The Manual for Streets: evidence and research

Prepared for Traffic Management Division, Department for Transport

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Executive Summary

Demand for the Manual for Streets emerged from the Government research report Better Streets, Better Places (ODPM, 2003), which was commissioned to establish whether there are any problems over the adoption of new highways meeting the requirements of Planning Policy Guidance Note 3, Housing (PPG3). This document focused on new residential streets and identified highway standards as a barrier to placemaking in the UK. The report concluded with a recommendation for development of a Manual for Streets to replace Design Bulletin 32 (DB32) with an updated set of design guidelines for local roads to provide a catalyst for innovative design that emphasises place over movement.

The resulting Manual for Streets is a guide to the design, construction, adoption and maintenance of new streets whose aim is to deliver streets that help strengthen communities, are pleasant and attractive, are cost-effective to construct and maintain, and are safe. The Manual for Streets has updated geometric guidelines for low trafficked residential streets, examined the effect of the environment on road user behaviour, and drawn on practice in other countries.

This research undertaken by TRL provides the evidence base upon which the revised geometric guidelines in the Manual for Streets are based, including:

- Link widths.
- Forward visibility.
- Visibility splays.
- Junction spacing.

In order to obtain primary data for examining the relationships between geometry, the environment, speed, and casualties, twenty survey sites were selected throughout the UK comprising a mixture of new build, Commission for Architecture and the Built Environment (CABE) good practice, DB32 compliant and historic (pre-war) street layouts, to produce a wide range of development type to ensure the results were applicable to many developments within the UK. Methods adopted to collect data included measurement of X- and Y-distances at junctions, visibility on links, road width, manual and automated speed data readings and observations on parking, signing, lining, and traffic calming. 190 links and 77 junctions were included in the research.

The headline findings from the site surveys can be summarised as follows:

- Lower vehicle speeds are associated with reduced road width and reduced visibility, both on links and at junctions.
- Site type (for example historic, new build, DB32 compliant etc) is not a significant determinant of speed. Junction and link geometries are the important variables.
- Speed is known to be a key factor for road safety. The findings of this research are consistent with this fact, indicating that higher speeds on links increase the likelihood of injury and its severity.
- Conflicting movements at junctions result in a higher number of accidents, but geometry can lower speeds which reduce both the likelihood and severity of accidents.
- Stopping distances on links and at junctions have a margin of safety down to a visibility of around 20 m in the environments studied, unless other speed reduction features are incorporated.
- The sites included roads with a range of surface types, varying use of speed restriction measures, different levels of on-street parking and a range of forward visibilities. The results are consequently applicable to a wide range of developments throughout the UK.
- Parking was found to reduce speeds on links and at junctions by 2 to 5 mph. That is, drivers react to the perceived danger by reducing their speed. The effect of this on safety is unclear. Reducing speed increases relative safety, but parked vehicles reduce lines of sight and can consequently obscure (crossing) pedestrians. There was no clear indication that this resulted in higher numbers of casualties from the accident statistics analysis. However, many of the reported accidents from the household survey were related to parked vehicles.
- The largest effect on speeds was found to be associated with reducing lines of sight. A reduction from 120 to 20 metres reduced approach speeds by approximately 20 mph on links and 11 mph at junctions. Modelling has shown the reduction in approach speed should result in sight distances of 40 metres being safe, i.e. there is an acceptable safety margin to stop should a danger present itself. However, the margin of safety becomes rapidly smaller below 40 metres.

In addition, a household survey was undertaken to obtain the residents' opinions of their streets at the twenty case study sites. This was to determine 'user satisfaction' of a variety of residential street layouts, and to consider residents' transport needs alongside their perceptions of safety and sustainability of their streets. Three hundred household questionnaires were returned for analysis to explore the relationship between resident perceptions of road safety and highway geometries.

With respect to the perceptions of residents surveyed, the following can be concluded:

- Across the sites there were mixed reactions to whether personal, or road, safety issues were of most concern. Residents at DB32 compliant sites considered personal safety (in relation to crime) to be of the greatest concern, but this was not the case at other sites. It is unclear whether this was owing to higher crime rates at the DB32 sites, the perception of road safety at other sites, or a combination of both these factors. However, overall nearly half the respondents considered road safety to be the main issue, compared with nearly 30% who considered personal safety to be the highest concern.

These results have been integrated into the Manual for Streets in the form of appropriate standards for residential street design, and will become the focus for Government guidance on new residential streets.

Acronyms

ATC	Automatic Traffic Count
CABE	Commission for Architecture and the Built Environment
CAD	Computer Aided Design
DB32	Design Bulletin 32
DCLG	Department for Communities and Local Government
DEFRA	Department for the Environment, Food and Rural Affairs
DETR	Department for the Environment, Transport and the Regions
DfT	Department for Transport
DPH	Dwellings per hectare
HA	Hectare
MfS	Manual for streets
MPH	Miles per hour
ODPM	Office of the Deputy Prime Minister
PPG	Planning Policy Guidance
SafeNet	Software for Accident Frequency Estimation for Networks

1 Introduction

The Manual for Streets (MfS) is intended to consolidate the necessary components for effective street design into a single source of information. The MfS builds upon and updates the guidance contained in Design Bulletin 32 (DB32) and its companion guide 'Places Streets and Movement: A Companion Guide To Design Bulletin 32, Residential Roads and Footpaths'. Its aim is to provide guidance for practitioners who will shape the developments of the future. It is therefore intended for:

- Developers.
- Local highway authorities.
- Local planning authorities.
- The emergency services.
- Utility and drainage companies.
- Access officers.
- Public transport providers.
- Architects.
- Highway engineers.
- Landscape architects.
- Town planners.
- Transport planners.
- Urban designers.

1.1 Manual for Streets

The Manual for Streets has been designed to recognise the full range of design criteria necessary for the delivery of multi-functional streets, assisting practitioners in making informed decisions relating to appropriate street design. The Manual will initially cover the design considerations for residential streets and other lightly trafficked local roads.

The Manual deals with underlying values that can be creatively deployed by practitioners in order to pursue the Government's 'placemaking' agenda of individually distinctive localities, while ensuring streets remain functional and safe. The Manual for Streets was prepared against a backdrop of sustainable development guidance and initiatives, including the Department for Communities and Local Government's Communities Plan 'Sustainable Communities: Building for the Future' (ODPM, 2003b) to ensure that it facilitates the long-term sustainability of streets, and contributes to an enhanced sense of place.

The Manual for Streets supports the objectives of the Government's commitment to sustainable development as expressed in 'A Better Quality of Life: A Strategy for Sustainable Development in the United Kingdom' (DETR, 1999) and in the latest document on delivering the UK's sustainable development strategy 'Securing the Regions' Futures: Strengthening Delivery of Sustainable Development in the English Regions' (DEFRA, 2006). This will ensure that residential streets meet the needs of all street users, not just motorised vehicles.

1.2 Design Bulletin 32

The document DB32 was used to assist in designing new housing developments. It was created to remove the restrictive criteria imposed in the post-war period that resulted in a high degree of conformity between estates within the UK. Its purpose was to permit a more flexible approach to design that enabled developments to be better tailored to the requirements of residents, for example Home Zones in which a variety of techniques (speed reductions and surface treatments) are used to create a greater impression of shared space.

However, a number of requirements are included to ensure safety of pedestrians and road users within the estate. These include minimum sight distances in order that vehicles travelling at a design speed are able to react to a danger and safely stop. The sight distances are specified for an observer's eye being between 1.05 and 2 metres above ground level and in the case of a junction, the car being 4.5 metres from the stop line. The required visibility distances are summarised in Table 1.1, and Figure 1.1.

Table 1.1 DB32 visibility (Y) distances for different design speeds

Speed (mph)	5	10	15	20	25	30
Speed (kph)	8	16	24	32	40	48
Distance (metres)	6	14	23	33	45	60

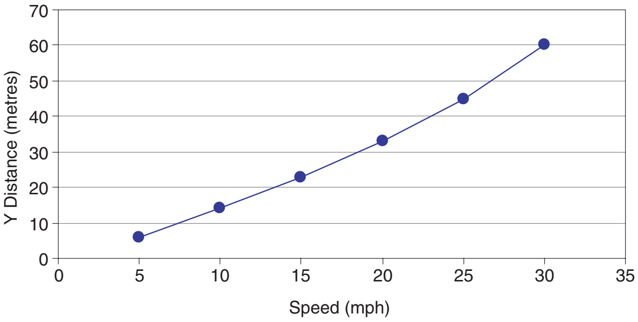

Figure 1.1 DB32 visibility (Y) distances for different design speeds

However, according to 'Places Streets and Movement: A Companion Guide To Design Bulletin 32, Residential Roads and Footpaths' these should be extended to 45 m in a 20 mph zone and 90 m in a 30 mph zone to allow for drivers exceeding the speed limit by up to 10 kph (Table 1.2). Also the Y-distance should be measured for vehicles at the following distances from the stop line on the minor arm of the junction:

- 9.0 m: The normal requirement for major new junctions and for the improvement of existing junctions between access roads and district or local distributor roads - for instances where the minor road is busy.
- 4.5 m: For less busy minor roads and busy private access points.
- 2.4 m: The minimum necessary for junctions within development to enable a driver who has stopped at a junction to see down the major road without encroaching onto it.
- 2.0 m: For single dwellings or small groups of up to half a dozen dwellings or thereabouts.

Table 1.2 Companion guide Y-distances

Speed (mph)	20	30	40	50	60	70
Speed (kph)	32	48	64	80	97	113
Distance (metres) allowing speeding	45	90	120	160	215	295
Distance (metres)	33	60	120	160	215	295

Consequently, consider a residential area with a 30 mph limit. A driver on a minor road approaching a junction should be able to see vehicles at a distance of 60 to 90 metres from the junction on the major road depending on whether the drivers on the major road remain within the speed limit. Further, they should have this field of view for a distance of 4.5 metres before the junction if showing caution, or 2.4 metres if they are stopping at the junction.

These calculations assume a design speed and the standard stopping model of a driver when presented with a danger: i.e. permitting a reaction time and then assuming the driver will apply a constant braking force. However, the situation can be considered from the opposite direction.

If sight lines are reduced below the recommendation in these guidelines, do drivers react to the lack of visibility? Suppose drivers reduce their speed when encountering reduced lines of sight and therefore increased risk. This could, in effect, result in the housing development being as safe as one with greater lines of sight and promote lower speeds. That is, the reduction in speed could still permit them to stop the same distance before a hazard even though they see it when it is closer to them.

1.3 Underlying research

TRL has performed research into identifying and investigating design elements whose impact was not fully understood, and in particular those not previously based on rigorous research. The study initially performed a literature review of local authority design guides: 32 were included. These indicated designs were constrained by the following critical aspects of highway geometry:

- Link widths.
- Forward visibility.
- Visibility splays.
- Junction spacing.

Little robust research supporting the DB32 standards was found in the review. Furthermore, the identified research did not explore detailed design elements, such as geometric dimensions.

The review revealed the majority of the local authorities complied with, and recommended, the same standards as DB32. Where standards differed, they were generally more stringent than those in DB32. As expected, road safety was the most significant barrier to the adoption of standards with relaxed values of width and visibility.

This research therefore aimed to assist in setting the design standards for MfS and to inform its development with respect to road widths, visual splays, parking, and removal of road markings. In particular, it aimed to:

- Examins the relationship between driver behaviour and highway geometry.
- Establish the safety of roads which do not meet DB32 standards in terms of casualty numbers, driver behaviour and resident perceptions.
- Investigate highway layouts to determine whether more permeable layouts are associated with higher levels of casualties than spine and cul-de-sac layouts.

Three strands of research were included:

1. The first consisted of observations, conducted at twenty residential developments, to examine links and junctions that were either at, or below, the limits specified in DB32.

   Observations included detailed information on the geometry and layout of each link and junction, observations of speed and obtaining accident statistics. Statistical analysis and predictive models based upon these observations indicated whether relaxed geometric and visibility values could be incorporated into the MfS. The features also varied in relation to:

   - Road width.
   - Whether speed humps were present.
   - Whether parking was permitted.
   - Whether lines were present to indicate priorities e.g. give way line.
   - The type of road surfacing used.

2. A household postal survey was conducted at the same twenty sites. This explored residents' opinions on a number of aspects of their living environment. However, the emphasis of the questionnaire was to consider whether they had any perceived safety or personal security concerns. A comparison across the sites could therefore investigate if junction and road geometries that do not meet DB32 standards are perceived by residents to be as safe as those that conformed to the standards.
3. Lastly, SafeNet, which can model a road network and consider the effect of changes on safety, was used to study the effect of junction spacing on casualty rates, and the effect of changing the characteristics of a residential area from a cul-de-sac approach to a more connected layout.

Within this report the following terminology is used:

- A *site* is a housing development that has been surveyed in this study.
- A *feature* is defined as being either a link or junction within the site.

1.4 Report structure

Section 2 discusses the research methodology used, including a rationale for selecting the research study sites and the variety of methods used to collect and analyse the field data.

Section 3 provides a literature review and gap analysis that supports the development of the primary research methodology.

Section 4 discusses the site surveys conducted, including a description of the different sites and the results and analysis of the surveys, particularly with regard to visibility on links and at junctions in relation to traffic speed and accident risk.

Section 5 describes the models used to consider whether any observed speed reductions are sufficient for a link or junction with limited visibility to be safe.

Section 6 considers the predicted effect of limited visibility on speeds, and models a number of situations to ascertain whether the speed reductions compensate for the lack of visibility.

Section 7 analyses road accidents statistics (STATS19 data) for the research sites and the relationship between speed and geometries on accidents.[1]

Sections 8 and 9 give an overview of results from the household survey intended to assess residents' opinions of the streets where they live and to identify particular issues that residents have about the design and layout of their street and built environment.

Section 10 presents the results and analysis of the junction spacing research using the Software for Accident Frequency Estimation for Networks (SafeNet) to compare hypothetical networks based on DB32 compliant and 'organic' street layouts.

Section 11 concludes with an overall summary of the research and a discussion about the proposed standards that will be included in the Manual for Streets.

The report concludes with a summary of results from the research, and how this affects the standards for residential street design, to be revised for the MfS.

2 Review of existing literature

A literature review (see Appendix A) was performed as an initial element of this research to collect together information relevant to the Manual for Streets. Its purpose was to perform a gap analysis. That is, to ascertain where research could underpin the DB32 standards so they could be directly included in the Manual for Streets, and to identify elements within the current guidance based upon limited research (either needing validating or further research). Reports and articles on the following subjects were sought:

- Policy, legal and technical frameworks.
- Objectives for streets.
- Sustainable communities.
- Quality places.
- Movement.
- Access.
- Parking.
- Materials, street furniture and planting.
- Lighting.
- Services and drainage works.
- Maintenance and management.

The literature evidence relating to each element is then listed, so that it may be cross-referenced to Appendix A. This gap analysis is shown in Table 2.1.

The review found few references concerned with the effect of geometric dimensions within the contexts required. However, references were located on the theoretical aspects of creating 'liveable' streets. The majority of elements were assessed as partially covered by current knowledge but needing validation before being used.

One element covered within a number of research reports was road or carriageway width. However, further research was necessary to determine suitable carriageway widths within residential areas: i.e. those promoting low traffic speeds, create a safe environment and ensure adequate access.

Traffic calming measures also have adequate coverage within the literature, again with the objective of slowing speeds and creating safer places. Whilst the majority of the robust evidence is concerned with physical traffic calming measures (humps, pinch points etc), there is recent research examining psychological traffic calming measures. These measures use the surroundings to influence driver behaviour (e.g. width of road, coloured surfaces, location and height of buildings close to the carriageway edge). However, this research was primarily conducted in rural areas and hence its applicability to residential areas requires further research.

There are a number of publications on Home Zones, or the Dutch 'Woonerven'. Research studies have also been undertaken focusing on traffic volumes, accident levels before and after implementation and the views of residents. However, there are some research gaps within the area of Home Zones, such as the inclusion of disabled people (research has recently been commissioned on this topic) and robust research focusing on the safety implications of Home Zones (as only limited 'after' data was analysed) and associated social impacts of schemes.

Parking research was fairly extensive, but not considered robust. Generally, research suggests parking should be incorporated within the design of residential streets as it can act as a traffic calming measure. However, its inclusion in residential streets should not create danger for playing children or crossing residents, especially parking at junctions, which may obstruct the vision of drivers.

Overall the research review highlighted a lack of robust research supporting DB32 standards and the information to be incorporated in the Manual for Streets. Where research has been undertaken, detailed design elements, such as geometric dimensions, have been neglected. Consequently, the following design aspects were investigated further:

- *Road widths* – which widths result in low speeds whilst maintaining safety, access and ease of traffic flow?
- *Visual splays* – which sight lines result in preferred driver behaviours, whilst maintaining safety?

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[1] *In this report, accidents are used to denote personal injury incidents.*

Table 2.1 Gap analysis of research literature

	Supported			
Chapter content specifications	*Fully*	*Partially*	*Not*	*Evidence source (see Appendix A for full details)*
Street networks and types				
Hierarchies of traffic and place functions			✓	
Travel demand by mode			✓	
Grids vs cul-de-sac			✓	
Block dimensions – find / course grain			✓	
Achieving appropriate speeds through network / environmental effects	See ‘Achieving appropriate speeds’ below			
Public transport, walk and cycle networks			✓	
Integration / segregation of cars / cycles / people			✓	
Guard railing			✓	English partnerships and Llewellyn Davis (2002)
Mixed use streets			✓	
Shared space			✓	
Shared surfaces		✓		Polus and Craus (1996)
Home Zones		✓		Barrel and Whitehouse (2004); Tilly *et al.* (2005); Layfield *et al.* (2005); Webster *et al.* (2005)
Rural lanes / Quiet lanes		✓		DfT (2004); Kennedy *et al.* (2004a and b)
Street dimensions				
Design vehicles – dimensions, dynamic envelopes			✓	
Widths – carriageways, cycleways, footways shared areas		✓		Burrow (1977) Daisa & Peers (1997); Gibbard *et al.* (2004); Oxley (2002); Lawton *et al.* (2003)
Capacity for vehicle movement			✓	
Street in cross-section – kerb height / crossfalls			✓	
Absence of centre-line markings		✓		Countryside Agency (2005)
Where streets meet				
Place importance of junctions / squares			✓	
Visibility splays			✓	
Unmarked junctions			✓	
Junction spacing			✓	
X junctions		✓		
T junctions		✓		
Roundabouts		✓		Lawton *et al.* (2003)
Signals			✓	
Informal squares			✓	
Footway crossings			✓	
Pedestrian crossings- signal / zebra / refuge / courtesy			✓	

Continued ....

Table 2.1 ***(Continued)*** **Gap analysis of research literature**

	Supported			
Chapter content specifications	*Fully*	*Partially*	*Not*	*Evidence source (see Appendix A for full details)*
Street alignments				
Gradients			✓	
Curve radii, horizontal and vertical			✓	
Forward visibility			✓	Kennedy *et al.* (1998); Layfield *et al.* (1996); Summersgill and Layfield (1996); Taylor *et al.* (1996)
Achieving appropriate speeds				
Ideally through network (and natural traffic calming)		✓		Scottish Executive (1999); Grayling *et al.* (2002); Vis *et al.* (1990) Kennedy *et al.* (2005); Hardy (2004); Elliott *et al.* (2003)
Traffic calming as fallback		✓		Engel and Thomsen (1992)
Integration of TC with environment			✓	
Access				
Access requirements to buildings – people and vehicles			✓	
Emergency access. References to building regulations			✓	
Servicing: refuse collection, deliveries, removals			✓	
DDA/disabled requirements – into buildings, along streets		✓		Oxley (2002)
Need to balance the perceived conflict between accessibility and crime – permeability versus security			✓	ODPM (2004)
Parking				
Layouts / design of on/off street parking		✓		Noble and Jenks (1996); TRL (1992); Noble *et al.* (1987); Westdijk (2001); Scottish Executive (2005)
Relationship with capacity and safety			✓	
Motorcycle / cycle parking			✓	

- *Parking* – How can parking be best incorporated into residential design? Can it be successfully used as a traffic calming measure? What are the impacts on safety? Can the quality of the area be retained?
- *Removal of road markings* – What effect does the removal of road markings have on driver behaviour?

3 Site selection and measurement

3.1 Site selection

Twenty survey sites were selected throughout the UK; ten of the sites were 'case study' and 'new build' areas selected by CABE. The remaining 10 sites were a mix of historic (pre-War), DB32 compliant and new build sites selected to produce a wide range of development type to ensure the results were applicable to many developments within the UK. The full list of sites is shown in Table 3.1, and their distribution within the UK is shown in Figure 3.1 (see Appendix B for a summary of each study site).

The sites were initially evaluated from CAD drawings and then assessed in detail during a site visit.

3.2 CAD measurements

Detailed site characteristics were measured from site plans: technical drawings of the selected sites depicting all structures in the area. Using AutoCAD it was possible to take accurate measurements of sight lines, as the drawings were detailed, accurate and all obscuring features were recorded (see Figure 3.2).

The X-distance was set at 2.4, 4.5 and 9 m from the junction measured down the centre line of the road, in

Table 3.1 Research study sites

Characteristic	*Town*	*Ward*	*Region*	*Rural / urban*	*Housing period*	*Land use*	*Density*	*Network type*
Historic (pre-war)	Reading	New Town	South East	Urban	Victorian	Mixed	High	Grid
	Lavenham	Suffolk	South East	Rural	Medieval	Residential	Low	Organic
	Oxford	Jericho	South East	Urban	Victorian	Residential	High	Grid
	Bloxham Village	Oxfordshire	South East	Rural	Victorian	Residential	Low	Organic
	Chichester	West Sussex	South East	Urban	Medieval	Mixed	High	Organic
	London	Belgravia	South East	Urban	Victorian	Mixed	High	Grid
Case study	Charlton Down	West Dorset	South West	Rural	Post 90s	Residential	High	Organic
	Lichfield	Darwin Park	West Midlands	Urban	Post 90s	Residential	High	Organic
	Eastleigh	Former Pirelli site	South East	Urban	Post 90s	Residential	High	Atypical grid
	Newhall	East Harlow	East of England	Suburban	Post 90z	Residential	High	Organic
	Guildford	Queen's Park	South East	Urban	Post 90s	Residential	Mid	Organic
	London	Tower Hamlets	South East	Urban	Post 90s	Residential	High	Grid
	Glasgow	Crown St.	Scotland	Urban	Post 90s	Residential	High	Organic
	Chelmsford	Windley Tye	East of England	Suburban	Post 90s	Residential	Low	Court layout
	Chelmsford	Beaulieu Park	East of England	Urban	Post 90s	Residential	Low	Grid
	Manchester	Hulme	North West	Urban	1990s	Residential	Low	Grid
New build	Ipswich	Rapier St.	South East	Suburban	Post 90s	Residential	High	Atypical grid
	Portishead	Port Marine	South West	Suburban	Post 90s	Residential	Mid	Organic
DB32 Compliant	Leicester	Syston	East Midlands	Urban	1980>	Residential	Mid	Cul-de-sac with spine
	Reading	Lower Earley	South East	Urban	1980>	Residential	Mid	Cul-de-sac with spine

Figure 3.1 Distribution of sites

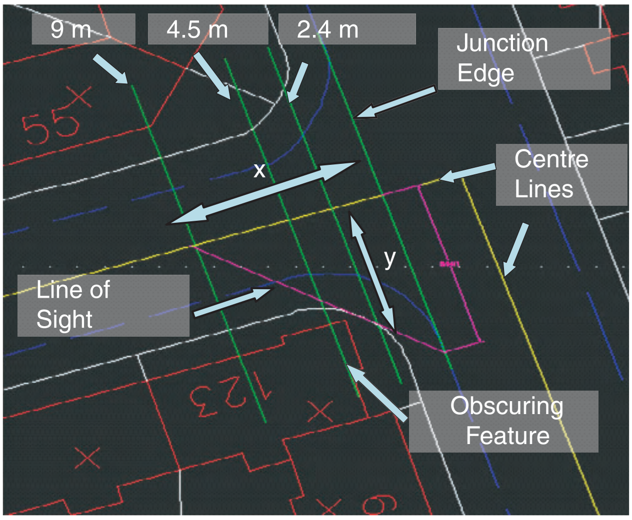


Figure 3.2 Y-distance at junctions

accordance with generally accepted practice. From these three distances the line of sight (Y-distance) is measured left and right looking out of the junction. The Y-distance is the furthest point of visibility on the kerb (the blue line), taking into account any obscuring features, and is measured from the centre line of the side road.

Lines of sight on links were measured using a similar method. The driver's (direct) sight line was used to find the shortest distance ahead of the vehicle that is visible when on the link. In addition, the width of the road, both with and without footways, was also measured from the CAD drawings.

This information gave a first indication of the range of geometries available across the chosen sites. However, this could not take account of all complications on site. Therefore this information was validated and enhanced by site surveys.

3.3 Site surveys

All site surveys were conducted from January to March 2006. Each survey comprised measurements of speed, road geometry and visibility, at a minimum of 10 junctions and 2 links within the site, and speed readings at a minimum of 5 junctions and 2 links. The purpose of the surveys was to validate the measurements taken from the CAD drawings and obtain a sample of speeds from a wide range of junctions and links throughout the sites. The following procedures were undertaken at each junction and link:

Junction visibility (Y Distance)

1. The centre line of the main road was ascertained.
2. The three X values were measured and marked off using chalk on the road.
3. Y-distances were measured at a height of 1.2 m from each X chalk mark to the left and right.
4. Where parking was explicitly marked on the road, a second measurement, assuming a parked vehicle was present, was also recorded. Lines of sight also took into account cars parked on the road, as these were assumed to be the general conditions that drivers would encounter.
5. Any visible obstructions were noted down, these included buildings, brow of a hill, phone boxes, hedges, parked cars etc.

Link forward visibility

1. A pre-defined place in the road calculated to have minimum visibility from the CAD drawings was located.
2. All obstructions, including parking, were recorded.
3. Taking the obstructions into account the pre-defined point of minimum visibility was confirmed as correct, or adjusted and recorded.
4. The distance between the correct position and the furthest point of visibility was measured: along the road if considered safe, or along the kerb, and the road width was recorded.

Manual speed measurements (speed gun)

- Recorded vehicle speeds for 20 minutes at a sub-sample of links and junctions.

Sample sizes

Estimates from CAD drawings and measurements from site surveys resulted in geometric information being collected for:

- 190 junctions, and
- 77 links.

A speed gun was used to record individual vehicle approach speeds for approximately twenty minutes at a sub-sample of the surveyed features. Exact speeds (to the nearest mph) were recorded above 10 mph, however, manually collected speeds at, or below, 10 mph were classified into one category. These observations were collated into an analysable form for

- 57 junctions, and
- 23 links.

Also, automatic traffic counters (ATCs) were installed for one week on:

- 18 links.
- The approach to 10 junctions.

The speed gun survey provided a snapshot of the approach speeds of drivers across a wide range of different junctions and links, and therefore a wide range of geometries. In contrast, the ATC data was restricted to a smaller number of features, and therefore geometries, but gave a robust picture of the approach speeds used.

The purpose of the next section is to examine how the speeds varied across the features studied and identify the characteristics that influenced those speeds.

4 Speeds and geometry data site ranges

A general understanding of the effect of road layout, and the resulting visibilities, on drivers' speeds can only be achieved if a wide range of different site conditions are studied. The selected 20 sites were consequently chosen to be representative of developments throughout the country. In terms of the type of sites studied there were:

- 6 historic (pre-war) sites.
- 6 sites conforming to CABE good practice guidelines.
- 2 sites conforming to DB32 specifications.
- 6 other (case study) sites.

Road surfacing within the sites varied from tarmac (12 sites), through to a mixture of tarmac and block paving (3 sites) to wide-scale use of block paving (5 sites). Half the sites had no speed restricting measures present (e.g. road humps or horizontal deflections), whilst some form of speed restricting measures were present in the others. The extent of on-street parking also varied across the sites with 7 sites having no parking near to junctions in evidence during the site visits, whilst some vehicles parked close to the junctions at other sites. Also, parking on the links varied between no observed parked vehicles, to parking on one side of the road on some links and parking on both sides of the road on others.

Forward visibilities on links, and visibility at junctions (Y-distance), were estimated from plans of the developments and measured during the site visits. Often, the observed visibilities were less than those estimated before the site visit (using AutoCAD). This was owing to the presence of street furniture and other obstructions (for example planting) that limited visibility. This study is considering the effect of actual visibility on drivers' speeds, therefore the visibilities measured on site have been used in assessing driver adaptive behaviour. The observed ranges of road width, forward visibility on links and visibility at junctions are shown in Figures 4.1 to 4.3.

Road widths (excluding footways) generally varied from 4 to 10 metres across the studied sites. Visibilities on links, and at junctions, varied from below 10 metres to approximately 100 metres. The sites can therefore be considered to be representative of the majority of situations occurring within residential developments in the UK.

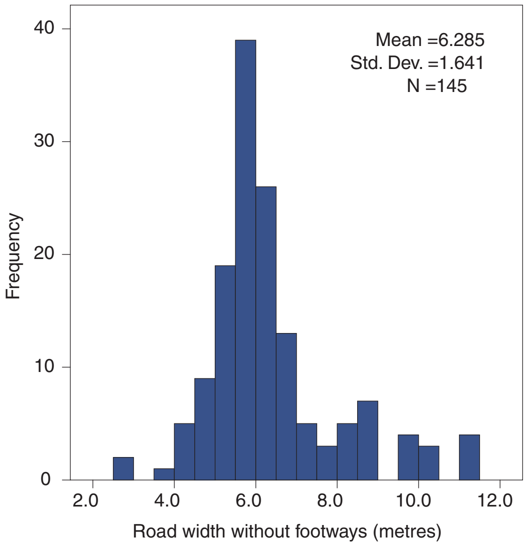


Figure 4.1 Range of observed road widths

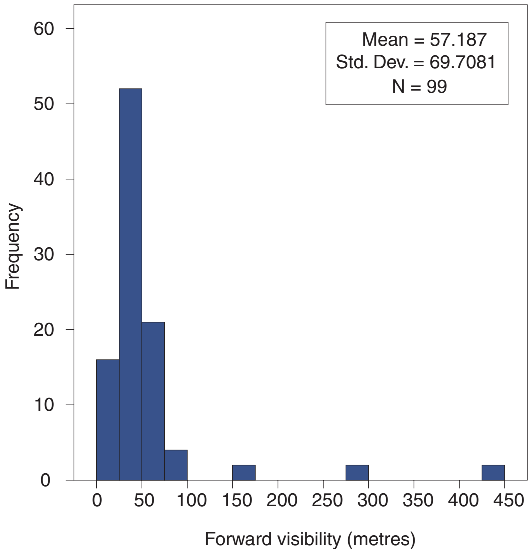


Figure 4.2 Range of observed link forward visibilities

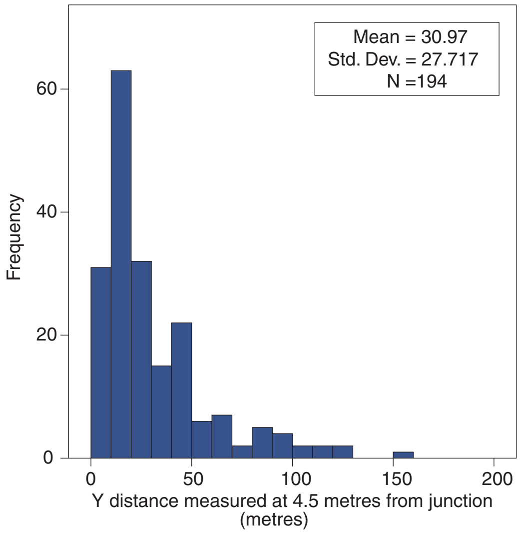


Figure 4.3 Range of observed junction visibilities

4.1 Outliers

Sites with abnormal characteristics can distort the findings of any statistical analysis. Such sites can produce observations that significantly differ from the trends present within, and across, other typical sites: such observations are referred to as outliers. These observations can therefore affect the statistical models fitted to the data, referred to as points of high influence.

The accepted approach in these situations is to exclude these abnormalities from the analysis and produce models that reflect the trends within the majority of situations. The previous section shows that nearly all the sites have road widths less than 10 metres (excluding footways) and lines of sight of less than 100 metres on links and at junctions. In addition, the average daily flows and average link speeds at each of the sites studied using ATCs are summarised in Table 4.1.

Observations from Belgravia were anomalous. The road width where the ATC was situated was 11.4 metres wide (excluding footways), and the average for all links surveyed in Belgravia was 10.5 metres. In addition, the

Table 4.1 Average flows and speeds

Site	*Average daily flow*	*Average speed (mph)*
Lower Earley	70.4	11.3
Guildford	481.9	18.2
New Town, Reading	242.6	14.4
Chichester	1372.8	19.4
Eastleigh	427.7	17.3
Belgravia	2029.5	25.7
Tower Hamlets	627.0	19.1
Ipswich	121.6	19.0
Lavenham	221.4	11.7
Newhall	482.9	15.6
Windley Tye	294.9	16.9
Beaulieu	83.8	10.2
Bloxham	112.3	12.5
Portishead	1161.1	15.8
Leicester	528.9	23.5
Manchester	1060.6	19.3
Lichfield	362.6	16.7
Glasgow	1575.4	10.3

forward visibility on the link where an ATC was installed was 446 metres and generally there was good visibility on the links throughout the Belgravia site. These conditions resulted in the highest average speed in any site. In addition, the daily vehicle flows were almost 30% higher than on any other site. Thus the Belgravia observations are generally excluded from the analysis performed. As a consequence, the results can be considered to be relevant for developments such as shown in Figure 4.4 with road widths up to 10 metres and visibilities on links (and at junctions) of up to 100 metres, and not for those with grid layouts such as Belgravia (see Figure 4.5) with wide roads and larger visibilities.

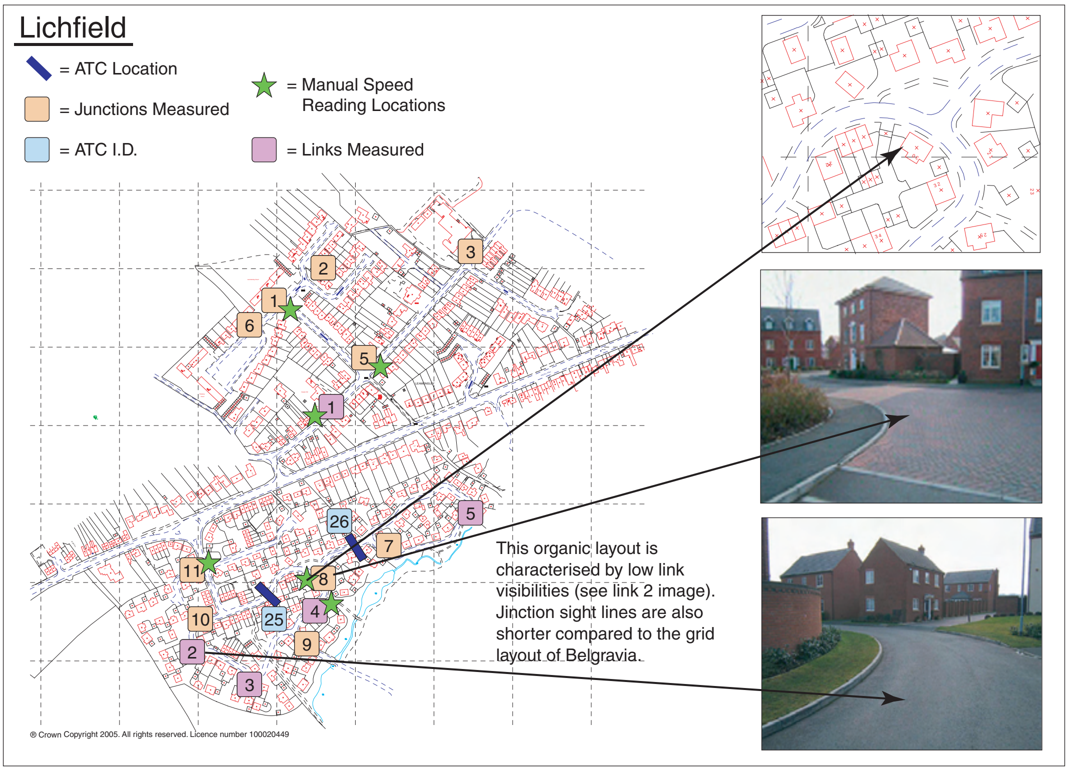
The site with the next highest average link speed was Leicester where the forward visibility was 65 metres, and the lowest average link speeds were at Beaulieu Park in Chelmsford, where the forward visibility was 10 metres. The following sections consider the effect of forward visibility on links (and visibility at junctions) and other relevant influencing factors on speed.

4.2 Variation within the data

Ranges in geometry, parking, signing and speed reduction methods present within the 20 studied sites have been explored. The sites (excluding Belgravia) provide a good variation in all these site dependent factors that may influence speeds. However, it is important to be able to ensure that these are the only factors affecting differences observed between the sites and features studied, in order that the results are not confounded by other differences. Other possible influences at a given feature include:

- Time of day, for example night driving.
- Day of week, weekend driving compared with weekday driving.
- Weather conditions.
- Age of driver.
- Driving style.
- Other vehicles present.

It is not possible to take account of all these factors within this type of analysis. However, the best consistency was sought between the manual speeds and loop speeds. All manual speeds were collected on weekdays in the daytime. Consequently, the speed loop analysis was also restricted to observations on a weekday between 0700 and 1900.



This organic layout is characterised by low link visibilities (see link 2 image). Jinction sight lines are also shorter compared to the grid layout of Belgravia.

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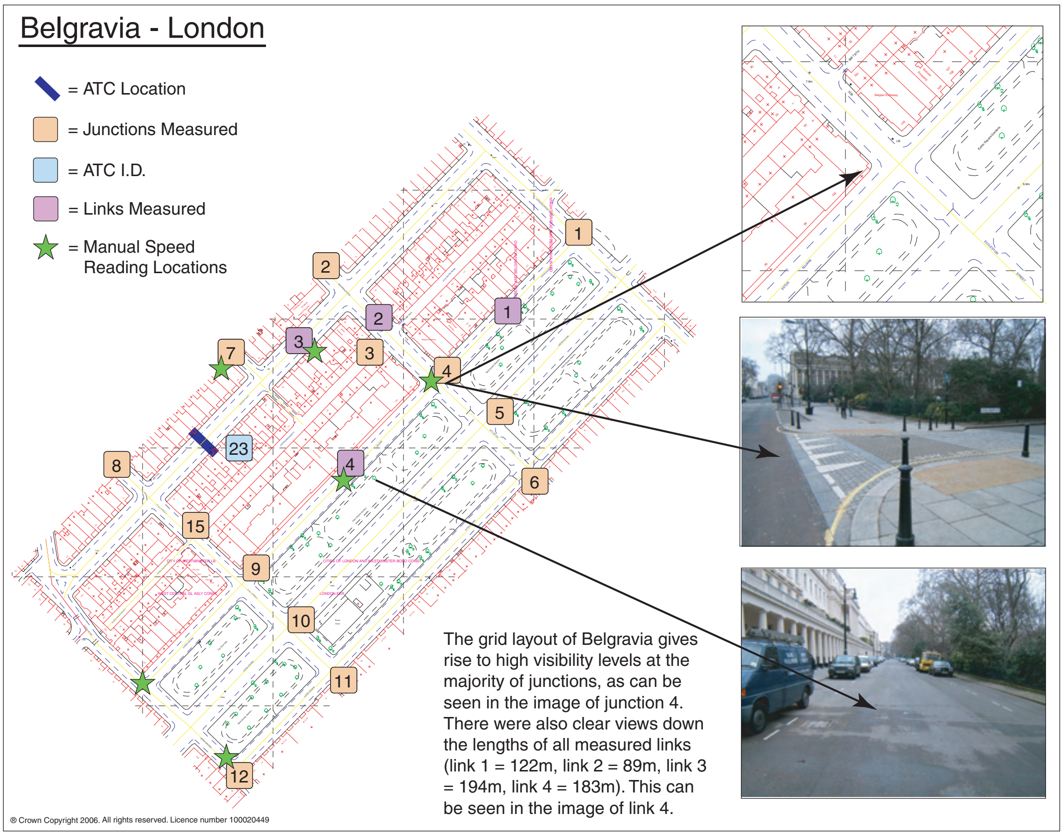
Figure 4.4 Lichfield – non-grid layout (limited visibilities)



The grid layout of Belgravia gives rise to high visibility levels at the majority of junctions, as can be seen in the image of junction 4. There were also clear views down the lengths of all measured links (link 1 = 122m, link 2 = 89m, link 3 = 194m, link 4 = 183m). This can be seen in the image of link 4.

Figure 4.5 Belgravia – grid layout (large visibilities)

It was also possible that differences could be influenced by the type of site. That is speeds could depend on the intrinsic design present within a historical site compared with one conforming to the DB32 standards: similar to the effect of the grid layout in Belgravia. If such variations were present the different type of sites would result in distinct data clusters. The resulting ATC link speeds according to the measured visibility are shown in Figure 4.6.

Observed speeds, and average speeds, on links within the sites increased with forward visibility. The type of site appeared to have no effect. Therefore, all sites and features within them were considered together and the effect of geometries, speed restriction measures and surface types explored across all non-anomalous data. Figure 4.7 shows the same link speeds according to forward visibility and the sites on which they were measured.

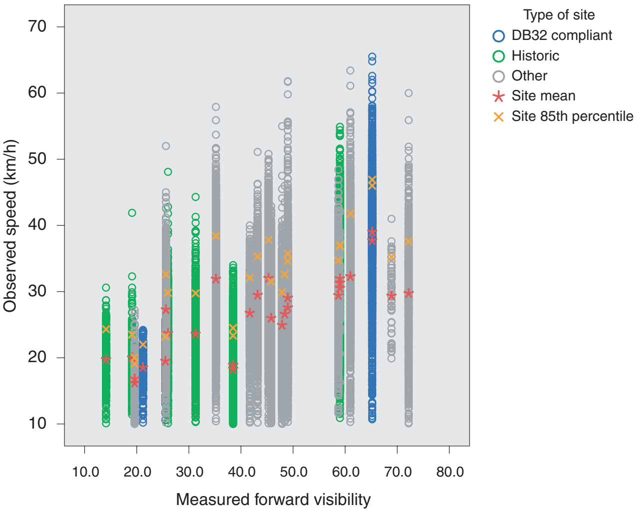


Figure 4.6 Speed ATC data for links (by site type)

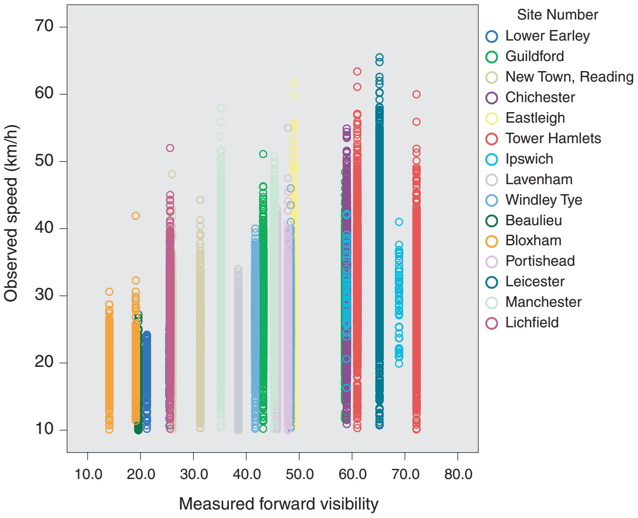


Figure 4.7 Speed ATC data for links

Even restricting observations to weekdays during the daytime, it is clear there was a large variation in speeds at each site and on any given link. The variation will have been affected by factors that cannot be accounted for within this study, for example, variations in driving style and individual circumstances occurring on the link.

Interestingly, some drivers were observed at approximately 10 mph at nearly all the sites though this could be owing to particular circumstances encountered by the drivers, for example, slowing to permit a vehicle through from the other direction.

Increasing variation with increases in an independent variable can be accounted for by transforming the dependent variable. However, even with this approach the size of the inherent variation at any one site and feature will ensure that the percentage of variation accounted for by a model will be low. The statistical models therefore investigated explanatory variables whose coefficient was significant, and hence captured a significant trend within the data, without placing any criteria on the overall model's fit, therefore the regression (R2) value could be low.

5 Speed adaptation

It is probable that drivers adapt their speed according to the perceived danger on the road. Initial investigation in the previous sections supports this as the observed average speed on a link decreased with forward visibility. The aim of the analysis was therefore to find significant trends in speeds explainable by the differences between the junction, and link, layouts.

Speed is an indicator of safety on a road. If the average speed is lower, then arguably the road is safer and less intimidating to vulnerable road users. There are two effects that make the road safer. Firstly, the stopping distance of vehicles is less and therefore the probability that a driver will be able to stop and avoid an accident is higher under the same conditions. Secondly, should an accident occur, its severity could be less owing to reduced impact speed.

Reductions occurring through non-geometric treatments (including the type of road surface, speed humps and signing) would be expected to increase safety compared with a similar road without the same measures. However, the situation is more complicated with respect to geometric differences where lines of sight are affected. On the one hand drivers may reduce their speeds owing to the perceived danger, but there is a potential increase in danger through drivers being unable to see hazards until they are closer to them. These two effects counteract each other. So, this research considers whether any observed speed reductions (through perceived danger) are sufficient for a link, or junction, with limited visibility to be as (actually) safe as one with good visibility.

5.1 Link speeds

Drivers within a development generally negotiate a number of links and junctions during their journey. They would be expected to have a highly variable drive cycle as they can be stationary at junctions, and possibly on links, to give way to other traffic. They would be expected to adapt their speed to perceived dangers such as parking and horizontal deflections that reduce their forward visibility. However, drivers will typically try to maintain the maximum speed to minimise their journey time.

Higher speeds, with greater variation, would be expected on links as vehicles would not be expected to show the same caution as at junctions. Therefore lines of sight are important on links because if lines of sight are reduced and speeds remain high, an unexpected occurrence such as a pedestrian stepping into the road, is more likely to result in a serious accident. For comparison the observed speeds on the approach to a junction and on a link in Tower Hamlets are shown in Figure 5.1.

Two (multi-linear) regression models were fitted to the available data. One to the manual speed data from 23 links and the other was fitted to the ATC data from 18 links. The forms of the regressions were:

$$\text{In}(speed) = a + b(road\ width) + c(forward\ visibility) + \\ d(parking) + e(surface\ type)$$

The natural logarithm of speed (km/h) was found to produce the best fit to the data. The results of the models are shown in Figures 5.2 and 5.3 respectively, and in Table 5.1.

The regressions explained only between 20 and 22% of the total variation in the data. However, all the variables were significantly different from zero at the 95% confidence level.

The models imply that either permitting parking on a link, or the use of block paving, can reduce link speeds by 2 to 5 mph which could improve safety, though there are clearly issues with pedestrians being obscured by parked

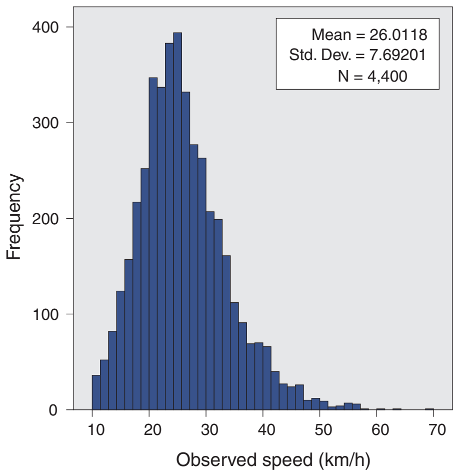


Figure 5.1a Junction speeds

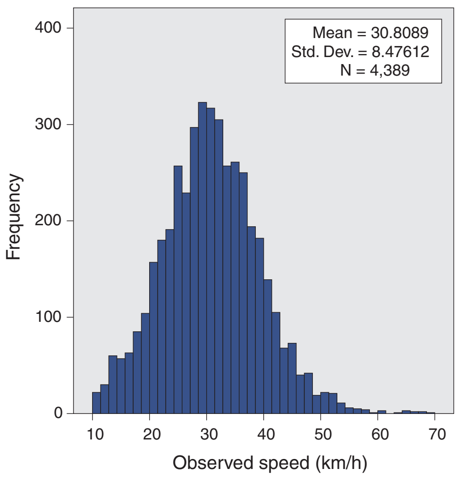


Figure 5.1b Link speeds

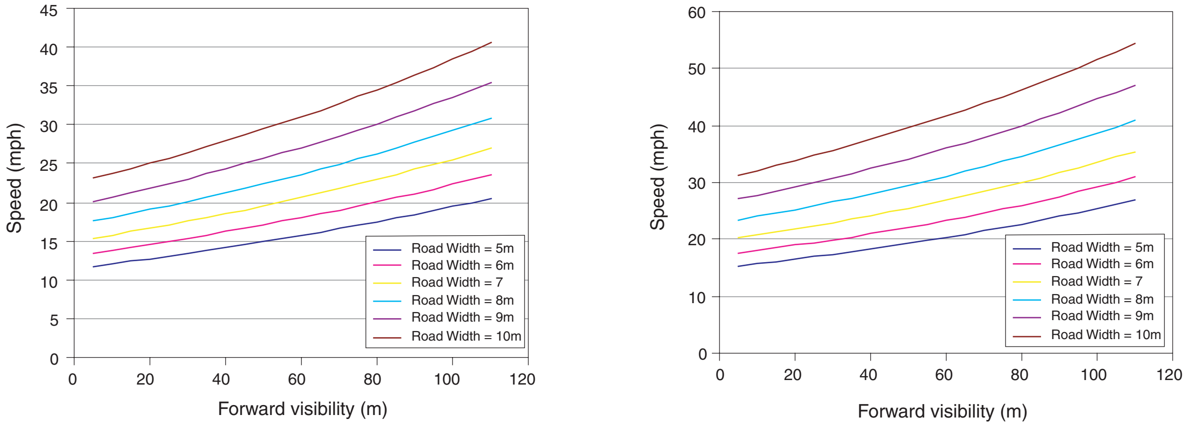


Figure 5.2 Link model – manual speeds with average site features

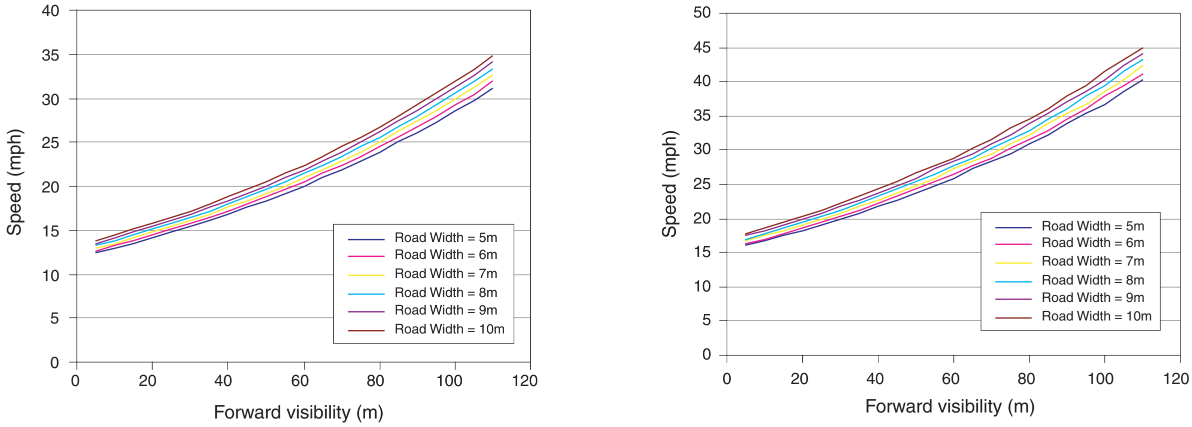


Figure 5.3 Link model – ATC speeds

Table 5.1 Predicted changes across roads with 5 metre widths and forward visibilities between 5 and 110 metres

	Decrease (mph)			
	No parking to parking on both sides of link		*Tarmac to block paving*	
Link model	*Minimum*	*Maximum*	*Minimum*	*Maximum*
Manual speeds with average site features	2.8	4.8	2.5	4.4
Loop speeds	1.5	3.5	1.3	3.2

vehicles. Similarly, reducing road width also has the effect of reducing vehicle speeds on the link. However, the two models disagree about the extent of the reduction. The manual speed data implies that a reduction from 10 to 5 metres could reduce the link speeds by between 9 to 20 mph, depending on the forward visibility on the link. In contrast, the ATC data implies the reduction is between 2 and 4 mph. It is the conservative estimate from the ATC data that is most likely to be accurate given that the model included nearly as many sites and also given that the average number of manual observations was 32 within any one site.

Both models agree that drivers do adapt their speed according to the forward visibility on the link. According to the model based on the ATC data an average driver reduces their speeds by approximately 20 mph if the forward visibility on the link is reduced from 110 to 20 metres.

5.2 Junction speeds

Approach speeds at junctions were generally found to be less than link speeds, as drivers slowed and showed caution on the approach in case they needed to give way to another driver with priority. The requirement to assess a number of factors during their approach seems to have both heightened awareness and also increased workload on the driver. Overall there appeared to be more accidents on the sites at junctions than on links: 110 accidents at 187 junctions compared with 21 accidents on 74 links. Hence reducing speeds and accidents at junctions is clearly important.

Information was available on the visibility (Y-distance) at each junction for a vehicle positioned at 2.4, 4.5 and 9 metres before the junction. Initial tests considered which visibility was the best predictor for the observed approach speeds. This model indicated that a visibility of 4.5 metres should be used within the regression modelling.

Regression models were formed on both the manually collected speed data and on the ATC data. In addition, whilst the ATC data recorded the speeds of all approaching vehicles, the manual data also classified the vehicles as to whether they turned at the junction. Therefore a separate model was also formed for all vehicles that did not turn at the junction for this data set. A summary of the models is shown in Figures 5.4 to 5.6 and Table 5.2.

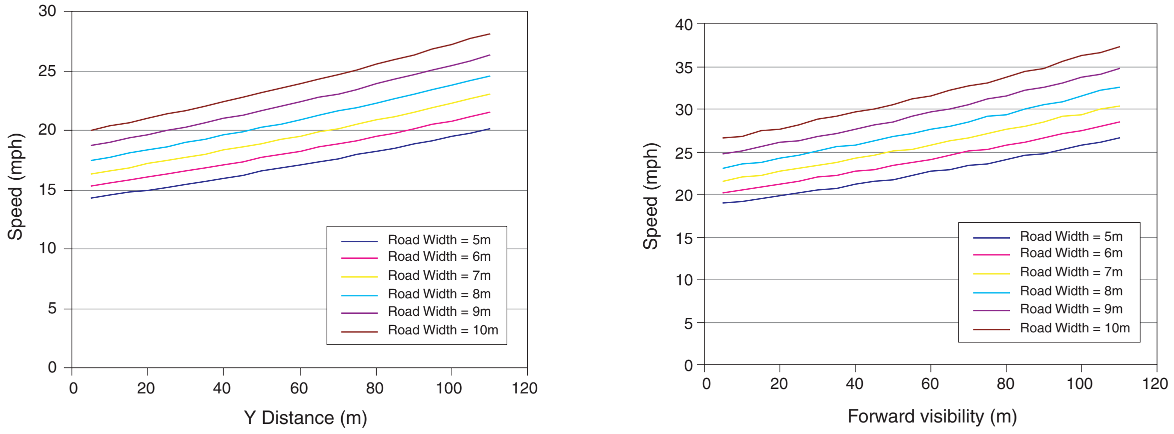


Figure 5.4 Junction model – manual speeds with average site features (all vehicles)

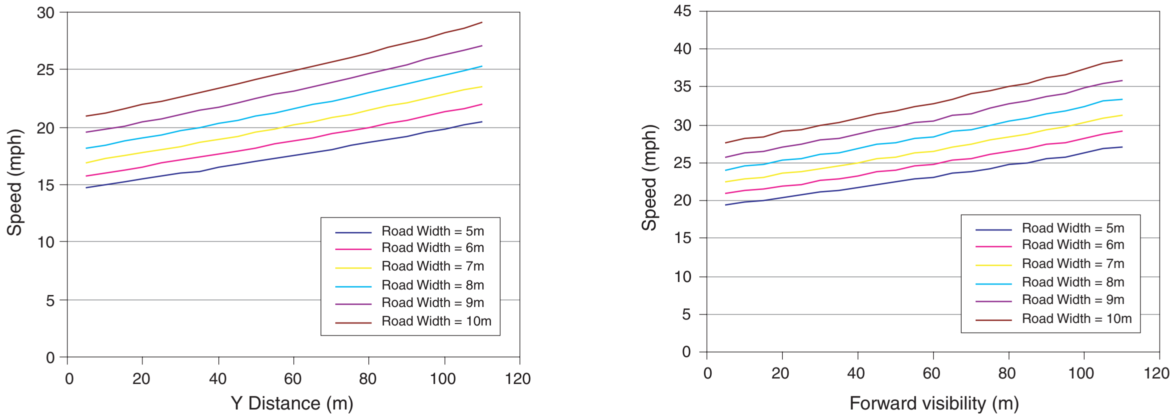


Figure 5.5 Junction model – manual speeds with average site features (non-turners only)

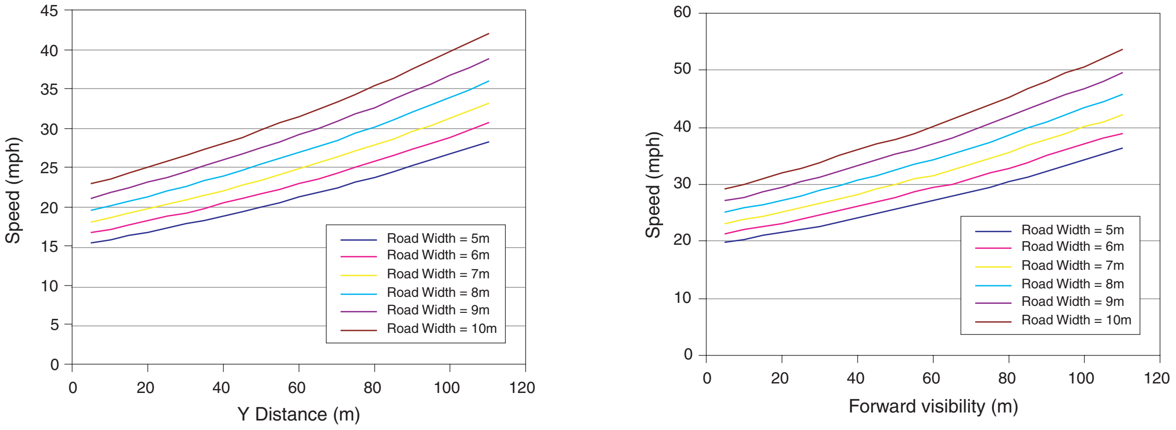


Figure 5.6 Junction model – ATC speeds

Table 5.2 Predicted changes across roads with 5 metre widths and Y-distances between 5 and 110 metres

	Decrease (mph)					
	No parking to parking near junction		*Tarmac to block paving*		*No junction markings to junction markings*	
Junction model	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
Manual speeds with average site features	1.5	2.1	3.7	5.2	-1.1	-0.8
Manual speeds with average site features (non-turners only)	1.8	2.5	3.9	5.5	-1.0	-0.7
ATC speeds	3.5	6.4	2.9	5.4	3.2	5.9

Parking and block paving were found to reduce vehicle speeds by approximately 2 to 5 mph, though there is an indication from the ATC data that parking near junctions could have a slightly stronger effect on speeds than parking on a link. The models disagree as to the effect of junction markings. The manual data implies that without junction markings, speeds were slightly greater. However, the ATC data indicates drivers reduced their speeds by between 3 and 6 mph when markings were absent.

The models agree on the order of magnitude of speed reductions through width reductions. For example at a junction with Y-distance at 4.5 metres of 40 metres, a reduction of road width from 10 to 5 metres would be expected to reduce approach speeds by between 6 and 9 mph.

Both models also agree that drivers reduced their approach speed if the visibility at the junction (Y-distance) was less. The manual data predicts a reduction of approximately 5 mph if the Y-distance is reduced from 110 to 20 metres at a junction where the road width is 5 metres. However, the ATC data considers that drivers are more sensitive to a lack of visibility. Under the same conditions the resulting model predicts that drivers would reduce their speed by 11 mph.

6 Modelled safety impacts

Drivers have been shown to alter their speed according to the conditions on the road. Reductions through the type of road surface and speed reduction measures (for example speed humps) almost certainly improve safety at a site. However, the implication of reduced speeds owing to reductions in forward visibility on links and visibility at junctions is less clear. The reduced speed results in a smaller stopping distance requirement, but less distance will generally be available for stopping when a hazard becomes visible. So, it is a question of whether drivers slow enough to make the junctions and links with limited visibility as safe as those with greater visibility.

This section considers the predicted effect of limited visibility on speeds, and models a number of critical situations to ascertain whether the speed reductions compensate for the lack of visibility. The average speeds predicted by the regression models formed on the ATC data are assumed within this modelling as they are based upon the largest data set, and the predictions are in approximate agreement with those formed on the manually collected data.

6.1 Braking modelling

It is possible to model relative safety of the schemes by considering the ability of the drivers to stop under different conditions. In order to create these braking models the following has been assumed (see Appendix C):

- The average perception-reaction time of a driver is 1.4 seconds when stopping in response to a hazard. This is a conservative estimate for the average driver, for example Olson (1997) reviewed 27 driver perception-reaction time studies and concludes ‘a great deal of data suggest that most drivers (i.e. about 85%) should begin to respond by about 1.5 seconds after first possible visibility of the object or condition of concern’. Guidance in DB32 is based on an assumed time of 2 seconds.
- The average deceleration rate of drivers stopping is 4.5 ms^{-2}. This is approximately half the maximum decelleration that can be achieved by cars under favourable conditions, and is consistent with firm braking (see, for example, Auto Express, 2005). Guidance in DB32 is based on an assumed rate of 2.5 ms^{-2}, approximately equivalent to stopping on snow without skidding.

For example, consider a driver travelling at 30 mph (13.4 ms^{-1}). If the driver reacts to a danger by stopping then they take $13.4 \times 1.4 = 18.8$ metres to react to the danger. Using standard equations of motion the driver takes $(13.4 \times 13.4)/(2 \times 4.5) = 20$ metres to become stationary when travelling at a constant rate of deceleration. That is, it takes a driver a total distance of 38.8 metres to stop from a speed of 30 mph.

6.2 Stopping distances on links

A range of links have been examined in which the forward visibility generally varied from less than 10 metres to approximately 100 metres. It was found that the average speed of drivers reduced with forward visibility. In addition, block paving and parking on the link were found to affect speeds. To remove this complication, within this modelling it is assumed that the link has a tarmac surface and no parking is permitted on the link. Furthermore, it was found that link width also influences speeds. It is therefore assumed that the link is either 5 or 9 metres wide, i.e. a narrow or wide road.

The situation considered is if an event occurs, for example a pedestrian stepping into the road at the limit of the driver’s forward visibility. It is assumed that the driver will react as fast as possible and apply a fairly high average deceleration to stop their vehicle, as discussed in Section 6.1 above. The distance required to stop is compared with the distance available for road widths of 5 and 9 metres in Figures 6.1 and 6.2 respectively, and Table 6.1. Further, the distance required to stop assuming drivers had not altered their speeds owing to the reduced forward visibility is included for reference.

Initially it was assumed that drivers did not adapt their speeds as forward visibility reduced, i.e. that they did not perceive limited visibility as a danger and react to it. Then the model predicts that a collision would occur if visibility was less than 40 to 50 metres depending on the width of the road.

According to the regression modelling, drivers adapted their speeds. However, the reduction does not fully compensate for the reduction in forward visibility. That is the margin for error is reduced as visibility falls. For example, with a forward visibility of 100 metres, should a pedestrian appear at the limit of their vision a driver is modelled as being able to stop at a distance of approximately 60 metres before the pedestrian. However, the model predicts that the driver would be able to stop with just over 20 metres to spare under the same conditions if the forward visibility was 40 metres. This

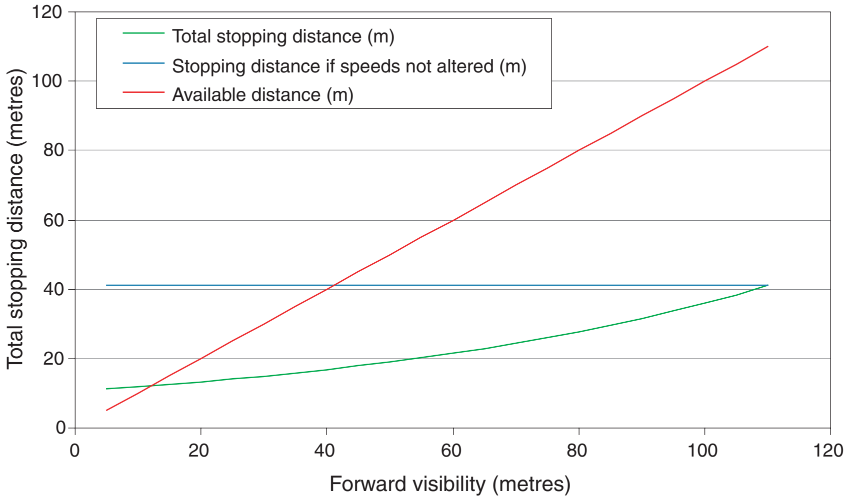


Figure 6.1 Modelled stopping distances on a link of width 5 metres

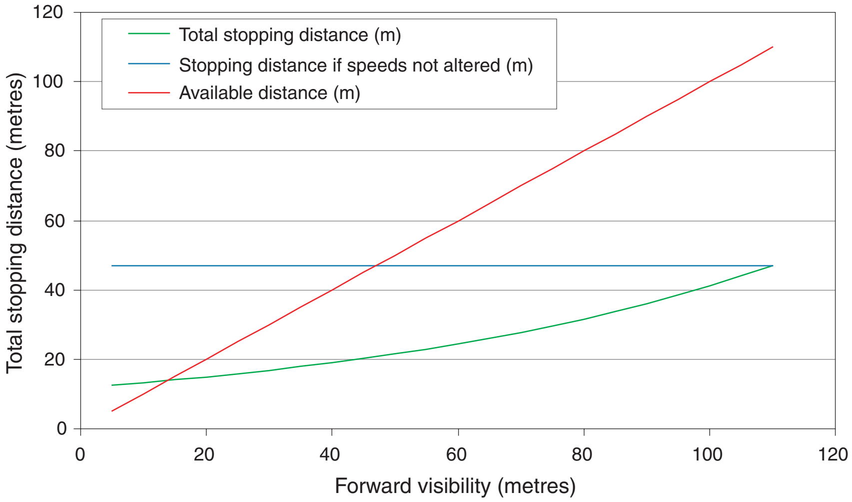


Figure 6.2 Modelled stopping distances on a link of width 9 metres

Table 6.1 Modelled stopping distances for links of varying width

Forward visibility (m)	*Road width (m)*	*Stopping distance if speeds not altered (m)*	*Estimated stopping distance (m)*	*Distance remaining (m)*
20	5	41.1	13.2	6.8
	7	44.0	14.1	5.9
	9	47.1	14.9	5.1
40	5	41.1	16.8	23.2
	7	44.0	17.9	22.1
	9	47.1	19.0	21.0
60	5	41.1	21.5	38.5
	7	44.0	22.9	37.1
	9	47.1	24.4	35.6
80	5	41.1	27.7	52.3
	7	44.0	29.6	50.4
	9	47.1	31.6	48.4
100	5	41.1	35.9	64.1
	7	44.0	38.4	61.6
	9	47.1	41.1	58.9

reduces to only 5 metres to spare with a forward visibility of 20 metres.

Given the driver behaviour observed and the modelling assumptions, it would be expected that schemes in which forward visibility is less than 40 metres could be reasonably safe for average drivers under these conditions owing to the reduction in drivers' approach speed. However, the margin for error decreases continually with forward visibility, and schemes with forward visibility on links of less than 20 metres are relatively unsafe, in the environments studied, unless other speed reduction features are incorporated.

6.3 Stopping distances at junctions

A range of junctions has been examined in which the Y-distance generally varied from less than 10 metres to approximately 100 metres. It was found that the average speed of drivers reduced with Y-distance. Also, block paving, parking and the presence of lines to indicate priority at the junction were found to affect speeds. Within this modelling it is assumed that the junction has a tarmac surface, there is no parking at the junctions and no lines to indicate priority.

The situation considered is when two vehicles approach a junction. The first vehicle is on a minor arm of the junction and the driver is assumed to show caution. They therefore decrease speed from the modelled (regression) approach speed (to 5 mph) as they approach over the 50 metres before the junction. The other vehicle has priority and the driver will approach at the modelled approach speed.

Modelling has been used to consider the effect of the first driver seeing the second vehicle on its approach. It considers the distance before the stop line at which they need to see the vehicle in order that the driver can react (taking 1.4 seconds) and then apply a higher deceleration (4.5 m/s-2) and be stationary at the stop line. These have been calculated using standard equations of motion, and are shown in Figure 6.3.

The driver approaching on the minor arm of the junction and showing caution needs to see the vehicle approaching on the major arm when they are more than approximately 4 and 6 metres from the junction in order to stop. Once closer to the junction they are committed to entering it. That is, drivers make a decision at or before 4 metres from the junction as to whether to stop or continue. This is in agreement with the regression modelling findings. The regression models found that the visibilities measured at 4.5 metres were the best predictors of approach speed, so drivers appear to be making a decision on whether to stop or continue at the junction based upon the information they have available at this distance.

Modelling has also been used to consider the effect of the second driver seeing the first vehicle on its approach. It considers the deceleration required for the vehicle to stop before the junction if the driver sees the first vehicle when at the 'Y-distance' before the junction and then decelerates after the reaction time of 1.4 seconds, Figure 6.4.

If the visibility at the junction is greater than 40 metres a driver travelling at 30 mph should easily be able to stop. Drivers have been shown to reduce their approach speed as the Y-distance reduces. However, it is insufficient to fully compensate for the potential reduced stopping distance available.

The predicted reduction in approach speed results in drivers being able to stop using reasonable deceleration rates (less than 4.5 ms-2) under the modelled conditions if the Y-distance is between 20 and 40 metres. Below 20 metres the model implies it is unlikely that the driver will be able to stop before the junction, and an accident would be more likely to occur.

6.4 Implications of modelled situations

DB32 guidelines indicate that the Y-distance at a junction where the speeds are 25 to 30 mph should not be less than 45 to 60 metres. Regression modelling on a road with a

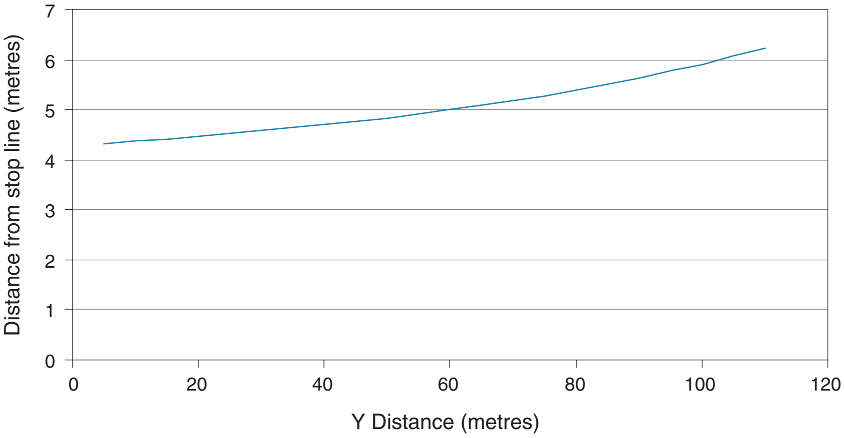


Figure 6.3 Distance at which first vehicle must see second vehicle in order to stop

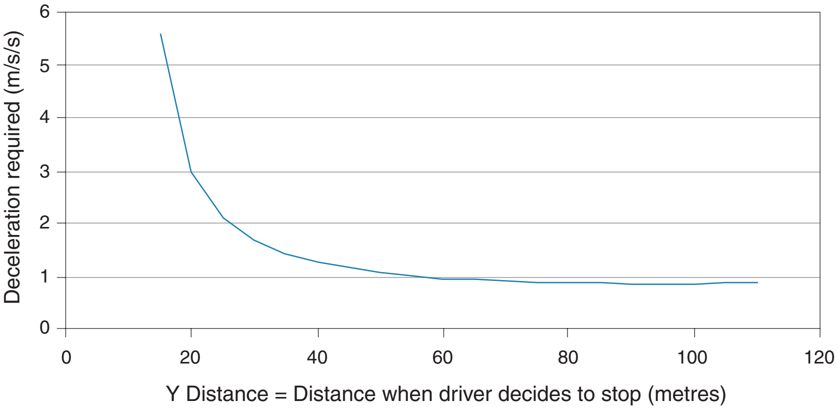


Figure 6.4 Deceleration rate required by second vehicle to stop if seeing first vehicle at 'Y-distance' metres from junction

width of 9 metres indicates that the average approach speed of a vehicle travelling towards a junction with such lines of sight would be 27 to 29 mph.

Modelling indicates that a vehicle approaching from a minor road has a decision point at approximately 4 to 6 metres from the junction after which they are committed to entering the junction. However, a vehicle on the major arm of the junction with a Y-distance of 45 to 60 metres should be able to comfortably stop should such a circumstance occur.

With smaller Y-distances, down to approximately 20 metres, the situation also appears relatively safe for average drivers. The extra caution shown by drivers on the minor road, and therefore the reduced approach speeds, result in them needing to decelerate at up to 3ms-2 in order to stop safely: less than the usually acceptable limit.

Below Y-distances of 20 metres, the modelling indicates that the reduction in speed observed amongst drivers is insufficient for the junction to be safe.

Observed standard deviations in approach speed imply that the 85th percentile of approach speeds could be 4 to 6 mph greater than the average assuming a normal distribution. Modelling implies drivers at these higher speeds would be able to safely stop if the Y-distance is 30 to 35 metres. Consequently, Y-distances between 20 and 40 metres, and slightly below the recommended values may be possible, but caution needs to be shown as the percentage of drivers approaching at speeds that require large decelerations if a conflict occurs quickly increases as Y-distance decreases.

Considering links with a forward visibility of over 40 metres, modelling indicates average drivers would be able to react to and stop safely before reaching a stationary object (say a pedestrian) appearing at the limit of their visibility. In fact the braking model indicates that an average driver would be able to stop with a margin for error (i.e. expected distance between the resulting stationary vehicle and stationary object) of over 20 metres.

However, this margin of error reduces to approximately 5 metres if the forward visibility reduces to 20 metres even taking into account the reduction in speed observed amongst drivers in these situations. That is, the extent that drivers slow down as forward visibility reduces is insufficient to result in geometries with a forward visibility of less than 20 metres being safe. This modelling was based upon a tarmac surface and no parking on the link: both of which reduced link speeds. Therefore a combination of speed reducing measures may further reduce speeds to safely permit lower forward visibilities.

Observed standard deviations in link speeds indicate that the 85th percentile of link speeds could be 3 to 8 mph greater than the average. Modelling implies drivers at these higher speeds would be able to stop with a margin of error of 8 metres when the forward visibility is 40 metres and 4 metres if the forward visibility was 35 metres. Consequently, forward visibilities of between 20 and 40 metres might be considered, but again caution needs to be shown as the percentage of drivers approaching at speeds where the margin of error is small quickly increase.

7 Observed safety

Road safety can be explored by observing behaviour and analysing trends in accident statistics. An investigation into observed behaviour showed that drivers adapted their speed on links where forward visibility was low and in response to road width and other speed limiting factors. The same was also seen at junctions where visibility, the Y-distance, was low. However, although these modelled responses indicated relatively small visibilities could be considered, drivers adapted insufficiently for visibilities below 20 metres (and possibly higher) to be as safe as links and junctions with higher visibilities.

The actual effect on the number of accidents was also explored by collecting information on the number of accidents each year between 1995 and 2005 on all the 20 sites (excluding Ipswich). However, where sites were built, or modified, between these dates, only data from the years since the site was in its current form were considered. Within the 19 sites, 261 links and junctions were studied, and at these features there was an average of 8.6 years of accident data at the 187 junctions and 8.3 years of data on the 74 links.

Over all junctions there was an average of 0.07 accidents per year, whilst at links the average was 0.03 accidents per year. Consequently, it would appear that accidents are more prevalent at junctions than on links. For this reason, junctions can be considered the most important feature with respect to the number of accidents occurring on the residential sites studied.

The STATS19 database classifies all accidents according to the severity of the injury to each of the casualties. The total number of accidents for all ten years at the 19 sites (i.e. including dates before the sites were inhabited) shows that 98% of the casualties at junctions were slightly (and 2% were fatally) injured, but just over half the casualties on links were seriously injured and the others were slightly injured. It is possible that this difference in severity is due to the lower speeds of vehicles approaching junctions. Overall only 27 casualties were seriously, or fatally, injured. Hence all accidents are considered together.

7.1 Belgravia

Section 4.1 showed that Belgravia was anomalous. The development had a grid layout which resulted in large visibilities on the links and at junctions. This combined with wide roads resulted in high vehicle speeds. In addition, the vehicle flows within this site were significantly higher than those at the other sites.

Considering all these factors, it is not surprising that Belgravia also has anomalous accident data (in that it had more accidents than the other sites). Of the 131 accidents occurring on all 19 sites, 65 occurred within Belgravia. The high incidence of accidents is shown in Figure 7.1 (note that the stars indicate the location of the accidents, some of which denote multiple accidents at the same location).

Excluding Belgravia, over all junctions there was an average of 0.034 accidents per year, whilst on links the average was 0.028 accidents per year. Consequently, on the remaining sites there appears to be an approximately equal likelihood of an accident at a junction, or on a link.

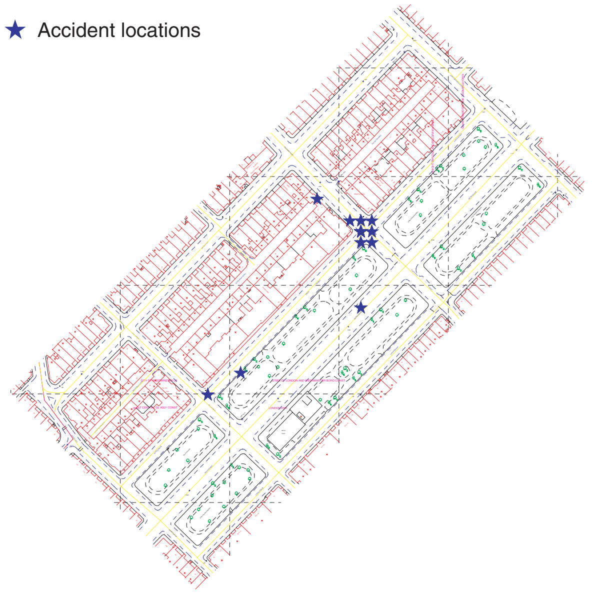


Figure 7.1 Accidents in Belgravia

7.2 Accidents at junctions

There are distinct variations in the number of accidents occurring at junctions in the sites, even when excluding Belgravia. For example, the number occurring in Glasgow is relatively high and the number in Windley Tye is low, see Figures 7.2 and 7.3 respectively.

Previous sections have shown that drivers alter their speed according to the junction's geometry. An investigation was therefore conducted into whether junction layout affected the number of accidents. Visibility would be expected to be one of the most important variables with respect to accidents at junctions. The average number of accidents per year at sites with different Y-distances at 4.5 metres from the junction is shown in Table 7.1.

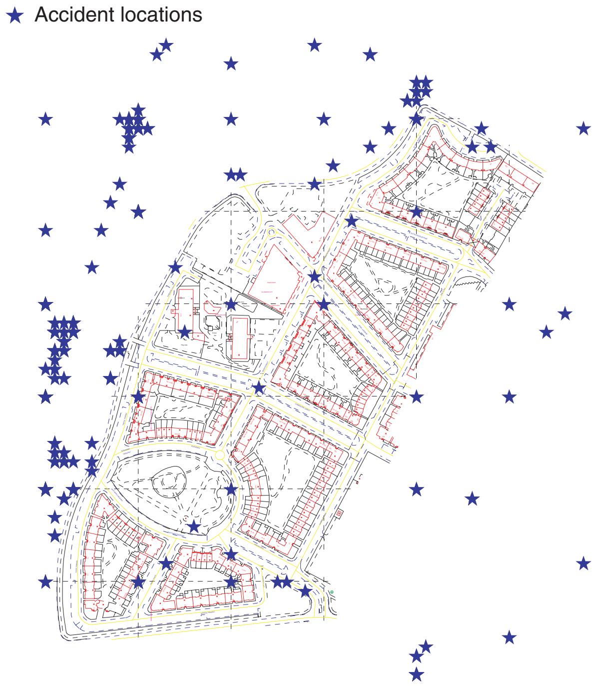


Figure 7.2 Accidents in Glasgow

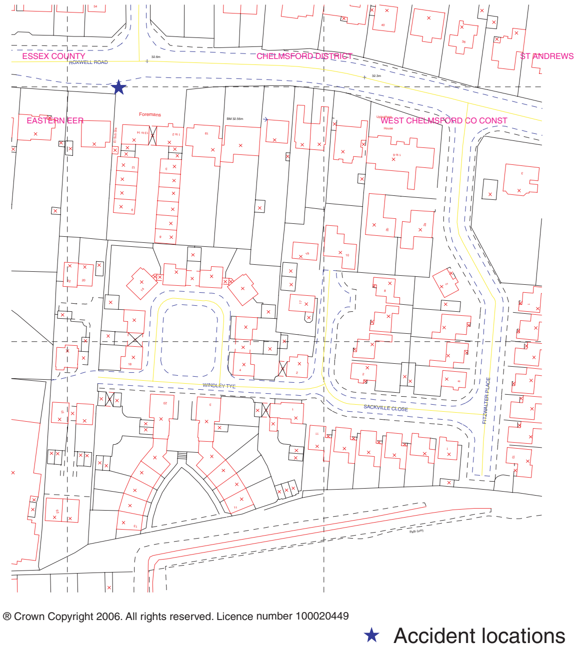


Figure 7.3 Accidents in Windley Tye

Table 7.1 Accidents with respect to visibility

Y Distance (metres)	*Number of junctions*	*Total accidents per year*	*Average number of accidents per junction per year*
0 to 25	107	2.7	0.03
25 to 50	48	2.6	0.05
50 to 80	14	0.3	0.02
Over 80	15	0.3	0.02

There appears to be little correlation between the number of accidents and visibility. Figure 7.4 shows the high variability present in the data.

Although a trend in the number of accidents appear to be present, the variation and sample size preclude any possibility of these being significant. A number of tests were performed. These included examining the percentage of junctions where accidents were observed according to different ranges of Y-distances. The conclusion was that the observed accident trends could have occurred as part of natural variation and it is possible that the actual number of accidents is independent of the junction geometry. This

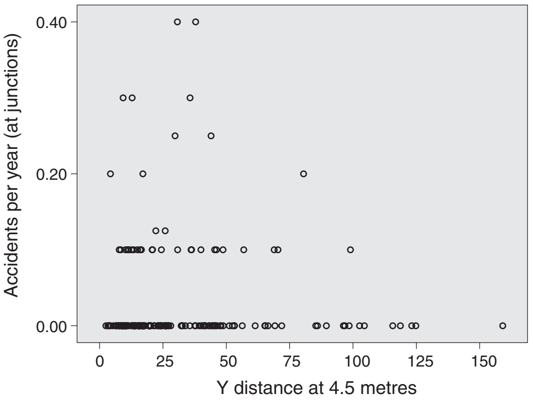


Figure 7.4 Junction accidents – according to Y-distance

could have occurred because of the behavioural modifications explored in previous sections; alternatively, it is possible that the sample size was insufficient given the size of the effect compared with the variation.

It would also be expected that the number of accidents at a feature would be dependent on the traffic flow. The observed link flows were used to calculate the average number of accidents per year for 1000 vehicles, these are shown in Figure 7.5.

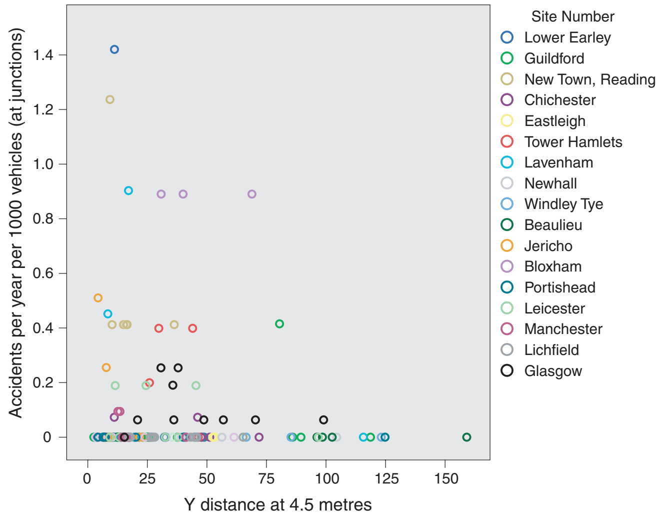


Figure 7.5 Junction accidents weighted by flow – according to Y-distance

Once again there are no statistical relationships between Y-distance and number of accidents. However, the sites with over 0.8 accidents per year per 1000 vehicles were Lower Earley, New Town, Lavenham and Bloxham. These four sites all had low flows of below 250 vehicles per day and low average speeds, and Beaulieu was the only other site with such small flows. There is therefore an implication that there are other factors affecting junction safety.

7.3 Accidents on links

There were only a small number of accidents observed on links. The differences between sites with a relatively large number of accidents (e.g. Tower Hamlets) and those with a small number of accidents is small (e.g. Lower Earley), as shown in Figures 7.6 and 7.7.

Strong statistical differences between accident rates owing to the site characteristics would not be expected given the small number of accidents. The accident rates per 100 metres of link according to the road width is shown in Figure 7.8, and the accidents per 100 metres of link and 1000 vehicles are shown in Figure 7.9.

Consequently, apart from the relatively high number of accidents given the flow in Lower Earley, there are no major differences between the sites. In agreement with this, a statistical analysis could not find any significant relationships between site characteristics and accidents.

However, one interesting relationship was identified between the percentage of links within a site having at least one accident and the observed amount of parking on the links (Table 7.2).

Figure 7.6 Accidents in Tower Hamlets

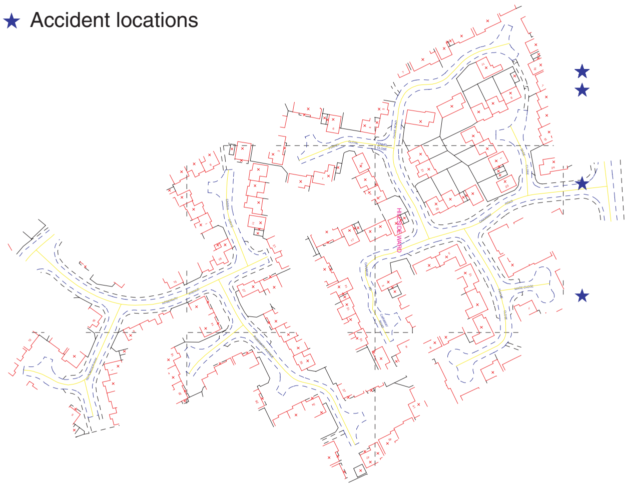


Figure 7.7 Accidents in Lower Earley

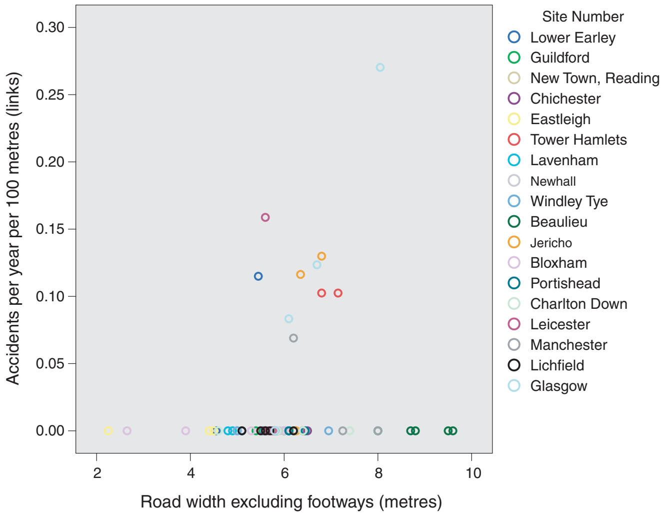


Figure 7.8 Link accidents per 100 m – according to road width

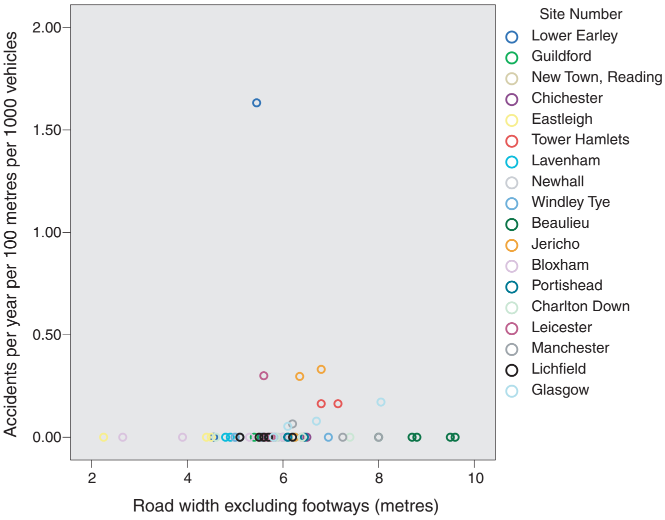


Figure 7.9 Link accident rates per 100 m and per 1000 vehicles – according to road width

Table 7.2 Personal injury incidents according to parking

Link parking	*Whether any accidents on link* *No*	*Yes*	*Sample size*	*Percentage of links with personal injury incidents*
No parking	32	3	35	8.6
Parking on one side	18	4	22	18.2
Parking on both sides	9	5	14	35.7

A test on the difference in the proportion of links with accidents occurring was significantly greater on those links with parking on both sides of the road compared to links without parking.

Modelling based upon site observations has shown that drivers adapt and reduce their speeds when sight lines and road widths are reduced. This in turn results in sites with limited visibility being safer than if this behavioural change did not occur. Therefore the analysis indicates developments with visibilities less than those considered in DB32 and its companion guide can be considered. The actual effect of reduced visibilities on accidents is not fully resolved in this study. There was no large and significant difference in accidents on sites with limited visibility which again indicates that such designs can be considered, however, parking on links appears to be detrimental to safety.

Residents' opinions were collected in addition to these observations. The next sections explore their opinions and investigate whether they perceive safety issues owing to reduced visibility or other geometric aspects of their living environment.

8 Household survey

A household survey was undertaken to obtain the residents' opinions of their streets at the twenty case study sites (see Appendix D for the household questionnaire). This was to determine 'user satisfaction' of a variety of residential street layouts, and to consider residents' transport needs alongside their perceptions of safety and sustainability of their streets.

The content, format and layout of the household survey were derived from previous surveys that had been conducted by TRL and by Leicestershire County Council. The TRL survey focused on a Home Zone site in Ealing. A 'Home Zone' is a street or a group of streets designed primarily to meet the interests of pedestrians and cyclists rather than motorists, opening up the street for social use. The TRL survey tried to gain residents' perceptions of their street and also how they used the street since the Home Zone had been built. The Home Zone survey has been extensively developed and trialled because of its use in a previous project and as a result was used to develop the household survey for this research in terms of the format and content of the questions used.

The Leicestershire County Council survey was again designed to address similar topics to this research. It concentrated on housing estate road design, focusing on the layout of estates including road designs, house driveway designs and car parking spaces. This survey was intended to assist the council in preparing and developing new design standards.

The topics surveyed were further developed, based on the particular objectives and research questions for this report. Residents' views were sought for the Manual for Streets research on the following topics:

- What they like and dislike about the street.
- How they spend their time in the street.
- Parked vehicles.
- Convenience of travel by a variety of transport methods.
- Road safety and personal safety issues.
- Behaviour of motorists.
- Safety of children.
- Whether they had been involved in an accident on their street.
- The changes they would make to improve the street.

8.1 Sampling

Two thousand survey forms were distributed across the twenty case study sites (100 questionnaires per site) in an attempt to obtain a statistically significant sample. Based on previous experience, it was estimated that the response rate to the surveys would be approximately 15-30%. An added incentive to complete and return the survey was provided with residents being able to enter a free prize draw to win £100 of shopping vouchers on the return of the survey in an attempt to improve response rates.

To ensure a representative sample across all twenty case study sites, one hundred households in each case study site were selected using purposive sampling, whereby the sample was limited to the geographical boundaries of the case study sites (see Appendix B). The boundaries of the sites cut across postcodes, and so the addresses were selected using maps of the case study sites. A spread of households was selected to ensure the sample was representative of the site, and the addresses were obtained using ‘Address Management Software’. Any addresses that were not present in this software package due to their relatively recent development (post-2003) were obtained using the Royal Mail’s online ‘Postcode Finder’ service. Addresses registered with the ‘Mail Preference Service’ had to be excluded from the sample.

Due to the variation in the number of households at each case study site, for small villages and sites that had been built very recently, it was not feasible to sample 100 households. To compensate, the shortfall in questionnaires were posted to other larger and more populous sites.

8.2 Sample composition

Out of the 2000 questionnaires distributed, only 1948 reached their destination (52 questionnaires were returned unopened) and a total of 296 completed responses (15%) were received.[2] Table 8.1 shows the distribution of questionnaires received from each site.

Of these respondents, 54% were female and 46% were male. A breakdown of the respondents’ age groups is shown in Figure 8.1. This shows that most of the respondents were aged 25 or over, with relatively even amounts responding in each age group over 25. The highest proportion of respondents lived in detached and terraced properties and Figure 8.2 shows that the most common number of people residing in a property was 2. Figure 8.3 indicates that most respondents (41%) have lived in their property for less than 3 years, which is consistent with the number of new build sites surveyed (five of the housing developments studied were constructed in the last three years).

Table 8.1 Distribution of questionnaires from each site

Site	*Frequency*	*Percent*
Lower Earley, Reading	29	9.8
Chichester	29	9.8
Guildford	26	8.8
Lichfield	25	8.4
Portishead	19	6.4
Leicester	18	6.1
Eastleigh	18	6.1
Bloxham Village	18	6.1
Glasgow	17	5.7
Charlton Down, Dorset	16	5.4
Manchester	15	5.1
Beaulieu Park, Chelmsford	11	3.7
Lavenham	10	3.4
New Town, Reading	10	3.4
Newhall, Harlow	10	3.4
Jericho, Oxford	9	3.0
Tower Hamlets	6	2.0
Belgravia	3	1.0
Ipswich	1	0.3
Windley Tye, Chelmsford	1	0.3

The survey findings were categorised according to aspects of:

- Streetscape.
- Parking.
- Main safety concerns.
- Road safety.
- Non-motorised road users.
- Accidents.
- Pavement.

These are discussed in the next section.

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[2] *The household survey sample did not provide any statistically significant responses because of the small number of questionnaires completed at each site. For this reason, caution should be taken when referring to the percentage of responses in the analysis.*

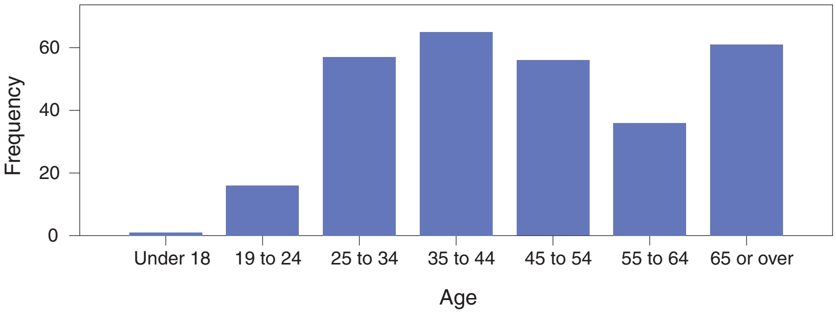

Figure 8.1 Age of respondents

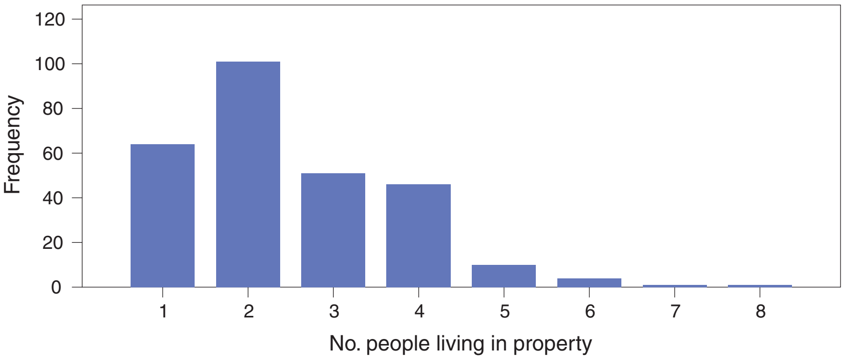

Figure 8.2 Number of people living in property

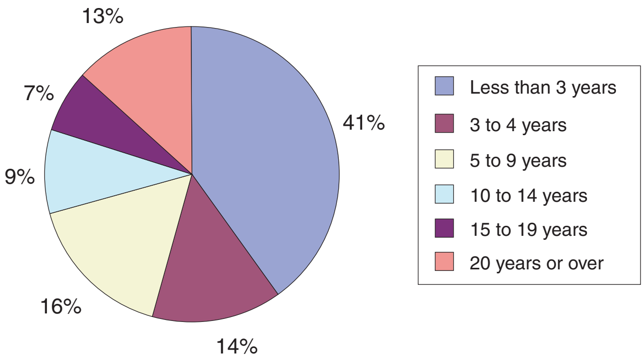

Figure 8.3 Length of time lived in property

9 Residents opinions

9.1 Streetscape

The Manual for Streets is intended to deliver safe and functional streets and meet the Government's 'placemaking' agenda, hence the respondents were asked to list the three things they liked and the three things they disliked about their streets with respect to the liveability of the streetscape. These are shown in Figures 9.1 and 9.2.

Over 120 (40%) of respondents liked their street because it was quiet. Other aspects of their streets that were liked included friendly neighbours, pleasant location and proximity to local amenities. Personal safety and security issues were also cited as positive aspects, for example 'security awareness/safety' was in ninth position, and 'community spirit' in sixteenth position which included participation in 'Neighbourhood Watch' schemes. For example, one respondent suggested as a way to improve safety:

> *'A "homewatch" scheme should be introduced – it would get the neighbours talking'* (Manchester resident).

Figure 9.2 shows that parking issues were the most frequent issue disliked by 97 respondents. This included having problems parking, other people parking inconsiderately and problems with other residents using designated parking spaces. Other stated concerns related to road traffic, including high traffic speeds and through traffic. The design of streets was also frequently disliked,

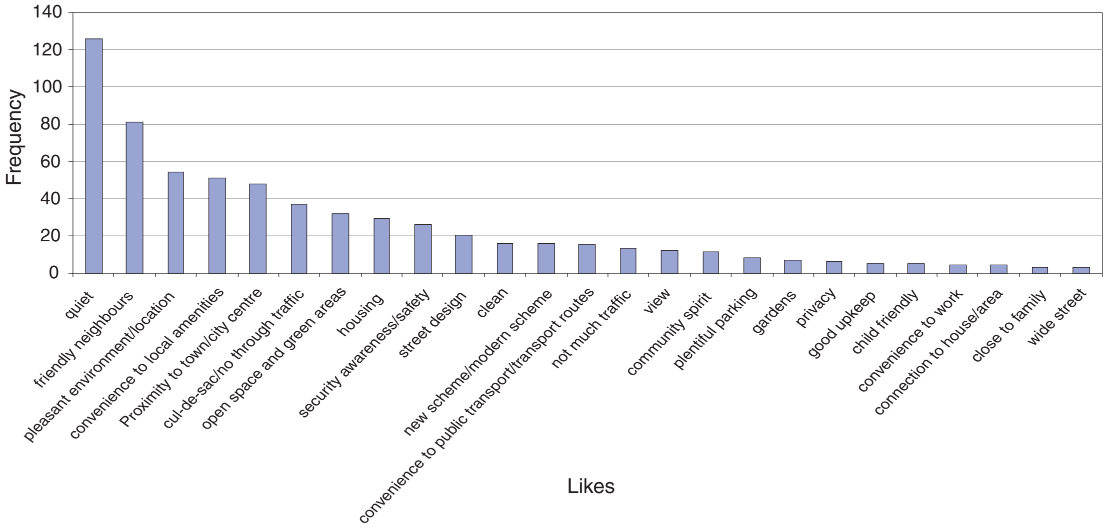

Figure 9.1 Respondents' 'likes' about their streets

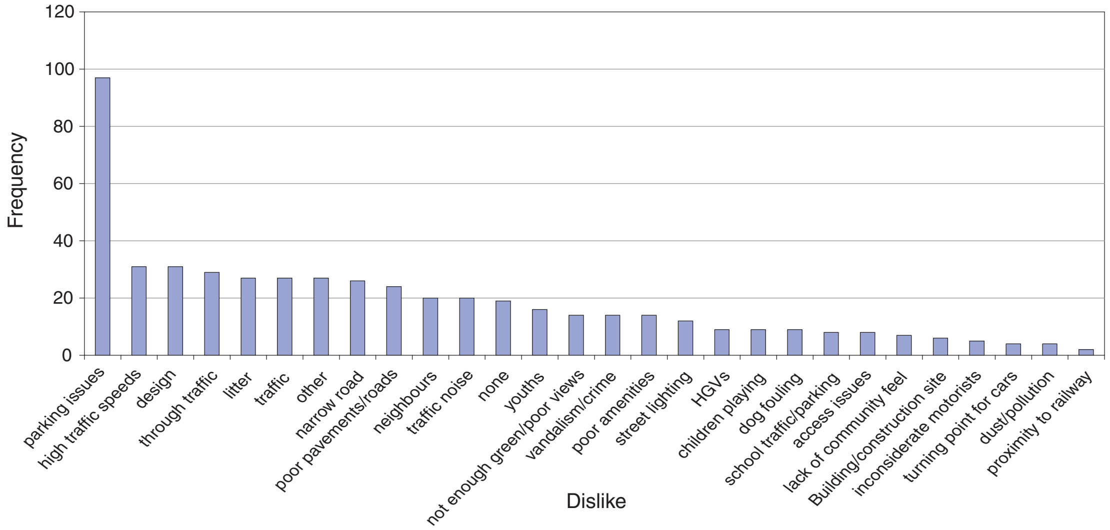

Figure 9.2 Respondents' 'dislikes' about their streets

including issues such as house frontages opening out onto roads, the design of isolated footpaths and houses being too close to footpaths.

Personal safety and security were also stipulated as concerns amongst residents. For example, the presence of 'youths' was the thirteenth most stated dislike, crime the fifteenth, and street lighting the seventeenth.

Respondents were asked to what extent elements of street design are a concern to them and their responses are reflected in Figure 9.3.

9.2 Parking

> *'When designing new towns and streets, more consideration should be given to parking'* (Lower Earley resident).

The survey revealed that parked vehicles were major concerns for residents about their streets. This is not unsurprising given that 37% of respondents have two vehicles per household, hence it is likely that parking facilities for residents are stretched to capacity, especially at historic sites, where off-road parking is at a premium and the majority of vehicles are parked on the street. Parking is a factor that residents believe should be incorporated into street design, as the above quote illustrates.

9.2.1 Car use and off-street parking

The survey revealed that 82% of residents have access to a car as the driver, with 90% of respondents having access to a car as either the driver or a passenger. Figure 9.4 shows that over 125 respondents have one vehicle per household and 110 respondents have two vehicles per household. A significant number of respondents therefore are motorists and require parking for at least one or two cars.

Figure 9.5 indicates that over a third of respondents have access to two off-street car park spaces. Over a fifth of respondents have access to one off-street parking space. As only 17.4% of respondents have no off-street parking facilities one might assume that parking is not a significant issue as the majority have one car and two car parking spaces. However, the respondents' comments suggest that some residents might not effectively use their allocated parking spaces. For example:

- *'People with garages or off-street parking that do not use them and park on the street instead'* (Lavenham resident).
- *'People do not use their allocated parking spaces'* (Portishead resident).

Hence, the provision of allocated off-street parking spaces is not a guarantee that people will use them effectively.

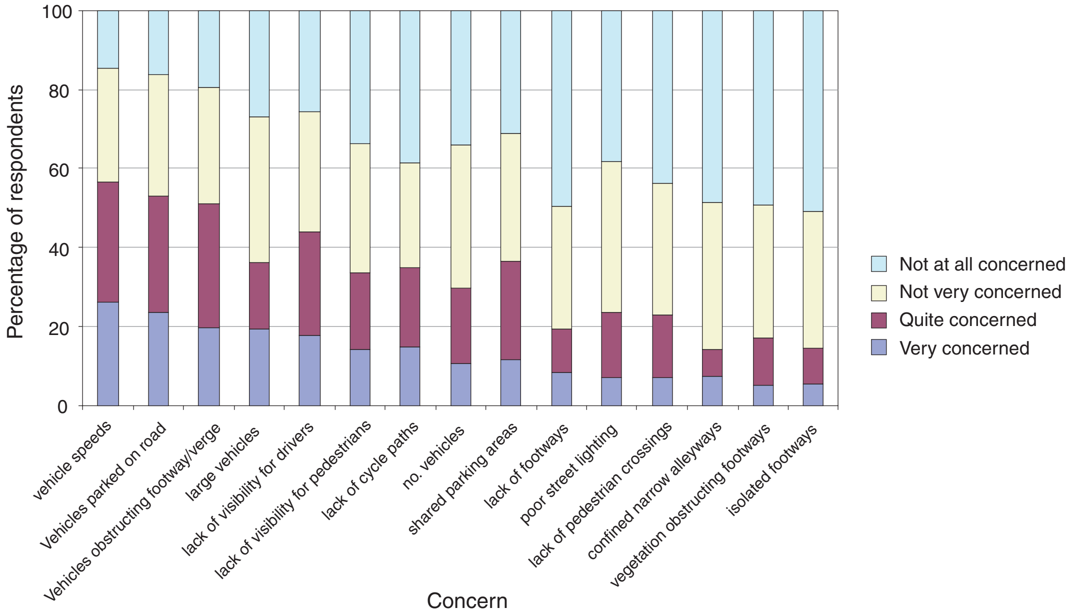

Figure 9.3 Respondents' road safety / personal safety concerns

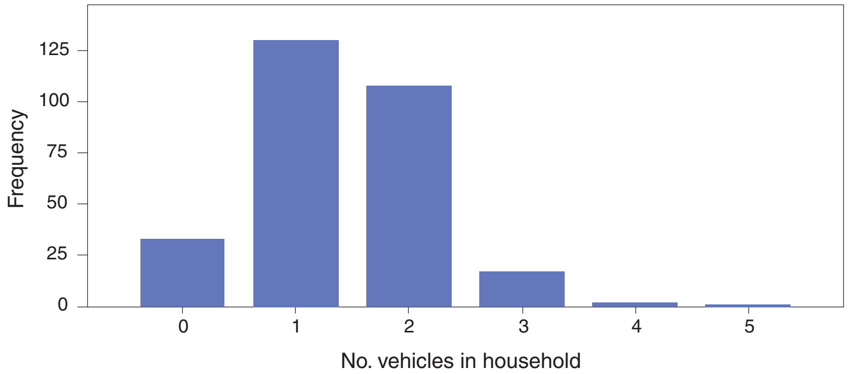

Figure 9.4 Number of vehicles per household

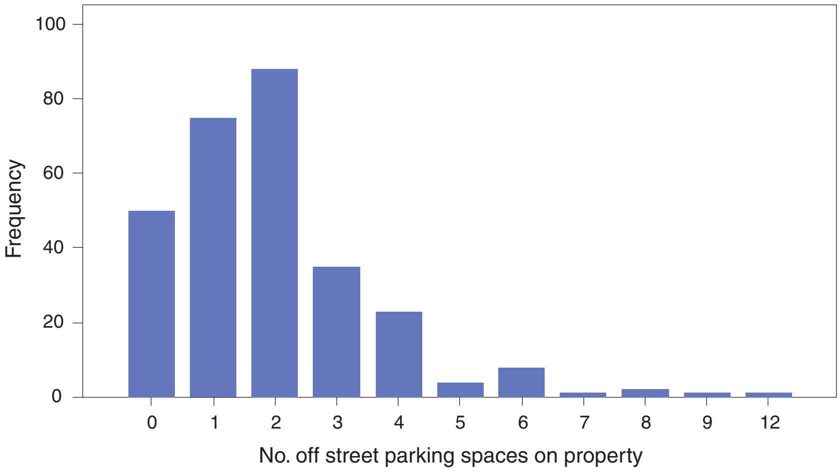

Figure 9.5 Number of off-street parking spaces on respondents' properties

Figure 9.5 further illustrates that over 50 respondents (17.4%) have no off-street parking at all, of whom 34 reside in the 'historic' sites. This implies that parking is more likely to be an issue at these sites, especially for households with multiple car ownership. However, 18% of respondents from the historic sites claimed not to have access to a car, which could indicate that residents are less reliant on cars and possibly that historic sites are closer to town centres and amenities.

9.2.2 Parking problems

Figure 9.6 shows that the majority of respondents (42%) claimed that being able to park outside their home was not a problem, with 31% stating there was 'sometimes a problem' and 17% that there was 'a big problem'.

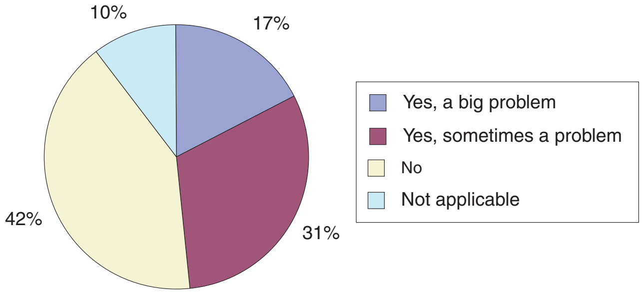

Figure 9.6 Is parking outside your home a problem?

There was found to be little variation between sites, 53% of residents at the historic sites stated that they have a problem with parking compared with 46% and 47% for new build and DB32 compliant sites respectively, which correlates with the proportion of residents who have off-road parking. Residents at historic sites have less off-street parking capacity and are therefore more likely to experience problems parking in limited on-street parking spaces. Table 9.1 summarises individual sites where parking is and is not deemed to be a problem.

9.2.3 Parked vehicles

Residents were asked about whether many vehicles park on the road outside their home. Figure 9.7 shows that 52% of respondents said that vehicles parked on the road near their home 'a lot of the time', 22.5% said 'sometimes' and 14.5% said that drivers did not park near their home at all.

Table 9.1 Parking problems at specific sites

Sites without parking problems	
Belgravia	100% of respondents said there was no problem.
Beaulieu Park	73% of respondents said there was no problem.
Sites with parking problems	
New Town	90% of respondents said there was a problem, of which 50% said it was a 'big problem'.
Eastleigh	62% of respondents said there was a problem, of which 40% said it was a big problem.

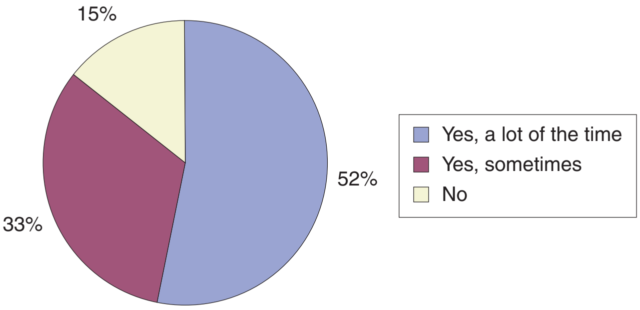

Figure 9.7 Do many vehicles park on the road/footway near your home?

Figure 9.8 illustrates the extent of on-street parking, with vehicles parking on both sides of the street and parking on kerbs and pavements, reducing the width of footways.

Fifty five percent of respondents in new build sites and 56% in historic sites said that people park their vehicles on the road/footway near their home 'a lot of the time', compared with 36% of respondents at DB32 compliant sites (these are summarised for specific sites in Table 9.2).

In addition, when asked whether vehicles parked on the road caused concern in terms of road safety or personal security, 51% of all respondents said they were concerned with vehicles parked on the road (see Figure 9.3). New build sites were shown to be more concerned about vehicles parked on the road in comparison to other sites

Figure 9.8 Parking in New Town

Table 9.2 Sites with vehicles parked outside their home 'a lot of the time' and 'sometimes'

Site	*Percentage of respondents*
Lichfield	100.0%
New Town	90.0%
Eastleigh	83.3%
Jericho	66.7%
Belgravia	66.7%
Chichester	58.6%
Manchester	57.1%
Lavenham	55.6%
Guildford	52.0%

(by a factor of 10%). Specific sites showed high proportions of concern over parked vehicles in the road and are summarised in Table 9.3.

Table 9.3 Case study sites with high proportions of concern over parked vehicles

Site	*Percentage of respondents concerned*
Portishead	78.9%
Lichfield	72.0%
New Town	60.0% (50.0% 'very concerned')
Chichester	60.7%
Manchester	60.0%

Figure 9.3 also shows the following respondent concerns with regard to parking:

- Over 50% of all respondents revealed concern about vehicles obstructing the footway. Residents in Lichfield and Eastleigh showed most concern about vehicles parked and obstructing footways (68% and 61.1% of respondents respectively).
- 27% of all respondents were concerned about shared parking areas. In Eastleigh, 68% of respondents were concerned over shared parking areas.

Parking as a prime issue is also shown in respondents' comments about what they like and dislike about their street (see Figures 9.1 and 9.2). Only 1.3% of respondents gave 'plentiful parking' as one of the factors they liked about their street. In contrast, 19% of respondents gave parking issues as a 'dislike' about their street.

9.2.4 Respondents' issues with parking in their street

The issues respondents have with parking relate to access, safety and aesthetics.

Firstly, parking is identified as a main culprit in restricting access to streets. For example:

- *'Access to my drive is often affected by cars parked on the street'* (Lichfield resident).
- *'There are not enough parking spaces, so cars sometimes block drives'* (Guildford resident).

Respondents also refer to the reduced visibility that parked cars cause, which both restricts access and has an effect on safety:

- *'You can't drive through. Cars park on bends and block the footpath'* (Beaulieu resident).
- *'Cars parked on double yellow lines at street corners obstruct the view of the driver'* (Chichester resident).
- *'There is a slalom effect driving down the road and vision is obscured on the bend of the road'* (Lower Earley resident).
- *'Cars are unable to drive straight through and wait to take their chance to pass'* (Chichester resident).

This implies that these streets are not functioning as they should because, according to the perceptions of residents in these streets, on-street parking creates hazardous driving conditions and impacts on access.

Respondents also commented on the impact of narrow roads. Respondents referred to how difficult it is to manoeuvre in narrow roads and how narrow roads plus on-street parking leads to congestion. For example:

- *'The streets are too narrow for the masses of people living in the area and visitors have to park elsewhere'* (Portishead resident).
- *'The neighbours opposite have a terrible time, often having damage done to their cars by traffic squeezing by. They park on one side of the road, but traffic has to go up on pavements on our side of the road'* (Guildford resident).

Figure 9.9 reflects respondents' concerns about narrow roads and parking, where parking has transformed the road into a single-traffic road and created hazards for drivers attempting to negotiate the road.

These issues raised are supported by the accident and near miss incidents reported by respondents in the survey. 20 out of 66 of those respondents who provided details of the accident/near miss they were involved in were related to parking. When describing these accidents, respondents referred to street parking on blind bends, narrow roads forcing one vehicle onto the other side of the road and where parked cars significantly reduce visibility.

Indeed, the primary research documented in Section 7 suggests that, while parking on links appears to be detrimental to safety, there is also a correlation between roads with no on-street parking and higher speeds,

Figure 9.9 Parking on a narrow road in Jericho, Oxford

indicating that drivers adapt and reduce their speeds when sight lines and road widths are reduced. Hence, for roads where sight lines and road widths are increased because there are no parked cars to reduce visibility, arguably drivers will adapt and increase their speeds leading to a more risky environment.

Respondents also commented on the design of parking in the street. Issues were raised about there not being enough off-road parking:

- *'There is not enough parking provided for houses, some houses on the street are four bedroomed, with only one off-street parking space'* (Portishead resident).
- *'With only having one parking space and two cars, I would like to park outside, but can't'* (Manchester resident).

However, some respondents note that it is people who have too many cars that cause the problem and not the design:

- *'People in executive houses use the road mainly to park cars and some appear to have two or more'* (Manchester resident).
- *'Many old houses with single frontages own 2 or 3 cars, so they have to park in front of someone else's house'* (Lichfield resident).

A further issue raised about the lack of parking is residents' frustration at not having anywhere for visitors to park and others who are frustrated by non-residents parking in their spaces:

- *'Too many cars park here as there is no parking restriction, so other people from other streets come and park there and leave it'* (Tower Hamlets resident).

School traffic is a particular issue:

- *'School run parking causes double parking, pavement parking and blocks driveways'* (Lichfield resident).
- *'School run mindless parking'* (Lichfield resident).
- *'It is a school location and there is easy access through the close, but there should be better parking access for parents. When off loading and loading at school time, parking is haphazard. All rules of the road are not adhered to'* (Chichester resident).

To resolve parking issues, residents highlighted two main points. Firstly, parking should be restricted:

- *'Lines to stop on street parking where dangerous to do so or where double parking may occur'* (Beaulieu Park resident).
- *'No more street parking at all. Cars could go in an underground car park'* (resident's location unknown).
- *'Stop cars from parking on both sides of the road – encourage people to use driveways and garages'* (Portishead resident).
- *'Widen road or put double yellow lines down so two cars can pass on the road without having to drive on pathway'* (Portishead resident).
- *'Council enforcement of parking regulations. Too many householders think they have a right to park as many vehicles as they please, despite others having paid to park'* (Eastleigh resident).

These comments convey a desire to limit parking by using road markings, better enforcement or alternative designs to deal with the problem. Secondly, to improve safety, residents would like to see more off-street parking designated, for example:

- *'Allocate more off street parking for each home at time of build. Why would any Local Authority think homes selling for £300K plus will attract purchasers with only one vehicle. Madness!'* (Portishead resident).
- *'If parking was sorted, this would improve safety. Maybe a car park for residents would help'* (Guildford resident).

This implies that residents feel that street design should accommodate cars, rather than attempting to restrict car parking and promote more sustainable travel modes such as provision for cyclists and bus routes.

Aesthetically, respondents highlight how parking, 'spoils the look' (Bloxham resident) of their street and, 'makes it congested and looks very ugly' (Guildford resident). This further adds to respondents' unpleasant experiences of their streets due to parking issues. However, one resident commented:

- *'Parking is provided away from road to improve aesthetics. Of course people don't use it and park on the narrow street. This is ridiculous, people want to park near the door, especially when they have kids/shopping/elderly. Improving aesthetics has caused the problem in our street' (Lichfield resident).*

Street design therefore faces a dilemma: how to improve aesthetics by providing parking away from houses and yet still allowing access for those who need it, especially vulnerable groups, notably elderly and disabled people.

9.3 Main safety concerns

Respondents were asked what they considered the main safety threat to be on their street. Figure 9.10 shows that the highest proportion of respondents (46%) considered

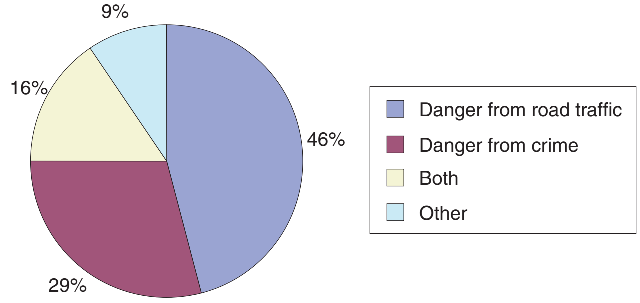

Figure 9.10 Main safety threat

'danger from road traffic' to be the main safety threat in their street. For example, one respondent commented:

> *'Road safety is the main issue and with further development proposed within the immediate location it is sure to escalate further. We have had a number of street protests and we are petitioning as much as possible for a solution to this growing problem'* (Guildford resident).

Table 9.4 illustrates the 'other' safety threats that respondents provided. Of these 'other' threats, poor driving, parked cars and narrow roads relate to road safety issues. Hence, 48.2% of respondents considered road safety issues to be the main safety threat.

Table 9.4 Main safety threat 'other' responses

Main safety threat 'other' responses	*Percentage*
Poor driving	0.4%
Parked cars	1.1%
Drugs	0.7%
Isolated cycle path	0.4%
Poor street lighting	0.7%
Narrow roads	0.7%
Pavements	0.7%
Children playing	0.4%
None	4.3%

Given that the Manual for Streets is intended to deliver safe and functional streets and meet the Government's 'place making' agenda, personal safety and security issues are an important part of the analysis:

- *'In future, design out back alleys – I always refer to them as 'burglar paradise' as it allows access via the side of the house'* (Eastleigh resident).
- *'There is a bus that comes near to the area, but you have to walk along a long lonely road or across a very lonely field to get to the local bus service'* (Newhall resident).
- *'Street lighting is not very well placed for cut through walkway opposite. One street light could be moved a small distance, which would make all the difference'* (Lower Earley resident).

At DB32 compliant sites (Lower Earley, Reading and Leicester), the main threat is considered to be 'danger from crime' (45.7%), with 32% of respondents citing 'danger from road traffic' as being the main threat to safety.

Road traffic as the main safety threat is supported by respondents' comments about what they dislike about their streets (Figure 9.2) including:

- High traffic speeds.
- Through traffic.
- Traffic volume.
- Narrow roads.
- Poor roads.
- School traffic.
- Inconsiderate motorists.
- Street being a turning point for cars.

Over half of respondents referred to road safety issues as a dislike about their street. The accident and near miss data show that 26% of respondents said they had been involved in an incident, which might be considered high considering the low trafficked streets surveyed.

Table 9.5 indicates new build sites had the highest proportion of reported accidents and near misses from amongst the residents surveyed. However, this difference is small and not statistically significant.

Table 9.5 Accidents / near misses recorded by site characteristic

Site characteristic	*No respondents*	*Number of reported accidents/ near misses*	*Percentage of respondents*
New build	162	56	34.6%
Historic	79	25	31.6%
DB32 compliant	47	10	21.3%

9.4 Road safety

Residents generally considered that road safety was the main aspect of concern within their neighbourhood. The questionnaire explored the underlying reasons for these concerns. One of the key issues that arose was traffic speed in the residential area, and over half (52.8%) of respondents claimed to be either 'very' or 'quite' concerned about speeds when asked about road and personal safety issues in their street.

In New Town (Reading), this was of particular concern: 80% of respondents were either 'very' or 'quite' concerned about vehicle speeds. Other sites where higher percentages of respondents indicated concern over high vehicle speeds include:

- Eastleigh (77.8% of respondents concerned).
- Lichfield (72% of respondents concerned).

Confirmation of the issue with speeds was obtained from comments about how residents would improve safety in their streets. Over 100 comments were received referring directly to improving speed calming measures such as road humps, lower speed limits and enforcing speed limits. For example, respondents requested:

- *'More traffic calming schemes in the narrow streets on new estates'* (Eastleigh resident).

- *'Road humps or speed signs that light up on excess speed'* (Lichfield resident).
- *'Clear signs and well enforced 10 mph speed limit'* (Eastleigh resident).
- *'Advance warning to motorists that the area is a 20 mph zone'* (Leicester resident).

Another lesser impact that influenced residents' perception of traffic safety was flow: 27.3% of respondents expressed concern over the number of vehicles passing through the street. This appeared to be a particular issue for residents in the historic sites. This could be a result of the lack of off-street parking spaces at historic sites and the narrow road widths, leading to congestion. Specific sites with notable concerns about the number of vehicles in their street include:

- New Town (50% of respondents concerned).
- Eastleigh (44.4% of respondents concerned).
- Bloxham village (44.4% respondents concerned).

Two of these were historic sites, and the other was a new development. Furthermore, none of these sites had particularly high flows (see Section 4), particularly in relation to the other sites. Residential perception of high flows must therefore be influenced by other factors in the street design.

Other concerns relating to road safety include:

- 38% of all respondents were concerned about the lack of visibility for drivers.
- 15% of all respondents were concerned about the lack of footways.
- Over 33% of all respondents were concerned about large vehicles.
- 28% of all respondents were concerned about the lack of cycle paths.
- 29% of all respondents were concerned about the lack of visibility for pedestrians.
- 19% of all respondents were concerned about the lack of pedestrian crossings.

Once more the greatest other safety concern for residents was over traffic, in this case the lack of visibility for drivers. All main aspects of traffic that result in higher accident rates (flow, speed and visibility) were cited amongst the highest concerns.

9.4.1 Walking and cycling safety

The Manual for Streets is intended to act as a guide to ensure streets are functional and safe for all road users. It has also been prepared against a backdrop of sustainable development initiatives and guidance. As a result, the issues and experiences of non-motorised users (comprising 9.5% of the sample) are vital components and are now discussed.

Respondents were asked to comment on how safe they considered their street to be, with regards to danger from road traffic for both children and adults to walk and cycle. Figure 9.11 shows that 12% of respondents consider their streets unsafe for adults walking due to road traffic (this includes both 'very' and 'quite' unsafe responses). The same proportion also considered adults to be unsafe whilst cycling. Twenty seven percent of respondents consider their streets to be unsafe for children walking and 41% of respondents considered children cycling to be unsafe as a result of road traffic.

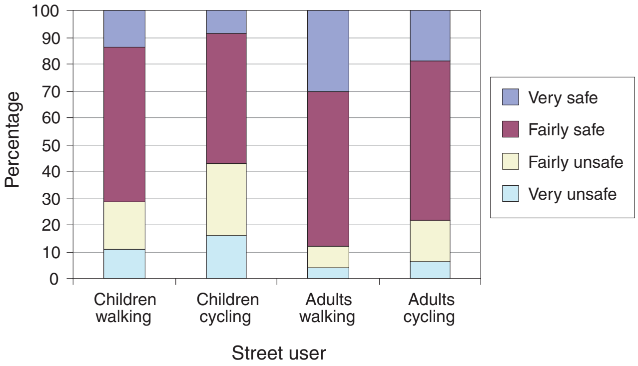

Figure 9.11 Safety of different street users with regards to danger from road traffic

DB32 compliant sites reported the lowest amount of 'unsafe' responses to this question. 8.5% of respondents considered it unsafe for adults to cycle, compared to 25.5% for new build and 15.6% for historic sites.

Over 50% of respondents were either 'very' or 'quite' concerned about 'vehicles parked obstructing footways' (see Figure 9.3). Vehicles obstructing footways was also a common theme that emerged from the respondents' comments, for example:

- *'Cars park fully on the pavement so you have no choice but to walk in the road, others park on bends so you cannot see what is coming'* (Charlton Down resident).
- *'Children have to walk on the road to get round cars parked on the pavement'* (Leicester resident).

Figure 9.3 illustrates respondents' concerns relating to non-motorised road users. These are summarised as follows:

- 15.2% of all respondents were concerned about the lack of footways.
- 28.0% of all respondents were concerned about the lack of cycle paths.
- 29.0% of all respondents were concerned about the lack of visibility for pedestrians.
- 18.6% of all respondents were concerned about the lack of pedestrian crossings.

In terms of concern over the lack of cycle paths, over a fifth of respondents consider this question 'not applicable' indicating that cycle use is minimal among the resident sample.

9.4.2 Safety of children

The survey also considered the safety of children of different ages. Figure 9.12 shows that 70.8% of respondents consider it unsafe for pre-school children to play unsupervised. Many respondents criticised this question, suggesting that pre-school children should never be left unsupervised. Over half (54.1%) of respondents believed their street is unsafe for primary age pupils to

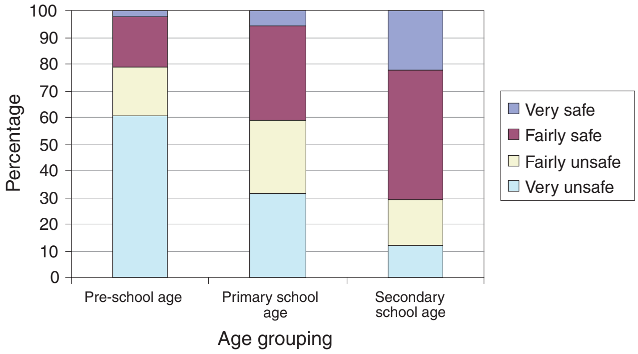

Figure 9.12 Safety of children spending time in their street unsupervised by an adult

play unsupervised, while 27% of respondents considered their streets to be unsafe for secondary school age children.

Respondents were asked to provide reasons if they gave 'unsafe' as a response. These are summarised in Table 9.6. The main reason given for 'unsafe' responses across all age groups was the speed of traffic. This correlates with respondents' concerns about road safety in their street. Respondents were most concerned about high traffic speeds (as previously discussed).

Eighty percent of New Town respondents considered their streets unsafe for pre-school age children, with 70% providing speed of traffic as the reason.

9.4.3 Improving road safety in residential streets

In addition to improving road safety by the speed calming measures discussed in section 9.4, other common themes were cited by respondents. These include:

- Making the street 'one-way': 'A solution would be to adopt a one way system in part of the area. This would allow an element of on street parking without compromising traffic safety and flow' (Portishead resident).
- Better road maintenance: potholes in the road are dangerous for all road users.
- Prohibiting large vehicles, including buses: 'Stop buses entering estates – roads are not wide enough and are too winding to accommodate large single-decker buses' (Leicester resident).
- Restricting access to the street: 'Removal of all vehicles would considerably improve safety, access and aesthetics' (Newhall resident).
- Road safety issues related to parking.

9.5 Accidents

Respondents' perceptions about the safety of non-motorised users in their street is reflected in the accident/near miss incidents reported in the survey. 13.3% of accidents/near misses recorded involved non-motorised road users (pedestrians or cyclists). All of the non-motorised incidents recorded involved a motorised road user. For example:

- *'My daughter was riding her bike on the pavement and a car reversed out of the drive and did not see her'* (Lichfield resident).
- *'Leaving my car on foot and a car travelling on the pavement at speed. I had to pull my children back'* (Guildford resident).

Non-motorised users are shown to be vulnerable to motorised users. Clearly, there are issues with regard to sharing the street space.

Figure 9.13 conveys how considerate respondents believe motorists are to non-motorised street users.

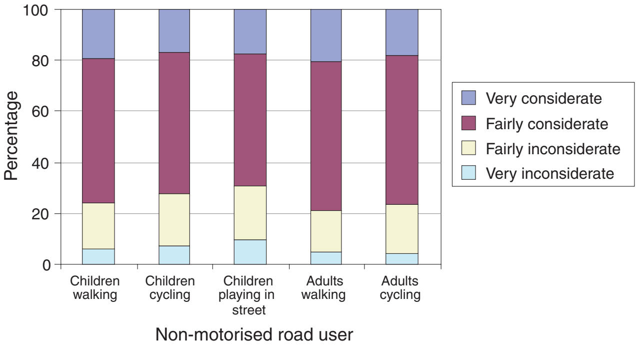

Figure 9.13 How considerate respondents perceive motorists to be towards non-motorised road users

Approximately three quarters of respondents considered motorists to be considerate to children walking, cycling and playing in the street. Three quarters of respondents also considered motorists to be considerate towards adults walking and cycling. Respondents who cited motorists as being considerate to non-motorised users are summarised by site type in Table 9.7.

Table 9.7 How considerate are motorists towards non-motorised road users by site type?

	DB32 compliant	*New build*	*Historic*
Children walking	76.6%	70.0%	68.4%
Children cycling	74.5%	63.1%	61.8%
Children playing in the street	72.3%	57.5%	53.9%
Adults walking	83.0%	73.1%	76.6%
Adults cycling	72.3%	66.9%	64.9%

Table 9.6 Reasons for 'unsafe' responses

	Pre-school age		*Primary school age*		*Secondary school age*	
Reason for unsafe response	*Frequency*	*Percentage*	*Frequency*	*Percentage*	*Frequency*	*Percentage*
Speed of traffic	135	46.7%	105	36.6%	53	18.5%
Amount of traffic	80	27.7%	56	19.5%	29	10.1%
Stranger danger	62	21.5%	47	16.4%	18	6.3%
Crime/mugging/physical assault	23	8.0%	24	8.4%	25	8.7%
Bullying from other children	19	6.6%	20	7.0%	19	6.6%

9.6 Non-motorised vs. Motorised users: Access

An overwhelming majority of the sample considered travelling on foot or by bicycle to be easy and convenient. Figure 9.14 illustrates that only 5% of respondents consider the ease and convenience of travelling around their street by foot to be either 'bad' or 'very bad'. Equally, 7% of respondents consider cycling to be 'bad' or 'very bad'. A surprising 29.1% of respondents considered this question not applicable, which might indicate that they do not regularly use these modes of travel around the streets in which they live.

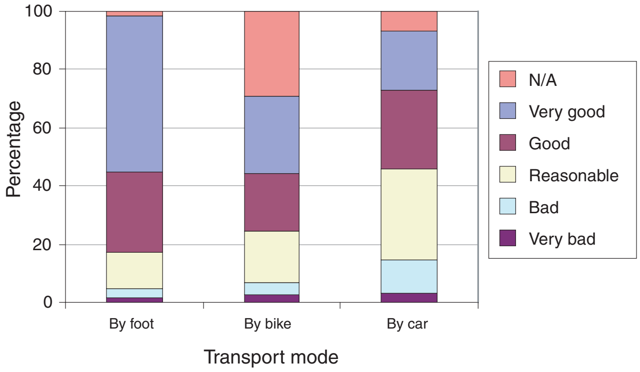

Figure 9.14 Ease and convenience of travelling around the street by different transport modes

Conversely, 15% of respondents said that the ease and convenience of travelling by car around their streets is 'bad' and 'very bad'. An additional third of respondents said that travelling around their street by car was 'reasonable'.

Respondents also highlighted how hard it was to travel around the street using 'other' modes of transport. These included travelling by wheelchair and with a pram/buggy. This is reflected in the respondents' comments:

- *'People in wheelchairs have their right of way blocked by parked cars'* (Lavenham resident).
- *'I can't get past with a double buggy and can't see properly when crossing the road'* (Leicester resident).

Non-motorised users with specific needs therefore need considering in street design, in particular those with mobility constraints and vulnerable groups (people with children and buggies, wheelchair users, deaf, blind and partially sighted people, and older people).

9.7 Footways

Figure 9.2 conveys respondents' dislikes about their street. This shows that respondents considered poor footways and poor amenities as pertinent issues after parking and traffic. Poor footways affect pedestrian use and how safe pedestrians feel using the footway. Poor amenities mean that people without motorised transport can feel excluded.

The need for better pedestrian and cycle routes emerged as an issue from respondents' comments. Respondents would like 'more cycle friendly facilities' and also criticise the design of 'grass verges' as pavements, for example:

- *'Pavement on both sides is grassed, therefore people tend to walk in the middle of the road, which is very unsafe'* (Lichfield resident).
- *'The council should get rid of grass pavements and provide a proper tarmac style pavement all around the road. These grass pavements force pedestrians into the road because it is impossible to push prams etc in the soft surface – more pedestrians in the road will eventually result in an accident'* (Lichfield resident).

Figure 9.15 shows the grass verges in Lichfield.

Some respondents criticised pedestrian and cycle access routes for encouraging crime:

- *'Due to the cycle path, kids have thrown stones and eggs, and broken fences as well as damaging trees and shrubs'* (Lower Earley resident).
- *'Our small set of local streets for a cul-de-sac with a pathway through which is not needed at the end. Closing this off would virtually eliminate crime'* (Lower Earley resident).

Figure 9.15 Grass verges as pedestrian walkways in Lichfield

The design of pedestrian and cycle access routes for non-motorised users could be exacerbating personal safety fears for residents. This might particularly be the case for DB32 compliant sites in Reading and Leicester, which have spine and cul-de-sac road layouts. These layouts are more likely to have isolated pedestrian and cycle routes compared to more permeable and shared use streets, such as Charlton Down.

9.8 Summary of household survey findings

The primary objective of this household survey was to explore residents' perceiptions. Results of the attitudinal survey provide a better understanding of how highway layouts that are considered successful, in terms of casualties and driver behaviour (for instance sites considered to be best practice by CABE) perform from the perspective of street users and residents.

The headline concern from the survey is that the majority of residents have little appreciation for the attributes that make streetscapes liveable, desirable and safe places to live (for example, reduced clutter, public areas to encourage children's play, neighbourly interaction, reduced congestion and sustainable travel).

Many respondents take particular issue with parking, which reflects the bias in the sample of residents who own a car, and in particular, households with multiple car ownership. Other key findings are listed as follows:

- Danger from road traffic is considered to be the main safety threat in the streets sampled.
- The main concern for respondents is high traffic speeds in their streets. High traffic speeds are also given as the main reason why roads are considered unsafe for children of all ages.
- Non-motorised road users are vulnerable to motor vehicles. Accidents and near misses reported by non-motorised users all involve a motorised user. Children cycling are perceived to be the most vulnerable. However, the findings suggest that cycling as a mode of transport is not widespread amongst respondents.
- In terms of personal safety and security, respondents are particularly concerned about poor street lighting and pedestrian walkways. Poor street lighting and deserted walkways increase insecurity, encourage crime and prevent residents from using their streets effectively and using more sustainable modes of transport.
- The presence of parked vehicles in their street is a major issue of concern for residents. On-street parking reduces safety, access and the aesthetic qualities of streets but conversely encourages lower speeds. The respondents would prefer more off-street parking or for parking to be restricted. The dilemma is how to respond to residents' needs whilst attempting to prioritise non-motorised users and more sustainable modes of transport.
- DB32 compliant sites performed consistently well in the household survey with regard to road safety and parking. These sites were viewed as safer from traffic by respondents compared to historic sites and new build sites but generated more negative responses with regard to personal security. In fact, the hypothetical analysis of junction spacing in Section 10 of this report indicates that there are only small differences in the effect on accidents using different road network layouts (when comparing DB32 compliant spine and cul-de-sac layouts with organic layouts that have more junctions and greater permeability for pedestrians and cyclists).
- Specific case study sites that stand out are New Town, Eastleigh and Lichfield. Respondents from these sites considered them to be consistently unsafe, showing concerns over vehicle speeds, the number of vehicles in their street, the lack of footways, the lack of cycle paths, the lack of visibility for drivers and the lack of visibility for pedestrians. Both adults and children were considered to be unsafe at these sites as a result of road traffic. Parking and the resultant safety issues were also major concerns for a high proportion of respondents at these sites.

Arguably, the Manual for Streets, which is aimed at transport practitioners in their various capacities, will reflect the user needs. However, it may be necessary to inform the public of advancements in street design contained within the Manual for Streets, in order to manage their expectations about street function over form.

The next section explores the effect of crossroads and junction spacing on predicted accident risk using a software model to predict accidents on urban road networks.

10 Testing of network layout using SafeNet

10.1 Junction spacing

It has been identified by work carried out to date that the form of highway layouts is to a significant degree shaped by highway safety concerns, with some engineers keen to maximise junction spacing and concentrate vehicle flows onto links higher in the road hierarchy. The negative consequence of this approach however can be to reduce permeability to pedestrians and to concentrate the negative impacts of traffic.

A secondary element of research will therefore be to test different highway layouts to determine whether, making reasonable assumptions about the distribution of traffic within those hypothetical networks, more casualties on aggregate could be expected. This test was carried out using SafeNet (TRL, 2006).

SafeNet (Software for Accident Frequency Estimation for Networks) was originally developed in 1999 with the support of the Department for Transport and was primarily designed to predict the number of accidents per year that would occur on an urban road network. SafeNet2 has been developed over the past six years with the support of the Highways Agency and extends the capability of SafeNet to cover the trunk road network.

SafeNet is based on extensively researched accident-risk models which started in the 1980s with the study of roundabouts (see Maycock and Hall, 1984) and continued with most of the junction and link types found on UK roads, and in particular urban priority junctions and link sections used here (Summersgill *et al.*, 1996; Summersgill and Layfield, 1996; Layfield *et al.,* 1996). The studies related accidents to traffic flow and to road geometry and control variables.

SafeNet2 can be used to model road networks which include:

- Urban single carriageway roads.
- Urban roads including minor junctions.
- Roundabouts and mini-roundabouts.
- Traffic signal junctions.
- Traffic calming measures.

It can be used to determine the safety implication of changes to a network or the effect on safety of increased or decreased traffic flows.

SafeNet2 uses vehicle flow, pedestrian flow and geometric data for each junction and road link within the road network. There are 4 levels at which the model can be used, ranging from simple inflow data (Level 0) to vehicle turning flows, pedestrian flows, and geometrical data (Level 3). The analysis here uses Level 1 models. The number of expected accidents and casualties (fatal, serious, slight) can then be calculated for a given junction or link. These values can then be summed to give an estimate of the number of accidents that would be expected to occur across the network as a whole.

10.1.1 Analysis

The area chosen for analysis was Thorpe Astley in Leicester. This site is a typical DB32 layout with cul-de-sacs and roundabouts onto the highway network. Flows were estimated by Phil Jones Associates for all the junctions and links within the given network, based on trip rates of 3 journeys inward bound and 3 journeys outward bound from each house (see Figure 10.1). These values were then entered into SafeNet2 together with the length of each link. Pedestrian flows were not included in the analysis. Geometric data was not included. The results showed that the total vehicle casualties per year expected would be 0.03 (fatal), 0.40 (serious) and 1.89 (slight) giving an estimated total of 2.32 casualties per year or 1.78 accidents per year.

Personal accident data was supplied by Leicestershire

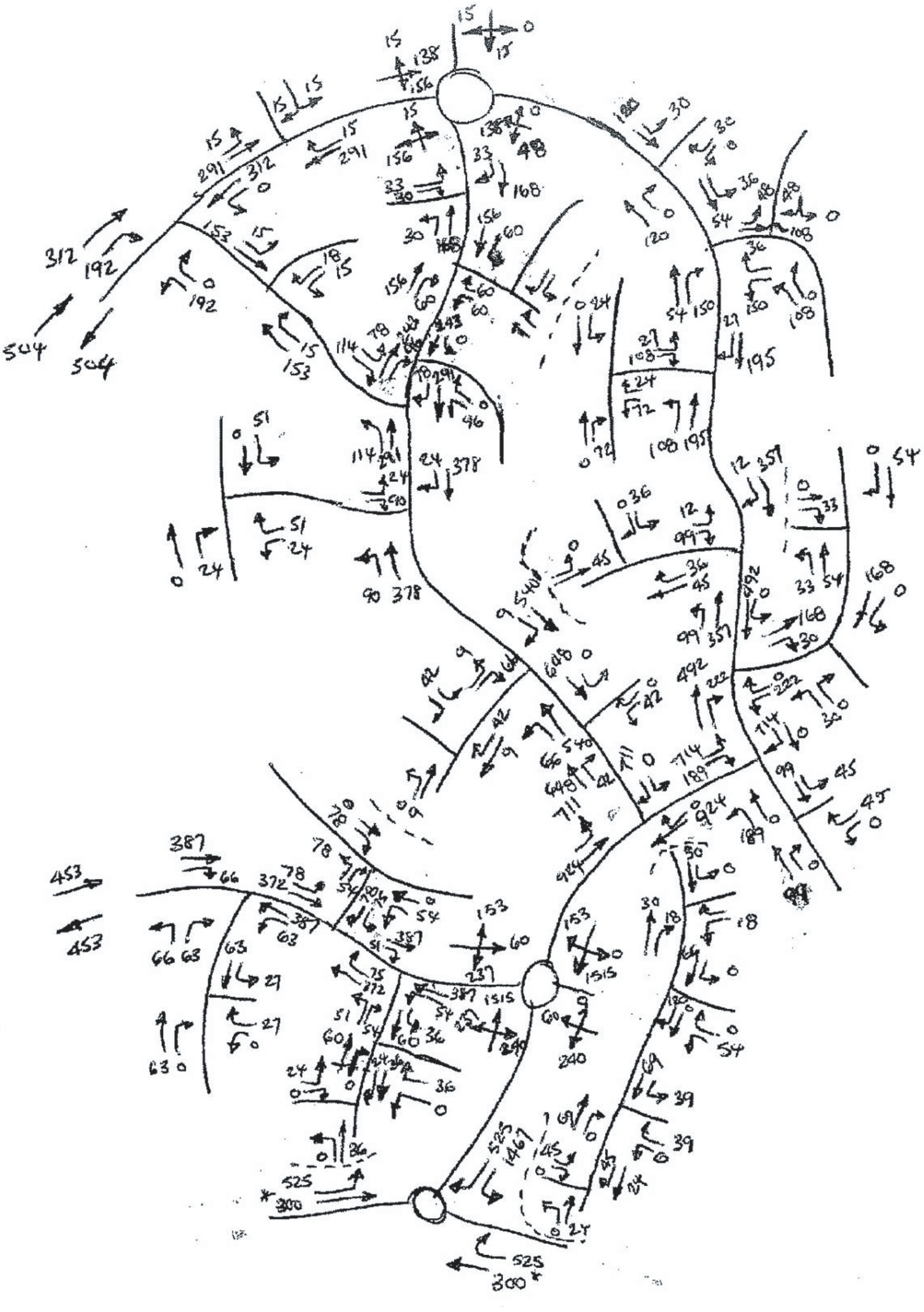

Figure 10.1 DB32 network for SafeNet analysis

County Council for 5 years which showed that there had been 3 slight accidents on the residential estate road junctions onto the highway network and 2 slight accidents on the residential estate roads giving an average of 1 accident per year overall.

Unconnected network (1)

Estimated by SafeNet	1.78 accidents per year (1)
Actual recorded	1 accident per year

These results show good agreement with the observed accidents. It should be noted that the accident data supplied by Leicestershire County Council stated that Thorpe Astley is 'an on-going settlement' and the effect of this on the 5 year accident data was unknown.

Connected network (2)

The roads in the DB32 compliant network (1) (see Figure 10.1) were connected so that the area was made more permeable and the street layout more organic. The flows through each line and junction were estimated, using the same assumptions as in the original network, for the new connected network (see Figure 10.2) and the SafeNet analysis was repeated.

Estimated by SafeNet	1.85 accidents per year (2)

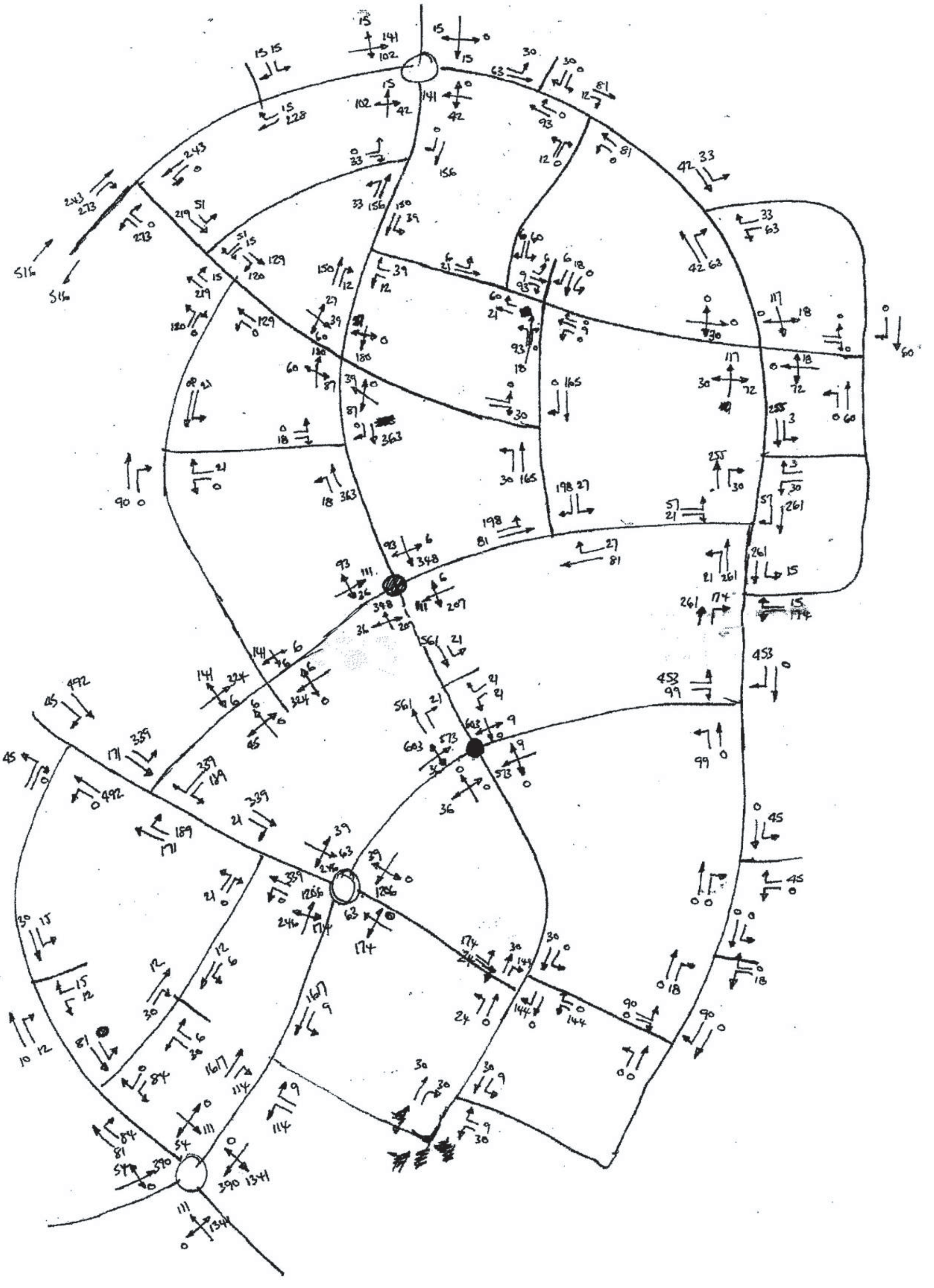

Figure 10.2 Connected network for SafeNet analysis (organic)

Connected network (3)

It was noted that two crossroads in the connected network (2) (marked as solid black circles in Figure 10.2) had a relatively high number of accidents per year. These two crossroads were replaced by two roundabouts and the SafeNet analysis was repeated.

Estimated by SafeNet 1.69 accidents per year (3)

10.1.2 Overall results

The overall link and junction results for the various networks estimated by SafeNet are summarised in Table 10.1, together with the average number of actual accidents recorded per year over a 5 year period.

Table 10.1 Results of SafeNet analysis compared with actual accidents

	Accidents per year		
Network type	*Links*	*Junctions*	*Total*
Actual	0.40	0.60	1.00
Estimated DB32 (1)	1.08	0.70	1.78
Estimated organic (2)	0.92	0.92	1.85
Estimated organic (3)	0.92	0.76	1.69

The SafeNet analysis showed that some of the data used was outside the lower limits of the validated working range of SafeNet (See Figures 10.1 and 10.2). The lower limit for ‘T’ junctions in SafeNet is 200 vehicles per day for the main road and the lower limit for circulating flows for roundabouts in SafeNet is 276 vehicles per day and for the entry/exit to an arm is 305 vehicles per day.

There were slightly more accidents predicted by SafeNet for the DB32 network (1) compared with the connected organic network (2), but it should be noted that some of the data used was outside the lower limits of the normal working range of SafeNet.

Substituting two roundabouts for two crossroads, the organic network (3) was predicted to have fewer accidents than the original DB32 network (1).

Bearing in mind that, for these networks, SafeNet is being used outside its normal working range (for some junctions) there appear to be only small differences in the effect on accidents using the different networks. However, it is encouraging that the actual numbers of accidents per year are below those predicted by SafeNet.

10.2 Crossroads analysis

SafeNet was used to study the effect of varying the vehicle flows on the major and minor arms of a hypothetical crossroads to see how the predicted accidents per year varied, based on speeds of up to and including 40 mph.

Major road flows were varied from 125 to 5000 vehicles per day in each direction and the flows on the minor arm were varied from 10% to 50% of the major road flow. All movements were across the junction only i.e. no turning.

Pedestrian flows were set to zero for the analysis.

Table 10.2 Effect of varying major and minor flows on accidents per year predicted by SafeNet

	Accidents per year for given percentage flow on minor arm		
Flow on major arm (vehicles per day)	*50%*	*25%*	*10%*
5000	3.31	1.93	0.99
4000	2.48	1.45	0.75
3000	1.72	1.01	0.52
2000	1.03	0.61	0.32
1000	0.44	0.26	0.14
500	0.19	0.12	0.07
250	0.09	0.05	0.03
125	0.04	0.02	0.02

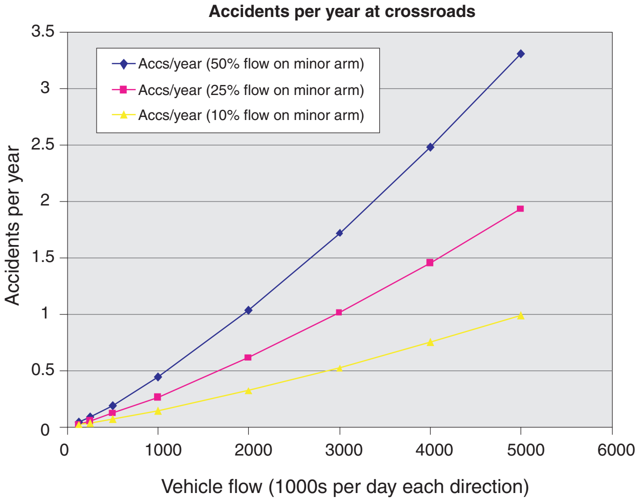

Figure 10.3 Effect of varying major and minor flows on accidents per year predicted by SafeNet

The results of the analysis are given in Table 10.2 and Figure 10.3. The results show that for the major road flows of 1000 vehicles per day the predicted accidents are less than 0.5 per year.

In summary, the hypothetical analysis exercise, undertaken using SafeNet, found that these types of network (DB32 compliant versus organic) appear to produce only small differences in the effect on accidents, except when crossroads were substituted for roundabouts. In support of this, an analysis of crossroad data found that accidents markedly increase to over one per year when flows on the minor arm exceed 1000 vehicles per day. However, it should be noted that the number of accidents overall was very low, no geometric or pedestrian flow variables were included, and only one sample network was tested.

The next section summarises the conclusions from this research and offers some possible recommendations.

11 Conclusions

This report constitutes the evidence base for the standards proposed in the Manual for Streets. Arguably, its radical findings are ground breaking because they demonstrate that residential street design can indeed be innovative, as evidenced by the headline findings:

- Lower speeds are associated with reduced road width and reduced visibility, on both links and junctions.
- Site type (for example historic, new build, DB32 compliant etc) is not a significant determinant of speed. Junction and link geometries (width and forward visibility) are the important variables.
- Speed is known to be a key factor for road safety. The findings of this research are consistent with this fact, indicating that higher speeds on links increase the likelihood of injury and its severity.
- Conflicting movements at junctions result in a higher number of accidents, but geometry can lower speeds which reduce both the chance and severity of accidents.
- Stopping distances on links and at junctions have a margin of safety down to a visibility of a round 20 m in the environments study, unless other speed reduction features are incorporated.
- The sites included roads with a range of surface types, varying use of speed restriction measures, different levels of on-street parking and a range of forward visibilities. The results are consequently applicable to a wide range of estates throughout the UK. However, the study could not encompass all situations. One site (Belgravia) was significantly different from the others, with wide road widths, large forward visibilities and high traffic speeds. This site had to be excluded from the analysis and therefore other exceptions could exist.
- Parking was found to reduce speeds on links and at junctions by in the region of 2 to 5 mph. That is, drivers react to the perceived danger by reducing their speed. The effect of this on safety is unclear. Reducing speed increases relative safety, but parked vehicles reduce lines of sight and can consequently obscure (crossing) pedestrians. Double parking was associated with higher numbers of casualties in the STATS19 analysis. Moreover, many of the reported near misses from the household survey were related to parked vehicles. On balance it would appear prudent to manage parking within an estate design. The household survey confirmed the importance to residents of having adequate provision close to their home, but that unmanaged on-street parking can cause issues and possibly dangers. Design could therefore aim to either use off-street parking, or reduce the interaction of pedestrians with parked vehicles near to a thoroughfare.
- Reducing road width reduces drivers approach speeds, a reduction from 10 to 5 metres was predicted to reduce speeds on links by up to 4 mph and speeds approaching junctions by up to 10 mph. Though these were absolute width measurements, it is possible that the same results may be achievable using psychological measures to give the appearance of reduced width.
- The largest effect on speeds was found to be associated with reducing lines of sight. A reduction from 120 to 20 metres reduced approach speeds by approximately 20 mph on links and 11 mph at junctions. Modelling has shown the reduction in approach speed should result in sight distances of 40 metres being relatively safe, i.e. there is an acceptable safety margin to stop should a danger present itself. However, the margin of safety becomes rapidly smaller below 40 metres, and sight distances of 20 metres are predicted to be unsafe unless other features are employed to further reduce vehicle speed.
- Other factors that can affect speeds at junctions were found to be block paving and junction markings. Block paving was found to reduce approach speeds by approximately 5 mph. The effect of having no junction markings was less clear with the models disagreeing as to whether removing them reduces speeds. The model based upon ATC data, and therefore the most robust dataset, predicted that removing junction marking reduced approach speeds by between 3 and 6 mph.

Residents' concerns

With respect to the perceptions of residents surveyed, the following can be concluded:

- Residents' opinions of their area, in particular with respect to safety, were investigated in twenty housing estates. The estates covered a mixture of historic sites, new build sites and ones that were DB32 compliant.
- The main reasons for residents choosing to live in these estates were because of the ambiance (quietness, friendly neighbours) and the location of the houses in relation to amenities.
- Across the sites there were mixed reactions to whether personal, or road, safety issues were of most concern. Residents at DB32 compliant sites considered personal safety (in relation to crime) to be of the greatest concern, but this was not the case at other sites. It is unclear whether this was owing to higher crime rates at the DB32 sites, the perception of road safety at other sites, or a combination of both these factors. However, overall nearly half the respondents considered road safety to be the main issue, compared with nearly 30% who considered personal safety to be the highest concern.
- One consistent comment stemming from this research in relation to crime was the association of youth crime with pedestrian and cycle routes. It was considered that these resulted in various forms of vandalism, presumably if these were off the main thoroughfares where perpetrators are less likely to be observed.
- Generally, respondents considered their street to be safe for adults walking, but less so for children. As would be expected, they considered the danger to children playing increased as age decreased. They also considered cyclists to be at risk, with over 40% considering child cyclists unsafe.
- Residents' strongest dislikes about their area were related to parking, in particular, inconsiderate parking causing difficulties of access, or the misuse of designated parking spaces. Inconsiderate parking included parking on the footway and therefore impeding pedestrians, parking on corners and reducing lines of sight and parking resulting in difficulty for other vehicles passing. Furthermore, respondents considered

that available off-street parking was not often optimally utilised, and nearly half of them had difficulties parking outside their home.

- Parking on-street can result in streets not functioning in the way they were designed, and this can create hazardous driving conditions. Twenty of the sixty-six incidents reported by respondents, who gave details of accidents and near-misses, were related to parking.
- Through traffic, particularly the high speeds of vehicles, was another major concern for residents: second only to parking. Overall approximately half the respondents were concerned about speeds, and in New Town (Reading) 80% expressed a concern over speeds.

These results have been integrated into the Manual for Streets in the form of appropriate standards for residential street design, and will become the focus for Government guidance on new residential streets.

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Appendix A: Literature review

Key content	*Source*	*Description of source*	*Country of origin*	*Recommendations / Key conclusions*
Objectives for streets				
What makes for good streets and networks.	English Partnerships / Llewelyn Davies (2000). *Urban Design Compendium.*	Has samples of model streets based on their position in a hierarchy covering the following classifications: Main Road; Avenue or Boulevard; High Street; Street or Square; and Mews or Courtyard (p. 75). It sets this in direct contrast to the engineering oriented perspective which sees streets solely in terms of vehicle carrying capacity and ignores the multi-functional role of streets.	England, UK	The current highway/engineering approach to road hierarchies is inappropriate. It suggests instead an alternative hierarchy of streets and spaces.
Local distinctiveness.	Scottish Executive (2005). *Residential streets, planning.* Advice Note 74.	This PAN focuses on the design of better quality residential streets, in particular, factors which can create good quality streets design.	Scotland, UK	Context, when considering design, is very important. Recommendations are made regarding fitting in with the local character, linking design to the surrounding area, and considering the movement through and within a site. Creating an identity for a street is also important, which will involve defining a street character type, selecting appropriate street furniture, materials and signage.
Hierarchy of modes.	Chorlton, E (2000). Just whose street is it anyway? *Surveyor,* 20th July 2000, pp. 15-18.	Chorlton (2000) questions street uses and whether all streets have to be made accessible to all. Progress on the 'Designing Streets for People' document is discussed.	UK	Streets are dominated by excessive signage, utility installations, barriers and clutter, while the highway space between buildings is given primarily to motorised modes of traffic. Vast acres of surfacing have been laid to ensure that the biggest articulated vehicles in the country can negotiate each bend and junction, while pedestrians, visitors, shoppers and residents make do with what is left.
Sustainable communities				
Security issues.	ODPM (2004). *Safer places: the planning system and crime prevention.*	The guide stresses the importance of structure and building block layout in order to minimise the likelihood of crime. A safe urban structure is characterised by buildings with limited exposure to the public realm, with active frontages looking onto streets, complemented by a regular movement framework.	UK	Creating defensible spaces and clear visibility are essential considerations.
	ODPM (2004). *Safer places: the planning system and crime prevention.*	The guide argues that car parking is ideally located in home garages or driveways behind curtailage. This is of course not always possible and not always desirable in design terms. The recent preference for courtyard parking needs to be carefully designed to maximise natural surveillance. Ideally only one entrance should be allowed. On street parking which is well supervised from neighbouring houses may actually be better than courtyard parking in safety terms in many cases.	UK	● Parking needs to be provided in a manner which allows for natural surveillance and reduces the likelihood of theft or vandalism. ● Permeability is not only about access, but also about visual permeability which improves surveillance and safety. ● Tackling fear of crime is multi-faceted and dependent on many factors, not all of which can be tackled by the design principles and effective management and policing can help to reduce fear of crime.

Key content	*Source*	*Description of source*	*Country of origin*	*Recommendations / Key conclusions*
Sustainable communities (Continued)				
Security issues *(continued).*		Streets should be part of a clear and legible movement framework. There should be a clear distinction between planning system alone. However a combination of good public, semi-private and private spaces. This definition need not be achieved by introducing obstacles to visual permeability and hence reducing surveillance and passive observation. Reducing fear of crime is a cross-cutting theme throughout the report. Fear can be reduced effectively by adhering to the principles outlined in the report. Among the most important which can make people 'feel' safer are: having clear and identifiable routes; having urban structures which provide for natural surveillance of public spaces and 'defensible' private spaces; having appropriate public lighting in darker areas at night and in certain locations (e.g. dark, enclosed laneways, under bridges etc.) during the day; CCTV and other management measures in certain extreme cases; and having active spaces. Crime can be deterred by the presence of onlookers. On the other hand too many people present opportunities for certain types of crime such as pick-pocketing.		● Planners should target an appropriate level of human activity for each location in order to reduce the risk of crime and create a sense of safety at all times.
	ACPO (2004). *Secured By Design.*	The Secured By Design scheme is run by the Association of Chief Police Officers (ACPO) which aims to encourage housing developers to design out crime, with particular emphasis on domestic burglary, at the planning stage. However, research behind the recommendations is not clear, and certain suggestions contradict measures suggested in other key areas (e.g. traffic calming).	UK	● Car parking – in-curtailage parking arrangements are preferred. Communal parking should be in small groups, close to or adjacent to the resident's property. ● Street lighting – all lighting must comply with BS 5489.
	Home Office (2000). *An evaluation of secured By Design housing within West Yorkshire*. Briefing Note 7/00.	This briefing note explores the implementation of Secured By Design (SBD) principles and its effects on actual levels of Crime. An evaluation of SBD housing took place in the West Yorkshire Area between April and October 1999.	UK	Comparisons of new build sites revealed that there were 26% fewer crime events per dwelling (using recorded crime figures) per dwelling in the SBD sample. For vehicle crime (Theft of Motor Vehicle, Theft from Motor Vehicle and TWOC) there were 42% fewer offences within the SBD sample. Attitudes towards safety were also found to be positive on the SBD housing estates. 11.4% of SBD respondents in a survey stated that they felt 'very unsafe' on the streets surrounding their home, alone, at night, compared to 19% of non-SBD respondents.
Mixing uses.	Ben-Joseph E (1995). Changing the residential street scene: adapting the shared streets	Ben-Joseph (1995) investigates the elements of shared streets, including social benefits, residents satisfaction, costs, local controls and design initiatives.	USA	States that more time spent playing in streets increases chances for social interaction. German study found that street re-design led to a 20% increase in play activity (Eubank, 1987). Studies in

Key content	*Source*	*Description of source*	*Country of origin*	*Recommendations / Key conclusions*
Sustainable communities (Continued)				
Mixing uses *(continued).*	concept to the suburban environment. *Journal of the American Planning Association,* Volume 61, Issue: 4.			Japan reported that 90% surveyed said that shared streets are for people rather than automobiles, 67% said their children play on the street and it is a safe place to play. 66% felt that the shared streets encourages social interaction and conversation between neighbours (Ichikawa, 1984).
	English Partnerships / Llewelyn Davies (2000). *Urban Design Compendium.*	The Compendium has a section which concentrates on developing a thriving public realm. The section on creating social spaces is of relevance here and suggests focusing activity areas on nodes of activity along with quiet areas to rest and relax. It also separately emphasises the importance active frontages in terms of generating activity and encouraging passive observation. It suggests that roads should better be understood as streets linking a network of places, rather than as a hierarchy of roads.	UK	Roads should be understood as streets and streets in turn as places. In this light the function of and activity within the space is important.
Provision for play, Home Zones.	ACPO (2004). *Secured By Design.*	The Secured By Design scheme is run by the Association of Chief Police Officers (ACPO) which aims to encourage housing developers to design out crime, with particular emphasis on domestic burglary, at the planning stage. However, research behind the recommendations is not clear, and certain suggestions contradict measures suggested in other key areas (e.g. traffic calming).	UK	Communal areas – playing and seating areas should be within view of residential properties.
Green spaces.	DTLR (2002). *Green spaces, better places: final report of the Urban Green Space Taskforce.*	This report suggests that urban parks and greens spaces have a crucial role to play in involving the community in providing the vision for and getting involved in their local environment. Variety of function is an important aspect in encouraging the community to make better use of such places and spaces.	UK	An essential element of providing high quality urban parks and green spaces in designing them with a wide range of users in mind, such as children, BME groups and people with disabilities.
	DTLR (2002). *Green spaces, better places: final report of the Urban Green Space Taskforce.*	Positive Green Spaces can improve the image of the locality and help to instil a sense of local pride. Creating attractive urban parks and green spaces does not happen by chance. The report suggests making use of design reviews for failing parks and green spaces. It argues strongly against using generic blueprints and instead argues that every space is contextualised. Better management of parks and open spaces is urgently required in order. The report advocates a better focus on parks among local authorities, in partnership with the local community in order to establish agreed priorities for maintenance and investment.	UK	Design reviews and better management can result in an improved urban park and green space product. Landscape design should meet the needs of efficient maintenance and cost effectiveness without compromising variety.

Key content	*Source*	*Description of source*	*Country of origin*	*Recommendations / Key conclusions*
Sustainable communities (Continued)				
Mixing uses *(continued).*	English Partnerships / Llewelyn Davies (2000). *Urban Design Compendium.*	It suggests using a variety of methods to make the urban environment more stimulating; it suggests that designers should consider the senses in terms of how they design spaces and places. Aside from the visual elements which can aid liveability and tasteful signage where necessary, there is also touch, sound and smell.	UK	Careful landscaping can be used to stimulate the senses and make the urban environment more appealing.
Quality places				
Layout, geometric and material choices.	Stewart (2000). Reclaiming the streets. *Surveyor,* 20th July 2000.	Stewart (2000) discusses the design of Ingress Park housing development, the site of 950 new homes in Greenhithe, south bank of the Thames in Kent. The roads within the development have been designed to reduce the impact of the car on the environment. The design features deployed to achieve this have challenged and stretched the current guidelines and accepted norms. There is a main spine road running through the development, but it ranges from only 5 to 6 m wide at the narrowest point, 1.25 m below the design guide minimum. The spine road also runs past the front of homes, encouraging safer driving and pedestrian use of space. The spine road also encompasses 90^{o} bends, crossroad junctions and pinch points, and drivers have to pass side elevations of buildings only a footpath's width away. It is envisaged that these design features will encourage vehicles to slow and increase pedestrian safety. Pedestrians and cyclists are provided with direct straight line routes across the site, whereas drivers are forced to follow the spine road as it snakes around the houses either in sharp or sweeping curves. Parking provision norms have also been challenged, with a maximum of 2 spaces per house, regardless of the number of bedrooms, provided. To encourage the use of public transport, no home is more than 300 m from a bus stop. However, no laybys are provided and there are landscaped central road islands adjacent to bus stops, ensuring that other vehicles have to remain behind buses until all passengers have boarded.	UK	● Challenging the domination of the car by prioritising other forms of transport. ● Using buildings to create strong pinch points on streets. ● 'Threading' the spine road through the site. ● Creating continuous frontage to spine road. ● Designing-in bus priority and including designated bus routes Creating 'Home Zones' where pedestrians, not cars, have priority Permeating the site with footpaths and cycle networks. ● Developing a strong car parking strategy. ● Restraining vehicular speed to 20 mph and below.
Street character.	Svensson T (2000). *Balancing car accessibility and good urban environment, transport systems organisation and planning*. Proceedings of 3rd KFB Research Conference, Stockholm, June 2000.	The purpose of the research was to investigate and analyse the balance between the benefits to an individual offered by unlimited car access and the related consequences of overall traffic volumes that individuals would choose if connections between these variables was made clear. Individuals were presented with a questionnaire, asking to choose a number of different scenarios, presented by different, but complementary, techniques. Four different	Sweden	44% (the majority) of all respondents stated that they would prefer the lower speed limit scenario. However, the scenario stresses the importance that car access does not jeopardise the safety and comfort of cyclists and pedestrians. The scenario advocates space sharing for the use of the entire street in residential areas. The overall results of the study revealed that individuals prefer scenarios where all kinds of road users relatively coexist on streets and roads in towns and cities where

Key content	*Source*	*Description of source*	*Country of origin*	*Recommendations / Key conclusions*
Quality places (Continued)				
Street character *(continued).*		scenarios of residential areas within an urban setting are described. The characteristics that vary between scenarios are the conditions for cars and parking, which will have consequences for public transport, pedestrians, cyclists and children's play on the streets.		this situation has been reached by traffic calming measures.
	DfT (2005). *Attitudes to streetscape and street uses.*	This report focuses on the results of the DfT's ONS omnibus survey (undertaken in October 2004) regarding people's attitudes to streets as part of the built environment, including public opinion on residential streets.	UK	One quarter of respondents stated that the impact of traffic on their quality of life was serious. 55% of all respondents thought that traffic in their area was dangerous to pedestrians and other road users. Of those that thought traffic was dangerous in their area, half thought that traffic calming would be a solution. When asked to rate the quality of their street in terms of how it is laid out or built, 80% of respondents agreed it was pleasant. People were asked which users should have priority in their street or road if it were to be redesigned. Parking for residents (46%), children playing (435) and walking (42%) were the three most popular responses. 67% of respondents agreed that it was important for them that their street should have more 'soft landscaping' such as trees and green areas. The majority (71%) thought that it was important for everyone to have a parking space outside their house. People generally thought that it was important for the street to be a good place to stop and talk to neighbours (81%). Respondents were asked which physical quality they looked for when choosing a place to live. 80% stated feeling safe when walking around, 75% thought that a good general environment was important, while 66% looked for a well-maintained street. 80% of respondents thought that it was important for their street to be a high quality environment (e.g. quality paving, green areas, street art).
Dimensions streets and squares, relationship to building heights and massing.	Scottish Executive (2005). *Residential streets, planning.* Advice Note 74.	This PAN focuses on the design of better quality residential streets, in particular, factors which can create good quality streets design.	Scotland	Dorset County Council's 'Highway Guidance for Estate Roads' (2002) was produced to ensure that estates were no longer indistinguishable from each other and not related to their locale. The document supports speed restraint that is designed into the development from the beginning and is not bolted on as an afterthought. Speed humps and chicanes are not acceptable, and speeds are kept low through the positioning of key buildings and spaces, and reducing the effective length of road sections to 60 m – speeds should therefore remain below 20 mph. Junctions with reduced radii are encouraged, as are speed restraining bends (which limit forward visibility) and varying the width of the horizontal alignment. On-street parking is allowed.

Key content	*Source*	*Description of source*	*Country of origin*	*Recommendations / Key conclusions*
Quality places (Continued)				
Dimensions streets and squares, relationship to building heights and massing *(continued).*	DTLR and CABE (2001). *By Design: better places to live.*	Brief reference to four possible ratios of street width to building height (residential areas only). There is also a discussion about 'setbacks' again in relation to the model provided by Poundbury.	UK	The key issue is the space between the buildings in relation to the scale of the buildings and the activities taking place in the street. Specific ratios should be taken as a guide only and adapted to the level of activity and the context.
Minimising clutter / signage / markings.	English Partnerships / Llewelyn Davies (2000). *Urban Design Compendium.*	The Urban Design Compendium offers an overview of urban design best practice in the UK and Internationally. It covers a wide range of interrelated topics which provide practitioners with a reference guide of what works well and why.	UK	Brief reference to prevalence of sloppily drawn lines and need to consider roads/streets more sensitively. Public Realm contains many different elements which need careful consideration. The design compendium argues that this is not often achieved well with too many organisations putting in too many different elements to the public realm in an uncoordinated manner. This can lead to excessive clutter which can have negative effects on non-car users. They cite the example of sheep-pen style traffic crossings which provide free flow for traffic, while impeding pedestrian movement. They make four specific recommendations in relation to street clutter: 1 Remove superfluous and obsolete elements – establish visual logic with clear messages for drivers, cyclists & pedestrians. 2 Design space so functions are clear and so need for signs is minimised. 3 Hide it or flaunt it – some elements are necessary evils – where they cannot be hidden they should be treated as a for of public art and highlighted tailored to the specific context. 4 Producing a comprehensive and coordinated strategy of elements for each space – again context driven.
	English Partnerships / Llewelyn Davies (2000). *Urban Design Compendium.*		UK	In relation to signage, the Compendium suggests that signage for pedestrians and cyclists is as important as that for motorists. They suggest four considerations: 1 Consistent and co-ordinated design. 2 Making the structure of the place legible so as to minimise the need for signs. 3 Concentrating pedestrian signage at key nodal points. 4 Implicit routing defined by the paving type and other methods to ease orientation.
	ODPM (2004). *Safer places: the planning system and crime prevention.*	Safer Places is intended as a general guide to the broad planning principles outlined in PPS1. The guide is not only about designing out crime, but also about promoting good design leading to safe, sustainable and attractive environments that meet the full set of planning requirements. The guide concentrates on how the planning system can deliver sustainable environments.	UK	The placing of street furniture, especially by utility companies, should be carefully considered so as to minimise the likelihood of anti-social behaviour such as vandalism. Each element of the streetscape needs to be considered as part of a total whole. Insensitively placed additions are a problem in many streetscapes and needed to be tackled on a coordinated basis.

Key content	*Source*	*Description of source*	*Country of origin*	*Recommendations / Key conclusions*
Quality places (Continued)				
Dimensions streets and squares, relationship to building heights and massing *(continued).*	Noordzij P C and Hagenzieker M P (1996). *Verkeersborden, bebakening en verkeersveiligheid.* SWOV, Leidschendam.	Investigation into the effects of traffic signs and road markings on safety.	Netherlands	The authors investigate the effects of traffic signs and road markings on safety. The following measures have been identified to improve the contribution of traffic signs and road safety: Make a distinction between important and less important traffic signs; Improving the design of these signs to make them more noticeable, recognisable and understandable (for example, introducing new signs to indicate what type of road a user is on); Placing speed limit signs everywhere at the entrance to a (section of) carriageway or to an area, and repeating them where necessary; Reinforcing the message on the signs of other, more natural indicators; Replacing some of the road makings whose message is intended to be read at different times of the day or night.
Movement				
Street networks and types.	English Partnerships / Llewelyn Davies (2000). *Urban Design Compendium.*	The Urban Design Compendium offers an overview of urban design best practice in the UK and Internationally. It covers a wide range of interrelated topics which provide practitioners with a reference guide of what works well and why.	UK	See comments under Signing/Clutter – it argues that minimising pedestrian barriers can help to create a more walking friendly environment. Guard Railing in particular though sometimes billed as pedestrian improvements can actually speed up impeding movement on foot and rather reinforce vehicular movement. The guide also offers an example of Canning Street in Liverpool where selective street closure in a historical layout has been used to achieve a better balance between vehicles and other users. This is a useful method as the barriers to vehicle movement are not actually 'dead-ends' as they are remain permeable to cyclists and pedestrians - and potentially emergency service vehicles and disabled drivers depending on the treatment used.
	DeRobertis M and Wachtel A (1996). *Traffic calming dos and don'ts to encourage bicycling*. ITE Annual Meeting Compendium.	This paper examines the effects of various traffic calming measures on cyclists, including discomfort, feelings of safety and inconvenience.	USA	Those traffic calming measures that are NOT recommended include meandering roadways (cause erratic movements by motorists and increased distances for cyclists); chicanes (cyclists are forced closer to vehicles); STOP signs (increase delay to cyclists); and rumble strips (causing discomfort to cyclists, and possibly steering difficulty/loss of control).
	Kennedy J V, Wheeler A H and Inwood C M (2004b). *Kent quiet lanes scheme.* TRL Report TRL603. Wokingham: TRL.	Quiet lanes are rural roads that mostly satisfy the following criteria: narrow single-track road; very low flow; not a main access route; no street lighting; national speed limit. This study focuses on a pilot undertaken on roads in Kent. The Quiet Lane network was implemented between August 2000 and May 2001. The network was designed to link towns, villages, public rights of way and the existing cycle routes. Traffic calming on busier stretches of road include false cattle grids (5 rumble strips) and colouring of the centre section of the road, leaving edges of the road	UK	Mean speeds in Kent reduced from 29.2 mph to 26.9 mph a reduction of -2.3 mph. Speeds at the 85th percentile reduced from 35.2 to 32.6, -2.6 mph. However, greater reductions, -2.8 mph (mean speed) and -3.2 (85th percentile) were recorded on control roads, showing negligible changes in speed . Traffic flows were reduced slightly when compared to the control roads, from 2,137 to 2,122 on weekdays and 1,577 to 1,453 at the weekends (Control road volumes increased). Support remained strong in both the before and after attitudinal surveys, with over 75% of respondents in favour of the schemes.

Key content	Source	Description of source	Country of origin	Recommendations / Key conclusions
Movement (Continued)				
Street networks and types *(continued).*		unchanged (narrowing effect). Footways have been widened and Quiet Lanes signs were erected. Extensive monitoring was undertaken, including before traffic and speed surveys and before and after attitudinal and video surveys.		
	Kennedy J V, Wheeler A H, and Inwood C M (2004a). *Norfolk quiet lanes Scheme.* TRL Report TRL603. Wokingham: TRL.	This study focuses on a pilot undertaken on roads in Norfolk. The Quiet Lane network was implemented in March 2000, with small modifications until November 2000. Extensive monitoring was undertaken, including before traffic and speed surveys and before and after attitudinal and video surveys.	UK	Mean speeds in Norfolk in the July reduced from 30.2 mph to 30.1 mph a reduction of -0.1 mph. Speeds at the 85th percentile reduced from 36.8 to 36, -0.8 mph. However, greater reductions, -1.1 (85th percentile), were recorded on control roads (+0.1 for the mean speed), showing negligible changes in speed. Mean speeds in Norfolk in the November reduced from 30.5 mph to 30.2 mph a reduction of -0.3 mph. Speeds at the 85th percentile reduced from 36.4 to 36.2, -0.2 mph. However, greater reductions, -0.8 mph (mean speed) and -1.5 (85th percentile) were recorded on control roads, showing negligible changes in speed. Traffic flows were reduced slightly when compared to the control roads, from 1,943 to 1,879 on weekdays and 1,245 to 1,091 at the weekends (Control road volumes increased by 10.1% in both cases). Support remained strong in both the before and after attitudinal surveys, with over 75% of respondents in favour of the schemes.
	DfT (2004). *Quiet lanes.* Traffic Advisory Leaflet 3/04, UK.	This Traffic Advisory Leaflet summarises the research undertaken by TRL (Kennedy *et al.*, 2004 a and b) on the implementation and monitoring of Quiet Lanes in Kent and Norfolk.	UK	Recommendations are made for local authorities on the implementation and monitoring of quiet lanes.
Street dimensions.	Daisa J M and Peers J B (1997). *Narrow residential streets: do they really slow down speeds?*	Road narrowing as a means of calming or slowing traffic is investigated within this paper. Speed data was collected from almost 50 streets in the San Francisco Bay area where kerb widths varied from 25 ft (7.62 m) to 50ft (15.24 m). Parking density was also surveyed. the selected streets had similar characteristics to allow comparison.	USA	Key conclusions included: wider residential streets experienced higher speeds for both the average and 85th percentile speeds; on-street parking density significantly affects speeds (where it is present, it reduces speeds); traffic volumes and vehicle headway affect speeds; and significant reductions in effective street width are required to dramatically reduce speeds.
	DTLR and CABE (2001). *By Design: Better places to live.*	'Better places to live' is a companion guide to PPG3 and is intended to aid practitioners in the delivery of the changes outlined in PPG3. It focuses on urban design principles as they relate to the residential environment, building on the principles outlined in the Urban Task Force Report and the Urban White Paper.	UK	The guide suggests that lessons from countless traditional towns point to the impact that the overall arrangement of buildings and spaces can have on driver's behaviour. It argues that buildings which obstruct drivers' forward vision can result in drivers adopting a more cautious and slower approach. Active traffic control elements such as chicanes, ramps etc are only necessary if the design has failed and corrective measures are required. Better design reduces the need for corrective measures.
	Polus A and Craus J (1996). *Planning and geometric aspects of shared streets.*	The concept of shared streets, in particular the planning and geometric aspects, are explored. Where narrow widths are present, only one vehicle can pass along a straight		

Key content	*Source*	*Description of source*	*Country of origin*	*Recommendations / Key conclusions*
Movement (Continued)				
Street dimensions *(continued).*		section of road, whereas at diagonal sections, vehicles can pass each other in opposite directions. the angle of the diagonal section, relative to a straight line, and its width are significant in determining the radius of the path of vehicles along this section.	Israel	Recommendations regarding shared streets include: transitions between streets should be made clear through an elevated or textured surface; a safety zone of 0.90 m to 1.50 m is desirable either side of the travel lane to provide further comfort when two opposing vehicles meet; sufficient parking should be provided to accommodate visitors/guests (insufficient parking is found to be significant in failed designs).
	Barrel and Whitehouse (2004). *Home Zones – an evolving approach to community streets.* Proceedings of the Institution of Civil Engineers, 157, pp. 257-265	The impacts of the DfT's pilot Home Zone schemes are discussed by Barrel and Whitehouse (2004). The main outcome of the schemes seems to be the development of stronger and more integrated local communities through the active involvement of residents in all levels of the continued social opportunities created as a result of Home Zone implementation. However, there are certain concerns regarding some design aspects of Home Zones, such a s catering for less able-bodied members of the community. Single surface areas have benefited those with mobility problems, but this design can disadvantage the partially sighted, where no guidance is given. Therefore, boundary features have had to be incorporated into the design to provide some guidance for those with sight problems.	UK	To achieve the tightest vehicle path for cars will often result in a clear width of only 3 m in places, and lateral shifts of up to 4 m over a length of less than 10 m have been recommended. This is on two-way streets with flows of less than 100 vehicles per hour – greater widths need to be provided in order for vehicles to pass each other.
	Tilly *et al.* (2005). *Pilot home zone schemes: evaluation of Northmoor, Manchester.* TRL Report TRL625. Wokingham: TRL.	A number of Home Zone measures were applied in Northmoor, a residential area 3 miles south-east of Manchester City Centre. These measures included replacing parallel parking with echelon parking on alternate sides of the road, slowing vehicles using chicanes, introducing 'green streets' between the parallel streets, introducing particular features such as small gardens and wall mounted pots outside the houses, planting trees in the streets, and renewing and upgrading street lighting. To assess the effectiveness of the schemes, TRL carried out before and after monitoring, including interview surveys with adults and children, collection of traffic flow, speed and accident data and video recording.	UK	Parking has been reduced from 56 kerb side spaces to just 26 echelon spaces; residents in the after survey regarded parking as an 'unresolved' issue. Over half of the respondents thought that the home zone had increased parking problems outside their house. On three of the streets, the mean speed was reduced to 11.5, 9.4 and 12.6 mph, with 85th percentile speeds of 14.2, 13.9 and 16.1 mph. The speed on the distributor road just outside of the area, 85th percentile speeds increased slightly to 21.3 mph. On the roads without any measures, speeds remained similar in both the before and after (18 mph and 23 mph). Streets with measures reduced traffic flows by 19 to 34%. on untreated streets, traffic reduced by 17%. 39% of respondents thought that drivers were more considerate to children playing in the street, whereas 53% thought they were about the same. 72% thought it was very safe or quite safe for adults walking or cycling in the Home Zone. Of the 28% who thought it was not very safe or not at all safe, reasons given included too many parked cars (19%), vehicles travelling too fast (20%) and lack of pavement width (16%). There was 5 years of 'before' accident data and 23 months of 'after' accident data. Although the sample was very small, the data showed that the number of accidents per year reduced from 1.0 before to 0.5 accidents per year after.

Key content	Source	Description of source	Country of origin	Recommendations / Key conclusions
Movement (Continued)				
Street dimensions *(continued).*	Layfield *et al.* (2005). *Pilot home zone schemes: evaluation of Magor Village, Monmouthshire.* TRL Report TRL633. Wokingham: TRL.	A number of Home Zone measures were applied in Magor village, 5 miles east of Newport. These measures included Gateway treatments, flat top humps, extensive planting , bollards and 'Stonemaster Flags', 20 mph zone outside the boundary of the zone, narrowing of the road. To assess the effectiveness of the schemes, TRL carried out before and after monitoring, including interview surveys with adults and children, collection of traffic flow, speed and accident data and video recording.	UK	Little change to the overall number of parking spaces occurred. However, residents in the after survey regarded parking as an 'unresolved' issue. Over half of the respondents thought that the Home Zone had increased parking problems. On Sycamore Terrace, speed humps had as small effect on the mean speed which reduced by 2.5 mph to 13.9 mph. (85 percentile – 16.8 mph). The speed humps north of The Square reduced the mean speed slightly by 1.7 mph to 12.2 mph (85 percentile – 14.8 mph). Just outside of the Home Zone, mean and 85th percentile speeds reduced by 4 mph to 22 mph and 28 mph respectively. Flows on Sycamore Terrace increased by 15%, whereas those on The Square reduced by 50% – mainly due to it becoming one-way after installation. 19% of respondents thought that drivers were more considerate to children playing in the street, whereas 61% thought they were about the same. 55% thought it was very safe or quite safe for adults walking or cycling in the Home Zone.
	Layfield *et al.* (2005). *Pilot home zone schemes: evaluation of Magor Village, Monmouthshire.* TRL Report TRL633. Wokingham: TRL.		UK	Of the 28% who thought it was not very safe or not at all safe, reasons given included too many parked cars (17%), vehicles travelling too fast (8%), problems at the school entrance 96%) and lack of pavements (6%). Only one slight injury accident occurred in the before period of 7 years giving an accident rate of 0.14 accidents per year (a car and a motorcyclists travelling in opposite directions north of The Square – this type of accident should no longer occur due to the new one-way system). The after period, of just 9 months shows that there have been no accidents in the Home Zone.
Junctions.	Lawton B J, Webb P J, Wall G T and Davies D G (2003). *Cyclists at 'continental' style roundabouts: report on four trial sites*. TRL Report TRL584. Wokingham: TRL.	This study focuses on the use of 'continental' style roundabouts, which feature narrower circulating carriageways than typical Britishroundabouts and typically have fewer entry and exit lanes on each arm, and their effects on the safety of cyclists. This style of roundabout is typically used on roads where there are lower traffic flows, as they are not designed with the aim of maximising vehicle flows. Because of the design, 'continental' style roundabouts appear to be easier for cyclists to negotiate, and it is suggested that they are therefore safer. The study used a series of 'before' and 'after' video and interview surveys, a study of roundabout flows using ARCADY, and an analysis of accident statistics at the roundabouts before and after installation.	UK	Due to the low number of cyclists in both survey types, it was difficult to come to any firm conclusions regarding changes that could be made to increase safety for cyclists at roundabouts. A number of positive measures were identified that appear to have an effect on safety of cyclists at geometry on approaches; a reduction in the number of entry and exit lanes; an enlarged central island; the introduction of toucan crossings on the arms of roundabouts; and the addition of cycle strips at the give-way lines.

Key content	*Source*	*Description of source*	*Country of origin*	*Recommendations / Key conclusions*
Movement (Continued)				
Junctions *(continued).*	English Partnerships / Llewelyn Davies (2000). *Urban Design Compendium.*	Applies worked example of the tracking principle to the design and layout of junctions. While junctions will always be place specific, it suggests that junctions be kept as tight as possible. Some tight corners have a traffic calming effect. It suggests that junctions should be weighted in favour of pedestrians in the majority of cases. Shared spaces (cars, cycles, pedestrians on the same route) are also advocated.	UK	Under the argument keep it tight the compendium suggests that tight corners have a major traffic calming effect.
	DETR and CABE (2000). *By Design: Urban design in the planning system: towards better practice.*	Some brief references to junctions, which it argues can be treated as spaces in their own right and/or as a point of entry, which can improve legibility by helping to identify places and to better define routes.	UK	As above.
	DTLR and CABE (2001). *By Design: better places to live.*	Gives example of tight junctions and pinch points in Poundbury which encourage drivers to take corners more carefully.	UK	As above.
Achieving appropriate speeds.	DTLR and CABE (2001). *By Design: better places to live.*	'Better place to live' is a companion guide to PPG3 and is intended to aid practitioners in the delivery of the changes outlined in PPG3. It focuses on urban design principles as they relate to the residential environment, building on the principles outlined in the Urban Task Force Report and the Urban White Paper.	UK	By Design suggests that developments can be laid out in such a manner as to encourage low(er) traffic speeds. They make four suggestions: 1 Developments should be designed with regard to their effect on traffic speeds. 2 Traffic speeds can be managed by the arrangement of buildings and spaces – physical traffic-calming measures should be secondary, but considered as integral as part of the design process and not as an afterthought. 3 Changes in materials or 'gateways' at the entrance to low speed areas can alert motorists to the need to reduce speed. 4 Smaller corner radii will encourage more careful vehicle movement. The layout and design of buildings and the spaces between them have the potential in themselves to reduce the speed of traffic. Where additional remedial measures are deemed necessary, they should ideally be integrated into the initial design of the public realm. Where this is not possible, new additions should be 'designed in' rather than merely conforming to engineering standards.
	Brindle R E (1996). *Designing for moderate speeds in new neighbourhoods*. ARRB, Special Report No. 53.	Road width – as a measure to reduce speeds. Street section length.	UK	A UK research report by Nobel (1984) found that minor reductions in available carriageway width appear to make very little difference to speeds. Drastic ones, like those produced by lines of parked cars, had only a limited effect. Nobel (1987) cites that on straight roads more than 200 m long, mean speeds will be close to 50 km/h (31 mph); below 200 m, mean speeds willbe progressively lower, reducing to about 30 km/h (19 mph) at 60 m. Bennett (1983) stated that it would be possible to achieve low speeds on streets of traditional cross-section and visibility standards, using short lengths of streets and

Key content	Source	Description of source	Country of origin	Recommendations / Key conclusions
Movement (Continued) Achieving appropriate speeds *(continued).*				frequent 90 degree bends – although such configurations would be far from conventional Avoid long and wide sight lines, whilst being careful that stopping sight distances are being observed. The design speed for vertical sight distance should not be less than that for horizontal sight distance, and should be greater if horizontal sight distance is at a minimum. Use occasional interruptions to the parking lanes (such as planting areas) to constrain the 'optical width' of the street, being careful to protect sight stopping distances
	Brindle R E (1996). *Designing for moderate speeds in new neighbourhoods*. ARRB Special Report No. 53.		UK	At the small scale, encourage innovative total design to produce speeds well below those in conventional estates. Total design of the street, combining considerations of length, visibility, texture and materials, cross-section, edge treatments, activity, roadside development and planting is required to make sure that all the variables work in concert to produce a safe, low-speed environment.
	Scottish Executive (1999). *Natural traffic calming: guidance and research report.*	This report for the Scottish Executive explores road environment factors which may have an effect on driver behaviour, focusing on 'natural traffic calming'. The study is based on a combination of real-life examples and behavioural or psychometric testing. Local authorities in Scotland were contacted which resulted in the identification of ten locations where traffic appeared to be 'naturally calmed'. Physical surveys were undertaken of each of the roads, including traffic surveys (composition), speeds (before and after). In five of the locations, these were complemented with more detailed data collection, including questionnaire surveys of drivers and pedestrians.	Scotland, UK	Scenarios which produce the lowest speeds (questionnaire responses) were revealed to be pedestrians crossing (20 mph), children present (23 mph), lorries unloading (24 mph) and cars parked on both sides of the road. These results suggest that the perceived risk of collision with pedestrians is one of the most powerful influences on people's average speeds. The next lowest average response speeds relate more to road and traffic conditions; the road surface is cobbled (26 mph), traffic is heavy (27 mph), several street intersections (28 mph) and high buildings located close to the road (29 mph). The case studies revealed that it is a combination of different features which have the most influential effect on driver behaviour. Transition was highlighted as being important: helping drivers adjust their perceptions and their speed to the environment which they are entering using a range of different physical and perceptual factors. Transition can include: sequential changes in landscape and townscape; changes in physical conditions of the road itself; activity and features within the road environment and associated 'ownership' of the street environment; and changes in driver perceptions of risk and uncertainty. One of the most important variables that needs to be taken into consideration is 'risk homeostasis' – the way in which drivers adjust their behaviour to maintain a consistent level of risk. As drivers feel safer, they begin to take more risks whereas conversely, if road conditions make them feel unsafe, drivers are likely to adjust their behaviour to take fewer risks.

Key content	*Source*	*Description of source*	*Country of origin*	*Recommendations / Key conclusions*
Movement (Continued)				
Achieving appropriate speeds *(continued).*	Grayling *et al.* (2002).	The study examined the relationship between deprivation and child pedestrian casualties in Britain and the use of 20 mph zones to reduce injuries and inequalities. A survey was undertaken of traffic-calmed 20 mph zones in England and Wales. Of the 171 county and unitary district councils, 119 questionnaire responses were received. 80% had implemented at least one traffic-calmed 20 mph zone, total of 684 zones, and there were a further 441 zones planned. Hull was found to have extensive 20 mph zone coverage, about 100 zones covering 25% of its road length. It was estimated that Hull's programme of 20 mph zones since 1994 has already saved about 200 serious injuries and 1,000 minor injuries.	UK	The main recommendation from the report is that a maximum 20 mph speed limit combined with traffic calming should become the norm in residential and built up areas and that priority should be given to traffic calmed 20 mph zones in deprived areas with high casualty rates.
	Vis A A, Dijkstra A and Slop M (1992). *Safety effects of 30 mph zones in the Netherlands.*	This study looks at the reason 30 kph (18.5 mph) zones were introduced, and the effects that these zones have in 15 areas within the Netherlands. The evaluation of zones used three types of study; traffic studies (mode split, traffic volume, speed, placement on the road, conflicts and behaviour at intersections); opinion research projects (resident's views); and an accident study (before and after – the zone, surrounding arterial roads and control areas). Four types of engineering measure were evaluated: informative measures; suggestive measures (road narrowing); persuasive measures; and obstructive measures.	Netherlands	Key results were as follows: speed; humps, narrowing of the road, (partial) barricades, elongated humps and entrance constructions almost always achieved a 85th percentile value (V85) of about 30 kph. The effect is much less for refuges and humps with cycle lanes. Traffic volume: traffic intensity generally fell by 5 to 30%, which was particularly prevalent in areas where measures affecting circulation were introduced which resulted in a considerable 'loss of time' for through traffic. traffic nuisance generally declined (problems exist regarding the comparability of before and after periods and interpretations). Resident's opinions: interviews were conducted with a random sample of the population showed that there was a high level of acceptance of the 30 kph regulation. Residents generally prefer the new situation over the old one, feel safer as the speed and intensity of the traffic is lower. A marked change in the actual use of the area was not reported, even though present conditions would favour such a change.
	Engel U and Thomsen L K (1992). Safety effects of speed reducing measures in Danish residential areas. *Accident Analysis and Prevention*, 24 (1) pp. 17-28.	The authors evaluate the safety effects of speed reducing measures, using studies based on accidents and vehicle speeds (accidents – all police reported accidents; personal injury and damage only; and casualty – personal injury only). Before and after periods were 3 years each in the accident studies.	Denmark	Accidents per km of road: 10 km of 15 kph (9 mph) and 223 km of 30 kph (18.5 mph) streets were used. No significant changes were found in the 15kph streets, although there were significant changes in the 30 kph streets; a change in accidents of 24% (77 fewer accidents in 3 year) Reductions in casualties in the same street type were 45% (88 fewer casualties in 3 years). in the streets adjoining the 30 kph streets, accidents reduced 18% (150 fewer accidents) and casualties reduced 21% (106 fewer casualties). Accidents per road km: There was a significant change in the number of casualties per road user km of 72%, with confidence limits ranging from 4 to 29% due to the change in street status. There was also a change in the number of seriously injured of 78% (Confidence 26-93%). Motor vehicle speeds: Speed reducing measures were implemented with a distance of a max of 100 m. The greatest change in speed was achieved through the use of humps (up to -13 kph).

Key content	Source	Description of source	Country of origin	Recommendations / Key conclusions
Movement (Continued)				
Achieving appropriate speeds *(continued).*	Countryside Agency (2005). *Mini guide to rural road safety and traffic calming.* Faber Maunsell.	This guidance prepared for the Countryside Agency looks at rural road safety and traffic calming.	UK	Natural traffic calming is recommended; using trees, hedges, walls and buildings to slow speeds. Examples are given of where this has been implemented, including Suffolk, where hedges have been created to give the perception of a narrowed carriageway without physical alterations. Bends, narrow roads and rough surfaces are also variances of rural traffic calming. Wiltshire County Council have taken an innovative approach to reducing speeds through removing white centre lane lines from roads that are lit and are subject to a 30 mph speed limit. 12 sites were assessed when resurfacing works were undertaken in the last three years. In the village of Seend, the council have noticed a reduction of 5% in speed. the long term removal of white centre lines on effectiveness is still to be seen.
	Aburahmah and Al Assar (1998). *Evaluation of neighborhood traffic calming techniques in residential areas*. ITE Annual Meeting Compendium, Washington DC: Institute of Transportation Engineers.	This study investigates whether the installation of physical measures such as speed humps reduce the operating speeds and volumes of traffic in residential areas. The study focuses on four residential locations in Manatee County where speed humps have been implemented to reduce traffic speeds. Speed and traffic volume data was collected before and after installation of the speed humps. Significance testing was also undertaken using the 't' test.	USA	The percentage reduction in speed (at the 85th percentile) varied from -6.9% to 36.7%, where was the percentage reduction in average daily traffic flows ranged from -200.5% to 30%. The overall conclusions included that the speed at midpoints between the humps and overall speed reduction was affected by the humps, and that traffic volumes were also reduced in some locations. However, traffic volumes remained the same or slightly increased in other locations.
	Hardy S (2004). Pushing the boundaries. *Surveyor*, 1st July 2004.	Hardy investigates the use of physical surroundings in creating traffic calming effects, and therefore, potentially safer environments. Although the positioning of key buildings or structures is important in forming 'place', there are also other considerations, such as from a traffic movement point of view. Hardy explores the concept that the placement of structures can be used as a positive influence to reduce vehicle speeds by virtue of their bulk and/or form.	UK	Intimidation has an impact on drivers through the perceived thrat they hold to the driver. Positive intimidation is achieved through the repercussions of collision with the built or natural form immediately adjacent to the vehicle path, whereas negative intimidation is achieved through the repercussions of falling into the void immediately adjacent to the vehicle path. the positive intimidation can result in the reduction of speeds as the driver is required to recognise and navigate a forward route. Build forms placed directly in front of the driver's path of travel will inhibit directional legibility as the route ahead has to be the subject of deliberate, selective thought process.
	Kennedy J V, Gorell R, Crinson L, Wheeler A and Elliott M (2005). *Psychological traffic calming.* TRL Report TRL641. Wokingham: TRL.	This paper examines the use of psychological means of traffic calming as an alternative to physical vertical measures, which can have a number of negative effects. A case study example of the village of Lattern, Wiltshire, where various psychological measures were implemented on a former trunk road. The scheme area is the main road through the village which carried approximately 2,000 vehicles a day. The speed limit was 40 mph within and just outside the built up area and was extended for about 1 km. 85th percentile speeds were in excess of the limit. The new	UK	Build-outs were used to define parking bays to narrow the road and give a gentle chicane effect (although road remained 5.5 m wide). Planting on the build-outs and parked vehicles were intended to limit the forward visibility and break up the sightlines. Gateways were introduced at each end of the village. Inbound mean speeds fell by 8 mph and 4 mph at the north and south gateway respectively, to 37 mph at both (47 mph 85th percentile speeds). In the village, two-way traffic speeds fell by 7-8 mph to 31 mph and 85th percentile speeds fell by 8-10 mph to 37-38 mph. This was despite under use of parking pays

Key content	Source	Description of source	Country of origin	Recommendations / Key conclusions
Movement (Continued)				
Achieving appropriate speeds *(continued).*		scheme consisted of stone gateways with village nameplate and 30 mph signs (new limit); build outs with planting to narrow the road and create parking bays on alternate sides of the carriageway; removal of centre white line; and lowering of lighting columns to a height more appropriate for a minor road.		(allowing vehicles to pass each other with ease through straddling the empty parking bay) and the forward visibility not being reduced as much as intended (particularly due to immature planting on build-outs).
	Elliott M A, McColl V A and Kennedy J V (2003). *Road design measures to reduce drivers' speed via 'psychological' processes: a literature review.* TRL Report TRL564. Wokingham: TRL.	This literature review considers the relevant psychological theories to provide an insight into how specific road design measures might reduce driving speeds.	UK	● Psychological measures to date have generally produced smaller speed reductions than those from physical measures and their effect may lessen over time. However, they may be more acceptable to drivers. ● In general, more complex environments tend to be associated with slower driving speeds, the likely mechanisms being increases in cognitive load and perceived risk. ● Roadside activity e.g. on-street parking or the presence of pedestrians tends to reduce speed. Bus or cycle lanes are more likely to reduce speeds when they are in use. ● Combinations of features tend to be more effective than individual measures.
	Scottish Executive (1999). *Natural traffic calming: guidance and research report.* Scottish Executive Development Department	The study attempted to identify the underlying principles behind natural traffic calming. Ten small or medium towns on through routes in Scotland that appeared to be naturally traffic-calmed were selected as case studies. Psychometric work, designed to highlight the relative importance of different features or situations, was undertaken.	Scotland, UK	The research suggested that traffic calming should be defined as a process of helping drivers adjust to the environment. It was concluded that drivers are influenced by a large number of different cues.
	Chinn L and Elliott M (2002). *The effect of road appearance on perceived safe travel speed: Final report.* PA3827/20. Wokingham: TRL.	The research by TRL for the Highways Agency on the effect of road appearance on perceived safe travel speed considered the design elements that can be used in influencing driver speed. A representative survey of 350 drivers was interviewed to assess the effect of a number of road design interventions on respondents' ratings of speed using sketches.	UK	The design elements identified were: ● Context e.g. roadside type. ● Scale e.g. road width and complexity. ● Proportion (height of enclosing features such as buildings or trees). ● Horizontal and vertical alignment. ● Activity e.g. presence of pedestrians, parked cars. ● Objects in the road corridor e.g. street furniture, landscape. ● Colour and material of surfacing. ● Historic character.
	Gibbard *et al.* (2004). *The effect of road narrowings on cyclists.* TRL Report TRL621. Wokingham: TRL.	This report considers the effects of road narrowings on cyclists the study consisted of consultation with cyclist user groups, video surveys of sites with features installed by highway authorities to assist cyclists in negotiating road narrowings, and virtual reality simulations of encounters between drivers and cyclists, measuring the reactions of drivers to be measured under a range of circumstances.	UK	The study revealed that negotiating narrowings constituted to a source of stress to cycle users.

Key content	*Source*	*Description of source*	*Country of origin*	*Recommendations / Key conclusions*
Movement (Continued)				
Achieving appropriate speeds *(continued).*	Kallberg V and Ranta S (2000). *Impacts of urban speed-reducing measures.* 2nd International Symposium on Highway Geometric Design, Mainz, Germany June 14-17, 2000, pp. 93-109.	This researched identified studies from different countries over the last 25 years where initial speed levels and the effects on speeds were measured of various urban speed-reducing measures.	Germany	
Emergency access.				
	Boulter *et al.* (2001). *The impacts of traffic calming measures on vehicle exhaust emissions.* TRL Report TRL482. Wokingham: TRL.	This study investigated the emission impacts of nine types of traffic calming measures; 75 mm-high flat top road humps, 80 mm-high round-top road humps, 1.7 m wide speed cushions, combined pinch point and speed cushion, 100 mm-high raised junctions, chicane, build out, mini-roundabout and 1.9 m wide speed cushion. As part of the study, the access of emergency vehicles and possible delays were investigated as a result of traffic calming installation.	UK	The experiment consisted of a fire tender and driver travelling through a residential circuit featuring various traffic calming measures. The speed reduction caused by the speed cushions was significantly smaller than that caused by the flat top humps. However, the time delay per measure was relatively small and, unless large numbers of traffic calming measures are encountered, it is unlikely that emergency fire tender response times would increase significantly.
	Engwicht D (2003). *Intrigue and uncertainty: towards new traffic-taming tools, version 2.1.* Creative Communities International.	Engwicht investigates the use of intrigue and uncertainty as a means of calming traffic without the need for implementing physical measures. It is suggested that through increased street activity and use by residents, drivers begin to expect the unexpected, therefore drive slower and increase safety.	UK	6 design principles are discussed; creating rooms rather than corridors (use of walls and entry/gateways, furniture and art); reducing traffic oriented devices (visual clues rather than excessive signage); evolving a unique personality for each street (less standardisation of design across a number of streets; create ever-changing streetscapes; build ambiguity and legibility; design after use.
	Scottish Executive (2005). *Residential streets, planning.* Advice Note 74.	This PAN focuses on the design of better quality residential streets, in particular, factors which can create good quality streets design.	Scotland	The needs of refuse, fire and other service vehicles should be considered in the planning of the street network – the size of vehicles to be accommodated should be established through dialogue with local agencies.
DDA/Disabled requirements.	Oxley (2002). *Inclusive mobility: a guide to best practice on access to pedestrian and transport infrastructure.*	The DfT (2002) have published 'Inclusive Mobility', which is best practice guidance on access to pedestrian and transport infrastructure. Although primarily aimed at improving access for disabled people, many of the designs will meet the needs of other people, including those travelling with small children or are carrying luggage/heavy shopping, and those with temporary mobility problems.	UK	Provides specific guidance (including measurements) for footways (widths), gradients, fences and guardrails, seating, barriers on footways, ramps and steps, street furniture, street works, colour contrast, surfaces (including tactile paving), road crossings, dropped kerbs and raised crossings.
	Williams K, Savill T and Wheeler A (2002). *Review of the road safety of disabled children and adults.* TRL Report TRL559. Wokingham: TRL.	This study provided a review of the information available on the road safety of children and adults with disabilities. The review looked at a variety of groups, including those with learning difficulties, ADHD, Autism, physically disabled, hearing impairment, visually impaired and multi-sensory impaired. The impact on mobility and safety, accident risk, and remedial measures, including engineering measures, were identified for each group.	UK	Learning Difficulties - Provision of guard-railing outside schools to guide learning disabled children to a crossing, or prevent running into traffic. Physically disabled – following of IHT guidance. Hearing Impairment – pelican crossing with visual clues, PUFFIN crossings are beneficial as green/red man signs are on same side as pedestrians. Visually impaired – widespread use of tactile paving to indicate crossing points, adopting standards for footways which incorporate 'unobstructed widths',

Key content	*Source*	*Description of source*	*Country of origin*	*Recommendations / Key conclusions*
Movement (Continued)				
DDA/Disabled requirements. *(continued).*				coloured pave (such as in home zones) should be avoided as it can be difficult to see where the carriageway starts or create an illusion of obstacles in path (Duncan Jones, 2001), and street corners with kerb flush with the carriageway on the radius can be hazardous, people may find it difficult to line themselves up with the opposite carriageway. It is recommended that for the benefit of those with learning difficulties, or those who suffer from ADHD, guard railing should be positioned outside schools to guide learning disabled children to a crossing, or prevent running into traffic.
Parking				
PPG3.	ODPM (2003c). *Delivering planning policy for housing: PPG3 implementation study.*	PPG3 states that parking can be used as a mechanism to slow traffic, with the intension of increasing safety.	UK	
Layouts/designs on/off-street parking.	DOT (1993). *Pavement parking.* Traffic Advisory Leaflet 04/93.	This traffic advisory leaflet looks at the consequences of pavement parking where there is a lack of formal parking provision. The consequences should be considered when parking provision is limited.	UK	DOT states that It [pavement parking] can create hazards for visually impaired, disabled and elderly people or those with prams or pushchairs. It may also cause damage to the kerb, the pavement or the services underneath.
	Noble and Jenks (1996). *Parking: demand and provision of private sector housing developments.* Oxford Brooks University	A study involving 1,526 dwellings served by 47 roads in Lower Earley and Woodley, Reading.	UK	Observations showed that on-street parking made it difficult for drivers in some places to see beyond the parked cars, thereby appearing to make overtaking hazardous. Vehicles parked on the footway were seen to force pedestrians to walk in the road, and parking on shared surfaces made access inconvenient for pedestrians using these surfaces and appeared to create hazards.
	Noble *et al.* (1987). *Roads and parking in private sector housing schemes: studies of accident records, innovative layouts and parking provision.* Housing Research Foundation.	Noble *et al.,* has identified a number of safety related objectives to be pursued when designing layout as a whole.	UK	It was found that very few accidents occur in cul-de-sacs and short loop roads which function as residential only roads, suggesting that traffic flow, rather than parking, is a major contributor to accidents. Cul-de-sacs serving up to 80 dwellings were included in the surveys and there were no statistically significant increase in the accident rate per dwellings associated with the size of cul-de-sacs at least up to that size. Ensure that non-access vehicular traffic is excluded or discouraged from entering the site; ensure that the shortest pedestrian routes to local amenities are along footways or separated footpaths; use the lowest categories of roads wherever possible for access to dwellings by roads carrying the least traffic; and ensure that the road layout encourages low driving speeds: e.g. by restricting the lengths of straight roads and using tighter radii on bends.

Key content	Source	Description of source	Country of origin	Recommendations / Key conclusions
Parking (Continued)				
Layouts/designs on/off-street parking *(continued).*	Westdijk (2001). *Designing a safe residential environment for children.* Proceedings of the Conference on Traffic Safety on Three Continents.	Westdijk makes recommendations as to how to achieve a safe street environment. One such approach is to create a transparent lay out.	Netherlands	Avoid long rows of parked cars; create communal parking areas away from homes; areas of child play (play area) must have an uninterrupted line of sight of 30 to 40 m either side; use of traffic calming measures to counteract the speeding that may result from good visibility.
	Scottish Executive (2005). *Residential streets, planning.* Advice Note 74.	This PAN focuses on the design of better quality residential streets, in particular, factors which can create good quality streets design.	Scotland	On-street parking is recommended to help reduce speeding traffic. Rather than rigidly defined parking bays, provision should be more informal, through either subtle widening of the road, or end-on or angled parking should be encouraged, using trees, plants or other street furniture to discourage indiscriminate parking. Where off-street parking is provided, care must be taken to ensure natural surveillance.
Environment				
Air Quality/Noise.	Boulter *et al.* (2001) *The impacts of traffic calming measures on vehicle exhaust emissions.* TRL Report TRL482. Wokingham: TRL.	This study investigated the emission impacts of nine types of traffic calming measures; 75 mm-high flat top road humps, 80 mm-high round-top road humps, 1.7 m wide speed cushions, combined pinch point and speed cushion, 100 mm-high raised junctions, chicane, build out, mini-roundabout and 1.9 m wide speed cushion.	UK	The results clearly indicated that traffic calming measures increase the emissions of some pollutants from passenger cars. Mean emissions of CO per vehicle-km was increased by 34%, 59% and 39% for petrol non-catalyst, petrol catalyst and diesel cars respectively. Emissions of NO_x from petrol only increased slightly whereas NO_x from diesel increased by around 30%. CO_2 emissions for the three vehicle types increased between 20 and 26%, and emissions of particulate matter from diesel increased by 30%. Although traffic calming generally increases emissions, it is unlikely to result in poor local air quality.
	Harris G J, Stait R E, Abbott P G and Watts G R (1999). *Traffic calming: vehicle generated noise and ground-borne vibration alongside sinusoidal, round-top and flat-top road humps* TRL Report TRL416. Wokingham: TRL.	As the maximum noise and ground-borne vibration alongside traffic-humps depends on the profile shape as well as the type, load and speed of the vehicle crossing the profile, TRL investigated three types of humps and their effects.	UK	The overall results of the study indicated that the flat-topped humps would produce higher noise and vibration levels than other designs. Even on roads where few heavy vehicles pass through, benefits will be gained for local residents, as even infrequent high noise levels can cause annoyance.
Materials and planting				
	English Partnerships / Llewelyn Davies (2000). *Urban Design Compendium.*	Brief reference to different materials which can be used, for example to indicate pedestrian routes and shared surface areas.	UK	Materials can help to define space and function and can impact on how drivers respond.
	DCLG (2006). *Tree roots in the built environment.*	Provides a review of current research and knowledge on tree roots and their interaction with the built environment.	UK	● Planting should be integrated into street designs where possible. ● Recommended sightlines for vehicles should be maintained around planted areas unless visibility is being deliberately kept short in order to limit traffic speeds.

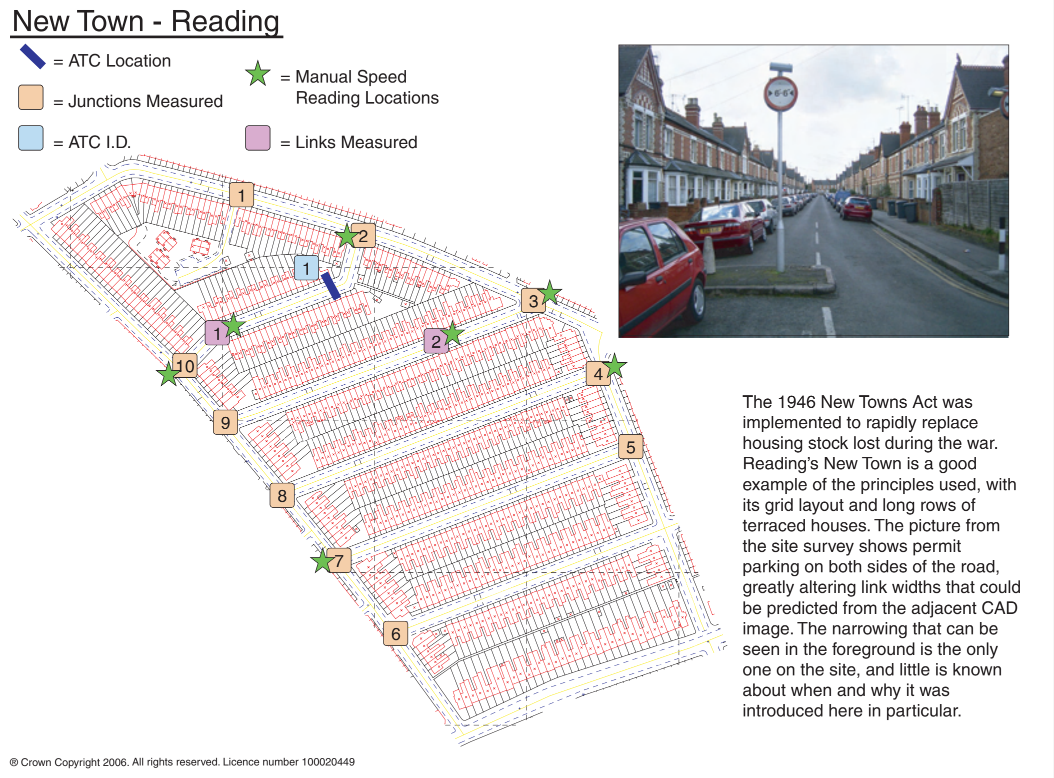
Appendix B: Case study sites

B.1 Research site characteristics

Characteristic	*Town*	*Ward*	*Region*	*Rural / urban*	*Housing period*	*Land use*	*Density*	*Network type*
Historic (pre-war)	Reading	New Town	South East	Urban	Victorian	Mixed	High	Grid
	Lavenham	Suffolk	South East	Rural	Medieval	Residential	Low	Organic
	Oxford	Jericho	South East	Urban	Victorian	Residential	High	Grid
	Bloxham Village	Oxfordshire	South East	Rural	Victorian	Residential	Low	Organic
	Chichester	West Sussex	South East	Urban	Medieval	Mixed	High	Organic
	London	Belgravia	South East	Urban	Victorian	Mixed	High	Grid
Case study	Charlton Down	West Dorset	South West	Rural	Post 90s	Residential	High	Organic
	Lichfield	Darwin Park	West Midlands	Urban	Post 90s	Residential	High	Organic
	Eastleigh	Former Pirelli site	South East	Urban	Post 90s	Residential	High	Atypical grid
	Newhall	East Harlow	East of England	Suburban	Post 90z	Residential	High	Organic
	Guildford	Queen’s Park	South East	Urban	Post 90s	Residential	Mid	Organic
	London	Tower Hamlets	South East	Urban	Post 90s	Residential	High	Grid
	Glasgow	Crown St.	Scotland	Urban	Post 90s	Residential	High	Organic
	Chelmsford	Windley Tye	East of England	Suburban	Post 90s	Residential	Low	Court layout
	Chelmsford	Beaulieu Park	East of England	Urban	Post 90s	Residential	Low	Grid
	Manchester	Hulme	North West	Urban	1990s	Residential	Low	Grid
New build	Ipswich	Rapier St.	South East	Suburban	Post 90s	Residential	High	Atypical grid
	Portishead	Port Marine	South West	Suburban	Post 90s	Residential	Mid	Organic
DB32 Compliant	Leicester	Syston	East Midlands	Urban	1980>	Residential	Mid	Cul-de-sac with spine
	Reading	Lower Earley	South East	Urban	1980>	Residential	Mid	Cul-de-sac with spine

B.1.1 New Town, Reading

- Site approximately 1.5 km from Reading Town Centre. Bus route on nearby London Road.
- Site area: 12.6 ha.
- Approximately 623 housing dwellings.
- Housing density: approximately 49 dwellings per hectare (dph)
- Predominantly residential. One school nearby.
- Residential mix: mostly terraces. Some conversions into flats.
- Housing tenure: None assigned, although prices in this area are probably lower than the average amount in Reading.
- 20 mph speed limit throughout area introduced in mid nineties as a road safety scheme.
- Parking: oversubscribed. Most of the houses in New Town were built for the workers of the old Huntley and Palmer Biscuit factory on King's Road to live in and work. They were never intended to accommodate on street parking, especially not on both sides of the road as occurs.
- Local planning authority and highway authority: Reading Borough Council.

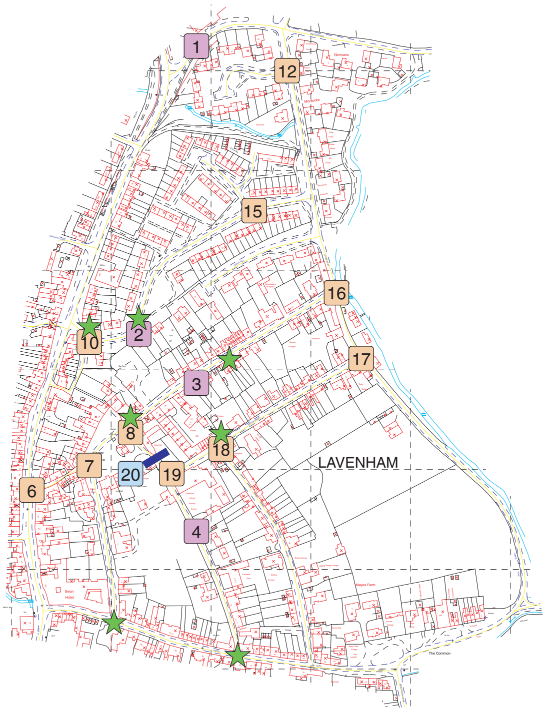


The 1946 New Towns Act was implemented to rapidly replace housing stock lost during the war. Reading's New Town is a good example of the principles used, with its grid layout and long rows of terraced houses. The picture from the site survey shows permit parking on both sides of the road, greatly altering link widths that could be predicted from the adjacent CAD image. The narrowing that can be seen in the foreground is the only one on the site, and little is known about when and why it was introduced here in particular.

B.1.2 Lavenham, Suffolk

- 30 mph speed limit in place.
- Organic network type.
- Local planning authority: Suffolk County Council.

Lavenham - Suffolk



╲ = ATC Location

▨ = Junctions Measured

▨ = ATC I.D.

★ = Manual Speed Reading Locations

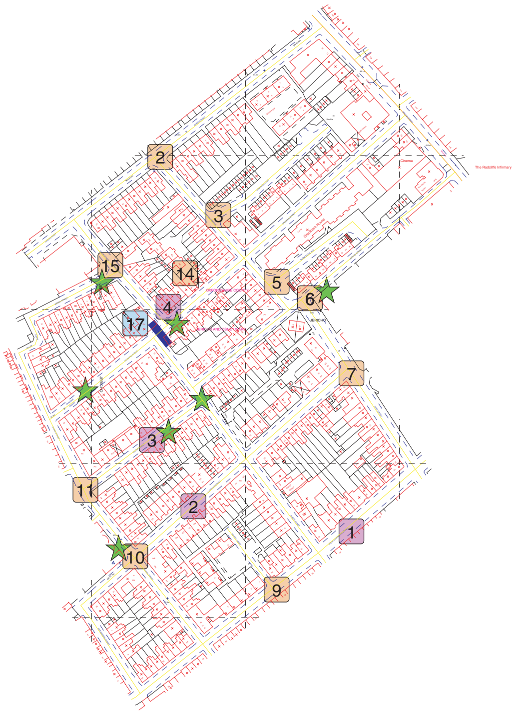
▨ = Links Measured

Lavenham is situated in rural Suffolk and dates back to the medieval period. The street layout is organic and highly varied. The picture shows a junction with relatively low visibility on approach, caused by building frontages being characteristically close to the carriageway. Parking also restricts the road to single file in this instance, but on other sections narrow streets are signed as one-way.

B.1.3 Jericho, Oxford

- Site located outside Oxford’s old city walls in a historic area, north of the city.
- Site area: 7.5 ha.
- Approximately 693 dwellings.
- Housing development began in the nineteenth century.
- Residential mix: mostly two-up two-down terraced housing, some semi-detached and flats.
- Housing tenure: 25% of people live in owner-occupied property, 57% rent from private landlords and 18% rent from social landlords, mostly the council.
- 30 mph speed limit on site.
- Grid network type with mostly on-street parking.
- Local planning authority: Oxford City Council.
- Local highways authority: Oxfordshire County Council.

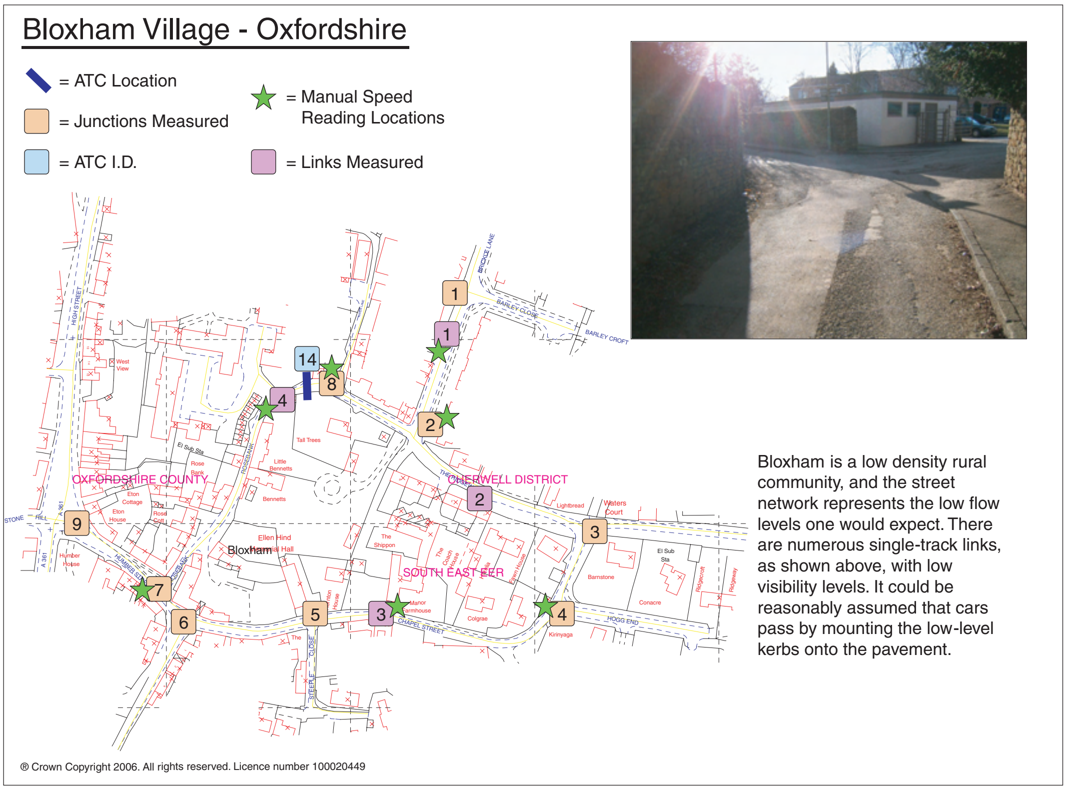
Jericho - Oxford



Jericho, just outside the centre of Oxford, is a Victorian development with a grid layout typical of the era and location. The rows of terraced houses, narrow streets (with permit parking bays) and frontages in close proximity to the carriageway create many junctions like the one shown in the picture. Visibility is poor on approach due to buildings, but when on the junction it is usually a parked vehicle that restricts visibility down the straight roads.

B.1.4 Bloxham Village, Oxfordshire

- Local planning authority: Oxfordshire County Council.
- 30 mph speed limit.



Bloxham is a low density rural community, and the street network represents the low flow levels one would expect. There are numerous single-track links, as shown above, with low visibility levels. It could be reasonably assumed that cars pass by mounting the low-level kerbs onto the pavement.

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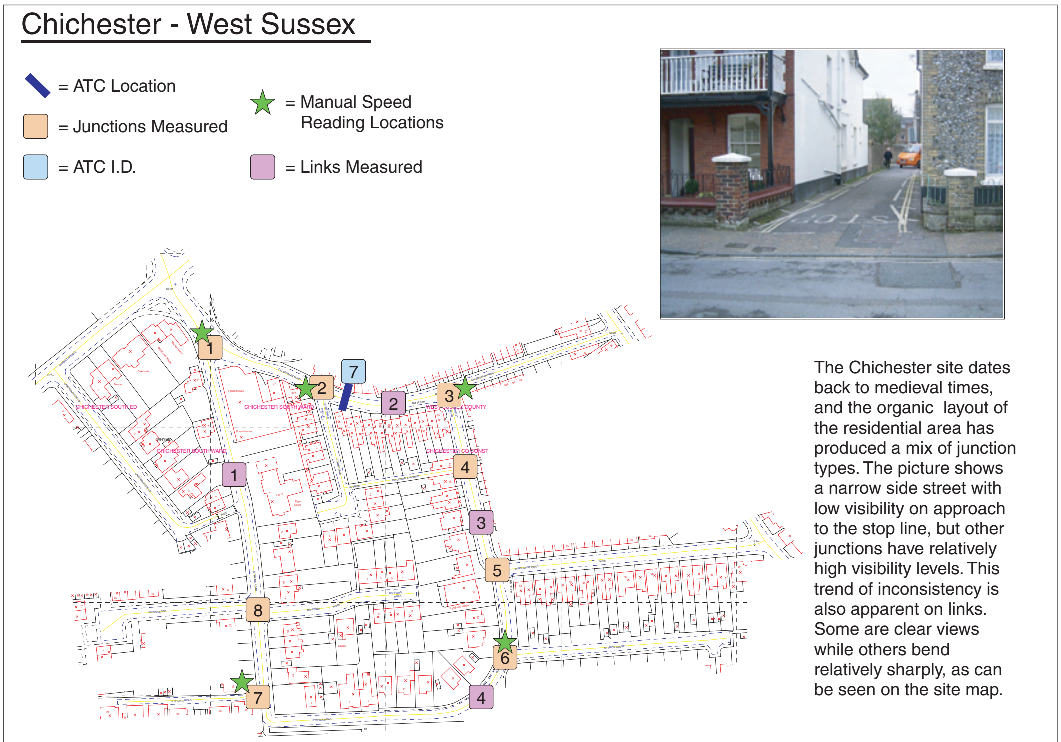
B.1.5 Chichester, West Sussex

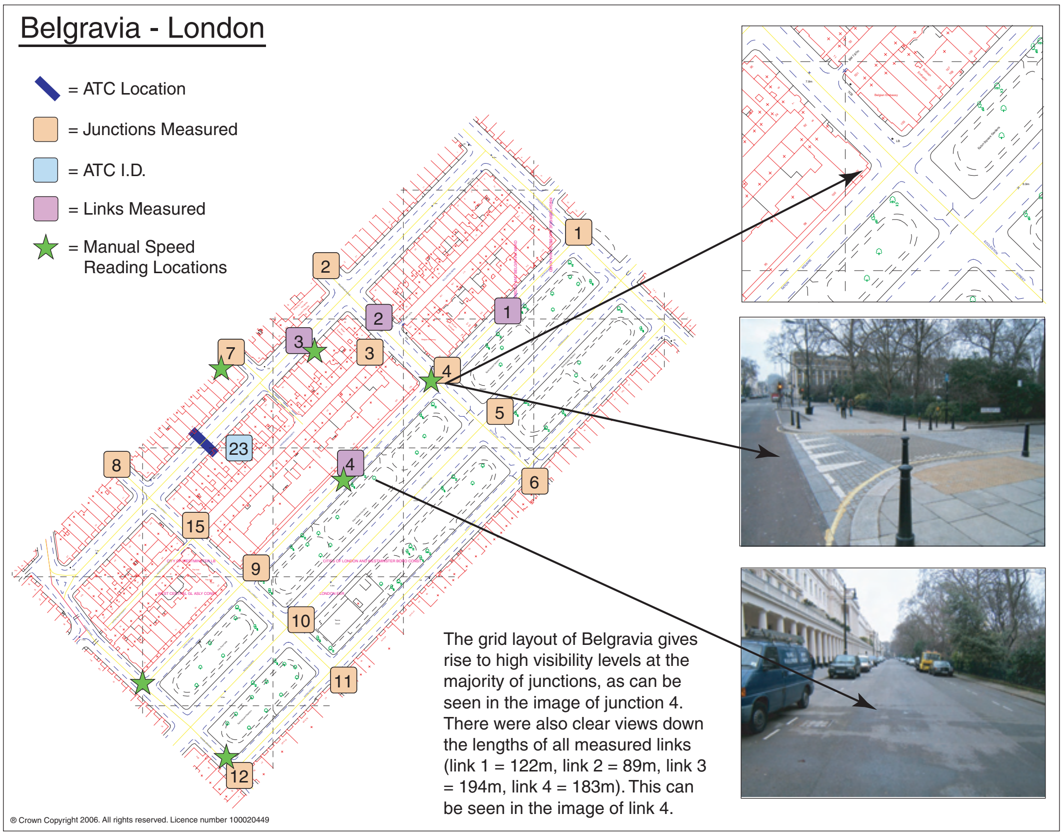
- Site located approximately 500 metres south west from Chichester town centre and approximately 1 km from the rail / bus stations located to the west of the site.
- Site area: 4.4 ha.
- Approximately 278 dwellings.
- Site is residential and affords a mix of detached and terrace houses, ranging in age and condition.
- Housing tenure: not known.
- 30 mph speed limit.
- Some houses benefit from on-site parking whilst many rely on parking within the highway. Dwellings that benefit from onsite parking provision do not normally exceed two spaces.
- Local planning authority: Chichester District Council.
- Highways authority: West Sussex County Council.



The Chichester site dates back to medieval times, and the organic layout of the residential area has produced a mix of junction types. The picture shows a narrow side street with low visibility on approach to the stop line, but other junctions have relatively high visibility levels. This trend of inconsistency is also apparent on links. Some are clear views while others bend relatively sharply, as can be seen on the site map.

B.1.6 Belgravia, London

- 30 mph speed limit.
- Local planning authority: Westminster City Council.

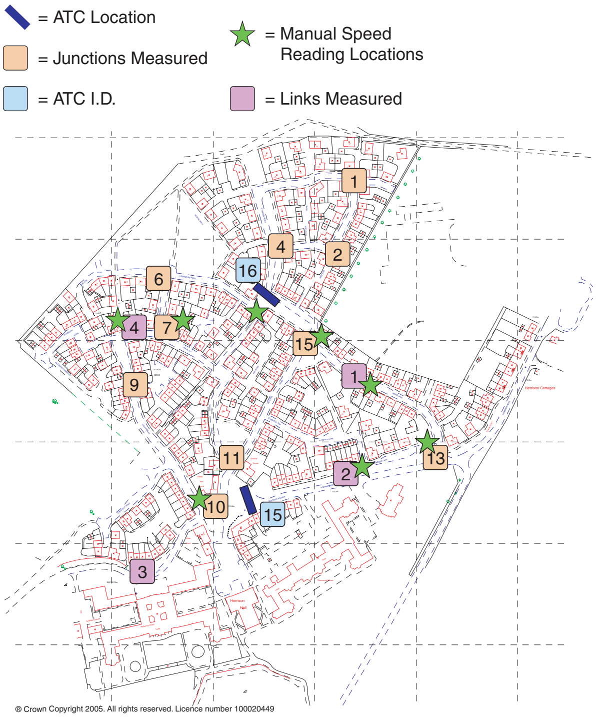


The grid layout of Belgravia gives rise to high visibility levels at the majority of junctions, as can be seen in the image of junction 4. There were also clear views down the lengths of all measured links (link 1 = 122m, link 2 = 89m, link 3 = 194m, link 4 = 183m). This can be seen in the image of link 4.

B.1.7 Charlton Down, West Dorset

- Charlton Down is mostly housing development on the site of a former mental hospital 5 km north of Dorchester, Dorset. A self-contained rural (village) development.
- When complete, the overall scheme will have 546 units, with a mix of apartments, terraced and detached units on a site area of 48ha.
- The case study phase has a density of 30 dph net.
- Initial development phase: 1998 – 2005.
- Developer: Bellway.
- DB32 was not used specifically and the designers felt that they had pushed the boundaries in terms of street specifications.
- Curvilinear layout of streets including cul-de-sac.
- Maximum vehicle speeds: 20 mph.
- Local Planning authority: West Dorset District Council.
- Highways authority: Dorset County Council.

Charlton Down - West Dorset



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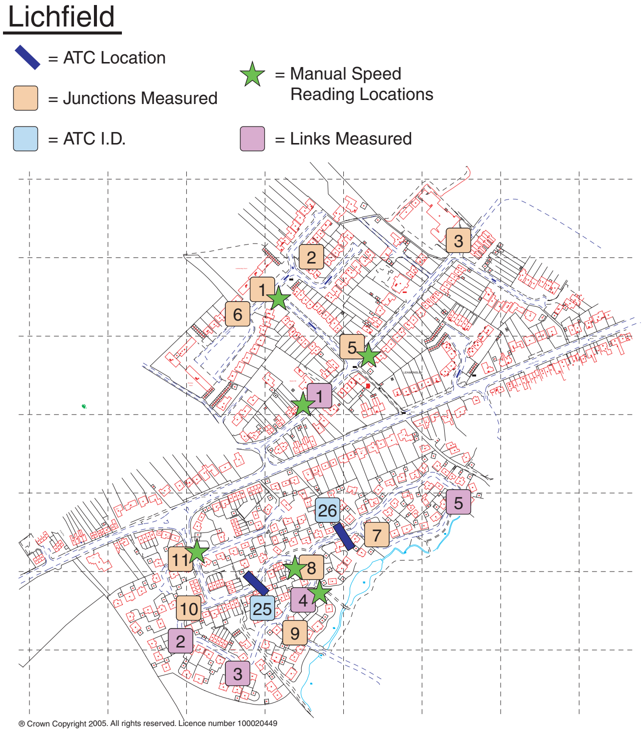
Charlton Down is a recently completed development situated in rural west Dorset. The picture shows one of several unconventional junctions on the site. Low flows allow for these informal squares to be created, though there could be confusion if vehicles were crossing paths. The bollards beyond the junction are also typical of the site. They are used widely to demarcate the pavement and road, as an alternative to kerbs.

B.1.8 Darwin Park, Lichfield

- Suburban area situated less than 2 miles south of Lichfield city centre, near to M6 toll road.
- Site area: approximately 33 ha.
- 1100 housing units when completed, supermarket, retail space.
- Housing density: approximately 33 dph.
- Residential mix: mixed apartments, terraced, semi-detached, detached.
- Housing tenure: 25% affordable housing.
- 20 mph speed limit on site.
- Parking ratio: believed to be approximately 1 or 1.5 per dwelling.
- Greenfield site.
- Development period: 1998 onwards (60% built). Due for completion in 2008/2009.
- Developer: Taylor Woodrow and Bryant Homes.
- Adopted Urban Design considerations. Curvilinear street layout. Some non-DB32 layouts used.
- Local planning authority: Lichfield District Council.
- Local highway authority: Staffordshire County Council.



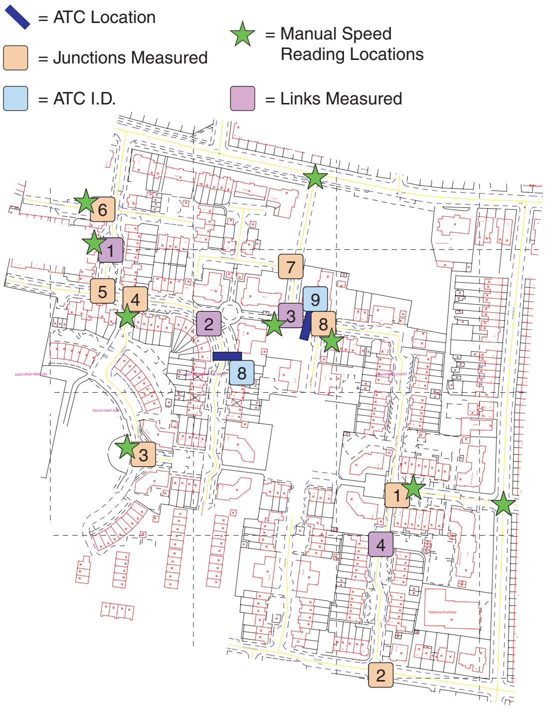
The Darwin Park development near Lichfield has some design elements which make it distinct from any other site included in the research. The photograph shows how grass has been used in some areas to make up the pedestrian surface. This may have aesthetic value but the practicalities, especially for a wheelchair user, can be challenged.

Another key characteristic of this site is the relatively low visibility levels on links (as shown in the picture) and junctions.

B.1.9 Former Pirelli Site, Eastleigh

- Location: 0.5 km to the west of Eastleigh town centre, 0.5 km from junction 13 of the M3, south of Leigh road. Proximity to town centre.
- Site area 11.7ha.
- 710 units (when complete).
- Density 60 dph gross.
- Mix of housing types, plus live work units and offices.
- Housing tenure: 17% affordable.
- 30 mph speed limit on site.
- Average residential parking to be no more than 1.5 spaces per unit. 33% of total parking to be shared on-street parking.
- Development period 2002-2006.
- Developers: Barratts and Kingsoak.
- DB32 loosely adhered to, design also influenced by Hampshire's advice 'Movement, access, streets and spaces' adopted in 2001.
- Local planning authority: Eastleigh Borough Council.
- Highways authority: Hampshire County Council.

Former Pirelli Site - Eastleigh

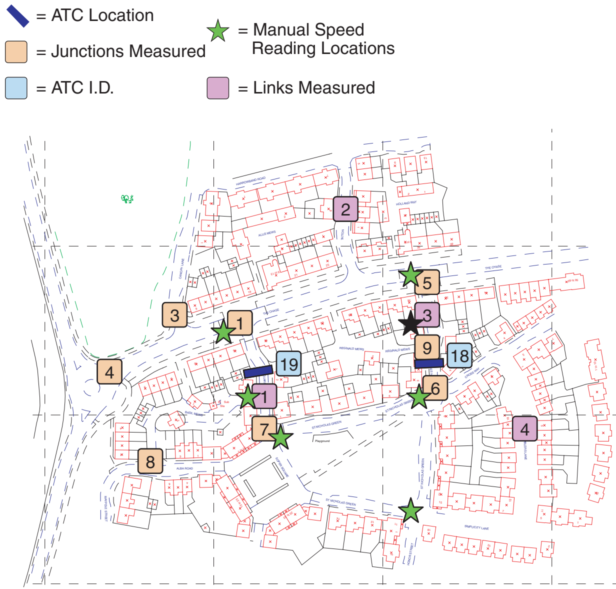


This site is a brownfield development in Eastleigh, to the northeast of Southampton. The atypical grid layout is characterised in this instance by built-in parking provision in the form of roadside bays. As the image shows, these act to drastically alter the visibility on links. A brick road surface has been widely used on the site, with some raised brick junctions. The site remains to be finished.

B.1.10 Newhall, East Harlow

- Large urban extension east of Harlow, Essex.
- Site area is 81ha.
- Population expected to reach 6000 in 2800 dwellings by 2018.
- Density 35 dph gross.
- Mixed land use. Residential mix of detached, terraced, semi-detached and flats plus community buildings, shops, services, pubs. Site includes district centre.
- Housing tenure: 25% lower cost dwellings.
- 30 mph speed limit.
- Parking ratio of 1.7 per dwelling plus 15 visitor spaces for the ‘Abode’ parcel.
- Different parcels within each phase (50-100 units per parcel) built out by different developers. Overall developers: Roger Evans Associates. Proctor Matthews Architects / Copthorn Homes, PCKO / Cala Homes also contributed.
- Development period started 2003. Not yet completed.
- Urban edge car-based Greenfield development.
- Street layout is deformed lattice shape.
- Local planning authority: Harlow District Council.
- Highways authority: Essex County Council.

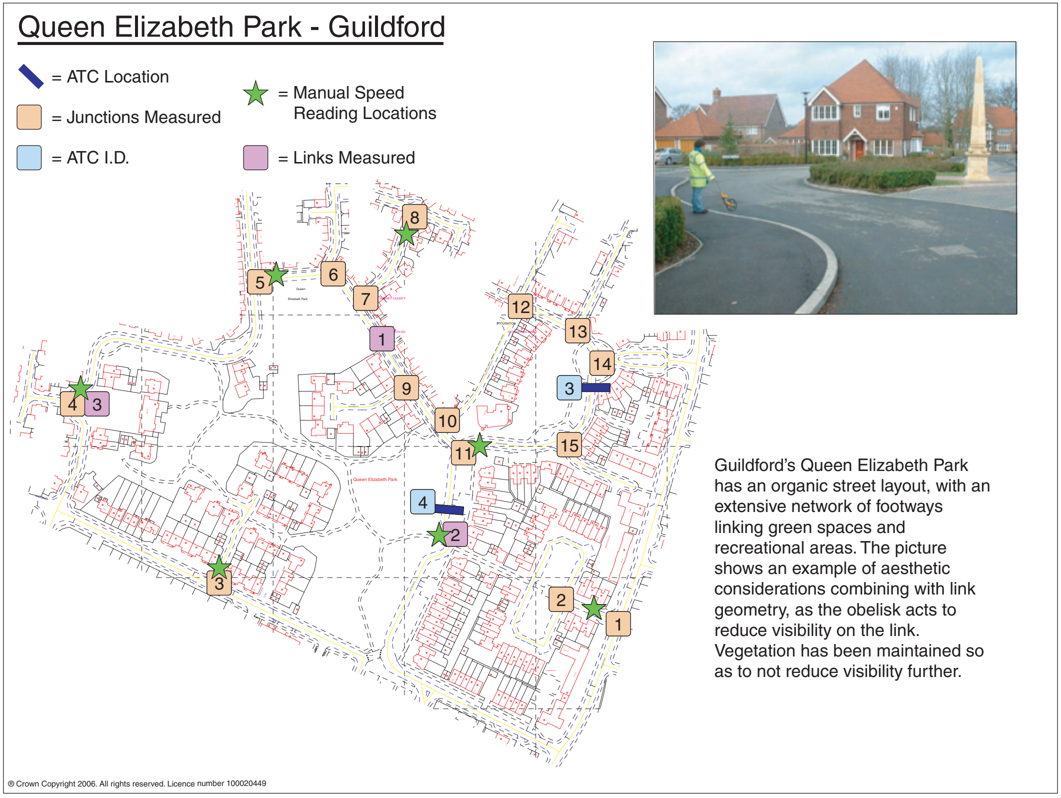
Newhall - East Harlow



This recently developed site has an organic layout and has adopted numerous modern design elements. The picture gives an example of the shared spaces, planting in the carriageway and green public recreational areas. These wide junctions require care from drivers, but the plantings act to funnel vehicles and separate them from pedestrians.

B.1.11 Queen Elizabeth Park, Guildford

- Located 2 miles north of Guildford, 30 miles west of London with close proximity to local bus routes and mainline railway route into London. Easy access to M25 via A3.
- Site area 23 hectares including open space and commercial uses.
- 525 units mix of houses and flats.
- Housing density 23 dph.
- Mix of uses: community centre, crèche, health and fitness centre, supermarket, doctor's surgery, 25 small business units and 4550 sqm offices.
- Housing tenure: high income (mostly), 35% affordable.
- 30 mph speed limit on site.
- Average parking ratio: 1.5 spaces per dwelling.
- Date of development 2003-2005.
- Developers: Laing and Linden.
- Former barracks site on suburban Brownfield site.
- Relaxation of DB32 highway design standards and innovative measures to control speed.
- Local planning authority: Guildford Borough Council.
- Highways authority: Surrey County Council.



Guildford's Queen Elizabeth Park has an organic street layout, with an extensive network of footways linking green spaces and recreational areas. The picture shows an example of aesthetic considerations combining with link geometry, as the obelisk acts to reduce visibility on the link. Vegetation has been maintained so as to not reduce visibility further.

B.1.12 Tower Hamlets, London

- Location: Central Stepney, inner East London housing area. The site is north of the river Thames, within close proximity to Canary Wharf and the Tower of London.
- Site area: 6 ha.
- 240 habitable rooms per hectare (up to 74 dph).
- 136 housing units developed (total development 445).
- Residential mix: terraces and flats.
- Housing tenure: almost all Registered Social Landlord (RSL).
- 20 mph speed limit on site.
- On-street parking except some in-curtilage for disabled.
- Development period: 1998-2004.
- Developer: John Laing Partnership. PRP Architects worked with local residents, the housing associations, Laing and the Free Form Arts Trust to develop the master plan.
- Residential development on site of a demolished 60s estate.
- Reproduction of Victorian terraced streets. Design based on DB32 and Section 38.
- Local planning authority and highways authority: London Borough of Tower Hamlets.

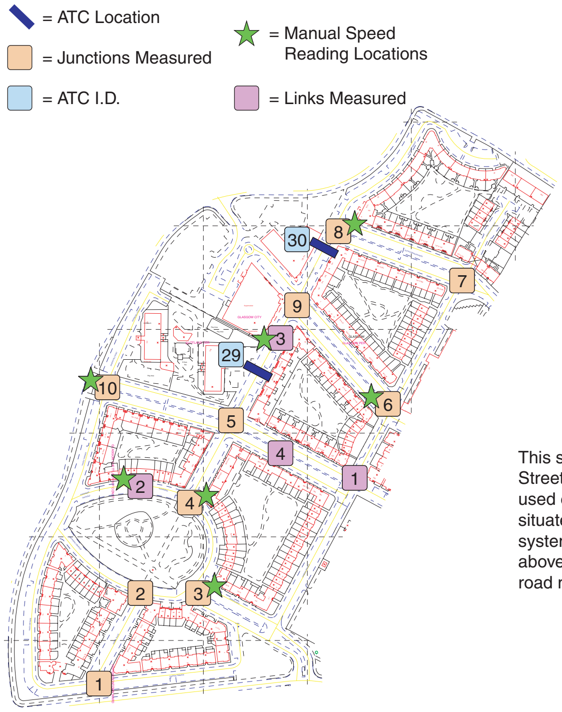

Tower Hamlets - London

Tower Hamlets saw extensive redevelopment during the 1990s, and is characterised by its grid layout with on-street parking provision. The image shows a typically wide carriageway to accommodate this parking. The major arm at this junction is one-way traffic, with the central reserve turned into a recreational area.

B.1.13 Crown Street, Glasgow

- Location: site within walking distance (20 minutes) of Glasgow city centre on the south bank of the river Clyde.
- Site area: 17.4 ha.
- 832 dwellings.
- Gross density 48 dph.
- Residential development along wider boulevards with retail and mixed use provision laid out along the narrowest street. Residential mix of town houses, flats and duplex apartments (four-storey urban blocks).
- Housing tenure: 659 owner occupied, 173 social rented homes.
- Mainly 30 mph speed limits, with some streets 20 mph.
- Parking ratio is less than 1:1 overall.
- Former site: poor quality 1960s high rise residential tower blocks.
- Development period: 1991-2000.
- Planner / Developer: Piers Gough.
- Strongly linear layout.
- Local planning and highways authority: Glasgow City Council.

The Gorbals - Glasgow

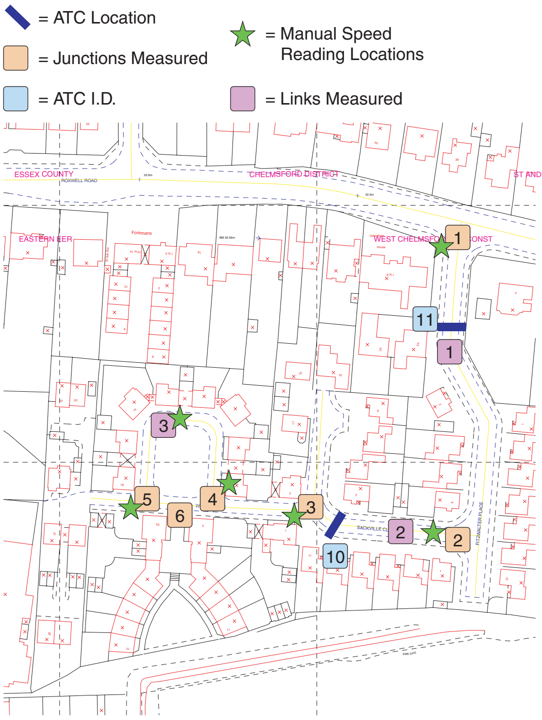


This site is a redevelopment based around Crown Street in the Gorbals area of Glasgow. Brick tables are used extensively at junctions, and parking provision is situated between the carriageways with a one -way system in operation. This is evident in the picture above, as is an apparent degradation in the quality of road markings on the brick surface.

B.1.14 Windley Tye, Chelmsford

- Located on town centre fringe to the west of Chelmsford.
- 4.3 ha site.
- 23 housing units (Willow Court development).
- Overall density 25 dph (Willow Court Development).
- Residential mix: 3 and 4 bedroom detached, semi-detached and terraced houses.
- Housing tenure: 0% affordable.
- 30 mph speed limit on site.
- Car parking: generally behind the building line.
- Brownfield site. Former industrial site.
- Development period: 2002-2004 (Willow Court).
- Developer: Bellway Homes (Willow Court).
- Local planning authority: Chelmsford Borough Council.
- Highway Authority: Essex County Council.

Windley Tye - Chelmsford



Windley Tye is a small, low density development with a court-style layout. The rumble strip in the photograph marks the entrance to the newer courtyard area of the site and signifies to drivers that care should be taken. Visibilities at junctions in this section are relatively low, but the curved link actually has good visibility as the central section consists of low-level grass and flowers.

B.1.15 Beaulieu Park, Chelmsford

- Part of the Beaulieu Park urban extension on the north east edge of Chelmsford, Essex. Linked to town centre via A130.
- Site area: 3.56 ha.
- 91 dwellings.
- Gross density within the site of 25.6 dwellings per hectare.
- Residential mix: three-bedroom townhouses to six-bedroom detached homes, terraces.
- Housing tenure: development aimed at high-income earners. 20% affordable.
- 20 mph speed limit on site.
- Greenfield site.
- Development period: 2001-2003.
- Developer: George Wimpy with local architect Ken Philpot.
- Non-standard street layout that goes beyond DB32 criteria. The Essex Design Guide had an influence on the design and architecture. DB32 sightline standards were avoided in the shared surface streets.
- Local planning authority: Chelmsford Borough Council.
- Highway authority: Chelmsford Borough Council acting as agents for Essex County Council.

Beaulieu Park - Chelmsford

Beaulieu Park is notable for its use of wide ranging materials within the streetscape. There are some shared surfaces where vehicle flows are relatively low, mixed with traditional asphalt on some access roads. The image shows innovative use of a brick surface, with a pattern created to denote the edge of one carriageway and the stopping point for vehicles on the minor arm.

B.1.16 Rapier Street, Ipswich

- Lies between main Wherstead Road (A137) and a route designated for a future strategic link into town centre. Situated on the west side of the docks.
- 35 houses, 139 flats.
- Residential development, consisting of high rise flats and four-storey town houses are arranged around the perimeter of the site. Terraces, detached and semi-detached properties.
- 20 mph speed limit on site.
- Brownfield site.
- Development period: 2003-2004.
- Developer: Bidwells.
- ‘Homezone’ design standards applied.
- Local planning authority: Ipswich Borough Council.
- Highways authority: Suffolk County Council.

Rapier Street Home Zone - Ipswich

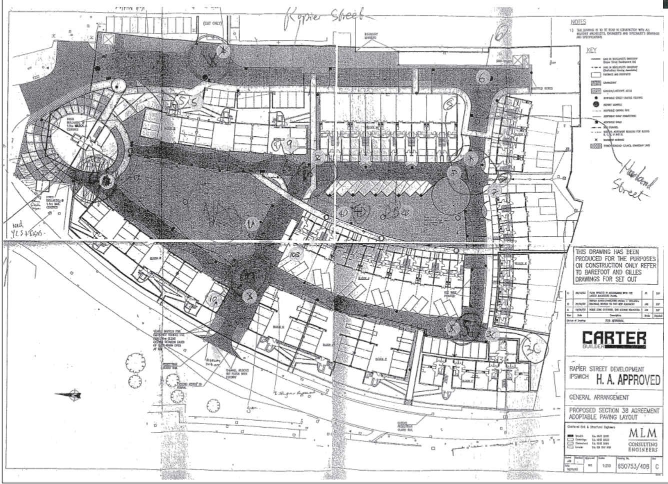
╲ = ATC Location

🟧 = Junctions Measured

🟦 = ATC I.D.

★ = Manual Speed Reading Locations

🟪 = Links Measured

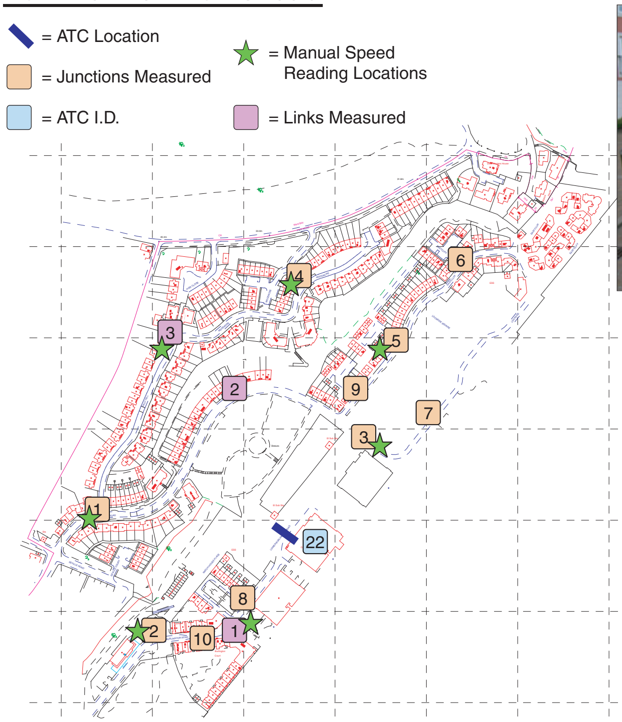


At the time of writing there were no CAD images available of Rapier Street due to it being a recent redevelopment. The adjacent site plans do at least give an impression of the layout. There are shared surfaces throughout, with a children’s play area at the centre of the site. Raised flats straddle the paved surface, with some parking provided underneath. A wide variety of materials were used to create a pedestrian focused streetscape.

B.1.17 Port Marine, Portishead

- Located north west of Bristol where the river Avon meets the Severn estuary.
- Site area: 18 ha
- Urban village of 920 dwellings.
- Approximately 45 dph.
- Residential mix of terraces, crescents, individual houses and apartment blocks. Properties range from two-storey mews houses to eight-storey blocks facing the marina.
- Housing tenure: 10% affordable.
- 20 mph speed limit on site.
- Parking ratio: 1 per dwelling.
- Former power station site.
- Development period: 1999-2003. Further development expected to be completed in 2006.
- Developer: Crest Nicholson.
- Local planning authority: North Somerset Council.
- Highways authority: North Somerset Council.

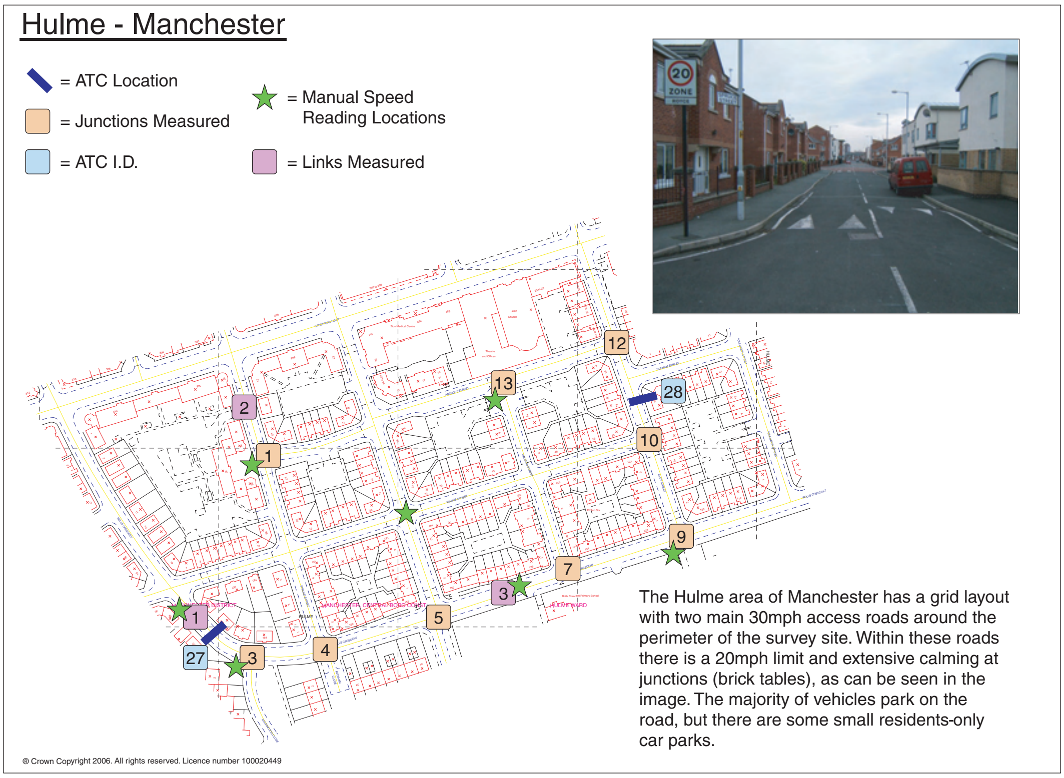
Port Marine - Portishead



Port Marine is a new build with an organic layout. The site is notable for its wide open grassed areas for recreation, along with prominent pieces of public art. There is little consistency in street design. The picture shows a wide link with a block paved surface and bollards to demarcate the carriageway, both of which are used only partially. The narrow courtyard entrance in the distance contrasts with the majority of junctions at the site .

B.1.18 Hulme, Manchester

- Hulme regeneration area south of Manchester city centre – replacement of unsuccessful 1960s comprehensive redevelopment. Site within walking distance (about 20 minutes) of city centre.
- Wider regeneration area is 121 ha. Site area: 6.6 ha.
- Density on average given as 90 dph. High density development.
- Mixed used development site. Resident mix: mainly flats.
- Housing tenure: dwellings are mostly social rented.
- Intended maximum traffic speed of 20 mph.
- Parking ratio 0.8-1.0 per dwelling.
- Replacement of 1960s comprehensive development. Brownfield site.
- Development period: 1992-1997.
- Traditional grid street pattern.
- Highway safety not an overriding objective, though personal safety was an important consideration.
- Local planning authority and Highways authority: Manchester City Council.

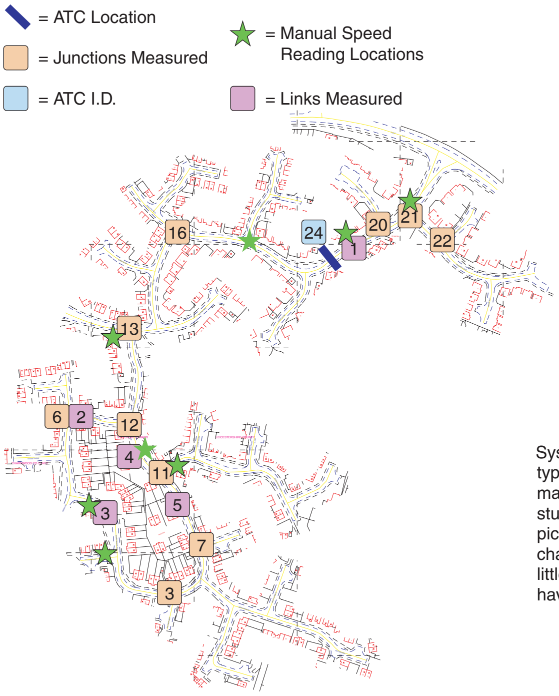


The Hulme area of Manchester has a grid layout with two main 30mph access roads around the perimeter of the survey site. Within these roads there is a 20mph limit and extensive calming at junctions (brick tables), as can be seen in the image. The majority of vehicles park on the road, but there are some small residents-only car parks.

B.1.19 Syston, Leicester

- Around 7 km from Leicester City centre and 1 km from Syston town centre. Regular bus service runs through estate, linking to Syston, Thurmaston and Leicester. Around 0.5 km – 1 km to railway station on Midland mainline.
- Previous greenfield site.
- Type of development: residential.
- Developer: Jelson Limited.
- Area of site: 24 ha (approximately).
- Number of dwellings: 678.
- Housing density: 28 houses/ha (approximately).
- 30 mph speed limit.
- Local planning authority: Charnwood Borough Council.
- Highways authority: Leicestershire County Council.
- Development period: 1988-mid 1990s.
- Residential mix: detached and semi detached 2, 3 and 4 bed houses.
- Housing tenure: not known for certain, believed to be 100% private.
- Parking ratios: dwellings with 4 or more bedrooms – minimum 3 spaces, dwellings with 3 or less bedrooms – minimum 2 spaces (as per the then current Leicestershire County Council design guide).

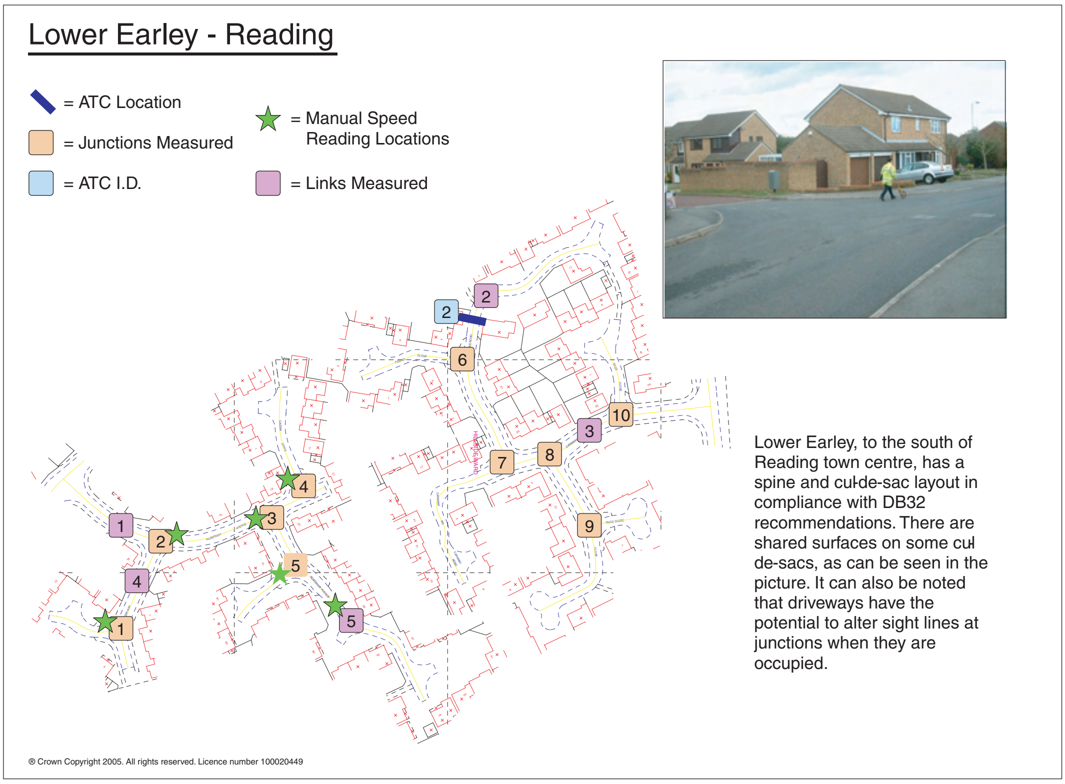
Syston - Leicester



Syston is a spine and cul-de-sac residential estate typical of 1980s suburban developments. Junction markings are only used on the entrance/exits of the study area, and other road markings are sparse. The picture shows a long and sweeping link, along with a characteristically wide junction aperture. There is very little on-street parking as the vast majority of houses have driveways.

B.1.20 Lower Earley, Reading

- DB32 compliant.
- 30 mph speed limit.
- Local planning authority: Reading Borough Council.



Lower Earley - Reading

= ATC Location

🟧 = Junctions Measured

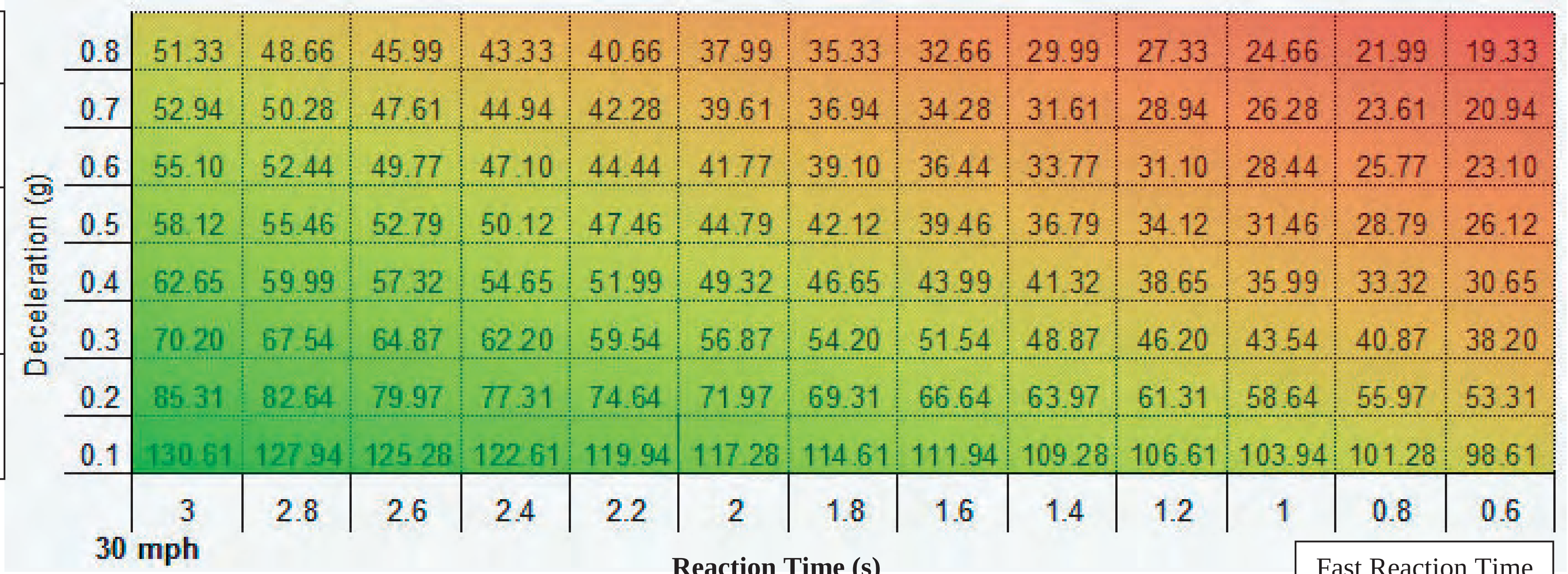
🟦 = ATC I.D.

★ = Manual Speed Reading Locations

🟪 = Links Measured

Lower Earley, to the south of Reading town centre, has a spine and cul-de-sac layout in compliance with DB32 recommendations. There are shared surfaces on some cul-de-sacs, as can be seen in the picture. It can also be noted that driveways have the potential to alter sight lines at junctions when they are occupied.

Appendix C: Braking distance matrix



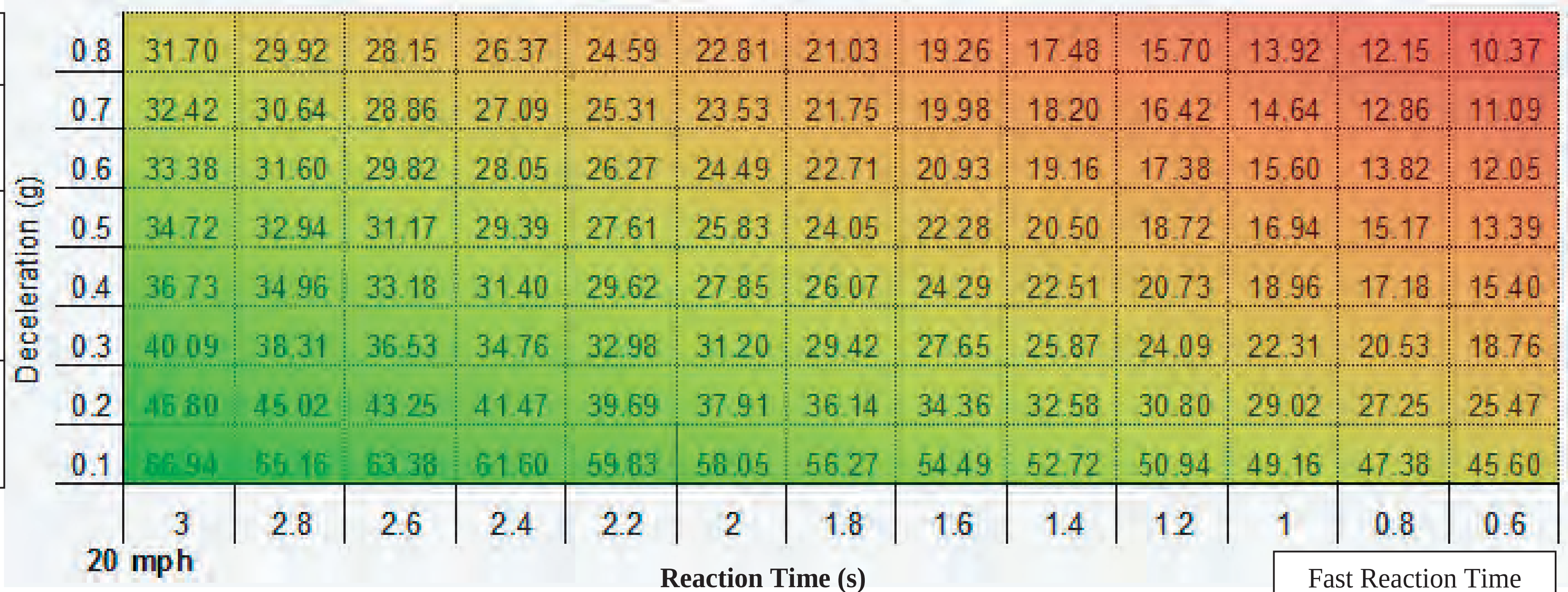
30 mph

	Deceleration (g)	3	2.8	2.6	2.4	2.2	2	1.8	1.6	1.4	1.2	1	0.8	0.6
Emergency	0.8	51.33	48.66	45.99	43.33	40.66	37.99	35.33	32.66	29.99	27.33	24.66	21.99	19.33
Heavy	0.7	52.94	50.28	47.61	44.94	42.28	39.61	36.94	34.28	31.61	28.94	26.28	23.61	20.94
	0.6	55.10	52.44	49.77	47.10	44.44	41.77	39.10	36.44	33.77	31.10	28.44	25.77	23.10
Average	0.5	58.12	55.46	52.79	50.12	47.46	44.79	42.12	39.46	36.79	34.12	31.46	28.79	26.12
	0.4	62.65	59.99	57.32	54.65	51.99	49.32	46.65	43.99	41.32	38.65	35.99	33.32	30.65
	0.3	70.20	67.54	64.87	62.20	59.54	56.87	54.20	51.54	48.87	46.20	43.54	40.87	38.20
Light	0.2	85.31	82.64	79.97	77.31	74.64	71.97	69.31	66.64	63.97	61.31	58.64	55.97	53.31
	0.1	130.61	127.94	125.28	122.61	119.94	117.28	114.61	111.94	109.28	106.61	103.94	101.28	98.61

Reaction Time (s)

		Fast Reaction Time
	85% Drivers Reaction to “ Clear and obvious stimulus” [Olson 1997]	
Slower driver reaction time		Highway Code
Possible night time reaction times		

Dry surface: Unchanged
Wet Surface: add 0.2g to deceleration
Alcohol (Low level): Unchanged
Cannabis: add 0.2s to reaction time



	Deceleration (g)	3	2.8	2.6	2.4	2.2	2	1.8	1.6	1.4	1.2	1	0.8	0.6
Emergency	0.8	31.70	29.92	28.15	26.37	24.59	22.81	21.03	19.26	17.48	15.70	13.92	12.15	10.37
Heavy	0.7	32.42	30.64	28.86	27.09	25.31	23.53	21.75	19.98	18.20	16.42	14.64	12.86	11.09
	0.6	33.38	31.60	29.82	28.05	26.27	24.49	22.71	20.93	19.16	17.38	15.60	13.82	12.05
Average	0.5	34.72	32.94	31.17	29.39	27.61	25.83	24.05	22.28	20.50	18.72	16.94	15.17	13.39
	0.4	36.73	34.96	33.18	31.40	29.62	27.85	26.07	24.29	22.51	20.73	18.96	17.18	15.40
	0.3	40.09	38.31	36.53	34.76	32.98	31.20	29.42	27.65	25.87	24.09	22.31	20.53	18.76
Light	0.2	46.80	45.02	43.25	41.47	39.69	37.91	36.14	34.36	32.58	30.80	29.02	27.25	25.47
	0.1	66.94	65.16	63.38	61.60	59.83	58.05	56.27	54.49	52.72	50.94	49.16	47.38	45.60

20 mph

Reaction Time (s)

Fast Reaction Time

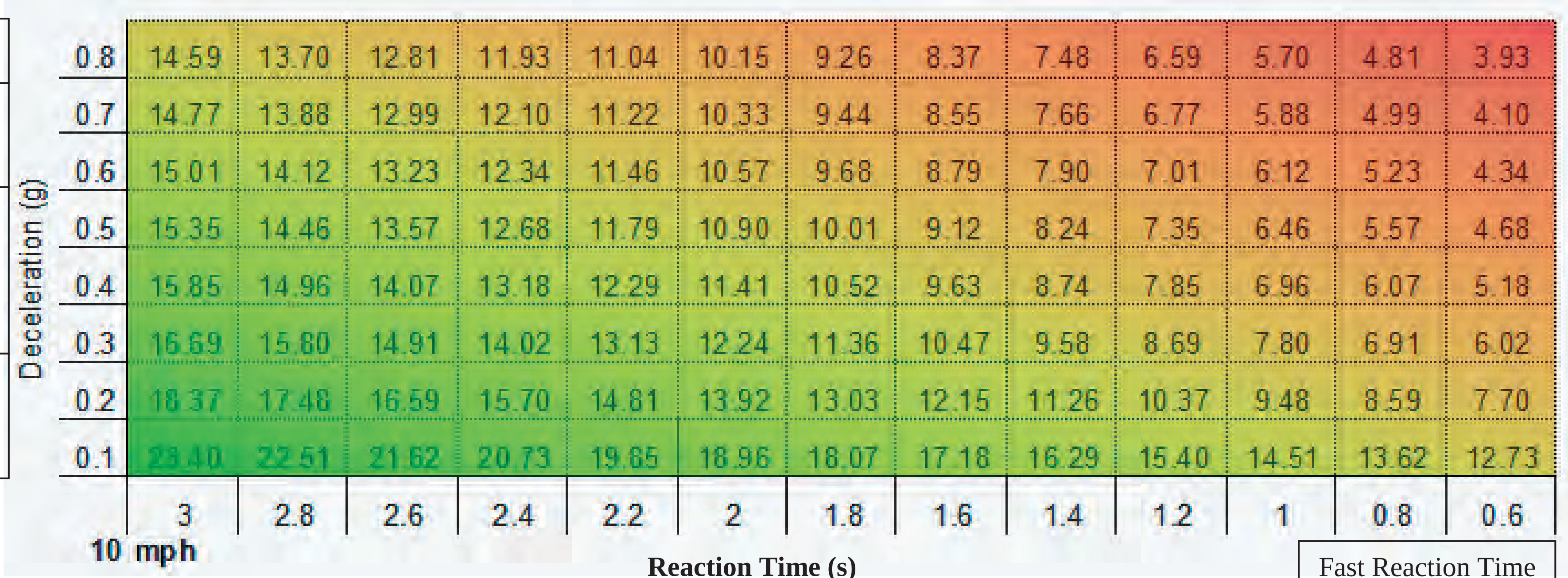
85% Drivers Reaction to “ Clear and obvious stimulus” [Olson 1997]

Slower driver reaction time

Highway Code

Possible night time reaction times

Dry surface: Unchanged
Wet Surface: add 0.2g to deceleration
Alcohol (Low level): Unchanged
Cannabis: add 0.2s to reaction time



	Deceleration (g)	3	2.8	2.6	2.4	2.2	2	1.8	1.6	1.4	1.2	1	0.8	0.6
Emergency	0.8	14.59	13.70	12.81	11.93	11.04	10.15	9.26	8.37	7.48	6.59	5.70	4.81	3.93
Heavy	0.7	14.77	13.88	12.99	12.10	11.22	10.33	9.44	8.55	7.66	6.77	5.88	4.99	4.10
	0.6	15.01	14.12	13.23	12.34	11.46	10.57	9.68	8.79	7.90	7.01	6.12	5.23	4.34
Average	0.5	15.35	14.46	13.57	12.68	11.79	10.90	10.01	9.12	8.24	7.35	6.46	5.57	4.68
	0.4	15.85	14.96	14.07	13.18	12.29	11.41	10.52	9.63	8.74	7.85	6.96	6.07	5.18
	0.3	16.69	15.80	14.91	14.02	13.13	12.24	11.36	10.47	9.58	8.69	7.80	6.91	6.02
Light	0.2	18.37	17.48	16.59	15.70	14.81	13.92	13.03	12.15	11.26	10.37	9.48	8.59	7.70
	0.1	23.40	22.51	21.62	20.73	19.85	18.96	18.07	17.18	16.29	15.40	14.51	13.62	12.73

10 mph

Reaction Time (s)

Fast Reaction Time

85% Drivers Reaction to “ Clear and obvious stimulus” [Olson 1997]

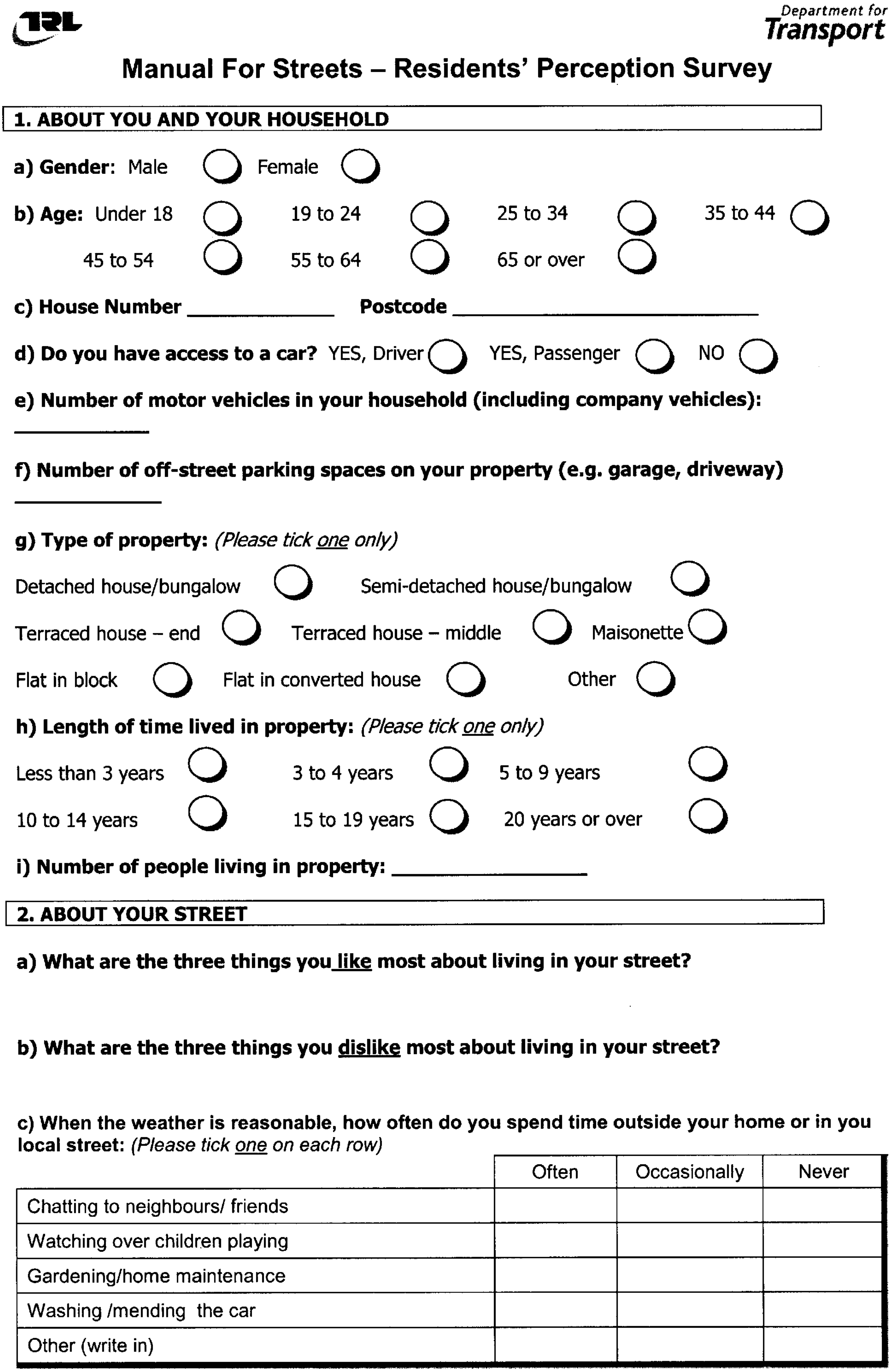
Slower driver reaction time

Highway Code

Possible night time reaction times

Dry surface: Unchanged
Wet Surface: add 0.2g to deceleration
Alcohol (Low level): Unchanged
Cannabis: add 0.2s to reaction time

Appendix D: Household survey questionnaire



TRL

Department for
Transport

Manual For Streets – Residents' Perception Survey

1. ABOUT YOU AND YOUR HOUSEHOLD

a) Gender: Male ○ Female ○

b) Age: Under 18 ○ 19 to 24 ○ 25 to 34 ○ 35 to 44 ○
45 to 54 ○ 55 to 64 ○ 65 or over ○

c) House Number ______________ **Postcode** ______________________________

d) Do you have access to a car? YES, Driver ○ YES, Passenger ○ NO ○

e) Number of motor vehicles in your household (including company vehicles):

____

f) Number of off-street parking spaces on your property (e.g. garage, driveway)

____

g) Type of property: *(Please tick one only)*

Detached house/bungalow ○ Semi-detached house/bungalow ○
Terraced house – end ○ Terraced house – middle ○ Maisonette ○
Flat in block ○ Flat in converted house ○ Other ○

h) Length of time lived in property: *(Please tick one only)*

Less than 3 years ○ 3 to 4 years ○ 5 to 9 years ○
10 to 14 years ○ 15 to 19 years ○ 20 years or over ○

i) Number of people living in property: __________________

2. ABOUT YOUR STREET

a) What are the three things you like most about living in your street?

b) What are the three things you dislike most about living in your street?

c) When the weather is reasonable, how often do you spend time outside your home or in you local street: *(Please tick one on each row)*

	Often	Occasionally	Never
Chatting to neighbours/ friends			
Watching over children playing			
Gardening/home maintenance			
Washing /mending the car			
Other (write in)			

d) Do you find being able to park outside your home to be a problem? *(Please tick one only)*

Yes, a big problem ○ Yes, sometimes a problem ○ No ○ Not applicable ○

If yes, please briefly explain why:

e) Do many vehicles park on the road/footway near your home? *(Please tick one only)*

Yes, a lot of the time ○ Yes, sometimes ○ No ○

f) What, if any, difficulties have you found because of parked vehicles on your street?

g) How easy and convenient is it to travel around your street (or streets local to yours)?
(Please tick one on each row)

	Very Good	Good	Reasonable	Bad	Very Bad	N/A (I do not regularly use this method)
On foot						
By bike						
By car						
Other (write in)						

h) Do any of the following cause you concern in terms of road safety or personal safety?
(Please tick one in each row, using not applicable where appropriate)

	Very concerned	Quite Concerned	Not Very Concerned	Not at all concerned	N/A
Number of vehicles passing your house					
Vehicle speeds on your estate roads					
Vehicles parked on the road					
Vehicles obstructing the footway/verge					
Large vehicles (e.g. bin lorries, buses)					
Shared parking areas					
Lack of footways					
Confined narrow alleyways					
'isolated' footways (e.g. across open space)					
Lack of pedestrian road crossings					
Lack of cyclepaths					
Lack of visibility for drivers					
Lack of visibility for pedestrians					
Vegetation that obstructs footways, creates hiding places					
Poor street lighting					
Other (please specify)					

3. ROAD SAFETY AND PERSONAL SAFETY/CRIME ISSUES

a) What do you consider to be the main threat to safety on your street? *(Please tick one only)*

Danger from road traffic ○ Danger from Crime ○

Both ○ Other (please specify) ○ ______________

b) With regards to danger from road traffic, how safe do you think it is in your street for:

	Very safe	Fairly safe	Fairly unsafe	Very unsafe	Don't know
Children walking					
Children cycling					
Adults walking					
Adults cycling					

c) In your opinion, how considerate are motorists on your street towards the safety of: *(Please tick one on each row)*

	Very considerate	Fairly considerate	Fairly inconsiderate	Very inconsiderate	Don't know
Children walking/crossing the street					
Children cycling					
Children playing on or near the street					
Adults walking/ crossing the street					
Adults cycling					

d) How safe do you think it is for children to play/spend time unsupervised by an adult in your street? *(Please tick one for each row)*

	Very safe	Fairly safe	Fairly unsafe	Very unsafe	Don't know
Pre-school / nursery / infant school age					
Primary school age					
Secondary school age					

e) If you stated it was 'fairly unsafe' or 'very unsafe', please explain you answer. *(Please tick one for each column where applicable)*

	Pre-school / nursery / infant school age	Primary school age	Secondary school age
The speed of traffic			
The amount of traffic			
Stranger danger			
Crime / mugging / physical assault			
Bullying from other children			
Other (Write in)			

f) Have you, or any member of your household, been involved in a road accident or a near miss in your street? (tick all that apply)

Yes, involved in an accident whilst: walking ○ cycling ○ in a car ○

Other (please specify) ○ ________________

Yes, involved in a near miss whilst: walking ○ cycling ○ in a car ○

Other (please specify) ○ ________________

No, not involved in either: ○

g) If yes, please briefly describe the incident (including member of household involved, what happened, other vehicles involved, location, approximate date/time of year, and whether anyone was injured and type of injuries. Include another sheet if necessary)

h) Considering safety, access and quality of street environment, what changes could be made to improve your street?

Safety:	
Access:	
Aesthetics:	

Thank you for taking the time to fill in this survey

To ensure that you are entered into the free prize draw with the chance to win £100 of vouchers, please send this questionnaire back as soon as possible in the freepost envelope provided. The draw will take place on 24th April 2006.

Abstract

The Department for Transport and the Office of the Deputy Prime Minister commissioned WSP, TRL, Llewelyn Davies Yeang and Phil Jones Associates to develop the Manual for Streets (MfS), which shall supersede Design Bulletin 32 (DB32) and its companion guide, Places, Streets & Movement in 2007.

The manual will deal with underlying values that can be creatively deployed by practitioners to pursue the Government's 'placemaking' agenda of individually distinctive localities while ensuring that streets remain functional and safe. It will be based around key elements of good design in residential streets and other lightly trafficked roads.

The development of the MfS has involved some primary research to establish the relationships between different link and junction characteristics and road safety. The research examines the limits of design practice as currently specified in DB32, to consider whether more liberal geometric and visibility values may be incorporated into the manual.

A review of literature and the contributions of industry stakeholders have indicated that, in terms of constraints on design, the critical dimensions for highway geometry are link widths, forward visibility, visibility splays and junction spacing. The most significant barrier to the adoption of standards which use reduced values for width and visibility is highway authority concern over road safety. The indicators of safety being considered in this research are recorded casualties and vehicle speeds. In addition, residents' perceptions of safety, sought through a household survey, have been relevant as a qualitative response to different geometries.

The research has been undertaken at twenty sites across England. In the context of residential highway layouts, the research considers:

- Are junction geometries and road widths that do not meet DB32 standards safe in terms of recorded casualties?
- Are more permeable highway layouts such as grids associated with higher levels of casualties than spine and cul-de-sac layouts?
- Does there appear to be a relationship between design/environmental quality and driver behaviour?

The Manual for Streets has been prepared against a backdrop of sustainable development guidance and initiatives to ensure that it facilitates the long-term sustainability of streets, and contributes to an enhanced sense of place. This research provides an evidence base for redefining residential street design in the Manual for Streets.

Related publications

TRL641	*Psychological traffic calming* by J V Kennedy, R Gorell, L Crinson, A Wheeler and M Elliott. 2005 (price £50, code HX)
TRL633	*Pilot home zone schemes: evaluation of Magor Village, Monmouthshire* by R Layfield, D Webster and S Buttress. 2005 (price £10 (special price))
TRL626	*Pilot home zone schemes: evaluation of Cavell Way, Sittingbourne* by D Webster, A Tilly and S Buttress. 2005 (price £10 (special price))
TRL625	*Pilot home zone schemes: evaluation of Northmoor, Manchester* by A Tilly, D Webster and S Buttress. 2005 (price £10 (special price))
TRL621	*The effect of road narrowings on cyclists* by A Gibbard, S Reid, J Mitchell, B Lawton, E Brown and H Harper. 2004 (price £50, code HX)
TRL603	*Norfolk Quiet Lanes Scheme* by J V Kennedy, A H Wheeler and C M Inwood. 2004a (price £40, code EX)
TRL602	*Kent Quiet Lanes Scheme* by J V Kennedy, A H Wheeler and C M Inwood. 2004b (price £40, code EX)
TRL584	*Cyclists at 'Continental' style roundabouts: report on four trial sites* by B J Lawton, P J Webb, G T Wall and D G Davies. 2003 (price £50, code HX)
TRL564	*Road design measures to reduce drivers' speed via 'psychological' processes: a literature review* by M A Elliott, V A McColl and J V Kennedy. 2003 (price £35, code E)

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