Effect of side raised entry treatments on road safety in London

by K Wood, I Summersgill, L F Crinson and J A Castle

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EFFECT OF SIDE RAISED ENTRY TREATMENTS ON ROAD SAFETY IN LONDON

Version: 4

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Executive summary

One of the measures intended to improve conditions for pedestrians in London has been the installation of Side Raised Entry Treatments (SRET) across side roads at their junctions with major roads. Many were installed as part of the development of the Transport for London Road Network (TLRN); the network of major roads that started out as Red Routes, which were introduced into London as a major change to the management of road users on the capital's roads. A SRET not only provides a convenient level place to cross for pedestrians walking along the main road, but also acts as a warning to drivers that they are leaving a main road and entering a network of roads of a quieter, probably more residential character.

An earlier study for TfL by Colin Buchanan and partners in about 1995 had considered the effects of SRETs and provided guidance on their design and where they should be used. Because few SRETs had been installed at the time of that study it was not possible to draw statistically significant conclusions on the effects of SRETs. Therefore, this project was undertaken to determine the extent to which the expected benefits on collisions have been achieved. It required the study of the collision statistics at a large number of SRETs, in addition a more detailed study was undertaken at a selection of sites to examine how users behave at SRETs.

The first part of the project estimated the effect of SRET treatment (in conjunction with conversion to Red Routes in the case of the TLRN junctions) on collisions at 777 junctions on the TLRN network and at 275 junctions that are on London Boroughs' roads. TLRN and London Borough sites were treated separately as the traffic characteristics of the TLRN are different from those of Borough roads and the installation policies were different. The statistical estimation used Generalised Linear Regression models. It has produced results which are different for the effect of SRETs at TLRN junctions compared with that at Borough junctions.

The results from the TLRN model estimate that there was no overall change in the number of collisions of all severities due to SRETs on the TLRN. Installation of a SRET across a side road of a road on TLRN would not be expected to change the overall number of collisions in a year. However, there are estimated to be changes in the types of collisions. The model estimated a statistically significant reduction, of 20%, in pedal cycle collisions following installation of a SRET. Some other classes of collisions: powered two-wheelers, powered two-wheelers turning, right turning into the side road, all turning collisions and all collisions on the minor road were estimated to have increased. No other statistically significant changes were determined. Powered two-wheelers in particular show a considerable increase in collisions above the underlying trend of an increase in such collisions in London. Although all turning collisions were estimated to have been increased by the installation of SRETS, the only individual movement to be statistically significant is in right turning into the side road.

The model of collisions at SRET sites on Borough roads shows a different picture; overall collisions are estimated to be reduced by 20% and all the statistically significant results are reductions. Installation of SRETs on the Borough roads in the data set modelled is estimated to have reduced collisions and not increased any of the categories of collisions that were included in the modelling. Significant reductions were estimated in several collision categories: total collisions, slight collisions, non pedestrian collisions, pedal cycle collisions, right turning out from minor arm collisions, all turning collisions and all collisions on the minor road.

It is difficult to explain the differences between the results for the TRLN sites and those for the Borough sites. The explanation may be related to a number of issues:

- The different traffic characteristics (e.g. traffic speed, traffic volume) between the TLRN and sites on Borough roads where SRETs have been installed.
- The TLRN sites included in the study are mostly in inner London whereas the Borough sites are mainly in outer London

- The TLRN were SRET treated at the same time as they became part of Red Routes so that it is not possible from the data used in this study to separate the two effects. The Borough sites are not on Red Routes
- There may be some element of bias by selection within the Borough dataset, since the treated junctions may have been selected for treatment because they had a poor collision record and are, therefore, more likely than average to show a reduction in collisions in subsequent years (regression to mean effect).

The second part of the project studied pedestrians' and drivers' behaviour at a selection of junctions, eight with SRETs and three control sites. Comparing pedestrian behaviour at SRET and control sites showed that pedestrians are more likely to obviously look for turning vehicles that may conflict with them when crossing a side road without a SRET than when there is a SRET. However, it is not clear whether pedestrians expect drivers to give way at SRETs. At two sites, one control and one with a SRET, a significant minority of pedestrians appeared to assert priority and force drivers to give way to them, but overall there was no clear difference in pedestrians' expectation of priority between SRET and control sites.

Drivers showed little difference in propensity to give way to pedestrians wishing to cross the side road at control and SRET sites. The severity of the interaction between individual pedestrians and vehicles was assessed from the video recordings. Interactions were classified in order of increasing severity for collision potential as "interaction", "encounter" and "conflict." The proportion of conflicts was low at all sites, but there was a significantly greater proportion of encounters and conflicts between vehicles turning into the side road at sites with a SRET than at control sites. The difference was most marked for vehicles turning right into the side road. The increase in the severity of the conflicts for turning movements is in good agreement with the statistical collision analysis, where a significant increase in the number of collisions involving vehicles turning right into the side road was found.

Pedestrians appeared to like the convenience of crossing the side road at a SRET, where the SRET provided a continuous level place to cross between the footways either side of the side road. Significantly fewer people diverted from the natural crossing line to walk behind a stationary vehicle, and avoid delay, at sites with a SRET than at the controls. The benefit of the convenient informal crossing appeared to exceed the disbenefit of the extra delay of waiting for the vehicle to clear.

The observed behaviour of drivers and pedestrians was used to provide insight into the collision study. The collision analysis estimated no significant change in pedestrian collisions, although pedestrians were observed to be less diligent in looking for potentially conflicting vehicles at sites with SRETs compared with control sites. It is possible that pedestrians' willingness to wait to cross along the SRET after a waiting vehicle had cleared rather than walk behind the vehicle to save delay results in better visibility of pedestrians by vehicles turning into the side road.

An increase in collisions involving turning vehicles at TLRN SRET sites was estimated by the collision modelling. The observations showed vehicles turning into the side road to be more likely to be delayed by another vehicle on the side road at SRET sites than elsewhere. However, no serious vehicle – vehicle interactions were observed.

There were too few powered two-wheelers or cyclists observed to draw any conclusions. However, the collision modelling showed no evidence of an adverse effect of SRETs on cyclists, in fact there was a significant reduction in cyclist collisions at SRET sites.

Neither the observational study nor the collision modelling raised particular issues for children or older pedestrians.

The routine treatment of all junctions on sections of the TLRN has not been as successful in reducing collisions as has the more targeted approach adopted by individual Boroughs. However, no analysis has been done on any possible regression to the mean effect at the Borough sites.

1 Introduction

One of the measures intended to improve conditions for pedestrians in London has been the installation of Side Raised Entry Treatments (SRET) across side roads at their junctions with major roads. Many were installed as part of the development of the Transport for London Road Network (TLRN); the network of major roads that started out as Red Routes, which were introduced into London as a major change to the management of road users on the capital's roads. A SRET not only provides a convenient level place to cross side roads for pedestrians walking along the main road, but also acts as a warning to drivers that they are leaving a main road and entering a network of roads of a quieter, probably more residential character. An example is shown in Figure 1-1

Figure 1-1: A Side Raised Entry Treatment

There was considerable interest in the implementation, application and performance of SRETs. Colin Buchanan and Partners (c.1995) undertook an early study of the performance of SRETs. That study was limited because at the time few SRETs had been installed and those that had been, had not been installed for long. However, the results appeared promising with fewer collisions in the after period than in the before. Most noticeable was a reduction in collisions involving turning vehicles in conflict with pedal cyclists on the main road. Collisions involving pedestrians showed a reduction that was concluded to be due to better driver behaviour and a reduction in speed on entry to and exit from the side roads.

The authors summarised the benefits of SRETs as a combination of threshold treatment, to delineate the change between main and side road, speed reduction measure and pedestrian crossing facility. That study also included guidelines on where raised entry treatments are of most value and they have been used in this project to provide indicators of factors that should be included. The guidelines stated that full raised and narrowed entry treatments should *not* be considered on main roads with high traffic flows and vehicle speeds, rather than speed limits, in excess of 30 mph because of a potential increase in the risk of shunt collisions on the main road.

Three principal factors that would increase the desirability for the installation of a SRET were identified:

- Land use activity as a proxy for the expected level of pedestrian activity
- Pedestrian / vehicle conflicts
- Vehicle turning speeds.

The Buchanan study was only able to look at a limited number (107) of SRET sites. Their findings on the collisions from a five-year (1 January 1989 to 31 December 1993) before and after period are shown in Table 1-1.

Table 1-1: Results of Buchanan collision study

	Before	After	% change
All personal injury collisions	108	105	- 3%
Pedestrian casualties minor road	9	6	- 33%
Pedestrian casualties major road	44	43	- 2%
Cyclist casualties	28	18	- 36%
P2W casualties	50	43	- 14%
Car right turn entry casualties	32	44	+ 38%
Car all other casualties	64	60	- 6%
All vulnerable road users	131	110	- 16%
All car users	96	104	+ 8%

Because of the small sample size and limited monitoring period, none of the results was statistically significant.

1.1 Study objectives

This study was designed to examine the collisions at a large number of SRETs, on both the TLRN and on Borough roads, to see whether the expected benefits had been achieved. It was a study of SRETs in general not a study of the effects of details of the design, e.g. ramp slope, width of raised table etc., of individual SRETs. A second part of this study was a video survey of the behaviour of pedestrians and drivers at a sample of SRETs and control sites to look for differences in behaviour that might impact on safety.

Throughout this report reference is made to “collisions;” these collisions are those that resulted in personal injury and are recorded in the Stats19 database. Other studies have used the term Personal Injury Accidents (PIA) to refer to the same event. It should be noted that collisions in this report refer to all severities; where analysis refers only to collisions involving fatalities and severe injuries, the categories are noted explicitly.

Two sets of collision data have been analysed, one set of collisions at or within 20m of major / minor junctions (on the TLRN itself or on side roads joining it) and a second set at or within 20m of major / minor junctions on roads for which the local Borough is the highway authority. At all the sites there was a SRET across the minor road at the junction with the major road.

The research questions set for the study were:

- SRETs as pedestrian crossings: Are SRETs beneficial to pedestrian safety on the feature itself? How large and long ranging are the pedestrian safety effects? In particular, what are the safety implications for children and older road users?
- SRETs as gateways: Are SRETs beneficial to road safety at the junction and on the side road? How large and long ranging are the safety effects for various road users? In particular, what are the safety implications for cyclists and motorcyclists?

In addition the study should explore how SRETs influence the behaviour of pedestrians and other road users and how this may affect road safety.

1.2 Other relevant studies

TfL provided the TRL study team with the results of other relevant studies and background material. A survey of public attitudes to the TLRN (called by the original name, Red Routes, in the study) and associated measures was undertaken by Synovate Research for TfL Customer Research in October 2004. The survey included in-depth, qualitative interviews with 16 members of the public who drove on the TLRN. With such a small sample, the opinions expressed must be considered indicative only. The study was not intended to be exhaustive or to produce fully representative views. Most respondents reported little or no noticeable impact on their driving from Red Routes. The comments that were made showed that the interviewees felt that Red Routes were to assist movement and there was a need to keep moving, “chasing the car in front,” avoid stopping and that the volume of moving traffic could make it difficult to turn right off a Red Route.

When prompted about their understanding of side raised entry treatments, respondents showed quite a low awareness and recall of SRETs. They were assumed to be primarily a pedestrian-focused measure of “traffic calming.” There was some awareness that a SRET can act as a warning to drivers on side roads that they are approaching a major road, but there was limited understanding of the relationship between SRETs and Red Routes. A minority of the respondents considered SRETs to be a measure to prevent parking at junctions.

Attitudes to SRETs were positive; they were considered to be a good idea in principle, but there was also some feeling that the measures are unnecessary “drivers already slow down for pedestrian crossings and at junctions.” There was no reported impact in terms of behaviour of the respondents when turning off a Red Route. Two quotes showed somewhat contrasting attitudes. One was a rather negative view of a threat to his vehicle, “It makes you lower your speed when you are approaching the junction…nobody wants to damage their vehicle.” Another showed a positive appreciation of a warning of potential conflict with pedestrians, “I see it as an area for pedestrians to cross. Therefore you should be aware of that and allow them to do so. It’s also to slow the traffic down.”

When preparing the brief for this study, TfL collected comments from various technical experts to ascertain their views on SRETs and where more information is needed. Some comments were very positive, e.g. “I think SRETs have been extremely successful: they have reduced accidents; they are welcomed by pedestrians in terms of not having to go up and down the kerbs.”

However, several respondents commented on the ambiguity over pedestrian priority. The Highway Code states in section 146, which is addressed to drivers, that drivers should “watch out for pedestrians crossing a road into which you are turning. If they have started to cross they have priority, so give way,” this advice is not supported by law. There was concern that SRETs could add to the potential confusion as a SRET is effectively a pedestrian crossing, but has no formal status as a crossing.

SRETs are popular with some Boroughs as a means of improving conditions for pedestrians in circumstances where the Borough cannot provide direct priority by, for example, signalising the junction. One comment was “Our observations suggest that these features are welcomed by pedestrians and tolerated by drivers. The latter tend to slow down and give way to pedestrians.”

2 Method

The main part of the study was a "before" and "after" analysis of the collision data to determine the effect of SRETs on collisions at junctions. It was necessary to define the number of SRET sites needed to provide robust results and to identify control sites to be used to allow for the effects of background changes in collision rates.

The findings of the Buchanan report were analysed to determine the number of sites that were likely to be needed in a study to provide the required level of statistical confidence in the results. The results of that analysis are in Table 2-1.

Table 2-1: Estimated sample size requirements

Type of collision or casualty	% change to be detected	No. of 'before' collisions /casualties required	No. of sites required	p-value
All personal injury collisions	*-3%*	*8,405*	*8,327*	*0.05*
Pedestrian collisions minor road	-33%	59	701	0.05
Pedestrian collisions major road	-2%	19,008	46,224	0.05
Cyclist collisions	-36%	49	187	0.05
P2W collisions	-14%	364	779	0.05
Car right turn entry collisions	+38%	63	211	0.05
Car all other collisions	-6%	2,069	3,459	0.05
All vulnerable road users	*-16%*	*276*	*225*	*0.05*
All car users	*+8%*	*1,248*	*1,391*	*0.05*

One of the primary objectives of the project brief was to analyse the effect of SRETS on pedestrian casualties on the minor road. The power calculation presented in Table 2-1 showed a required sample size of 700, however, given the relatively small numbers in the Buchanan study it was recommended that a minimum sample size of 1000 SRETs should be used.

The sample size calculations further indicated that a sample of 1000 SRETs should provide robust statistical findings for most collision categories, including those involving vulnerable road users.

2.1 Site selection

During the implementation of the original Red Routes, the policy was that entry treatments were a fundamental part of the changes to the operation of the roads. They were introduced at all junctions; there was no selection by any special need, such as a particular collision record. However, raised entry treatments were not normally used on sections of suburban red routes where typical vehicle speeds exceeded 30 mph. The reason for the exemption was a fear of shunt accidents on the main road because of drivers slowing down to make a slow turn across an entry treatment. Consequently there was a large number of SRETs on the TLRN in inner London available to study.

TfL has a large asset management database, AIMS, that holds, amongst much other data, details of entry treatments on the TLRN. Using AIMS, TfL provided TRL with location and other details of 777 SRETs on the TLRN for the study. To ensure the accuracy of the AIMS data, TfL staff visited the sites to visually check the details of the SRETS. There were further SRETs on the TLRN (about

300), but these were not surveyed by TfL and not included in the study. The majority of the selected sites, (632 of 777) were within inner London Boroughs.

The aim of the study was to investigate SRETs across London, not just those on the TLRN. Therefore, each London Borough was contacted to request data for SRETs on Borough roads. Information was received from five outer London Boroughs on 249 SRETs and one inner London Borough on 26 sites, see Table A-1 of Appendix A for details. This gave 1,052 SRET sites in total. In Sutton and Camden sites are included for both Borough roads and TLRN roads. Figure 2-1 shows a map of the sites.

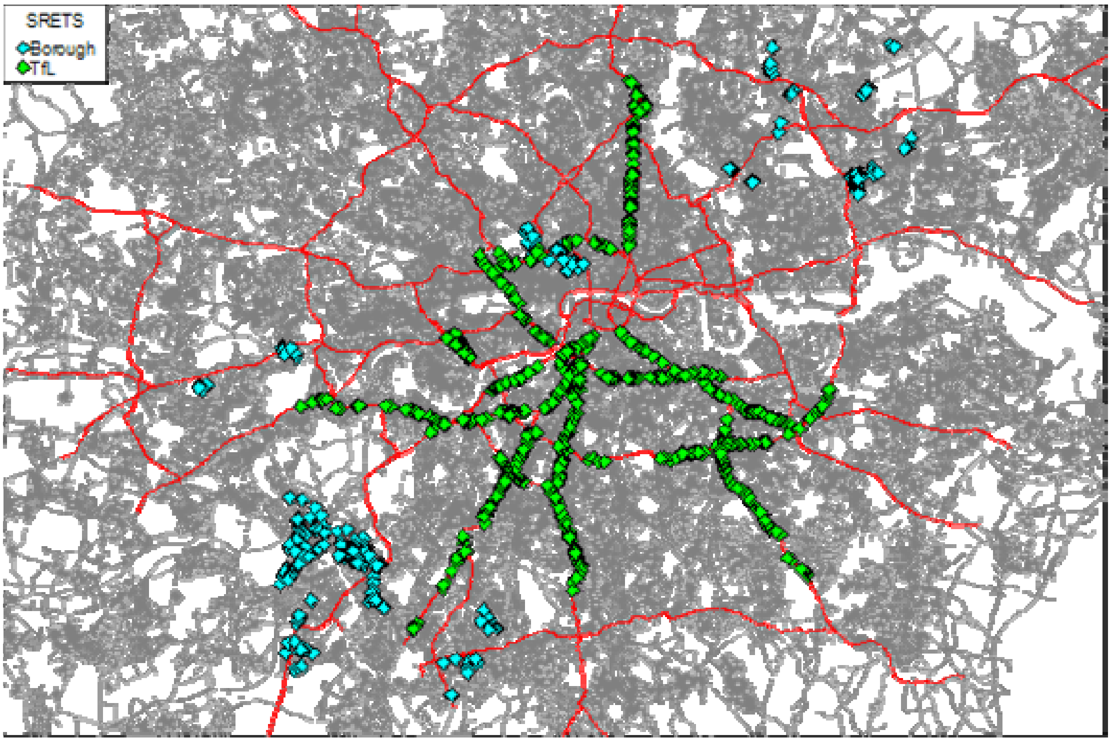

Figure 2-1: Map of TLRN and Borough SRETS

The TLRN consists of the major traffic routes in London, a selected set of roads of strategic importance. The use of the roads, traffic volume, speed, parking and driver behaviour will, therefore, be different from those of other roads in the capital. Because of the different characteristics, and possible different installation criteria (see section 2.4.2) the SRETs on the TLRN were analysed separately from those on the Borough roads.

2.2 Allocation of collisions to sites

A collision was assigned to a SRET if its grid reference was within 30m of that of the SRET. However, analysis of the collision and casualty data was restricted to collisions coded as "junction accidents" on Stats19. The Stats19 collision report includes the type of junction at which the collision occurred. For the purposes of Stats19, a collision at a junction is defined as one occurring within 20m of a junction. Collisions occurring further than 20m from a junction should be coded as non-junction. The collisions within 30m of the SRET junction therefore include some non-junction collisions and were subsequently removed from the sample, but should include all of the junction collisions associated with that junction. It should be noted that the grid reference location of a collision is only recorded to the nearest 10m.

2.3 Control data

Collision data from control sites is frequently used to help take account of time dependent effects, such as the reduction in injuries and their severity due to improvements in vehicle technology and medical treatment. All of the TLRN SRET sites are on the TLRN network so it was necessary for the control data also to be on that network in the analysis of the SRET sites. The London Borough SRETs are not on the TLRN and hence for these, control data were needed that are on Borough roads.

It was not feasible to select a matched control site for each TLRN or Borough site, as there are many factors which may influence the safety at a particular junction, for example, the major and minor road vehicle flows and the pedestrian flow, which would need to be measured at each site. Matching each of over 1000 SRET sites with an equivalent untreated site was not feasible.

The specific locations of the control junctions were not known and hence it was not possible to allocate the Stats19 collision records to individual junctions. Instead, a single control was used which included the combined total of collisions that occurred at the many control junctions. Thus, in the analysis, the control acted as if it was a single junction at which large numbers of collisions had occurred. This single "junction" averaged the characteristics and collision record of many junctions. It was not an accurate control for any one SRET site, but was taken to represent the general time trend in collisions.

The control data were the total collisions at all non-signalised T-junctions or crossroads of the types included in the SRET dataset on the TLRN or Borough road network, excluding those in the SRET data set. It was not possible to take account of one-way streets or of the proximity of nearby junctions.

It is desirable that the control junctions have not themselves been subject to SRET treatment. Unfortunately, a few of the junctions selected for the TLRN control did include some that had been treated, but were not in the sample analysed as SRET junctions. They were included because there was no ready means of filtering them out.

2.4 SRET characteristics

An outline of the characteristics of the selected sites is given below, further details are provided in Appendix A.

2.4.1 Background data

TfL provided TRL with details of the 777 selected SRETs (see section 2.1) on the TLRN for the study.

The data supplied included:

- Unique ID of SRET from the TfL AIMS database
- Condition and material
- Whether raised
- Number of side road lanes
- Whether in a 20 mph zone (includes entries to 20 mph zones)
- Borough, road name and route description

- Implementation start and end date taken from the Priority Route Accident Monitoring System (PRAMS)

The data on the 275 Borough sites was generally limited to the location and implementation start and end dates. Only data on raised entry treatments was requested and supplied.

2.4.2 Installation criteria

The installation criteria of the SRETs may differ between the TLRN sites and the Borough sites and between the individual Boroughs. The majority of the SRETs on the minor roads at the TLRN sites have been installed as part of a mass-action scheme, whereas the Borough SRETs may have been installed as accident-remedial measures. The possibility of different installation criteria was another reason why Borough and TLRN sites were treated separately throughout the analysis. Boroughs that supplied data were asked for the criteria that had been used to select sites for SRET treatment. Replies were received from four Boroughs and are reproduced below with their permission at least some of the Borough sites will have been targeted at sites with high collision records.

2.4.2.1 Waltham Forest

“In the London Borough of Waltham Forest, Raised Side Road Entry Treatments (RSRETs) are generally used as an Accident Improvement Programme measure to improve pedestrian safety and accessibility, and also reduce the speed of traffic entering and exiting junctions. The RSRETs are generally introduced either singly or at targeted junctions along a length of road.

“RSRETs have also been used to treat some of the junctions on the boundary to area traffic calming and 20mph zones. However, due to the high cost of constructing a full RSRET the majority of junction entry treatments bounding 20mph zones are not raised but instead use red coloured surfacing.

“At locations where a cycle lane has been introduced on a main road, RSRETs have been introduced to regulate traffic speeds on the adjoining side roads. “

2.4.2.2 Kingston-upon-Thames

“The main objective of installing SRETs in Kingston-upon-Thames is to reduce the speeds of vehicles entering and exiting junctions. SRETs usually form part of traffic management schemes that aim to reduce potential accidents at junctions and improve accessibility and safety for pedestrians and cyclists. These entry treatments are also used as part of an overall traffic management measure for an area treatment proposal, to emphasise the residential and amenity nature of the area. “

2.4.2.3 Redbridge

“In Redbridge, SRETs are installed for the following reasons;

- As part of traffic calming scheme, at the entrance to the road/s
- At the entry points to safer routes to school schemes and 20 mph zones
- Side roads that have a large number of failure to give way accidents
- Side roads where there are a large number of pedestrian accidents at the junctions
- SRETs are not generally installed to improve pedestrian access unless it is part of a walking scheme to provide access to a shopping area, railway station etc.”

2.4.2.4 Wandsworth

"Entry treatments are often provided as part of an area package of measures and may also be provided as part of the following scheme types in Wandsworth :-

- Walking / access improvement (i.e. on pedestrian routes into town centres and near schools)
- Local Safety Schemes (to reduce accidents by reducing vehicle speeds through junctions, improve intervisibility, etc)
- As part of School Travel Strategy schemes to improve the walking environment and to slow traffic
- Cycling schemes (improve intervisibility of cyclists waiting at junctions, reduce vehicle speeds through junctions etc in line with guidance in London Cycling Design Standards manual)
- On most side road junctions along Red Routes as a matter of TfL policy

We currently have not undertaken any schemes specifically to reduce the volume of traffic along a road or through an area other than by use of one way streets and road closures."

2.4.2.5 TfL

The importance assigned by TfL to helping pedestrians and introducing raised entry treatments is demonstrated by the following extracts from annual reports of the Traffic Director For London.

> 1996-1997 "Concern for the safety of all road users is a key consideration in the organisation's work. A first step is to prohibit vehicles parking in dangerous positions by introducing double red lines at junctions and at traffic signals.
>
> Other safety features help reduce the number of pedestrians injured. These include new and improved pedestrian crossings and changes at side road junctions to reduce the speed of vehicles turning off the main road."
>
> 1997-1998 "Another way of helping pedestrians to cross the road is to introduce traffic calming measures at side road junctions.
>
> A good example of this is work carried out by Hounslow as part of the council's local road Red Route works on the A312. In all, 15 junctions along a 3km stretch of road have been altered by raising the carriageway to the same level as the footway, making crossing easier. Bollards prevent parking dangerously at the junctions and tactile paving guides blind and partially sighted people to the crossing points."
>
> 1998-1999 "Good progress is being made towards the Traffic Director's revised objectives, with 127 new signalled crossings for pedestrians introduced in the year and 342 side road junctions improved. These measures will contribute towards achieving the new target of increasing by 30% the number of pedestrians who find it easier to cross the road after the introduction of Red Routes."

Most of the TLRN sites were not associated with 20 mph zones. Information on 20 mph zones was not available for the Borough sites.

2.4.3 Installation date

A summary of the year in which installation was completed is shown in Appendix A. The installation dates for the Borough sites were estimated in some cases, as the only data available were the calendar year or financial year of installation. In these cases, the installation period was defined as the whole year. In all cases the installation period was excluded from the analysis, the "before" period ended at the start of installation and the "after" period started at the end of installation. Some of the site data provided by the Boroughs were not included as no dates were given. The earliest installations were at 12 Borough sites in 1991 and the latest at 35 Borough sites in 2004. These latter 35 sites have limited collision data for the after period. The majority of TLRN SRETS were installed between 1998 and 2000.

2.4.4 Construction

Over 90% of the TLRN sites were constructed of block paving. The remaining, 7%, that were described as flat or in between flat and raised to the level of the adjoining footway were excluded from the analysis.

2.5 Extraction of collision data for SRETs

TfL supplied TRL with collision data from the Stats19 database from 1980 to 2004. Some variables were not coded before 1982. These related to turning movements and whether pedestrians were on the major or minor road. Analysis was therefore restricted to 1982 to 2004. The allocation of collisions to SRETs followed the process described above in Section 2.2. In addition the grid reference of each SRET was used to determine the proximity of nearby SRETS. Where two junctions were within 60m of each other, collisions were assigned to the nearer junction to provide a unique junction allocation for each collision, see Appendix A for details.

The analysis concentrated on collisions not casualties because the error structure of collision data is quasi-Poisson and matches that of the standard models used. Because there can be multiple casualties per collision, the error distribution of casualty data is not quasi-Poisson, therefore the accepted procedure is to model collisions rather than casualties.

2.6 Junction type

When the collisions had been assigned to SRETs, the Stats19 junction type field was used to define the junction type. The resulting classification is shown in Table 2-2.

Table 2-2: Sites by junction type

Junction type	Description	TLRN	Borough	Total
1	T/Staggered junction, no other SRET within 60m	330	144	474
2	Crossroads, no other SRET within 60m	14	23	37
3	T/Staggered junction, at least one other SRET within 60m	370	85	455
4	Crossroads, at least one other SRET within 60m	63	23	86
Total		777	275	1,052

2.6.1 Collision types

The collisions were categorised into the following types using the Stats19 variables, as in the Buchanan Study. Each collision can be categorised as more than one type, for example a serious collision involving a powered two-wheeler (PTW) turning and a pedestrian on the minor road. It is known that not all injury collisions, particularly pedestrian and pedal cycle collisions, are reported to the police, see for example Mills (1989). The analysis assumed that the reporting level of collisions did not change significantly during the period studied. The main emphasis in the study has been on total collisions, including those only involving slight casualties. Even with a large sample size of over 1000 sites, results based on only collisions involving fatalities and serious injuries would not be expected to provide statistically significant results.

The following collision types were defined:

- All collisions
- Fatal collisions
- Serious collisions
- Slight collisions
- KSI collisions
- Collisions involving a pedestrian
- Collisions not involving a pedestrian
- Collisions involving a pedal cycle
- Collisions involving a pedal cycle turning
- Collisions involving a powered two-wheeler
- Collisions involving a powered two-wheeler turning
- Collisions involving a pedestrian on the minor road
- Collisions involving a pedestrian on the major road
- Collisions involving a vehicle turning left into the minor road
- Collisions involving a vehicle turning right into the minor road
- Collisions involving a vehicle turning left out of the minor road
- Collisions involving a vehicle turning right out of the minor road
- Collisions involving any of the four above manoeuvres
- Collisions involving any of the four above manoeuvres or a pedestrian on minor road

2.7 Preliminary data investigation

2.7.1 Objective

This analysis provided an initial insight into the collisions before and after the SRET installations. It also provided information for the selection of sites for the behavioural study (see Section 5).

2.7.2 Method

As the collision data were received from TfL and assembled into a dataset for analysis an initial investigation was undertaken on the number and type of collisions to identify classes of collisions with substantial numbers of collisions in them.

The next stage was a quick comparison of 3 years before and 3 years after data for each SRET by accident type. The collision data set described in Section 2.5 was used for this analysis. The collisions that occurred in the three years before the start of the installation period, and those that occurred in the three years after the end of the installation period of each site were extracted from the database. Any collisions which occurred during the installation period were excluded from the analysis. Non-junction collisions were also excluded.

For this preliminary data investigation considering 3 years before and after data, 134 Borough sites were excluded as they were installed after 2001 and did not have complete 3 year after data, leaving 141sites.

The 3 years before and after at each site covers a different period, as the installation dates differ. The collisions in the 3 years before and after were then summed over all sites.

These analyses did not use a control and hence do not take account of any overall trend in collisions.

2.8 Data analysis

2.8.1 Objective

The aim of the detailed collision analysis was to extract the effect of the presence of a SRET on the entrance to a side road from all the other factors that affect collisions to the greatest extent possible with the data available.

2.8.2 Method

The collision data set described in Section 2.5 was used. Any collisions which occurred during years of installation were excluded from the analysis. Only collisions with the "junction" attribute set in the Stats19 database were included. The analysis was based on summaries of collisions in calendar years.

2.8.3 Time dependence and controls

Although the collision records of SRET junctions after treatment is known, what is not known is what the record would have been if the junctions had not been treated. The latter must be estimated. Without it, it is not possible to know whether the treatment has been effective or not. Future effects can be estimated by extrapolating long term trends or by comparing the performance of the SRET sites with the performance of other similar junctions. It was decided to do both in these analyses.

The investigation was based on Stats19 data extending from 1982 to 2004. The purpose of using an extended period is to establish the overall trend in the numbers of collisions over time, so that this can be taken into account in the analysis. In general the numbers of collisions/casualties have been declining over the years and hence, if this were not taken into account, the effect could easily be misinterpreted as a reduction attributable to the introduction of SRETs.

A further reason for extending the collision period is that it is common practice for local authorities to introduce remedial features on those junctions which have the worst collision record over the previous years (often 3 or 5 years). Although some of these junctions may be inherently less safe than others and hence require effective remedial treatment, others may not be inherently less safe. The number of collisions per unit of time at any junction has a large random component especially when the numbers are low as is the case at most SRET sites. Hence, some of the junctions selected for treatment will not be inherently unsafe, but will have generated a poor collision record by chance. These junctions would on average have been likely to have produced fewer collisions in the future even without treatment (regression to mean effect). It follows that a reduction in collisions/casualties following the introduction of SRETs may not indicate that the treatment is effective if the sites to be treated have been selected on the basis of their previous short term record. Extending the collision period will tend to reduce the impact of such a selection procedure.

A further way in which the time dependent effects can be taken into account is by including junctions which have not been subject to SRET treatment, but are otherwise similar. These statistical control sites can be expected to have collision records over time which are similar to those that the SRET junctions would have had if they had remained untreated. The selection of control data is discussed in Section 2.3.

2.8.4 Form of analysis

In essence, the analysis aimed to seek evidence for a step change in the numbers of collisions that occur at the junctions at the time that they were converted to SRETs. However, there are many other variables which affect the numbers of collisions at a site and these must be taken into account. The technique used was generalised linear modelling which is a form of regression analysis which is particularly suited to the analysis of collisions. The form of model used was:

$$A = k.\exp(\theta.T).\exp(sret.SRET).\exp(site_i.SITE_i).\exp(c.C).\exp(a.x_1 + b.x_2 \ldots)$$

for the Borough sites and was:

$$A = k.\exp(\theta.T).\exp(sretred.SRETRED).\exp(site_i.SITE_i).\exp(c.C).\exp(a.x_1 + b.x_2 \ldots)$$

for the TLRN sites

where:

. is used to signify multiplication

A is the number of collisions in year T

θ is the fitted time trend or change in collisions in successive years

SRET=1 if the junction has been treated and is a Borough site, SRET=0 otherwise

sret is the fitted coefficient for the SRET effect

SRETRED=1 if the junction has been treated and is a TLRN site, SRETRED=0 otherwise

sretred is the fitted coefficient for the SRET effect on the TLRN,

$SITE_i$=1 if the data refers to the i^{th} site, $SITE_i$=0 otherwise

$site_i$ is the fitted coefficient for the local characteristics of site i

C=1 for the control, C=0 otherwise

c is the fitted coefficient for the effect of the controls

$x_1, x_2, \ldots$ are factors or continuous variables representing other characteristics, for example, junction type.

The regression gave central estimates and standard errors for the coefficients k, θ, sret, sretred, $site_i$, c, a, b,….

The coefficient of greatest interest is sretred (sret for Borough sites), since exp(sretred) is the estimated proportion of collisions that occurred at treated sites compared with what would have occurred if the sites had been untreated.

2.8.5 Range of models

Separate models were developed for:

- Borough and TLRN SRETS
- with and without control data
- with and without a site factor (the site factor was used to allow for the different characteristics: flows, turning movements etc. of the different sites)

- including flow data for TLRN sites 1993-2004 only
- each of the groups of collisions that have been considered earlier in the report

For each of the 10 separate models, the relevant data set was separately modelled using a generalised linear modelling package. Flow data were only available for about half of the Borough sites, so were not included as a variable. For the models with a control, the control data is included in the form of an extra site, so the number of sites is the same as in the model without the control, plus one. The site factor is a single variable for each site used to represent the particular characteristics of that site, such as pedestrian flows, vehicle turning movements, detailed site geometry etc, that were not available as independent variables.

Consideration was given to developing additional models for:

- each of the four junction types defined in Table 2-2
- whether there were any restricted turning movements or not

This would have given a total of 32 types of model. However, it was decided not to pursue this option, partly because the number of sites was small for many of the runs, 12 of the 32 potential models had fewer than 10 sites, and because of the difficulty in interpreting the results obtained from the more aggregated analysis of the 10 models that were used, see the results section.

3 Results from preliminary data investigation

The first step was to examine the total data set including before, during and after SRET installation to investigate the relative importance of different types of collisions at SRETs and to identify classes of collisions that should be included in the main analysis.

3.1 Collision categories

Table 3-1 shows the number of collisions of each type, by the pedestrian involvement, over the 23 year period (1982-2004). As explained in the methodology above, the categories are not exclusive and the period includes collisions occurring before, during and after installation of a SRET at each site. The overall collision rate is 1.3 collisions per site per year. For fatal and serious injury collisions the average is less than 0.2 per site per year.

26% of the total collisions involved pedestrians, 13% involved pedal cycles and 29% involved PTWs. Two-thirds of the fatal collisions and 40% of the serious collisions over the 23 year period involved a pedestrian. There were few collisions involving a pedal cycle or PTW turning.

The left turn manoeuvre collisions had a higher pedestrian involvement than the right turn manoeuvres, but there were fewer left turn collisions than right turning collisions overall. There were more collisions associated with right turning than with turning left, but the difference is less marked for collisions involving a pedestrian.

Table 3-1: Collisions by collision type (1982-2004) at 1052 London SRET sites

Collision type	Pedestrian involved	No pedestrian involved	Total	% of collision type involving pedestrian	% of pedestrian collisions	% of Total
Total collisions	7,882	22,495	30,377	26%	100%	100%
Fatal collisions	171	79	250	68%	2%	1%
Serious collisions	1,998	2,968	4,996	40%	25%	16%
Slight collisions	5,713	19,448	25,161	23%	72%	83%
KSI collisions	2,169	3,047	5,216	42%	28%	17%
Pedal cycle	77	3,973	4,050	2%	1%	13%
Pedal cycle turning	6	237	243	2%	0%	1%
PTW	1,006	7,697	8,703	12%	13%	29%
PTW turning	13	390	403	3%	0%	1%
Left out of side road	84	614	698	12%	1%	2%
Left in to side road	127	891	1,018	12%	2%	3%
Right out of side road	157	3,648	3,805	4%	2%	13%
Right in to side road	194	3,671	3,865	5%	2%	13%
Turning left/right in/out	560	8,730	9,290	6%	7%	31%

3.1.1 Casualty summary

Table 3-2 shows the number of casualties by injury and user group for all collisions at the SRET sites between 1982 and 2004. The relative importance of the various categories follows that of the collisions. 255 people were killed over the 23 year period, of whom 168 (66%) were pedestrians.

The majority of casualties were adults, and about one third of casualties were car occupants. 17% of PTW riders/passengers in collisions and 13% of pedal cyclists were killed or seriously injured.

Table 3-2: Casualties in collisions at 1052 London SRET sites (1982-2004)

Casualty type	Killed	Seriously injured	Slightly injured	Total	% of total	%KSI
Total casualties	255	5,303	29,715	35,273	100.0%	15.8%
Children (<16)	6	535	2,501	3,043	8.6%	17.8%
Adults	243	4,459	25,418	30,120	85.4%	15.6%
Unknown age	6	309	1,795	2,110	6.0%	14.9%
Pedestrians	168	2,006	6,011	8,185	23.2%	26.6%
Pedal cyclists	18	498	3,466	3,982	11.3%	13.0%
PTW riders/passengers	32	1,369	6,687	8,088	22.9%	17.3%
Car occupants	29	1,118	10,571	11,718	33.2%	9.8%
Bus occupants	6	245	2,30	2,556	7.2%	9.8%
LGV occupants	0	52	510	562	1.6%	9.3%
HGV occupants	1	7	68	76	0.2%	10.5%
Other motor	1	7	93	101	0.3%	7.9%
Other non-motor	0	1	4	5	0.0%	20.0%

3.2 Before and after results

As described in the methodology section, the data for the TLRN sites and the Borough sites were analysed separately because of the different traffic characteristics of the two networks and the possible different criteria for installation of SRETs. No controls or other methods of allowing for time trends were used in this preliminary analysis.

3.2.1 TLRN sites

Table 3-3 shows the collisions by collision type for the three years before and after installation of a SRET for the 777 TLRN sites.

At the TLRN SRET sites, there was an overall reduction in collisions of 1.5%, with a reduction of 2.2% in KSI collisions following installation. Collisions involving pedestrians reduced by 5.5%, and pedal cycles by 21%, while the number of PTW collisions increased by 25% (although this may be part of a national trend). In the whole of Greater London, PTW casualties increased substantially between 1995 and 2001, but reduced from 2001 to 2004. (Collisions and Casualties on London's Roads, TfL 2005). Collisions involving vehicles turning left or right in or out of the junction all increased.

Table 3-3: Preliminary collision investigation – results for 777 SRETs on TLRN for 36 months before and after implementation

Collision type	Before	After	Difference	% change
Total collisions	2,998	2,952	-46	-1.5%
Fatal collisions	11	18	+7	63.6%
Serious collisions	447	430	-17	-3.8%
Slight collisions	2,540	2,504	-36	-1.4%
KSI collisions	458	448	-10	-2.2%
Pedestrian collisions	653	617	-36	-5.5%
Non pedestrian collisions	2,345	2,335	-10	-0.4%
Pedal cycle collisions	457	363	-94	-20.6%
Pedal cycle turning collisions	24	12	-12	-50.0%
PTW collisions	841	1,053	+212	25.2%
PTW turning collisions	34	49	+15	44.1%
Left out of side road*	60	68	+8	13.3%
Left in to side road*	103	108	+5	4.9%
Right out of side road*	358	396	+38	10.6%
Right in to side road*	401	455	+54	13.5%
All turning collisions*	908	1021	+113	12.4%
Pedestrian collisions on major road	599	574	-25	-4.2%
Pedestrian collisions on minor road	54	42	-12	-22.2%
Pedestrian collisions on minor road or turning collisions	931	1,052	+121	13.0%

* All collisions involving any vehicle (including PTW and pedal cycles making the manoeuvre)

Table 3-4 shows the total casualties in collisions in the before and after periods for the TLRN sites. All of the casualties at the TLRN sites were adults. The total casualties reduced by 2.4%. Female casualties showed a greater reduction than male casualties, and pedestrian casualties reduced by 8.9%. PTW user casualties increased by 22.6%. Overall the casualty analysis produced similar results to the collision analysis.

Table 3-4: Preliminary casualty investigation – results for 777 SRETs on TLRN for 36 months before and after implementation

	Before	After	Difference	% difference
Total casualties	3,790	3,699	-91	-2.4%
Killed	11	20	+9	81.8%
Seriously injured	520	485	-35	-6.7%
Slightly injured	3,259	3,194	-65	-2.0%
KSI	531	505	-26	-4.9%
Children (<16)	0	0	0	
Adults	3,790	3,699	-91	-2.4%
Unknown age	0	0	0	
Male	2,436	2,414	-22	-0.9%
Female	1,354	1,285	-69	-5.1%
Pedestrians	794	723	-71	-8.9%
Pedal cyclists	491	371	-120	-24.4%
PTW riders/passengers	840	1,030	190	22.6%
Car occupants	1,361	1,230	-131	-9.6%
Bus occupants	228	278	50	21.9%
LGV occupants	56	45	-11	-19.6%
HGV occupants	8	9	1	12.5%
Other Motor	12	11	-1	-8.3%
Other Non-Motor	0	2	2	–

3.2.2 Borough sites

Table 3-5 shows the number of collisions by type in the before and after periods at the 141 Borough sites that had a full 3 years' after data. The Borough sites showed a larger reduction (18%) in total collisions than the TLRN sites and showed reductions in most of the collision types, apart from fatal collisions, which increased from 1 to 4. The total casualties reduced by 23% (Table 3-6).

Table 3-5: Preliminary collision investigation – results for 141 SRETS on Borough roads 36 months before and after implementation

Collision type	Before	After	Difference	% change
Total collisions	199	163	-36	-18.1%
Fatal collisions	1	4	+3	300.0%
Serious collisions	38	25	-13	-34.2%
Slight collisions	160	134	-26	-16.3%
KSI collisions	39	29	-10	-25.6%
Pedestrian collisions	48	43	-5	-10.4%
Non pedestrian collisions	151	120	-31	-20.5%
Pedal cycle collisions	31	27	-4	-12.9%
Pedal cycle turning collisions	5	1	-4	-80.0%
PTW collisions	35	29	-6	-17.1%
PTW turning collisions	1	2	+1	100.0%
Left out of side road*	6	6	0	0.0%
Left in to side road*	6	3	-5	-50.0%
Right out of side road*	24	14	-10	-41.7%
Right in to side road*	23	21	-2	-8.7%
All turning collisions*	58	44	-14	-24.1%
Pedestrian collisions on major road	46	41	-5	-10.9%
Pedestrian collisions on minor road	2	2	0	0.0%
Pedestrian collisions on minor or turning collisions	58	46	-12	-20.7%

* All collisions involving any vehicle (including PTW and pedal cycles making the manoeuvre)

Table 3-6: Preliminary casualty investigation – results for 141 SRETS on Borough roads 36 months before and after implementation

	Before	After	Difference	% difference
Total casualties	261	201	-60	-23.0%
Killed	3	4	1	33.3%
Seriously injured	43	29	-14	-32.6%
Slightly injured	215	168	-47	-21.9%
KSI	46	33	-13	-28.3%
Children (<16)	4	7	3	75.0%
Adults	257	193	-64	-24.9%
Unknown age	0	1	1	–
Male	156	106	-50	-32.1%
Female	105	95	-10	-9.5%
Pedestrians	58	48	-10	-17.2%
Pedal cyclists	34	28	-6	-17.6%
PTW riders/passengers	35	31	-4	-11.4%
Car occupants	119	86	-33	-27.7%
Bus occupants	8	8	0	0.0%
LGV occupants	5	0	-5	-100.0%
HGV occupants	0	0	0	–
Other Motor	2	0	-2	-100.0%
Other Non-Motor	0	0	0	–

4 Results of detailed statistical analysis of collision data

As described in the methodology section, the main results are based on a generalised linear modelling approach to the analysis. The models relate the number of injury collisions at each SRET site in each year to several factors and variables:

a time trend (common to all sites)

a factor representing the effect of SRET treatment

a multi-level factor where each site is represented by a separate level (some models)

a variable representing the control data (some models)

a variable representing the AADT flow on the major road for each year during the period from 1993 to 2004 only (some models).

The details of this analysis are presented in Appendix B.

4.1 Model selection

The different models produced somewhat different results, which complicates their interpretation. Flow data (AADT) were only available for the TRLN sites and for a limited number of years. Inclusion of the flows made relatively little difference to the predicted effect of the installation of a SRET, see Table B-2, and will not be considered further here.

Inclusion of an individual junction factor is not common practice in collision analysis. The characteristics of the individual junctions are normally allowed for by the explicit inclusion of relevant variables. The particular variables will vary from study to study, but could include vehicle flows, vehicle speeds, pedestrian flows, turning movement, junction geometry etc. Such explanatory variables were not available for this study, hence the inclusion of the individual site factor. The site factor is taken to represent the individual combination of (unknown) explanatory factors at each site. The data showed a large variation in collision numbers, implying that the effect of site characteristics was important. That is, there was a need to include the effect of explanatory variables although they were not available. Therefore, because of the lack of explanatory variables and the variation in the number of collisions between sites, it was decided that the conclusions of the study should be based on models including a site factor.

One of the major reasons for adopting the generalised linear modelling technique is that it can be considered as fitting both a general time trend to the data and a step change due to the effect of the installation of a SRET. The modelling intrinsically allows for the effect of time trends (the θ parameter in the equations in section 2.8.4).

Control data can provide additional confidence that the effects of general trends have been allowed for. However, to do this the control data must be matched to the sites under investigation. The normal process for selecting matched control sites would be to select sites with matched site characteristics, the explanatory variables of vehicle flow etc. Such matching was not possible in this project; it was not even possible to collect the explanatory variables for the treated sites. As explained in section 2.3, the best available set of control data was assembled, but it was an unusual data set consisting of one super junction averaging the characteristics of many junctions and summing their collision records.

One measure of the match is the agreement in the trend of collisions over time. Figure 4-1 shows the time trends for the controls and SRET sites on TLRN and Borough roads. For the purpose of comparison, the number of collisions in each year relative to the number occurring in 1982 are plotted against year. Figure 4-1 indicates that the time trends for the Borough SRETS, Borough controls and TLRN controls are similar, so that there were only about half (50%) the number of collisions recorded in 2004 compared with 1982. The time trend in the number of collisions on the TLRN SRET junctions is different so that the number of collisions in 2004 was about 70% of those occurring in 1982. Thus, the relative decline in the number of collisions was much less on the TLRN SRET junctions than on the TLRN controls, the Borough SRET junctions or the Borough controls. Much of this difference is attributable to a pause in the decline of the TLRN SRET trend between about 1994 and 2001. This is almost precisely the period during which TLRN junctions were being treated to SRET and became part of Red Routes.

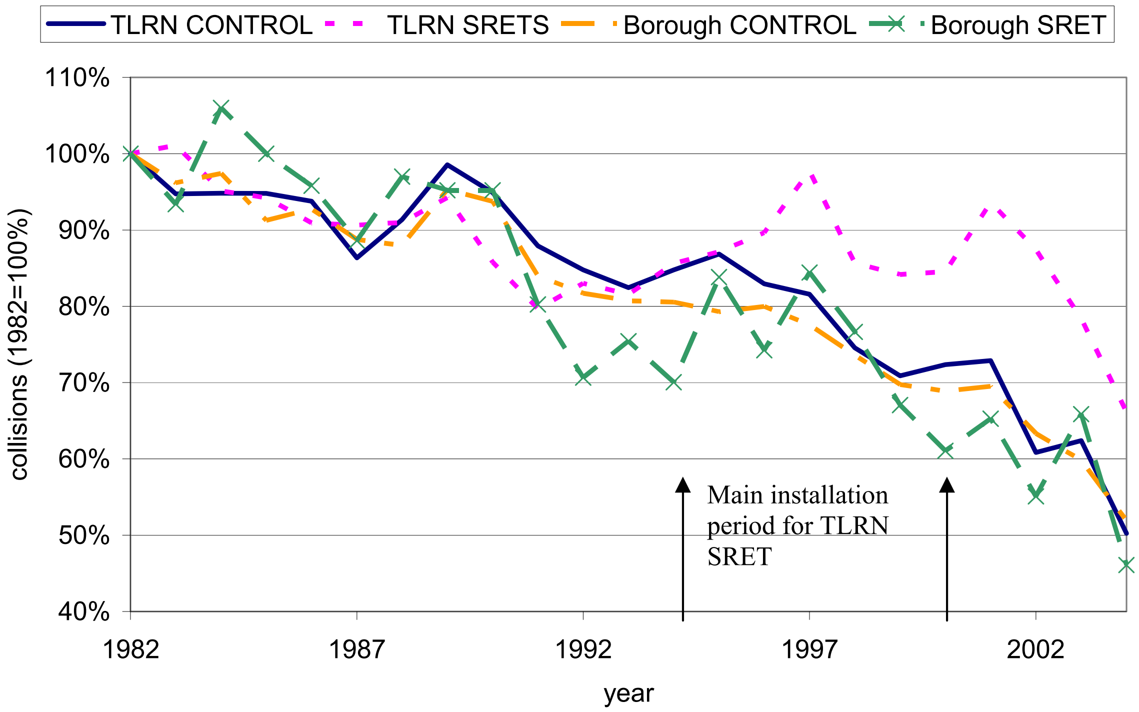

Figure 4-1: Trend in collisions at SRETS and controls

One known difference between the TLRN SRET junctions and the other sites is that the TLRN SRET junctions are located mostly in inner London, whereas the TLRN controls, the Borough SRET junctions and the Borough controls are mainly in outer London. Different trends may have occurred in the two regions. A further complication is that a few of the TLRN control junctions have actually had SRETs installed (see section 2.3). The objective in selecting the control sites was to provide suitable matched controls. Therefore, the control sites for the TLRN SRET treated junctions were similar junctions also on the TLRN. The TLRN is the network of major traffic routes in London, therefore, comparing with sites not on the TLRN would not be appropriate. However, selecting control sites on the TLRN raises the issue of why these control sites had not been SRET treated. There is no documented reason for why a large proportion of the junctions on the TLRN in outer London had not been treated. It could be due to resource constraints or other reasons. It is interesting to note that the policy was not to install SRETs where the main road speeds were above 30mph. If that were the reason why SRETs had not been installed on many of the control sites, then they would not be a suitable matched control.

Overall it was concluded that the differences between the control sites and the treated sites meant that the control data did not provide a reliable indication of the time trends for the junctions in the TLRN SRET data set. The effect of the installation of SRETs on the TLRN should, therefore, be based on the models with an individual junction factor and without a control. As noted above, this model does include the effect of the time trends separately from those of the SRET treatment. For consistency, the equivalent models were used for the Borough sites. The results for the models with controls are included in Appendix B for completeness.

4.2 Model results

The statistically significant (at the 5% level, p=0.05, Student's t-test) results from the modelling exercise, that is, the estimated effect of SRET/Red Route treatment (TLRN junctions) and SRET treatment (Borough junctions) on collisions are presented in Table 4-1.

Table 4-1: Summary of the results from the statistical analysis of the estimated effect of SRET/ Red Route (TLRN) and SRET (Borough) on collisions

Collision type	TLRN 1982-2004 No control Factor No flow	Borough 1982-2004 No control Factor No flow
Total	ns	-21%
Fatal	ns	ns
Serious	ns	ns
Slight	ns	-22%
Pedestrian	ns	ns
Non pedestrian	ns	-25%
Pedal cycle	-20%	-51%
Pedal cycle turning	ns	ns
Powered two-wheeler	+66%	ns
Powered two-wheeler turning	+76%	ns
Left in	ns	ns
Left out	ns	ns
Right in	+21%	ns
Right out	ns	-40%
All turning	+18%	-25%
Pedestrian on major road	ns	ns
Pedestrian on minor road	ns	ns
All minor road	+18%	-27%

ns = Not statistically significant at the 5% level (p=0.05)

The results from the TLRN regression model (second column in Table 4-1) estimate that there was no overall change in the number of collisions of all severities due to the installation of SRETs. Installation of a SRET across a side road of a road on TLRN would not be expected to change the overall collision rate. However, there are estimated to be changes in the types of collisions occurring after SRET implementation.

The model estimated a statistically significant reduction, of 20%, in pedal cycle collisions following installation of a SRET. Some other classes of collisions: powered two-wheelers, powered two-wheelers turning, right turning into the side road, all turning collisions and all collisions on the minor road were estimated to have increased significantly. No other statistically significant changes were obtained. Powered two-wheelers in particular show a considerable increase in collisions. Although all turning collisions were estimated to have been increased by the installation of SRETS, the only individual movement to be statistically significant is in right turning into the side road. Table B-1 in

Appendix B includes the results for the model with controls, where it can be seen that that model estimated more statistically significant increases in collisions.

The model of collisions at SRET sites on Borough roads shows a different picture; overall collisions are estimated to be reduced by 21% and all the statistically significant results are reductions. Installation of SRETs on the Borough roads in the data set modelled is estimated to have reduced collisions and not increased any of the categories of collisions that were included in the modelling.

Significant reductions at Borough SRETs were estimated in several collision categories: total collisions, slight collisions, non pedestrian collisions, pedal cycle collisions, right turning out from minor arm collisions, all turning collisions and all collisions on the minor road. Although the results estimate overall savings in collisions at the Borough sites, compared with no change at the TLRN sites there was no significant change in pedestrian collisions estimated at the Borough sites.

The large number of sites included in the dataset for this study has greatly increased the statistical power of the analysis compared with the early study by Buchanan, but because of the variability in the number of collisions over time and between sites, it has not been possible to produce statistically significant results in all categories.

4.3 Discussion

It is difficult to explain the difference between the results for the TLRN sites and those for the Borough sites. No detailed figures are available on relative changes in exposure on the two types of road, for instance, on any relative change in the numbers of powered two-wheelers on the TLRN compared to Borough roads. The TRLN consists of the main traffic routes in London and is operated to assist the movement of people. Different traffic characteristics would, therefore, be expected on the TLRN compared to Borough roads and the interaction of those differences with drivers' and pedestrians' behaviour at SRETs may result in a relative increase in collisions of some sorts. No adverse effects on pedestrians were found.

Other differences that may help explain the difference between TLRN and Borough SRET sites include:

- The SRET TLRN sites included in this study are mostly in inner London whereas the Borough sites are mainly in outer London
- The TLRN were SRET treated at the same time as they became part of Red Routes so that it is not possible from the data used in this study to separate the two effects. The Borough sites are not on Red Routes.

The routine treatment of all junctions on sections of the TLRN has not been as successful in reducing collisions as has the more targeted approach adopted by individual Boroughs. However, no analysis has been done on any possible regression to the mean effect at the Borough sites.

5 Behavioural survey

5.1 Objective

The objective of the project was to perform a thorough assessment of the effects of SRETs on the safety of road users. A possible concern had been raised before the study that pedestrians might assume that they have priority when crossing a side road by walking along a SRET that appears to be a continuous footway across the entry. Vehicle drivers may, however, consider that they have priority, leading to potentially dangerous conflicts. A study of the behaviour of pedestrians and interactions between pedestrians and vehicles at SRET sites was included in the brief. The aim was to compare behaviour at junctions with SRETs with that at untreated junctions to detect different types of behaviour and make a judgement on the safety effects of any differences observed. The apparent assumption of priority by pedestrians was an important topic for the behavioural study.

5.2 Site selection

Observing behaviour is potentially time consuming and expensive when looking for infrequent incidents that reveal unsafe behaviour. The initial collision analysis showed considerable variation between sites and it was decided that behavioural studies at the safest sites would be less likely to show unsafe behaviour than studies at sites with more collisions. Conversely, we did not wish to concentrate just on the sites with the largest numbers of collisions as these are likely to be atypical and could have site specific factors that would reduce the applicability of results drawn from a study restricted to such sites.

Ideally the site selection would be based on a structured analysis of vehicle flows and turning movements, pedestrian flows and site characteristics. Unfortunately, the only flow data available, and then only approximate, were main road vehicle flows, whereas the preliminary analysis had identified turning movements into and out of the side roads as a potential problem. Also there was little difference between the site characteristics as almost all the SRETs were built to a standard design with block paving raised to the level of the adjoining footway.

The final site selection was made during a series of visits to a shortlist of sites. The collision data showed that sites could be grouped by collision frequency as:

- Low, fewer than 5 collisions in 3 years (62%)
- Medium, between 5 and 8 collisions in 3 years (28%
- Medium high, between 9 and 12 collisions in 3 years (7%)
- High, over 12 collisions in 3 years (3%)

It was decided to concentrate on the medium and medium high groups, selecting two groups of sites for the shortlist, one with between 5 and 7 collisions in 3 years and one with between 10 and 12 collisions in 3 years. After considering the information available the following selection criteria were defined:

- Number of collisions, two groups as above
- High usage sites, estimated from land use and consideration of main road flows (high pedestrian use, high turning movements etc. would be expected to have higher numbers of collisions)
- Exclude sites with one-way side roads
- A range of main road speeds to be selected if possible, however, the policy for the installation of SRETs (Buchanan 1995) was not to install them adjacent to main roads where the speed exceeded 30 mph because of a fear of shunt collisions. Therefore, it was not expected that the speed would be a significant factor

- Include sites in inner and outer Boroughs and on Borough roads as well as the TLRN
- Factors to record on site in addition to sample vehicle turning and pedestrian counts were:
    - Narrowing of entrance
    - Gradient of SRET ramps
    - Turning radius

A total of 11 sites were chosen, 8 SRET sites grouped in 3 geographical areas and a control site for each group.

At each chosen site video recordings were made of pedestrian and vehicle movements in the vicinity of the SRET for 12 hours on one weekday in October 2005 from 7 am to 7 pm. The selected sites are listed in Table 5-1. Permission to mount cameras and make video recordings was obtained from the various Highway Authorities.

Table 5-1: Site locations

Borough	SRET or control	Major road	Minor road
		Borough sites	
Kingston-upon-Thames	SRET	Neville House Yard	Eden Street
Redbridge	SRET	Britiannia Road	Ilford Lane
Kingston-upon-Thames	Control	Douglas Road	Ewell Road
		TLRN sites	
Lambeth	SRET	Clapham High Street	Tremadoc Road
Hackney	SRET	Stamford Hill	Holmleigh Road
Wandsworth	SRET	Tooting High Street	Selkirk Road
Ealing	Control	Uxbridge Broadway	Green Man Lane
Hackney	SRET	Kingsland Road	Bentley Road
Haringey	SRET	Stamford Hill	Craven Park road
Lanbeth	SRET	Clapham Road	Clapham Road Estate
Hackney	Control	Stamford Hill	Olinda Road

5.3 Method

The video recordings were analysed to study the interactions between pedestrians and vehicles. Vehicle movements into and out of the side roads were considerably less frequent than individual pedestrian crossings of the side roads. Analysing each pedestrian movement would provide relatively little information; they walked along the footway and crossed the side roads, normally without pause and without obvious large head movements to look for traffic. Most pedestrians seemed confident to judge that the main road traffic was not slowing to turn into the side road, or could not make a right turn because of opposing traffic. Vehicles near the exit of the side road could be seen from the footway as part of the view of the area ahead of the pedestrian. Therefore, the analysis concentrated on the interesting events, vehicles entering or leaving the SRET and their interactions with other vehicles, almost all on the main road, and with pedestrians at a sample of times through the day.

For each vehicle in the sample, the following data on interactions with other vehicles were extracted from the video:

- Delay in the main road when turning into the side road (for vehicles turning right into the side road)
- Delay leaving the side road due to main road traffic
- Reasons for the delay (opposing main road traffic, vehicle on side road, pedestrian, narrowing of SRET)
- Type of vehicle (car, motor cycle, pedal cycle, van, lorry)
- Details of manoeuvre (enter or leave SRET, left turn, right turn)

For the interactions with pedestrians the information tabulated was:

- Whether the vehicle gave way to pedestrians or vice versa
- Whether the pedestrian or vehicle appeared to have been forced to cede precedence
- Category of pedestrian (adult, accompanied or unaccompanied child, visible infirmity, adult with pushchair, wheelchair, powered wheelchair/scooter, cyclist)
- Whether pedestrians were in a group or separate individuals
- Pedestrian behaviour (stopped at kerb, looked for traffic, direction)
- Pedestrian and vehicle delay
- Nature of interaction between pedestrian and vehicle (just interaction, encounter, conflict, collision as defined in section 5.4.3)
- Comments

Examples of the views from the video cameras are given in Appendix C.

5.4 Results

5.4.1 Pedestrian characteristics

The data extracted from the video recordings were assembled into a spreadsheet for analysis and cross-tabulation of results. The first stage of the analysis was to compare the pedestrian characteristics at the sites. A large difference in the types of pedestrians seen at the SRET and control sites would make it very difficult to draw general conclusions. The proportions of each type of pedestrian observed at each site are shown in Table 5-2. The control sites are shaded in this and the following tables that give results for individual sites. For convenience and to reduce the size of the subsequent tables, the sites are referred to in those tables by the reference numbers defined in the first column of Table 5-2.

In those tables, where results for sites with a SRET are statistically significantly different from the control sites at the 5% level, the SRET results are shown in bold and marked with an asterisk in the tables. A t-test for proportions was used to test for significance.

Table 5-2: Pedestrian characteristics by site

Site	Adult	Accompanied child	Unaccompanied child	Visible infirmity	Adult & pushchair	Wheelchair /scooter	Cyclist	Total
1 Tremadoc Road	90.3%	5.2%	0.0%	0.3%	3.8%	0.3%	0%	289
2 Holmleigh Road	76.4%	6.9%	0.0%	0.0%	11.1%	4.2%	0%	72
3 Selkirk Road	94.2%	2.3%	0.8%	0.0%	2.7%	0.0%	0%	249
4 Green Man Lane	93.5%	1.2%	0.3%	0.3%	4.5%	0.1%	0%	718
5 Bentley Road	89.6%	1.6%	0.0%	0.0%	6.0%	0.3%	2.3%	353
6 Craven Park Road	83.1%	12.4%	0.0%	0.4%	3.4%	0.0%	0.8%	263
7 Clapham Road	95.0%	1.3%	0.0%	1.3%	0.0%	0.0%	2.6%	77
8 Olinda Road	92.4%	1.1%	2.2%	0.0%	2.2%	0.0%	2.5%	80
9 Neville House Yard	97.7%	0.8%	0.0%	0.0%	1.5%	0.0%	0%	129
10 Britannia Road	88.9%	0.9%	0.4%	0.2%	7.9%	0.2%	1.5%	551
11 Douglas Road	64.3%	14.3%	0.0%	0.0%	10.7%	0.0%	7%	43
All SRET sites	89.5%	3.6%	0.2%	0.2%	5.1%	0.3%	1.1%	1983
All control sites	91.5%	2.1%	0.5%	0.2%	4.7%	0.1%	0.9%	841

There is some variation between sites in the types of pedestrians observed, but overall there is a good match between the types of pedestrians seen at the sites with a SRET and at the control sites. A total of 3273 pedestrian-vehicle interactions were observed at SRET sites and 1279 pedestrian vehicle-interactions at control sites.

5.4.2 Drivers giving way to pedestrians

SRETs are designed to inform drivers of the change from main to (minor) residential roads and to alert them to the possibility that pedestrians may be crossing their path. As a consequence of a SRET marking a clear place for pedestrians to cross the road and slowing vehicles, some drivers may be more willing to give way to pedestrians at a SRET than elsewhere. Whether drivers gave way to pedestrians was one of the variables coded from the video recordings and Table 5-3 shows the proportions of interactions between vehicles and pedestrians where drivers gave way to pedestrians. The proportions include some cases where one vehicle gave way to multiple pedestrians. There were other more complicated cases: a pedestrian could be delayed by a vehicle that had arrived at the potential conflict point before the pedestrian and so could not be expected to give way. However, a second vehicle could give way, resulting in a pedestrian receiving precedence from one driver, but also suffering delay waiting to cross the road. There was considerable variation between individual sites, but overall there was little difference between the sites with a SRET and the control sites. However, there were differences between the behaviour of drivers turning left at the control and SRET sites. Drivers were significantly more likely to give way to a pedestrian when turning left into a control site than into a SRET site, but significantly more likely to give way when turning out at a site with a SRET.

At controls and particularly at SRET sites, drivers were more likely to give way to pedestrians when turning out of the side road than when turning into it.

Table 5-3: Proportion of interactions where drivers gave way to pedestrians by vehicle movement (%). Total numbers of drivers giving way in parentheses

Site	1	2	3	4	5	6	7	8	9	10	11	SRET	Control
ALL movements	71 (106)	31 (15)	42 (84)	65 (230)	61 (71)	63 (104)	22 (14)	47 (24)	48 (58)	70 (181)	21 (9)	56 (633)	59 (263)
Left in	50 (5)	21 (4)	34 (17)	66 (39)	63 (2)	63 (15)	30 (4)	43 (6)	80 (8)	34 (10)	0 (0)	**44*** (65)	61 (45)
Left out	84 (68)	40 (4)	58 (30)	74 (114)	69 (22)	70 (52)	0 (0)	54 (6)	22 (2)	82 (111)	26 (5)	**73*** (289)	63 (125)
Right in	17 (4)	33 (2)	21 (9)	36 (28)	29 (10)	36 (8)	11 (1)	6 (1)	49 (40)	30 (12)	0 (0)	34 (86)	28 (29)
Right out	81 (29)	38 (5)	49 (28)	80 (49)	76 (37)	63 (29)	27 (9)	85 (11)	42 (8)	86 (48)	31 (4)	62 (193)	74 (64)

* Statistically significantly different from the control sites at the 5% level.

Some pedestrians are more forceful than others and will try to assert priority over a vehicle driver and cause the driver to give way. The presence of a SRET, which provides both a continuous pavement for pedestrians and an impediment to drivers, could assist pedestrians to assert priority. The behaviour of pedestrians was judged during the video analysis and all cases where a pedestrian appeared to force a vehicle driver to give way were noted and the results are presented in Table 5-4. Weather conditions were similar during the observations and would not be expected to have affected the results.

Table 5-4: Proportion of interactions where pedestrians appeared to force drivers to give way (%). Total numbers of drivers giving way in parentheses

Site	1	2	3	4	5	6	7	8	9	10	11	SRET	Control
ALL movements	0 (0)	19 (6)	5 (9)	0 (0)	0 (0)	33 (54)	0 (0)	31 (21)	4 (5)	1 (2)	2 (1)	7 (76)	5 (22)
Left in	0 (0)	21 (4)	10 (5)	0 (0)	0 (0)	50 (12)	0 (0)	36 (5)	0 (0)	0 (0)	0 (0)	11 (21)	7 (5)
Left out	0 (0)	0 (0)	4 (2)	0 (0)	0 (0)	31 (23)	0 (0)	31 (8)	11 (1)	0 (0)	0 (0)	7 (26)	4 (8)
Right in	0 (0)	17 (1)	5 (2)	0 (0)	0 (0)	27 (6)	0 (0)	7 (1)	5 (4)	0 (0)	0 (0)	5 (13)	1 (1)
Right out	0 (0)	8 (1)	0 (0)	0 (0)	0 (0)	28 (13)	0 (0)	54 (7)	0 (0)	4 (2)	8 (1)	6 (16)	9 (8)

It can be seen that there was a large variation between sites; at site 6, Craven Park Road, with a SRET, and site 8, Olinda Road (Table 5-4), a control site, a large minority of pedestrians forced drivers to give way to them. At most other sites few, or no, pedestrians asserted priority. It is unclear why so much more assertiveness was seen at two sites than at the others, for instance pedestrian flow at Olinda Road was low, but moderately high at Craven Park Road. Over all sites there is not a great difference between the control sites and those with a SRET in the proportion of pedestrians asserting priority.

5.4.3 Interactions between vehicles and pedestrians

When a pedestrian and a vehicle were in the vicinity of a SRET at the same time there was an interaction between them. The degree of observable conflict between the pedestrian and vehicle varied between interactions and the degree of conflict is likely to be an indicator of potential problems. Sites where the average level of conflict was highest would be expected to have the highest risk of a collision between a pedestrian and a vehicle. The categories used were:

- Interaction: normal behaviour with no apparent safety implications
- Encounter: somewhat more serious than an interaction with some avoiding action, e.g. moderate braking by vehicle or abrupt stop by pedestrian
- Conflict: no contact between the pedestrian and vehicle, but clear avoiding action required, e.g. hard braking or pedestrian hurriedly swerving or stepping back off the road.

Table 5-5 shows the proportion of interactions in each class separated by the turning movements made by the vehicle.

Table 5-5: Proportion of vehicle turning movements for each interaction class. Totals in parentheses

	Left in		Left out		Right in		Right out		All	
Interaction	**SRET**	**Control**	**SRET**	**Control**	**SRET**	**Control**	**SRET**	**Control**	**SRET**	**Control**
Interaction	69% (117)	76% (50)	91% (393)	90% (177)	**78%*** **(160)**	90% (92)	90% (246)	87% (69)	84% (916)	88% (388)
Encounter	25% (43)	21% (14)	8% (36)	9% (17)	18% (37)	5% (5)	9% (26)	11% (9)	13% (142)	10% (45)
Conflict	5% (9)	3% (2)	1% (5)	2% (3)	3% (8)	5% (5)	1% (3)	1% (1)	3% (25)	2% (11)
Total	16% (169)	15% (66)	40% (434)	45% (197)	19% (205)	23% (102)	25% (275)	17% (79)	100% (1083)	100% (444)

* Statistically significantly different from control at the 5% level

Overall there was little difference in the severity of the encounters between pedestrians and vehicles at the SRET sites and the controls, but some movements did show differences. Table 5-5 gives details for individual movements. Combining movements the following differences were noted:

- Turning right into the side road at a site with a SRET caused significantly more encounters and conflicts (22%) than turning into a control site (10%); the interactions between pedestrians and vehicles turning right into the side road were more serious at sites with a SRET than at the controls.
- Combining the figures in the table for all turns into a side road, left and right, gives 26% encounters and conflicts at sites with a SRET against 15% at control sites. Again, this difference is significant at the 5% confidence level.
- Turning left into a site with a SRET was more likely, in the sample of movements observed, to result in an encounter or a conflict than turning right into the site, but the difference was not statistically significant at the 5% level.

5.4.4 Pedestrians looking for potential conflicts with vehicles

It was difficult to see minor head movements from the videos to determine how much pedestrians were looking for traffic before crossing the side road. Clear head movements, or pedestrians who clearly did not look round, were recorded appropriately; others were coded as unclear.

Table 5-6: Pedestrians looking for conflicting vehicles

	Did not look	Looked for vehicles	Unclear
SRET	113 (**7%**)*	245 (17%)	1106 (76%)
Control	12 (1%)	151 (19%)	646 (80%)
	Proportion of those with clear head movements		
SRET	**32%***	**68%***	
Control	7%	93%	

* Statistically significantly different from the control at the 5% level

Of those that clearly did or did not move their heads to look for traffic, 68% looked when crossing at a SRET, but 93% did at the control sites. The difference in behaviour was statistically significant at the 5% level. Most of the sites were at junctions with busy main roads, pedestrians walking along the main road facing traffic would be able to judge whether vehicles were likely to turn into the side road and have a reasonable view of any vehicles approaching on the side road without moving their heads. As the main roads were busy, it would be reasonable to assume that for considerable periods it would be possible to assume that no vehicle approaching from behind would be able to right turn into the side road because of the visible opposing main road vehicles. Therefore, there could be less reason for pedestrians to noticeably turn their heads to look for conflicting vehicles when facing approaching, nearside traffic than when walking with their backs to approaching traffic.

As shown in Table 5-7, pedestrians are more inclined to look for conflicting vehicles when approaching a SRET with the nearside main road traffic approaching from behind them, than when they are facing it, but the difference is not quite statistically significant at the 5% level. Regardless of whether they are facing the traffic or not, they are still considerably less likely to obviously look for potentially conflicting vehicles than at the control sites and the difference is statistically significant both when facing traffic and when walking with their backs to traffic. It might be considered from these results that some pedestrians have a false sense of security when crossing the minor road at a SRET. However, the analysis of collision statistics showed a reduction in collisions at SRETs.

Table 5-7: Proportion looking for conflicting vehicles by direction

	Facing traffic	**Back to traffic**
SRET	112 **(64%)***	126 (**74%)**
Control	70 (93%)	68 (92%)

* Statistically significantly different from the control at the 5% level

5.4.5 Pedestrian delays

Pedestrian delays waiting to cross the side road were modest at most sites and few pedestrians were delayed at all, see Table 5-8. The figures in the table refer only to those pedestrians who had some level of interaction with a vehicle; many others crossed the side road without any such interaction. The proportion delayed would have been considerably smaller if all pedestrians had been included. There was appreciable variation between sites, particularly in the proportion that was delayed, but overall the differences between sites with a SRET and the controls were small. The difference in average delay to those pedestrians who were delayed is not statistically significant, but the difference in the proportion delayed is just significant at the 5% level. Pedestrians were more likely to be delayed by vehicles at the sites with a SRET than at the control sites.

All the figures for pedestrian delay refer to pedestrians interacting with a vehicle at the SRET. Therefore, the greater proportion delayed at the sites with a SRET cannot be explained by a difference in the probability of a vehicle arrival to cause an interaction. However, it was noticeable that considerably more pedestrians walked behind waiting vehicles at control sites rather than at SRET sites, 36% against 7%, again of those who interacted with a vehicle. The presence of a SRET provides a convenient place for pedestrians to cross a side road and appears to attract pedestrians to cross there even when the pedestrian would be less delayed by crossing at a slightly different place, further into the side road to walk round the back of a conflicting vehicle.

Table 5-8: Pedestrian delay

Site	1	2	3	4	5	6	7	8	9	10	11	SRET	Control
Average for those delayed	4 s	7 s	5 s	4 s	4 s	3 s	23 s	4 s	7 s	4 s	11 s	5 s	6 s
Proportion delayed	8%	49%	34%	8%	8%	25%	8%	22%	42%	5%	60%	**16%***	12%
Number delayed	25	35	89	60	31	64	6	20	54	28	36	332	116

* Statistically significantly different from the control at the 5% level

The observations were also analysed to examine the delay to mobility impaired individuals, defined as those: with a visible infirmity, pushing a pushchair or using a wheel chair or electric scooter. The results are shown in Table 5-9. A total of 156 mobility impaired pedestrians were observed at all the sites (5.5% of pedestrians) of whom the vast majority, 139, were adults pushing push chairs. Those pedestrians in this group who were delayed at the control sites were delayed for longer than those delayed at a site with a SRET (statistically significant), but they were less likely to be delayed (not statistically significant). The total delay per person was very similar at the two types of site.

As noted above, some pedestrians appeared to be prepared to wait for the SRET to be clear so that they had the convenience of crossing on the SRET, rather than walk round a waiting vehicle and have to step up and down a kerb. This behaviour would explain the greater proportion of pedestrians with a mobility impairment who were delayed crossing a side road with a SRET compared with crossing at a control site. Also shown in the table is the proportion of these pedestrians who received precedence from at least one vehicle driver. Pedestrians at sites with a SRET were more likely to receive precedence, but this difference was not statistically significant at the 5% level. As explained in section 5.4.2, pedestrians can be delayed by one vehicle, but receive precedence from another and this was the case for some mobility impaired pedestrians at the SRET sites, resulting in 80% receiving precedence, but 25% delayed.

Table 5-9: Delay to pedestrians with a mobility impairment

Site	1	2	3	4	5	6	7	8	9	10	11	SRET	Control
Pedestrian delay. Average for those delayed	9 s	12 s	5 s	5 s	3 s	5 s	40 s	4 s	0 s	7 s	22 s	**8 s***	12 s
Proportion delayed	30%	55%	55%	5%	15%	40%	100%	50%	0%	10%	85%	25%	15%
Number delayed	6	5	4	2	3	4	1	1	0	4	5	27	8
Received precedence	100%	60%	60%	70%	100%	55%	100%	100%	100%	80%	30%	80%	65%

* Statistically significantly different from the control at the 5% level

5.4.6 *Vehicle delays*

Vehicles could be delayed by main road traffic, by other vehicles waiting to turn or by pedestrians when turning into and out of the SRET. The resulting delays are shown in Table 5-10. As expected, the delays were greater for vehicles turning out of the side road rather than into it, both in terms of the average delay to a delayed vehicle and in the proportion of vehicles delayed. Right turning vehicles, both in and out, were considerably more likely to be delayed than left turning ones. More vehicles were delayed turning into side roads that had a SRET than turning into an untreated side road. When vehicles were delayed turning left, either into or out of the side road, they were delayed for significantly longer at sites with a SRET than at the control sites.

Table 5-10: Vehicle delays

	Average delay (s) to those vehicles that were delayed		Number and proportion of vehicles delayed	
Manoeuvre	**SRET**	**Control**	**SRET**	**Control**
Left in	**7***	4	79 (15%)	10 (9%)
Left out	**10***	8	541 (40%)	178 (48%)
Right in	7	7	144 (24%)	38 (18%)
Right out	15	14	417 (79%)	83 (80%)

* Statistically significantly different from the control at the 5% level

The principal reasons for the delay were: opposing main road traffic, vehicle in the minor road and pedestrians as shown Table 5-11. Vehicles were more likely to be delayed by other vehicles on the side road at sites with a SRET than at those without. A vehicle slowing to cross a SRET on entering a side road is more likely to delay a following vehicle than one making a turn into a side road without any restriction in the road. As might be expected from the similarity in drivers' willingness to give way to pedestrians shown in Table 5-3 there was little difference in the proportion of vehicles delayed by pedestrians at the SRET sites and the controls. The exception was for left turns into the side road, where at sites with a SRET, half the delays were caused by other vehicles on the side road, reducing the proportion delayed by pedestrians. However, only 10 vehicles were delayed turning left into the control sites providing little evidence on the causes of delay for this manoeuvre. Because of the small number of delayed vehicles, the differences between the SRET and control sites are not statistically significant.

Table 5-11: Reasons for vehicular delay

Reason for delay*	Opposing main road traffic		Vehicle on side road		Pedestrian	
Manoeuvre	**SRET**	**Control**	**SRET**	**Control**	**SRET**	**Control**
Left in	0 (0%)	0 (0%)	37 (50%)	0 (0%)	21 (28%)	9 (90%)
Left out	342 (63%)	113 (63%)	49 (9%)	12 (7%)	105 (19%)	36 (20%)
Right in	82 (57%)	28 (74%)	13 (9%)	1 (3%)	22 (15%)	4 (11%)
Right out	280 (65%)	54 (64%)	25 (6%)	4 (5%)	56 (13%)	15 (18%)

*N.B. the percentages do not sum to 100 as there were other minor reasons for the delay to some vehicles.

5.4.7 Reversing vehicles

Vehicles occasionally reverse in and out of side roads. Such manoeuvres are potential sources of problems between pedestrians and vehicles and between vehicles. Reversing is not normally expected and the driver's view of the surroundings is not as good when reversing as when driving normally. Vehicles were only seen to reverse at 4 sites, all SRET sites, and no undue problems were observed:

- Three at Clapham Road, but without any problems including a wheelchair lift equipped midi-bus that dropped off at least one person.
- Similarly the 4 vehicles seen reversing at Britannia Road caused no problems or delay to pedestrians.
- Of the three vehicles that reversed at Bentley Road, two were classed as having encounters with pedestrians, but the pedestrians were not delayed and there were no serious consequences.
- The vehicle that reversed at Neville House Yard did cause a pedestrian to pause but then realised that the vehicle was using the side road to turn round and crossed in front of the car.

5.5 Comparison with collision analysis

The collision analysis estimated no significant change in pedestrian collisions, although pedestrians were observed to be less diligent in looking for potentially conflicting vehicles at sites with SRETs compared with control sites. It is possible that pedestrians' willingness to wait to cross along the SRET after a waiting vehicle had cleared rather than walk behind the vehicle to save delay results in better visibility of pedestrians by vehicles turning into the side road.

An increase in collisions involving turning vehicles at TLRN SRET sites was estimated by the collision modelling and the observations showed vehicles turning into the side road to be more likely to be delayed by another vehicle on the side road at SRET sites than elsewhere. However, no serious vehicle – vehicle interactions were observed during the one survey day at each of the selected sites.

Vehicles turning right into a side road with a SRET were statistically significantly more likely to have an "encounter" or a "conflict" with pedestrians than vehicles turning right into a side road without a SRET. The right turn in manoeuvre appeared to be more likely to result in a problem where there was a SRET than where there was not. The statistical analysis of the collision data also found a problem with turning right into a side road with a SRET. The analysis showed a significant increase in collisions involving right turns into a side road with a SRET.

There were too few powered two-wheelers or cyclists observed to draw any conclusions. Some, but by no means all, cyclists were seen cycling on the pavement. Those who do cycle along the pavement can cross a side road on a SRET without having to slow down to drop off or mount the kerb, possibly surprising turning motorists. However, the collision modelling showed no evidence of an adverse effect of SRETs on cyclists, in fact there was a significant reduction in cyclist collisions at SRET sites.

Neither the observational study nor the collision modelling raised particular issues for children or older pedestrians.

6 Conclusions

6.1 Collision analysis

The first part of the project estimated the effect of SRET treatment (in conjunction with conversion to Red Routes in the case of the TLRN junctions) on collisions at 777 junctions on the TLRN network and at 275 junctions that are on London Boroughs' roads. TLRN and London Borough sites were treated separately as the traffic characteristics of the TLRN are different from those of Borough roads and the installation policies were different. The statistical estimation used Generalised Linear Regression models. It has produced results which are different for the effect of SRETs at TLRN junctions compared with that at Borough junctions.

The results from the TLRN model (Table 4-1) estimate that there was no overall change in the number of collisions of all severities due to SRETs on the TLRN. Installation of a SRET across a side road of a road on TLRN would not be expected to change the overall number of collisions in a year. However, there are estimated to be changes in the types of collisions. The model estimated a statistically significant reduction, of 20%, in pedal cycle collisions following installation of a SRET. Some other classes of collisions: powered two-wheelers, powered two-wheelers turning, right turning into the side road, all turning collisions and all collisions on the minor road were estimated to have increased. No other statistically significant changes were determined. Powered two-wheelers in particular show a considerable increase in collisions above the underlying trend of an increase in such collisions in London. Although all turning collisions were estimated to have been increased by the installation of SRETS, the only individual movement to be statistically significant is in right turning into the side road.

The model of collisions at SRET sites on Borough roads (Table 4-1) shows a different picture; overall collisions are estimated to be reduced by 20% and all the statistically significant results are reductions. Installation of SRETs on the Borough roads in the data set modelled is estimated to have reduced collisions and not increased any of the categories of collisions that were included in the modelling. Significant reductions were estimated in several collision categories: total collisions, slight collisions, non pedestrian collisions, pedal cycle collisions, right turning out from minor arm collisions, all turning collisions and all collisions on the minor road.

It is difficult to explain the differences between the results for the TRLN sites and those for the Borough sites. The explanation may be related to a number of issues:

- The different traffic characteristics (e.g. traffic speed, traffic volume etc.) between the TLRN and sites on Borough roads where SRETs have been installed.
- The TLRN sites included in the study are mostly in inner London whereas the Borough sites are mainly in outer London
- The TLRN were SRET treated at the same time as they became part of Red Routes so that it is not possible from the data used in this study to separate the two effects. The Borough sites are not on Red Routes
- There may be some element of bias by selection within the Borough dataset, since the treated junctions may have been selected for treatment because they had a poor collision record and are, therefore, more likely than average to show a reduction in collisions in subsequent years (regression to mean effect)

6.2 Behavioural study

The second part of the project studied pedestrians' and drivers' behaviour at a selection of junctions, eight with SRETs and three control sites. Comparing pedestrian behaviour at SRET and control sites showed that pedestrians are more likely to obviously look for turning vehicles that may conflict with them when crossing a side road without a SRET than when there is a SRET (Table 5-6). However, it is not clear whether pedestrians expect drivers to give way at SRETs. At two sites, one control and one with a SRET, a significant minority of pedestrians appeared to assert priority and force drivers to give way to them, but overall there was no clear difference in pedestrians' expectation of priority between SRET and control sites.

Drivers showed little difference in propensity to give way to pedestrians wishing to cross the side road at control and SRET sites (Table 5-3).

The severity of the interaction between individual pedestrians and vehicles was assessed from the video recordings. Interactions were classified in order of increasing severity as "interaction", "encounter" and "conflict." The proportion of conflicts was low at all sites, but there was a significantly greater proportion of encounters and conflicts between vehicles turning into the side road at sites with a SRET than at control sites. The difference was most marked for vehicles turning right into the side road (Table 5-5). The increase in the severity of the conflicts for turning movements is in good agreement with the statistical collision analysis where a significant increase in the number of collisions involving vehicles turning right into the side road was found.

At the control sites very few vehicles turning into the side road were delayed by vehicles in the side road, but the presence of a SRET made interactions between vehicles in the side road much more likely. Delay by a vehicle on the side road was not, however, associated with an increase in the severity of interaction with pedestrians.

Pedestrians appeared to like the convenience of crossing the side road at a SRET, where the SRET provided a continuous level place to cross between the footways either side of the side road. Significantly fewer people diverted from the natural crossing line to walk behind a stationary vehicle, and avoid delay, at sites with a SRET than at the controls. The benefit of the convenient informal crossing appeared to exceed the disbenefit of the extra delay of waiting for the vehicle to clear.

6.3 Comparison of collision analysis and behavioural study

The collision analysis estimated no significant change in pedestrian collisions, although pedestrians were observed to be less diligent in looking for potentially conflicting vehicles at sites with SRETs compared with control sites. It is possible that pedestrians' willingness to wait to cross along the SRET after a waiting vehicle had cleared rather than walk behind the vehicle to save delay results in better visibility of pedestrians by vehicles turning into the side road.

An increase in collisions involving turning vehicles at TLRN SRET sites was estimated by the collision modelling and the observations showed vehicles turning into the side road to be more likely to be delayed by another vehicle on the side road at SRET sites than elsewhere. However, no serious vehicle – vehicle interactions were observed.

There were too few powered two-wheelers or cyclists observed to draw any conclusions. Some, but by no means all, cyclists were seen cycling on the pavement. Those who do cycle along the pavement can cross a side road on a SRET without having to slow down to drop off or mount the kerb, possibly surprising turning motorists. However, the collision modelling showed no evidence of an adverse effect of SRETs on cyclists, in fact there was a significant reduction in cyclist collisions at SRET sites.

Neither the observational study nor the collision modelling raised particular issues for children or older pedestrians.

The routine treatment of all junctions on sections of the TLRN has not been as successful in reducing collisions as has the more targeted approach adopted by the individual Boroughs. However, no analysis has been on any possible regression to the mean effect at the Borough sites.

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Appendix A. Details of site characteristics and collision data

A.1 Location

The details of the location of the SRET sites and the London Boroughs that supplied data are shown in Table A-1.

Table A-1: SRET sites by Borough

Region		Borough	TLRN sites	Borough sites
Inner London	1	Westminster	46	
	2	Camden	9	26
	3	Islington	7	
	4	Hackney	58	
	6	Greenwich	24	
	7	Lewisham	136	
	8	Southwark	37	
	9	Lambeth	139	
	10	Wandsworth	144	
	12	Kensington and Chelsea	42	
Total Inner			642	26
Outer London	13	Waltham Forest		10
	14	Redbridge		62
	19	Bromley	20	
	20	Croydon	33	
	21	Sutton	5	21
	22	Merton	27	
	23	Kingston		143
	24	Richmond	18	
	25	Hounslow		13
	31	Hillingdon	32	
Total Outer			135	249
Total			777	275

A.2 Installation

A summary of the year of end of installation of the SRET sites studied is shown in Table A-2.

Table A-2: SRET sites by year of end of installation

Year of end of installation	TLRN sites	Borough sites
1991		12
1992	10	
1993		5
1994		1
1995	11	16
1996	25	20
1997	52	20
1998	293	2
1999	173	20
2000	202	9
2001	11	36
2002		23
2003		76
2004		35
Total	777	275

A.3 Construction

Table A-3 shows the construction materials of the SRETs and Table A-4 the height; little information was available on the construction of the Borough sites.

Table A-3: SRET sites by construction material

Material	TLRN sites	Borough sites
Rolled Asphalt	4	19
Bitmac	3	
Block Paving	722	
Granite	41	
Other	7	
Fine picked setts		6
Course setts		1
No data		249
Total	777	275

The majority (720) of the TLRN SRETs were described as raised although there were some that were described as flat or in between, which were excluded from the analysis.

Table A-4: SRET sites by height

SRET height	TLRN sites	Borough sites
Raised	720	
Flat	39	
In between	18	
No data		275
Total	777	275

A.4 One-way roads

MapInfo was used in conjunction with a map of roads in London to select SRET sites which were within 30m of a section of one-way road or a banned or mandatory turn. The selected sites were then examined individually to determine which movements were permitted at each. Movements permitted at minor road opposite (at crossroad sites) have not been categorised. The number of sites by one-way character is shown in Table A-5. At 772 sites (73%) all traffic movements were permitted. The traffic movements and pedestrian behaviour at the gated roads will differ from those at the other sites, so these sites were excluded from analysis.

Table A--5: SRET sites by one-way character

One way	Left in?	Left out?	Right in?	Right out?	TLRN	Borough	Total
All movements permitted	y	y	y	y	506	265	771
Turn left in and out only	y	y			95	2	97
Turn out only		y		y	42	1	43
Turn in only	y		y		41	4	45
Turn Right in and out only			y	y	24		24
Turn left in only	y				23	1	24
Turn left out only		y			14	1	15
Turn right in only			y		11	1	12
Turn Right out only				y	8		8
No right in	y	y		y	6		6
No right out	y	y	y		4		4
No left in		y	y	y	1		1
No left out	y		y	y	1		1
Gated road					2		2

A.5 Flow data

Average annual daily flow data (AADF) for the main road at each SRET was available for all of the TLRN sites and about half of the Borough sites. The data was available for 1993-2004 and based on the nearest DfT census points to each SRET. The flows for the minor arms were not available.

Table A-6: SRET sites by AADF

2004 flow level	TLRN	Borough
<20k	132	76
20-30k	438	61
30-40k	130	7
40-60k	60	3
>60k	17	
Unavailable		128
Total	777	275

A.6 Proximity to other SRETs

The grid references of the SRETs were used to determine the proximity of nearby SRETs. Table A-7 gives a summary of the number of SRETS within 60m for the TLRN and Borough sites. About half of the sites had no other SRETS within 60m.

Table A-7: SRET sites by number of other sites within 60m

Number of other SRETS within 60m	TLRN	Borough
0	344	167
1	287	79
2	112	23
3	27	5
4	7	1
Total	777	275

A.7 Collision data at SRET sites

Stats19 collision data (attendant circumstances, vehicle and casualty details) were obtained from the TfL ACCSTATS system for all collisions that occurred within a 30m radius of each SRET between 1980 and 2004. Since about half of the SRETs have other sites within 60m, there were collisions that could be assigned to more than one SRET. In these cases, the collision was assigned to the nearest SRET. Figure A-1 shows the collisions selected for some example sites.

Figure A-1: Collisions within 30m of SRETs with overlapping regions

A.8 Junction detail

The Stats19 collision report includes the type of junction at which the collision occurred. For the purposes of Stats19, junction collisions are defined as those occurring at or within 20m of a junction. Collisions occurring further than 20m from a junction should be coded as non-junction. The collisions within 30m from the SRET junction therefore include some non-junction collisions, but should include all of the junction collisions associated with that junction. Note that the grid reference location of collisions is only recorded to the nearest 10m.

The junction detail field in the collision record was used to determine whether each junction was a T-junction or crossroads. However, junction type is not always recorded consistently. At each junction where at least 55% of the collisions were recorded as one junction type, the junction was defined as that type. Table A-8 shows the number of sites by majority junction detail. Roundabout, private drive, multiple junction and the sites with a mix of junction detail types recorded (including sites with no collisions) were checked on a map to determine junction detail. Crossroads on dual carriageways where there was no gap in the central reservation were treated as T-junctions and staggered crossroads were treated as two T-junctions.

Table A-8: Sites by majority Stats19 junction detail

Junction Detail	TLRN	Borough
T-junction/Staggered	680	197
Crossroads	62	33
Roundabout	1	0
Private drive	1	4
Multiple junction		1
No collisions		14
Unable to assign junction type due to inconsistent junction detail entries	33	26
Total	777	275

For those junctions where it was not possible to automatically assign a junction type from the Stats19 data, manual assignment using map data was used. Table A-9 shows the final junction detail classifications.

Table A-9: Sites by finalised junction detail

Junction Detail	TLRN	Borough
T-junction/Staggered	700	229
Crossroads	77	46
Total	777	275

The presence of a SRET site within 60m and the junction detail can be used together to determine the junction type and the treatments as shown in Figure A-2.

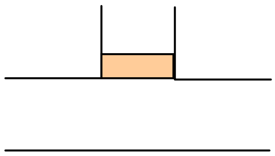
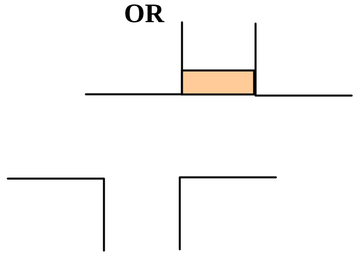
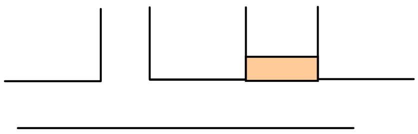
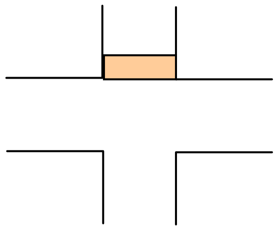
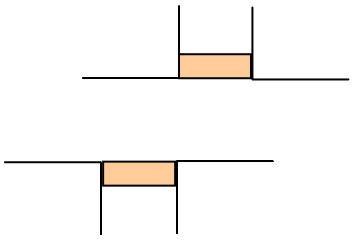
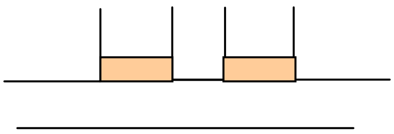
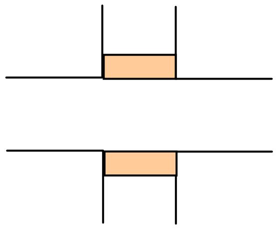
	Junction detail	
	T-junction/Staggered	**Crossroads**
No SRET within 60m	**Type 1**  **OR**  **OR** 	**Type 2** 
SRET within 60m	**Type 3**  **OR** 	**Type 4** 

Figure A-2: Junction types

Table A-10 shows the number of sites of each of the junction types shown above. The majority of the sites were at T/staggered junction (although there is no definition of staggered junction in Stats20).

Table A-10: Sites by junction type

Junction type	Description	TLRN	Borough	Total
1	T/Staggered junction, no other SRET within 60m	330	144	474
2	Crossroads, no other SRET within 60m	14	23	37
3	T/Staggered junction, at least one other SRET within 60m	370	85	455
4	Crossroads, at least one other SRET within 60m	63	23	86
Total		777	275	1,052

Appendix B. Modelling of the collision data

Some explanation is given below on regression modelling and in particular, on why different models are tested and how the final model was selected.

B.1 The format of the results

The results of the SRET collision analysis and the Borough sites are presented for a range of types of collision. The main results are based on a generalised linear modelling approach to the analysis but these are presented alongside the results of the previous exploratory analysis for the purpose of comparison.

The results are based on models which relate the number of injury collisions at each SRET site in each year to several factors and variables:

a time trend (common to all sites);

a factor representing the effect of SRET treatment;

a multi-level factor where each site is represented by a separate level (some models);

a variable representing the AADT flow on the major road for each year during the period from 1993 to 2004 only (some models).

The results are presented in Tables B-1 to B-3 which show the percentage changes associated with the introduction of the SRET treatment. The tables present the central estimates and an indication of whether the results are statistically significant (*=statistically significant) from 'no change' (at the 5 per cent test level, p=0.05) . The percentage changes have been rounded to the nearest integer. Also shown are measures of the goodness of fit, R^2 (a standard measure of the goodness of fit of a regression model which shows the percentage of the overall variance which is explained by the model parameters), and the estimated annual percentage change in the number of collisions.

Statistical controls have been used in the analysis where indicated. For the TLRN sites, these include only those junctions which are on Red Routes. However, the available data did not allow each control junction to be treated separately nor to include a separate estimate of the effect on numbers of injury collisions of conversion to Red Routes. This means that the percentage changes for the TLRN sites include both a SRET effect and some aspects of a Red Route effect as well. There was no main road flow available for the statistical controls and therefore models which include the main road flow as an explanatory variable do not have statistical controls. For the Borough sites, the control consists of all unsignalised T and staggered junctions and crossroads in the Boroughs that were not subjected to the SRET treatment.

The entry NA (Not Applicable) refers to collision groups for which no suitable control was available and hence modelling with a control has not been performed.

B.2 TLRN sites for the period 1982-2004

Table B-1 contains results for the TLRN sites. It contains results only from models which excluded major road flows, since flows were not available for the period prior to 1993. The columns in Table B-1 are as follows.

Column 1 Injury collision type.

Column 2 Results of the exploratory collision analysis based on 3 years of 'before' data and 3 years of 'after' data at each SRET.

Column 3 Results of an analysis of injury collision data from 1982 to 2004 without statistical controls where each SRET is not represented by a separate factor.

Column 4 Results of an analysis of injury collision data from 1982 to 2004 without statistical controls where each SRET is represented by a separate factor (preferred model, column shaded).

Column 5 Results of an analysis of injury collision data from 1982 to 2004 with a statistical controls where each SRET is not represented by a separate factor. The control is represented by a separate factor.

Column 6 Results of an analysis of injury collision data from 1982 to 2004 with statistical controls where each SRET is represented by a separate factor. The control is represented by a separate factor.

There are three entries on each row: the goodness of fit (R^2) expressed as a percentage; the estimated percentage increase or decrease in injury collisions associated with SRET/Red Route treatment; and the estimated annual time trend (per cent per year).

As an example, consider the first row of the table which records the results for total collisions. The simple comparison of 3 years before and three years after data predicts a reduction of 2% (-2) on average in the total number of collisions at a junction due to the installation of a SRET. The next column presents the results of the modelling analysis without the use of controls or the use of a site specific factor to allow for the characteristics of a particular site. As with all the models represented in the table, the effect of flow was not modelled. This model had an R^2 of 0.3 and predicted an average reduction in collisions of 6% due to the installation of a SRET. The estimated time trend was an annual reduction in accidents of 0.6%. The remaining columns show the equivalent results for the other models that were fitted to the data.

The results differ according to whether each SRET junction is represented by a separate factor in the analysis or not, and whether or not a statistical control is used.

It is instructive to consider the results for total collisions first. The goodness of fit, represented by R^2 is very high for the models that used a control. However, these findings are deceptive. As explained previously, the control appears as a single entity in the analysis, as if it were a single junction at which a large number of collisions has occurred. However, most of the SRET junctions have few collisions and hence for the null model (that which does not include any explanatory variables and which is the starting point in the modelling process) the initial variance is very high. When a factor is introduced to represent the control, the variance is substantially reduced, so that the resulting model fits substantially better than the null model. However, this substantial improvement in fit only occurs because the null model was such a poor fit because of the very different characteristics of one site, the control.

Table B-1: Injury collision analysis: TLRN sites for the period 1982-2004

Collision type		3 years before & after	1982-2004			
		Exploratory collision analysis	No control		Control	
			No factor	Factor	No factor	Factor
			No flow	No flow	No flow	No flow
Total	R^2		0.3	32.9	95.8	97.2
	sretred	**-2**	**-6**	**+6**	**+11 ***	**+17 ***
	θ		-0.6	-1.2	-1.9	-2.0
Fatal	R^2		1.5	38.2	81.1	88.0
	sretred	**+64**	**+41**	**+37**	**+40**	**+37**
	θ		-7.0	-6.9	-6.9	-6.9
Serious	R^2		0.6	17.7	89.3	91.1
	sretred	**-4**	**-3**	**+7**	**+9**	**+15 ***
	θ		-2.0	-2.5	-3.0	-3.0
Slight	R^2		0.1	30.1	95.2	96.7
	sretred	**-1**	**-7**	**+5**	**+11 ***	**+18 ***
	θ		-0.3	-0.9	-1.7	-1.8
Pedestrian	R^2		1.1	26.7	89.7	92.3
	sretred	**-6**	**-5**	**+4**	**+12 ***	**+17s ***
	θ		-2.5	-3.0	-3.8	-3.8
Non pedestrian	R^2		0.1	28.9	95.3	96.6
	sretred	**0**	**-7**	**+6**	**+12 ***	**+19 ***
	θ		0.0	-0.6	-1.4	-1.5
Pedal cycle	R^2		0.2	24.9	86.0	89.4
	sretred	**-21**	**-29 ***	**-20 ***	**-3**	**+2**
	θ		+1.1	+0.5	-1.4	-1.5
Pedal cycle turning	R^2		0.3	41.0	78.5	86.9
	sretred	**-50**	**-31**	**-27**	**+12**	**+16**
	θ		0.0	-0.4	-4.0	-4.0
PTW	R^2		0.5	22.3	91.0	92.9
	sretred	**+25**	**+50 ***	**+66 ***	**+36 ***	**+43 ***
	θ		-2.4	-2.9	-1.6	-1.7
PTW turning	R^2		0.2	32.9	81.9	87.7
	sretred	**+44**	**+49**	**+76 ***	**+47 ***	**+59 ***
	θ		-3.3	-4.1	-3.2	-3.3
Left in	R^2		0.1	27.9	81.2	86.4
	sretred	**+13**	**-14**	**-1**	**+14**	**+22 ***
	θ		0.0	-0.7	-2.3	-2.4
Left out	R^2		0.6	29.1	85.5	89.6
	sretred	**+12**	**+55 ***	**+58**	**+45 ***	**+45 ***
	θ		-4.7	-4.8	-4.1	-4.2
Right in	R^2		0.1	27.7	85.6	89.5
	sretred	**+11**	**+4**	**+21 ***	**+17 ***	**+26 ***
	θ		-1.2	-1.9	-2.2	-2.3
Right out	R^2		0.6	29.6	87.1	90.0
	sretred	**+14**	**+3**	**+13**	**+25 ***	**+31 ***
	θ		-2.4	-2.8	-3.9	-4.0
All turning	R^2		0.4	28.4	91.1	93.6
	sretred	**+12**	**+5**	**+18 ***	**+23 ***	**+30 ***
	θ		-1.8	-2.4	-3.1	-3.2
Pedestrian on major road	R^2		1.1	26.5	87.7	90.8
	sretred	**-4**	**-6**	**+3**	**+2**	**+7**
	θ		-2.5	-3.0	-3.1	-3.2
Pedestrian on minor road	R^2		1.4	31.1	59.5	71.4
	sretred	**-22**	**-25**	**-22**	**-6**	**-3**
	θ		-3.6	-3.8	-5.3	-5.4
All minor road	R^2		0.5	28.1	91.7	94.0
	sretred	**+13**	**+5**	**+18 ***	**+6**	**+12 ***
	θ		-1.9	-2.5	-2.0	-2.1

Θ is the fitted time trend, the estimated percentage change in collisions from one year to the next

When no control and no factor is used in the analysis (column 3), the variance of the null model represents only the variability in the numbers of collisions that occur between normal junctions. Since this variance is only moderate, adding explanatory variables does not produce a substantial reduction in the variance and so the values of R^2 are relatively small. Because of the unusual data set, adding the control adds one compound junction with all the conclusions at control sites, a vastly different type of junction from the read junctions with SRETs. Consequently the explanatory variable control / not control site explains a very large proportion of the variability in the data resulting in a large value of R^2.

It is concluded that although presented in Table B-1 (and Table B-2 and Table B-3), the values of R^2 do not provide a useful indication of the validity of the models.

Table B-1 shows that SRET treatment in combination with Red Routes is estimated to be associated with a 2% reduction in total collisions (exploratory analysis), a 6% reduction (no control and no site factor), a 6% increase (no control with site factor), an 11% increase (control without a site factor), and a 17% increase (control with a site factor). It is noticable that there is a relationship between the central estimates of 'sretred' and of θ, such that as θ becomes more negative, 'sretred' becomes more positive. This is not surprising, but it raises the issue of whether the modelling process can properly distinguish between 'sretred' and the time trend, θ.

The issue was addressed by fitting models using data only from the periods before SRET/Red Route treatment on the TLRN junctions, for which a large number of years of data was available for most of them. This analysis showed that the values of θ that were obtained in this way (no 'sretred' factor was present or needed in these models) were similar to those obtained and presented in Table B-1. This suggests that any benefits of SRET/Red Route treatment are not being misinterpreted as contributing to long term trends (θ).

It would be possible to engage in a detailed discussion of the many results presented in Table B-1. However, given that there are doubts about the validity of the controls and that it is desirable to include a factor to represent individual junctions, only the statistically significant findings presented in Column 4 will be considered further. These are:

- Pedal cycle collisions 20% reduction
- Powered two-wheeler collisions 66% increase
- Powered two-wheeler turning collisions 76% increase
- Right turn in collisions 21% increase
- All turning collisions 18% increase
- All minor road collisions 18% increase

B.3 TLRN sites for the period 1993-2004

Table B-2 contains results for the TfL sites. It contains results only from years in which major road flows are available. The columns in Table B-2 are as follows.

Column 1 Injury collision type.

Column 2 Results of the exploratory collision analysis based on 3 years of 'before' data and 3 years of 'after' data at each SRET.

Column 3 Results of an analysis of injury collisions from 1993 to 2004 without statistical controls where data for all SRETS is combined and where main road flow is not taken into account.

Column 4	Results of an analysis of injury collisions from 1993 to 2004 without statistical controls where data for all SRETS is combined but where main road flow is taken into account.
Column 5	Results of an analysis of injury collisions from 1993 to 2004 without statistical controls where each SRET is represented by a separate factor and where main road flow is not taken into account.
Column 6	Results of an analysis of injury collisions from 1993 to 2004 without statistical controls where each SRET is represented by a separate factor and main road flow is taken into account.

The goodness of fit measures (R^2) show that the inclusion of a variable representing major arm traffic flow has little explanatory power.

The models that contain a site factor and a factor representing flow are probably little more reliable than those without a factor representing flow. The results from those models where the estimated effect of the SRET/Red Route treatment is statistically significant are presented in column 6 of Table B-2. They are:

- Pedal cycle collisions 25% reduction
- Powered two-wheeler collisions 36% increase
- Right in collisions 33% increase
- Right out collisions 35% increase
- All turning collsions 29% increase
- All minor road collisions 28% increase

Table B-2: Injury collision analysis: TLRN sites for the period 1993-2004

Collision type		3 years before & after	1993-2004			
		Exploratory collision analysis	No control		No control	
			No factor	No factor	Factor	Factor
			No flow	Flow	No flow	Flow
Total	R^2		0.3	1.7	36.5	36.5
	sretred	**-2**	**-19 ***	**-18 ***	**+8**	**+7**
	θ		+1.3	+1.4	-1.8	-1.6
Fatal	R^2		0.3	0.6	53.7	53.7
	sretred	**+64**	**+67**	**+68**	**+88**	**+88**
	θ		-8.7	-8.5	-9.3	-9.5
Serious	R^2		0.1	0.3	25.8	25.8
	sretred	**-4**	**-11**	**-10**	**+4**	**+4**
	θ		+0.3	+0.3	-1.5	-1.5
Slight	R^2		0.3	1.7	34.6	34.7
	sretred	**-1**	**-20 ***	**-20 ***	**+8**	**+7**
	θ		+1.5	+1.6	-1.8	-1.6
Pedestrian	R^2		0.4	1.0	30.2	30.2
	sretred	**-6**	**-15**	**-14**	**+7**	**+5**
	θ		-0.7	-0.7	-3.3	-2.9
Non pedestrian	R^2		0.2	1.3	33.8	33.8
	sretred	**0**	**-20 ***	**-19 ***	**+8**	**+7**
	θ		+1.8	+1.9	-1.4	-1.3
Pedal cycle	R^2		0.6	1.0	32.9	32.9
	sretred	**-21**	**-39 ***	**-38 ***	**-24 ***	**-25 ***
	θ		+3.0	+3.1	+0.6	+0.9
Pedal cycle turning	R^2		0.4	0.5	54.7	55.4
	sretred	**-50**	**-36**	**-36**	**-49**	**-43**
	θ		+0.8	+0.8	+3.2	-1.1
PTW	R^2		0.4	0.7	27.8	27.9
	sretred	**+25**	**+15**	**+15**	**+39 ***	**+36 ***
	θ		+1.0	+1.1	-1.1	-0.5
PTW turning	R^2		0.0	1.1	49.6	49.6
	sretred	**+44**	**+25**	**+26**	**+120**	**+126**
	θ		-1.8	-1.5	-8.0	-8.5
Left in	R^2		0.2	1.7	40.0	40.0
	sretred	**+13**	**-35**	**-33**	**-5**	**-3**
	θ		+4.8	+4.9	+0.5	+0.1
Left out	R^2		0.1	0.1	42.8	43.0
	sretred	**+12**	**+34**	**+35**	**+21**	**+12**
	θ		-2.7	-2.6	-1.4	+1.7
Right in	R^2		0.0	0.0	37.1	37.2
	sretred	**+11**	**-8**	**-8**	**+35 ***	**+33 ***
	θ		+0.9	+0.9	-3.4	-3.1
Right out	R^2		0.2	0.2	36.6	36.6
	sretred	**+14**	**+15**	**+14**	**+38 ***	**+35 ***
	θ		-3.7	-3.8	-5.7	-5.4
All turning	R^2		0.0	0.1	34.7	34.8
	sretred	**+12**	**-1**	**-1**	**+31 ***	**+29 ***
	θ		-0.7	-0.6	-3.7	-3.5
Pedestrian on major road	R^2		0.5	1.1	30.5	30.5
	sretred	**-4**	**-9**	**-8**	**+16**	**+14**
	θ		-2.2	-2.1	-4.9	-4.5
Pedestrian on minor road	R^2		0.5	1.2	47.8	48.1
	sretred	**-22**	**-34**	**-32**	**-26**	**-30**
	θ		-0.1	-0.1	-1.5	0.0
All minor road	R^2		0.0	0.1	34.7	34.7
	sretred	**+13**	**-1**	**0**	**+30 ***	**+28 ***
	θ		-0.7	-0.7	-3.7	-3.4

Θ is the fitted time trend, the estimated percentage change in collisions from one year to the next

B.4 Borough sites for the period 1982-2004

Table B-3 contains results for the Borough sites. It contains results only from models which excluded major road flows, since flows were not available for the Borough sites. The columns in Table B-3 are as follows.

Column 1	Injury collision type.
Column 2	Results of the exploratory collision analysis based on 3 years of 'before' data and 3 years of 'after' data at each SRET.
Column 3	Results of an analysis of injury collision data from 1982 to 2004 without statistical controls where each SRET is not represented by a separate factor.
Column 4	Results of an analysis of injury collision data from 1982 to 2004 without statistical controls where each SRET is represented by a separate factor (preferred model, column shaded).
Column 5	Results of an analysis of injury collision data from 1982 to 2004 with statistical controls where each SRET is not represented by a separate factor. The control is represented by a separate factor.
Column 6	Results of an analysis of injury collision data from 1982 to 2004 with statistical controls where each SRET is represented by a separate factor. The control is represented by a separate factor.

The results are not markedly different from each other regardless of whether a control is used or not, or whether a site factor is used or not (except for the values of R^2), which provides an indication that the the results are reasonably reliable. In order to be consistent with the presentation of the results from the TLRN sites, the results that are discussed further are those with a site factor but without a control and which are statistically significant. These are:

- Total collisions 21% reduction
- Slight collisions 22% reduction
- Non-pedestrian collisions 25% reduction
- Pedal cycle collisions 51% reduction
- Right out collisions 40% reduction
- All turning collisions 25% reduction
- All minor road collisions 27% reduction

Table B-3: Injury collision analysis: Borough sites for the period 1982-2004

Collision type		**3 years before & after**	**1982-2004**			
		Exploratory collision analysis	No control		Control	
			No factor	Factor	No factor	Factor
			No flow	No flow	No flow	No flow
Total	R^2		1.3	34.5	99.8	99.8
	sret	**-18**	**-20 ***	**-21 ***	**-17 ***	**-18 ***
	θ		-2.0	-1.9	-2.3	-2.3
Fatal	R^2		0.9	44.6	98.7	99.2
	sret	**+300**	**+142**	**+164**	**+129**	**+137**
	θ		-5.4	-5.7	-4.9	-4.9
Serious	R^2		0.6	24.7	99.4	99.5
	sret	**-34**	**-22**	**-23**	**-8**	**-5**
	θ θ		-1.7	-1.6	-3.3	-3.3
Slight	R^2		1.2	32.8	99.8	99.8
	sret	**-16**	**-20 ***	**-22 ***	**-20 ***	**-21 ***
	θ		-2.0	-1.9	-2.1	-2.1
Pedestrian	R^2		1.1	32.7	99.6	99.7
	sret	**-10**	**-16**	**-6**	**-13**	**-6**
	θ		-3.1	-3.4	-3.4	-3.4
Non pedestrian	R^2		0.9	32.1	99.7	99.8
	sret	**-21**	**-21 ***	**-25 ***	**-18 ***	**-21 ***
	θ		-1.6	-1.5	-1.9	-1.9
Pedal cycle	R^2		1.5	30.6	99.3	99.5
	sret	**-13**	**-40 ***	**-51 ***	**-40 ***	**-48 ***
	θ		-2.7	-2.1	-2.6	-2.6
Pedal cycle turning	R^2		1.8	41.7	99.7	99.8
	sret	**-80**	**-5**	**-26**	**-32**	**-44**
	θ		-6.4	-5.7	-3.4	-3.4
PTW	R^2		1.6	26.0	99.4	99.5
	sret	**-17**	**+6**	**-2**	**-9**	**-16**
	θ		-4.5	-4.3	-3.0	-3.0
PTW turning	R^2		2.0	43.8	98.9	99.3
	sret	**+100**	**+65**	**+44**	**+5**	**-9**
	θ		-8.1	-7.7	-4.1	-4.1
Left in	R^2		0.6	36.5	99.1	99.4
	sret	**0**	**-30**	**-36**	**-19**	**-21**
	θ		-2.3	-2.1	-3.7	-3.7
Left out	R^2		1.9	37.6	99.2	99.5
	sret	**-14**	**-17**	**-32**	**-38**	**-48**
	θ		-5.7	-5.2	-3.1	-3.1
Right in	R^2		0.2	29.7	94.6	96.1
	sret	**-42**	**+11**	**-6**	**+66 ***	**+59 ***
	θ		-2.0	-1.5	-5.7	-5.7
Right out	R^2		1.6	33.4	99.3	99.5
	sret	**-9**	**-34 ***	**-40 ***	**-35 ***	**-39 ***
	θ		-3.2	-2.9	-3.1	-3.1
All turning	R^2		1.2	31.5	99.5	99.6
	sret	**-24**	**-15**	**-25 ***	**-11**	**-18**
	θ		-2.9	-2.6	-3.3	-3.3
Pedestrian on major road	R^2		1.1	32.4	90.8	90.9
	sret	**-11**	**-11**	**+1**	**-74 ***	**-79 ***
	θ		-3.2	-3.5	+10.3	+10.3
Pedestrian on minor road	R^2		1.3	41.4	98.6	99.0
	sret	**0**	**-61**	**-63**	**-38**	**-36**
	θ		-2.0	-1.9	-6.3	-6.3
All minor road	R^2		1.3	31.5	99.6	99.7
	sret	**-21**	**-17**	**-27 ***	**-33 ***	**-29 ***
	θ		-2.9	-2.5	-2.2	-2.2

Θ is the fitted time trend, the estimated percentage change in collisions from one year to the next

Appendix C. Behavioural studies

Examples of the views from the video recordings used to assess the behaviour of users are given below.

Figure C-1: Homeleigh Road

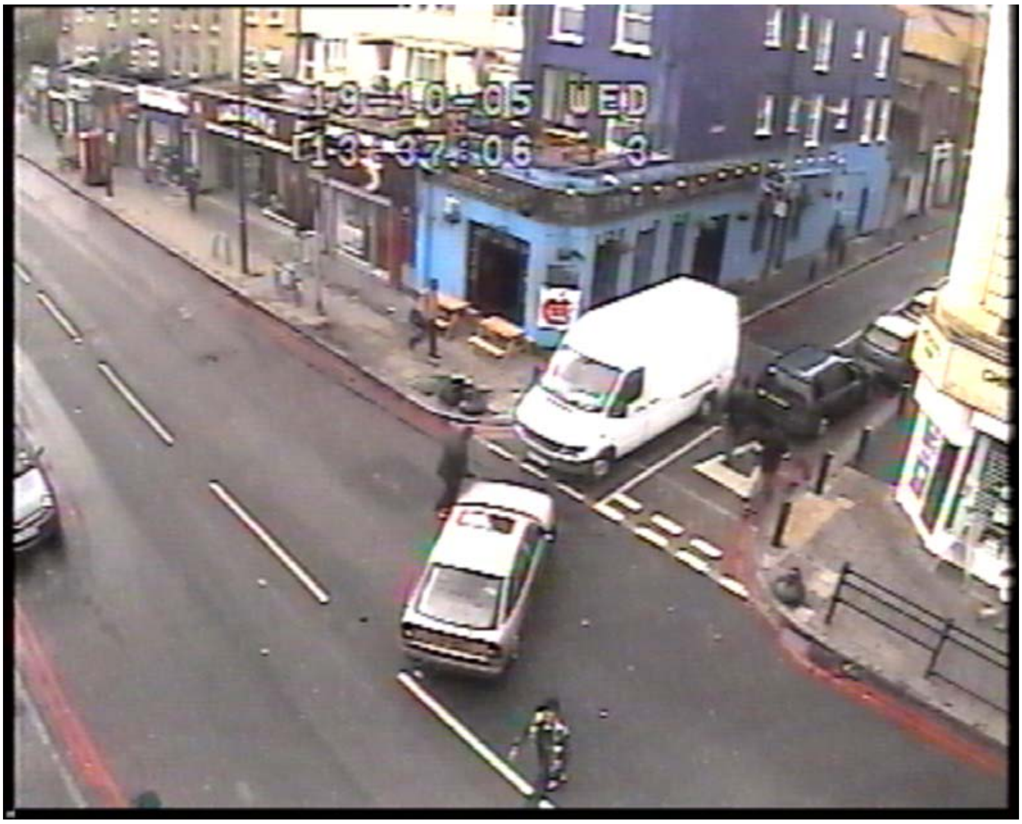


Figure C-2: Bentley Road

Figure C-3: Britannia Road

Figure C-4: Selkirk Road

Figure C-5: Clapham Road