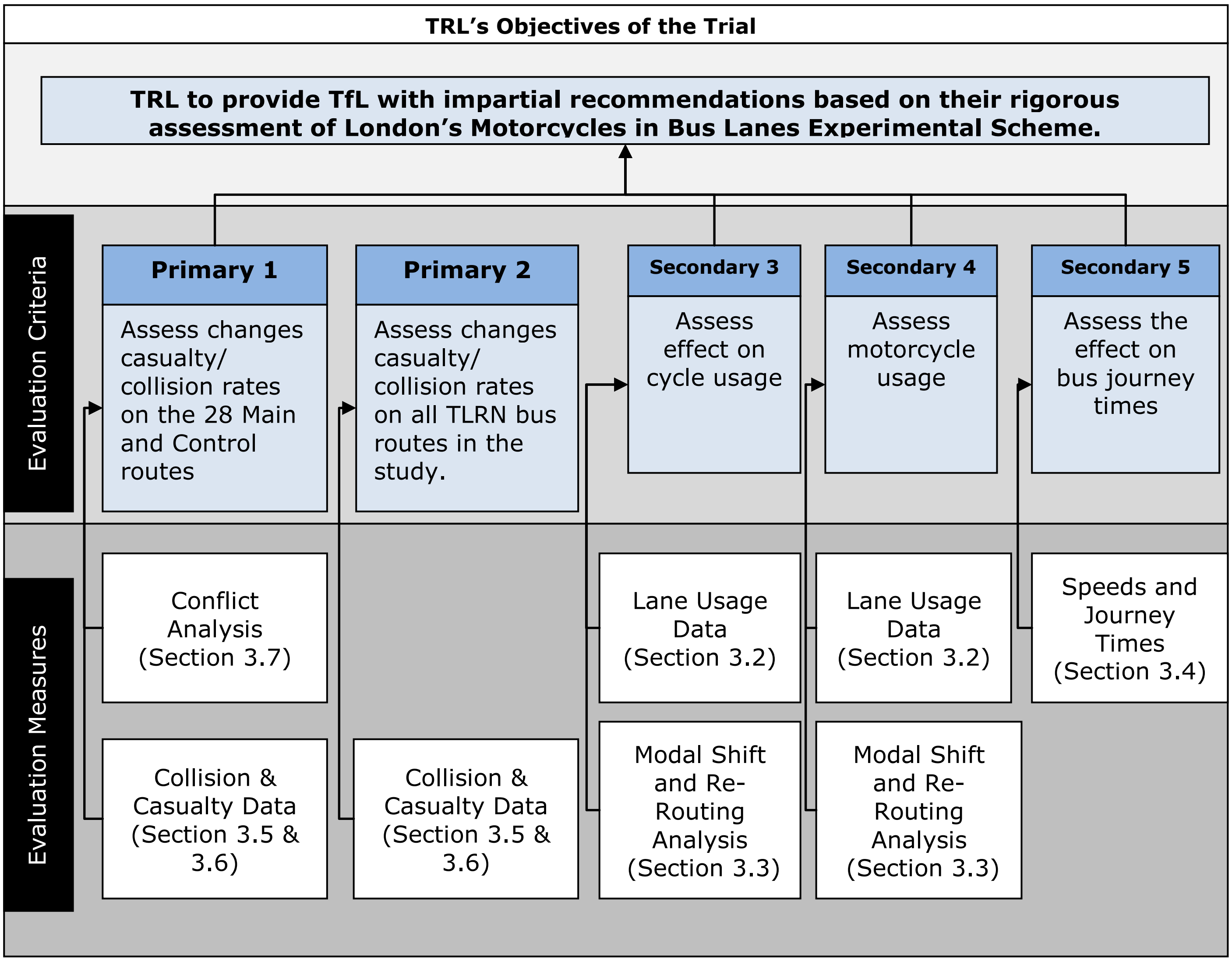


Figure 64: Study Objectives

Meeting Monitoring Criteria

- Data was successfully collected from video surveys for two days before and after motorcycles were permitted access to the bus lanes.

- Complete week classified flows were obtained from temporarily installed Automatic Traffic Counters (ATCs) and this data was successfully patched and calibrated where necessary.

- Yearly motorcycle and cycle flows were estimated using the weekly counts and seasonal trends available.

- A series of rules were developed between TRL and TfL to correctly capture collisions occurring between vehicles (and pedestrians) on the approach, within and leaving all bus lanes on the TLRN.

- Network flows were modelled by extrapolating the modelled flows on the twenty-eight sites to forming an average flow in each London borough.

The findings were:

Collisions involving Motorcycles, Cycles and Pedestrians

- Collisions involving motorcycles increased on the Main sites. The implied relative increase in motorcyclist collision rates was statistically significant (at the 95% confidence level), although some caution should be used as the sample sizes were relatively small. It did not appear to be a result of a settling down period for the scheme, and the increase in collisions generally involved cars turning left into and out of side roads. The severity level of the motorcycle collisions had increased with a 25% increase in slight injury and a 50% increase in serious injury collisions, albeit this was only a weak finding due to small samples.

- Collisions involving cyclists had increased. However, these collisions were generally with cars and through poor observation. The increase could also be partially explained by the increase in cycle flows that were observed on both the Main and the Control sites. It would therefore appear that the change in collisions amongst cyclists were not a result of motorcyclists being permitted access to the bus lane.

Conflicts involving Motorcycles and Cycles

- The number of low level conflicts involving motorcycles decreased after they were permitted access to the bus lane. This was as a result of the motorcyclists being segregated from the main traffic flow in the bus lanes, although the interactions observed in the Before survey were generally a result of them passing traffic queues and were unlikely to have safety implications.

- There was a very small increase in the number of conflicts at level 2 (from 4 to 8) and only 1 at level 3 after motorcycles were permitted access to the bus lane. This increase was not significant. It was found to be a result of conflicts with cars turning left into, and out of, side roads. Thus the cars were generally crossing a gap in the bus lane to use the side road, whilst the motorcycles were using the bus lane to gain a journey time advantage (i.e. using a relatively high speed compared to other bus lane users). This increase in conflicts could therefore be related to allowing motorcycles access to the bus lanes.

Network Collisions involving Motorcycles, Cycles and Pedestrians

- The relative change in motorcycle collision rates on the TLRN roads with a bus lane compared and other lanes appears to imply that permitting motorcycles access to bus lanes increased their chance of being involved in a collision.
- In percentage terms there was a large increase in collisions involving motorcycles on the Network Sites, which was not seen on the Network Control Sites. The percentage increase in motorcyclists involved in collisions in operational hours was 27% compared to 15% overall on the Network Sites. Therefore, their safety appears to have particularly been adversely affected in operational hours when they were observed to have generally increased their use of the bus lanes. Most motorcycle collisions were with cars and these had increased by 16% over all hours and by 25% during operating hours. This is consistent with the findings on the twenty-eight Main Sites where collisions with cars had increased, particularly where the cars were turning left into, or out of a side road.

- In collisions involving motorcycles the vast majority of casualties were motorcyclists, between 73% and 85% depending on time of day and survey.

- The relative change in cycle collision rates on the TLRN roads with a bus lane compared and other lanes appears to imply that permitting motorcycles access to bus lanes did not affect their chance of having a collision. Overall, the analysis implies that there was some evidence that cycle collision rates had increased, but the degree of change was uncertain, and appeared to be unrelated to the presence of motorcycles in the bus lanes.

- The relative change in pedestrian collision rates on the TLRN roads with a bus lane compared and other lanes appears to imply that permitting motorcycles access to bus lanes did not affect their chance of having a collision. Overall, the analysis implies that there was no evidence that a significant change in pedestrian safety had occurred.

- The percentage change in cycle collisions within operational hours was less than that over all hours, implying that any potential changes in safety were mainly outside of operational hours. It would be difficult to attribute such changes to the presence of motorcycles in bus lanes owing to the wide variation in changes in their lane usage outside operational hours. Further, over all hours there was no significant change in the safety of these users on the road network. It would appear their safety has not been affected to a significant degree.

Vehicle Flow

- The overall level of traffic flow (PCU/hr) varied widely between the two surveys across the sites studied, from -20 to +15% on the Main sites. Overall, there was a small decrease in flows of approximately 1% on the Main sites and a similar decrease in flows on the Control sites. This was possibly a result of the change in economic conditions in the UK between the two surveys.

- There was a small overall increase in the number of motorcycles using the Main routes after they were permitted access to the bus lanes. Across a comparable period there was a 4% increase on the Main sites and a 2% decrease on the Control sites. This implies there was a slight migration of motorcycles onto the Main routes which was statistically significant.

- The number of cyclists increased on both the Main and the Control routes, by 16% on the Main and 13% on the Control routes.

- The modal share remained fairly constant on both the Main and the Control routes, with the variation being 1% or less, except a reduction of 2% in light goods vehicles using the Main routes. On the Main routes approximately 55% of the flow was cars, with 21% light goods vehicles, 6% motorcycles, 5% cycles, 5% taxis, 4% buses, 3% heavy goods vehicles.

Bus Lane and Footway Use

- Permitting motorcycles into the bus lane did not adversely affect the percentage of cyclists using the bus lane; the main difference between the surveys was a slight reduction in the percentage of cyclists using the footway.

- The level of illegal use by motorcycles (in the Before survey) varied greatly between the sites: 0 to 35% (with an average of 6%). However, the percentage of motorcycles using the bus lanes increased on all sites in the After survey and ranged from 27 to 80%, with an average usage of 51%.

Vehicle Speed & Journey Times

- Bus speeds were unaffected by permitting motorcycles access to the bus lanes.

- General, non-priority traffic, speeds remained reasonably constant on the Main and Control sites.

- Motorcycle speeds increased after they were permitted access to the bus lanes, and there was an increase in the percentage of motorcycles exceeding the speed limit. This is consistent with the hypothesis that motorcycles used the bus lanes to gain a journey time advantage.

Overall Conclusions

The effect of permitting motorcycles into bus lanes has been assessed after 10 months of implementation. This analysis period is the minimum where any reasonably large effects can be ascertained. This has identified that motorcyclists appear to be less safe since the scheme has been introduced. There were no changes in the safety of cyclists and pedestrians that could be directly attributed to the motorcycles being permitted access to the bus lanes.

Appendix A Site Details

PROVIDED IN SEPARATE ATTACHMENT

Appendix B Calculations

A.1 Deriving Annual Flows

07:00 – 19:00

Scale ATC Axles to get Weekly Flow Profiles

1. Calculate total vehicles per hour per day of week
    a. Tot(h,d) = ATC axle counts/2 * 0.98, where h=7 to 18, d = 1 to 7 (Mon-Sun)
2. Calculate total vehicles per hour per day of week on video day
    a. TotV(h,d), where h=7 to 18, d = 1 to 5 (Mon-Fri)
3. Calculate the ATC to Video scalars for each hour of the video day
    a. TotV(h,d)/Tot(h,d) , where h=7 to 18, d = 1 to 5 (Mon-Fri)
    b. examine variation to see accuracy of averaging
4. Calculate the average over both days for each hour 07:00 to 19:00
    a. Propdiff(h) = average of TotV(h,d)/Tot(h,d) over both video survey days, where h=7 to 18, d = 1 to 5 (Mon-Fri)
5. Scale ATC Counts, for 07:00 to 19:00
    a. TotVehicles(h,d) = Tot(h,d) * Propdiff(h), where h=7 to 18, d = 1 to 7 (Mon-Sun)

Calculate day-time Modal Proportions

1. Use Video classified data to form proportion of flow for each vehicle class and for each hour of the day and for each day of the week ***surveyed***: propV(m,h,d), where m = mode, h=7 to 18, d = 1 to 5 (Mon-Fri)
2. Calculate the average over both days for each hour 07:00 to 19:00
    a. propV(m,h) = average of propV(m,h,d)/prop(m,h,d) over both video survey days, where m = mode, h=7 to 18, d = 1 to 5 (Mon-Fri)

Calculate Flows

1. Calculate total classified flow for each hour of each day for one week.
    a. TotFlow(m,h,d) = propV(m,h) * TotVehicles(h,d), where h=7 to 18, d = 1 to 7 (Mon-Sun)

19:00 - 07:00

Scale Modal Proportions

1. Use ATC classified data to form proportion of flow for each vehicle class and for each hour of each night of the week:
    a. prop(m,h,d), where m = mode, h=0 to 7 and 19 to 23, d = 1 to 7 (Mon-Sun)
    b. Note: where the classified count has failed, use average from similar day or the average proportion from the first reliable hour before and after the missing data.
2. Calculate universal under-counting or over-counting proportions for each mode using video days with reliable ATC classified data.
    a. UnderCounting(m) = propVgood(m)/propgood(m), where m = mode

Calculate Flows

1. Calculate total classified flow for each hour of each day for one week.
    a. TotFlow(m,h,d) = prop(m,h,d) * UnderCounting(m), where m = mode, h=0 to 7 and 19 to 23, d = 1 to 7 (Mon-Sun)

Appendix C Collision Maps (STATS19)

This Appendix contains STATS19 collision maps for each site, with the Before survey on the left and the After survey on the right. The collisions presented involved at least one motorcycle. They also show:

- Whether a car was involved (dot)
- The severity of injuries (slight/serious/fatal)
- The start and end road of the area considered
- Bus stops and pedestrian crossings

INDIVIDUAL SITE MAPS WITH COLLISION DETAILS PROVIDED IN SEPARATE ATTACHMENT

Appendix D Journey Time Tables

Average Journey Times for Individual Sites in Seconds

Site		Mph Limits	Before/After Survey	Motorcycles		Buses		Cars	
				Average Journey Time	Standard Deviation	Average Journey Time	Standard Deviation	Average Journey	Standard Deviation
A	Main	30mph	Before	13.2	4.0	16.5	3.7	14.8	7.3
			After	14.7	4.1	20.1	7.9	21.0	20.4
	Control	30mph	Before	12.8	3.2	24.4	16.5	18.9	16.4
			After	13.2	3.2	25.7	16.2	21.9	18.2
B	Main	30mph	Before	15.1	4.9	30.9	19.4	21.1	12.2
			After	12.1	3.0	24.5	16.1	14.1	2.1
	Control	30mph	Before	15.2	5.3	25.6	17.0	13.7	1.8
			After	13.5	4.1	17.8	3.5	13.4	1.9
C	Main	30mph	Before	14.4	3.1	18.7	3.3	15.3	2.4
			After	13.2	2.6	19.7	3.7	14.9	1.8
	Control	30mph	Before	16.2	4.1	19.9	5.3	18.8	3.7
			After	16.6	4.6	20.5	3.6	18.4	2.6
D	Main	30mph	Before	18.5	4.0	22.9	3.5	18.2	2.0
			After	17.4	3.1	23.9	4.4	18.4	1.9
	Control	30mph	Before	31.0	16.9			58.1	37.6
			After	28.1	16.5			79.5	71.3
E	Main	30mph	Before	22.5	11.0	18.0	4.4	29.7	17.0
			After	13.2	2.6	18.4	4.8	21.0	10.6
	Control	30mph	Before	15.9	3.7	17.9	3.4	15.8	1.7
			After	15.7	3.5	21.9	13.0	15.7	1.8
F	Main	30mph	Before	14.2	4.4	18.0	4.4	18.0	7.7
			After	12.9	3.5	25.3	6.4	20.7	20.1
	Control	20mph	Before	13.4	2.6			14.6	2.0
			After	12.6	2.8			15.1	3.7
G	Main	30mph	Before	25.1	11.8	26.8	8.7	65.0	37.4
			After	19.2	5.4	25.3	6.4	41.2	36.9
	Control	30mph	Before	14.1	2.3	18.8	2.5	15.3	1.6
			After	12.6	2.4	17.0	3.2	13.6	2.1
H	Main	30mph	Before	12.8	2.3	20.9	3.0	14.4	1.6
			After	12.9	3.7	22.6	8.8	24.3	42.5
	Control	30mph	Before	11.5	2.2	17.1	3.3	13.2	1.8
			After	12.0	2.7	17.2	3.5	12.9	1.7
I	Main	30mph	Before	19.3	6.7	20.6	4.7	30.4	17.6
			After	14.1	3.8	18.9	5.2	29.7	31.0
	Control	30mph	Before	15.2	4.2	20.3	9.6	15.3	5.1
			After	13.4	3.7	17.3	3.5	14.4	2.0
J	Main	30mph	Before	15.7	2.9	18.1	2.5	15.8	1.9
			After	14.2	1.5	18.9	3.4	15.5	1.4
	Control	30mph	Before	18.0	3.9	24.5	6.6	17.7	1.9
			After	15.3	3.6	19.9	3.8	15.9	1.8
K	Main	50mph	Before	18.2	13.6	17.5	3.0	12.9	1.7
			After	10.6	2.3	16.1	2.4	12.0	1.6
	Control	30mph	Before	15.2	2.9	16.2	1.9	14.1	1.9
			After	16.5	5.2	16.8	2.5	14.7	1.7
L	Main	30mph	Before	14.8	3.5	15.9	2.1	14.2	2.1
			After	13.3	3.2	16.1	2.5	17.0	3.4
	Control	30mph	Before	10.8	2.3	22.3	4.2	12.7	1.8
			After	14.8	3.1	29.1	13.7	14.1	2.0
M	Main	30mph	Before	13.1	2.7	16.7	2.2	13.4	1.5
			After	14.3	19.1	25.2	28.6	27.1	42.1
	Control	30mph	Before	20.2	5.3	25.3	9.3	24.3	10.7
			After	21.0	5.7	30.2	17.2	27.8	18.3
N	Main	30mph	Before	13.6	2.6	19.1	3.2	13.4	1.2
			After	13.0	2.5	17.9	3.8	13.6	1.5
	Control	30mph	Before	20.4	4.1	30.9	7.6	20.8	3.0
			After	17.1	3.4	22.8	3.1	18.2	2.1

Average Journey Times for Individual Sites in Seconds									
Site		Mph Limits	Before/After Survey	Motorcycles		Buses		Cars	
				Average Journey Time	Standard Deviation	Average Journey Time	Standard Deviation	Average Journey	Standard Deviation
O	Main	30mph	Before	13.2	3.1	17.3	3.5	15.2	3.6
			After	12.1	2.5	16.4	2.8	13.7	1.7
	Control	30mph	Before	21.3	6.7			19.2	3.4
			After	18.6	5.1			18.1	3.5
P	Main	30mph	Before	12.6	1.5	17.6	2.6	13.1	1.4
			After	14.4	5.2	23.4	11.1	26.4	33.4
	Control	30mph	Before	20.8	8.7	31.7	23.0	19.3	6.4
			After	32.2	23.8	60.3	45.8	45.7	48.0
Q	Main	30mph	Before	12.1	2.4	15.7	2.3	13.5	1.4
			After	12.7	2.3	16.4	2.5	13.4	1.8
	Control	30mph	Before	14.3	3.1	23.5	18.6	15.4	3.0
			After	13.9	3.2	19.3	5.1	14.8	3.2
R	Main	30mph	Before	13.2	2.7	22.8	11.0	14.0	2.3
			After	12.3	2.5	20.6	7.1	14.3	1.9
	Control	30mph	Before	17.1	2.7	21.8	5.0	21.1	9.4
			After	18.8	5.1	23.4	7.5	35.5	42.2
S	Main	30mph	Before	11.6	2.3	16.8	1.6	14.1	1.9
			After	11.6	2.1	16.4	1.4	14.0	1.7
	Control	20mph	Before	18.7	5.6			18.3	2.1
			After	17.5	5.3			20.8	4.4
T	Main	30mph	Before	15.0	3.7	21.4	3.8	17.9	4.0
			After	12.1	2.0	20.6	3.6	15.0	2.0
	Control	30mph	Before	18.9	4.0	23.4	3.5	21.8	4.1
			After	16.2	3.8	19.9	2.6	17.4	2.0
U	Main	30mph	Before	11.7	2.5	23.4	9.7	12.6	1.7
			After	12.3	3.5	22.0	8.7	13.8	3.2
	Control	30mph	Before	17.6	3.8	25.8	3.8	18.9	2.1
			After	17.3	3.4	23.4	2.7	19.8	3.0
V	Main	30mph	Before	20.0	7.7	32.7	11.8	19.0	6.2
			After	15.5	3.7	30.5	13.1	17.3	3.9
	Control	20mph	Before	14.6	3.9			17.2	3.1
			After	15.3	3.2			16.5	2.0
W	Main	30mph	Before	15.6	8.4	35.9	35.6	16.7	18.6
			After	13.3	4.6	22.0	12.2	14.5	6.4
	Control	30mph	Before	19.0	4.9	30.4	10.2	20.9	6.5
			After	20.2	7.0	29.8	14.6	25.1	14.3
X	Main	30mph	Before	21.3	6.8	29.2	10.1	18.9	2.2
			After	22.6	9.5	34.5	18.5	33.5	40.1
	Control	30mph	Before	15.5	3.4	20.8	2.9	16.4	2.0
			After	14.0	2.5	18.8	2.9	15.2	1.6
Y	Main	30mph	Before	12.2	2.5	16.9	3.5	14.1	3.5
			After	12.8	2.8	20.6	7.6	24.0	22.1
	Control	20mph	Before	18.0	3.7			20.1	3.3
			After	16.1	3.1			17.1	2.0
Z	Main	30mph	Before	11.7	2.0	14.6	2.1	12.8	1.4
			After	13.6	6.6	24.1	41.0	14.0	1.9
	Control	30mph	Before	16.3	4.4	30.3	19.0	16.7	6.7
			After	14.7	4.4	29.0	27.3	14.8	1.8
AA	Main	30mph	Before	12.3	5.6	15.9	3.4	36.1	35.7
			After	8.7	1.7	13.8	2.1	32.8	43.2
	Control	30mph	Before	14.1	2.2	17.2	2.0	14.6	1.9
			After	14.4	2.6	18.6	5.4	14.7	2.0
AB	Main	30mph	Before	12.7	2.7	16.2	4.1	13.3	2.4
			After	12.4	2.4	17.7	4.6	17.3	13.2
	Control	30mph	Before	13.8	3.5	17.0	3.7	15.6	4.8
			After	15.1	4.9	18.4	3.0	16.4	6.0

Figure 65: Average Journey Time for Individual Sites in Seconds

Appendix E Glossary of Terms and Abbreviations

ACCSTATS	Accident Statistics
ATC	Automatic Traffic Counter
COBA	Cost Benefit Analysis
DfT	Department for Transport
HGV	Heavy goods vehicle
LGV	Light goods vehicle
P2W	Powered two wheeler/motorcycle
PCU	Passenger Car Unit
RPI	Retail Price Index
SPSS	Statistical Package for the Social Sciences
TfL	Transport for London
TLRN	Transport for London Road Network
TRL	Transport Research Laboratory

'A' tube	Tube A of the ATC
AM morning peak	From 7:30 to 9:30
ANOVA model	Statistical program used to assess trends in data
ATC Over-counting	Automatic flow data more than video flow counts
ATC Under-counting	Automatic flow data less than video flow counts
Attributed cause of collision	Attributed by the police at the collision
Average speed	Sum of all vehicle speeds divided by the number of vehicles
Axle counts	Automatic counts of vehicle axles to estimate vehicle type
‘B' tube	Tube B of the ATC
Bus	Includes coaches but excludes minibuses with less than 17 seats
Bus lane	A lane which gives buses priority at certain times of the day
Classified vehicle count	Number of vehicles passing along a road classified by cycle/motorcycle/car or lgv/hgv/bus

Clean data	Data from ATC axle counts which is consistent for both measuring tubes
Collision rate	Number of collisions taking traffic flow into account
Confidence level	Statistical term which gives the probability of the effect
Conflict	This is when 2 road users attempt to use the same road space which can result in a 'near miss'. Conflicts are graded as to the severity.
Conflict grade 5	This would be an accident but may not be an injury accident
Conflict zone	Area used to monitor conflicts
Congestion charge	The charge of £8 per day to enter Central London
Contra-flow bus lane	Buses travel against the main direction of travel
Contributory factor	Factors which lead to a collision
Control sites	Comparable sites where motorcycles cannot use bus lanes if available
Data sources	These included video, ATC, ACCSTATS etc
Day-time data	From 7:00 to 19:00
Downstream camera	Camera showing the end of the bus lane
Downstream timing point	Point used for the end of the journey time
Extrapolate the flows	Estimates outside the given data range
Fatal (Killed) casualty	Death occurs within 30 days as a result of the collision
Fatal collision	A collision which includes at least one death
Fault in collision	Fault given by the police at the collision
Filtered data	Data which has had some data removed
Filtering through traffic	Passing between two traffic queues
Hauer approach	A statistical method approach (see appendix)
Illegal use of bus lane	This is based on vehicle type and time of day
In-flow bus lane	Similar to a with-flow bus lane
Injury collision	An accident which results in at least one casualty
Journey time	The time taken for a specific distance to be covered
Link capacity	Theoretical maximum number of vehicles (PCUs) which can use a stretch of road

Long bus lane	Bus lane more than 200 metres long
Main sites	Sites where motorcycles have been allowed to use the bus lane
Migration	This is when road users change from one route to another due to a change on the initial route
Mode of transport	Type of vehicle used or by foot
Night-time data	From 19:00 to 7:00
Non filtered data	Data which has not been filtered
Non-priority lane	A lane which can be used by all road users at any time
Not statistically significant	This means that any difference is probably due to chance
Object vehicle	Vehicle monitored e.g. motorcycle or cycle
Observation	A motorcycle or cycle observed in the conflict analysis
Off peak	From 12:00 to 14:00
Overtaking	Passing on the offside
Partial failure of ATC	Classified counts fail if speed falls below 6 mph
Patch (data)	Estimated data used to fill missing data due to equipment failure
Pedal cycle	Includes tandems, tricycles and electrically assisted bicycles and tricycles with a maximum speed of 15 mph
PM evening peak	From 16:00 to 18:00
Potential conflict	Motorcycles potentially conflicting with oncoming traffic
Powered 2 wheelers	Includes mopeds, scooters and motorcycles but excludes those with sidecars.
Propagation	This is when the number of road users increases on a particular route
Screenshot	This captures a frame of video taken from the filming
Seasonal trend (factor)	Trend obtained from 5 years of data
Seasonal variation	The fluctuation in flow along a road split by month
Serious casualty	Includes fractures and detention in hospital and includes those who die 30 days or more after the collision

Serious collision	A collision which includes a serious casualty but no fatalities
Settling in period	Time usually allowed after a change in conditions for users to adjust
Short bus lane	Bus lane less than 200 metres long
Slight casualty	Slight cuts, bruises etc needing medical treatment
Slight collision	A collision which only includes slight casualties
Statistically significant	This can be at various confidence levels usually 95%
STATS19 data	Casualty and collision data collected by the police for all injuries on the highway
Tanner test	A statistical method test
Total failure of ATC	No data available from ATC
Trip attractor	Something which causes people to make new journeys e.g. a supermarket
Turning movement	The percentage of vehicles turning at a junction compared to the total flow
Undertaking	Passing on the nearside
Upstream camera	Camera showing the start of the bus lane
Upstream timing point	Point used for the start of the journey time
Vehicle flow	Either counted from video or from Automatic Traffic Counters
Vehicle speed	Either calculated from video or from Automatic Traffic Counters
With-flow bus lane	A bus lane in the same direction as traffic on the left of the adjacent lane
Z statistic	A statistical method test statistic

Appendix F Analysis by sites (Hauer approach)

There are several sites with no P2W collisions either in the Before or After periods, and where there are data then the numbers are small. Use of the Hauer approach by site is thus unreliable and is not reported. However an analysis taking into account sites using GLM has been used.

This approach is to fit a generalised linear model and given that collision counts are generally distributed as Poisson or Negative Binominal then a log link function is used. The following model structures were defined:

- Log(collisions) = a + b.log(traffic flow) + c.control + d.after + e.control*after +f_i.$site_i$
- Log(collisions/traffic flow) = a + c.control + d.after + e.control*after +f_i.$site_i$

Where a, b, c, d, e and f_i are parameters to be estimated (there are i sites), the second model uses traffic flow as an offset when modelling collision rate, i.e. b=1.

Not using site parameters generates a more parsimonious model. The example shown below is the least parsimonious and includes a statistically significant parameter for traffic flow, and a parameter associated with each site – which overall explains some of the variation in the data. The parameters associated with 'Control' and 'after' are not statistically significant. However, the interaction between the parameters is statistically significant, although it is easier to interpret the interaction if the main effects are also used.

sites and ln(flow) fitted together with after and Control					
	estimate	exp	se	deviance	prob
sites				63.176	<0.001
ln(flow)	0.6992	2.0121	0.2323	46.56	<0.001
after	0.3096	1.3629	0.2632	0.10	ns
control	-0.0899	0.9140	0.3732	3.68	0.055
after.control	-1.0020	0.3671	0.5252	4.30	0.038

The following table shows the multiplicative levels of the control, after and control.after interaction, i.e. if there were 1,000 collisions in the Main site before the use of bus lanes by motorcyclists, then the model would suggest there would be 1,004 collisions for the Control sites before use of bus lanes, 1,332 collisions for the Main sites after bus lanes could be used and meanwhile the collisions in the Control sites during the same After period would have dropped to 512 collisions.

	Main site	Control Site
Before	1	0.914
After	1.363	0.457
Relative Increase	**172.40%**	

The relative increase of motorcyclists involved collisions in the After period on Main sites can thus be calculated relative to the Control sites, and is a 172% increase. This is higher than that suggested by the previous analyses, but does take traffic flow into account as well as allowing for sites having different underlying motorcyclist collision risk. It is possible that this model is over-parameterised in fitting a site factor, and there are some sites with zero collisions and hence huge variability between collision rates being modelled, i.e. it may be best to combine all sites.

The 95% confidence interval associated with this estimate is derived by simulating the relative increase ratio (for 20000 simulations) taking into account the standard error of the estimated parameters. For this example the 95% confidence interval was from 16% to 557% with a medium value of 173%, i.e. there is smaller than a 2.5% probability that the increase in motorcyclists' collision rate in bus lanes is less than 16% higher.

Appendix G Missing Data

Table of Missing Data and Reasons (2008)

Site no.	Date	Day	Symbols			Problem Type
1	22/24 Sept	1 & 2	🚌	⇔		video failure, upstream was re-filmed bus stop in view
2	18/19 Sept	1 & 2	🚌			bus stop in view
11	25/26 Sept		🖧			missing video data (2hrs 16mins)
16	06 Oct	1 & 2	↗	🎥	🖧	Camera in distance Cameras 44 secs difference in settings 22 minutes missing data
21	08/09 Oct	2	🖧			lost video data on 9/10/2008 re-filmed 10/10/2008 51 minutes missing video data
25	01/03 Oct	1 & 2	II	V	🚌	tubes damaged 3 times camera pushed down by vandals bus stop in view
28	01/03 Oct	1 & 2	Ⓟ	🚌	II	car parked on tube bus stop in view
29	14/15 Oct	1 & 2	×			road works near junction site dropped
30	16/17 Oct		🖧			12 minutes missing video data
31	8/9 Oct	1 & 2	‡			downstream camera erected in wrong location
33	29/30 Sept	1 & 2	V			request bus stop - alighting only
37	06/07 Oct		🖧			58 mins missing video data upstream
40	16/17 Oct	1 & 2	Ⓟ			parked vehicles along length of road
41	18/19 Sept	1 & 2	🚌			bus stop in view
42	29/30 Sept	1	Ⓟ	🎥		jerky tap day 1 camera 8 seconds different day 1 parked vehicles
44	06/07 Oct	1 & 2	Ⓟ			parked vehicles along road
48	22/24 Sept	1	🖧	⇔		contractor late start-rescheduled filming 20/10/2008 8-10 minutes missing video data
49	20/21 Oct	2	🎥	V		temp road works faulty tape cameras 11 seconds difference
50	06/07 Oct	1 & 2	↗	V		faulty tape one camera view from a distance
51	01/03 Oct	1	🖧			48 minutes video data lost day 1
53	14/15 Oct		🎥	Ⓟ		40 seconds difference in cameras parked vehicles along road
55	08/09 Oct	1 & 2	↗			one camera view from distance
56	16/17 Oct		🖧	V		8 minutes missing video data,
57	08/09 Oct		↗			one camera view from distance
59	01/03 Oct	2	⇔			lost video data re-filmed 10/10/2008
63	14/15 Oct	1 & 2	↗			one camera view from distance
64	16/17 Oct	1 & 2	🚌	🎥		13 seconds difference in cameras/ bus stop in view
66	29/30 Sept		🖧	🎥		camera timings different 35 minutes missing video data

Table 42: Missing Data 2008

Table of Missing Data and Reasons (2009)						
Site no.	**Date**	**Day**	**Symbols**			**Problem Type**
1	30 Sep	2	🚔			police car check
2	08 Oct	1	II			tubes damaged by road sweeper-repaired
4	08 Oct	1	II	V		tubes damaged by road sweeper-repaired cones in bus lane
8	14/15 Sept	1 & 2	⇔			roadworks-rescheduled
12	10/11 Sept	1 & 2	⇔			roadworks-rescheduled
15	20 Oct	1	🚔			police car check cleared at 16:20
20	12 Oct	1	II			tubes damaged by road sweeper-repaired
22	17/18 Sept	1 & 2	Ⓟ	II		parking on tubes
38	08 Oct	1	II			tubes damaged by road sweeper-repaired
38	09 Oct	2	⇔			cabinet flooded dvd failed 2 hours-re-filmed
32	02 Nov	1 & 2	×			roadworks ongoing unable to reschedule
42	14/15 Sept	1 & 2	Ⓟ	II		parking on tubes
43	28/29 Sept	1 & 2	II			tubes vandalised
46	10/11 Sept	1 & 2	⇔			roadworks-rescheduled
51	21/23 Oct	1	V			bus hit camera pole-view slightly moved
66	02 Nov	1 & 2	×			roadworks ongoing unable to reschedule

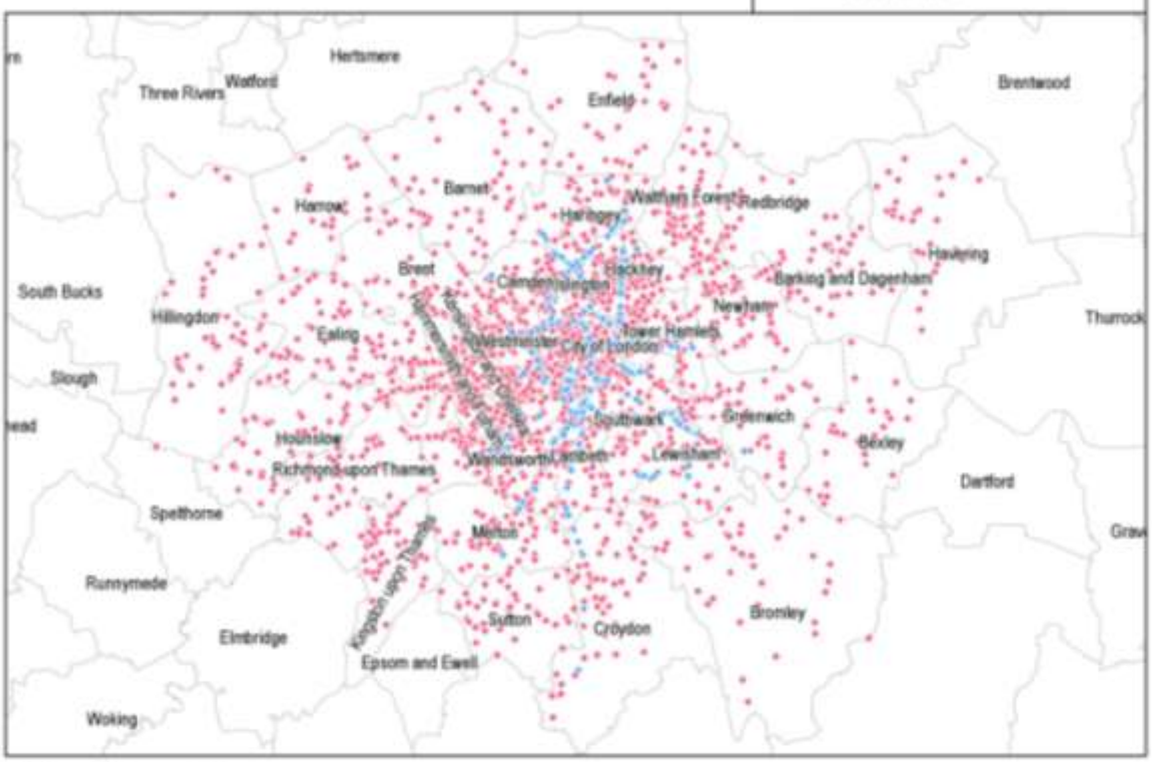
KEY for symbols	
II	atc parking/vandalised/damaged by road sweeper
🚍	Obscured view when bus stopped
🖧	missing video data-technical fault
×	roadworks unable to reschedule/site dropped
⇔	roadworks rescheduled/re-filmed
‡	wrong camera position
🚔	police car check
Ⓟ	parked vehicles along length
📼	tape time difference-corrected
↗	camera view from distance
V	miscellaneous

Table 43: Missing Data 2009 and Symbol Key

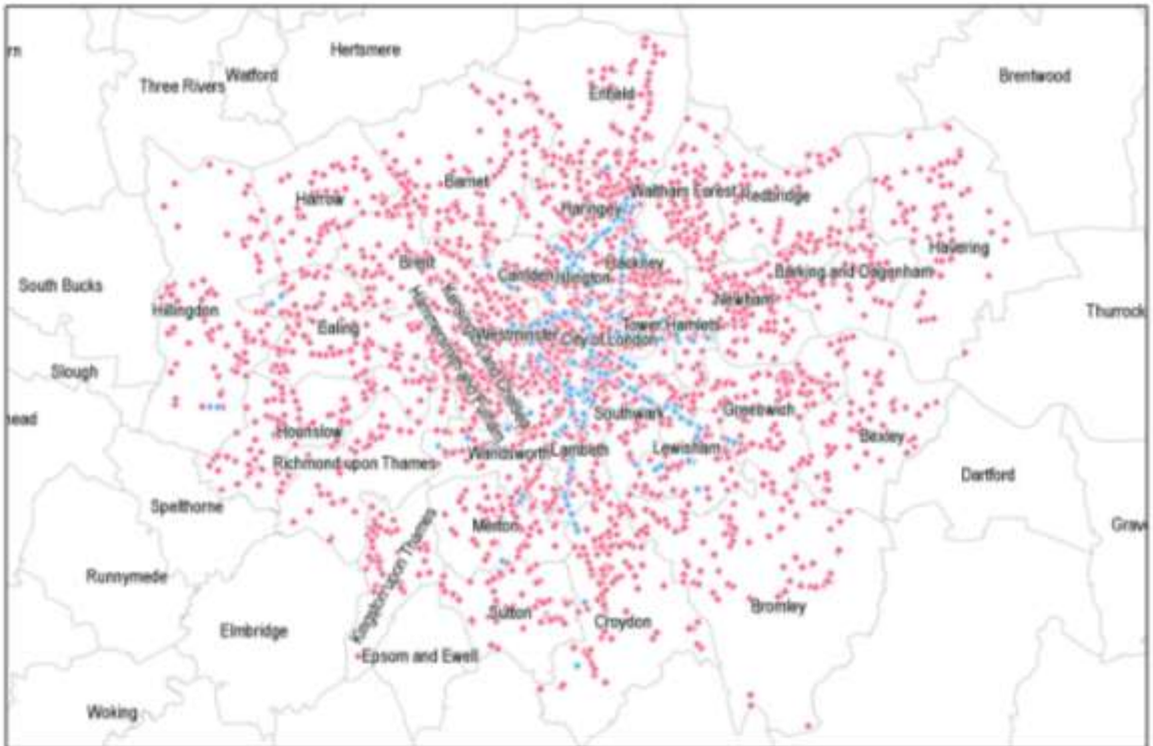
Appendix H Additional STATS19 Network Maps

Cycle collisions - Before

Legend
- London (not TLRN) collisions
- TLRN collisions

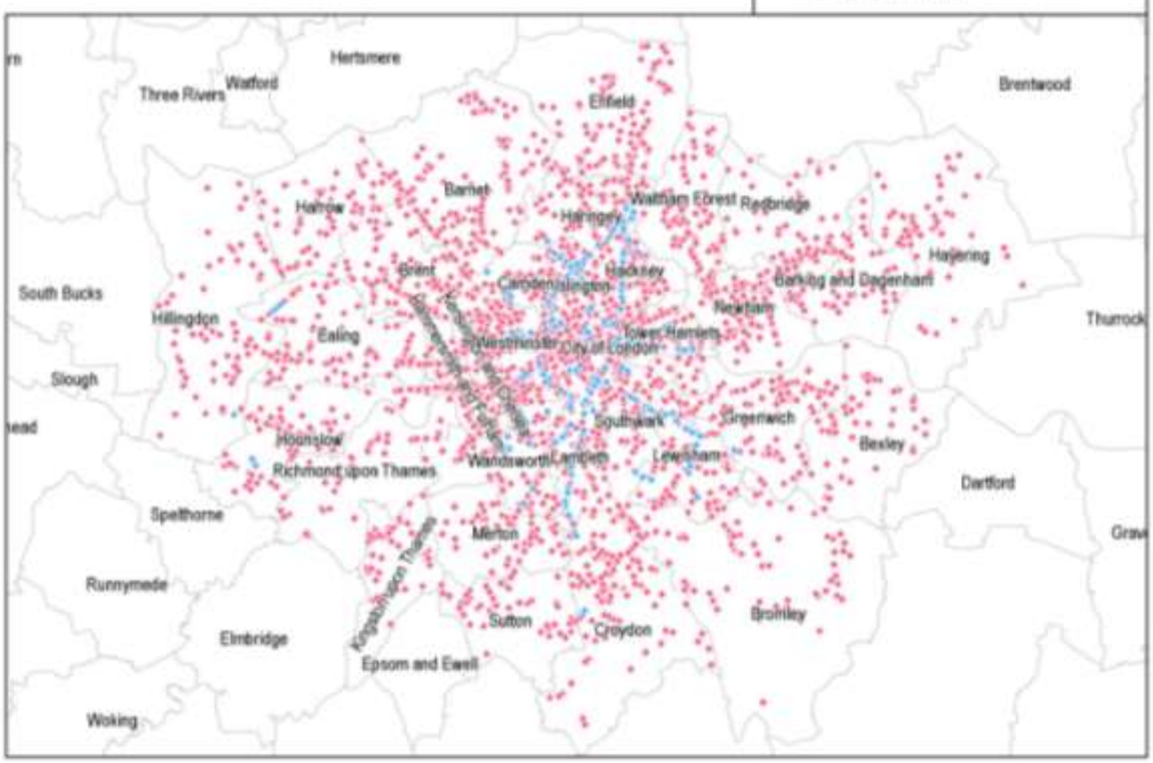


Cycle collisions - After



Pedestrian collisions - Before

Legend
- London (not TLRN) collisions
- TLRN collisions



Pedestrian collisions - After

Appendix I Permitted Deviations in Site Selection Criteria

It was thought probable that some sites would not, in reality, meet all the requirements for an ideal site; i.e. have an 'Attribute', such as: a bus stop, turning movement or pedestrian crossing between the locations for the timing points. In these circumstances, the following deviations from the ideal were permitted as they would not unduly affect the information being collected:

Main site:

- If the Attribute was at the end of the bus lane, the downstream timing point was moved upstream to approx 5 metres "before" the Attribute;
- If the Attribute was 150 to 250 metres from the downstream timing point, the upstream timing point was moved to just after the Attribute and therefore slightly reduced the distance between the timing points;
- If the Attribute was located elsewhere between the timing points, but was on a long bus lane, if possible the downstream timing point was placed before the Attribute. In addition to this, the upstream timing point was placed 150 metres to 250 metres upstream of that point, such that the upstream timing point was no more than 50 metres before the start of the bus lane;
- Otherwise, if the Attribute was a bus stop, consideration was given as to whether to retain the site and collect additional bus stop time information;
- Otherwise, the site was unsuitable.

Control site:

- There was no restriction with respect to a bus lane on these sites. Only 250 metres clear of Attributes on the road was needed;
- If unable to find 250 metres, the timing points were moved closer together to a minimum distance of 150 metres;
- Otherwise, if the Attribute was a bus stop, consideration was given as to whether to retain site and collect additional bus stop time information;
- Otherwise, the site was unsuitable.

Appendix J Combining Data Sources & Forming Annual Flows

J.1 Combining Data Sources

Data was collected on classified flows, journey times, lane usage and conflicts from the video surveys over two 12 hour periods (0700 to 1900) in each survey. ATC information was collected on each site over one week in each survey. Collision data was available for 10 months both before and after motorcyclists were permitted into the bus lane, and seasonal trends in motorcycle and cycle flows were available from previous surveys on London's network.

J.2 Forming Annual Flows

Three data sources were available to understand the flow of vehicles on each site. These were: the Video survey data that provided two accurate 12-hour classified counts of vehicles on the site in each survey; ATC tube counters that recorded the number of vehicles, and where possible classified these vehicles on each site for one week in each survey; and general monthly flow variations of motorcycles and cycles in London supplied by TfL.

The Automatic Traffic Counters (ATCs) consist of two rubber tubes a fixed distance apart, lying across the carriageway and covering all lanes in one direction. This equipment records the "hits" of each vehicle's axles as they cross the tubes. Differences in times between the two tubes being crossed provides details of the vehicle's speed, and differences in times between the axles of the vehicle crossing the tubes provides information for calculating the vehicle's axle spacing and therefore the class of vehicle.

The data logger collects this information and is able to provide counts of the number of axles crossing each tube and a classified count. These counts can be accurate under ideal conditions, but there are a number of known issues with the counters that affect data quality:

1. Classified counts undercount by approximately 10% even under ideal conditions
2. Axle counts slightly over-count the number of vehicles

3. Both axle and classified data can be missing through a vehicle parking on a tube, ingress of water into the tube, or other similar situations
4. Classified counts fail at below approximately 6mph

Points 1 and 2 were addressed through the method described below. Points 3 and 4 were addressed through data patching, as described in J.2.2.

The basic method used to form yearly flows consisted of utilising the strengths of each of the available data sources. It involved using the relative flows of ATC axle counts and the video counts, assuming the video counts were correct, to scale the ATC axle counts between 0700 and 1900 for each weekday. The modal split of the flows was estimated by applying the hourly proportions of each mode from the video counts between 0700 and 1900 to the scaled ATC axle counts.

Also, the average degree of under-counting for each mode in the ATC classified counts was calculated from a comparison of the video and ATC classified data for times between 0700 and 1900. These universal under-counting figures were used to scale the ATC classified count observations between 1900 and 0700.

The approach assumed that there was both a full 12-hour video count on two weekdays and ATC data for one week. This information was available for many sites, but some data was missing either through one of the known issues with the survey methodology, or through equipment failure; for example road sweepers pulling up the tube counters. In these cases it was necessary to use the available data to form the best estimate (patch) of the missing data. The following sections show how the method worked with complete data and how patching was achieved when data was missing.

J.2.1 Directly Combining Video and Tube Data

The video data was the more reliable data source of the two; an independent 2nd observer conducted spot checks on several sites and the original data was correct to a high level of accuracy. However, the video data only covered two 12-hour day-time periods. A combination of the ATC axle and ATC classified data was scaled to the video data and used to extrapolate the flows for the night-time and other days of the week.

The ATC tube data was collected from two tubes next to each other, near the upstream camera. The first indicator of accurate ATC data is the hit profile. This shows the number of times an axle crossed each of the two ATC tubes in each hour. In clean data the axle counts from both tubes agree and there are no occurrences of zero counts. An example of such data can be seen below for Site 8 ATC data in the Before survey.

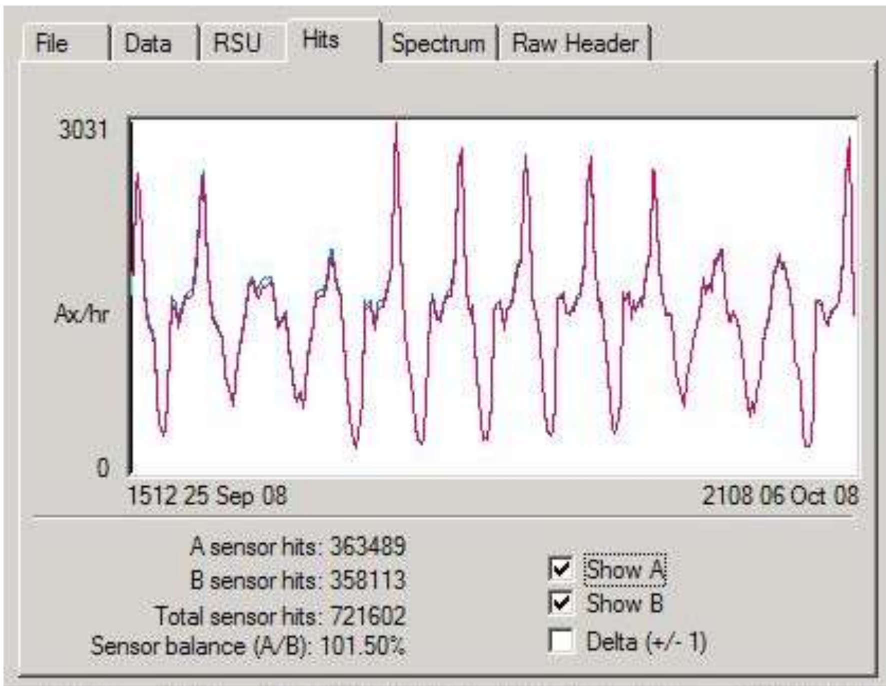


Figure 66: Weekly Traffic Flow for Site 8: Before Survey (ATC 'A' and 'B' Tube Hit Count Data)

The five weekdays can be seen with the higher evening peak. This was a good site, where both the 'A' tube and the 'B' tube functioned correctly over the whole period. The corresponding video data for Site 8 in the Before survey is shown in Figure 67.

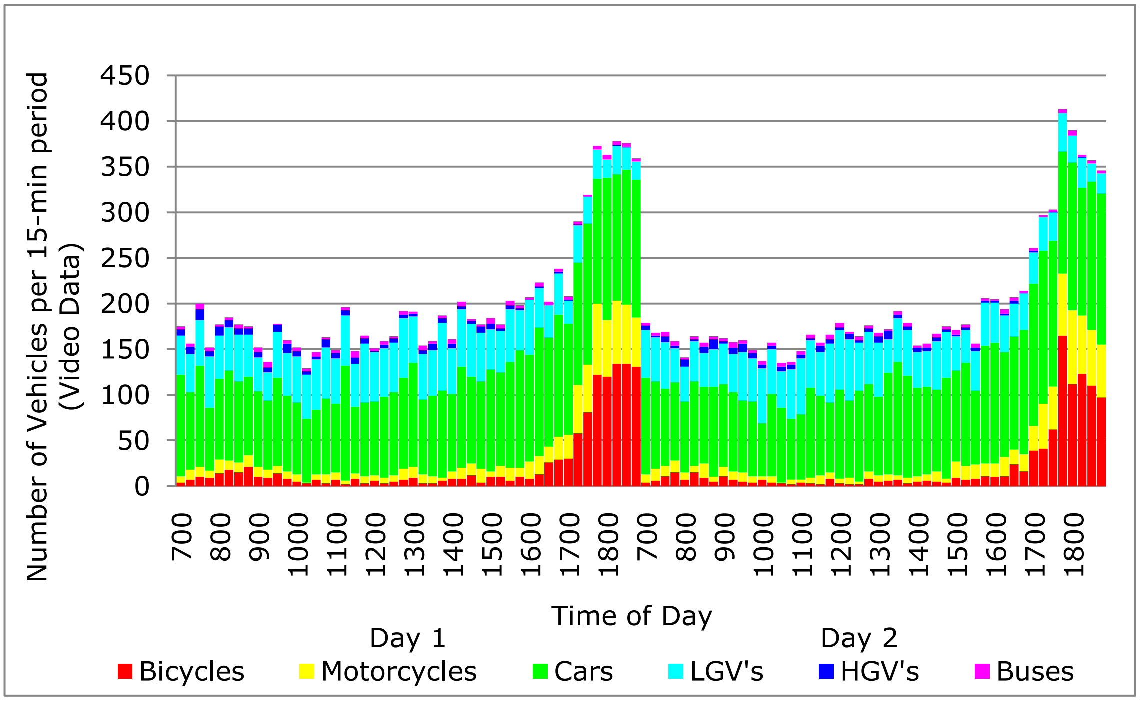


Figure 67: Traffic Flow by Mode for Site 8: Before Survey (Video Data)

The video data was analysed in 15-minute periods, and can be seen to be consistent with the axle counts. For example, between 1800 and 1900, the quarter-hour vehicle count was approximately 360. Thus, the hourly count was approximately 1440, and assuming two axles per vehicle, the hourly axle count was approximately 2880, and this compares favourably with the evening peak axle counts in Figure 66.

For each site, the 15-minute counts were grouped into hourly periods across the day. The hourly video flows (total over all six modes) were divided by the respective hourly ATC axle counts on the same days. These overall ratios were used to scale the degree of overall under-counting, or over-counting in the ATC axle counts for all days of the week. For example, this accounts for the percentage of vehicles with more than two axles in the classified flows. For Site 8, this ratio ranged from 0.905 to 1.036.

The average was computed across the two video days for the proportion of each of the six modes, for each hour, 07:00 to 19:00 in the video data. These average hourly proportions were then applied to the seven days of scaled ATC axle counts for 07:00 to 19:00 for each mode.

For night-time data between 19:00 and 07:00, the classified ATC counts were used. Average proportional modal under-counting figures were applied to these, as described further in J.2.2.2.

See Appendix B for calculations used.

J.2.2 Patching – Sources of Error

The previous section describes the methodology applied. However, this method assumes that the data was complete and could be processed. In reality some data was missing and needed to be estimated from the available data: i.e. the collected data needed to be patched to form complete 12-hour video counts and seven-day ATC counts. ATC tube data is liable to two types of failure:

- Total failure – Both axle and classified data can be missing through a vehicle parking on a tube, ingress of water into the tubes, or other similar situations.
- Partial failure - Classified counts fail, for example if the vehicle speed falls below approximately 6 mph this vehicle is lost.

Total failure can occur when a vehicle has parked on the tubes; in this case there are gaps in the data for up to several hours. Total failure also occurs when tubes are filled with water or ripped up, for example by road sweepers or maliciously by members of the public. In these cases the gaps in data can be multiple days.

Partial failure can occur at speeds below approximately 6 mph. In this case, the axle count is usually still collected, however the classified count omits some vehicles.

The ATC classified counts were derived from using both the ‘A’ and ‘B’ tube, whereas the ATC axle counts used just one of the tubes in isolation. The ATC axle counts used just the ‘A’ tube as the default, but it was also possible to use the ‘B’ tube instead if necessary. Therefore total failure occurred in the ATC classified count if either of the tubes malfunctioned, whereas the ATC axle count was less susceptible to total failure.

J.2.2.1 Patching – ATC Classified and Axle Tube Data, Total failure

Figure 68 shows an example of total failure for a 5-hour period, where no data was collected. This is the ATC classified count for Site 53 in the Before survey.

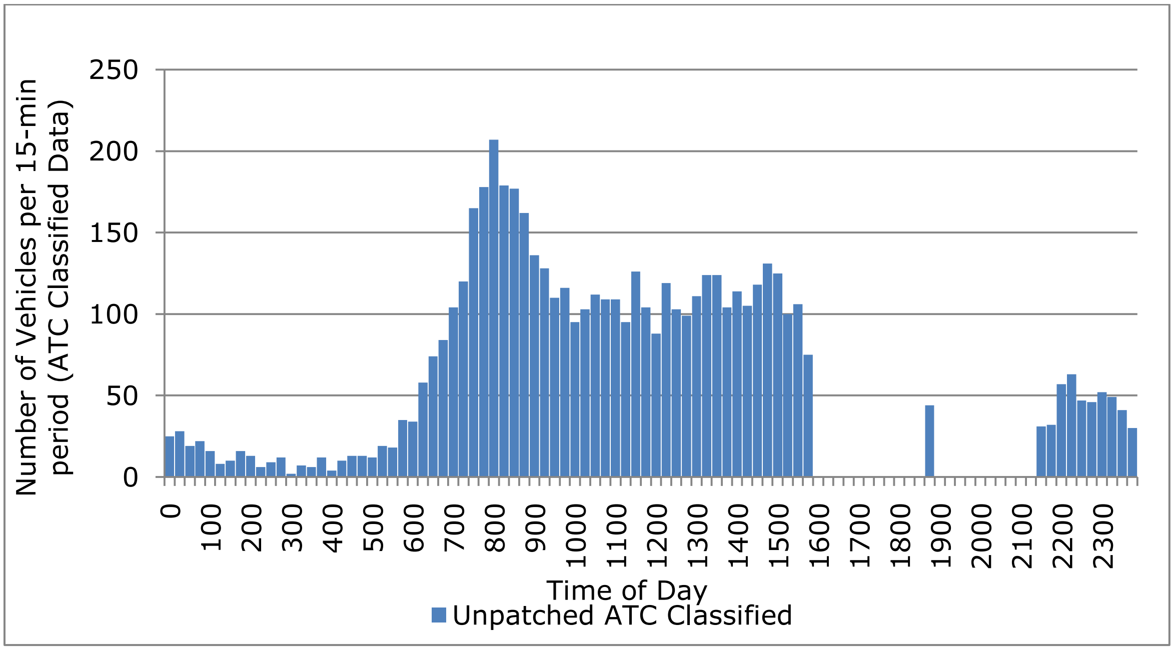


Figure 68: Unpatched Traffic Flow for Site 53: Before Survey, 14/10/08 (ATC Classified Data)

In such a case, patching was required. For the missing period, the average 15-minute flow from similar days was taken, e.g. weekend or weekday. Furthermore, the ATC data was collected for a period longer than seven days where possible, in which case the counts from the correct day of the week could be used from the following week. Figure 69 shows Site 53 in the Before survey once patched.

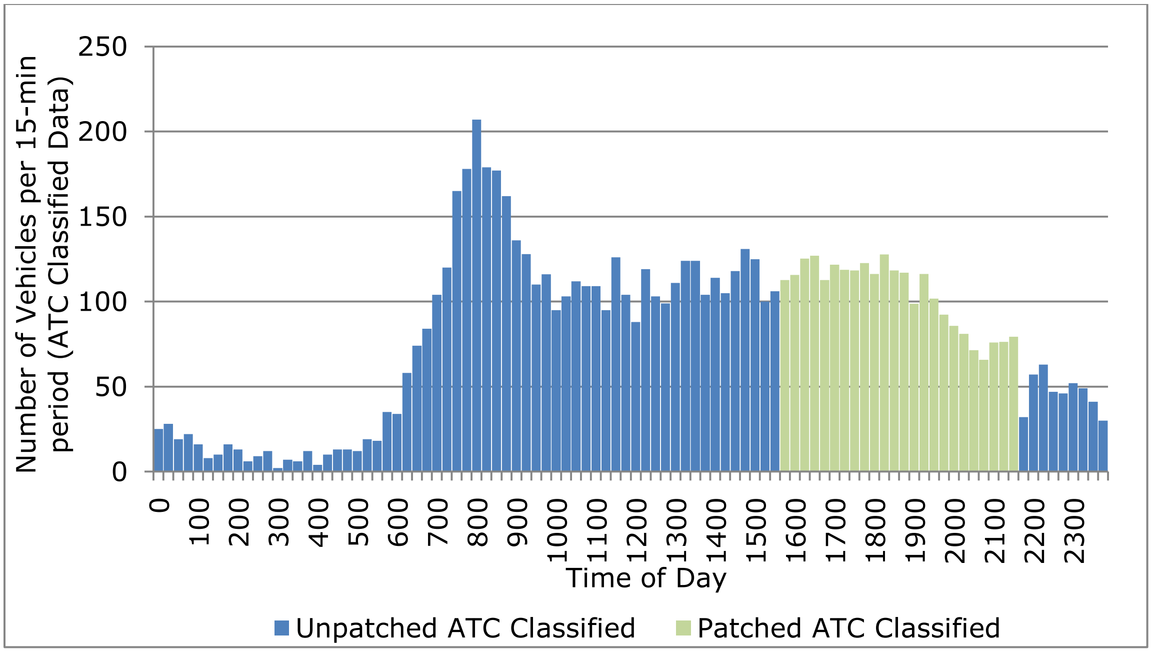


Figure 69: Patched Traffic Flow for Site 53: Before Survey, 14/10/08 (ATC Classified Data)

Such patching was undertaken on both the ATC axle counts and the ATC classified flows where necessary. Figure 70 shows the hit count for both the 'A' and 'B' Tubes for Site 42 in the Before survey.

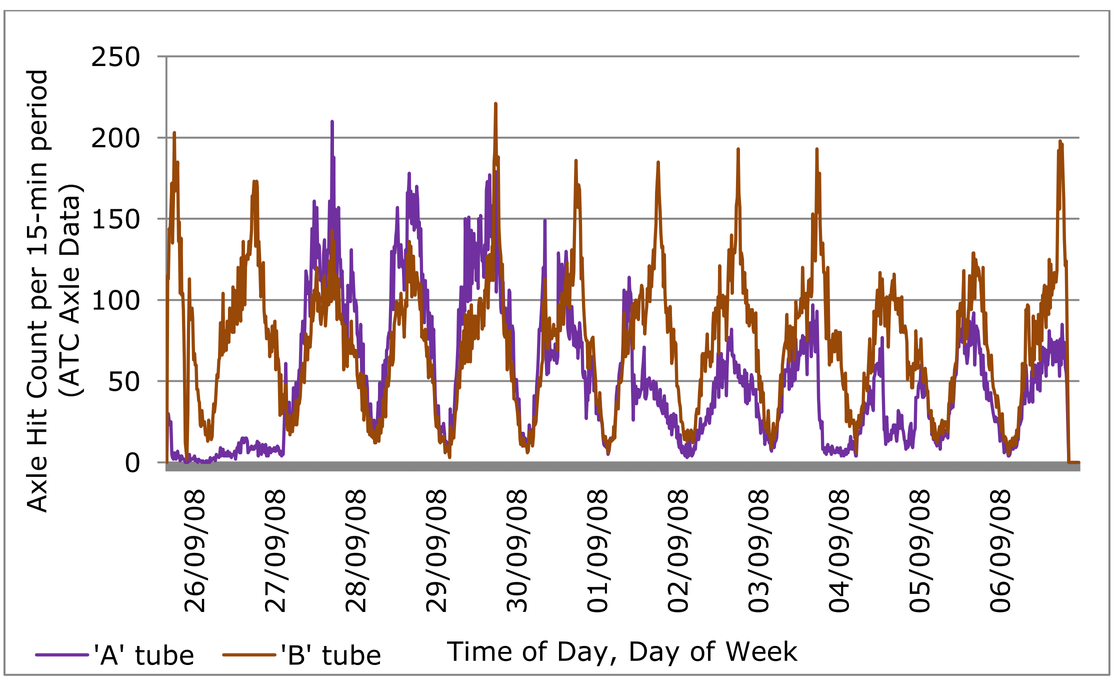


Figure 70: 'A' and 'B' Tube Axle Count for Site 42: Before Survey, (ATC Axle Data)

The 'A' tube was operating incorrectly for most days, but the 'B' tube was assumed to be correct. In this case it was possible to use the 'B' tube for the axle count instead of the 'A' tube. This was only necessary on 3 occasions out of 112 sites.

The ATC axle data was fully patched using these two methods described so far. Table 44 summarises the number of sites that required patching of the ATC axle data. However, the ATC classified count required further patching.

	Before Survey	After Survey
No patching	37	45
Some patching	19	11

Table 44: Number of Sites Requiring Patching (ATC Axle Data)

J.2.2.2 Patching - ATC Classified Tube Data, Partial failure

The ATC classified count was computed by an algorithm that assesses the distance between axles and this was liable to failure at low speeds. Figure 71 shows the classified count for Site 14 in the After survey. Red indicates speeds of 0-10 km/h and orange indicates speeds of 10-20 km/h.

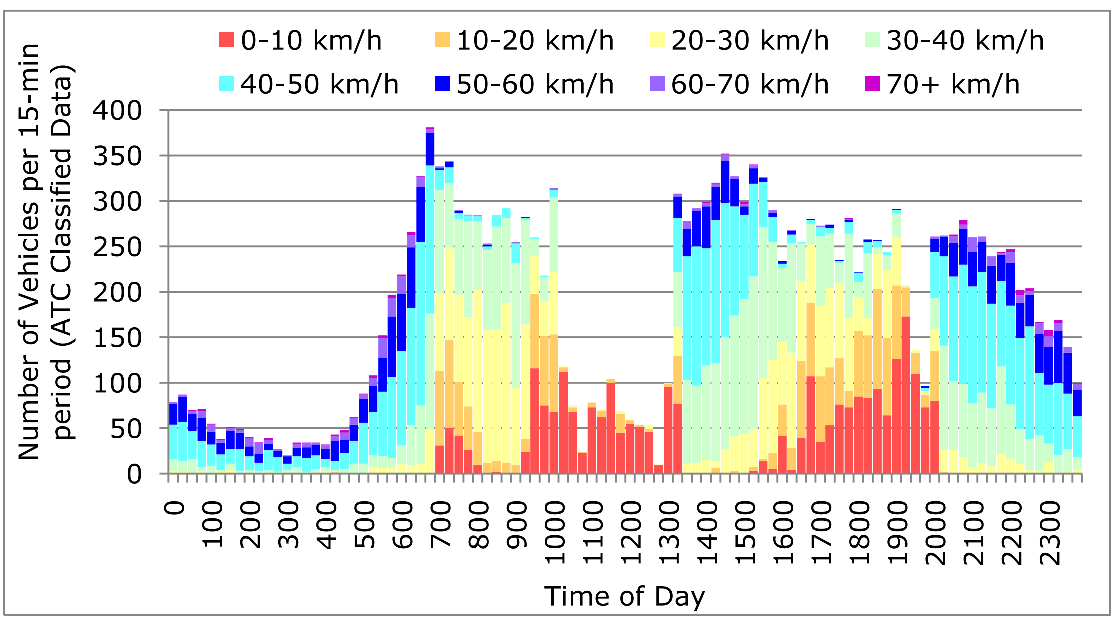


Figure 71 : Traffic Flow and Speed for Site 14: After Survey, 09/09/09 (ATC Classified Data)

It can be seen that the count is affected heavily by the low speeds during the day-time. Figure 72 compares the ATC axle count to the ATC classified count for the same site.

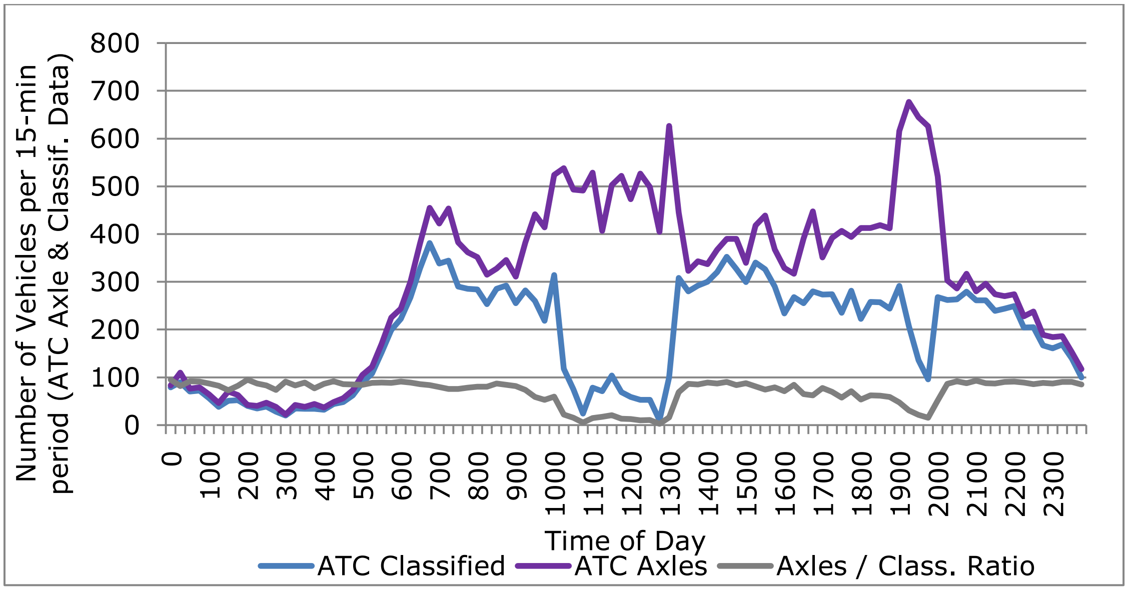


Figure 72: Traffic Flow for Site 14: After Survey, 09/09/09 (ATC Classified Data and ATC Axle Data)

This clearly shows that for the periods with low speeds, the ATC classified count was inaccurate. This was a common problem, with 64 out of 112 sites affected, with many sites affected on all days. However, Figure 72 also shows that the classified ATC count was generally accurate through the night, when there were higher speeds. It was therefore decided to adopt the methodology for the day-time 07:00-19:00 flows that is described in J.2.1. The night-time 19:00-07:00 ATC classified flows were not as badly affected by the speed problem, however there was still under-counting or over-counting for each mode.

In order to resolve this problem, universal ATC under-counting proportions were derived from all good ATC sites, as shown in Table 45.

Mode	Cycles	Motorcycles	Cars	LGVs	HGVs	Buses	All
ATC Classified Undercounting %	65%	70%	114%	50%	202%	104%	97%

Table 45: Universal ATC Under-counting / Over-counting Proportions for each Mode (ATC Classified Data and Video Data)

As expected, even when operating correctly, the ATC classified counts undercounted cycles and motorcycles by 65% and 70% respectively. HGVs were over-counted and LGVs undercounted, whereas cars and buses were the most accurate.

These undercounting percentages were then applied to all patched data 19:00-07:00. The modal proportions from the videos were applied to the scaled ATC axle counts for 07:00 to 19:00.

J.2.3 Patching – Video Data

The video data did not require as much patching as the ATC Tube data. There were two special cases that did require patching.

For Site 56 in the Before survey (Figure 73), cycles had been recorded as being on the pavement rather than in the bus lane on the 2nd video day. This was checked on the videos and corrected.

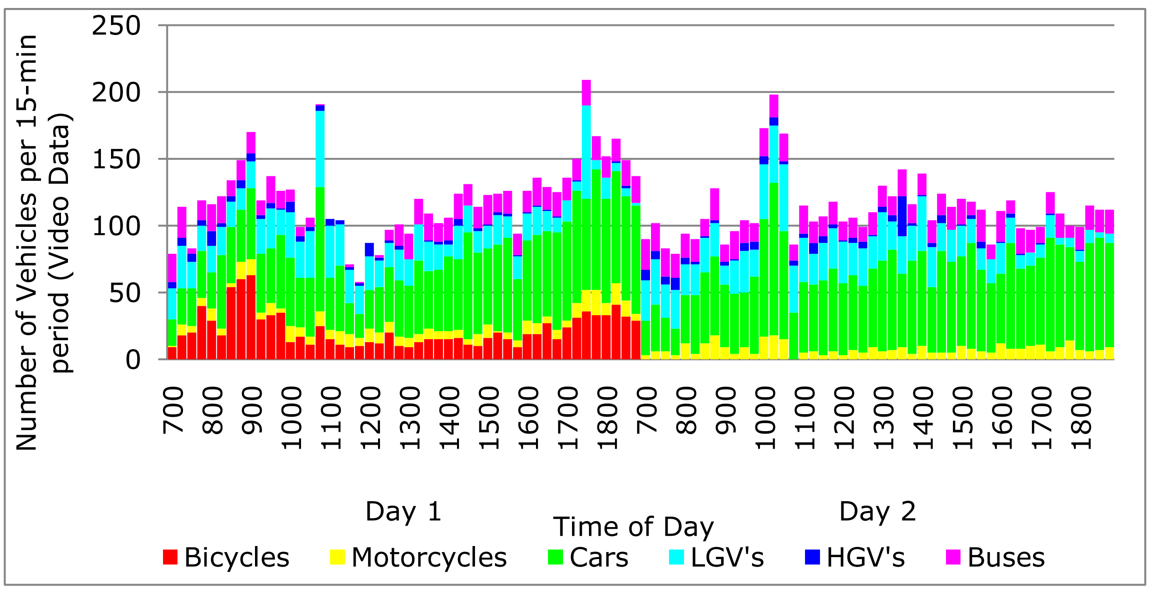


Figure 73: Unpatched Traffic Flow by Mode for Site 56: Before Survey (Video Data)

For Site 51 in the Before survey (Figure 74), there was 1 hour of video data missing on the 1st day. To correct this, the data from the 2nd day was used.

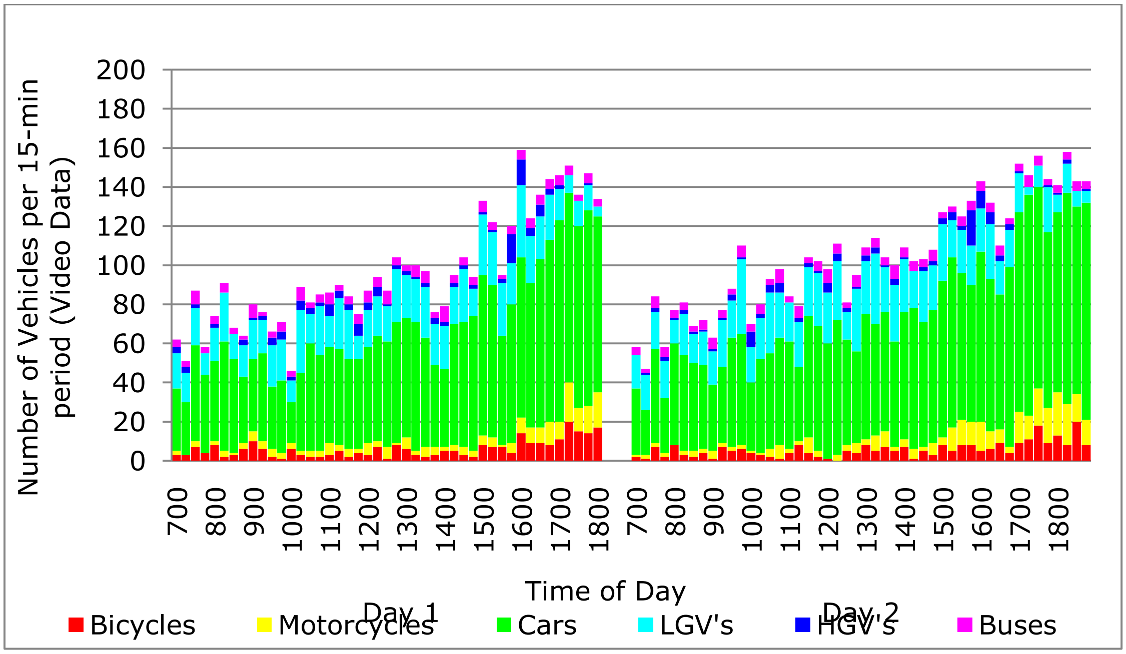


Figure 74: Unpatched Traffic Flow by Mode for Site 51: Before Survey (Video Data)

J.2.4 Applying Seasonal Factors

In order to scale the weekly flows to annual flows, ATC data from the TLRN was analysed to produce the seasonal factors for motorcycles and cycles. Available data from 2004 to 2009 was analysed, so as to not include data from before the Congestion Charge was implemented. The average seasonal trend was taken across the five years. 10-monthly flows (Jan-Oct) were created for use with the STATS19 data, as well as annual flows.

The seasonal factors for motorcycles and cycles are shown in Figure 75 and Figure 76, respectively. In both graphs, October is taken as the base month, with a value of 100, and all other months have a seasonal factor relative to October.

For motorcycles there was a large peak in usage in December to February, also with a peak in August. For cycles, there was a smaller rise in flows for February to August.

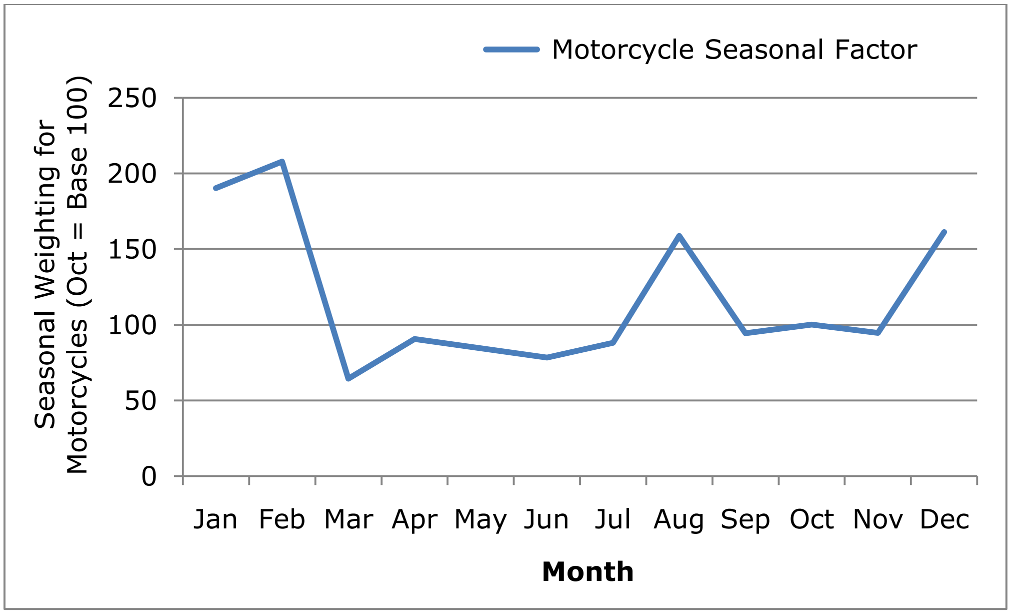


Figure 75: Motorcycle Seasonal Variations (Data Provided by TfL)

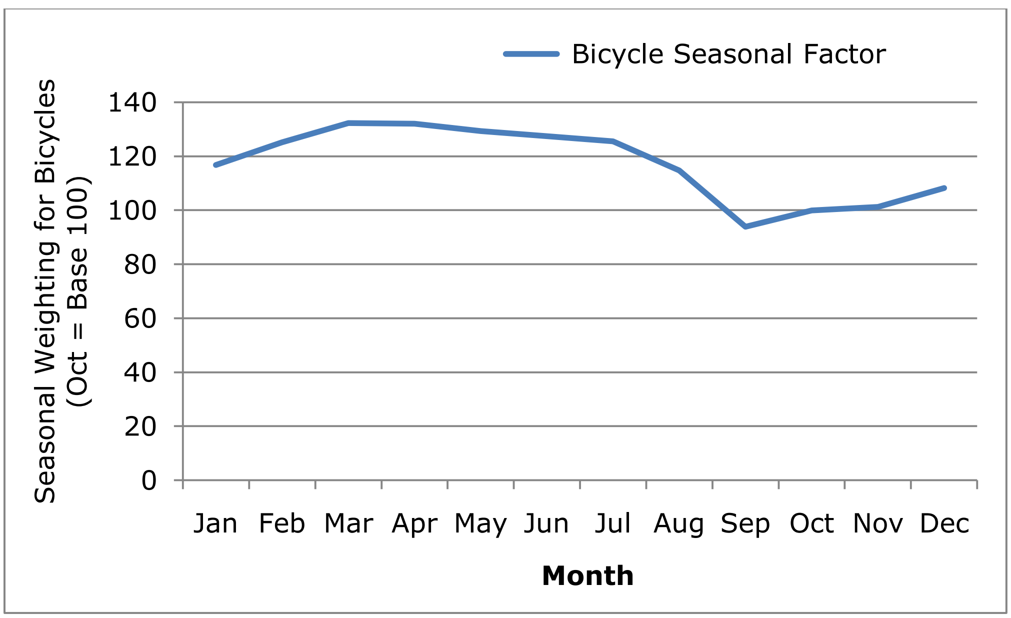


Figure 76: Cycle Seasonal Variations (Data Provided by TfL)