‘Psychological’ traffic calming

Prepared for Traffic Management Division, Department for Transport

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Executive Summary

Background

The direct link between reduced speeds and reduced accidents is well-established. Physical traffic calming measures, generally defined as those which introduce either vertical or horizontal deflection to vehicles as they pass along a road, are in widespread use. There are, however, several problems associated with physical measures:

- They may be unpopular.
- They can lead to a style of driving involving a high degree of acceleration and deceleration, which in turn can result in increased vehicle emissions, although reductions in traffic flow may compensate for such increases.
- Vehicles traversing vertical deflections can generate increased noise nuisance.
- If crossed at inappropriate speeds, road humps can damage vehicles and cause excessive discomfort to their occupants.
- The construction of physical measures can be costly, limiting their application.
- The uses of physical measures are limited and the required associated signing can be a cause of unwanted visual intrusion.

TRL was commissioned by the Charging and Local Transport Division (now the Traffic Management Division) of the Department for Transport (DfT) to develop and test traffic calming techniques which make greater use of psychological (non-physical) measures than hitherto, but which still have a significant speed-reducing capability. Urban Designers David Huskisson Associates, under sub-contract to TRL, assisted in the development of new ideas and produced sketches and photomontage material. This is the final report on the project.

In addition to being effective in reducing speed, traffic calming measures used in a rural context in particular need to be aesthetically acceptable. A constraint on rural measures developed was to avoid visually intrusive signing, markings, brightly coloured surfacing and physical measures, in favour of more sensitively designed signing, fewer markings, and surface treatments in keeping with the colour or character of local building materials.

Methodology

The research methodology adopted was as follows. At the start of the project, a review of psychological measures was undertaken to look at the cognitive mechanisms involved in drivers' responses to different situations. This was intended to facilitate the development of measures with greater potential for success. A variety of traffic calming ideas were then developed, designed to influence speeds through psychological mechanisms for a range of different scenarios. A photograph of a particular scene without any traffic calming measures was taken as a baseline scenario and suitable traffic calming ideas developed. The scenes selected comprised three villages, a gateway, a town centre and a distributor road. Photomontage was used to illustrate the various traffic calming ideas in a series of plates. The plates were used as a basis for two focus group discussions and, with some refinements, in face-to-face interviews of a sample of 100 respondents, who were asked about their speed choice. The focus groups were held early in the project and were used to gauge reactions to the initial ideas, with the questionnaire survey intended to give a better idea of the speed reductions that might be obtained. The more promising ideas were tested on the TRL Driving Simulator.

Following on from this, the aim was to liaise with local authorities to identify trial sites for installation and monitoring of the measures developed, including measurement of traffic speeds and flows, and public attitude surveys. In the event, although schemes were developed at a number of sites, only one has been implemented, in the village of Latton in Wiltshire.

Review of psychological measures

Various broad psychological design principles were established. Reduced speeds might be generated by: more complex environments (greater cognitive load); enclosing a distant view; breaking up linearity; creating uncertainty; increasing roadside activity; emphasising a change of environment (e.g. village boundary); or making use of the properties of natural traffic calming (e.g. winding road). Perceptual techniques which make the environment seem more complex or less safe (i.e. they increase perceived risk and not actual risk) have the potential for success.

Psychological traffic calming works with a number of design elements, such as: context; scale; proportion; roadside activity; and road surfacing.

The measures developed for investigation were based as far as possible on these broad principles and design elements. They included, for example, techniques to visually or physically narrow the road; use of road markings and features to highlight potential hazards or changes in the environment; use of road markings/ coloured surfacing to create the perception of an uneven road; and the use of planting to change the forward view.

Focus groups and questionnaire survey

The main findings from the focus groups and questionnaire survey were as follows:

- The concept of psychological measures was generally welcomed in the focus groups, with the main disadvantages seen as the cost of some of the measures illustrated, and the possible reduction in effectiveness over time.
- Whilst the focus groups participants thought the use of coloured surfacing would reduce speeds, it had little effect on estimated speeds in the questionnaire survey. Features that had a physical effect (causing horizontal deflection) were more successful than those which did not.

- A combination of measures tended to produce bigger estimated speed reductions than individual measures.
- Using edge markings to visually narrow the road reduced estimated speeds. The reduction was greatest where the edging was textured and therefore appeared to be unsuitable for driving on.
- Physically narrowing the road by adding a footway reduced mean estimated speeds.
- The presence of pedestrians in the plates tended to reduce mean estimated speeds. However, participants in the focus groups were concerned about the safety implications of encouraging people to sit by the roadside.
- The most effective measures included 'Red brick narrowing' and 'Tree build-outs' shown below.

The 'Red brick narrowing' was continuous, narrowed the road both physically and visually, and created uncertainty as it was not clear to motorists whether it was a footway or part of the road. The lack of a centre line meant that drivers were concerned about meeting other vehicles head-on. The 'Tree build-outs' are examples of a repeated measure that narrowed the road at regular intervals, creating a degree of uncertainty as to road width. They also reduced forward visibility.

Simulator study

The main findings from the Driving Simulator trials were as follows:

- Continuous or repeated measures were required to sustain speed reductions. For example, the village gateway alone had little effect on speed within the village.
- Coloured surfacing alone, however elaborate, did little to slow traffic.
- Uncertainty appeared to reduce speed; for example, build-outs were particularly effective where there was another vehicle approaching.
- In general, the faster drivers showed the greater speed reductions when traversing the more effective measures.
- The most effective measures were the 'Red brick narrowing' or 'Tree build-outs', as above, and 'Build-outs' involving the use of bollards rather than trees.

Latton scheme

In Latton, the scheme was implemented in spring 2004. It extends for about 800m on the C419, formerly a trunk road carrying heavy traffic, now bypassed. Although the scheme was intended to reduce speeds and increase perceived safety, there was no history of accidents at the site. The main components of the scheme were:

- Stone gateways where the speed limit was reduced from 40mph to 30mph.
- Build-outs with planting to create new parking bays on alternate sides of the carriageway.
- Removal of centre white line.
- Enhancement at and around the main junction, with paved build-outs, a paved section of footway, and paving around the stone monument.
- Buff surfacing near the bus stops and the main junction, a section considered most likely to be crossed by pedestrians.
- New bus bay.
- Lowering of the lighting columns to a height more appropriate for a minor road.

The build-outs gave a gentle chicane effect, resulting in physical and visual narrowing of the road. The road remained at least 5.5m wide at all points. The planting on the build-outs and use of the parking bays were intended to limit the forward visibility and break up the sightlines.

Inbound mean speeds fell by 8mph and 4mph at the gateways, to 37mph. There was a similar decrease in 85th percentile speeds, to about 45mph. In the village, two-way mean speeds fell by 7-8mph to 31mph and 85th percentile speeds fell by 8-10mph to 37-38mph. This was despite under-use of the parking bays that allowed two large vehicles to pass alongside each other by partially straddling the parking bay. The under-use also meant that forward visibility was not reduced as much as intended, particularly whilst the planting on the build-outs is immature. Although within the village over half of vehicles still exceeded the new 30mph speed limit during the 'after' survey, the proportion exceeding 40mph fell from 50% to around 10%.

A total of 91 residents, representing a high proportion of households within the village, took part in a public opinion survey of the scheme. The main findings were that over three-quarters of the respondents supported the scheme and liked its appearance, with about half of respondents thinking it was safer to cross the road than before. Opinion was divided over the removal of the centre white lining, with the one-third of respondents against it concerned about opposing vehicles in the centre of the road.

Discussion

The most effective measures in the off-road trials were those with a physical as well as a psychological effect. A combination of measures that was either repeated at suitable intervals or continuous was more effective and an isolated measure. In the on-road trial in Latton, the gentle chicane effect over the length of the scheme, the reduction in forward visibility and an element of uncertainty from the lack of a centre line, narrowed carriageway and parked cars all combined to reduce speeds; in addition, the measures changed the feel of the road from a trunk road to a local road and emphasised the presence of the village.

Much greater speed reductions have been produced in Latton than are generally attained in this type of scheme and there was a large decrease in the proportion of drivers exceeding 40mph. Although a small part of this reduction must be attributed to the lowering of the speed limit, it is not considered that a reduction in the speed limit alone would have given more than about a 3mph reduction in mean speed. Even greater speed reductions might have been attained had the planting been more mature and/or the flows greater. The parking bays are often under-used and this allows two large vehicles to pass alongside each other by partially straddling the parking bay. It also means that forward visibility is not reduced as much as intended, particularly whilst the planting is immature. Although the costs were higher than for some schemes of this type, they were not excessive at around £40,000.

It has been demonstrated that it is possible to design an effective traffic calming scheme that is aesthetically pleasing without resort to measures such as road humps, chicanes or one-way working. The reasons for success are likely to have been:

- Consistent treatment of a whole length of road.
- Centre of village treated in addition to gateways.
- Visual and physical road narrowing.
- Limiting of forward visibility / breaking up of sightlines to increase driver awareness / cognitive load.
- Removal of white line in conjunction with the physical narrowing at parking bays, to create uncertainty.

A key element in developing the scheme was an understanding of the theoretical mechanisms that help to explain and predict the effects of the road environment on drivers' speed choice. This was combined with an understanding of 'natural' traffic calming, alterations to the environmental context of the scheme and extensive consultation with the main stakeholders.

Overall, the project has shown that there is no simple, unique, widely applicable psychological measure. Rather it is a matter of applying psychological principles to each new situation in a holistic manner. There will continue to be situations where physical measures are needed. However, psychological schemes can be effective, their effect can be lasting (at least over a period of months) and they are highly acceptable to local people.

1 Introduction

1.1 Background

The direct link between reduced speeds and reduced accidents is well-established (see, for example, Taylor *et al.*, 2000; Taylor, 2001) and it is the most serious accidents which have the greatest potential to be affected by reductions in vehicle speeds that are too fast for the prevailing conditions. Physical traffic calming measures, generally defined as those which introduce either vertical or horizontal deflection to vehicles as they pass along a road, are in widespread use. These measures – for example, road humps, speed cushions, speed tables and chicanes – have been shown to generate substantial reductions in vehicle speeds and accidents. The most notable evidence of this is from the monitoring of 20mph zones, in which mean speed reductions of about 10mph have been generated, resulting in a reduction in injury accidents of more than a half (Webster and Mackie, 1996).

However, there are a number of concerns associated with the application of physical measures, as follows:

- They may be unpopular.
- They can lead to a style of driving involving a high degree of acceleration and deceleration, which in turn can result in increased vehicle emissions although reductions in traffic flow may compensate for such increases (Cloke *et al.*, 1999).
- Vehicles traversing vertical deflections can generate increased noise and vibration; whilst the latter is generally imperceptible, the former has been shown to be a source of nuisance (see for example, Abbott *et al.*, 1997, Traffic Advisory Leaflet 10/00).
- If crossed at inappropriate speeds, road humps can damage vehicles and cause excessive discomfort to their occupants.
- The construction of physical measures can be costly, limiting their application.
- The use of physical measures is governed by Highways Regulations and because of their nature, they can only be used in a limited range of situations, and/or with prominent signing warning of their presence. Such signing can be a cause of unwanted visual intrusion.

A number of UK research projects in recent years have sought to develop traffic calming measures which overcome some or all of these difficulties, whilst still retaining the capability to reduce vehicle speeds. In addition, a more holistic approach to traffic calming, aimed at using measures that are appropriate to the context, has been undertaken for a range of situations on both urban and rural roads. Key examples are:

- Department for Transport (DfT) Village Speed Reduction (VISP) initiative and study of traffic calming on major roads (e.g. Wheeler *et al.*, 1993, 1994, 1996, 1997; Wheeler and Taylor, 1999; DfT Traffic Advisory Leaflets 01/94, 02/97, 01/00 and 11/00).
- DfT Bypass Demonstration Project (Ross Silcock, 1995).
- DfT / English Historic Towns Forum study of traffic calming in Historic Core Zones (e.g. Wheeler, 1997, 1999a and 1999b; Traffic Advisory Leaflets 10/97, 02/98, 08/98, 13/99).
- DfT / Countryside Traffic Measures Group (CTMG) study of measures designed with sensitivity to the rural environment (e.g. Kennedy and Wheeler, 2001).
- Investigations of how naturally occurring features, or aspects of urban design, can be used to develop 'psychological' measures for speed reduction (e.g. Scottish Executive Development Department, 1999, Highways Agency, 2002; Chinn *et al.*, 2002; Chinn and Elliott, 2002a and b).

From some of these studies have emerged non-physical measures which are now in common use – for example, various village gateway treatments, such as the use of coloured surfacing, and painted speed limit 'roundels'. They have included 'perceptual' measures which are designed to convey a greater level of risk than actually prevails – for example, visually narrowing the carriageway through road markings / use of coloured surfacing. However, some of the measures have produced only a limited effect on speeds, with 85th percentile speeds remaining above the prevailing speed limit, whilst some others with a greater speed-reducing capability are visually intrusive.

The idea of 'self-explaining' roads i.e. ones on which drivers naturally adopt the correct speed originated in the Netherlands (e.g. Theeuwes, 1998). Another initiative is 'shared space', where the whole of the road space is available to all road users including cyclists and pedestrians. The main uses have been in Home Zones (e.g. Layfield *et al.*, 2003, Tilly *et al.*, 2005, Webster *et al.*, 2005, Traffic Advisory Leaflets, 10/01 and 08/02), where there are likely to be physical constraints to reduce speeds sufficiently to allow children to play in the street, and in Quiet Lanes (Kennedy *et al.*, 2004a and b, Traffic Advisory Leaflet 03/04). The latter are lanes that already have low flows and low speeds, the intention being to maintain these conditions and increase driver awareness of the possibility of non-motorised users. In the Netherlands, more radical experiments have been undertaken with 'naked streets', notably by Hans Monderman. This concept relies on the removal of signage, traffic signals and footways to encourage drivers and pedestrians to interact with each other. However, concerns remain regarding the legibility and safety of such designs for vulnerable users, particularly those with sensory or mobility impairments, and the effects where there are higher levels of traffic, or higher proportions of heavy vehicles.

In addition to being effective in reducing speed, traffic calming measures need to be aesthetically acceptable; particularly those developed for use in a rural or historic context. It is important to avoid unnecessarily visually intrusive signing, markings, brightly coloured surfacing and physical measures. Surface treatments and physical measures should be designed to be in keeping with the colour or character of local building materials.

1.2 Outline of project

TRL was commissioned in 2001 by the Charging and Local Transport Division (now the Traffic Management

Division) of the Department for Transport to develop and test traffic calming techniques which make greater use of psychological (non-physical) measures than hitherto, but which still have a significant speed-reducing capability.

The intention was to take the development of traffic calming measures a step further than previous UK research. The speed-reducing measures needed to be inexpensive to install, not (visually or otherwise) environmentally intrusive, but still effective in reducing speeds.

Professional Urban Designers David Huskisson Associates (DHA), under sub-contract to TRL, had a key role in assisting with the development of new approaches and presentation of material for discussion. They also produced ideas and sketches for on-road schemes.

The project involved:

- A review of psychological measures (Elliot *et al.*, 2003) which looked at the cognitive mechanisms involved in drivers' responses to different situations in order to facilitate the development of measures with greater potential for success.
- Reviews of other rural measures.
- Identification of further innovative measures, through consultation and brainstorming with professionals, followed by group discussions with members of the public.
- Assessment of a selection of psychological and other measures using photomontage techniques and the TRL driving simulator.
- Liaison with local authorities to identify trial sites on the public highway and assist with the detailed design of suitable measures.
- Monitoring of selected schemes before and after installation.
- Interpretation of the results and recommendations.

1.3 Structure of report

This is the final report on the project. Section 2 describes the review of psychological principles, whilst Section 3 outlines the methodology used to develop suitable measures. Section 4 presents the results from focus group discussions and a questionnaire survey respectively, both designed to establish subjects' opinions of the effect on speed of different road features. Section 5 describes a trial using the TRL Driving Simulator to assess the speeds adopted with different measures. Section 6 describes the on-road schemes developed. Results are summarised in Section 7, with discussion and conclusions in Section 8.

2 Review

2.1 Psychological principles

An important difference from earlier work is that the project started by looking at psychological principles. Elliott *et al.* (2003) reviewed the cognitive mechanisms involved in drivers' responses to speed-reducing factors and assessed how psychological measures might achieve a reduction in speed. Various broad principles were established:

- More complex environments tend to be associated with slower driving speeds, the likely mechanisms being increases in cognitive load and perceived risk.
- Natural traffic calming such as a hump back bridge or a winding road can be very effective in reducing speeds, as well as being more acceptable to drivers. Carefully designed schemes, using the properties of natural traffic calming, have the potential to achieve a similar effect.
- Emphasising changes of environment e.g. highway / village boundary can increase awareness and/or reduce speed.
- Enclosing a distant view and/or breaking up linearity can reduce speeds.
- Creating uncertainty can reduce speeds.
- Combinations of measures tend to be more effective than individual ones, but can be visually intrusive and may be costly.
- Roadside activity e.g. parked vehicles, the presence of pedestrians or a cycle lane can reduce speeds.
- Vertical objects in the visual periphery such as buildings or a row of trees might enhance the perception of speed by providing vertical contrast.

Perceptual techniques which make the environment seem more complex or less safe therefore have the potential for success. It is important to ensure that measures that increase perceived risk do not increase actual risk.

2.2 Design elements

Psychological traffic calming works within a number of design elements, such as:

- Context.
- Scale.
- Proportion.
- Roadside activity.
- Road surface.

Context relates to the type of road and its historical character. Scale is related to road width, whilst proportion is determined by the height of enclosing features such as buildings or trees. These three elements act together to set the dimensions of the road corridor, which may in itself give some natural traffic calming, or may need to be modified. For example, if the road is unnecessarily wide for the traffic it carries, then some form of physical or visual narrowing might be needed. The alignment of the road, especially the horizontal alignment, has a large effect on speed. Limiting forward visibility is one way of reproducing the effect of a bend without having to engineer it.

Roadside activity might be cars parked at the roadside (parallel or en echelon), pedestrians on the pavement, delivery vehicles or a bus or cycle lane.

Coloured surfacing is a technique that is widely used either to highlight a particular road feature where drivers need to take extra care or to delineate the road space (e.g. by use of cycle or bus lanes). It can also be used to visually narrow the road. Textured surfacing has a more limited application, as rough road surfaces can be noisy and uncomfortable. Rumblewave surfacing (Watts *et al.*, 2002

and Traffic Advisory Leaflet 1/05) is designed to generate noise for the driver (i.e. inside the vehicle) but not for residents or pedestrians (i.e. outside the vehicle); it can be used over short lengths as an alerting device. Textured surfacing used in the centre or along the edge of a road can serve as a reminder to drivers to keep away from this area. Several UK local authorities have tested the removal of centre white lining (Debell, 2003).

3 Focus groups and questionnaire surveys using photomontage techniques

3.1 Methodology

The research methodology adopted was to use a range of different scenarios for which a variety of traffic calming ideas were developed, based on the psychological principles outlined in Section 2.1. A photograph of a particular scene without any traffic calming measures was taken as a baseline scenario. Photomontage was used to illustrate the various ideas. The methodology was similar to that adopted by Uzzell and Leach (2001) and in an earlier TRL project (Chinn and Elliott, 2002a and b; Chinn *et al.,* 2002) for the Highways Agency, although the TRL project used sketches rather than photomontage.

The plates resulting from the photomontage were used as a basis for the focus group discussions and questionnaire survey. The more interesting ideas were subsequently tested in the driving simulator trial and the on-road measures.

The road scenarios selected initially were as follows:

1 Village with parked cars.

2 Village gateway.

3 Town centre.

4 Distributor road.

5 Village with church.

The plates were discussed with two focus groups at an early stage of the project. Subsequently a slightly revised set of plates and a sixth scenario were used as the basis of a questionnaire survey in face-to-face interviews of a sample of 100 respondents. The sixth scenario was:

6 Village with phone box.

The descriptions ‘with parked cars’, ‘with church’ and ‘with phone box’ are simply included as aides-memoir and are not intended to imply that these features have any significance in the context of the traffic calming.

3.2 Focus groups

Two focus groups were used to gauge the response to the traffic calming measures illustrated in the photomontage, in order to establish which types of non-physical traffic calming were likely to be most effective. Once identified, these potential measures were evaluated in more detail.

It was important to ensure that the participants were representative of the population as a whole and had no direct involvement in the design of traffic calming schemes. For its work using a driving simulator (described in Section 4), TRL maintains a database of over 1000 subjects, that is people who do not have a direct involvement in the work of TRL, but are available for participation in simulator experiments and are also willing to take part in other trials, such as focus groups.

Two focus groups were held in June 2002, one in the evening and the second in the morning. Ten participants attended each, of whom equal numbers were male and female and a range of ages was represented. All were regular drivers, with a spread of experience.

A projector was used to show 31 plates with and without traffic calming features relating to the five different scenarios listed in Section 3.1 and described below in Sections 3.4 to 3.8. The plates were first presented in random order and the participants were asked to look at each and write down how fast they would drive if they encountered the scene in real life. Estimated speeds for each scenario with and without the various traffic calming features were then compared. Because of the small sample, no tests were undertaken of the statistical significance of the differences in speed.

The participants were then asked to discuss the plates in each scenario in terms of speed, safety and aesthetics and to comment on any other issues arising.

3.3 Questionnaire surveys

For the questionnaire survey, 100 members of the general public representative of the general population were interviewed face-to-face to establish their opinions on driving speeds in the different scenarios with the various traffic calming features. The sample of respondents was selected at random from the electoral register in the area close to TRL. Approximately equal numbers of men and women were interviewed and a good age range was obtained. All drove a motor vehicle.

Most of the plates from the focus groups were also used in the questionnaire survey, but a few were omitted to cut down the total number and an additional village scenario was added. This gave a total of six scenarios, each with five plates, illustrated in the following sections. The results presented are for the plates that were common to both the focus group and the questionnaire survey (except for Scenario 5, where several changes were made following the focus groups), plus the new scenario.

Respondents were asked three questions relating to speed choice about each plate:

i The speed at which they themselves would drive?

ii The speed at which most other drivers would drive?

iii What would be a safe speed?

The plates were presented to respondents in four different random orderings, to reduce the possibility of responses being affected by the ordering.

The overall effects of the different countermeasures on mean speed ratings were tested for statistical significance using repeated measures analysis of variance (ANOVA). There were some differences between the three types of speed ratings respondents were required to make. Overall, respondents reported that:

- Most other drivers would drive significantly faster than they themselves would (statistically significant at the 5% level).

- The speed at which most other drivers would drive would be significantly greater than what they themselves considered to be a safe travelling speed (statistically significant at the 1% level).
- There were no statistically significant differences between respondents' estimated speed and their ratings of what they considered to be a safe speed – in other words, for each plate, respondents said they would drive at a speed consistent with what they considered to be safe for the road conditions.

The 'speed of most other drivers' was consistently about 4 to 5mph higher than their own estimated speed and this difference was statistically significant. In this report, only the first speed i.e. (i), the speed at which drivers said they themselves would drive, is given.

3.4 Scenario 1: Village with parked cars

Figure 1 illustrates the five plates for this scenario. Plate 1 represents the baseline situation before traffic calming measures have been applied. Plates 2 to 5 have various measures added and the centre line removed for all or part of the road.

Plate 2 emphasises the driveways ('Curved edging to mark driveways'), with the intention of creating uncertainty by reminding drivers of the possibility of an emerging vehicle. Plate 3 has red brick edging with the appearance of cobbles that narrow the road ('Red brick narrowing') both physically and visually, and the band of red across the road acts as a gateway for the village centre. Plates 4 ('Coloured patch') and 5 ('Curved patch') have patches of coloured surfacing intended to remind the driver to slow down, with the 'curved' patch in Plate 5 giving the illusion of excessive camber.

As noted above, each driver in the focus groups was asked to write down the speed they would adopt if driving through the scene shown in each plate and respondents in the questionnaire survey were asked two further questions relating to safe speeds and those of other drivers.

The mean and standard deviation of the estimated speed each driver would adopt for each plate in Scenario 1 is shown in Table 1 for the focus groups and the questionnaire survey separately.

Overall, the 'Red brick narrowing' in Plate 3 was predicted to have the greatest effect on speed, with an estimated reduction of about 5mph compared to the baseline scenario.

The participants in the focus groups thought that the 'Red brick narrowing' in Plate 3 would slow drivers down due to the narrowing. There was concern that the paving stones would be a safety hazard if they became loose. The participants liked these measures better than the other measures in Scenario 1, commenting that they made the area look more attractive. The bench at the side of the road in Plate 2 ('Curved edging') was introduced as a calming measure, but was considered by some participants to be a safety hazard because it encouraged pedestrians to sit by the roadside. The white fencing in Plate 4 was highlighted as a good mechanism for slowing down traffic because some participants associated it with schools and children. The participants thought that the patches of coloured surfacing in Plates 4 and 5 would be the least effective in slowing down drivers, suggesting that they merely looked as if the road had been re-surfaced. There was concern that the effectiveness of the measures would not be sustained over time.

3.5 Scenario 2: Village gateway

Figure 2 illustrates the five plates for Scenario 2, the 'Village gateway'. Plate 1 is the baseline before any measures were added. Plate 2 shows a gateway and trimmed verge, Plates 3 and 4 add patches of coloured surfacing in the distance to enclose the forward view. The additional red patch at the gateway in Plate 4 and the more elaborate surfacing in Plate 5 are intended to emphasise the transition from highway to village. Plate 5 shows additional trees and a neatly trimmed hedge that exposes more of the housing behind it, again to emphasise the change in environment.

The mean speed attributed to Plate 1 was 42mph in the focus groups and 39.6mph in the questionnaire survey (Table 2). All of the measures suggested worthwhile speed improvements in the focus groups, although not surprisingly, the plates with the most measures were associated with the lowest mean driving speeds. However, the participants in the questionnaire survey thought that the gateway alone would have little effect.

The participants in the focus groups agreed that the openness of the road in Plate 1 encourages the driver to speed. Although Plate 5 was associated with the lowest mean speed, some participants suggested that the road looks open and would encourage drivers to speed up, whilst others thought it would slow traffic because it emphasises the village entry and the trees give a narrowing effect. The measures in Plate 5 were regarded as the safest for pedestrians. The participants identified the measures in Plate 3 as the most cost effective. The measures in Plate 5 were considered the most attractive, but participants thought they would be very expensive.

It was suggested that changing the speed limit from 40 to 30mph would encourage people to slow down, although regular drivers would take little notice of a change in speed limit.

3.6 Scenario 3: Town centre

Figure 3 illustrates the plates for Scenario 3. Plate 1 is the baseline. Plate 2 shows a mock road hump, intended as an informal crossing, with the aim of making drivers slow down both because the feature looks like a hump and because of the possibility of pedestrians crossing there. Plate 3 shows the same mock hump with an island with a tree in the background which the driver will have to negotiate, adding to the complexity of the scene. Plates 4 and 5 emphasise the hump in different ways.

The mean estimated speed associated with all the plates was less than 25mph (Table 3). Speed reductions in the questionnaire surveys were modest, up to 3mph.

1: Baseline

2: Curved edging to mark driveways

3: Red brick narrowing

4: Coloured patch

5: Curved patch

Figure 1 Plates for Scenario 1: Village with parked cars

Table 1 How fast would you drive in Scenario 1: Village with parked cars

Study (sample size)		*Focus groups (20)*			*Questionnaire survey (100)*		
Picture	*Description*	*Mean speed (mph)*	*Standard deviation (mph)*	*Difference from base (mph)*[1]	*Mean speed (mph)*	*Standard deviation (mph)*	*Difference from base (mph)*[2]
1	Baseline	36.0	6.4		31.1	5.0	
2	Curved edging to mark driveways	32.5	5.4	-3.5	28.6	5.4	-2.5
3	Red brick narrowing	30.6	5.6	-5.4	26.5	5.6	*-4.6*
4	Coloured patch	31.5	6.1	-4.5	30.0	4.5	-1.1
5	Curved patch	31.1	5.3	-4.9	29.1	4.1	-2.0

[1] *Sample too small for statistical testing.*

[2] *Differences in italics are statistically significant at the 5% level or better.*

1: Baseline

2: Gateway

3: Gateway and patches

4: Alternative gateway and patches

5: Gateway and continuous coloured surface with patches

Figure 2 Focus group plates for Scenario 2: Village gateway

Table 2 How fast would you drive in Scenario 2: Village gateway

Study (sample size)		*Focus groups (20)*			*Questionnaire survey (100)*		
Picture	*Description*	*Mean speed (mph)*	*Standard deviation (mph)*	*Difference from base (mph)*[1]	*Mean speed (mph)*	*Standard deviation (mph)*	*Difference from base (mph)*[2]
1	Baseline	42.1	7.7		39.6	5.1	
2	Gateway	38.2	6.8	-3.9	38.6	5.4	-1.0
3	Gateway and patches	38.6	6.8	-3.5	37.9	5.4	-1.7
4	Alternative gateway and patches	37.4	6.5	-4.7	36.6	5.4	*-3.1*
5	Gateway and continuous coloured surface with patches	35.7	7.5	-6.4	35.4	5.7	*-4.3*

[1] *Sample too small for statistical testing.*

[2] *Differences in italics are statistically significant at the 5% level or better.*

1: Baseline

2: Mock hump

3: Mock hump with island

4: Mock hump with holes

5: Mock humps with brown holes

Figure 3 Focus group plates for Scenario 3: Town centre

Table 3 How fast would you drive in Scenario 3: town centre

Study (sample size)		*Focus groups (20)*			*Questionnaire survey (100)*		
Picture	*Description*	*Mean speed (mph)*	*Standard deviation (mph)*	*Difference from base (mph)*[1]	*Mean speed (mph)*	*Standard deviation (mph)*	*Difference from base (mph)*[2]
1	Base line	23.7	4.4		22.1	5.8	
2	Mock hump	19.7	4.4	-4.0	21.2	6.0	-0.9
3	Mock hump and island	18.7	5.6	-5.0	19.5	6.5	*-2.6*
4	Mock hump and 'holes'	18.3	5.6	-5.4	19.8	6.3	*-2.3*
5	Mock hump, brown 'holes'	20.3	5.9	-3.4	20.5	6.3	-1.6

[1] Sample too small for statistical testing. One participant consistently chose a very low speed because of the car in the foreground and was excluded.
[2] Differences in italics are statistically significant at the 5% level or better.

Participants in the focus groups remarked that the presence of pedestrians in Plate 1 would cause drivers to slow down, without the need for traffic calming measures. The measures in Plate 2 were considered the most attractive in Scenario 3. Participants commented that the false hump looked like a pedestrian crossing and might encourage pedestrians to walk out in front of cars.

3.7 Scenario 4: Distributor road

In Scenario 4, the 'Distributor road', the measures were all variants of wavy edge lines, intended to create uncertainty and to visually narrow the road. For the focus groups, the wavy edge line patterns were random. For the questionnaire survey, they were re-drawn to show two different symmetrical cases (plan views as in Figure 4) the 'snake' and the 'boa constrictor'.

Figure 5 illustrates the five plates for this scenario. In these plates, the main difference between measures appears in the effect on the centre lines. Plate 1 is again the baseline. Plates 2 and 3 illustrate the 'snake', with and without a centre line. Plate 4 is the same as Plate 2, but the colour is continued onto the pavement. Plate 5 shows the 'boa constrictor' with a centre line.

The baseline was the same for both the focus groups and the questionnaire survey and two of the plates were sufficiently similar for the differences to be ignored. Estimated speeds associated with all plates in the questionnaire survey and for those common to the focus groups are shown in Table 4.

Results from the questionnaire surveys showed relatively modest estimated speed reductions of up to about 3mph, compared with a baseline of 38mph, whereas in the focus groups, the average speed for the baseline was 41mph, with a reduction of about 6mph associated with the measures in the two other plates.

The participants in the focus groups found all the measures for this scenario confusing. Most remarked that road users may try to follow the wavy edging. It was considered that the schemes would be effective in reducing speed initially, making drivers more cautious. Some participants remarked that the curves would distract the driver, making the driver a danger to other road users.

3.8 Scenario 5: Village with church

The plates for this scenario are illustrated in Figure 6. Plate 1 is the baseline. The measures in Plates 2 and 3 narrow the road physically by adding a footway and a ditch respectively. The footway is retained in Plate 4 and the driveways are also emphasised to create uncertainty; a patch of grass with a bench in the distance emphasises the narrowing of the road at that point. The measures in Plate 5 extend those in Plate 4 with more coloured surfacing and benches with pedestrians.

Mean estimated speeds are shown in Table 5. Participants in the focus groups thought that the residential feel in this scenario would be enough to cause drivers to slow down. They commented that narrowing the road reduces speeds. Accentuating driveways may make drivers more cautious because they are aware that a vehicle may reverse from them.

In terms of estimated speed reduction, the footway was more effective than the ditch, although both narrowed the road to the same extent.

The measures in Plate 5 gave the greatest reduction in mean estimated speeds, of about 8mph. The focus group participants liked the appearance of these measures, but highlighted the cost implications.

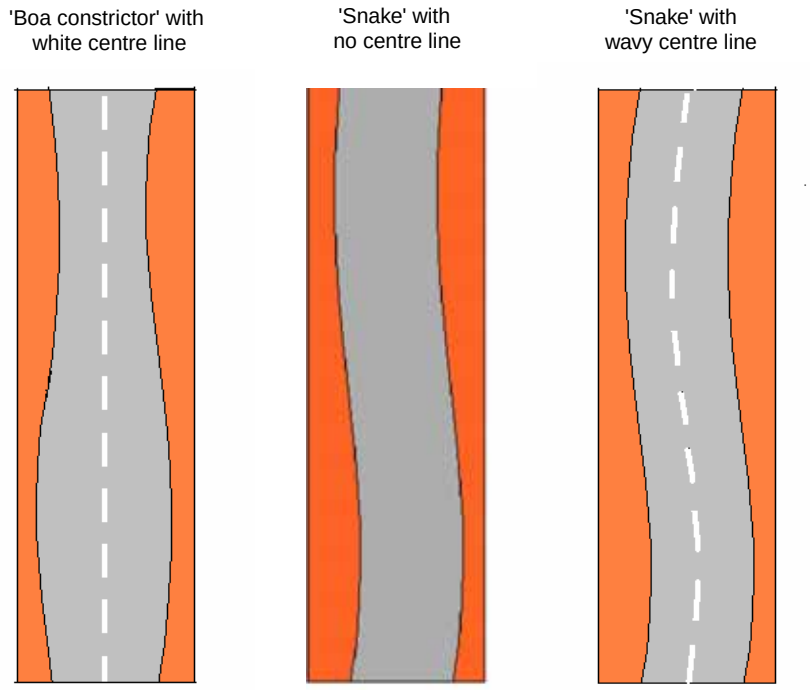


Figure 4 Plan view of 'Boa constrictor' and 'Snake' road markings

1: Baseline

2: Snake, no centre white line

3: Snake, wavy centre white line

4: Snake with red pavement, no centre white line

5: Boa constrictor, red pavement, straight centre white line

Figure 5 Questionnaire survey plates for Scenario 4: Distributor road

Table 4 How fast would you drive in Scenario 4: Distributor road

		Focus groups (20)			*Questionnaire survey (100)*		
	Study (sample size)	*Mean speed (mph)*	*Standard deviation (mph)*	*Difference from base (mph)*[1]	*Mean speed (mph)*	*Standard deviation (mph)*	*Difference from base (mph)*[2]
Picture	*Description*						
1	Baseline	41.0	9.8		38.0	6.7	
2	Snake, no centre line	35.0	10.0	-6.0	35.3	7.1	*-2.7*
3	Snake, wavy centre white line	–	–	–	35.4	6.5	*-2.6*
4	Snake with red pavement, no centre line	–	–	–	35.2	6.5	*-2.8*
5	Boa constrictor with centre line	34.6	9.8	-6.4	36.0	6.8	-2.0

[1] *Sample too small for statistical testing.*
[2] *Differences in italics are statistically significant at the 5% level or better.*

1: Baseline

2: Footway

3: Ditch

4: Footway and driveways

5: Footway and continuous coloured surface

Figure 6 Focus group plates in Scenario 5: Village with church

Table 5 How fast would you drive in Scenario 5: Village with church

Study (sample size)		*Focus groups (20)*			*Questionnaire survey (100)*		
Picture	*Description*	*Mean speed (mph)*	*Standard deviation (mph)*	*Difference from base (mph)*[1]	*Mean speed (mph)*	*Standard deviation (mph)*	*Difference from base (mph)*[2]
1	Baseline	33.7	9.1		32.5	6.5	
2	Footway	30.9	8.3	-2.8	30.4	5.6	-2.1
3	Ditch	35.1	9.4	+1.4	30.0	6.6	-2.5
4	Footway and driveways	27.9	7.6	-5.9	25.9	6.1	*-6.6*
5	Footway and coloured surface	25.0	7.4	-8.7	24.1	6.1	*-8.4*

[1] *Based on 19 participants - sample too small for statistical testing.*

[2] *Differences in italics are statistically significant at the 5% level or better.*

3.9 Scenario 6: Village with telephone box

Figure 7 shows the plates used for Scenario 6, 'Village with telephone box'. This scenario was not used in the focus groups. Plate 1 is the baseline. Plate 2 shows build-outs on both sides of the road, each with a tree protected by a fence. Plate 3 shows the same build-outs, but with posts rather than trees. Plate 4 is the same as Plate 2, but there is no centre white line, and the build-outs with coloured surfacing are emphasised. Plate 5 is identical to Plate 3, but horizontal lines on the road surface are added to emphasise the posts.

Table 6 shows that estimated speeds were significantly lower ($p<0.001$ in all cases) by between 4 and 7mph. The biggest estimated speed reduction was associated with the measures in Plate 5.

3.10 Summary and discussion

3.10.1 Summary of focus groups

The focus groups considered that road narrowing reduced speeds and this was generally consistent with the participants' average estimated speed. For example, with the 'Red brick narrowing' in Plate 3 in the 'Village with parking' scenario, participants' mean estimated speed was 6mph below the baseline speed. In the 'Village with church' scenario, adding a footway narrowed the road and was more effective at reducing estimated speeds than a ditch, but a footway combined with other measures gave greater estimated speed reductions.

The use of continuous coloured surfacing produced mixed responses from the participants. In the 'Gateway' scenario, participants thought that continuous coloured road surfacing highlighted the transition from rural road to village, accentuated the village characteristics and made the area more aesthetically pleasing ('Village gateway' scenario, Plate 5 and 'Village with church' scenario, Plate 5, in Figures 2 and 6 respectively).

Patches of coloured surfacing were not considered very effective by the participants, but in terms of estimated speeds, they were just as effective as continuous coloured surfacing, whilst being less expensive. Curved edging to mark driveways had slightly less effect on estimated speed than the patches of coloured surfacing which stretched across the road.

The use of shrubs and trees to reduce forward visibility was a concern to some of the participants.

In all cases, where pedestrians were illustrated in the plates, such as in the 'Town Centre' scenario or sitting on a bench, the participants commented they would drive more cautiously. However, they were concerned about the safety implications of encouraging people to sit by the roadside.

Participants commented that psychological measures are likely to become less effective over time.

3.10.2 Summary of questionnaire survey

Respondents considered that most other drivers would drive significantly faster than they would, and that their own speed corresponded to a safe speed for the scenario shown. The results from the questionnaire survey generally reinforced the findings on speed from the focus groups.

The greatest reductions in estimated speed were obtained with the 'Footway and continuous coloured surface' in the 'Village with church' scenario (8.3mph), the 'Build-outs with posts, lines on the road surface' and 'Build-outs with trees, no centre line' in the 'Village with telephone box' scenario (7.1mph and 5.4mph respectively), and the 'Red brick narrowing' in the 'Village with parked cars' scenario (4.6mph).

In contrast to the focus groups, coloured surfacing alone did little to slow vehicles. It was again found that features with a physical impact were more successful than those without.

3.10.3 Discussion

The mean estimated speeds in the focus groups are based on the small numbers of participants, but those in the questionnaire survey were more broadly based. Neither is necessarily realistic. However, unpublished research at TRL found good correlation between mean estimated speed from video clips and actual observed mean speeds on the same road. Chinn *et al.* (2002) found good agreement between speed ratings for sketches and speeds obtained using the TRL Driving simulator.

4 Driving Simulator trial

The TRL Driving Simulator was used to assess the more promising measures examined through the focus groups and questionnaire surveys. The advantage of using the simulator was the greater realism and the ability to consider the effect of a measure on downstream speeds. Some variations were made to the previous measures for practical reasons: for example, the mock road humps from the Town Centre scenario were not included.

4.1 The TRL Driving Simulator

The simulator consists of a real car (Rover 414) surrounded by four large projection screens (one in front, one behind and two either side). The car remains static as high-resolution images are projected on to the screens. The images are generated by computer and respond to the steering, gears and pedals of the car. As the car is 'driven', the images change creating the illusion that the car is moving. Hydraulic equipment is used to induce some pitch, roll and heave to the car. However, these movements are limited and cannot reproduce the full range of forces that occur, for instance, during emergency braking. In order to generate the illusion of movement, a 3D computer model is constructed.

Simulator trials have several advantages over public road trials:

- novel measures can be assessed safely and cheaply;
- a larger number of measures and variants can be tested much more quickly and cheaply;
- a range of combinations of measures can easily be tested;
- the conditions are controlled (i.e. comparison of the effectiveness of measures is not hampered by variations in other factors, as happens in public road trials).

1: Baseline

2: Build-outs with trees, centre line

3: Build-outs with posts, centre line

4: Build-outs with trees, no centre line

5: Build-outs with posts, lines on road surface, no centre line

Figure 7 Questionnaire survey plates for Scenario 6: Village with telephone box

Table 6 How fast would you drive in Scenario 6: Village with telephone box

Study (sample size)		*Questionnaire survey (100)*		
Picture	*Description*	*Mean speed (mph)*	*Standard deviation (mph)*	*Difference from base (mph)*[1]
1	Baseline	34.9	6.1	
2	Build-outs with trees, centre line	30.9	5.7	*-4.0*
3	Build-outs with posts, centre line	30.9	6.1	*-4.0*
4	Build-outs with trees, no centre line	29.5	6.0	*-5.4*
5	Build-outs with posts, lines on road surface, no centre line	27.8	6.4	*-7.1*

[1] *Differences in italics are statistically significant at the 5% level or better.*

It is important to consider the interpretation of the results, especially as there are no data from existing installations against which the results could be checked. Lockwood (1997) investigated the accuracy of the simulator in predicting the speed reduction at trial traffic calming measures on public roads in rural or semi-rural areas. The report concluded that the relative effects of signing/marking measures could be broadly reproduced in the simulator. Therefore it would be reasonable to expect that during the current trial, the relative effectiveness of the different measures being evaluated will be established, although it should be noted that one of the three models used simulated an urban environment.

During the current trial, the simulator generated vehicles travelling in the opposite direction to the subject's vehicle. These vehicles were intended to give the impression of traffic on the carriageway. However, the amount of computer power required severely limited the amount of traffic generated, and so the rural context may have been better represented than the urban context. No traffic was generated in the same direction as the driven vehicle. This was to avoid the driver being influenced by the car in front when novel measures were encountered.

4.2 The models

It was important to build a plausible computer model of the environments being simulated. The models comprised relatively short sections of road which were used in different combinations to form three routes. Two of these routes (designated A and B) consisted of a series of villages joined by sections of rural road while the third (Route C) consisted of urban roads connected by rural links. The treatments being evaluated were then modelled and applied to some of the road sections. These sections formed an approximate arc, with gentle curves which ensured that the route did not become monotonous. There was a control section for each measure.

4.3 The measures

The measures were applied to the three routes as shown in Table 7. Two versions of each route were developed, each version testing the same measures but presented in a different order.

Table 7 Description of measures tested in simulator trial

Reference	*Description*	*Route*
V1	Gateway only	A
V2	Gateway with patches at intervals through village	A
V3	Gateway with coloured surface continued through village	A
V4	Red brick narrowing continued through village	B
V5	Build-outs with trees and lines on road surface	B
V6	Curved patch	B
DR1	Wavy red edge markings – boa constrictor, with centre line	C
DR2	Wavy red edge markings – snake, no centre line	C
DR3	Build-outs with bollards and lines on road surface	C

Routes A and B each tested three village measures. After the start-up section, each route had eight villages, each having one of the three measures or acting as a control. Each measure was repeated twice and there were two control villages. The villages were each 2km long and were separated by rural single carriageway sections.

Route C tested three measures on an urban distributor road. The start-up section had villages separated by sections of rural single carriageway. The urban sections with measures were separated by similar sections of distributor road with no measures. Each of the measures and the control appeared twice.

Images of the measures as modelled on the simulator are shown in Figure 8, Figure 9 and Figure 10.

Measure V1: Gateway only (Figure 8)

This measure featured a gateway with the village name plate and speed limit signs. For the purposes of the simulator trial the plate displayed a simple village name up to eight characters long. The gateways were placed at the entry to the 30mph zone. They had the appearance of being constructed out of Cotswold stone and were similar to those developed in the photomontage for the focus groups and questionnaire surveys (Figure 2, Plate 2).

Measure V2: Gateway with patches at intervals through village (Figure 8)

This measure featured the gateway used in V1 with the centre line removed and with a red centre strip, red edging, and long patches of contrasting surfacing repeated at intervals through the village. Edges and centre red strips were each 0.5m wide. The gateway strip (between the gate posts) was 5m long. The patches were 100m long with gaps of 100m between them. Both edge and centre red strips were started 50m in advance of the gateway.

Measure V3: Gateway with coloured surfacing continued through village (Figure 8)

This measure was similar to V2. However, the coloured surfacing was continued throughout the village and a second colour was applied to the road surface to form a series of rectangles on each side of the road. Each rectangle was intended to emphasise a private drive.

Measure V4: Red brick narrowing continued through village (Figure 9)

In this measure, the red brick footway was extended into the road, giving a narrowing effect. The use of textured surfacing was intended to discourage drivers from encroaching onto it as well as to visually narrow the road. Posts were used to indicate a boundary between the pedestrian and car areas.

Measure V5: Trees build-outs with horizontal markings (Figure 9)

This measure incorporated a series of build-outs, each featuring a small shrub or tree protected by four wooden bollards. Each bollard was emphasised by a buff line on

Entry to control village

Gateway (V1)

Gateway with patches (V2) – view at gateway

Gateway with patches (V2) – view in village

Gateway and coloured surface (V3) – view at gateway

Gateway and coloured surface (V3) – view in village

Figure 8 Route A

the road surface, emerging from the build-out. These had a length of about one third of the width of the road and a width of about 300mm. The build-outs were spaced at 70m intervals over a distance of more than 1000m.

Measure V6: Curved patch (Figure 9)

This measure was intended to give the impression that there was excessive camber on the road. This was intended as an illusion. In reality the camber of the road surface would be unchanged.

Measure DR1: Wavy red edge markings – 'Boa constrictor with centre line' (Figure 10)

This measure consisted of wavy red edging on both sides of the road. The pattern was symmetrical about the centre of the road, and the white centre line was retained (Figure 4). The edging had a minimum width of 1m and a maximum width of 1.5m on each side. The wavelength (distance between maximum narrowings) was 30m.

Red brick narrowing (V4) – view at gateway

Red brick narrowing (V4) – view in village

Tree build-outs (V5)

Curved patch (excessive camber) (V6)

Control section corresponding to curved patch

Figure 9 Route B

Measure DR2: Wavy red edge markings – 'Snake with no centre line' (Figure 10)

This measure was similar to DR1, but the pattern on one side of the road was displaced so that it was no longer symmetrical about the centre line, the maximum on one side occurring at the same point as the minimum on the other (Figure 4). The centre white line was removed, as it was considered that drivers would only be able to follow a curved centre line on the simulator if a very long wavelength was used.

Measure DR3: Build-outs with bollards and horizontal markings (Figure 10)

This measure consisted of build-outs at regular 70m intervals, on both sides of the road. There were four black bollards on each build-out. Corresponding to the bollards were buff lines of block paving emerging from the build-outs, as in measure V5.

'Boa constrictor' (DR1)

'Snake' (DR2)

Build-outs (DR3)

Figure 10 Route C

4.4 Participants

A total of 72 drivers took part in the trial. All were members of the public who were familiar with the TRL driving simulator and had not taken part in a similar traffic calming trial. Routes A1, A2, B1 and B2 were each driven by 12 subjects split into equal numbers of men and women, with a good age range. One-third of the drivers were inexperienced, having held a driving licence for 5 years or less. The remainder had at least 10 years driving experience.

Initially, 24 drivers drove Route C with the same split between male and female and experienced and inexperienced drivers. Preliminary analysis of the data indicated that the drivers had stopped before they had completed the second control section. Twelve additional subjects were therefore recruited to drive the whole of Route C. The second variant of route C was not used.

4.5 Analysis

The speed and lateral displacement of each subject were measured on the simulator up to 60 times a second. The results were converted to values every 5m along the routes.

Figure 11 shows an example of the speed profile of an individual driver over the whole of Route B2. The low speed regions indicate the villages (30mph speed limit), and the high speed regions are the rural single carriageway sections linking the villages where the national speed limit applies (60mph). The speed reductions along the rural single carriageway sections are due to bends in the route.

4.6 Mean speeds on control sections

Each driver on Routes A and B drove through a control village with no measures twice. Although a total of 36 subjects drove Route C, only 12 drove through both control sections of distributor road. The mean speed of the 12 drivers was compared for the two control sections. For most of the section, the speed was between 0.5mph and 1.0mph higher at the second control section than at the first. The difference at each point was applied to the first control section for the 24 drivers who did not complete the second control. The data were then analysed as for Routes A and B; however, because of the problems with this data set, no statistical tests were used to test for the significance of changes in speed. The speed limit was 30mph.

4.7 Mean speeds at measures

The 'speed relative to control' for each driver was calculated by subtracting the mean speed at a point in the control section from the mean speed at the equivalent point on the section with a measure. The mean speed relative to control was then calculated as the mean for all drivers. A negative speed relative to control indicates a reduced speed at the measure. Results are shown in Table 8 and illustrated in Figures 12-17.

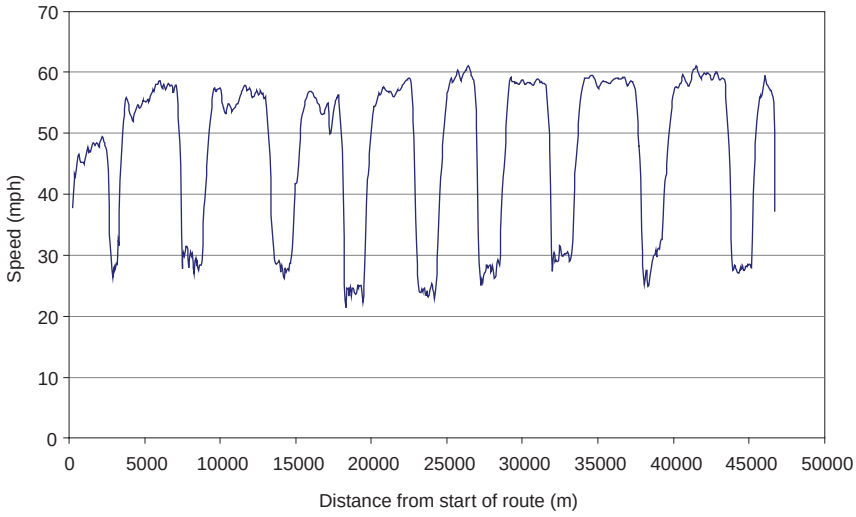


Figure 11 Speed profile for driver 24 (Route B2)

Table 8 Mean speeds and minimum mean speed

Distance from start of village / start of distributor measures (m)	*Mean speed (mph)*			*Mean speed relative to control (mph)*			*Minimum mean speed relative to control*	
	0	*300*	*1000*	*0*	*300*	*1000*	*Distance (m)*	*Speed (mph)*
Route A								
Village control	40.0	34.0	35.6					
Gateway and coloured surface	39.6	32.6	33.8	-0.4	-1.4	-1.7	80	-3.1
Gateway and patches	39.1	33.5	34.3	-0.9	-0.5	-1.3	90	-3.0
Gateways only	39.6	34.4	34.9	-0.4	0.4	-0.6	65	-1.3
Route B								
Village control	41.3	33.8	33.7					
Curved patch	40.3	33.5	34.4	-1.0	-0.2	0.8	490	-3.0
Red brick narrowing	37.4	30.0	30.7	-3.9	-3.7	-3.0	115	-4.7
Tree build-outs	38.2	29.6	30.6	-3.2	-4.2	-3.1	1250	-7.0
Route C								
Distributor road control	34.0	33.5	33.1					
Build-outs	31.7	29.2	30.1	-2.4	-4.4	-3.0	330	-4.6
Boa constrictor, centre line	33.2	32.0	32.3	-0.9	-1.5	-0.8	145	-2.2
Snake, no centre line	33.2	31.4	31.3	-0.8	-2.1	-1.8	880	-2.8

Table 8 shows the results at the village gateway (0m) and at 300m and 1000m into the village. The figures in italics are statistically significant at at least the 5% level. The table also gives the minimum mean speed relative to control (the greatest effect) and the distance into the village at which this occurred. The latter was a statistically significant reduction in speed for all the measures tested.

On Route A, a reduction in speed compared with the control was achieved with all three measures. At the village gateway (0m), the measures gave reductions of 0.4 to 0.9mph, none of which was statistically significant. The greatest reduction in mean speed (3.1mph) for the 'Gateway and coloured surface' occurred 80m into the village. At 1000m into the village, the reduction was 1.7mph, which was still statistically significant. Similar results were obtained for the 'Gateway and patches', but the 'Gateway only' gave a maximum reduction of only 1.3mph.

On Route B, the most effective measure was the 'Tree build-outs', followed by the 'Red brick narrowing'. Figure 12 and Figure 13 show the mean speed profile and the mean speed relative to control for the measures trialled on Routes B1 and B2. The maximum mean speed reduction for the 'Tree build-outs' was 7.0mph, 1250m into the village. At this point (and at some other build-outs), some of the drivers slowed down to allow a vehicle in the opposite direction to drive through the build-out (even though there was enough room for both vehicles to pass). The greatest reduction for the 'Red-brick narrowing' was 4.7mph, 115m into the village.

On Route C, the 'Build-outs' were the most effective measure, giving a reduction of at least 2mph for the length of the section, with a maximum reduction of 4.6mph, at 330m from the start of the section. The two wavy edge markings gave similar, but slightly lower speed reductions, the maximum being 2.8mph for the 'Snake'.

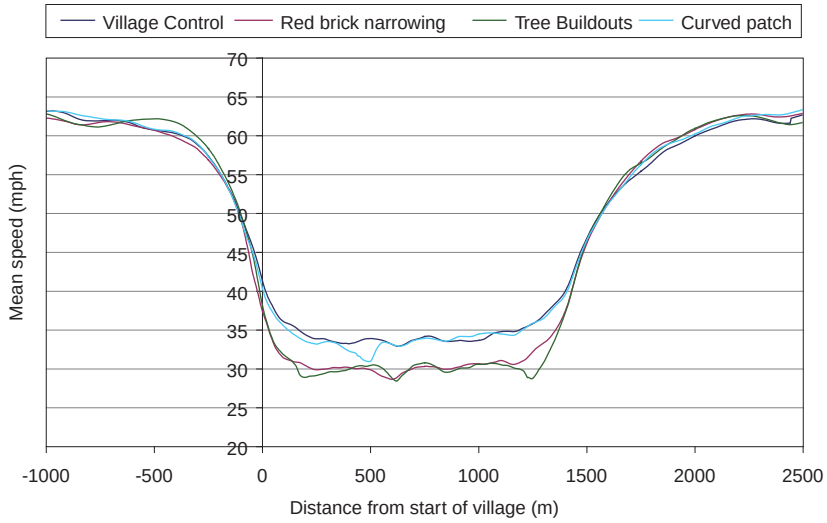


Figure 12 Mean speed profile for Route B

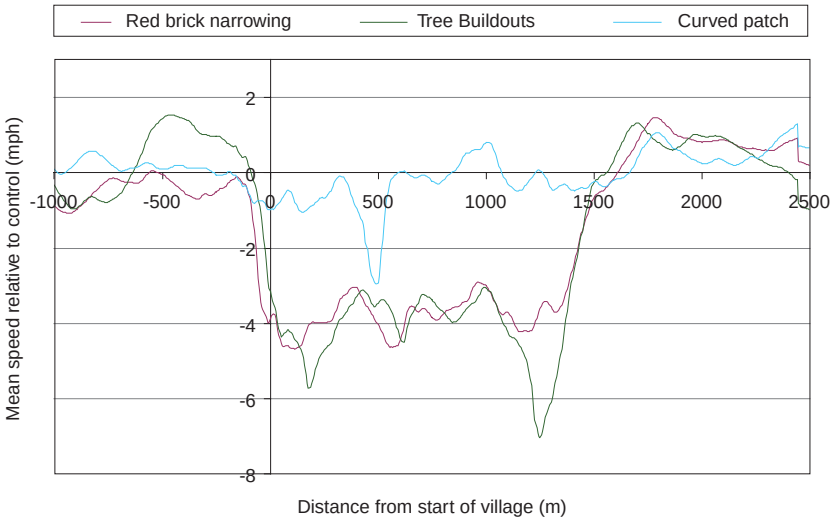


Figure 13 Mean speed profile relative to control for Route B

4.8 Experience and gender effect

Figure 14 shows the mean speed profile for drivers through the control village by gender and experience. At 1000m before the village gateway, the fastest group was the experienced males, with a mean speed of 66.4mph. At the village gateway, the fastest group was the inexperienced males, with a mean speed of 44.1mph. The inexperienced males were also the fastest group throughout most of the village, having reduced their speed from the village approach rather less than the experienced males.

Figure 15 shows the mean speed relative to control for the 'Gateway and patches' by gender. An initial reduction of around 3mph was achieved for both males and females, but further into the village, the effect for the males was smaller, whereas for the females a speed reduction was sustained 1500m into the village.

Figure 16 shows the mean speed profile relative to control for the 'Gateway and coloured surface' measure by experience. Reductions of about 3mph for inexperienced drivers and 4mph for experienced drivers were achieved. The inexperienced drivers braked earlier, in advance of the gateway, but further along the village, they reduced speed less.

4.9 Occurrence number effect

Each subject drove through each measure (and the control other than on Route C) twice. For each subject, the mean speed relative to the control for the first and second drive through the measure was calculated by subtracting his/her mean speed for the two control sections from the speed at the measure. Subjects were generally slower on the first occurrence of each measure. However, the 'Red brick narrowing', the 'Tree build-outs' and the 'Build-outs', i.e. the measures with relatively large effects on speed, broadly retained their effectiveness. This is shown for the 'Red brick narrowing' in Figure 17.

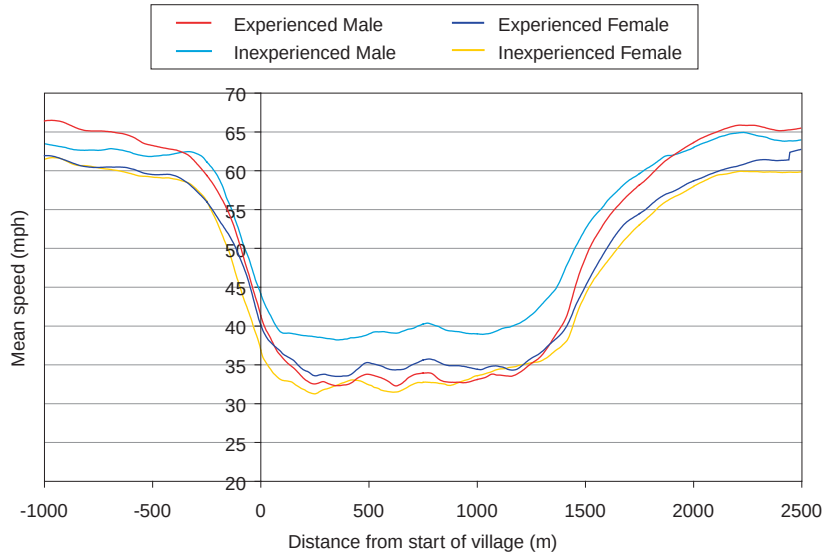


Figure 14 Mean speed profile for control village by experience and gender

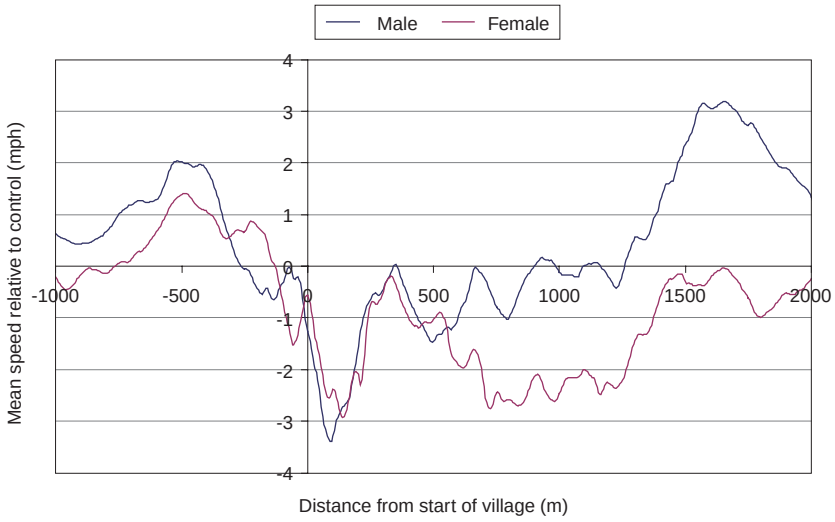


Figure 15 Mean speed profile relative to control for ‘gateway and patches’ by gender

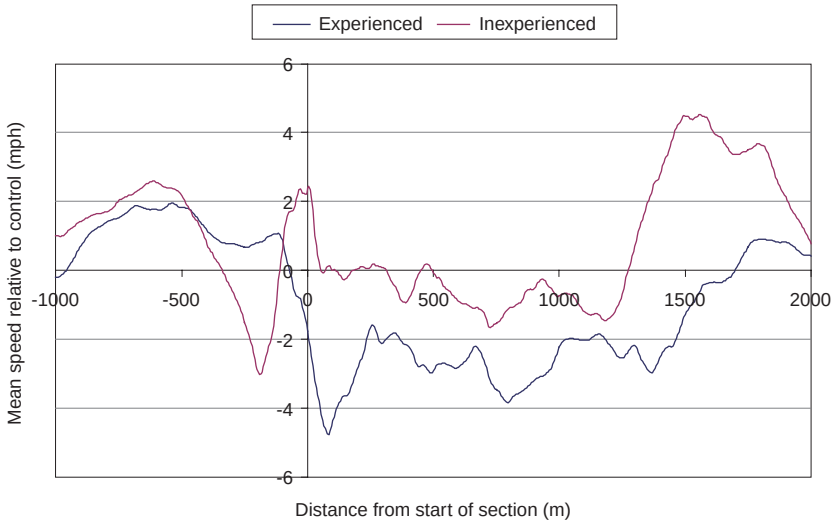


Figure 16 Mean speed profile relative to control for ‘gateway and coloured surface’ by experience

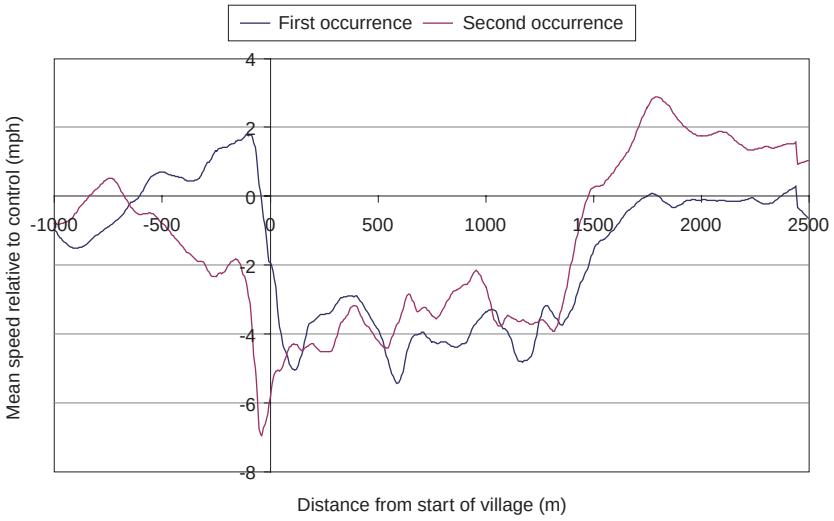


Figure 17 Mean speed profile relative to control for 'red brick narrowing' by occurrence

4.10 Speed choice of driver effect

Since increased accident frequency is particularly associated with the speeds of the fastest drivers (Taylor *et al.*, 2000; Taylor, 2001), measures that influence the speed of these drivers are likely to be the most successful in reducing accidents.

The mean speed of each driver through both control villages was calculated. For Route A (A1 and A2 combined), the fastest 8 drivers were grouped as 'fast', the slowest 8 as 'slow' and the middle 8 as 'medium'. The same procedure was used for Routes B and C.

Table 9 shows the effect of the different measures by speed group relative to the control at 300m into the measure. Where there was a substantial speed reduction, generally it was the case that the fast drivers reduced speed the most.

Table 9 Mean speeds 300m into measure by speed group

	Mean speed (mph)			*Mean speed relative to control (mph)*		
Measure	*Fast*	*Med-ium*	*Slow*	*Fast*	*Med-ium*	*Slow*
Route A						
Village Control	42.4	30.8	28.8			
Gateway and coloured surface	38.3	30.9	28.7	-4.2	0.2	-0.1
Gateway and patches	39.0	32.2	29.4	-3.4	1.4	0.6
Gateway only	41.0	33.1	29.0	-1.4	2.4	0.2
Route B						
Village Control	41.9	31.8	27.6			
Red brick narrowing	36.3	28.8	24.90	-5.5	-3.0	-2.7
Tree build-outs	36.5	28.5	23.6	-5.3	-3.3	-4.0
Curved patch	41.9	31.7	27.0	0.0	-0.1	-0.6
Route C						
Distributor road control	37.8	32.8	30.0			
Build-outs	32.4	28.1	26.9	-5.3	-4.6	-3.1
Boa constrictor	36.5	30.6	28.8	-1.2	-2.2	-1.2
Snake	35.9	30.0	28.3	-1.9	-2.8	-1.7

4.11 Lateral displacement

Lateral displacement (i.e. the horizontal position adopted by drivers, relative to the centre of the road) in Route A was similar to the control section for all of the measures, despite the lack of a centre white line. In Routes B and C, the lateral displacement from the centre of the road was less with the 'Build-outs' and the 'Red brick narrowing', the 'Boa constrictor' and the 'Snake' than the other measures. This is illustrated for Route C in Figure 18 (the more negative the lateral displacement in this figure, the further from the centre of the road was the vehicle). The 'Boa constrictor' with centre line appeared to have slightly less effect on lateral displacement compared to the control than the 'Snake' with no centre line, probably because drivers followed the centre line. The frequency of the 'Snake' was such that it was difficult for drivers to follow the curved edge of the pattern. Drivers tended to move closer to the centre of the road with the 'Red brick narrowing' (not shown in Figure 18) than either the 'Boa Constrictor' or the 'Snake', but less than the 'Build-outs'. Driving closer to the centre of the road increases perceived risk and may therefore slow drivers down.

4.12 Summary of simulator results

The main findings from the Driving Simulator trials were as follows:

- Using edge markings to visually narrow the road reduced speed. The reduction was greatest where the edging appeared to be unsuitable for driving on.
- Continuous or repeated measures were required to sustain speed reductions. For example, the village gateway alone had little effect on speed within the village.
- Coloured surfacing alone, however elaborate, did little to slow traffic.
- Uncertainty appeared to reduce speed; for example, build-outs were particularly effective where there was another vehicle approaching.

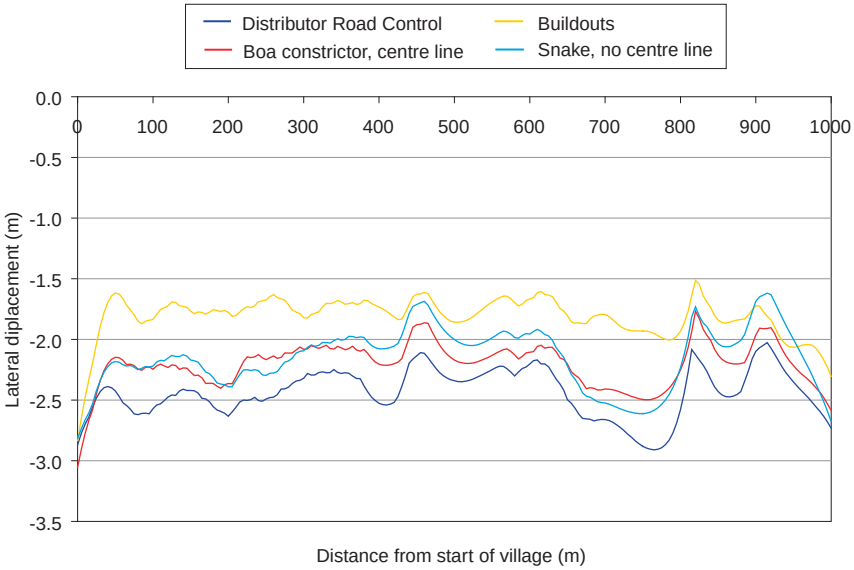


Figure 18 Mean lateral displacement profile for Route C

- In general, the faster drivers showed the greater speed reductions when traversing the more effective measures.
- The most effective measures were the 'Red brick narrowing' or 'Tree build-outs' and 'Build-outs' involving the use of bollards rather than trees. The 'Red brick narrowing' was continuous, narrowed the road both physically and visually and created uncertainty as it was not clear to motorists whether it was a footway or part of the road. The lack of a centre line meant that drivers were concerned about meeting other vehicles head-on. The 'Build-outs' and 'Tree build-outs' were examples of a repeated measure that narrowed the road at regular intervals, creating a degree of uncertainty as to road width. The trees or bollards on the build-outs were intended to reduce forward visibility and to provide vertical contrast, whilst the presence of lines on the road surface emphasised the narrowing effect and the presence of the vertical features. Drivers tended to place their vehicles closer to the centre of the road alongside all of these measures compared with the control sections.

5 On-road schemes

Following on from the off-road trials, the aim was to liaise with local authorities to identify trial sites for the measures developed. Monitoring was to include measurement of traffic speeds and flows, and public attitude surveys. The original aim was to undertake trials at three urban and three rural sites. In the event, although schemes were developed at a number of sites, only one has so far been implemented on the road, in the village of Latton in Wiltshire (described below in Section 6). There were various reasons for the other schemes not being implemented: two schemes were delayed indefinitely, one scheme was implemented only in part and the other was changed by the local authority to more conventional traffic calming.

5.1 Schemes developed but not implemented

Schemes developed, but not implemented, were as follows:

5.1.1 Proposed Sustrans cycle route along a narrow rural road

The scheme involved the use of mock cattle grids, repeated at regular intervals. The cattle grids were comprised of mock gates and innovative road surfacing (Figure 19).

5.1.2 Spine road on housing estate

The estate had extensive on-street parking (which led to poor visibility for drivers turning onto the spine road) and two deceptive bends where there had been accidents. The proposed measures involved suitable bend treatment, including reducing the forward visibility, some en echelon parking and junction treatment. The latter is illustrated in Figure 20.

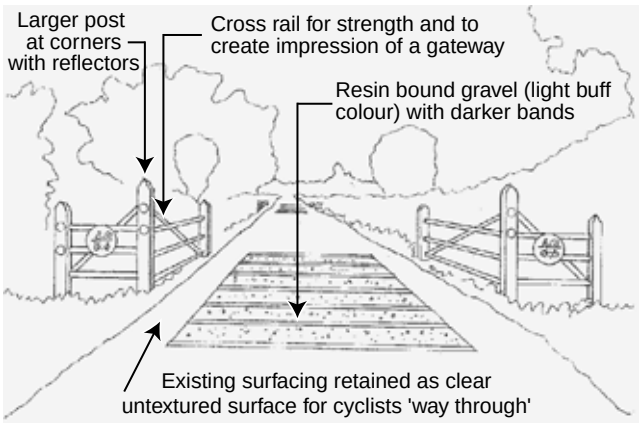
5.1.3 Narrow urban residential / shopping road

The road was on the edge of a proposed home zone and had a history of accidents involving non-motorised users. The scheme used a mixture of traditional and psychological traffic calming, with two raised junctions close to shops, some en echelon parking where the road was wider, coloured edging to visually narrow the road and junction treatment to improve the visibility of drivers turning out of side roads whose view was blocked by parked cars. Figure 21 shows some design ideas.

5.1.4 Village on a main A-road

The road was narrow but heavily trafficked with a perceived speeding problem, although there had been no accidents in the three years prior to scheme development. It had a narrow footway on one side only. The scheme involved realigning a junction to give space for a pedestrian refuge and innovative use of road surfacing to emphasise accesses.

Before



Suggested measure (to be repeated at intervals)

Figure 19 Proposed Sustrans route

Before

Proposed junction treatment

Figure 20 Spine road with parking problems

Before

Design ideas

Figure 21 Narrow urban road

5.2 Latton

5.2.1 The village

Latton is a small village on the C419, formerly the A419, which now bypasses the village. It is about halfway between Swindon and Cirencester, close to the local market town of Cricklade.

The road is wide and straight (except for a slight curve at the southern end) and carries very little traffic. It has one main junction, with Gosditch, the main access to much of the remainder of the village. The layout of the village (and traffic monitoring positions) is shown in Figure 22.

Before scheme installation, the C419 carried just under 2,000 vehicles per day, with some gravel traffic to and from

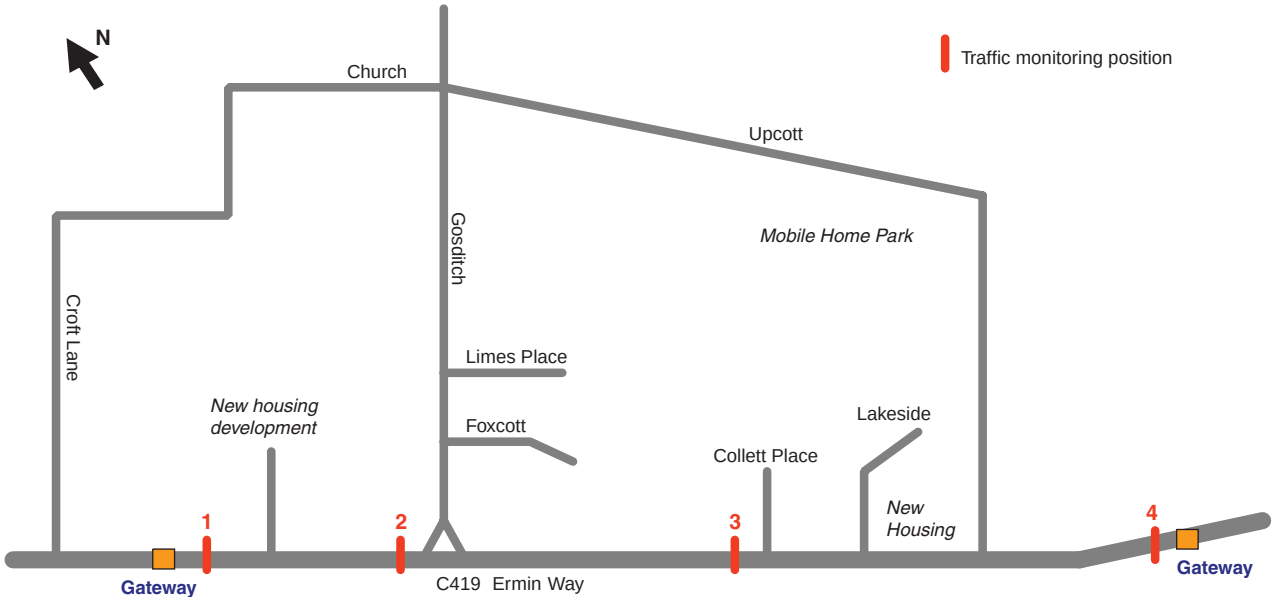


Figure 22 Village layout and traffic monitoring positions

local pits. The village speed limit was 40mph within, and just outside, the built-up area, and extended for about 1km. 85th percentile speeds were considerably in excess of this.

Until recently, almost all of the village population lived off the main road. In 2003, between the 'before' and 'after' monitoring, a large housing development was completed at the northern end of the village, along with a smaller development at the opposite end. Both developments access the main road directly. There is also some new development along the main road itself.

5.2.2 The scheme

The scheme was implemented in spring 2004. Its main aim was to reduce speeds in order to increase perceived safety through the village. The Parish Council had received money for traffic calming from the developer of one of the new housing schemes and was also keen to increase formal parking provision on this road. The total cost was approximately £40,000. It was implemented in March 2004.

The scheme extends for about 800m. It was designed by TRL in conjunction with David Huskisson Associates, Wiltshire County Council, Latton Parish Council and other consultants. The main components were:

- Stone gateways where the speed limit was reduced from 40mph to 30mph; the gateways were placed where they linked visually to the start of the housing to mark the transition to the village.
- Build-outs with planting to create new parking bays on alternate sides of the carriageway.
- Removal of centre white lining.
- Enhancement at and around the main junction, with paved build-outs, a paved section of footway, and paving around a stone monument.
- Buff surfacing near the bus stops and the main junction, a section considered most likely to be crossed by pedestrians.
- New bus bay and shelters.
- Lowering of the lighting columns to a height more appropriate for a minor road.

A plan of the scheme is shown in Figure 23.

Gateways

The sketch for the gateway design, produced by DHA, is shown in Figure 24. Originally a wall curving inwards to a second lower pillar was proposed but this was abandoned in favour of the existing design due to budgetary constraints. It was thought that planting, particularly shrubs, could achieve a similar effect.

Sited about 100m closer to the village than the original 40mph terminal signs, the as-built version of the gateways comprised a stone feature incorporating signing, a build-out and hatching on each side of the carriageway (Figure 25). The stone features, built of reconstituted limestone blocks of local origin, each consist of a 1m square pillar about 2.2m high with a planter extending rearwards.

A 30mph sign on a grey background with the village name and 'please drive carefully' message was mounted on each pillar, with a 'national speed limit' sign on the back. Yellow backed signing, 30mph roundel markings and coloured surfacing were all considered to be too visually intrusive. Rumble strips were considered too noisy, as they would have been within 200m of housing (Webster and Layfield, 1993, TAL 11/93).

The gateway build outs were kerbed and surfaced in asphalt. They were 7.5m long and 1.0m wide, reducing the carriageway width to about 6m. The hatching emphasised the narrowing and made it more visible, especially at night. Inside the south gateway, the hatching on the nearside was extended to the first build-out. For vehicles entering via the north gateway, other than a new parking bay on their offside, the first feature encountered is the buff surfacing.

Note that the hatching by the gateway features should have a dashed boundary line.

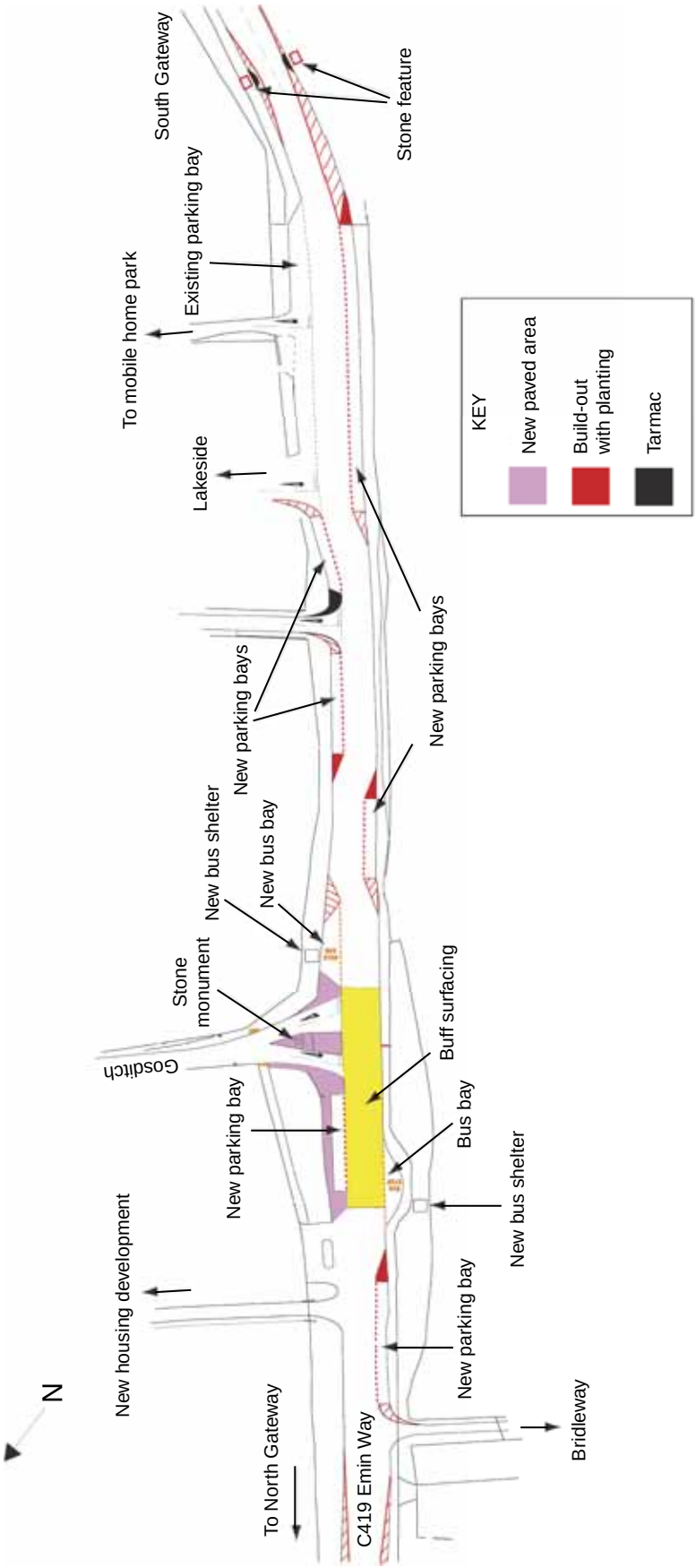


Figure 23 Plan of the scheme

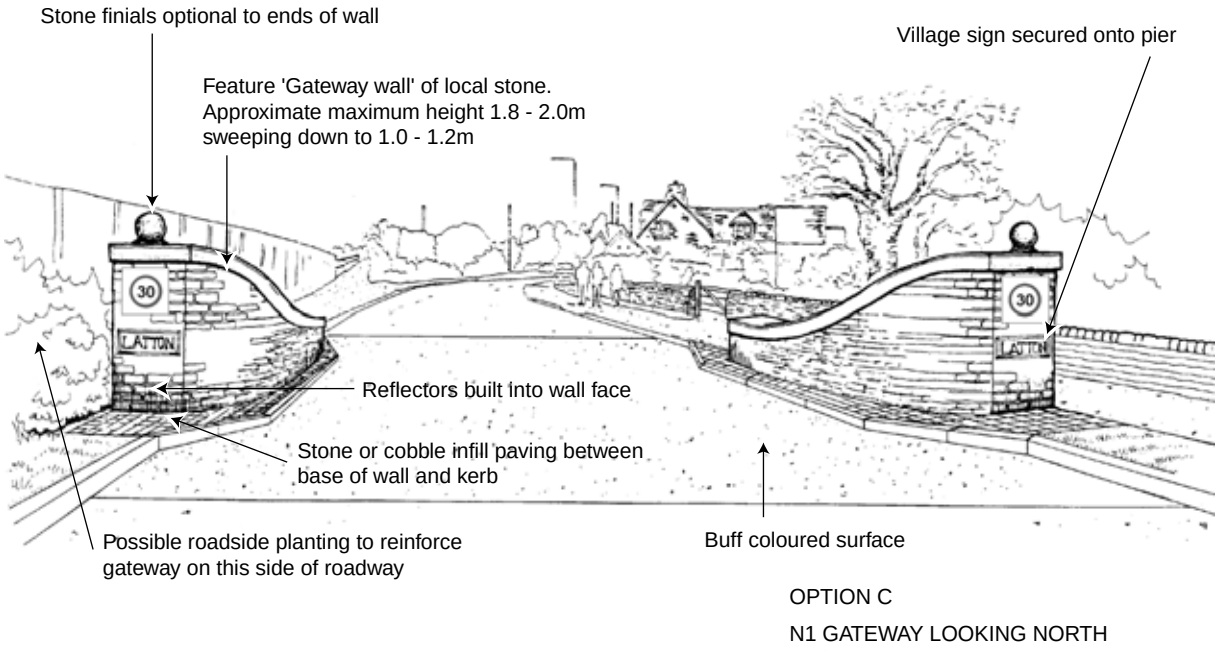


Figure 24 Sketch of proposed gateway

(a) South gateway

(b) North gateway (after)

(c) Close-up of stone feature at south gateway with planter

Figure 25 Gateways in Latton

Removal of centre white lining

In the village, the centre line was removed between the gateways (Figure 25a and Figure 27). This technique was first used with the intention of slowing drivers at Starston in Norfolk and has subsequently been used in a number of villages in Wiltshire and Norfolk (Debell, 2003). Centre lining helps to identify the carriageway width and is thought to help drivers judge how much space there is to pass one another. Lack of a centre line can make drivers concerned about meeting other vehicles head-on, thus increasing perceived risk, which can reduce speeds.

Build-outs and parking bays

Kerbed build-outs, between 1.8m and 2.0m wide, were installed on alternate sides of the carriageway to create parking bays. The design sketch for the build-outs is shown in Figure 26 and examples are plated in Figure 27.

The parking bays gave a gentle chicane effect (Figure 27b and 27c), although the minimum road width at any point was 5.5m. 'Heritage style' black marker posts with red reflectors near the base were installed on the build-outs; the majority were fitted with small 200mm 'keep right' signs. (Note that this is below the legal minimum of 270mm for such signs).

To reduce costs, hatched areas were used rather than physical build-outs at the far end (in the direction of travel) of all but one of the parking bays (and also the new bus bay). The build-outs included low level planting (Figure 27c), intended to reduce forward visibility. It had originally been intended to use trees, but because of maintenance considerations, shrubs were selected as the most suitable alternative. To date the planting remains too low to directly affect forward visibility. The five new bays provide about 250m of parking space.

At the junction with Collett Place, a new (asphalt) build-out was installed on one side of the junction mouth with hatching on the other and the give-way lines were brought forward (Figure 27d). At the junction with Gosditch, pink block paving was used as part of the enhancement works shown in Figure 27e.

Features around Gosditch junction

Before scheme installation, the junction of Gosditch was flared and split by a partially grassed island with a stone monument and a seat. Large direction signs indicated 'Latton village only'.

As part of the scheme, the island was extended to the original edge-of-carriageway markings at the junction, the markings also defining the limit of the build-outs on each side (Figure 28), visually narrowing the road and reducing the junction splay. The enlarged island was completely resurfaced in block paving (Figure 29), the seat refurbished and the direction signing removed as this was not only too large, but also now inappropriate since the extensive new development along the C419 itself. Had funds permitted, local stone would have been more appropriate than block paving.

The more extensive grassed area on the north side of the junction was retained, with paving installed outwards from the original kerb line forming a new footway and a parking

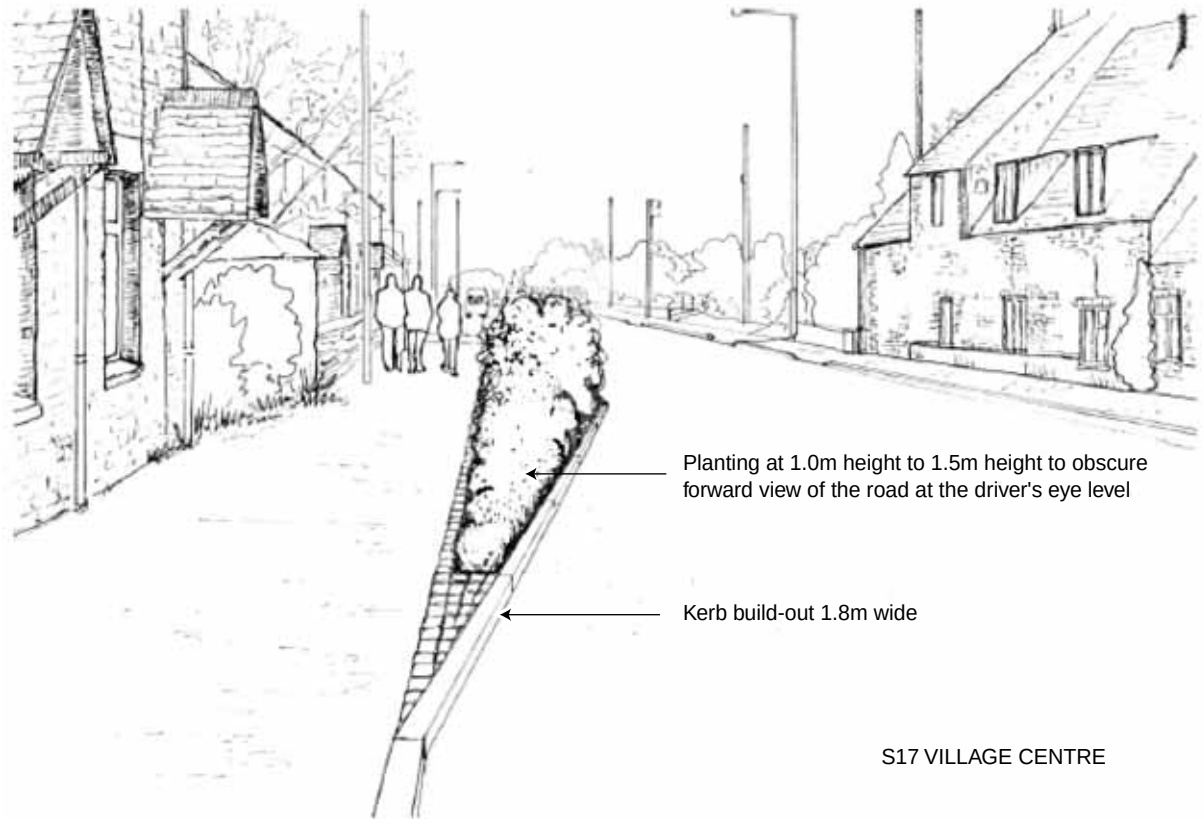


Figure 26 Sketch of proposed build-out

(a) Removal of centre lining within village. Also shown: hatching between sough gateway and first build-out, with new parking bay beyond

(b) Build-outs with planting north of the junction with Collett Place (looking south)

(c) Build-out with parking bay beyond

(d) Build-out at junction with Collett Place

(e) Paved build-out at the junction with Gosditch

Figure 27 Parking bays and build-outs in Latton

Figure 28 Enhancement at junction of Gosditch with new parking bay in foreground and extended island

Figure 29 Enhancement at junction of Gosditch showing sign removal and seat refurbishment

bay between two build-outs (Figure 28). One purpose of this bay, with another further to the north, was to cater for visitors to the new housing development which had limited parking facilities.

A new bus bay on the southbound side of the road was created to the south of the Gosditch junction, again having the effect of narrowing the road. Two new bus shelters were provided, one by the developer of the new housing development, the other by the Parish Council.

Buff surfacing

Buff anti-skid surfacing was laid for 85m between the southern side of the junction with Gosditch and the pedestrian access to the new housing development. This was intended to serve as a general warning to drivers and defines the section on which pedestrians were considered most likely to cross the road e.g. from the new housing development or the remainder of the village to the northbound bus bay.

Reduction in height of lighting columns

The lighting columns were reduced in height by about 40% to make them look less 'urban' and thus more in keeping with the village.

5.2.3 Traffic flows, speeds and accidents

Seven days of traffic flow and speed data were collected using automatic traffic classifiers (ATCs) with tube detectors before (January 2003) and after (November 2004) scheme installation (which took place in spring 2004). The tubes were placed just inside each gateway and at two locations in the village, as shown in Figure 22.

Two-way traffic flows in the 'after' survey were 2,200 per day, averaging about 16% higher than in the 'before' survey (Table 10). The increase was probably due to a combination of effects: the new housing in the village, the national trend over the 22 month period, and differences in flow between the months of January and November (typically November flows are about 7% higher than those in January). The classification of vehicles gave a total of 8% heavy goods vehicles on weekdays in the 'before' survey and 10% in the 'after' survey, surprisingly high in view of the bypass.

Mean and 85th percentile speeds are shown in Table 11, Figure 30 and Figure 31.

Following scheme installation, inbound mean speeds fell by 8mph and 4mph at the north and south gateways respectively, to 37mph at both ('before' speeds being lower at the south gateway). There was a similar decrease in 85th percentile speeds, to about 45mph. In the village,

Table 10 Vehicle flows (mean over 7 days)

Location Days	Mean daily (24 hour) two-way flow[1] 'Before' January 2003	 'After' November 2004	 Change (%)
Site 1: Inside north gateway			
Weekdays	1905	2256	+18.4
Weekend	1373	1523	+10.9
Site 2: Just north of Gosditch			
Weekdays	1905	2229	+17.0
Weekend	No data[2]	1474	–
Site 3: Just north of Collett Place			
Weekdays	1936	2216	+14.5
Weekend	1436	1518	+5.7
Site 4: Inside south gateway			
Weekdays	2001	2288	+14.3
Weekend	1480	1528	+3.2

[1] *'Before': 15-21 January 2003 (4-6 February 2003 at Site 2); 'after': 6-12 November 2004 (11-18 December at Site 3). Dates in brackets are of repeated monitoring following detector tube damage.*

[2] *Detector tube damage during repeat monitoring.*

Table 11 Vehicle speeds (mean over 7 days)

Location Direction	Vehicle speed (mph)[1] 'Before' January 2003 Mean	 85%ile	 'After' November 2004 Mean	 85%ile	Change (mph) Mean	 85%ile
Site 1: Inside north gateway						
Northbound	43.5	51.4	36.8	44.1	-6.7	-7.3
Southbound[2]	44.8	53.0	36.7	45.2	-8.1	-7.8
Two-way	44.2	52.2	36.7	44.5	-7.5	-7.7
Site 2: Just north of Gosditch						
Northbound	39.1	47.6	31.2	38.0	-7.9	-9.6
Southbound	39.7	49.0	30.4	37.4	-9.3	-11.6
Two-way	39.4	48.3	30.8	37.8	-8.6	-10.5
Site 3: Just north of Collett Place						
Northbound	35.6	44.1	30.0	35.8	-5.6	-8.3
Southbound	39.0	46.8	30.9	37.1	-8.1	-9.7
Two-way	37.4	45.5	30.5	36.7	-6.9	-8.8
Site 4: Inside south gateway						
Northbound[2]	41.4	49.0	36.8	44.5	-4.6	-4.5
Southbound	40.4	47.6	37.1	44.1	-3.3	-3.5
Two-way	40.9	48.3	36.9	44.3	-4.0	-4.0

[1] *See Note 1 for Table 10.*

[2] *Inbound (towards village).*

two-way mean speeds fell by 7-8mph to 31mph and 85th percentile speeds fell by 8-10mph to 37-38mph.

The proportions of vehicles exceeding 30mph and particularly 40mph were very much reduced, as shown in Table 12. In spite of the reduction in the speed limit to

Figure 30 Mean (two-way) speeds through Latton

Figure 31 85th percentile (two-way) speeds through Latton

30mph within the village over half of vehicles still exceeded 30mph during the 'after' survey, but the proportion exceeding 40mph fell from 50% to around 10%. Greater speed reductions were possibly prevented by a low level of opposing traffic and under-use of the parking bays which allowed drivers to straddle the parking bays in order to pass each other.

Table 12 Vehicles exceeding 30mph and 40mph within the village

Location	Percentage >30mph 'Before'	 'After'	Percentage >40mph 'Before'	 'After'
Gosditch	86.3	52.2	50.4	10.3
Collett Place	87.9	49.0	38.0	7.8

There were no reported injury accidents in Latton in the three years prior to scheme implementation and there had been none following implementation to the latest date for which data was available at the time of writing (31 December 2004).

5.2.4 Public opinion survey

The aim of the survey was to establish people's perceptions of the measures and their effectiveness, or otherwise, in reducing any traffic problems in the village, after scheme installation. Views on the appearance of the scheme were also sought. The survey was undertaken in the afternoon and early evening, to ensure that the sample was representative, with a weekend visit also used to obtain a sufficient response.

Sample

A total of 91 village residents were interviewed. This total includes one couple who made a joint response. Of the remainder, 46% were male and 54% female. All were familiar with the village prior to scheme installation. About a quarter (24%) of respondents lived on the main road. Almost half (44%) were aged 40-59, about a quarter each were aged 25-39 and 60+, with 4% under 25. These proportions are broadly similar to those for the North Wiltshire adult population as a whole (6% under 25, 31% aged 25-39, 37% aged 40-59 and 26% over 60). Over half of the respondents were employed (full time, part time, self-employed), with almost a quarter (23%) retired. One-third of the respondents had children aged under 16.

Two-thirds (67%) of respondents had heard about the scheme prior to installation, mainly from the Parish Council, friends and relatives and the media (local newspapers, church magazines). These respondents were fairly equally divided between those who thought there had been enough, and those who thought there had been too little, consultation.

Overall support for the scheme

Over three-quarters (77%) of respondents supported the scheme as a whole, with less than a fifth (17%) against it. The main concerns were that traffic speeds were still too high, that the parking bays reduced visibility for traffic emerging from side roads and accesses, and that the removal of the centre white lining led to confusion over right of way, with some drivers hogging the centre of the road and others encroaching on the parking bays when there was an oncoming vehicle.

Three-quarters of respondents liked the visual appearance of the scheme as a whole with 17% disliking it. The most common reason given for liking its appearance was that it was 'in keeping' with the village. Reasons given for disliking the appearance of the scheme included that it was not 'in keeping' with the village or that it was dangerous/had not improved safety.

Perceived effect on traffic speed, volume and noise

Table 13 shows respondents' perception of the scheme's effect on traffic. Two-thirds of respondents (67%) thought that speeds had reduced on the main road as a result of the scheme, whilst only 2% thought they had increased. The amount of traffic was not considered to have changed: only 9% of respondents thought that it had decreased as a result of the scheme, with 4% thinking the opposite. Nearly a fifth (19%) of respondents perceived a reduction in traffic noise along the main road (ignoring the traffic from the bypass), whilst a tenth (11%) perceived an increase.

Table 13 Perceived overall effect of the scheme on traffic speed, volume and noise

Perceived change	*Traffic speed*		*Traffic volume*		*Traffic noise*	
Increased a lot	2	2%	0	0	3	3%
Increased a bit	0	0	4	4%	7	8%
No change	26	29%	69	77%	47	52%
Decreased a bit	42	47%	5	6%	15	17%
Decreased a lot	18	20%	3	3%	2	2%
Don't know	2	2%	9	10%	16	18%
Total	90	100%	90	100%	90	100%

Perceived effect on safety

The 79 respondents who said they regularly walked along the main road were asked whether, when crossing it, they now felt safer, less safe, or about the same compared with before scheme installation. About half (49%) claimed that they felt no difference, but almost as many (43%) felt safer and only one felt less safe.

Half (50%) of all respondents felt that it was now safer for children to cross the main road; just over a third (36%) felt there was no difference; and only 6% felt that it was less safe. However, respondents with children were slightly less positive (Table 14).

Table 14 Perceived safety of children walking across the main road since scheme installation

Perceived change	*Respondents with children under 16*		*Respondents without children under 16*		*All respondents*	
Safer	10	33%	35	58%	45	50%
The same	16	53%	16	27%	32	36%
Less safe	3	10%	3	5%	6	6%
Don't know	1	3%	6	10%	7	8%
Total	30	100%	60	100%	90	100%

Speed limit reduction

Figure 32 shows that almost all respondents (93%) thought that reducing the speed limit from 40mph to 30mph was a good idea. The most common reasons given were that this had reduced the speed of traffic and increased safety (in general, for children and for the elderly). The 4% who thought it was a bad idea said it had made no difference, that 'lorry drivers ignored it'; that 'the speed limit should be lower'; that 'there was no warning' or that there was a need for other traffic calming measures (see additional comments on the scheme). The general consensus was that drivers were exceeding the new speed limit by up to 10mph.

Sign repositioning

Nearly two-thirds (64%) of all respondents had noticed that the speed limit signs to the north of Latton had been moved closer to the village. When respondents were asked whether they thought it was a good or bad idea (whether or not they had noticed the relocation), 40% were unsure, 39% felt that it was a good idea and 22% thought it was not (Figure 32). The main reasons given for it being a good idea were that it would 'increase driver awareness', 'reduce their speed' and 'make the speed limit more evident'. Most of those who thought it was a bad idea thought there was insufficient time to reduce speed before entering the village.

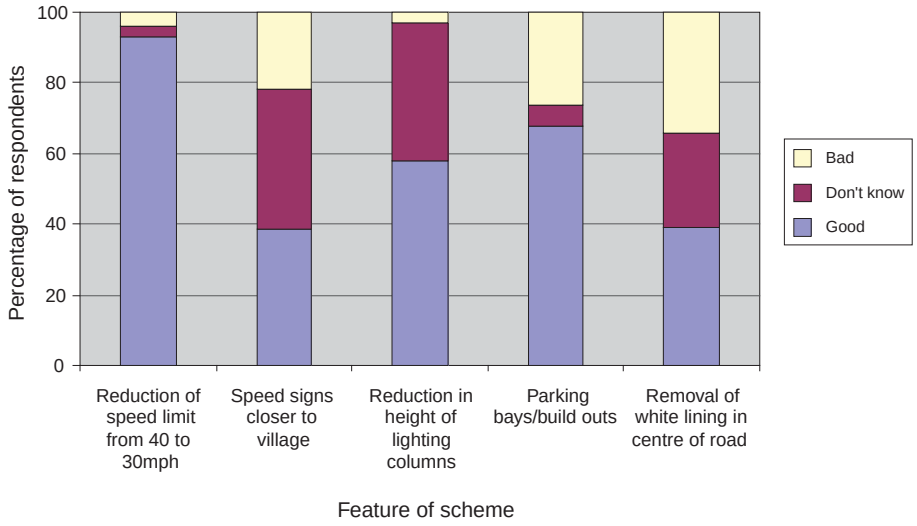


Figure 32 Percentage of respondents thinking features of scheme were a good or bad idea

Reduction in height of lighting columns

Half the respondents (49%) had noticed prior to the interview that the height of the lighting columns had been reduced. Figure 32 shows that 58% of all respondents thought that this was a good idea, split about 2:1 between those who had previously noticed the change and those who had not. Thirty-nine per cent of respondents did not know whether reducing the height of the lighting columns was a good idea or not and only 3% thought it was a bad idea. The most common reason given by those in favour was to encourage drivers to reduce their speed by making the village look more like a 30mph zone. As well as increasing the amount of light (generally, on the road, for walking and at the bus stop), respondents were also pleased that the light was less intrusive/bright and no longer shone into bedroom windows.

Parking bays and build-outs

Over two-thirds (68%) of respondents thought that the parking bays and build-outs were a good idea (Figure 32), with about a quarter (26%) thinking they were a bad idea. On the one hand they were believed to have reduced traffic speed/increased safety and to have met the need for safe/legal/orderly parking (i.e. not on the footway); on the other hand some believed they have reduced visibility when emerging from side roads/accesses and when crossing the road, and were ineffective at reducing speeds, or at worst dangerous, because of the nature of the build-outs and confusion over who has the right-of-way.

Over half (54%) of respondents liked the appearance of the parking bays/build outs with about one-fifth (22%) disliking their appearance. The remaining quarter (24%) had no opinion on their appearance.

Removal of centre white lining

The removal of the centre white lining on the main road was the least popular feature of the scheme as shown in Figure 32, with a third (34%) of respondents thinking it was a bad idea. The main reasons were concern about oncoming vehicles in the middle of the road, with drivers – particularly lorry drivers – 'hogging' the middle of the road, confusion as to who had right of way, confusion as to whether traffic was one-way and excessive speeds. However, slightly more respondents felt that it was a good idea (39%) with about a quarter (27%) unsure. The main reasons for respondents thinking that the removal of the centre lining was a good idea were that the road was now not wide enough for centre lining and that its removal had increased driver awareness and reduced speeds.

Gateways

Nearly three-quarters of respondents (72%) thought that the gateways had reduced the speed of traffic, 19% saying 'by a lot'. Just under a quarter (23%) perceived no change. One respondent thought that speeds had actually increased.

Eighty-seven per cent of respondents liked the appearance of the gateways, as being 'in keeping' with the village and defining the entrance/exit to it. Some of those who disliked the appearance of the gateways in fact gave safety reasons, i.e. that 'it is more dangerous now' or 'the road is not narrowed enough'. Negative comments about the appearance included 'they look like cow troughs' or 'they look untidy'.

Additional comments on the scheme

Respondents were given the opportunity to voice any concerns they had about the scheme. The main comments were that:

- The scheme had not reduced speeds enough and that further traffic calming measures should be introduced e.g. speed camera, vehicle-activated signs or road humps.
- There was concern over the ambiguity as to the right-of-way past the parking bays.
- there were too many lorries travelling too fast through Latton.

Summary of attitude survey

A total of 91 residents, representing a high proportion of households within the village, took part in a public opinion survey of the scheme. The main findings were:

- Over three-quarters of the respondents supported the scheme.
- Two-thirds thought that it had reduced speeds.
- Very few thought there had been any change in traffic levels.
- About half of respondents thought it was safer to cross the road than before.
- Over half approved of the parking bays, but many of those who had to join the main road from a side road or access said that their visibility had been reduced.
- Opinion was divided over the removal of the centre white lining, with the one-third of respondents against it concerned about opposing vehicles in the centre of the road.
- Some respondents called for additional speed-reducing measures such as safety cameras, vehicle-activated signing and more enforcement.
- Three-quarters liked the appearance of the traffic calming scheme as a whole, although some felt that the block paving at/near Gosditch looked 'urban' and the colour was disliked.
- Over half were in favour of the reduced height of the lighting columns, because they thought it was more 'in keeping' with a village and a 30mph speed limit.

5.2.5 Summary of Latton results

Inbound mean speeds fell by 8mph and 4mph at the north and south gateways respectively, to 37mph at both ('before' speeds being lower at the south gateway). There was a similar decrease in 85th percentile speeds, to about 45mph. In the village, two-way mean speeds fell by 7-8mph to 31mph and 85th percentile speeds fell by 8-10mph to 37-38mph. This was despite under-use of the parking bays that allowed two large vehicles to pass alongside each other by partially straddling the parking bay. The under-use also meant that forward visibility was not reduced as much as intended, particularly whilst the planting on the build-outs is immature. Although within the village over half of vehicles still exceeded the new 30mph speed limit during the 'after' survey, the proportion exceeding 40mph fell from 50% to around 10%.

A total of 91 residents, representing a high proportion of households within the village, took part in a public opinion survey of the scheme. The main findings were that over three-quarters of the respondents supported the scheme and liked its appearance, with about half of respondents thinking it was safer to cross the road than before. Opinion was divided over the removal of the centre white lining, with the one-third of respondents against it concerned about opposing vehicles in the centre of the road.

6 Summary and discussion

6.1 Summary

The potential for psychological traffic calming measures has been investigated through:

- Reviews.
- The identification of innovative measures.
- The assessment of measures using photomontage techniques (focus groups and questionnaire surveys) and the TRL driving simulator.
- An on-road trial.

Results from the various off-road surveys were broadly consistent, although the focus groups tended to be more optimistic than the other surveys:

- In the focus groups, the concept of psychological measures was generally welcomed, with the main disadvantages seen as the cost of some of the measures illustrated, and the possible reduction in effectiveness over time.
- In the focus groups and questionnaire survey, a combination of measures tended to produce bigger reductions in speed than individual measures.
- The simulator trial showed that continuous or repeated measures are required to sustain speed reductions, with a gateway alone having little effect on speed within the village.
- Uncertainty appeared to reduce speed. For example, in the simulator trial, build-outs were particularly effective where there was another vehicle approaching.
- Using edge markings to visually narrow the road reduced participants' estimated self-driven speeds in the focus groups and questionnaire surveys and actual speeds in the simulator trial. The reduction was greatest where the edging was textured and therefore appeared to be unsuitable for driving on ('Red brick narrowing').
- In the simulator trial, coloured surfacing alone, however elaborate, did little to slow traffic, whereas this measure looked promising in the focus groups and questionnaire survey (though not necessarily cost-effective).
- In general, the faster drivers in the simulator trial showed the greater speed reductions when traversing the more effective measures.
- There was an expectation by focus group participants that schemes would become less effective over time.

The most effective measures were those with a physical as well as a psychological effect. The 'Red brick narrowing' was continuous, narrowed the road both physically and visually and created uncertainty as it was not clear to motorists whether it was a footway or part of the road. The lack of a centre line meant that drivers were concerned about meeting other vehicles head-on. The 'Build-outs' and 'Tree build-outs' were examples of a repeated measure that narrowed the road at regular intervals, creating a degree of uncertainty as to road width.

In the on-road trial in Latton, the gentle chicane effect, the reduction in forward visibility and an element of uncertainty from the lack of a centre line, narrowed carriageway and parked cars all combined to reduce speeds.

6.2 Discussion

Much greater speed reductions have been produced in Latton than are generally attained in this type of scheme and there was a large decrease in the proportion of drivers exceeding 40mph. Although a small part of this reduction must be attributed to the lowering of the speed limit, it is not considered that a reduction in the speed limit alone would have given more than about a 3mph reduction in mean speed. Even greater speed reductions might have been attained had the planting been more mature and/or the flows greater. The parking bays are often under-used and this allows two large vehicles to pass alongside each other by partially straddling the parking bay. It also means that forward visibility is not reduced as much as intended, particularly whilst the planting is immature. Although the costs were higher than for some schemes of this type, they were not excessive at around £40,000.

It has been demonstrated that it is possible to design an effective traffic calming scheme that is aesthetically pleasing without resort to measures such as road humps, chicanes or one-way working. The reasons for success are likely to have been:

- Consistent treatment of a whole length of road.
- Centre of village treated in addition to gateways.
- Visual and physical road narrowing.
- Limiting of forward visibility / breaking up of sightlines to increase driver awareness / cognitive load.
- Removal of white line in conjunction with the physical narrowing at parking bays, to create uncertainty.

A key element in developing the scheme was an understanding of the theoretical mechanisms that help to explain and predict the effects of the road environment on drivers' speed choice. This was combined with an understanding of 'natural' traffic calming, alterations to the environmental context of the scheme and extensive consultation with the main stakeholders.

Overall, the project has shown that there is no simple, unique, widely applicable psychological measure. Rather it is a matter of applying psychological principles to each new situation in a holistic manner. There will continue to be situations where physical measures are needed. However, psychological schemes can be effective, their effect can be lasting (at least over a period of months) and they are highly acceptable to local people.

7 Acknowledgements

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8 References

Abbott P, Taylor M and Layfield R E (1997). The effects of traffic calming measures on vehicle and traffic noise. *Traffic Engineering and Control* **38** (8).

Chinn L, Elliott M, Baughan C, Evans R and Odgers C (2002). The effect of road appearance on perceived safe travel speed: Interim report. Papers and Articles PA3828/20. Wokingham: TRL Limited.

Chinn L and Elliott M (2002a). *The effect of road appearance on perceived safe travel speed: Results of group discussions and exploratory simulator trials*. Papers and Articles PA3826/20. Wokingham: TRL Limited.

Chinn L and Elliott M (2002b). *The effect of road appearance on perceived safe travel speed: Final report.* Papers and Articles PA3827/20. Wokingham: TRL Limited.

Cloke J, Boulter P, Davis G, Hickman A J, Layfield R E, McCrae I S, and Nelson P M (1999). *Traffic management and air quality research programme, final report.* TRL Report TRL327. Wokingham: TRL Limited.

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 Limited.

Countryside Agency (2000). *Design issues for rural traffic management.*

Debell C (2003). White lines – study shows their absence may be a safety plus. *TEC*, October 2003, pp, 316-317.

Department for Transport, London:

Traffic Advisory Leaflet 11/93. Rumble devices.

Traffic Advisory Leaflet 01/94. VISP (Village Speed Control Working Group) – a summary.

Traffic Advisory Leaflet 02/97. Traffic calming on major roads – A49, Craven Arms, Shropshire.

Traffic Advisory Leaflet 10/97. Halifax Historic Core Zone.

Traffic Advisory Leaflet 02/98. Lincoln Historic Core Zone – Newport Arch.

Traffic Advisory Leaflet 08/98. The High Street route, Shrewsbury.

Traffic Advisory Leaflet 13/99. Historic Core Zones: Bury St Edmunds.

Traffic Advisory Leaflet 01/00. Traffic calming on major roads.

Traffic Advisory Leaflet 10/00. Road humps: discomfort, noise and ground-borne vibration.

Traffic Advisory Leaflet 11/00. Village traffic calming – reducing accidents.

Traffic Advisory Leaflet 10/01. Home Zones – planning and design.

Traffic Advisory Leaflet 08/02. Home Zones – public participation.

Traffic Advisory Leaflet 03/04. Quiet Lanes.

Traffic Advisory Leaflet 01/05. Rumblewave Surfacing.

Highways Agency (2002). *Self-calming roads.* Oxford: Roger Evans Associates.

Kennedy J V and Wheeler A H (2001). *Countryside Traffic Measures Group: demonstration schemes.* TRL Report TRL502. Wokingham: TRL Limited.

Kennedy J V, Wheeler A H and C M Inwood (2004a). *Kent Quiet Lanes scheme.* TRL Report TRL602. Wokingham: TRL Limited.

Kennedy J V, Wheeler A H and C M Inwood (2004b). *Norfolk Quiet Lanes*. TRL Report TRL603. Wokingham: TRL Limited.

Layfield R, Chinn L and Nicholls D (2003). *Pilot home zone schemes: evaluation of The Methleys, Leeds.* TRL Report TRL586. Wokingham: TRL Limited.

Lockwood C R (1997). *Using the TRL simulator to evaluate traffic calming measures*. TRL Report TRL245. Wokingham: TRL Limited.

Ross Silcock (1995). *Better places through bypasses: report of the bypass demonstration project*. London: Department for Transport.

Scottish Executive Development Department (1999). *Natural traffic calming – guidance and research report.*

Taylor M C, Lynam D A and Baruya A (2000). *The effects of drivers' speed on the frequency of road accidents*. TRL Report TRL421. Wokingham: TRL Limited.

Taylor M (2001). Managing vehicle speeds for safety: Why? How? *Traffic Engineering and Control,* **42** (7).

Theeuwes J (1998). Self-explaining roads: Subjective categorisation of road environments. In A G Gale, I D Brown, C M Haslegrave and S P Taylor (Eds), *Vision in Vehicles VI.* Netherlands: North - Holland.

Tilly A, Webster D and Buttress S (2005). *Pilot Home Zone schemes: Evaluation of Northmoor, Manchester*. TRL Report TRL625. Wokingham: TRL Limited.

Uzzell D and Leach R (2001). *Engineering Quiet Lanes in the Surrey Hills AONB: Predicting drivers' speed.* Guildford: Department of Psychology, University of Surrey.

Watts G R, Stait R E, Godfrey N S, Chinn L and Layfield R (2002). *Development of a novel traffic calming surface 'Rippleprint'*. TRL Report TRL545. Wokingham: TRL Limited.

Webster D C and Layfield R E (1993). *An assessment of rumble strips and rumble areas*. Project Report PR33. Wokingham: TRL Limited.

Webster D C and Mackie A (1996). *Review of traffic calming schemes in 20mph zones*. TRL Report TRL215. Wokingham: TRL Limited.

Webster D, Tilly A and Buttress S (2005). *Pilot Home Zone schemes: Evaluation of Cavell Way, Sittingbourne.* TRL Report TRL626. Wokingham: TRL Limited.

Wheeler A (1997). *Traffic calming in Historic Core Zones: Crossley Street, Halifax*. TRL Report TRL288. Wokingham: TRL Limited.

Wheeler A (1999a). *Traffic calming in Historic Core Zones: Bury St Edmonds.* TRL Report TRL388. Wokingham: TRL Limited.

Wheeler A (1999b). *Traffic calming in Historic Core Zones: High Street route, Shrewsbury*. TRL Report TRL374. Wokingham: TRL Limited.

Wheeler A H, Abbott P G, Godfrey N S, Lawrence D J and Phillips S M (1996). *Traffic calming on major roads: the A49 trunk road at Craven Arms, Shropshire.* TRL Report TRL212. Wokingham: TRL Limited.

Wheeler A H, Abbott P G, Godfrey N S, Phillips S M and Stait R (1997). *Traffic calming on major roads: the A47 trunk road at Thorney, Cambridgeshire.* TRL Report TRL238. Wokingham: TRL Limited.

Wheeler A H and Taylor M C (1999). *Traffic calming on major roads. Final report.* TRL Report TRL385. Wokingham: TRL Limited.

Wheeler A, Taylor M and Barker J (1994). *Speed reduction in 24 villages: details from the VISP study*. Project Report PR85. Wokingham: TRL Limited.

Wheeler A H, Taylor M C and Payne A (1993). *The effectiveness of village gateways in Devon and Gloucestershire*. Project Report PR35.

Abstract

Excessive and inappropriate speeds are a major concern for road safety. Such speeds have an adverse effect on the number and severity of road traffic accidents and significantly reduce the quality of life in many urban and rural areas. Physical traffic calming measures - road humps and chicanes, for example - can generate substantial reductions in vehicle speeds and accidents, but can be unpopular. On behalf of the Department for Transport, TRL has developed and tested alternative traffic calming techniques that make greater use of psychological (non-physical) measures, but are intended to still have a significant speed-reducing capability.

Psychological theories that provide insight into how specific road design measures might reduce driving speeds are reviewed. Ideas for traffic calming based on these principles are illustrated using photomontage and evaluated by means of focus groups, a questionnaire survey, on the TRL Driving Simulator and finally in on-road trials.

Related publications

TRL626 *Pilot Home Zone schemes: Evaluation of Cavell Way, Sittingbourne* by D Webster, A Tilly and S Buttress. 2005 (price £40, code HX)

TRL625 *Pilot Home Zone schemes: Evaluation of Northmoor, Manchester* by A Tilly, D Webster and S Buttress. 2005 (price £40, code JX)

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