TRANSPORT RESEARCH LABORATORY

A traffic calming scheme at Costessey, Norfolk

Prepared for Driver Information and Traffic Management Division, Department of the Environment, Transport and the Regions

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Executive Summary

A study is being carried out by TRL to examine the effectiveness of traffic calming measures in reducing the speed of traffic passing through villages. The research has been commissioned by the Department of the Environment, Transport and the Regions' Driver Information and Traffic Management Division. It follows on from the VIllage SPeed Control Working Group (VISP) initiative in which a range of techniques was studied, from gateway signing only, through signing/marking measures at the gateways and within the village, to physical restrictions such as pinch points. The success of many of these schemes in reducing speeds was limited, especially those schemes lacking physical measures or any measures in the village itself.

Changes to legislation and special authorisation procedures now enable local authorities to install a wide range of measures in villages on busy roads. The aim of the current study is to assess the effectiveness and environmental effects of more comprehensive schemes, especially those with physical measures. One such scheme, at Costessey, in Norfolk, is the subject of this report.

Costessey is situated on two adjoining minor roads carrying 5000-6000 vehicles per day, including a good deal of commuter traffic 'rat-running' between parallel radial routes to Norwich. The roads also serve as access to local gravel pits and HGVs can make up over 20% of the traffic flow early on weekday mornings. Prior to scheme installation, the village was subject to a 30mph speed limit throughout. Fifteen injury accidents had occurred in the previous 5 years. The purpose of the scheme was not only to reduce mean speeds towards 20mph but to stem further increases in traffic flows through the village.

The scheme, designed by Norfolk County Council, was completed in July 1997. It comprises a 20mph zone entered from two directions via a single-lane working carriageway narrowing with a speed cushion, and from a third direction via a new mini-roundabout. A fibre-optic 30mph speed limit sign (triggered by vehicles exceeding 35mph) is located several hundred metres in advance of the 20mph zone on one approach. The features within the 20mph zone are: 1500mm wide speed cushions spaced at 60-80m; a number of carriageway narrowings of single vehicle width; and a flat-top hump outside a school access.

Before and After monitoring included measurements of traffic flows, vehicle speeds (automatic and radar), and vehicle and traffic noise, at a number of locations in the village. Public opinion surveys of residents were also carried out in their homes before and after scheme installation.

The scheme has been successful in reducing speeds in the village, particularly of cars. Mean traffic speeds before the scheme was installed ranged from 26mph to 38mph at different locations and were reduced by between 5 and 10mph at the various measures. In particular, 9mph reductions were obtained both at and between the speed cushions. Despite the fact that mean speeds have not generally been reduced to below 20mph, steady speeds through this part of the scheme have resulted, indicating optimum spacing of the cushions. Reductions in 85th percentile speeds were similar to mean speed reductions. The scheme appears to have been successful in containing traffic growth expected within the village.

The speed reductions have led directly to reductions of about 4 dB(A) in the maximum noise levels generated by individual vehicles, both at and between the speed cushions. The smooth driving patterns may also be expected to result in lower vehicle emission levels, compared to calming schemes where more acceleration and deceleration takes place. Overall daytime traffic noise levels have reduced at the two calming measures where they were monitored (cushions, narrowing), as have the numbers of noisy events. None of the noise measurements made suggested that any aspect of the noise climate, including low frequency noise and noise at night, had worsened after the introduction of the scheme.

Despite these encouraging results, local residents have been disappointed with the scheme - in particular, few have noticed the reduction in noise levels and most are still concerned about vehicle speeds which were generally averaging about 5 to 7mph above the 20mph speed limit. Some believe congestion to have worsened, which may be due to the slower-moving traffic particularly at the single-lane working carriageway narrowings. There is, however, a perception of increased safety, especially for pedestrians. Residents perceive the speed cushions to be ineffective at reducing speeds, and the large number of these devices has probably strongly influenced their overall views.

The scheme has not been in place sufficiently long to detect any changes in accident occurrence, but no injury accidents have been reported since its installation. The relationship between speeds and accidents is now well-established and the measured reductions in vehicle speeds at Costessey would be expected to have a beneficial effect on safety.

1 Introduction

A traffic calming scheme in the village of Costessey, near Norwich, was completed in July 1997. It has been studied by TRL as part of a research project to assess the effectiveness of traffic calming measures at reducing the speed of vehicles passing through communities on heavily-trafficked rural roads. This project was commissioned by the Department of the Environment, Transport and the Regions' (DETR) Driver Information and Traffic Management Division and follows on from previous studies for the DETR of traffic calming in villages: one study formed the research input to the VIllage SPeed Control (VISP) initiative (County Surveyors' Society/ Department of Transport, 1994; Department of Transport, 1994a; Wheeler, Taylor and Barker, 1994; Wheeler and Taylor, 1995), and the other assessed schemes in Devon and Gloucestershire (Wheeler, Taylor and Payne, 1993). These earlier studies considered a range of techniques, from gateway signing only, through measures both at the gateway and within the village (mainly signing and/or contrasting road surface treatments), to physical restrictions such as pinch points. The success of many of these schemes in reducing speeds was limited, especially those schemes lacking physical measures or any measures in the village itself.

Changes to legislation, together with special authorisation procedures, now enable local authorities to install a wider range of measures in wider circumstances. Locations include, for example, villages on trunk and other major roads which carry high traffic flows, typically with a significant proportion of heavy goods vehicles (HGVs). The purpose of the current project is to assess the effectiveness of more comprehensive schemes aimed at reducing 85th percentile speeds at least to the speed limit in the village, for example by the inclusion of physical measures (Wheeler *et al*; 1996, 1997; Department of Transport, 1997; DETR, 1997).

Costessey differs from previous villages studied under this project in that it is situated in the outer suburban area of a large town (Norwich) on minor roads serving as distributors for the immediate area. These roads are being used by heavy goods vehicles accessing local gravel pits, and evidently by 'rat-running' commuter traffic. The scheme features mainly speed cushions and a number of road narrowings, enabling the introduction of a 20mph zone in the village. Speed cushions are road humps designed to limit the vertical deflection of large vehicles with wide track widths by allowing these vehicles to straddle the cushions. Vertical deflection of smaller vehicles such as cars is maintained, as these vehicles, with smaller track widths, are forced to ride over the cushions with at least one set of wheels.

Sections 2 and 3 of this report describe the village and the traffic calming scheme respectively. Monitoring of the scheme's effectiveness was carried out through Before and After observations of vehicle flows and speeds (Section 4) and vehicle and traffic noise (Section 5). A public opinion survey of residents' views was carried out before and after scheme installation and is described in Section 6. The accident history is given in Section 7 and the overall results are summarised in Section 8.

2 The village and its characteristics

Costessey, situated on the western outskirts of Norwich, lies on the C171 West End/Town House Road and C162 Longwater Lane/The Street (Figure 1). These roads form links between adjacent radial routes from the city centre (A1074 and A1067). Longwater Lane runs from the Al074 at New Costessey to join West End in the centre of Old Costessey.

The scheme was installed on West End and on part of Longwater Lane; the village layout, showing the extent of the scheme, is shown in Figure 2. These roads are mostly built-up except for a short section of Longwater Lane adjacent to the River Tud. Much of the development is well set back imparting an open aspect, except in the centre of the village where frontages, trees and garden boundaries are closer to the carriageway. A number of side road junctions serve further residential development (including some new housing), and one also serves a golf course. A newsagents and primary school are situated near the West End/Longwater Lane junction, with a post office and public house at the junction with The Street. Before the introduction of the 20mph zone, the speed limit was 30mph throughout the village. The carriageway, which is lit, is 5-6m wide. Figure 3 shows four photographs of West End before scheme installation.

Prior to scheme installation, the mean two-way traffic flow on West End and Longwater Lane was 5000-6000 vehicles per day. A study by Norfolk County Council in 1995 indicated that commuter traffic, mainly from neighbouring settlements, e.g. Drayton, Taverham and Thorpe Marriott, passed through Costessey between the A1074 and A1067 (see Figure 1). Pronounced morning and evening peaks suggested commuter 'rat-running'. There were also indications that much of the traffic was using West End/Longwater Lane to access the Norwich Outer Ring Road/Southern Bypass (A47) which had affected traffic movements in the area. It was identified that, while traffic volume on the A47 and the main radials from Norwich had not grown significantly, flows on West End had doubled between the periods 1987/92 and 1992/95.

Further increases in traffic were expected as a result of out-of-town retail development near the junction of the A1074 and A47 (Figure 1) and of housing development, particularly at Thorpe Marriott and Horsford (up to 2000 houses).

Longwater Lane and West End to the west were also classified as HGV access routes in Norfolk County Council's Route Hierarchy, serving gravel pits to the west of Costessey (Figure 1). Automatic traffic flow measurements indicated that on weekdays the proportion of HGVs was about 10% of the daily flow, but exceeding 20% early in the morning.

3 The traffic calming measures

The purpose of the scheme was not only to reduce mean speeds towards 20mph but to stem further increases in traffic flows through the village. The scheme was designed by Norfolk County Council following extensive consultations. A working party, made up of representatives

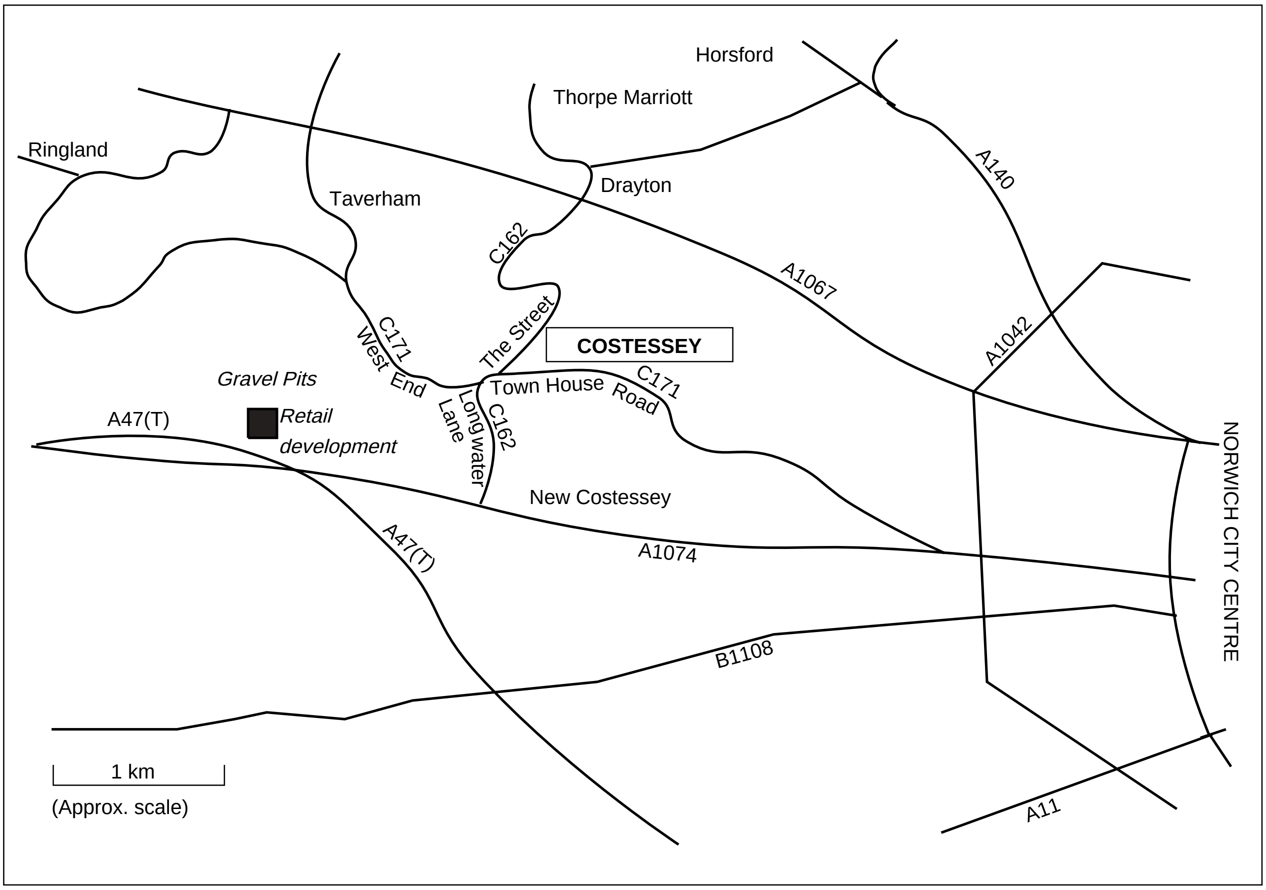


Figure 1 Location plan for Costessey (not all roads shown)

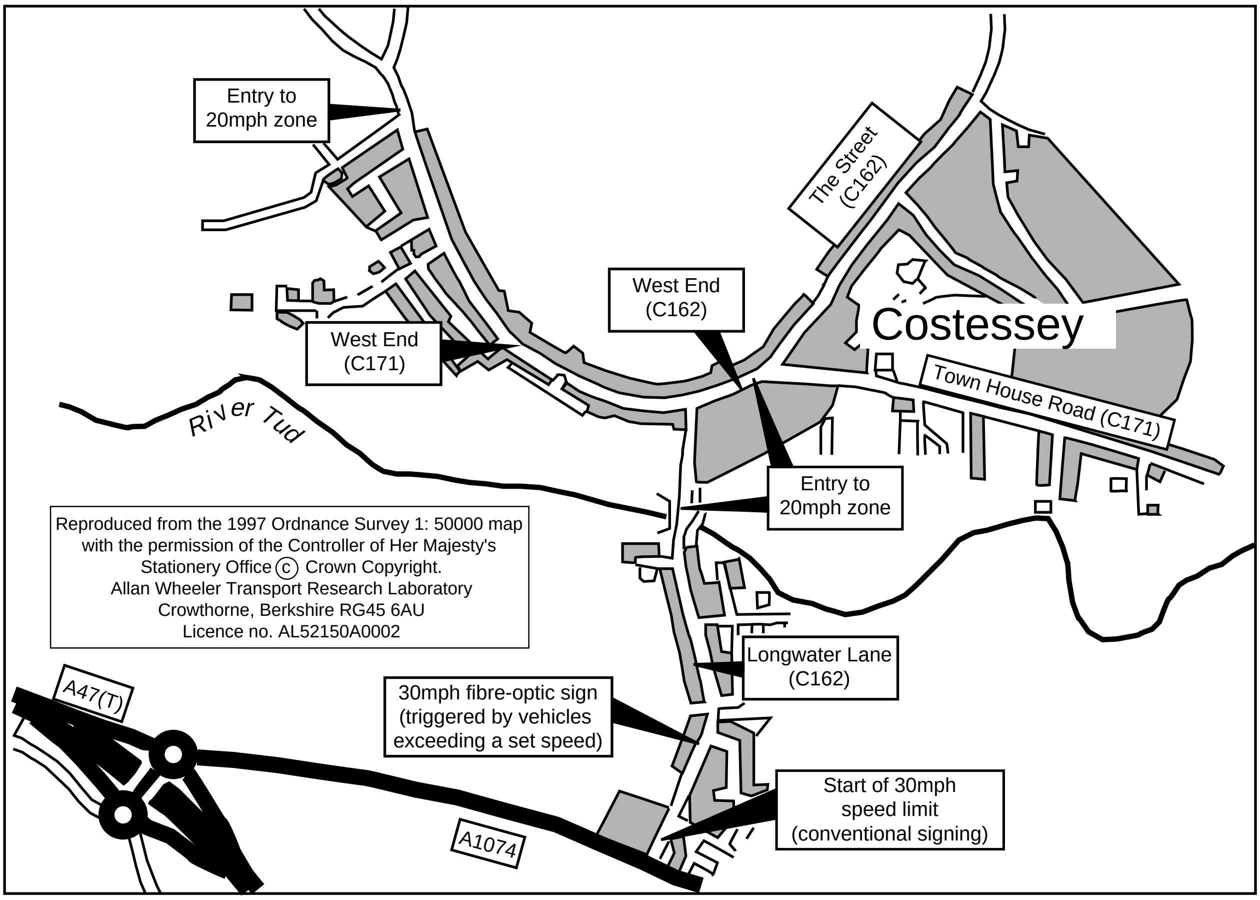


Figure 2 Village layout showing limits of scheme

(a) West End (C162), towards site of mini-roundabout at junction with The Street (left) and Town House Road (right)

(b) West End (C162), looking east, outside school access. Site of flat-top hump

(c) West End (C171), 250m west of junction with Longwater Lane, looking west. Site of carriageway narrowing (between speed cushions) and related noise monitoring

(d) West End (C171), looking east, about two-thirds of the way between junction with Longwater Lane and western entry to scheme. Speed cushions were installed along this stretch and related noise and radar speed measurements took place near the white cottage.

Figure 3 Costessey before scheme installation (January 1997)

from local councils, the residents association, the business community, the school and the County Council planning staff, was established to guide scheme development and assist public consultations. It explored a range of calming measures, favouring speed cushions over reduced height flat-top humps because of the HGV traffic. Scheme installation took about three months and was completed in July 1997 at a cost of £72,500.

The 20mph zone extends for 1300m on West End and for 275m on Longwater Lane, the 30mph speed limit being retained on the remainder (see Figure 2). In April 1997, a vehicle-actuated fibre-optic 30mph sign, installed 225m inside this 30mph limit, had come into operation (see Section 3.1). Its location, 625m in advance of the 20mph zone, is shown in Figure 2.

The locations of the measures associated with the 20mph zone are shown in Figure 4 and comprise the following:

- a single-lane working carriageway narrowing incorporating a speed cushion at two of the three entries to the 20mph zone (Longwater Lane, West End);
- a mini-roundabout, at the third entry to the 20mph zone, at the junction of West End/The Street/Town House Road (20mph signing is on the West End exit from the mini-roundabout);
- pairs of speed cushions on West End and Longwater Lane;
- single-lane working carriageway narrowings on West End and Longwater Lane;
- a flat-top hump outside the school access (West End).

3.1 Fibre-optic sign

This radar detection sign required special authorisation from the DETR. Illustrated in Figure 5, it is situated on a downhill stretch of carriageway about 150m ahead of a

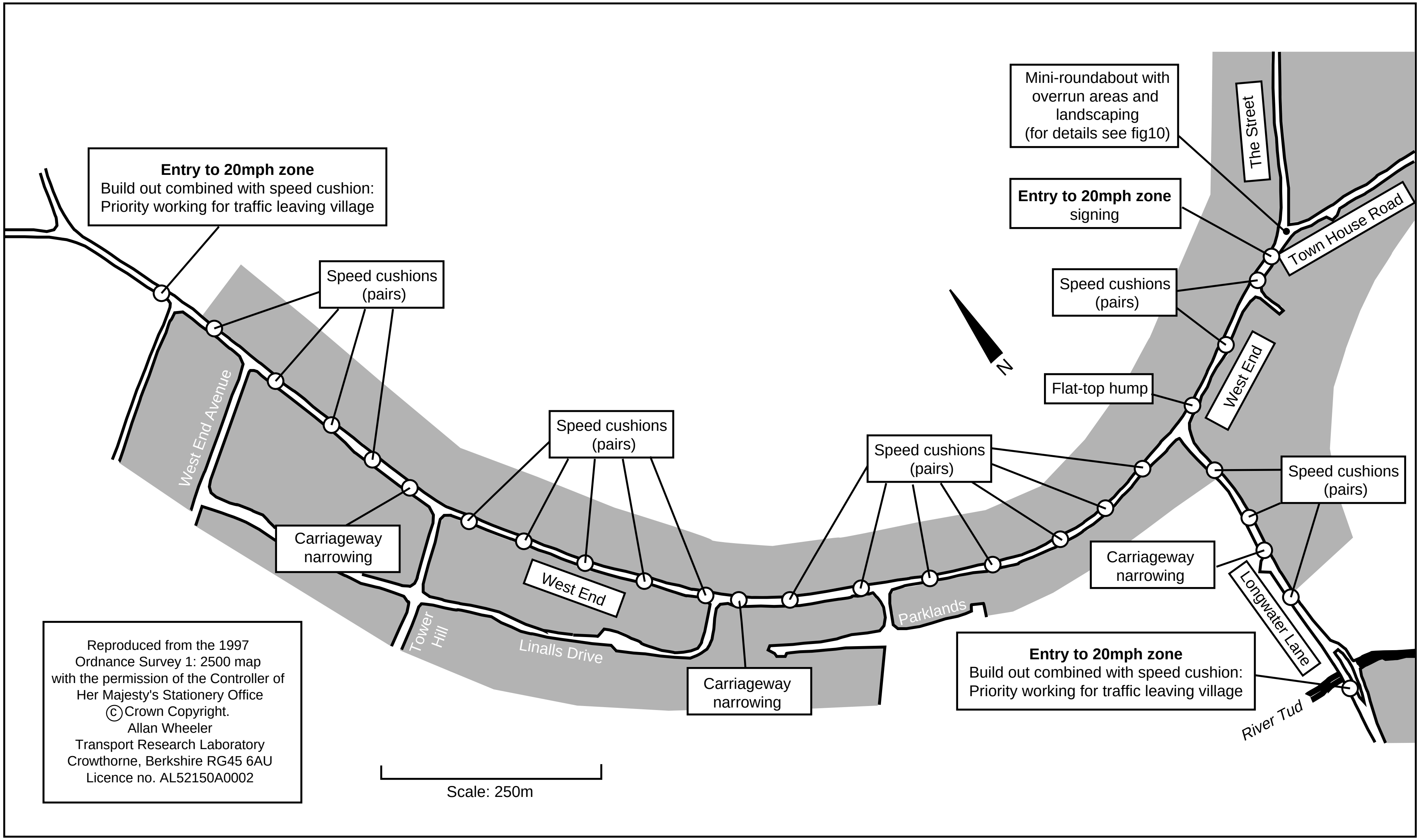


Figure 4 The measures

bend where loss-of-control accidents have occurred (see Section 7). The sign is blank until triggered by a vehicle exceeding a preset speed of 35mph, when a '30' roundel and flashing amber lights appear. It has been used successfully at a number of villages in Norfolk, e.g. Scole on the A140 (Barker, 1997), and is intended to make drivers more aware of their own excess speed and of the speed limit itself.

Figure 5 30mph fibre-optic speed limit sign, Longwater Lane

3.2 Entries to the 20 mph zone

At the Longwater Lane and West End (west) entries to the 20mph zone, the carriageway was narrowed to 3.5m using a single build-out on the inbound side. Outbound traffic was given priority, with 'give way' markings for inbound traffic and priority signing. Edge markings were also laid. A speed cushion, finished in rolled asphalt, was installed within the narrowing. The feature is shown in plan in Figure 6 and is illustrated in Figure 7. The cushion dimensions are as for the other cushions within the scheme (see Section 3.4).

The eastern entry on West End comprises 20mph zone signing only, situated as it is between the mini-roundabout and a pair of speed cushions. The signing can be seen in Figure 8 on the far side of the mini-roundabout.

3.3 Mini-roundabout

The mini-roundabout replaced a priority controlled T-junction with West End and Town House Road forming the major roads. The mini-roundabout is illustrated in Figures 8 and 9 and a plan is shown in Figure 10. During installation, a refuge in the mouth of The Street was remodelled and a new one was installed on West End. Both feature rearward extensions in pinkish coloured concrete block paving with 15mm high kerbs to accommodate overrunning. The refuge islands are finished in polyurethane-bound gravel macadam.

The junction kerblines were realigned. The pink block paving was used for a build-out on the public house side of the junction, and for the outer part of the mini-roundabout island, 3m in diameter. 15mm kerbing to accommodate overrunning was again used. Both features are best seen in Figure 8. The inner part of the island, with higher kerbing, is of road haunching material.

The kerbline was built out at standard height on the other two sides of the junction. Outside the post office, the enlarged area was surfaced in gravel macadam and the following were installed: a stone-setted rain channel along the former kerbline; a tree pit; wooden bollards; two cycle stands, and a parking bay for two cars (Figures 8 and 9). On the third side of the junction, the footway was widened.

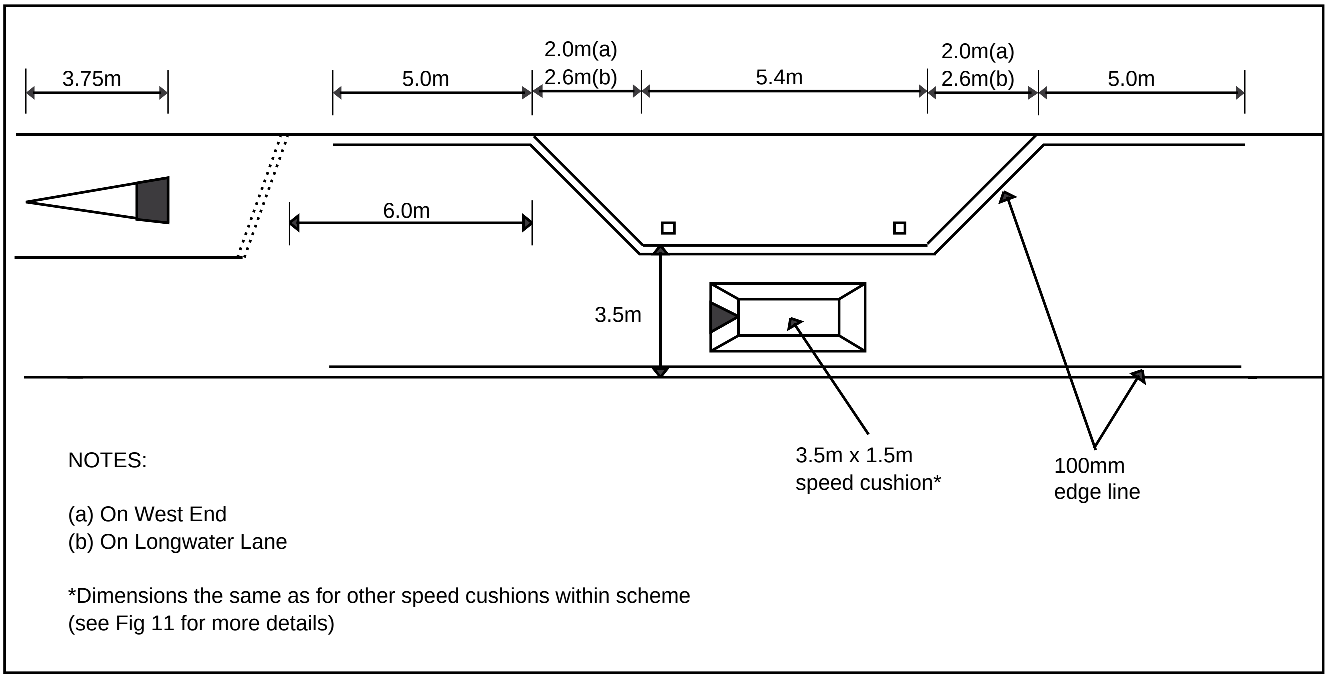


Figure 6 Plan of entry to 20mph zone on Longwater Lane and West End (west)

Figure 7 Entry to 20mph zone on Longwater Lane (top), and at the western end of West End (Bottom)

Figure 8 Mini-roundabout looking down West End where 20mph zone signing can be seen beyond the roundabout exit. The first pair of speed cusions can be seen beyond the signing. Block paved build-out with low kerb to permit overrunning in foreground; the roundabout island and refuge extensions show the same features

Figure 9 Mini-roundabout, looking east from West End towards The Street (left) and Town House Road (right). Landscaping outside post office on left, featuring cycle parking, tree planting and wooden bollards

3.4 Speed cushions

Inside the 20mph zone, 21 pairs of cushions (one in each lane) were installed, 18 of the pairs on West End. The spacing between each pair of cushions and the distance from other measures is 60-80m, to encourage constant speed driving through the scheme. Figure 11 shows a plan and section of an individual cushion, together with plans of a pair of cushions. Examples are illustrated in Figures 12 and 13, the latter showing a cushion being crossed by a car, and an HGV typical of those that regularly go through the village to and from the gravel pits.

The cushions were surfaced with buff coloured anti-skid material containing Chinese calcined bauxite aggregate - red surfacing was considered too visually intrusive, the colour adopted better matching the colour of the buildings. A white triangle on the leading slope was omitted (except on the entry cushions), as this was not required within a 20mph zone. Each cushion is 3.5m long, 1.5m wide and 60mm high, with a 10% (1:10) forward and leaving gradient and a 20% (1:5) side slope. The buff surfacing was extended beyond the edges of the cushion making them appear larger. The dimensions were chosen to minimise any physical effect on large vehicles, and so reduce the likelihood of increased vehicle noise occurring. The design of the cushions is in accordance with generally agreed parameters, and reflects the latest findings of the current research into these devices (Department of Transport, 1994b; Abbott *et al*, 1995a, 1995b, 1997; Watts and Harris, 1997; DETR, 1998; Layfield and Parry, 1998).

3.5 Carriageway narrowings

Narrowings allowing single-lane working were installed at three locations inside the 20mph zone: two on West End and one on Longwater Lane. A plan of a narrowing is shown in Figure 14 and two examples are illustrated in Figure 15. The degree of narrowing (reducing carriageway width to 3.5m) is the same on each side of the carriageway,

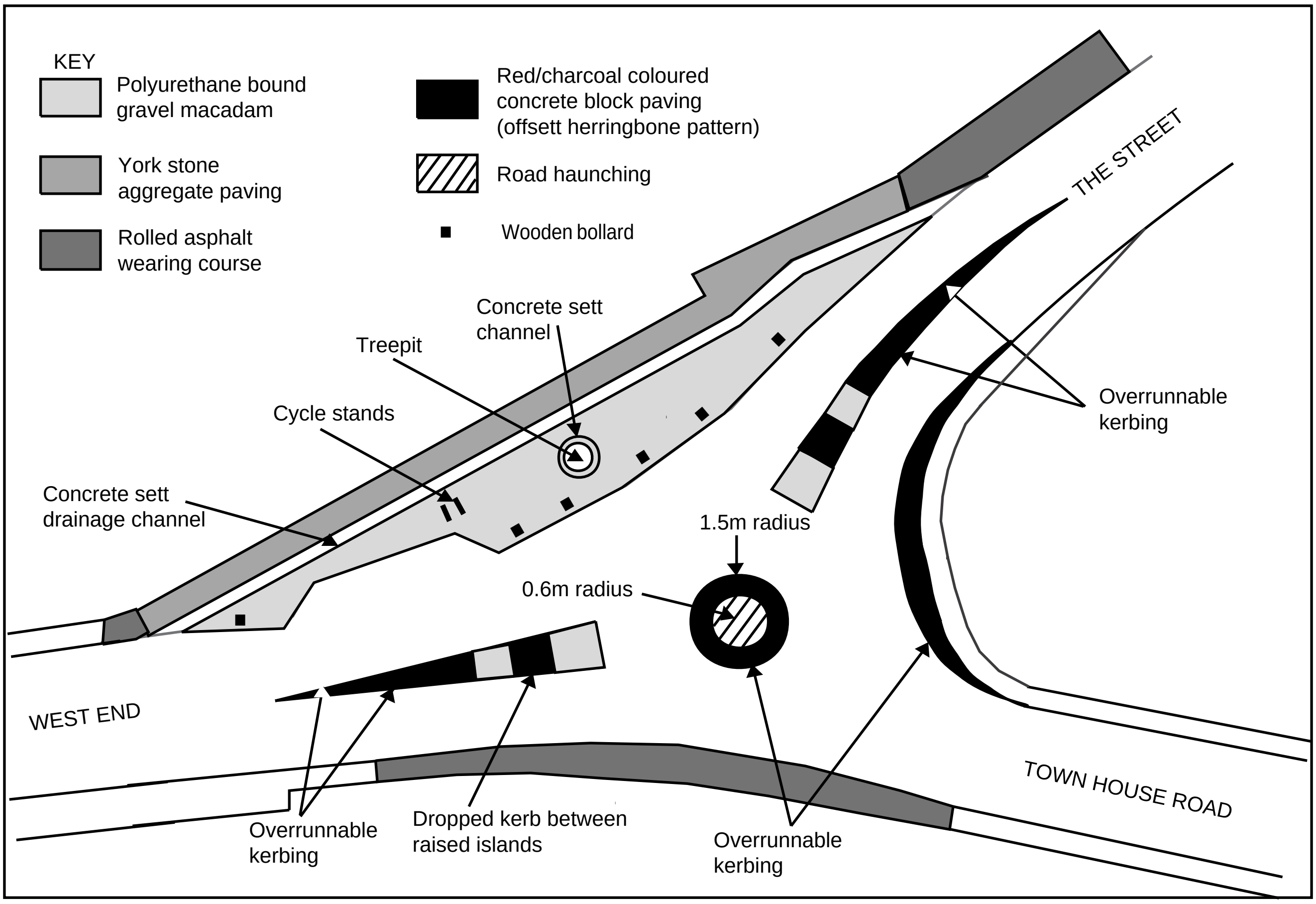


Figure 10 Plan of mini-roundabout and surroundings (Courtesy: Norfolk County Council)

and the build-outs incorporate dropped kerbs for pedestrians, between wooden bollards. Edge markings were installed but the 20mph zone status made priority signing and ‘give way’ markings unnecessary.

3.6 Flat-top hump

Installed outside the school access, the ramps to this hump are rounded at the top to enable smoother passage by buses, which number over 20 per weekday in each direction on this section of road. A plan and section of the hump is shown in Figure 16. The hump, illustrated in Figure 17, is 75mm high with a ramp gradient of 7.5% (approximately 1:13), and is constructed of a reddish grey concrete block paving which has a stone-like appearance. Adjoining blocks of different sizes were laid to give the random pattern shown in Figure 16.

4 Measurement of vehicle speeds and flows

4.1 Speed/flow surveys

Monitoring of the scheme’s effectiveness at reducing speed was carried out through Before and After measurements, by automatic traffic classifier (ATC) which also recorded flow, and by radar gun. Monitoring took place in both directions on Longwater Lane and West End.

The dates of data collection were as follows:

ATC measurements (continuous)
1-7 February 1997, 14-20 April 1997 (Before);
15-21 September 1997 (After).

Radar speed readings
27 January 1997 (Before);
15 and 16 September 1997 (After).

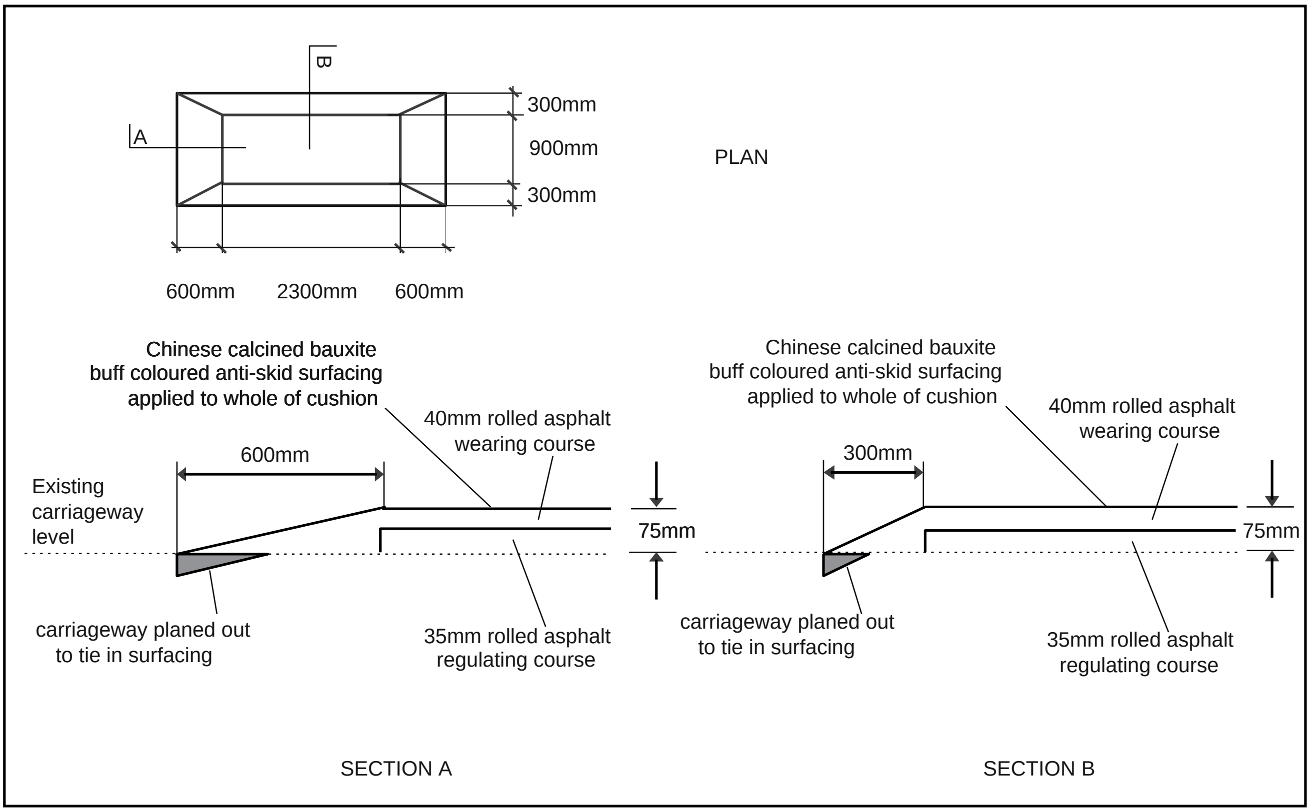
The After monitoring was conducted about two months after scheme completion.

The radar data were collected principally to assist in the analysis of the noise monitoring, described in Section 5. The ATC hourly speed and flow data coinciding with the noise surveys were also used for that purpose.

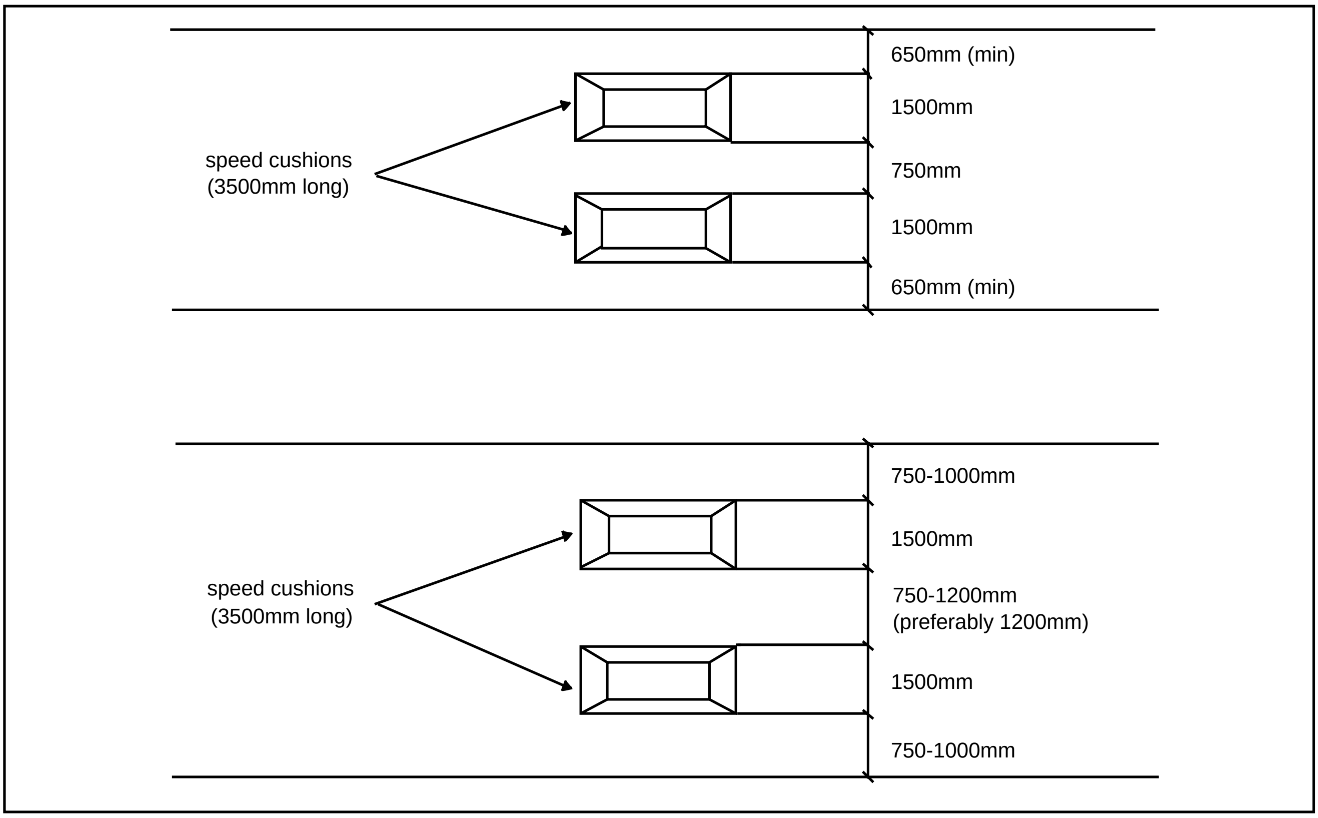
4.1.1 ATC measurements

The ATC measurements were carried out by Norfolk County Council for TRL at seven positions - two on Longwater Lane (including one in advance of the 30mph fibre-optic sign) and five on West End. The County also made available additional measurements made for their own use at the following:

- At and downstream of the fibre-optic sign: the data were collected over three weeks (March/April 1997), the sign being installed and switched on half-way through this period;
- Before and after flow measurements taken during November 1996 and 1997 on West End and Longwater Lane.



Section A



Section B

Figure 11 Detail of speed cushion layout. Layout of pair (middle and bottom diagrams) apply to narrowest and wider sections of carriageway respectively

(a) West End, looking west towards exit of 20mph zone

(b) West End, between junctions with Linalls Drive and Tower Hill, looking west

(c) Longwater Lane, looking north towards junction with West End

Figure 12 Speed cushions

Figure 13 Car and HGV crossing speed cushion, West End

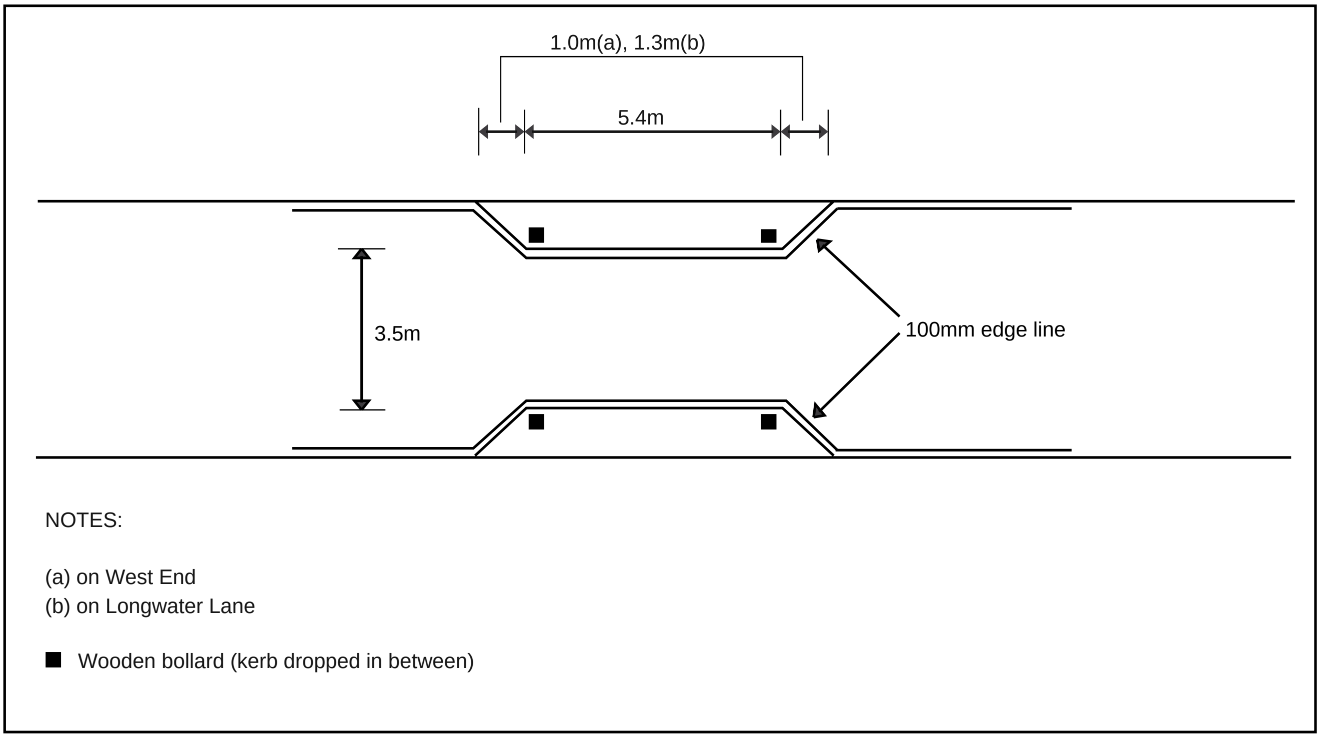
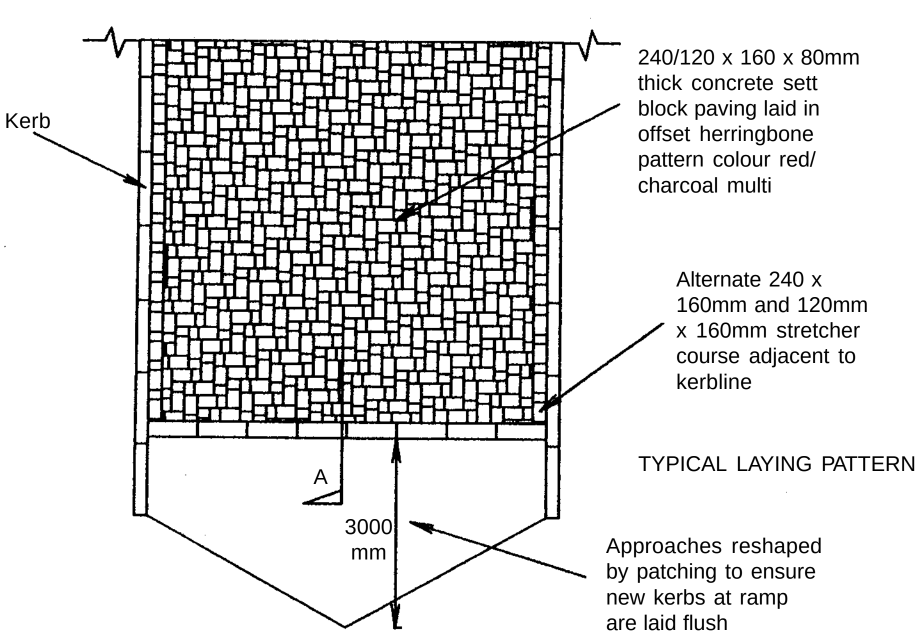
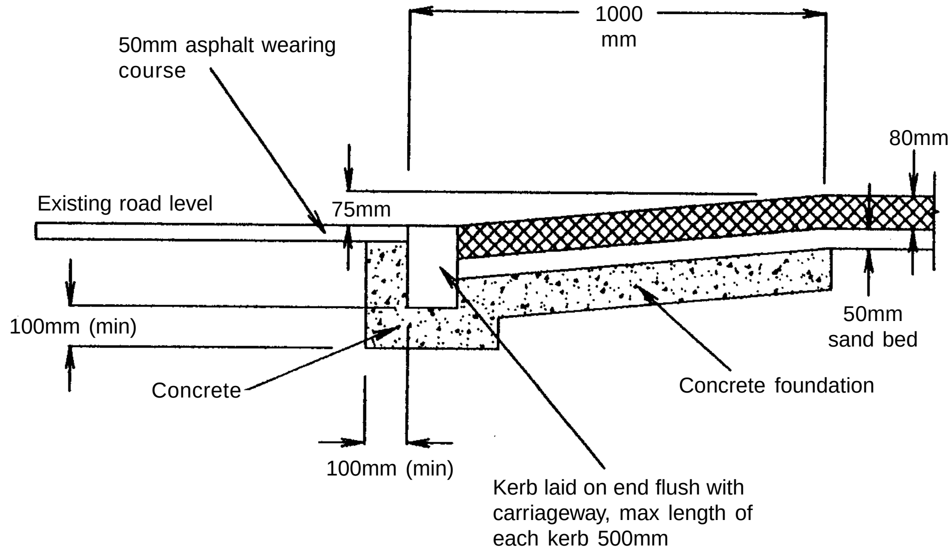


Figure 14 Plan of carriageway narrowing

Figure 17 Flat-top hump, looking east

Figure 15 Carriageway narrowing near Tower Hill on West End, looking west (top), Longwater Lane, looking north (bottom)





Notes:

1. Ramp Height 75mm relative to carriageway at approaches
2. Slope gradient 7.5%
3. Top of slope rounded to form smooth transition to flat top

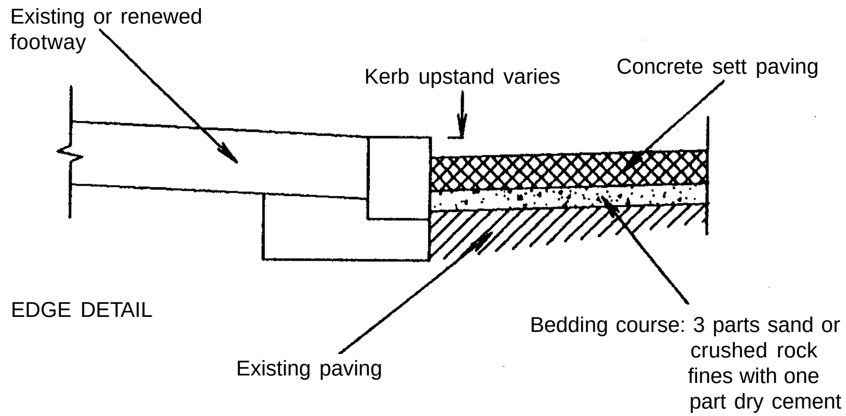


Figure 16 Plan and section of flat-top hump, West End (Courtesy: Norfolk County Council)

The positions of the TRL-commissioned ATC measurements, shown in Figure 18, were:

- Longwater Lane
  - 75m in advance of the 30mph fibre-optic sign on Longwater Lane (site 1);
  - Just inside the 20mph zone (site 2);
- West End
  - 10m from the flat-top hump outside the school access (site 3);
  - Between the mini-roundabout and the first pair of speed cushions inside the 20mph zone (site 4);
  - Adjacent to a pair of speed cushions near the junction with Parklands (site 5);
  - Between a pair of speed cushions about 300m west of site 5 (site 6);
  - Just inside the 20mph zone at the western edge of the village (site 7).

The sites of the additional measurements by Norfolk County Council are designated 1A and 1B (at and downstream of the fibre-optic sign) and 6A (on West End between sites 6 and 7).

4.1.2 Radar speed readings

The radar speed readings, of free-flowing light and heavy vehicles (vehicles over 1.5 tonne unladen and buses), were taken during daytime periods, at and between two pairs of cushions. These cushions lie about midway along West End between ATC sites 5 and 6 (see Figure 18). The speeds of 200 light vehicles and 100 heavy vehicles in each direction were recorded.

4.2 Results from the speed/flow surveys

4.2.1 Flow changes

Before and After mean daily two-way flows over one week are shown in Figure 19. Additional flows measured by Norfolk County Council are shown in italics. The TRL counts, taken about six months apart, showed that the After flows were on average little changed on West End but were up by about 9% on Longwater Lane. The Norfolk County Council counts taken exactly one year apart give similar results. It is uncertain whether seasonal variation applies at Costessey, where most of the traffic appears to be generated locally (see Section 2), but taking the TRL and Norfolk results together, it would seem that the measures on West End have stemmed any effect of a general increase in traffic in the area.

There was no consistent pattern in the changes between weekdays and weekends.

The data suggest little change in the proportion of HGVs (2-axle rigid and larger) in the daily flows following scheme installation; averaged across all monitoring positions it was measured at 10% Before and 9% After, with little difference between West End and Longwater Lane. Early in the morning, before the scheme was installed, the proportion of HGVs exceeded 20%, peaking between 05:00 and 06:00. During the After period, the proportion reached 18% between 06:00 and 07:00. It was not expected, however, that HGV traffic would reduce, as its only practicable access to the gravel pits was through Costessey.

4.2.2 Speed changes

Radar

Table 1 shows the radar speeds in each direction at the two monitoring positions.

Before mean speeds were 32-34mph for light vehicles and 28-30mph for heavy vehicles. Corresponding 85th percentile speeds were 36-38mph and 32-35mph.

Both mean and 85th percentile speeds at and between cushions fell 5-7mph for light vehicles and 3-5mph for heavy vehicles. For both light and heavy vehicles, After mean speeds of 25-27mph and 85th percentile speeds of 29-31mph were achieved both at and between the cushions.

These results suggest that the close and regular spacing between measures has influenced drivers to travel at a steady speed through the scheme.

All changes were statistically significant at the 0.1% level.

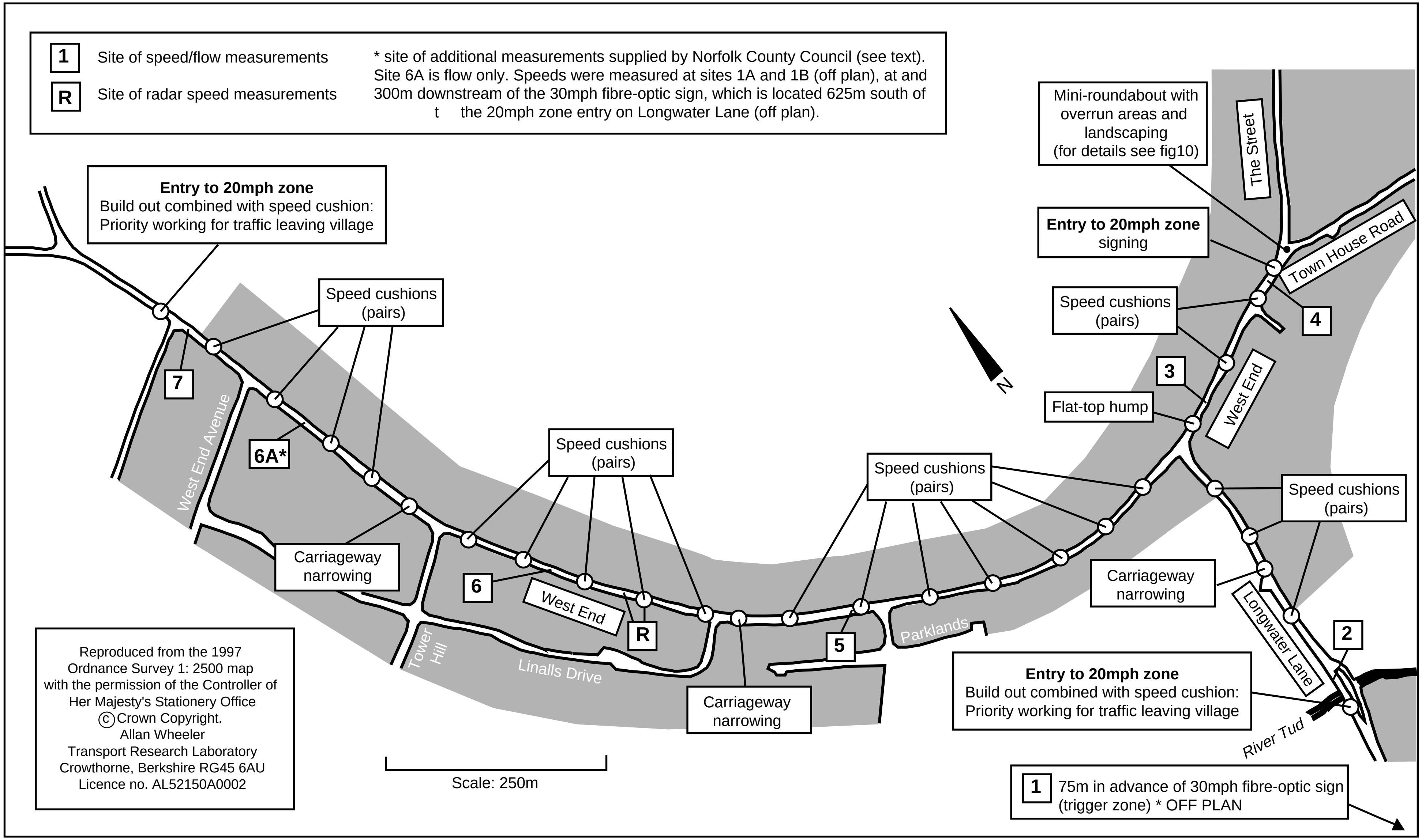
ATC

The main results of the ATC speed measurements are shown in Figures 20 and 21, which respectively show Before and After mean and 85th percentile speeds over seven/fourteen days for each of the TRL-commissioned sites. For all sites except sites 1, 2 and 6 both sets of Before data were combined. At sites 1 and 2 (20mph zone entry on Longwater Lane), the Before 1 and Before 2 results are shown separately because the 30mph fibre-optic sign had come into operation by the Before 2 period. The sign was assumed not to have affected speeds at sites in West End, and this was supported by the data. At site 6, only Before 2 results are shown as the Before 1 speeds in one direction appeared to be erroneous.

In the trigger zone of the 30mph fibre-optic sign (site 1), inbound mean and 85th percentile speeds were respectively 35mph and 42mph before its installation. Just after commissioning of the sign in April 1997 (prior to installation of the measures associated with the 20mph zone), inbound mean and 85th percentile speeds both fell by 4mph. Outbound speeds were little changed. The results derived from additional data collected by Norfolk County Council just before and just after sign commissioning showed similar reductions *at* the sign. Data collected 300m downstream of the sign in November 1996 (Before) and November 1997 (7 months after commissioning) showed a reduction in inbound mean and 85th percentile speeds of about 3mph.

At site 2, 625m downstream of the sign, the Before mean and 85th percentile inbound speeds (February 1997) were 36mph and 43mph respectively. Inbound mean and 85th percentile speeds (measured 2-3 weeks after the sign was switched on) fell by 2-3mph, indicating that the sign was still having an effect there.

Following the installation of the 20mph zone entry feature at site 2, and at the corresponding site 7 on West


1 Site of speed/flow measurements
R Site of radar speed measurements
* site of additional measurements supplied by Norfolk County Council (see text). Site 6A is flow only. Speeds were measured at sites 1A and 1B (off plan), at and 300m downstream of the 30mph fibre-optic sign, which is located 625m south of t the 20mph zone entry on Longwater Lane (off plan).
Entry to 20mph zone
Build out combined with speed cushion: Priority working for traffic leaving village
Speed cushions (pairs)
7
6A*
West End Avenue
Carriageway narrowing
Speed cushions (pairs)
6
West End
R
Tower Hill
Linalls Drive
Carriageway narrowing
Speed cushions (pairs)
5
Parklands
N
Mini-roundabout with overrun areas and landscaping (for details see fig10)
The Street
Entry to 20mph zone
signing
Town House Road
Speed cushions (pairs)
4
3
Flat-top hump
West End
Speed cushions (pairs)
Carriageway narrowing
Longwater Lane
2
Entry to 20mph zone
Build out combined with speed cushion: Priority working for traffic leaving village
River Tud
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Licence no. AL52150A0002
Scale: 250m
1 75m in advance of 30mph fibre-optic sign (trigger zone) * OFF PLAN

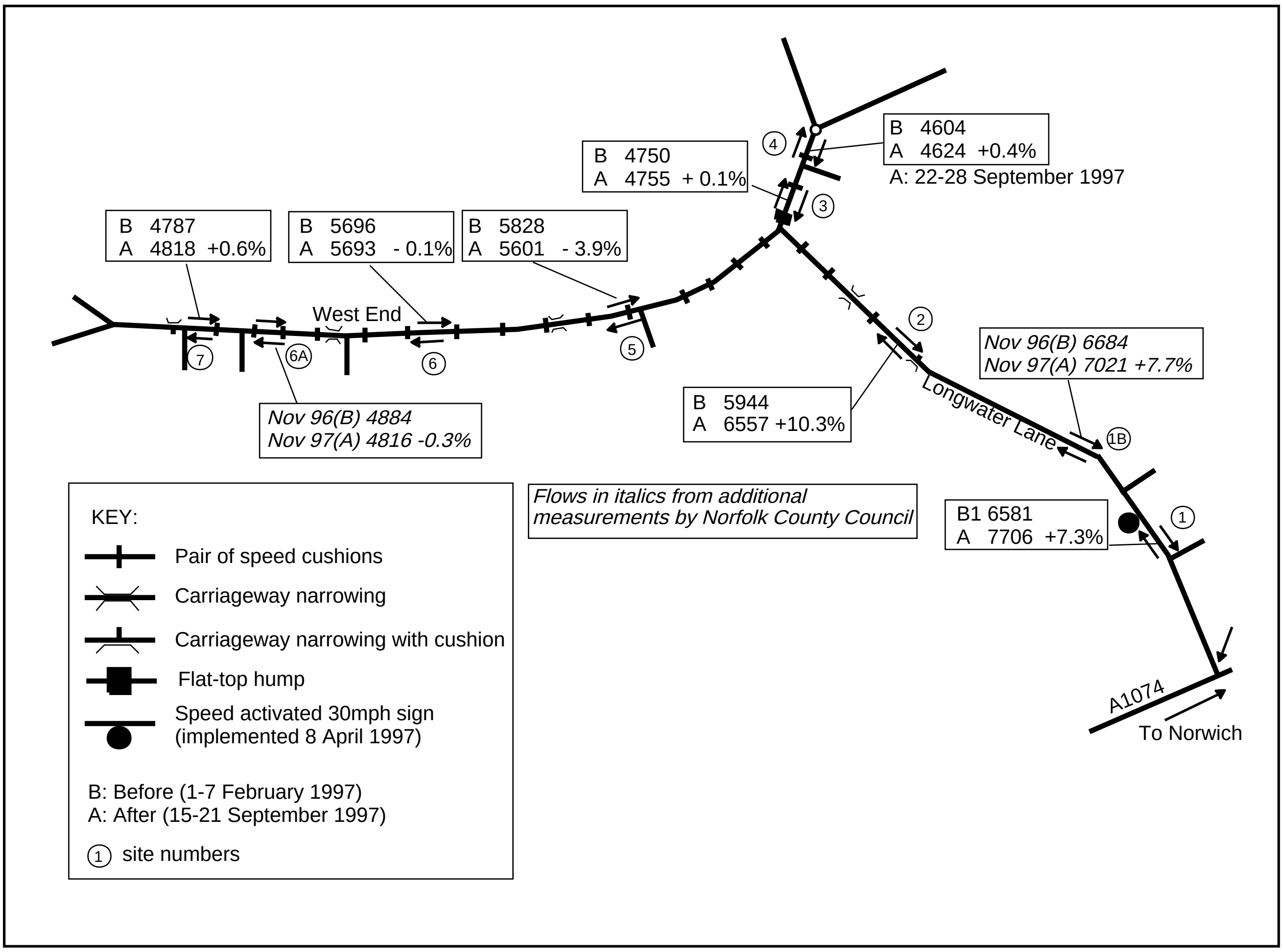


Figure 19 Daily mean two-way vehicle flows over one week

Table 1 Radar speeds at and between speed cushions: West End, between Tower Hill and Linalls Drive

Location and direction	*Mean speed (mph)* Before	*Mean speed (mph)* After	*Mean speed (mph)* Change	*85th percentile speed (mph)* Before	*85th percentile speed (mph)* After	*85th percentile speed (mph)* Change
Light vehicles						
Site R1 (on cushions)						
Eastbound (towards Norwich)	31.8	25.9	-5.9	35.7	30.2	-5.5
Westbound (towards Ringland)	33.6	26.5	-7.1	38.2	30.9	-7.3
Site R2 (between cushions)						
Eastbound (towards Norwich)	31.8	26.4	-5.4	35.7	30.5	-5.2
Westbound (towards Ringland)	33.6	27.0	-6.6	38.2	31.5	-6.7
HGVs & buses						
Site R1 (on cushions)						
Eastbound (towards Norwich)	28.3	24.9	-3.4	32.4	29.3	-3.1
Westbound (towards Ringland)	30.5	26.1	-4.4	35.2	30.2	-5.0
Site R2 (between cushions)						
Eastbound (towards Norwich)	28.3	25.2	-3.1	32.4	28.9	-3.5
Westbound (towards Ringland)	30.5	25.6	-4.9	35.2	29.9	-5.3

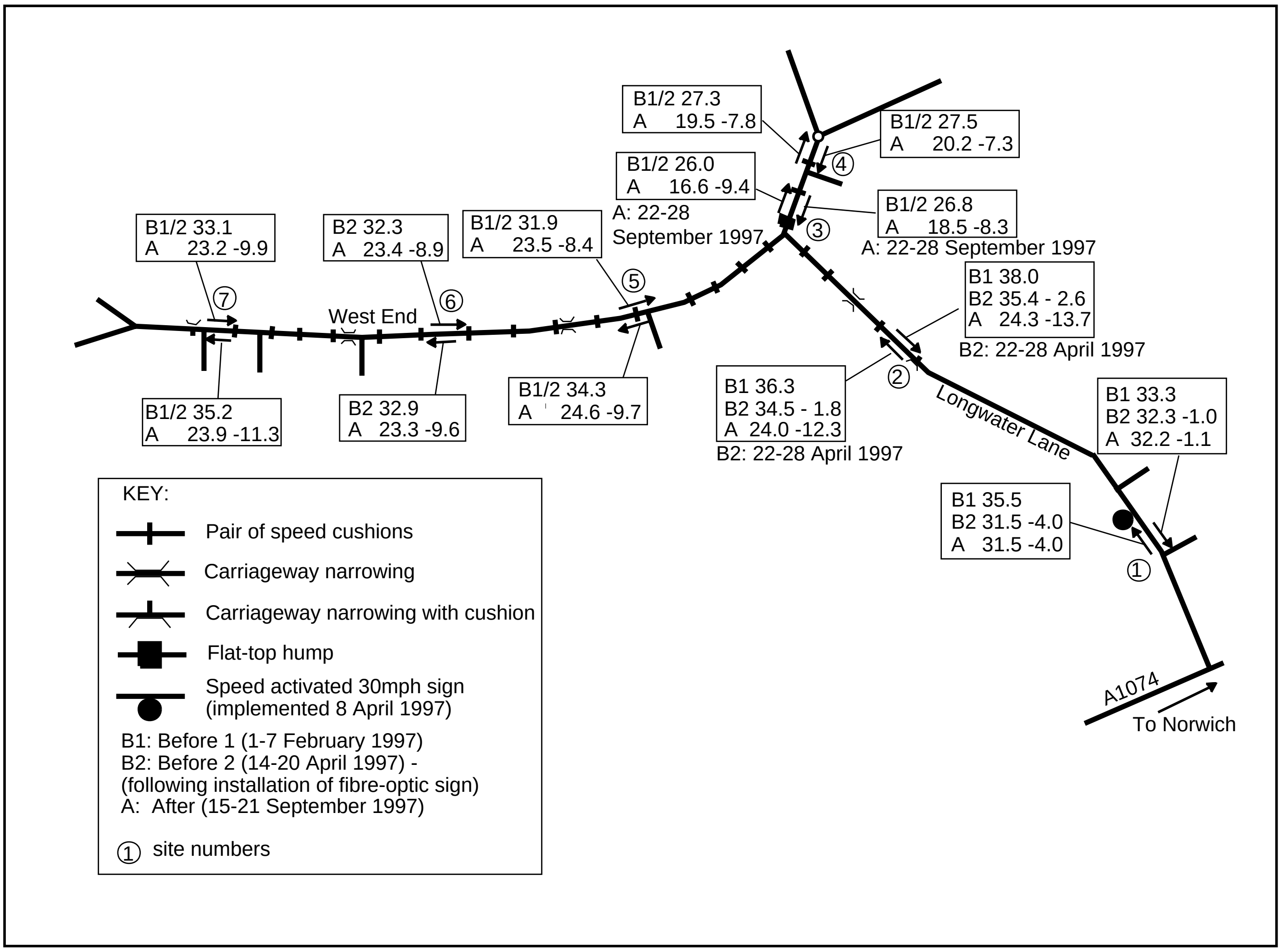


Figure 20 Mean speeds (mph) over one/two weeks (automatic count: all vehicles)

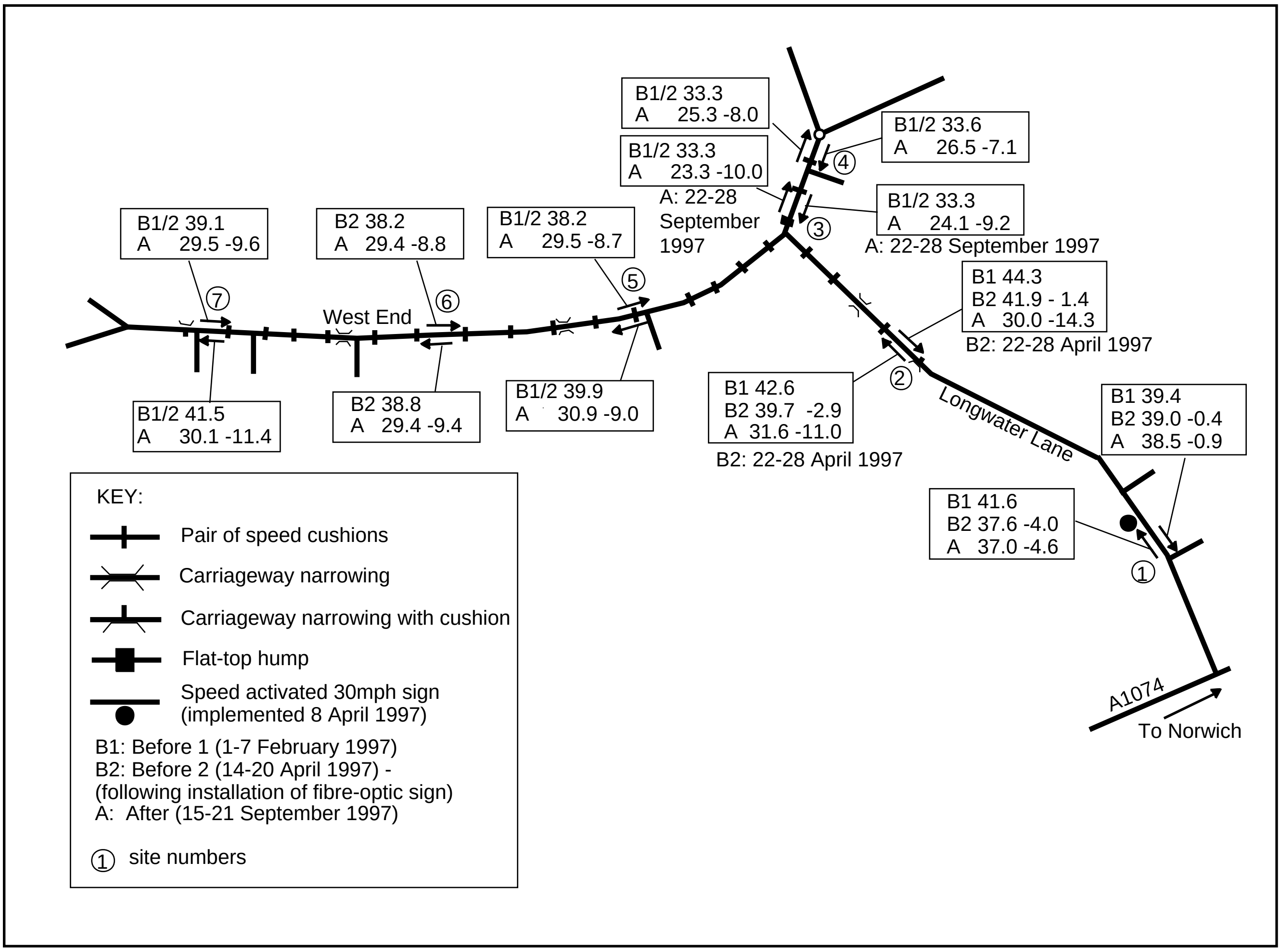


Figure 21 85th percentile speeds (mph) over one/two weeks (automatic count: all vehicles)

End (west), inbound mean and 85th percentile speeds were down by about a further 10mph; reductions were about a further 12mph for outbound traffic, even though this had priority. After mean and 85th percentile speeds were about 23mph and about 30mph inbound, with similar outbound speeds.

On West End, sites 3-6, Before mean and 85th percentile speeds were about 27mph and 33mph respectively east of the junction with Longwater Lane and up to 34mph/ 40mph to the west.

Inside the entrance to the 20mph zone on West End, downstream of the mini-roundabout (site 4), mean and 85th percentile speeds in both directions fell by 7-8mph. At site 3, between the flat-top hump outside the school and a pair of speed cushions to the east, mean and 85th percentile speed reductions were in the range 8-10mph.

At and between the speed cushions on West End (sites 5 and 6), mean and 85th percentile speed reductions were also in the range 8-10mph.

The results from sites 3-6 further indicate that there was little opportunity to accelerate between measures. To the east of the junction of West End and Longwater Lane, mean and 85th percentile speeds were down to 17-20mph and 23-27mph respectively. To the west, the corresponding speeds were 23-25mph and around 30mph.

At all sites, weekend mean and 85th percentile speeds were on average no more than 1mph higher than weekday speeds before and after scheme installation. Corresponding night-time speeds were on average 3mph higher than daytime speeds before scheme installation and 2mph higher after.

All changes were statistically significant at the 0.1% level.

4.3 Summary and discussion

The scheme appears largely to have contained growth in the level of traffic using the village, particularly in West End. This suggests that some drivers may be avoiding the speed cushions. On the whole, the scheme has been very effective at reducing speeds, typically by between 5-10mph. However, the 85th percentile speed at all the monitoring sites following scheme installation was still somewhat above the speed limit (both in the 20mph zone and in the remaining 30mph-limited section).

In the trigger zone of, and at, the 30mph fibre-optic sign, the 85th percentile speed of inbound vehicles was reduced from about 12mph above the speed limit to 7mph above. This result is influenced by the fact that this section of Longwater Lane is downhill towards the village and has an open aspect. Monitoring 300m and 625m downstream of the sign indicates that the sign (when installed alone) was still having an effect, with speeds 3mph lower than before its installation. Speeds were starting to rise, however, at the 625m position, which later became the entry to the 20mph zone.

Within the 20mph zone, 85th percentile speeds were mostly 5-10mph above the new speed limit. The required mean speed of 20mph was not attained except on West End between the junctions of Longwater Lane and the mini-roundabout, where Before speeds were lower than elsewhere. Mean speeds on the remainder of West End were about 25mph, but the results suggest that the fairly close spacing of the measures induced constant speeds through the scheme. This behaviour is generally associated with less noise and pollution (Abbott, *et al*, 1995c, 1997; Boulter and Webster, 1997). 20mph might be achieved with full-width road humps, but almost certainly there would be a noise penalty with the number of HGVs going through the village.

5 Vehicle and traffic noise measurements

5.1 Background

Measurements of traffic and vehicle noise were taken at selected sites in West End before and after the installation of the traffic calming scheme. Previous work has shown that the level of noise from roads is directly proportional to the volume and speed of the traffic and the proportion of heavy vehicles (Department of Transport and Welsh Office, 1988). The volume of traffic was not expected to alter significantly as a result of the traffic calming scheme in Costessey. However, it was anticipated that the mean vehicle speed would reduce causing a decrease in overall traffic noise levels.

Measurements of vehicle noise were taken alongside a cushion position before and after the scheme was installed. The purpose of this was to assess the change in maximum noise levels generated by vehicles passing through the survey site. Measurements were also taken at a position between two cushions to determine whether the noise of vehicles crossing the cushions differed from that generated on level sections of road in between.

Changes in traffic noise exposure were also monitored over 24-hour periods outside residential properties before and after the installation of the traffic calming measures. Two properties were selected: one alongside a cushion position and the other alongside a road narrowing.

As well as measuring traffic noise exposure, the noise instrumentation was configured to record the number of individual noise events exceeding a selected high noise level threshold in each hour. The maximum noise level in each hour was also recorded. It was intended that these results would give some indication of the effect of the traffic calming measures on the generation of short duration noisy events. For example, it was known that a large proportion of heavy vehicles passing through the survey site were articulated and rigid tipper vehicles. These vehicles can give rise to high levels of noise caused by impacts between suspension components or parts of the vehicle body (Harris and Nelson, 1996). A video camera was set up during the 24-hour traffic noise surveys to give a visual record of vehicles passing through the site. From this it was hoped that the types of vehicles generating high noise levels could be identified. The camera was set up overlooking the cushion position. This particular site was selected as it was thought that body noise might be generated by the vertical deflection of certain types of heavy vehicle passing over the cushion.

5.2 Vehicle and traffic noise surveys

Table 2 shows the types of noise measurements carried out at the various sites before and after the installation of the traffic calming scheme. The measurement positions relative to the various traffic calming measures are shown in Figure 22.

Table 2 Data collected before and after scheme installation

	Data collected at each survey[1]					
	Site R1 (alongside cushion)		*Site R2 (between cushions)*		*Site 5A (alongside road narrowing)*	
Data	*Before*	*After*	*Before*	*After*	*Before*	*After*
Vehicle noise	✔	✔	✔	✔		
Traffic noise (A-weighted)	✔	✔			✔	✔
Traffic noise (C-weighted)	✔	✔				
Maximum noise (A-weighted)	✔	✔			✔	✔
Maximum noise (C-weighted)	✔	✔				
High noise level events	✔	✔			✔	✔
Video record	✔	✔				

[1]*Before survey - February 1997*
After survey - September 1997 (after traffic calming scheme installed)

5.2.1 Vehicle noise surveys

The Statistical Pass-by (SPB) method was used to measure vehicle noise before and after the installation of traffic calming measures. A full description of the methodology for the SPB technique can be found in Appendix A. The measurement microphone was located 1.2m above the road surface and 5m from the centre of the westbound carriageway at sites R1 and R2 (i.e. alongside the cushion position and between cushions respectively).

The microphone was connected to a noise analyser configured to record the maximum A-weighted sound level (L_{Amax}) during individual vehicle pass-bys. A-weighting gives the noise measuring instrument a frequency response equivalent to that of the human ear. For many noise assessment purposes the dB(A) scale has been found to correlate well with the subjective perception of noise. Vehicles chosen for measurement were judged to be sufficiently separated in the traffic stream so that their noise characteristics were not influenced by other vehicles.

Each selected vehicle was subsequently classified as either ‘light’ (i.e. all cars and vans with an unladen weight less than 1.5 tonnes) or ‘heavy’ (goods vehicles with an unladen weight more than 1.5 tonnes). Vehicle speed was measured concurrently using a radar speed gun.

This was positioned to be as unobtrusive as possible, in order to reduce the likelihood of altering driver behaviour.

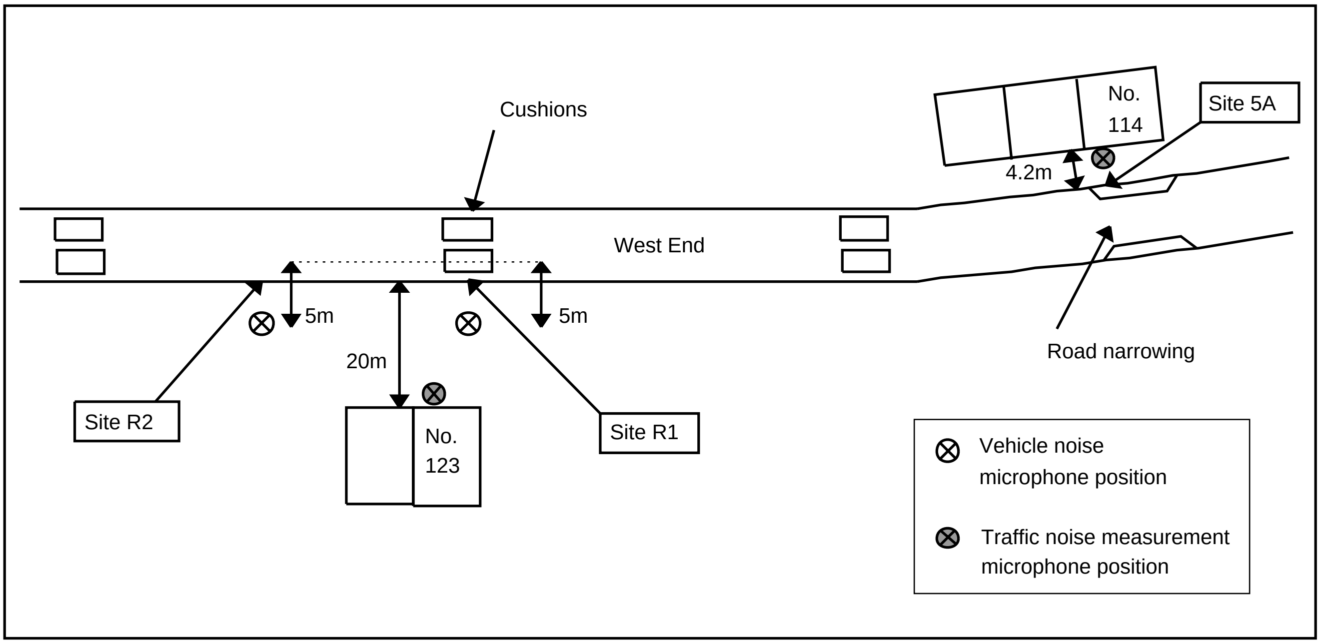


Figure 22 Vehicle and traffic noise measurement positions

As each vehicle passed the microphone position, its speed was recorded and vehicle classification noted.

5.2.2 Traffic noise surveys

Traffic noise measurements were conducted outside residential properties at sites R1 and 5A at the positions shown in Figure 22. Noise measurements were taken using environmental sound level meters. At each site the microphone was positioned at a distance of 1m from the façade at a height of approximately 4m to minimise any screening effects of low walls or other obstructions. The façade of the property at site R1 was approximately 20m from the edge of the road. The façade of the property at site 5A was 4.2m from the edge of the road. In each case measurements were carried out over a period of at least 24 hours.

i **Traffic noise exposure:** Previous studies have shown that disturbance from traffic noise in the home is correlated with the noise index $L_{A10,18h}$ measured outside residential properties (Baughan and Huddart, 1993; Morton-Williams, Hedges and Fernando, 1978). The index is currently used in the UK for assessing the impact of traffic noise from new and altered road schemes (Department of Transport and Welsh Office, 1988) and for the determination of entitlement to statutory sound insulation of dwellings as described in the 1975 Noise Insulation Regulations amended by the Noise Insulation (Amended) Regulations (Statutory Instrument, 1988). $L_{A10,18h}$ is derived from noise levels measured in an 18-hour period from 06:00 to 24:00. For each of the one-hour periods, the A-weighted noise level exceeded for 10 per cent of the time is calculated to give the noise index $L_{A10,1h}$. An arithmetic average of the 18 individual $L_{A10,1h}$ values is then calculated to give the $L_{A10,18h}$. Night-time noise levels can also be calculated by averaging the 6 one-hour $L_{A10,1h}$ values to give the $L_{A10, 6h}$.

The sound level meter at each survey site was conigured to calculate the $L_{A10,1h}$ and $L_{A90,1h}$ in each hour. The $L_{A90,18h}$ and $L_{A90,6h}$ indices can also be used in traffic noise assessment. These are calculated in the same manner as the corresponding L_{A10} measures, but are derived from the level exceeded for 90 per cent of the time in each one-hour period. The L_{A90} indices provide a measure of the background noise levels at a given site.

$L_{C10,1h}$ and $L_{C90,1h}$ values were also recorded at the cushion site. These indices were calculated as described above but from the C-weighted noise level. The dB(C) scale is more sensitive to low frequency noise and it was intended, therefore, that this measure would give information about changes in low frequency noise that might occur as a result of the traffic calming scheme.

ii **Maximum noise levels:** Previous surveys had indicated that maximum noise event levels may increase after installing cushions and may give rise to disturbance to residents living close by (Abbott *et al*, 1997). At both measurement sites the sound level meters recorded the maximum A-weighted noise levels occurring in each hour of the monitoring period. As it was thought that body noise, which often contains high levels of low frequency noise, was most likely to occur at a cushion site, the C-weighted maximum noise level was also recorded at site R1.

iii **High noise level events:** The sound level meters were also configured to record the number of noise events in each hour exceeding a certain noise threshold level for a duration of one second or more. For the Before survey, a threshold level of 80 dB(A) was set for the sound level meters at both sites. However, it was found that the number of noise events exceeding this threshold at the road narrowing site was in excess of 1000 due to the proximity of the microphone to the road. This number of events was sufficient to fill the data memory of the instrument before the 24-hour period had expired. Consequently the threshold for the After survey at site 5A was raised to 85 dB(A).

5.3 Vehicle and traffic noise survey results

5.3.1 Vehicle noise

The maximum vehicle noise levels measured using the SPB method were regressed against the logarithm of vehicle speed for data obtained before and after the installation of the calming scheme. Where appropriate, the regression relations were used to calculate the maximum noise level for a vehicle travelling at the average speed for the site. Figures 23 and 24 show the data obtained from individual vehicle measurements for light and heavy vehicle categories respectively. Summary analysis statistics for the measurement data are given in Appendix B. The results of the vehicle noise monitoring surveys are discussed below.

i **Light vehicles:** The maximum light vehicle noise levels measured before and after scheme installation are shown in Table 3.

The maximum noise levels were reduced at both sites after the installation of the traffic calming measures. The mean site speed was reduced by 7.1mph at the cushion site and 6.6 mph at the between cushions site (see Section 4.2.2). Noise reductions of 3.8 and 4.1 dB(A) respectively were measured.

The estimated reduction in noise due to the same decrease in mean site speed alone is shown in brackets. This was calculated by using the relations between vehicle speed and noise derived from the measurements taken before the introduction of traffic calming measures. It was estimated that a speed reduction of 7.1mph would give a decrease in noise levels of 3.5 dB(A) at site R1. At site R2 the reduction in speed of 6.6mph gave an estimated noise reduction of 3.6 dB(A). This would suggest that, for both the measurement sites, the change in mean vehicle noise level can largely be attributed to the change in mean vehicle speed.

A statistical analysis showed there was no significant difference between the resulting noise/speed relations for the Before and After surveys carried out at site R1. For this reason, Figure 23a shows a single regression line representing the combined data set. In the case of the data obtained at site R2, the relations were found to be statistically significantly different at the 5% level. However, it can be seen that the Before and After relations for site R2 are very close. The small difference is probably a result of the larger number of vehicles travelling at speeds of less than 20mph in the After survey. This had the effect of reducing the gradient of the regression line by a small amount.

ii **Heavy vehicles:** Maximum heavy vehicle noise levels before and after scheme installation are shown in Table 4. It should be noted that the Before survey data samples for both sites were relatively small. To increase the sample size the Before samples include maximum noise levels of vehicles travelling on the farside lane. In order to correct the noise levels to account for the greater propagation distance, a correction factor was derived. This was calculated using the difference in mean noise level between the nearside and farside results obtained for the After survey. As the heavy vehicle data samples were larger for the After survey it was considered that the correction factors for each site would be more representative.

For heavy vehicles the noise level at the mean speed for each site was not calculated from a regression analysis. An analysis of the data from both sites showed that the relations between noise level and heavy vehicle speed were not statistically significant. Therefore, the vehicle noise levels shown in Table 4 are the means of the range of noise levels obtained for each sample. The reduction in mean speed at site R1 was 4.4 mph for heavy vehicles following the installation of the cushion. A reduction in mean noise level of 2.7 dB(A) was found to have occurred in the After survey. A t-test was carried out to determine whether the mean noise levels obtained for the independent Before and After data samples were significantly different. In this case, the difference in the means was found to be significant at the 5% level. At site R2, between cushions, the reduction in mean speed was 4.9 mph. The change in mean noise level was 1.6 dB(A). This difference in mean noise level was not found to be statistically significant.

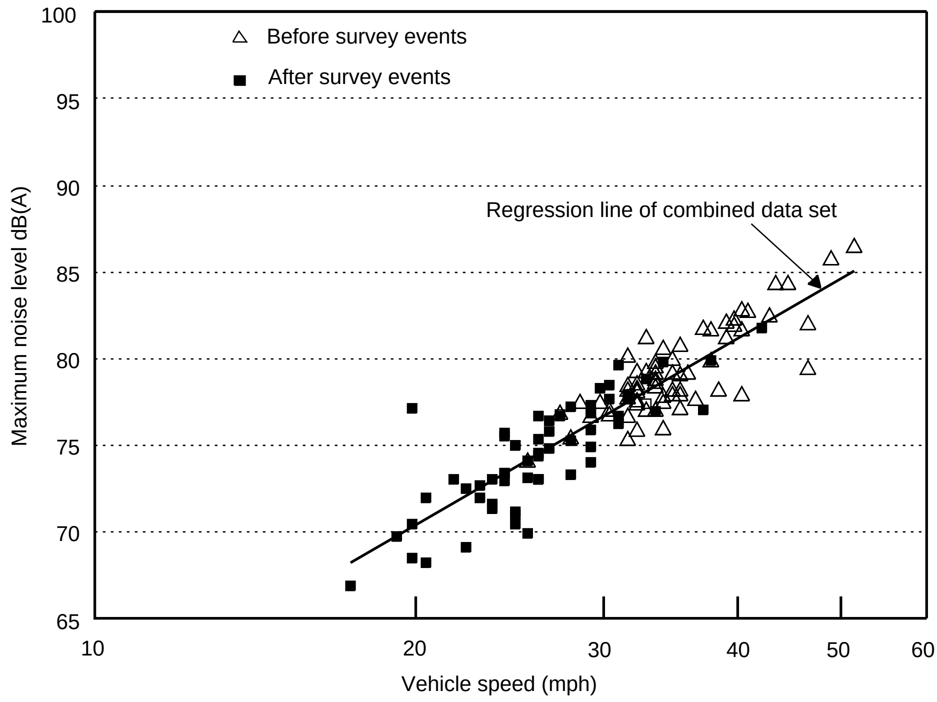
Instead of regression lines, Figure 24 shows the 'centre of gravity' for Before and After data sets; i.e. the mean noise level at the mean logarithmic speed value for each sample. The standard deviation of each sample is also shown.

5.3.2 Traffic noise

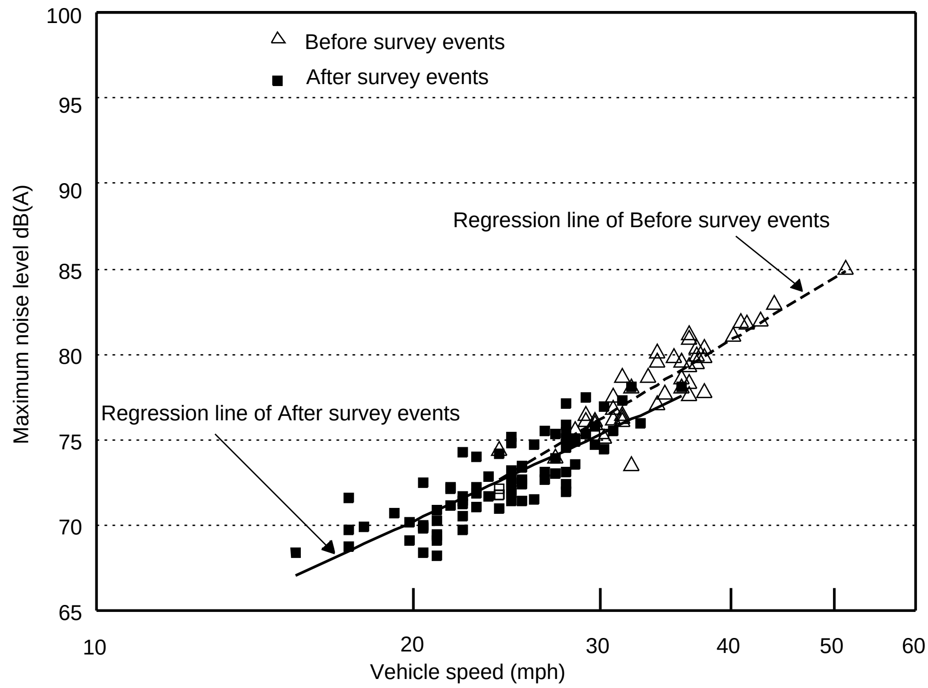
Figure 25 compares the variations in hourly $L_{A10,1h}$ and $L_{A90,1h}$ levels during the 24-hour periods of the Before and After surveys at the cushion site and road narrowing site. Corresponding C-weighted traffic noise levels are shown in Figure 26 for the cushion site only. The overall daytime and night-time noise levels recorded before and after the installation of the traffic calming measures are shown in Table 5. The final column shows the change in noise levels between the After survey and the Before survey.

i **A-weighted noise exposure:** The hourly noise level data shown in Figure 25 shows that the $L_{A10,1h}$ levels at both sites were consistently lower throughout the daytime period after the installation of the traffic calming measures. During the night-time, the difference between Before and After survey results did not show the same consistent reduction.

These differences are reflected in the Before to After $L_{A10,18h}$ and $L_{A10,6h}$ reductions given in Table 5. At both sites the daytime noise level ($L_{A10,18h}$) reduced noticeably following the installation of the traffic calming scheme. Reductions in $L_{A10,18h}$ levels were 3.7 and 4.7 dB(A) for the cushion site and the narrowing respectively. Night-time noise levels ($L_{A10,6h}$) were decreased by 2.6 dB(A) at the cushion site and 1.9 dB(A) at the narrowing.

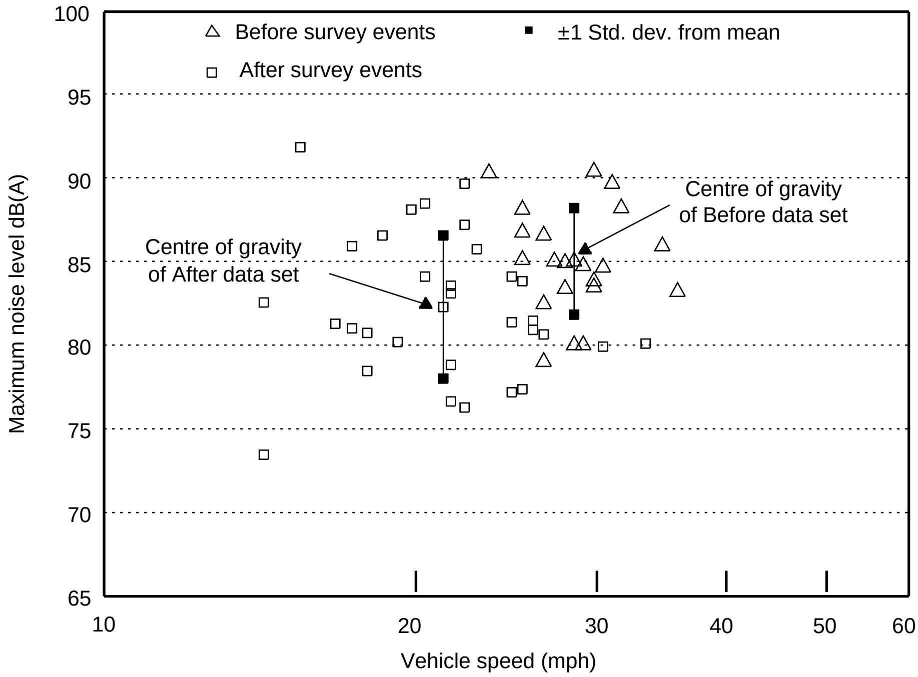


(a) Site R1 – alongside cushion

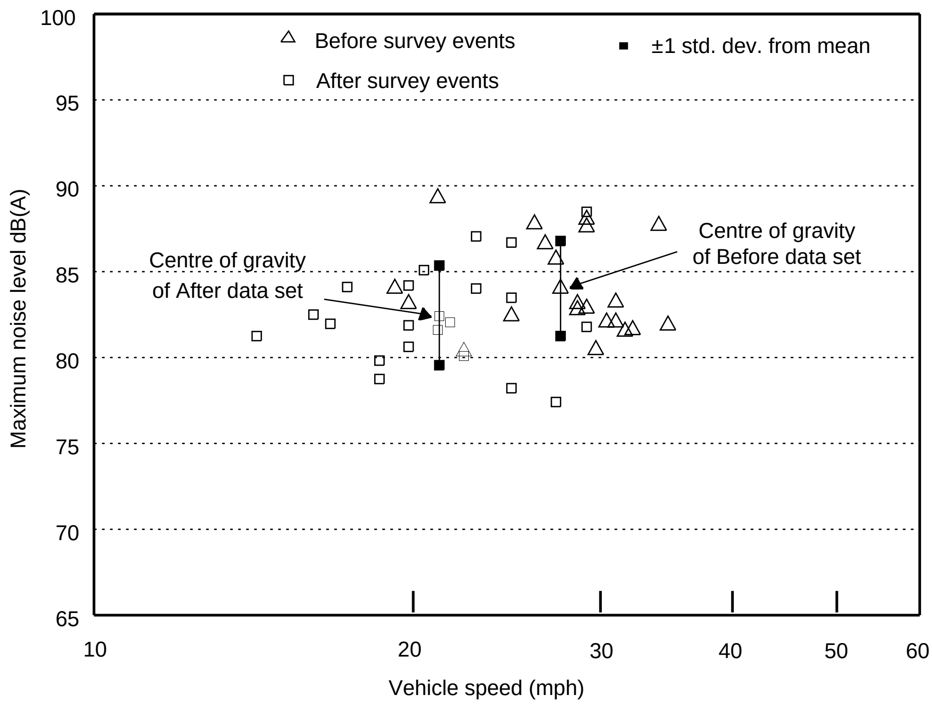


(b) Site R2 – between cushions

Figure 23 Comparison of ***light*** vehicle noise levels before and after the installation of the traffic calming scheme



(a) Site R1 – alongside cushion



(b) Site R2 – between cushions

Figure 24 Comparison of ***heavy*** vehicle noise levels before and after the installation of the traffic calming scheme

Table 3 Before and After *light* vehicle noise levels

		Before		*After*		*Change in*[1]	
Site	*Site description*	*Mean site speed*[2] *(mph)*	*Vehicle noise level (L_{Amax}) at mean speed (dB(A))*	*Mean site speed (mph)*	*Vehicle noise level (L_{Amax}) at mean speed (dB(A))*	*Mean site speed (mph)*	*Vehicle noise level (L_{Amax}) (dB(A))*
R1	Alongside cushion position	33.6	78.5	26.5	74.7	-7.1	-3.8(-3.5[3])
R2	Between cushions positions	33.6	78.0	27.0	73.9	-6.6	-4.1(-3.6[3])

[1]*Negative numbers indicate a reduction in speed or noise level*
[2]*Measured using radar equipment as described in Sections 4.1.2 and 4.2.2*
[3]*Estimated reduction in noise level at the mean speed measured in the After study, calculated from the relation between speed and noise determined in the Before study*

Table 4 Before and After *heavy* vehicle noise levels

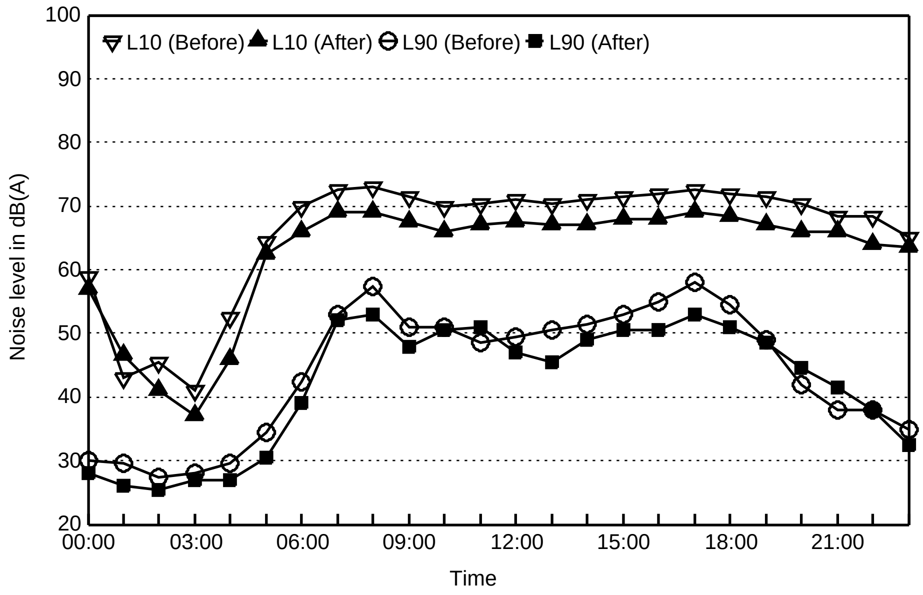
		Before		*After*		*Change in*[1]	
Site	*Site description*	*Mean site speed*[2] *(mph)*	*Mean vehicle noise level (L_{Amax}) (dB(A))*	*Mean site speed (mph)*	*Mean vehicle noise level (L_{Amax}) (dB(A))*	*Mean site speed (mph)*	*Mean vehicle noise level (L_{Amax}) (dB(A))*
R1	Alongside cushion position	30.5	85.0	26.1	82.3	-4.4	-2.7
R2	Between cushions positions	30.5	84.0	25.6	82.4	-4.9	-1.6

[1]*Negative numbers indicate a reduction in speed or noise level*
[2]*Measured using radar equipment as described in Sections 4.1.2 and 4.2.2*

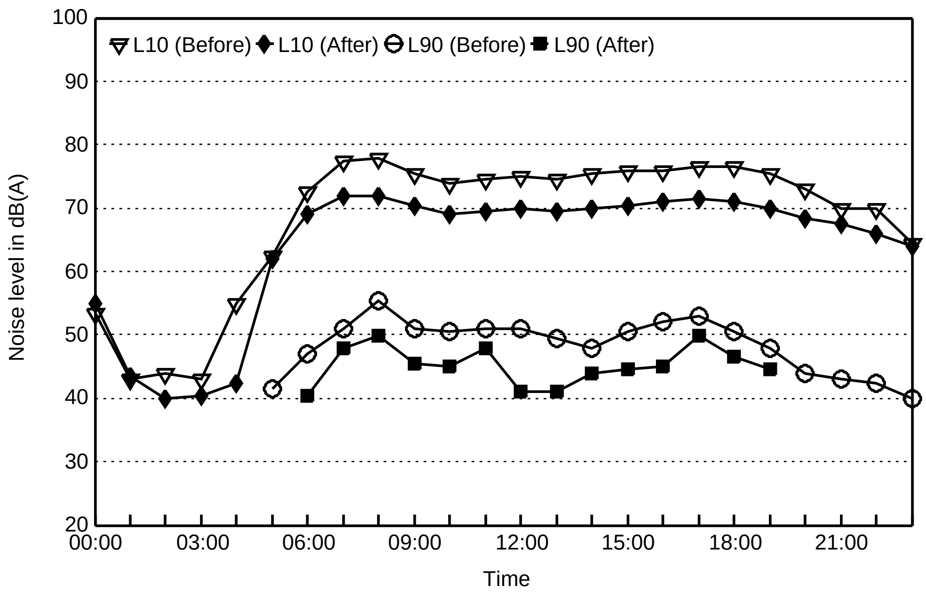
Table 5 Before and After traffic noise levels

Site	*Site description*	*Noise index*	*Time period*[1]	*Before noise level*	*After noise level*	*Change in noise level*[2] *(After level - Before level)*
R1	Alongside cushion	L_{A10}	18 hr daytime levels	70.7	67.0	-3.7
			6 hr night-time levels	50.9	48.3	-2.6
		L_{A90}	18 hr daytime levels	48.8	46.9	-1.9
			6 hr night-time levels	29.8	27.3	-2.5
		L_{C10}	18 hr daytime levels	76.4	75.0	-1.4
			6 hr night-time levels	60.2	56.9	-3.3
		L_{C90}	18 hr daytime levels	56.8	56.2	-0.6
			6 hr night-time levels	45.2	40.9	-4.3
5A	Alongside road narrowing	L_{A10}	18 hr daytime levels	74.2	69.5	-4.7
			6 hr night-time levels	50.2	47.3	-1.9
		L_{A90}	18 hr daytime levels	48.8	-	-

[1]*The 18-hour daytime and 6-hour night-time periods are measured between 06:00 to 00:00 and 00:00 to 06:00 hours respectively*
[2]*Negative numbers indicate a reduction in noise level.*

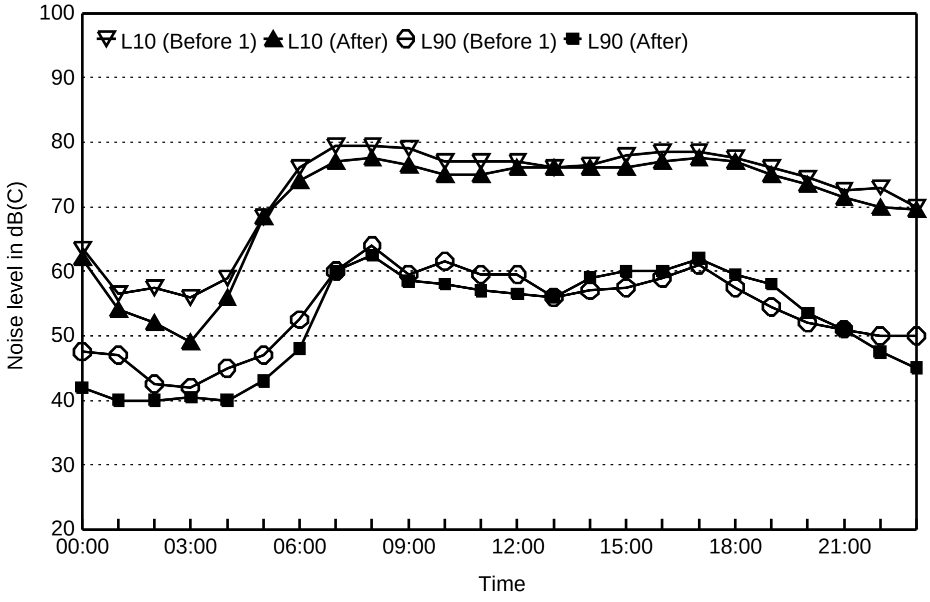


(a) Site R1 – alongside cushion



(b) Site 5a – alongside road narrowing

Figure 25 Hourly noise levels $L_{A10,1h}$ and $L_{A90,1h}$ values before and after scheme installation



Site R1 – alongside cushion

Figure 26 Hourly noise levels $L_{C10,1h}$ and $L_{C90,1h}$ value before and after scheme installation

At both the cushion and road narrowing sites, the hourly $L_{A90,1h}$ levels obtained during the After survey were generally lower than those obtained during the Before survey. The reduction in overall daytime background level ($L_{A90,18h}$) at the cushion site was 1.9 dB(A), and the decrease in the night-time background level ($L_{A90,6h}$) was 2.5 dB(A). $L_{A90,18h}$ and $L_{A90,6h}$ indices could not be calculated for the road narrowing site as the noise levels were below the operating range of the sound level meter during certain hours of the measurement period.

ii **C-weighted noise exposure:** Hourly $L_{C10,1h}$ and $L_{C90,1h}$ noise levels obtained at the cushion site are shown in Figure 26. Like the corresponding $L_{A10,1h}$ levels, the $L_{C10,1h}$ daytime levels measured in the After survey were consistently lower than those obtained in the Before survey. However, the reductions were less than those observed for the A-weighted levels. The decrease in $L_{C10,18h}$ level was 1.4 dB(C), compared with 3.7 dB(A) measured on the dB(A) scale. The $L_{C10,1h}$ levels during the night-time period showed greater reductions. The overall night-time noise level ($L_{C10,6h}$) was decreased by 3.3 dB(C) which, in this case, was marginally greater than the corresponding decrease in A-weighted level of 2.6 dB(A).

Background daytime $L_{C90,1h}$ levels obtained in the After survey were generally very similar to the Before survey levels. The background $L_{C90,18h}$ level was reduced by only 0.6 dB(C). Night-time background $L_{C90,1h}$ levels obtained in the After survey were consistently less than those measured during the Before survey. The overall background night-time level ($L_{C90,6h}$) was 4.3 dB(C) lower when measured during the After survey.

iii **The effect of changes in traffic flow and composition:** To establish to what extent the measured reduction in daytime traffic noise levels ($L_{A10,18h}$) at the cushion site was influenced by changes in traffic flow and composition, a prediction model was used. The model takes into account vehicle noise levels as well as traffic flow and the percentage of heavy vehicles. It was not possible to carry out this prediction for the road narrowing site, as vehicle noise levels and speeds were not measured. However, it would be expected that the change in noise level resulting from changes in traffic flow and composition at this site would be similar to that predicted for the cushion site.

The traffic noise prediction model estimates the change in the 'equivalent continuous sound level' or $L_{Aeq,T}$ noise index. This alternative index for assessing the impact of traffic noise is widely used in Europe and the USA, and considers the energy content of the noise. It can be defined as a notional steady noise level which, at a given location and over a defined time period T, would have the same acoustic energy as the actual fluctuating noise.

Although the indices $L_{A10,18h}$ and $L_{Aeq,18h}$ are very different in describing traffic noise, surveys have shown that for the majority of situations of practical interest $L_{A10,18h}$ generally exceeds $L_{Aeq,18h}$ by approximately 3 dB(A). Therefore, changes in traffic noise levels described using either noise index should be numerically similar (Noise Advisory Council, 1978). Full details of the prediction method are described in Appendix C together with the input variables necessary for the prediction. The results of this analysis predicted that, had the traffic flow and composition during the After survey been the same as that in the Before survey, the measured After $L_{A10,18h}$ level would have been 0.5 dB(A) greater than it was. In other words, 0.5 dB(A) of the observed reduction could be attributed solely to the small changes in traffic flow and composition, as measured on the days of the noise surveys.

iv **Maximum noise levels:** The maximum A-weighted noise levels (L_{Amax}) recorded in each hour of the Before and After surveys are compared in Figure 27. For the cushion site, it can be seen that there was no consistent increase or decrease in maximum hourly noise level following the installation of the cushions. The results obtained for the road narrowing site also show little difference between the Before and After survey results during the hours of 5:00 to 19:00. Outside these hours, the L_{Amax} levels obtained during the After survey were consistently less than those measured during the Before survey. Figure 28 shows the hourly L_{Cmax} levels recorded at the cushion site. Again, the levels were generally unchanged following the installation of the cushions.

v **High noise level events:** Figure 29 shows the distribution of noise events exceeding a given noise threshold for a duration of one second or more. The results from both sites show that fewer noisy events were recorded during the After survey. It should be noted, however, that the measurements for each survey only reflect a single 24-hour period, and that the number of events obtained during different 24-hour periods may well be quite variable.

5.4 Summary and discussion

Mean vehicle speeds for light and heavy vehicles were found to have reduced as a result of the traffic calming measures installed at West End in Costessey. The effect of these measures on vehicle and traffic noise levels alongside the road is discussed below.

Light vehicle noise levels measured beside the cushion site (site R1) decreased, on average, by 3.8 dB(A) following the installation of the traffic calming scheme. The regression relation between vehicle noise level and speed derived from the Before survey data showed that a similar reduction would have been expected simply as a result of the decrease in mean vehicle speed. Light vehicle noise measured at a nearby position between cushions (site R2) was reduced by a similar amount. This result confirmed that, for a given vehicle speed, light vehicle pass-by noise alongside the cushion was comparable with that measured beside a level section of road.

The relation between heavy vehicle speed and pass-by noise was not statistically significant at either site for the Before or After surveys. However, the mean heavy vehicle noise was found to have reduced by 2.7 dB(A) alongside the cushion. The reduction in mean noise level of 1.6 dB(A) at the site between the cushions was not found to be statistically significant.

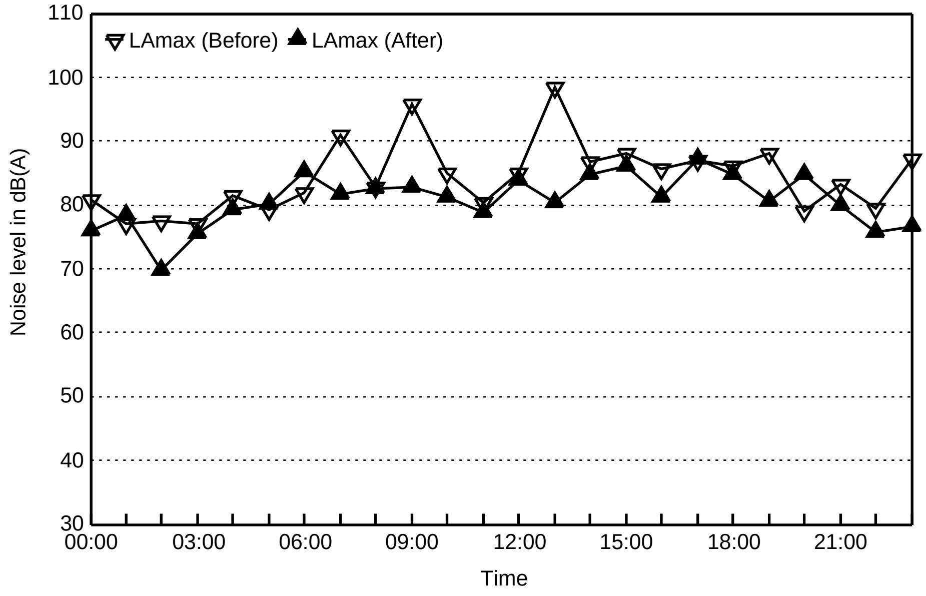
Daytime traffic noise levels were reduced at the property close to the cushion and also at another monitoring site alongside the road narrowing (site 5A). The $L_{A10,18h}$ levels decreased by 3.7 and 4.7 dB(A) at the cushion and narrowing sites respectively. It was estimated that 0.5 dB(A) of the observed reductions was attributable to the small decreases in traffic flow and the proportion of heavy vehicles observed on the day of the After survey. Because of the presence of the narrowing, vehicles travelling in the nearside lane would have been at least 1m further from the microphone than was the case during the Before study. Conversely, vehicles in the farside lane would have been at least 1m closer to the microphone after the installation of the narrowing. As the proportionate change in distance from the microphone was greatest for nearside traffic, it would be expected that overall traffic noise levels would be reduced. It is estimated that the decrease in noise level caused by the change in propagation distance would be less than 1 dB(A) but may partly explain the larger decrease in noise observed alongside the road narrowing.

Comparing night-time noise levels is complex because traffic flows are reduced and therefore the noise from local traffic is less. In addition, during the night-time period the noise from other extraneous sources such as traffic on distant roads or the noise from bird-song during the dawn chorus will influence the noise recordings to a greater extent than during the day when the dominant noise is from local traffic. It is therefore important to be very cautious when interpreting changes in night-time noise levels. However, there is some consistency in the data in that all the night-time noise indices measured using either A- or C-weightings showed reductions in levels after the installation of the scheme. Therefore, there is no evidence from these observations that the introduction of the traffic calming scheme has had a detrimental effect on the noise climate during the night.

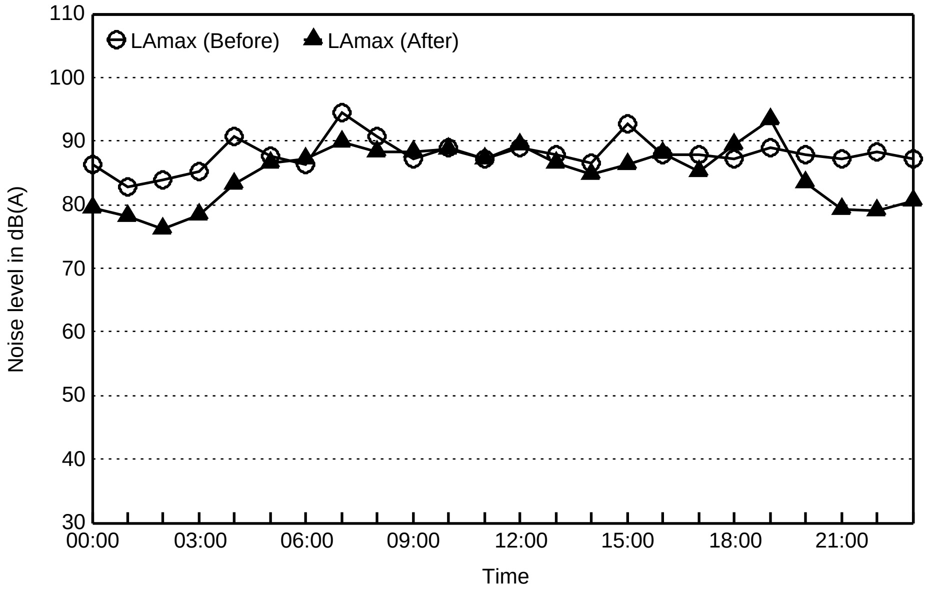
It was speculated prior to the surveys that low frequency body noise from commercial vehicles traversing the cushions might cause the daytime $L_{C10,1h}$ (i.e. C-weighted levels) to increase. Clearly this did not occur and the $L_{C10,18h}$ level at the cushion site was, in fact, reduced by 1.4 dB(C). However, the decrease was smaller than the 3.7 dB(A) reduction measured using the $L_{A10,18h}$ index, indicating that low frequency noise exposure was not reduced to the same extent as higher frequency noise. As heavy vehicles contribute more noise at low frequencies than light vehicles the results suggest that at low frequencies the noise reduction from heavy vehicles was small. This result is supported to some extent by the reduction in L_{Amax}, which showed a greater reduction for light vehicles than for heavies at the cushion site.

$L_{C90,1h}$ levels during the daytime period also showed a smaller reduction after the installation of the scheme compared to the corresponding decrease in $L_{A90,1h}$. Again this may be explained by the small reduction in low frequency noise from heavy vehicles. Low frequency noise attenuates less than higher frequency noise and so is maintained at higher levels and for longer periods of time. It therefore influences daytime, $L_{C90,1h}$, noise levels but has less influence on daytime, $L_{A90,1h}$, noise levels.

Prior to the installation of the scheme, it was thought that occasional high level noise events might occur either as a result of body noise at the cushion site, or by drivers adopting a more aggressive style of driving at the road narrowing such as severe braking/acceleration. The results of the After study showed that the incidence of high noise level events did not increase. In fact, the number of noisy

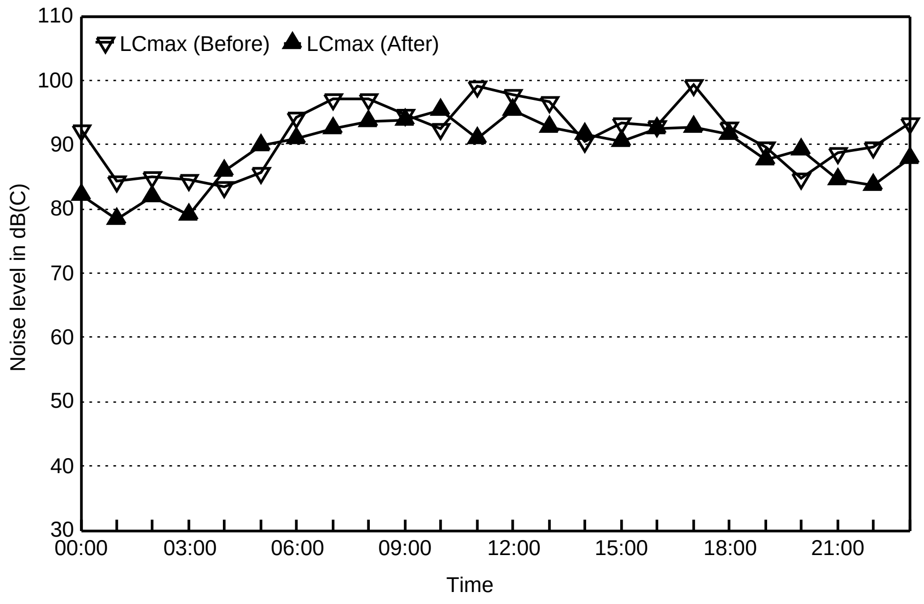


(a) Site R1 – alongside cushion



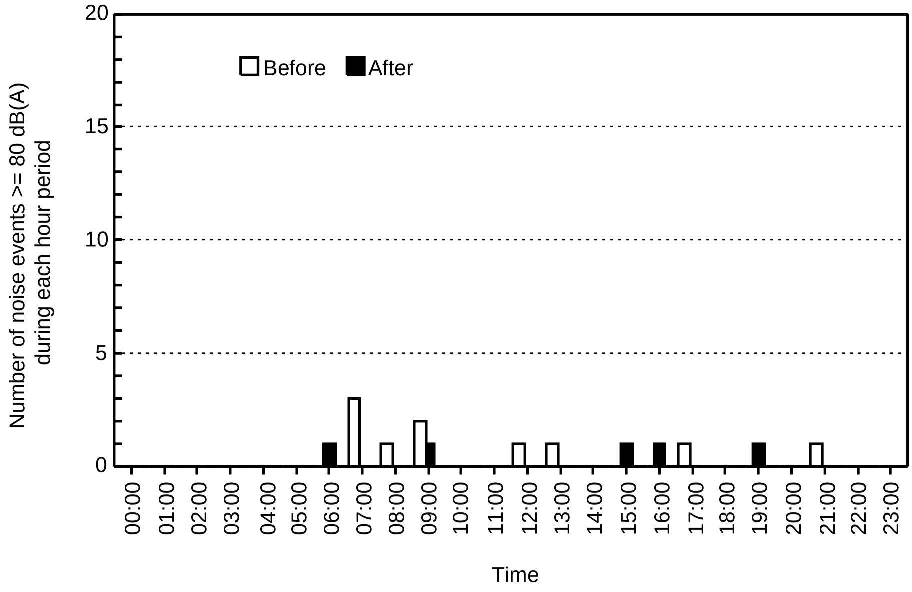
(b) Site 5a – alongside road narrowing

Figure 27 Hourly noise levels $L_{Amax,\ 1h}$ values before and after scheme installation

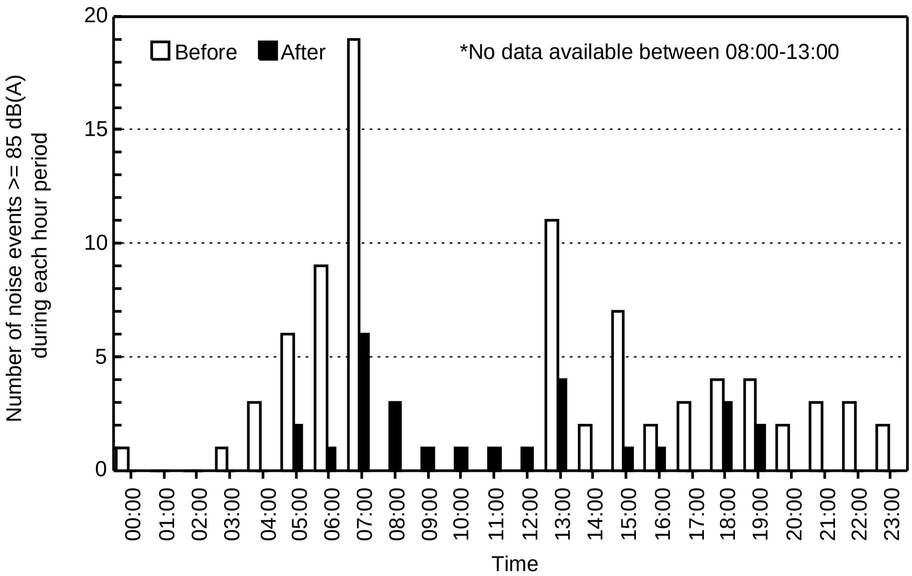


(a) Site R1 – alongside cushion

Figure 28 Hourly noise levels $L_{Cmax,1h}$ values before and after scheme installation



(a) Site R1 – alongside cushion



(b) Site 5A – alongside road narrowing

Figure 29 Number of noise events in each hour exceeding perdetermined threshold levels before and after scheme installation events reduced at both sites for the 24-hour survey periods monitored for this study.

The video record of the Before survey at the cushion site showed that the noisy events recorded were caused by a variety of sources. These included buses accelerating away from a nearby bus stop, car horns sounding, agricultural vehicles and noisy mopeds. Of the few noisy events recorded during the After survey at the cushion site, none was caused by body noise. Highly impulsive body noise *not* exceeding the event threshold for at least 1 second would not have been included in the event record. However, any increase in very high level transient noise would have been observed in the hourly record of maximum noise levels but this was not apparent at either the cushion or the road narrowing sites.

6 Public opinion surveys

Residents in Costessey were interviewed in their homes before the traffic calming scheme was introduced (February 1997) and again after installation (September 1997). The aim was to establish people's perceptions of the measures and their effectiveness, or otherwise, in reducing any traffic problems resulting from the roads through the village. In the Before survey, 100 residents were interviewed in total, 60 residing in West End or Parklands to the west of Longwater Lane, 15 in West End to the east of Longwater Lane, and 25 in Longwater Lane itself (see Figure 4). In the After survey, interviewers were instructed to re-interview as many of the original respondents as possible. When a respondent was unavailable for re-interview or refused, a close neighbour of the same sex was taken as a substitute. Ninety-nine respondents were interviewed in the After survey, 69 of whom had been interviewed in the Before survey. Only those respondents living in the village at least 6 months prior to the Before survey were eligible for interview. Appendix D contains the questions used in the Before and After surveys, and gives the distribution of responses to each question. The remainder of this section should be read in conjunction with this Appendix.

6.1 Sample profile

The classification of the respondents is given in Appendix D. At both phases of interviewing at least 70 per cent of respondents had lived at their address for 10 years or more. Almost half of respondents were over 60 years of age, about 40 per cent were retired, and only about 20 per cent had children living at home. The percentage of females in the sample was 55 in the Before survey, and 59 in the After survey.

6.2 Survey results

The principal findings are described below and, where relevant, the results from the Before and After surveys are compared. Percentages given throughout, for both the Before and After surveys, are of *all* respondents interviewed, since results for only the 69 respondents completing both Before and After phases of interviewing showed little difference from those for the total samples.

Results quoted for statistical significance are based on the 5% confidence level throughout. In the Tables, statistically significant changes are denoted by * and remaining changes are not statistically significant.

Responses were broadly similar (Chi-square test) for the different age groups and for both sexes, although some differences were observed in opinions of the specific measures (see Section 6.2.4).

After scheme installation, fewer people claimed to walk to the shops or to visit friends, and more claimed to use their cars. However, the overall effect of the scheme on modes of travel is not clear cut (Q1).

6.2.1 General nuisance caused by road traffic

Respondents in both the Before and After surveys were asked how much they were bothered by possible traffic problems in the area. The possible problems were read out and respondents could say whether they were bothered 'very much', 'quite a lot', 'not very much' or 'not at all' (Q2). The percentages bothered 'very much' or 'quite a lot' by each potential problem, both before and after installation of the scheme, are given in Table 6.

It can be seen that while the scheme did have some impact on the number of people bothered by speeding traffic (reducing from 85 to 72 per cent of respondents bothered) it had no impact on the number bothered by the amount of traffic. The number bothered by lorries reduced from 76 to 63 per cent, but the percentage of respondents bothered by traffic congestion increased from 59 to 72 per cent.

Table 6 Cause of nuisance from traffic in the area

	Percentage of respondents bothered 'very much' or 'quite a lot'	
	Before	*After*
Speeding traffic*	85	72
The amount of traffic	86	86
Danger or difficulty crossing the road	72	71
Danger to children	89	80
Traffic congestion*	59	72
Lorries*	76	63
Parking problems	37	39
Rat running	90	81
Poor driving standards/ behaviour	57	55
Sample Size	100	99

**Before/After difference significant (Chi-square test)*

Safety

Respondents were asked to rate the safety of their road on a scale of 0 to 6, where 0 was labelled 'very good' and 6 was labelled 'very bad' (Q19 (Before) and Q17 (After)). The mean rating before the installation of the scheme was 4.7. After installation the rating fell slightly to 4.0, indicating a small increase in perceived overall safety.

6.2.2 Nuisance from traffic indoors at home

Respondents were asked to rate various forms of traffic nuisance that they might experience indoors at home (Q3 (Before), Q3a (After)). They were asked to use the same worded 'bother' scale as described in Section 6.2.1. The results are summarised in Table 7.

Table 7 Nuisance from road traffic when indoors at home

	Percentage of respondents bothered 'very much' or 'quite a lot'	
	Before	*After*
Noise	43	42
Vibration	46	37
Dust and Dirt	41	31
Smoke and fumes	34	34
Sample Size	100	99

It can be seen that overall that there was no change in the percentages of respondents bothered by noise or smoke and fumes. Slightly fewer respondents were bothered by vibration and dust and dirt after the implementation of the scheme, although these differences were not statistically significant.

The contribution of lorries to bother from noise, vibration and dust and dirt was lower after the introduction of the scheme (Q3b (Before), Q4 (After); Table 8), although again these differences were not statistically significant.

Table 8 Percentage of respondents thinking lorries were cause of nuisance indoors at home

	Percentage of respondents thinking lorries caused nuisance	
	Before	*After*
Noise	61	54
Vibration	58	51
Dust and Dirt	52	44
Smoke and fumes	47	48
Sample Size	100	99

Bother from noise and vibration did not vary significantly (Chi-square test) according to where people lived in the village, respondents being no more likely to be bothered by noise and vibration if living close to a calming measure rather than further from it. Likewise, the particular type of calming measure closest to the respondent's home did not influence the degree of nuisance from noise or vibration.

Respondents were asked a series of more detailed questions about nuisance from traffic noise when indoors at home, both before and after the installation of the scheme (Q5 to Q7 (Before) and Q4 to Q6 (After)). Details are given in Appendix D. The results show no consistent change in traffic noise nuisance following the implementation of the scheme. Traffic noise nuisance was greatest on weekday mornings both before and after scheme installation, with 52 and 45 per cent of respondents respectively bothered 'very much' or 'quite a lot' (Q7a (Before) and Q6a (After)). Lorries caused the greatest nuisance at this time, both before and after the scheme was installed (Q7b (Before) and Q6b (After)). The types of noise heard most frequently were vehicle bodywork rattling, the squeal of brakes and tyres, and police, fire and ambulance sirens (Q6b (Before) and Q5b (After)). Brake/tyre squeal and siren noise were perceived to be significantly less (Chi-square test) in the After survey.

When asked in the After survey to rate traffic noise nuisance experienced indoors before and after implementation of the scheme (Q7a and 7b), using a 7 point satisfaction scale, Before and After mean ratings were almost identical, at 3.6 and 3.7 respectively (0 = definitely satisfactory and 6 = definitely unsatisfactory). When asked directly if the calming had affected the level of noise heard indoors (Q7c), 42 per cent felt it had, with 30 per cent thinking it was noisier, and 12 per cent thinking it was now quieter (Q7d).

Slightly fewer people overall were bothered by vibration after scheme implementation (see Table 7), and this manifests itself mainly in a reduction in respondents experiencing windows and doors rattling and buzzing (Q8; Table 9).

Table 9 Nuisance from vibration when indoors at home

	Percentage of respondents experiencing vibration	
	Before	*After*
Windows or doors rattling or buzzing*	48	32
Floors shaking or trembling	10	9
Ornaments rattling, buzzing or moving about	13	13
Feelings of vibration in the air	26	21
Sample size	100	99

**Before/After difference significant (Chi-square test)*

6.2.3 Nuisance from traffic as a pedestrian

Those respondents who ever walked along the footpath outside their home were asked to rate various forms of traffic nuisance that they might experience when a pedestrian (Q9b), using the same worded bother scale as used previously (Section 6.2.1). The responses are given in Table 10, for both before and after installation of the calming scheme, the percentages given being of all survey respondents who walked along the footpath.

Table 10 Nuisance from road traffic when walking along the footpath

	Percentage of respondents bothered 'very much' or 'quite a lot'	
	Before	*After*
Noise	58	56
Vibration	48	44
Dust and Dirt*	57	41
Smoke and fumes	66	65
Sample Size	88	86

**Before/After difference significant (Chi-square test)*

It can be seen that the scheme made little difference to perceived nuisance levels, other than from dust and dirt. The percentage of respondents bothered reduced from 57 to 41 per cent.

The reduction in perceived nuisance from dust and dirt following the scheme installation is reflected in a small change in concern by respondents for their own and their family's health, resulting from dust and dirt and smoke and fumes. Following the introduction of the scheme the percentage of respondents 'very' or 'quite' concerned fell from 66 to 58 (Q11).

Both lorries and cars contributed to the various forms of traffic nuisance to pedestrians (Q10 (Before) and Q9c (After)), and the nuisance caused by cars increased significantly following scheme installation. The percentage of respondents bothered by the various forms of nuisance from lorry traffic (Q10 (Before), Q9c (After); Table 11) showed little change following scheme installation.

Table 11 Percentage of respondents thinking lorries were cause of nuisance when walking along the footpath

	Percentage of respondents thinking lorries caused nuisance	
	Before	*After*
Noise	59	65
Vibration	57	53
Dust and Dirt	60	62
Smoke and fumes	64	66
Sample Size	88	86

Table 10 suggested little change in nuisance from traffic noise to pedestrians. However, as for noise nuisance indoors, this masks conflicting views. When asked directly if traffic noise to pedestrians had changed (Q10), 42 per cent of respondents said it had, with 28 per cent saying it had increased, and 14 per cent saying it had decreased.

Respondents who walked along the road outside their home were asked a series of questions on their concerns about road safety both before and after the installation of the scheme (Q12). They were asked if they were 'very', 'quite', 'a little' or 'not at all' concerned about danger from traffic in specified situations. The results are summarised in Table 12, where it can be seen that the scheme resulted in quite large reductions in perceived danger to pedestrians, particularly from lorry traffic.

6.2.4 Attitudes to the traffic calming scheme

Ninety-two per cent of respondents had heard about the scheme prior to its installation, most commonly from leaflets and public meetings (Q13 (Before)). Most thought it necessary to control the speed and amount of lorry traffic and traffic in general (Q14 (Before)).

Prior to installation, 80 per cent of respondents had thought the scheme was a good idea (Q18). However, when asked in the After survey (Q13) how satisfactory overall the changes in the village were, the mean score was 4.3 on a 7 point scale where 0 = definitely satisfactory and

Table 12 Concern over safety as a pedestrian

	Percentage of respondents 'very' or 'quite' concerned	
	Before	*After*
Danger from lorries when walking along the footpath*	76	52
Danger from lorries when crossing the road*	75	52
Danger from traffic in general when walking along the footpath *	76	63
Danger from traffic in general when crossing the road*	78	58
Sample size	88	86

**Before/After difference significant (Chi-square test)*

6 = definitely unsatisfactory, indicating that the majority were dissatisfied; almost a third responded 'definitely unsatisfactory'.

Respondents were asked who would benefit or had benefited from the scheme (Q16 (Before), Q14 (After)). The results showed that the expected benefit to local residents was far from realised in practice (Table 13). Similarly, the benefit for children was far less than anticipated, although 25 per cent of respondents did feel that children had benefited from the scheme.

Table 13 Respondents' views on who will benefit/has benefited from the scheme

	Percentage of respondents thinking group of people will benefit	
	Before	*After*
People who live round here*	57	9
Children*	46	25
Old people*	26	10
Disabled people	1	0
Drivers	4	0
Pedestrians*	18	1
Cyclists	8	3
Everyone*	33	5
No-one*	4	58
Sample size	100	99

**Before/After difference significant (Chi-square test)*

Despite the reduced concern over safety for pedestrians and the belief that nuisance from dust and dirt was reduced (Section 6.2.3) only one respondent believed that pedestrians had benefited from the scheme.

The anticipated advantages of the calming scheme were likewise perceived not to have been realised in practice (Q17 (Before), Q15 (After); Table 14). In particular, the residents' expectations of reductions in the amount and speed of lorry and general traffic were not perceived to have been achieved (and in fact, although mean speeds were reduced typically by 5 to 10mph, they were not brought below 20mph). However, 28 per cent of respondents did think the scheme had been successful in reducing the speed of traffic in general.

Before scheme installation, respondents were asked which particular measures were a good idea for controlling

Table 14 Main advantages of the traffic calming scheme

	Percentage of respondents thinking an advantage of scheme	
	Before	*After*
Fewer lorries*	36	3
Less traffic in general*	51	3
Less noise*	10	1
Less dirt*	8	0
Slows down lorries*	21	4
Slows down traffic in general*	46	28
Fewer accidents*	5	0
Safer for children*	16	5
Safer in general*	20	6
Easier to cross road	3	3
Makes the area look better	0	0
Nothing*	3	52
Sample size	100	99

** Before/After difference significant (Chi-square test)*

the speed and amount of traffic through the village (Q15). The replies are given in Table 15. It can be seen that speed controls, particularly speed cameras and speed limits, were considered to be a good idea for influencing both the speed and amount of traffic. However, speed cameras were statistically significantly less likely to be considered a good idea by the over sixties than by respondents in other age groups. Mini-roundabouts and road narrowings were generally not very popular.

Table 15 Respondents thinking measures are a good idea for controlling speed and amount of traffic on road

	Percentage of respondents	
	Speed of traffic	*Amount of traffic*
Speed limits	75	71
Better signing of speed limits	65	n/a
20 mph zone	69	63
Speed cameras	86	82
Mini-roundabouts	33	n/a
Road narrowing	39	40
Speed humps	61	58
Speed cushions	65	61
Weight restrictions	n/a	81
Sample size	100	

In the After survey, respondents were asked about the usefulness of the measures actually installed, and whether each had any disadvantage or problems (Q16). The results are summarised in Table 16.

Most measures were seen as ‘very’ or ‘fairly’ useful in practice by the majority of respondents. In particular the road hump outside the school was considered useful by 93 per cent of respondents. The road narrowings and mini-roundabout, which attracted prior scepticism (Table 15), were also favoured by about 70 per cent of respondents. However, the mini-roundabout was statistically significantly more likely to be considered of little use by the over sixties

Table 16 Percentage of respondents saying specific measure was useful or had disadvantages or problems

	Percentage of respondents	
	Measure ‘very’ or ‘fairly’ useful	*Measure has disadvantages or problems*
Speed cushions	22	74
Road hump outside school	93	19
Road narrowing with cushions in Longwater Lane	72	38
Other road narrowings	67	30
Mini-roundabout near post office	74	35
30mph reminder sign in Longwater Lane	65	34
20 mph zone signs	53	40
Sample size	99	

than by respondents in other age groups. The 20mph zone signs and the 30mph reminder sign were considered useful by about 60 per cent of respondents. Few felt the speed cushions were useful (22 per cent), and many (74 per cent) perceived them as having disadvantages or problems. When asked (Q16c) why, the main reason given was that they were ineffective at slowing the traffic, most vehicles straddling them. The main concerns about this and other measures are summarised in Table 17.

Opinions on the appearance of the scheme were mixed, with few people having strong feelings either way. The main concern (13 respondents) was that there were too many signs, making the village look untidy.

6.3 Summary and discussion

Before the traffic calming scheme was installed, most respondents thought it was a good idea, but after installation it was considered unsatisfactory by the majority. While fewer were bothered by speeding traffic or lorries after installation, bother from the total amount of traffic was unchanged, and the nuisance from traffic congestion increased. This may have resulted from vehicles having to stop to give way to opposing traffic at the narrowings (see Table 17), or perhaps to moving queues forming behind vehicles crossing cushions particularly slowly.

There was, overall, a perceived improvement in safety. In particular, there was a reduction in perceived danger to pedestrians, especially from lorries, following the introduction of the scheme. This is likely to reflect the perception by some that speeds had reduced.

The traffic calming scheme had little overall effect on the noise levels perceived by respondents either in their homes or as pedestrians. There was almost no change in the number of respondents bothered by traffic noise and over half thought noise levels had stayed the same. Slightly fewer respondents were bothered by vibration after scheme implementation, mainly due to a reduction in people experiencing windows and doors rattling and buzzing. There was a statistically significant reduction in the number of people who, as pedestrians, perceived dust and dirt to be a nuisance. It is possible that reductions in

Table 17 Main concerns about measures installed

Measure	*Main concern*	*% of respondents expressing main concerns*
Speed cushions	Ineffective at slowing traffic	59
20 mph zone signs	People don't take any notice	30
Road narrowing with cushions in Longwater Lane	People don't give way/congestion	15/10
Other road narrowings	People don't give way/priority unclear	14/11
Mini-roundabout near post office	Difficult to turn	12
30mph reminder sign in Longwater Lane	People don't take any notice	10
Road humps outside school	Difficult to see	7
Sample size	99	

traffic speed have, in fact, led to less dust being thrown up by moving vehicles.

Bother from noise and vibration for those respondents living close to a traffic calming measure did not differ significantly from that experienced by those living further from a measure. Nor did the type of calming measure closest to the respondent's home affect the degree of nuisance from noise or vibration.

Most respondents had favoured speed controls (in particular speed cameras and speed limits) as a means of reducing both the speed and volume of traffic. In practice most of the measures installed were considered useful, with the speed hump by the school being considered useful by almost all respondents. The speed cushions were not thought to be of much use, mainly because larger vehicles were able to straddle them, making them less effective at reducing speeds. It should be noted that the radar speed measurements showed that speeds at and between the cushions fell by 5 to 7mph for light vehicles and 3 to 5mph for heavy vehicles (see Section 4.2.2). Since the speed cushions were the most frequently used measure in the scheme as a whole, their unpopularity may be responsible for much of the negative reaction towards the scheme.

7 Accidents

Accident data for five years prior to the introduction of the traffic calming measures (1 July 1992 - 30 June 1997) were obtained for Longwater Lane (excluding its junction with the A1074) and West End. There were 15 reported injury accidents, of which six occurred on Longwater Lane (excluding the junction with West End). Of the 15 accidents, 2 involved serious injury. Five of the accidents were reported during the last three years up to scheme installation.

The 15 accidents can be classified as follows:

nose-to-tail (on main road, including vehicle turning off)	4
head-on collision	3
loss of control on bend	2*
collision on emerging	2
right turn off main road and oncoming vehicle	1
pedestrian (fell in road playing)	1
circumstances not known	2

**One on Longwater Lane and the other at the junction with The Street*

Following scheme implementation, no injury accidents have been reported in the period to April 1998. The After period is quite short and more time will be needed before a comprehensive accident analysis can be carried out.

8 Summary and conclusions

In July 1997, a traffic calming scheme was completed in Costessey on the western outskirts of Norwich. The village is situated on two adjoining minor roads carrying 5000-6000 vehicles per day, including a good deal of commuter traffic 'rat-running' between parallel radial routes to the city. The roads also serve as access to local gravel pits and HGVs can make up over 20% of the traffic flow early on weekday mornings.

Prior to scheme installation the village was subject to a 30mph speed limit. The scheme comprises a 20mph zone entered from two directions via a single-lane working carriageway narrowing with a speed cushion, and from a third direction via a new mini-roundabout. A fibre-optic 30mph speed limit sign (triggered by vehicles exceeding 35mph) is located several hundred metres in advance of the 20mph zone on one approach. The features within the 20mph zone are: 1500mm wide speed cushions spaced at 60-80m; a number of carriageway narrowings of single vehicle width; and a flat-top hump outside a school access.

Before and After monitoring (February 1997 and September 1997) included measurements of vehicle speeds and flows, and vehicle and traffic noise, at a number of locations in the village. Public opinion surveys of residents were also carried out in their homes before and after scheme installation. The results are summarised below and conclusions drawn.

8.1 Vehicle speeds and flows

The TRL counts taken about six months apart showed that, after scheme installation, traffic flows were on average little changed on West End but were up by about 9% on Longwater Lane. Some Norfolk County Council counts taken exactly one year apart gave similar results. It is uncertain whether seasonal variation applies at Costessey, where most of the traffic appears to be generated locally, but taking the TRL and Norfolk results together, it would seem that the measures on West End have stemmed any effect of a general increase in traffic in the area. It could be that some drivers may be deliberately avoiding the speed cushions in West End. The scheme did not affect the proportion of HGVs, but it was not expected that HGV traffic would reduce, as its only practicable access to the gravel pits was through Costessey.

Before scheme installation, 85th percentile speeds measured automatically ranged from 33mph to 44mph and mean speeds from 26mph to 38mph, with the highest speeds on Longwater Lane. Following commissioning of the 30mph fibre-optic sign, inbound mean speeds fell by 4mph in the trigger zone, 5mph at the sign and 3mph 300m beyond it. After completion of the whole scheme, mean speeds fell: by 10mph just inside the ‘cushioned’ zone entry features; by 9mph on average at and between the speed cushions and near the flat-top hump; and by 7mph at the zone entry near the mini-roundabout. Eighty-fifth percentile speed reductions were similar to mean speed reductions. The speed reductions at the cushions are broadly consistent with those obtained at cushions of the same width on the A49 trunk road at Craven Arms in Shropshire (Wheeler *et al*, 1996).

Mean and 85th percentile speeds measured by radar gun, both at and between cushions, fell by 6mph and 4mph for light and heavy vehicles respectively.

A requirement of a 20mph zone is that average speeds of 20mph should be maintained within it. This was only achieved along the section of West End near the school; at the remaining monitoring positions mean speeds were still up to 25mph measured automatically and up to 27mph for free-flowing light vehicles measured by radar gun. The close spacing of the speed cushions has, however, resulted in constant speeds through this part of the scheme.

The 30mph fibre-optic sign was effective in reducing speeds. The section of Longwater Lane where it is installed is downhill towards the village and has an open aspect. This probably contributes to the 85th percentile speeds still being about 7mph above the speed limit.

8.2 Traffic and vehicle noise measurements

Reductions in vehicle noise and traffic noise were recorded at the survey sites following the installation of the traffic calming scheme.

Light vehicle noise at a cushion and between cushions was reduced, on average, by about 4 dB(A) after the installation of the scheme, for corresponding reductions in mean speeds of about 7mph. These reductions were shown to be entirely consistent with those expected had the same reduction in mean vehicle speed been achieved without installing the cushions. Heavy vehicle noise at both sites was not found to be significantly related to speed in either the Before or After surveys. However, heavy vehicle noise was reduced by about 2 dB(A) alongside the cushion and between cushions, for corresponding reductions in mean speeds of about 5mph.

Traffic noise exposure levels during the day ($L_{A10,18h}$) decreased by nearly 4 dB(A) and 5 dB(A) at a cushion and a road narrowing respectively. Using a traffic noise model, it was estimated that 0.5 dB(A) of the observed reductions were attributable to small differences in the traffic flow and composition during the two surveys.

Comparing night-time noise levels is complex because the noise from other extraneous sources such as traffic on distant roads or the noise from bird-song during the dawn chorus will influence the noise recordings to a greater extent than during the day when the dominant noise is from local traffic. However, there was consistency in the data in that all the night-time noise indices measured using either A- or C-weightings showed reductions in levels after the installation of the scheme. Therefore, there is no evidence from these observations that the introduction of the traffic calming scheme has had a detrimental effect on the noise climate during the night.

It was speculated prior to the surveys that low frequency body noise caused by commercial vehicles traversing the cushions might cause the daytime $L_{C10,1h}$ to increase. However, the $L_{C10,18h}$ level at the cushion site was reduced by 1.4 dB(C) following the scheme installation, thereby, showing no evidence of an increase in low frequency body noise.

Observations comparing the maximum noise levels within each hour and the incidence of short duration high noise level events, such as body noise or noise from excessive braking/acceleration, at both the cushion and road narrowing sites, did not show any increase as a result of the traffic calming measures. In fact, the number of noisy events reduced at both sites for the 24-hour survey periods monitored for this study.

8.3 Public opinion surveys

The opinion surveys revealed a relatively elderly population in Costessey, more than half of the 100 people interviewed before and after scheme installation being over 60. After the scheme was installed, fewer people claimed to walk to the shops or visit friends and more claimed to use their cars. On a scale of 0 - 6, where 0 was ‘definitely satisfactory’ and 6 ‘definitely unsatisfactory’, respondents scored an average of 4.3 for overall satisfaction with the scheme.

Residents generally had high hopes that the scheme would reduce traffic levels and speeds, particularly of lorries, but afterwards were less enthusiastic. Fewer were bothered by the speed of vehicles than previously, but more were bothered by traffic congestion. There were mixed views about the appearance of the scheme, but most did not hold strong opinions on this matter.

Overall, safety was believed to have improved, especially for pedestrians, but the scheme as a whole seemed to be perceived to have little else to commend it. However, when asked specifically about the individual measures, most people considered most of them to be useful. The road hump outside the school was extremely popular, followed by the mini-roundabout and the road narrowings. The speed cushions were disliked by the majority, mainly because they were perceived to be ineffective at reducing speed as most vehicles could straddle them.

The traffic calming scheme had little effect on the noise levels perceived by respondents either in their homes or as pedestrians. Slightly fewer respondents were bothered by windows and doors vibrating, and the nuisance from dust and dirt in the street was thought to have reduced. Bother from noise and vibration did not vary according to where respondents lived in relation to the measures.

8.4 Accidents

A total of 15 injury accidents were reported on West End and Longwater Lane during the five years prior to the introduction of the traffic calming measures. None have been reported in the nine months following scheme installation, but this After period is too short for any meaningful conclusions to be drawn about the safety benefit of the scheme.

8.5 Conclusions

The scheme has been successful in reducing speeds in the village, particularly of cars, and in containing traffic growth within the village, particularly on West End. Although mean speeds below 20mph have not generally been attained, steady speeds through much of the scheme have resulted, indicating optimum spacing of the measures. The speed reductions have led directly to substantial reductions in the maximum noise generated by individual vehicles. The smooth driving patterns over the cushions may also be expected to result in lower vehicle emission levels, compared to those generated at calming schemes where more acceleration and deceleration takes place. Overall daytime traffic noise levels have reduced at the two calming measures where they were monitored, as have the numbers of noisy events. None of the noise measurements made suggested that any aspect of the noise climate, including low frequency noise and noise at night, had worsened after the introduction of the scheme.

Despite these encouraging results, local residents have been disappointed with the scheme - in particular, few have noticed the reduction in noise levels and most are still concerned about vehicle speeds. Some believe congestion to have worsened, which may be due to the slower-moving traffic particularly at the single-lane working carriageway narrowings. There is, however, a perception of increased safety, especially for pedestrians. Residents perceive the speed cushions to be ineffective at reducing speeds and the large number of these devices has probably strongly influenced their overall views.

The scheme has not been in place sufficiently long to detect any changes in accident occurrence. However, the relationship between speeds and accidents is now well-established and the measured reductions in vehicle speeds at Costessey would be expected to have a beneficial effect on safety.

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Appendix A: Vehicle noise measurement – the statistical pass-by method

The Statistical Pass-by Method was initially developed at TRL for road surface noise surveys (Franklin, Harland and Nelson, 1979). The technique is used by researchers in many other countries and has become an internationally accepted method for measuring the influence of road surfaces on vehicle and traffic noise levels (International Organisation for Standardisation, 1996).

The method requires the simultaneous measurement of the maximum noise level and speed of individual vehicles in the traffic stream. A typical measurement site layout is shown in Figure A.1 and the site at Costessey is illustrated in Figure A.2. The traffic population is categorised into 'light' vehicles (which includes all cars and vans with an unladen weight less than 1.5 tonnes) and 'heavy' vehicles (all other vehicles). Under normal conditions, approximately 50 vehicles from each category are selected for measurement.

From this data set, a regression of noise against the logarithm of vehicle speed is performed for both vehicle groups. The general relation between the maximum sound level (L_{Amax}) and the speed of a passing vehicle has been shown (Harland, 1974) to take the form:

$$L_{Amax} = a + b \, log_{10} V \text{ dB(A)}$$

where V is the speed of the vehicle and a and b are constants to be determined

The regression lines calculated are then used to determine the noise levels at suitable reference speeds. These levels are used to compare the sites studied. This method has been found to give results for surface noise surveys which are repeatable to within 1.0 dB(A) when using the vehicle sample size indicated.

All noise measurements should be taken when the road is dry and during light wind conditions, ie. wind speeds less than 10 m/s. To further minimise the effects of any turbulence due to wind, all measurements should be conducted with a microphone fitted with a standard foam windshield. The microphone system and recording level are calibrated both prior to, and following each measurement session, using a precision 1 kHz tone calibrator. The maximum and minimum air temperatures during each of the monitoring sessions are also recorded.

In the analysis, the acoustic data are combined with the vehicle speed and classification data. The maximum noise levels for each vehicle event are regressed against the logarithm of the vehicle speed using the general relation given above.

Figure A2 Arrangement for Statistical Pass-By measurements in West End (photograph taken during Before measurements)

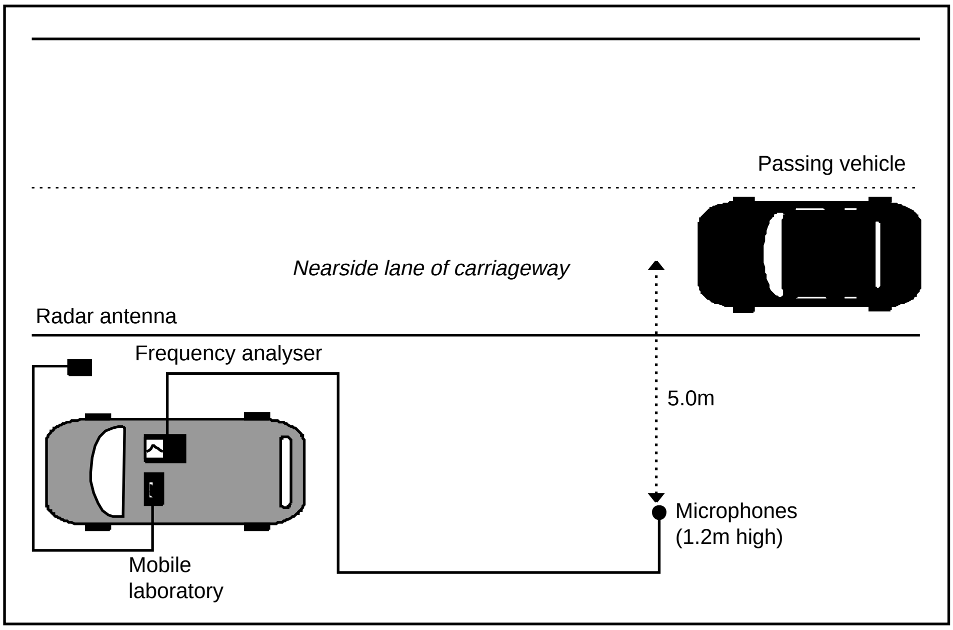

Figure A1 Site layout for Statistical Pass-By (SPB) measurements

Appendix B: Vehicle noise — regression statistics

Table B.1 Regression analysis of vehicle and speed for light vehicles

		Regression analysis statistics[1,2]				
Site	*Survey*	*Constant (a)*	*Slope (b)*	*(se)*	*Corr. (r)*	*Standard Dev. dB(A)*
R1	Before	19.19	34.23	(2.98)	0.82	1.44
	After	17.46	35.1	(3.03)	0.82	1.78
R2	Before	13.52	37.18	(2.89)	0.89	1.14
	After	28.68	28.85	(2.03)	0.84	1.31

1. Regression analysis of maximum noise level, L_{Amax} dB(A) and the logarithm of vehicle speed, V km/h, takes the form:

$$L_{Amax} = a + b\ log_{10} V \text{ dB(A)}$$

where a = the constant term
b = the slope of the regression line, b
se = the standard error of the slope
r = the correlation coefficient
and Standard Dev. = the residual standard deviation.

2. Note that for consistency with other sections in the report, speeds presented in Section 5 (Noise measurements) have been converted to mph.

All of the regressions were significant at at least the 1% level.

Appendix C: Traffic noise prediction model

C.1 General

A method for predicting traffic noise using the L_{Aeq} scale was developed by a Working Party for the Technical Sub-Committee of the Noise Advisory Council (Noise Advisory Council, 1978). The first section below, Section C.1.1, briefly outlines the method and describes the input parameters. The following section, Section C.1.2, then applies the method to predict the change in traffic noise at the survey site.

C.1.1 Basic equation for predicting traffic noise levels, $L_{Aeq,18h}$.

The basic equation for predicting traffic noise level, $L_{Aeq,18h}$ is given by the following formula:

$$L_{Aeq,18h} = 10Log_{10}[N\sum_{n=1}^{n=m} p_n.10^{L_{ax_n}/10}] + C \qquad ...(C.1)$$

where N = total traffic flow over the 18-hour period

m = the number of different vehicle categories

p_n = the percentage of vehicles in the traffic stream which are classified as vehicle category n

and $L_{AXn} = L_{Amax} - 10Log_{10}v$

where L_{Amax} is the maximum pass-by noise level from a vehicle travelling at a speed of v km/h.

L_{AXn} is a measure of the total energy associated with a single vehicle pass-by for a vehicle classified as vehicle category n

The final term, C, is constant for a given location, site layout, and specified time period.

To calculate, using equation (C.1), the change in traffic noise level, $L_{Aeq,18h}$, after the traffic calming scheme was installed, requires the following input parameters for both the Before and After situations:

a the traffic flow over a specified time period;

b the number of vehicles in each vehicle category expressed as a percentage of the total flow (%);

c the mean road speed (km/h) for each vehicle category together with the maximum pass-by noise level, L_{Amax} dB(A), at the mean road speed.

C.1.2 Predicting the change in traffic noise level

Table C.1 shows the input parameters to the prediction model which were used to predict the change in traffic noise levels attributable to the change in traffic flow and composition. The vehicle speed and noise level data used for the prediction was that obtained alongside the cushion. However, the change in noise level resulting just from changes in traffic flow and composition can be assumed to be the same at the road narrowing.

The L_{AXn} value was calculated for each vehicle category by combining the noise contribution from each vehicle within the category, taking account of the proportion of those vehicles travelling on the road. For each survey the noise contribution from each vehicle category was combined to give the total predicted noise level from all the traffic.

For this analysis the vehicle speeds and maximum vehicle noise levels (L_{Amax}) from the After survey were used as input parameters for the predictions of traffic noise during both survey periods. The expected difference in overall traffic noise due to changes in traffic flow and composition *alone* could then be determined. The results of these predictions estimated that the changes in traffic flow and composition would have caused a reduction of 0.5 dB(A) in $L_{Aeq,18h}$ level. The reduction in $L_{A10,18h}$ can be assumed to be equivalent.

Table C.1 Input parameters to the prediction model used to predict the change in traffic noise levels resulting from changes in traffic flow and composition alone

		Light vehicles (n=1)			*Heavy vehicles (n=2)*		
Survey	*Traffic flow* N (veh/18h)*	*Flow p* (%)*	*Speed v (km/h)*	*L_{Amax} dB(A)*	*Flow p* (%)*	*Speed v (km/h)*	*L_{Amax} dB(A)*
Before	6084	88.7	*(42.7)***	*(74.7)*	11.3	*(42.0)***	*(82.3)*
After	5876	91.5	42.7	74.7	8.5	42.0	82.3

**The traffic flow and percentages were based on actual counts of traffic passing the sites on the same day as the noise measurements (as explained in Section 4.1).*

***For the purposes of this analysis it was assumed that vehicle speed and maximum vehicle noise level (L_{Amax}) were the same during both surveys.*

Appendix D: Public opinion survey results

D1. BEFORE SURVEY (Sample size = 100)

Q1. First, how do you usually travel when you ....?

	Walk	Cycle	Drive	Car passenger	Bus	Other	Varies	N/A
Go to the shops	30%	2%	26%	5%	2%	0%	30%	2%
Go to work	4%	2%	34%	3%	0%	0%	3%	54%
Accompany children to school	8%	0%	7%	0%	0%	0%	0%	84%
Go to visit friends	19%	1%	46%	11%	1%	1%	20%	0%

Q2. How much are you bothered by..........?

	Very Much	Quite a lot	Not very much	Not at all
Speeding vehicles	52%	33%	11%	4%
The amount of traffic	62%	24%	7%	7%
Danger or difficulty crossing the road	50%	22%	17%	10%
Danger to children	57%	32%	7%	3%
Traffic congestion	28%	31%	24%	15%
Lorries	54%	22%	15%	9%
Parking problems	19%	18%	21%	42%
Rat-running	68%	22%	5%	2%
Poor driving standards/behaviour	28%	29%	28%	13%

Q3. Overall, how much are you bothered by........... from road traffic when you are indoors at home?

	Very much	Quite a lot	Not very much	Not at all
Noise	17%	26%	26%	31%
Vibration	19%	27%	22%	32%
Dust and dirt	11%	30%	17%	42%
Smoke and Fumes	18%	16%	21%	45%

Q4. Which types of vehicles cause the ...... which bothers you when you are indoors at home? (Asked of all respondents bothered very much, quite a lot or not very much at Q3, percentages given are of all respondents)

	Cars	Motorcycles	Lorries	Buses
Noise	17%	11%	61%	7%
Vibration	3%	0%	58%	9%
Dust and dirt	17%	8%	52%	9%
Smoke and Fumes	16%	2%	47%	14%

Q5a. When you are indoors at home does noise from road traffic ever......?

Q5b. Is this often or occasionally?
(Q5a and Q5b asked of all respondents bothered very much, quite a lot or not very much by noise at Q3, percentages given are of all respondents)

	Q5a		Q5b	
	Yes	No	Often	Occasionally
Interfere with conversation	17%	55%	5%	12%
Make it difficult to hear the TV or radio	18%	54%	8%	10%
Stop you opening windows	46%	26%	23%	23%
Stop you getting to sleep	22%	48%	9%	13%
Wake you up	35%	37%	16%	17%

Q6a. When you are indoors at home do you ever hear noise from.......?

Q6b. How much are you bothered by noise from.......when you are indoors at home? (Q6a and Q6b asked of all respondents bothered very much, quite a lot or not very much by noise at Q3, percentages given are of all respondents)

	Q6a		Q6b			
	Yes (hears)	No (does not hear)	Very much	Quite a lot	Not very much	Not at all
Vehicles changing gear	31%	40%	4%	8%	18%	1%
Vehicles accelerating	41%	30%	10%	16%	14%	1%
Squeal of brakes and tyres	51%	20%	8%	24%	17%	2%
Vehicle bodywork rattling	52%	19%	14%	22%	15%	1%
Police, fire and ambulance sirens	55%	16%	2%	5%	25%	22%
Any other traffic noises which disturb you	9%	61%	4%	4%	1%	0%

Q7a. On Mondays to Fridays, when you are indoors at home, how much are you bothered by noise from road traffic during the ....?
(Asked of all respondents bothered very much, quite a lot or not very much by noise at Q3, percentages given are of all respondents)

	Very much	Quite a lot	Not very much	Not at all	Not at home at that time
Evening (6pm - 11pm)	10%	16%	30%	12%	1%
Night (11pm - 6am)	0%	14%	36%	17%	2%
Early morning (6am - 9am)	28%	24%	12%	5%	0%
Daytime (9am - 6pm)	8%	15%	29%	12%	5%

Q7b On Mondays to Fridays, which types of vehicle cause the noise which bothers you during the.......?
(Asked of all respondents bothered very much or quite a lot at Q7a, percentages given are of all respondents)

	Cars	Motorcycles	Lorries	Buses
Evening (6pm - 11pm)	19%	3%	16%	1%
Night (11pm - 6am)	12%	1%	11%	0%
Early morning (6am - 9am)	28%	4%	42%	5%
Daytime (9am - 6pm)	13%	3%	23%	1%

Q7c. At weekends, when you are indoors at home, how much are you bothered by noise from road traffic during the ....?
(Asked of all respondents bothered very much, quite a lot or not very much by noise at Q3, percentages given are of all respondents)

	Very much	Quite a lot	Not very much	Not at all	Not at home at that time
Evening (6pm - 11pm)	3%	12%	37%	16%	1%
Night (11pm - 6am)	0%	10%	35%	22%	1%
Early morning (6am - 9am)	4%	16%	30%	18%	1%
Daytime (9am - 6pm)	4%	19%	33%	12%	1%

Q7d. At weekends, which types of vehicle cause the noise which bothers you during the.......?
(Asked of all respondents bothered very much or quite a lot at Q7c, percentages given are of all respondents)

	Cars	Motorcycles	Lorries	Buses
Evening (6pm -11pm)	18%	5%	2%	1%
Night (11pm - 6am)	12%	2%	2%	0%
Early morning (6am - 9am)	17%	3%	13%	0%
Daytime (9am -6pm)	24%	6%	7%	0%

Q8. When you are indoors at home, does vibration from road traffic cause......?
(Asked of all respondents bothered very much, quite a lot or not very much by vibration at Q3, percentages given are of all respondents)

	Yes	No	Don't know/can't say
Windows or doors to rattle or buzz	48%	18%	1%
Floors to shake or tremble	10%	57%	0%
Ornaments to rattle, buzz or move about	13%	54%	0%
Feelings of vibration in the air	26%	39%	0%

Q9a. Do you ever walk along this road?

Yes 88%
No 11%

Q9b. Overall, how much are you bothered by............ from road traffic when you are walking on the footpath along this road?
(Percentages given are of all respondents who walk (88 respondents))

	Very much	Quite a lot	Not very much	Not at all
Noise	33%	25%	17%	26%
Vibration	20%	28%	24%	28%
Dust and dirt	27%	29%	18%	26%
Smoke and Fumes	31%	35%	16%	19%

Q10. Which types of vehicles cause the ...... which bothers you when you are walking on the footpath along this road?
(Asked of all respondents bothered very much, quite a lot or not very much by noise at Q9b. Percentages given are of all respondents who walk (88 respondents))

	Cars	Motorcycles	Lorries	Buses
Noise	30%	11%	59%	14%
Vibration	9%	1%	58%	7%
Dust and dirt	27%	10%	60%	15%
Smoke and Fumes	35%	9%	64%	23%

Q11 How concerned are you about the effects of dust and dirt or smoke and fumes on you or your family's health?
(Asked of all respondents bothered very much, quite a lot or not very much by dust, dirt, smoke or fumes at Q9b. Percentages given are of all respondents who walk (88 respondents))

Very concerned 40%
Quite concerned 26%
A little concerned 18%
Not at all concerned 14%

Q12a. How concerned are you about danger from lorries when walking along the footpath?
(Percentages given are of all respondents who walk (88 respondents))

Very concerned 60%
Quite concerned 15%
A little concerned 16%
Not at all concerned 9%

Q12b. How concerned are you about danger from lorries when crossing the road?
(Percentages given are of all respondents who walk (88 respondents))

Very concerned 47%
Quite concerned 26%
A little concerned 14%
Not at all concerned 13%

Q12c. How concerned are you about danger from traffic in general when walking along the footpath?
(Percentages given are of all respondents who walk (88 respondents))

Very concerned 52%
Quite concerned 23%
A little concerned 14%
Not at all concerned 11%

Q12d. How concerned are you about danger from traffic in general when crossing the road?
(Percentages given are of all respondents who walk (88 respondents))

Very concerned 50%
Quite concerned 27%
A little concerned 11%
Not at all concerned 12%

Q13a. Now I'd like to ask you about the traffic calming scheme planned for this area. Have you heard about the scheme?

Yes	92%
No	8%

Q13b. How did you hear about the traffic calming scheme?

From friends or relatives	14%
Visit from council	5%
Leaflets about the scheme	70%
Articles in local paper	12%
Announcements in local paper	7%
Public meetings	30%
Local radio	2%

Q14a. Do you think it is necessary to control the <u>speed</u> of lorries on this road?

Yes	86%
No	11%
Don't know	2%

Q14b. Do you think it is necessary to control the <u>number</u> of lorries on this road?

Yes	88%
No	6%
Don't know	5%

Q14c. Do you think it is necessary to control the <u>speed</u> of traffic in general on this road?

Yes	95%
No	3%
Don't know	0%

Q14d. Do you think it is necessary to control the <u>amount</u> of traffic in general on this road?

Yes	95%
No	1%
Don't know	3%

Q15a. Do you think the following ways of controlling the <u>speed</u> of traffic are a good idea for this road?

	Yes	**No**
Speed limits	75%	25%
Better signing of speed limits	65%	35%
20 mph zones	69%	30%
Speed cameras	86%	11%
Mini-roundabouts	33%	64%
Road narrowing	39%	60%
Speed humps	61%	36%
Speed cushions	65%	32%

Q15b. Do you think the following ways of controlling the <u>amount</u> of traffic are a good idea for this road?

	Yes	**No**
Speed limits	71%	26%
20 mph zones	63%	32%
Speed cameras	82%	14%
Road narrowing	40%	55%
Weight restrictions	81%	15%
Speed humps	58%	38%
Speed cushions	61%	35%

Q16. What sort of people do you think will benefit from a traffic calming scheme in this area?

People who live round here	57%
Children	46%
Old people	26%
Disabled people	1%
Drivers	4%
Pedestrians	18%
Cyclists	8%
Everyone	33%
No-one	4%

Q17. What do you think will be the main advantages of a traffic calming scheme in this area?

Fewer lorries	36%
Less traffic in general	51%
Less noise	10%
Less dirt	8%
Slows down the lorries	21%
Slows down the traffic in general	46%
Fewer accidents	5%
Safer for children	16%
Safer in general	20%
Easier to cross road	3%
Makes the area look better	0%
Nothing	3%

Q18. Do you think a traffic calming scheme in this area is a good idea?

Yes	80%
No	14%
Don't know/not sure	6%

Q19. Overall, how would you rate this area for road safety?

Nought means 'very good' and 6 means 'very bad'.

0	1	2	3	4	5	6	Mean
0%	2%	4%	11%	20%	30%	28%	4.7

Q20. Is this house fitted with double or secondary glazing in the windows facing the road?

Yes, all	62%
Yes, some	12%
No	26%
Don't know	0%

Q21. May we come and talk to you again after the traffic calming scheme has been installed?

Yes	86%
No	13%

CLASSIFICATION

Length of time living at address	6 month but less than 1yr	2%
	1 yr but under 2 yrs	2%
	2 yrs but under 5 yrs	12%
	5 yrs but under 10 yrs	10%
	10 yrs but under 15 yrs	18%
	15 yrs but under 20 yrs	11%
	20 yrs or more	41%
AGE	18-29	2%
	30-44	19%
	45-59	31%
	60 and over	48%
SEX	Male	45%
	Female	55%
WORKING STATUS	Employed full time (30hrs+)	20%
	Employed part time (8-29hrs)	17%
	Self employed	5%
	Unemployed	2%
	Housewife	15%
	Retired	40%
CHILDREN IN HOUSEHOLD	Any under 5	6%
	Any 5-10	9%
	Any 11-16	13%
	No children	80%

D2. AFTER SURVEY RESULTS (Sample size = 99)

Q1. First, how do you usually travel now when you ....?

	Walk	Cycle	Drive	Car passenger	Bus	Other	Varies	N/A
Go to the shops	16%	5%	41%	11%	2%	0%	22%	0%
Go to work	4%	3%	27%	4%	0%	0%	3%	58%
Accompany children to school	3%	0%	8%	0%	0%	0%	0%	88%
Go to visit friends	10%	2%	52%	9%	2%	0%	22%	0%

Q2. How much are you bothered now by..........?

	Very Much	Quite a lot	Not very much	Not at all
Speeding vehicles	39%	33%	24%	3%
The amount of traffic	45%	41%	10%	3%
Danger or difficulty crossing the road	37%	34%	24%	4%
Danger to children	42%	38%	14%	5%
Traffic congestion	34%	38%	21%	5%
Lorries	37%	26%	31%	5%
Parking problems	19%	20%	27%	31%
Rat-running	47%	34%	8%	10%
Poor driving standards/behaviour	26%	29%	30%	14%

Q3a. Overall, how much are you bothered now by........... from road traffic when you are indoors at home?

	Very much	Quite a lot	Not very much	Not at all
Noise	23%	19%	19%	38%
Vibration	14%	23%	20%	42%
Dust and dirt	9%	22%	21%	46%
Smoke and Fumes	12%	22%	22%	43%

Q3b. Which types of vehicles cause the ...... which bothers you when you are indoors at home? (Asked of all respondents bothered very much, quite a lot or not very much at Q3a. Percentages given are of all respondents)

	Cars	Motorcycles	Lorries	Buses
Noise	16%	13%	54%	5%
Vibration	5%	3%	51%	3%
Dust and dirt	18%	6%	44%	9%
Smoke and Fumes	25%	9%	48%	9%

Q4a. When you are indoors at home now does noise from road traffic ever......?

Q4b. Is this often or occasionally?
(Q4a and Q4b asked of all respondents bothered very much, quite a lot or not very much by noise at Q3a. Percentages given are of all respondents)

	Q4a		Q4b	
	Yes	No	Often	Occasionally
Interfere with conversation	18%	46%	11%	7%
Make it difficult to hear the TV or radio	18%	46%	4%	14%
Stop you opening windows	47%	17%	31%	16%
Stop you getting to sleep	21%	42%	10%	11%
Wake you up	37%	26%	24%	12%

Q5a. When you are indoors at home now do you ever hear noise from.......?

Q5b. How much are you bothered now by noise from.......when you are indoors at home? (Q5a and Q5b asked of all respondents bothered very much, quite a lot or not very much by noise at Q3a. Percentages given are of all respondents)

	Q5a		Q5b			
	Yes (hears)	No (does not hear)	Very much	Quite a lot	Not very much	Not at all
Vehicles changing gear	27%	36%	3%	10%	13%	1%
Vehicles accelerating	40%	24%	9%	19%	9%	3%
Squeal of brakes and tyres	43%	21%	7%	17%	17%	2%
Vehicle bodywork rattling	49%	15%	13%	23%	11%	2%
Police, fire and ambulance sirens	44%	19%	2%	0%	14%	28%
Any other traffic noises which disturb you	9%	53%	6%	2%	0%	1%

Q6a. On Mondays to Fridays, when you are indoors at home now, how much are you bothered by noise from road traffic during the ....?
(Asked of all respondents bothered very much, quite a lot or not very much by noise at Q3a. Percentages given are of all respondents)

	Very much	Quite a lot	Not very much	Not at all	Not at home at that time
Evening (6pm - 11pm)	10%	21%	28%	1%	1%
Night (11pm - 6am)	2%	10%	36%	13%	0%
Early morning (6am - 9am)	27%	18%	14%	2%	0%
Daytime (9am - 6pm)	6%	21%	26%	4%	4%

Q6b On Mondays to Fridays, which types of vehicle cause the noise which bothers you during the.......?
(Asked of all respondents bothered very much or quite a lot a Q6a. Percentages given are of all respondents)

	Cars	Motorcycles	Lorries	Buses
Evening (6pm - 11pm)	25%	4%	20%	1%
Night (11pm - 6am)	13%	2%	11%	0%
Early morning (6am - 9am)	26%	7%	37%	4%
Daytime (9am - 6pm)	22%	4%	27%	2%

Q6c. At weekends, when you are indoors at home now, how much are you bothered by noise from road traffic during the ....?
(Asked of all respondents bothered very much, quite a lot or not very much by noise at Q3a. Percentages given are of all respondents)

	Very much	Quite a lot	Not very much	Not at all	Not at home at that time
Evening (6pm - 11pm)	8%	12%	30%	11%	1%
Night (11pm - 6am)	4%	10%	33%	13%	1%
Early morning (6am - 9am)	8%	13%	32%	17%	1%
Daytime (9am - 6pm)	2%	18%	29%	9%	2%

Q6d. At weekends, which types of vehicle cause the noise which bothers you during the.......?

	Cars	Motorcycles	Lorries	Buses
Evening (6pm - 11pm)	25%	4%	4%	1%
Night (11pm - 6am)	18%	3%	2%	0%
Early morning (6am - 9am)	23%	2%	7%	0%
Daytime (9am - 6pm)	28%	5%	8%	0%

Q7a. Thinking back to the time before the traffic calming was introduced, how did you feel about the level of traffic noise you heard when indoors at home then?

Q7b. And since the calming scheme was introduced, overall, how do you feel about the level of traffic noise you hear when indoors at home?

(Nought means 'definitely satisfactory', and 6 means 'definitely unsatisfactory').

Q. No	0	1	2	3	4	5	6	Mean	Number of respondents giving rating
7a	5%	13%	6%	23%	20%	11%	22%	3.6	97
7b	5%	14%	6%	19%	16%	11%	29%	3.7	98

Q7c. Do you think the traffic calming scheme has affected the level of noise you hear when indoors at home?

Yes	42%
No	55%
Don't know	2%

Q7d. As a result of the traffic calming scheme, would you say the traffic is......?
(Asked of all respondents saying yes at Q7d. Percentages are of all respondents)

A lot noisier	19%
A little noisier	11%
A little quieter	10%
A lot quieter	2%

Q8. When you are indoors at home now, does vibration from road traffic cause......?
(Asked of all respondents bothered very much, quite a lot or not very much by vibration at Q3a. Percentages given are of all respondents)

	Yes	No	Don't know/can't say
Windows or doors to rattle or buzz	32%	21%	4%
Floors to shake or tremble	9%	45%	3%
Ornaments to rattle, buzz or move about	13%	47%	3%
Feelings of vibration in the air	21%	31%	5%

Q9a. Do you ever walk along this road now?

Yes	86%
No	13%

Q9b. Overall, how much are you bothered now by........... from road traffic when you are walking on the footpath along this road?
(Percentages given are of all respondents who walk (86 respondents))

	Very much	Quite a lot	Not very much	Not at all
Noise	21%	35%	28%	16%
Vibration	14%	30%	30%	26%
Dust and dirt	21%	41%	19%	20%
Smoke and Fumes	27%	65%	17%	17%

Q9c. Which types of vehicles cause the ...... which bothers you when you are walking on the footpath along this road?
(Asked of all respondents bothered very much, quite a lot or not very much by noise at Q9b. Percentages given are of all respondents who walk (86 respondents))

	Cars	Motorcycles	Lorries	Buses
Noise	47%	16%	65%	9%
Vibration	28%	1%	53%	3%
Dust and dirt	50%	12%	63%	7%
Smoke and Fumes	50%	6%	66%	10%

Q10a. Do you think the traffic calming scheme has affected the level of noise you hear when walking along the footpath?
(Percentages given are of all respondents who walk (86 respondents))

Yes	42%
No	50%
Don't know	8%

Q10b. As a result of the traffic calming scheme, would you say the traffic is......?
(Asked of all saying yes at Q10a. Percentages given are of all respondents who walk (86 respondents))

A lot noisier	18%
A little noisier	10%
A little quieter	12%
A lot quieter	2%

Q11. How concerned are you now about the effects of dust and dirt or smoke and fumes on you or your family's health?
(Asked of all respondents bothered very much. quite a lot or not very much by dust, dirt, smoke or fumes at Q9b. Percentages given are of all respondents who walk (86 respondents))

Very concerned	28%
Quite concerned	30%
A little concerned	29%
Not at all concerned	10%

Q12a. How concerned are you now about danger from lorries when walking along the footpath?
(Percentages given are of all respondents who walk (86 respondents))

Very concerned	26%
Quite concerned	27%
A little concerned	36%
Not at all concerned	10%

Q12b. How concerned are you now about danger from lorries when crossing the road?
(Percentages given are of all respondents who walk (86 respondents))

Very concerned	28%
Quite concerned	24%
A little concerned	35%
Not at all concerned	12%

Q12c. How concerned are you now about danger from traffic in general when walking along the footpath?
(Percentages given are of all respondents who walk (86 respondents))

Very concerned	35%
Quite concerned	27%
A little concerned	29%
Not at all concerned	8%

Q12d. How concerned are you now about danger from traffic in general when crossing the road?
(Percentages given are of all respondents who walk (86 respondents))

Very concerned	36%
Quite concerned	22%
A little concerned	33%
Not at all concerned	8%

Q13. Overall, how satisfactory are the changes that have been made?
Nought means 'definitely satisfactory' and 6 means 'definitely unsatisfactory'.

0	1	2	3	4	5	6	Mean
3%	2%	5%	21%	21%	15%	31%	4.3

Q14. What sort of people do you think will have benefited from the traffic calming scheme?

People who live round here	9%
Children	25%
Old people	10%
Disabled people	0%
Drivers	0%
Pedestrians	1%
Cyclists	3%
Everyone	5%
No-one	58%

Q15. What do you think are the main advantages of the traffic calming scheme?

Fewer lorries	3%
Less traffic in general	3%
Less noise	1%
Less dirt	0%
Slows down the lorries	4%
Slows down the traffic in general	28%
Fewer accidents	0%
Safer for children	5%
Safer in general	6%
Easier to cross road	3%
Makes the area look better	0%
Nothing	52%

Q16a. How useful do you consider each of the changes that have been made in the village?

Q16b Are there any disadvantages or problems with the ....?

	Q16a				Q16b	
	Very useful	Fairly useful	Of little use	Don't know/no opinion	Yes	No
1. Speed cushions	4%	18%	76%	1%	74%	16%
2. Road humps outside the school	65%	28%	6%	0%	19%	66%
3. Road narrowing with cushions in Longwater Lane	33%	39%	24%	3%	38%	48%
4. Other road narrowings	25%	44%	24%	6%	30%	51%
5. Mini-roundabout near post office	41%	33%	24%	1%	35%	52%
6. 30mph reminder sign in Longwater Lane	44%	21%	31%	3%	34%	49%
7. 20 mph zone signs	29%	24%	38%	6%	40%	36%

Q16c What in particular is the disadvantage or problem with.............?

1. Speed Cushions	
Too small, narrow/ traffic doesn't have to slow/ vehicles straddle them/ lorries go straight over/ Should go right across the road/ only very small cars slowed down	59%
Cause problems for cyclists	5%
Can't see them/ poorly visible/ can't see them at night	5%
Not high enough/severe enough	5%
People drive dangerously to avoid them	4%
Problems if two vehicles want to pass/ restrict flow of traffic	3%
Cause noise	2%
Cause vibration/empty lorries rattle	2%

2. Road humps outside school	
Can't see it/ poorly visible/ needs signing/ needs painting	7%
Jolts you/ too severe/ too high	5%
Noise	2%
Should have 10-15mph speed limit	1%
Takes too long to get through	1%

3. Road narrowing with cushions in Longwater Lane	
People don't give way/cars struggle with each other/race to get through/causes aggressive driving	15%
Traffic piles up/causes congestion	10%
No signing/nothing to say who has priority	7%
Grass untidy, needs cutting	2%
Hard to see at night	2%
People ignore the signs	1%

4. Other road narrowings	
Causes aggressive driving/ people don't give way	14%
Not clear who has priority	11%
Restricts traffic/ causes queues/ congestion	5%
Creates blind spot with parked cars	3%
Hard to see at night	3%
Dangerous for cyclists	2%
Cars stopping causes noise/vibration	2%

5. Mini-roundabout near post office	
Can't turn round/ difficult to turn/ too tight	12%
People don't treat it like a roundabout/people ignore it/no use/go straight over it	7%
In wrong place/ causes parking problems for shop and post office	5%
People confused over priority/ don't know how to approach it	3%
Too congested	1%

6. 30mph sign in Longwater Lane	
Not effective/ people don't take any notice	10%
Doesn't work/ never switched on	7%
Needs a camera	4%
Doesn't come on soon enough -not until 38-40mph	4%
People accelerate after it	4%
Need more of these in village	4%
People/young people speed up to activate the sign	3%

7. 20mph zone signs	
People don't take any notice	30%
Not very visible/not large enough	8%
Need to be more of them	3%
Not enough warning	1%
Not sure if they are legal	1%

Q17. Overall, how would you rate this area now for road safety? Nought means 'very good' and 6 means 'very bad'.

0	1	2	3	4	5	6	Mean
1%	3%	5%	34%	21%	12%	22%	4.0

Q18a. What do you think of the look of the scheme?

Very attractive	4%
Fairly attractive	34%
No opinion either way	21%
Fairly unattractive	28%
Very unattractive	11%
Don't know	1%

Q18b. Which features do you find unattractive? Why do you find them unattractive?

Too many signs generally/looks muddled, bitty, untidy, hazardous, unsightly	13%
Chicanes are full of weeds/should be maintained/better tarmacked	6%
Humps unattractive, ugly (in listed village)	4%
Cushions would look better if they went right across the road	3%
Road narrowings look urban	1%
Colour and design wrong	1%
Need to plant trees outside the Post Office	1%

Q19. Is this house fitted with double or secondary glazing in the windows facing the roac

	Yes, all	61%
	Yes, some	13%
	No	24%
	Don't know	4%

CLASSIFICATION

Length of time living at address	6 months but less than 1yr	4%
	1 yr but under 2 yrs	3%
	2 yrs but under 5 yrs	10%
	5 yrs but under 10 yrs	9%
	10 yrs but under 15 yrs	23%
	15 yrs but under 20 yrs	11%
	20 yrs or more	41%
AGE	18-29	3%
	30-44	20%
	45-59	30%
	60 and over	49%
SEX	Male	42%
	Female	59%
WORKING STATUS	Employed full time (30hrs+)	17%
	Employed part time (8-29hrs)	19%
	Self employed	6%
	Unemployed	3%
	Housewife	18%
	Retired	37%
CHILDREN IN HOUSEHOLD	Any under 5	7%
	Any 5-10	10%
	Any 11-16	13%
	No children	79%

Abstract

TRL has assessed the effectiveness of traffic calming measures in reducing the speed of traffic passing through villages on busy main roads where there is a significant proportion of heavy goods vehicles (HGVs). Changes to legislation and special authorisation procedures now enable local authorities to install a wide range of measures in these situations. This report concerns a scheme at Costessey, near Norwich, which was one of nine sites chosen for study.

Costessey is situated on busy minor roads carrying traffic commuting between parallel radial routes to Norwich, as well as considerable HGV traffic travelling to and from local gravel workings. The speed limit in the village core was reduced from 30mph to 20mph and speed cushions and single-lane working carriageway narrowings were installed. Elsewhere a mini-roundabout and a vehicle-actuated fibre-optic 30mph reminder sign were introduced.

Before and After measurements of vehicle speeds, flows and traffic noise were carried out, together with a public opinion survey of residents. The scheme yielded good speed reductions, with steady speeds maintained between measures. However, some reservations about the scheme were expressed by residents.

Related publications

TRL312 *Traffic calming – speed cushion schemes* by R E Layfield and D I Parry. 1998 (price £30, code H)

TRL307 *Traffic calming and vehicle emissions: a literature review* by P G Boulter and D C Webster. 1997 (price £30, code H)

TRL238 *Traffic calming on major roads: the A47 trunk road at Thorney, Cambridgeshire* by A H Wheeler, P G Abbott, N S Godfrey, S M Phillips and R Stait. 1997 (price £40, code L)

TRL235 *Traffic calming: vehicle generated ground-borne vibrations alongside speed control cushions and road humps* by G R Watts, G J Harris and R E Layfield. 1997 (price £30, code H)

TRL212 *Traffic calming on major roads: the A49 trunk road at Craven Arms, Shropshire* by A H Wheeler, P G Abbott, N S Godfrey, D J Lawrence and S M Phillips. 1996 (price £40, code L)

TRL202 *Trials of rural road safety engineering measures* by J Barker. 1997 (price £30, code H)

TRL180 *Traffic calming: vehicle noise emissions alongside speed control cushions and road humps* by P G Abbott, J Tyler and R E Layfield (price £30, code H)

TRL174 *The environmental assessment of traffic management schemes: a literature review* by P G Abbott, S Hartley, A J Hickman, R E Layfield, I S McCrae, P M Nelson, S M Phillips and J L Wilson. 1995 (price £40, code L)

PR103 *Vehicle and traffic noise surveys alongside speed control cushions in York* by P G Abbott, S M Phillips and R E Layfield. 1995 (price £20, code E)

PR85 *Speed reduction in 24 villages: details from the VISP study* by A H Wheeler, M Taylor and J Barker. 1995 (price £40, code L)

PR85 Annexe *Speed reduction in 24 villages: colour photographs from the VISP study* by A H Wheeler, M Taylor and J Barker. 1995 (price £23, code F)

PR35 *The effectiveness of village 'gateways' in Devon and Gloucestershire* by A H Wheeler, M Taylor and A Payne. 1993 (price £23, code F)

LR652 *Rolling noise and vehicle noise* by D G Harland. 1974 (price £10, code AA)

LR896 *Road surfaces and traffic noise* by R E Franklin, D G Harland and P M Nelson. 1979 (price £10, code AA)

CT1.2 Traffic calming update (1994-1997). *Current Topics in Transport: abstracts selected from TRL Library's database*. (price £15)

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