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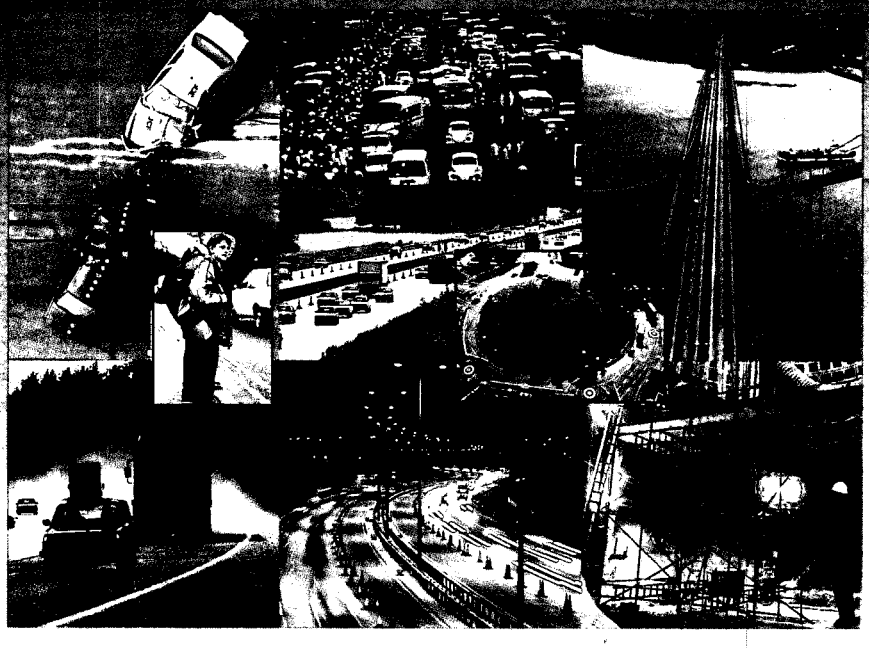

# Traffic calming
# - four schemes on distributor roads

by David C Webster

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THE DEPARTMENT
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TRL Report 182

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**TRL REPORT 182**

# TRAFFIC CALMING - FOUR SCHEMES ON DISTRIBUTOR ROADS

**by David C Webster**

**Prepared for:** **Project Record:** **UG16 Traffic Calming: Distributor Roads**
**Customer:** **DITM Division, DOT** **(Mr E H E Wyatt)**



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1995

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# CONTENTS

# EXECUTIVE SUMMARY


Traffic calming can be applied to many different situations, but historically the majority of schemes have been on residential roads. These roads usually have relatively low flows which are typically only a few thousand vehicles/ day, however many local highway authorities wish to implement local area-wide safety schemes involving urban distributor roads carrying higher traffic flows. In area-wide safety schemes, traffic tends to be diverted from the residential areas onto the distributor roads which may be operating at, or near capacity and have higher accident rates. Traffic calming measures on urban distributor roads are often required to improve safety and enhance the environment whilst preserving the road capacity.

The aim of this study has been to provide information so that Driver Information and Traffic Management Division (DITM), DOT can provide advice on suitable traffic calming measures for urban distributor roads. This report describes studies of traffic calming measures on distributor roads at four sites:- Wych Hill Lane in Woking; Mayfield Road, Farnborough; Dedworth Road, Windsor and four roads in North Watford. All of the roads had two-way flows of approximately 8,000 to 12,000 vehicles/day after traffic calming.

All of the four schemes studied had flat-top humps as the main speed reducing measure which were designed to slow cars and to reduce problems of discomfort and delay for bus passengers and the emergency services. The humps were 75 mm high with on/off ramp gradients of 1:15 at two sites, 75 mm high with 1:10 or 1:13 on/off ramps at one site and 100 mm high with 1:15 on/off ramps at the other site. The plateaux lengths varied from 3 metres for humps between junctions to 22 metres for humps at junctions.

A variety of additional measures were used at the sites which included; new roundabouts, kerb alignments, pedestrian islands, new road markings, humped zebra crossings and chicanes.

The results from this study show that the 85th percentile speeds on the four distributor roads were reduced by about 11 mph to levels below or near the 30 mph speed limits and indicate that 75 mm high flat-top humps with 1:10 to 1:15 ramp gradients can be used as the main speed reducing measure on urban local distributor roads and town centres carrying flows of 8,000 to 17,000 vehicles per day before calming. There is likely to be some transfer of traffic onto alternative routes because the flows were reduced by between 13% and 65% on the four distributor roads in this study. Injury accidents were reduced by 32% but the result was not statistically significant due to the small number of accidents.

The reactions to the schemes indicate that they are generally working well and causing few problems.


CR107/95/12

**Flat-top humps and pedestrian refuges forming part of a distributor road traffic calming scheme at Dedworth Road in Windsor**

# TRAFFIC CALMING - FOUR SCHEMES ON DISTRIBUTOR ROADS


## ABSTRACT

In the past the majority of traffic calming schemes have been on residential roads. Traffic calming measures used on distributor roads need to take account of the higher flows, the higher speeds, the higher accident rates and the need to maintain capacity. TRL is assessing the effectiveness of traffic calming measures on urban distributor roads so that Driver Information and Traffic Management Division (DITM), DOT can provide advice on suitable traffic calming measures for these roads. This report describes a study of traffic calming measures at 4 sites on (1) Wych Hill Lane, Woking with a two-way flow of 12,000 vehicles per day (2) Mayfield Road, Farnborough (8,000 vehicles/day), (3) Dedworth Road area, Windsor (11,500 vehicles/day) and (4) North Watford area (8,000 vehicles/day). The study showed that traffic calming measures including flat-topped road humps can be used on distributor roads to reduce speeds while generally satisfying bus operators, emergency services and the residents of the roads; overall the 85th percentile speeds between the humps were reduced by 11 mph from 38 to 27 mph and mean speeds by 10 mph from 34 to 24 mph respectively.


## 1. INTRODUCTION

Traffic calming aims to create safer roads and better environmental conditions by using engineering and environmental measures to improve driver behaviour and awareness, to reduce speed and anxiety, and to enhance the environment. Many different types of traffic calming techniques have been used and it has been shown that vertical deflection devices, such as road humps and speed cushions, are the most effective at reducing speeds and can provide a substantial reduction in accidents (Webster, 1993).

Traffic calming can be applied to many different situations although the majority of schemes have been on residential roads (County Surveyors Society, 1994). These roads usually have relatively low flows which are typically only a few thousand vehicles/day. However, many local highway authorities wish to implement local area-wide safety schemes involving urban distributor roads. In area-wide safety schemes, traffic tends to be diverted from the residential areas onto the distributor roads which may be operating near capacity and have higher accident rates. Traffic calming measures on urban distributor roads are often required to improve safety and enhance the environment whilst preserving the road capacity.

Urban distributor roads carry more traffic than residential roads and often include scheduled bus services, in addition to being important fire and ambulance service emergency routes. Speeds on distributor roads are likely to be higher than residential roads and whist the aim of the traffic calming measures will be to reduce speeds, the target speed 85th percentile speed is likely to be around 30 mph rather than 20 mph, which is often the aim in residential areas. The traffic calming measures used on distributor roads need to reflect these additional constraints.

Because of passenger discomfort, some local authorities are seeking ways of calming traffic without the use of road humps or other vertical deflections. Several authorities do not use vertical deflections on main, or distributor, roads or major access roads used by bus services, except as a last resort. In some areas traffic calming road hierarchy has been developed in conjunction with the bus operators and emergency services. Maps are produced which show those roads which will not have any form of traffic calming measures installed and those which, if traffic calmed, will not incorporate vertical deflections (County Surveyor's Society, 1994).

The aim of this study has been to provide information so that Driver Information and Traffic Management Division (DITM), DOT can provide advice on suitable traffic calming measures for urban distributor roads. Few schemes have been implemented, but assessments have been made at four traffic calming schemes using road humps on urban local distributor roads with traffic flows of 8000 to 12000 vehicles per day. This report describes a study of four traffic calming schemes on distributor roads in Wych Hill Lane, Woking; Mayfield Road, Farnborough; Dedworth Road area, Windsor and North Watford.

## 2. DETAILS OF SCHEMES

### 2.1 WYCH HILL LANE, WOKING

Woking has a population of approximately 100,000 people and Wych Hill Lane is located to the south west of the town between the A324 and the A320 main roads (see Fig 1). The railway lines limit the number of routes which can be used to get from west Woking to south Woking and therefore Wych Hill Lane is an ideal route which forms a link between the two areas via Triggs Lane.

Wych Hill Lane is 500 metres long, 6 to 7 metres wide, with an average gradient of 1:20. There is a speed limit of 30 mph

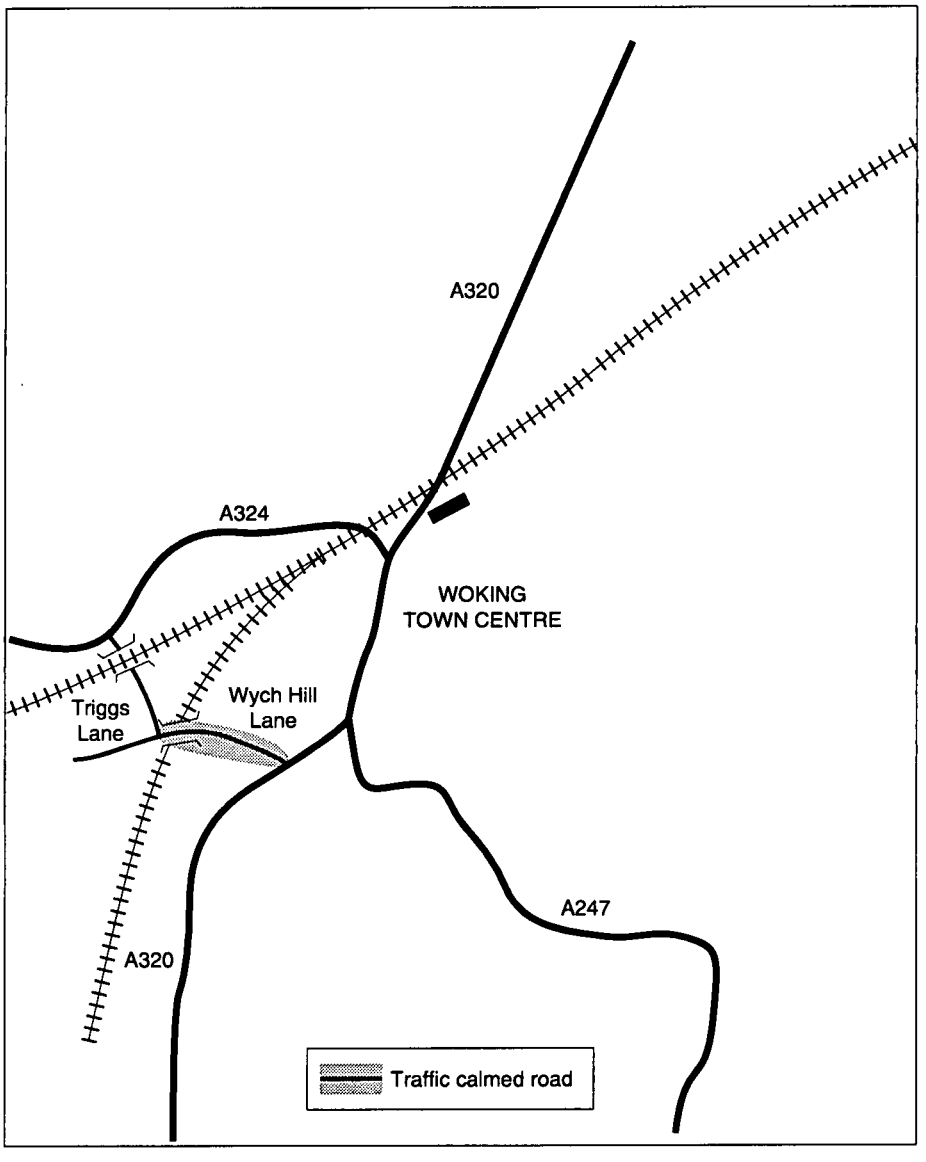


**Fig. 1 Location of Wych Hill Lane, Woking**

along the entire length of the road. There are 5 road junctions which give access to the residential areas. The frontages along the road are residential with ample off-street parking.

Wych Hill Lane is a bus route and it is also an important route for the emergency services.

Originally 75 mm high round-top humps were proposed, but the bus company (which had previously supported round-top humps) persuaded Woking to use flat-top humps which they regarded as more acceptable to their passengers and their buses, based on their experiences at other local schemes. The buses used are predominantly midi-buses but some double-decker buses are also used during the morning and afternoon peaks. Consequently six flat-top asphalt humps were installed at spacings of 65 to 85 metres. All of the humps are 75 mm high with 1:15 on/off ramps and the plateaux lengths vary from 6 to 22 metres with the shorter humps being between junctions and the longer humps being at junctions (see Figs 2a and 2b). There were already roundabouts at each end of Wych Hill Lane (see Figs 2c and 2d). The humps were all installed during May 1993. The redesigned scheme cost £40,000.

Pedestrian refuges were installed, shortly after the scheme had been completed, on York Way on the approach to the junction with Wych Hill Lane (see Fig 2b).

## 2.2 MAYFIELD ROAD, FARNBOROUGH

Mayfield Road is located to the north of Farnborough (See Fig 3) and is a convenient route for getting to and from

CR108/95/10

**Fig. 2a Short flat-top hump between Wych Hill Way and Mount Hermon Road**

CR108/95/8

**Fig. 2b Long flat-top hump at Wych Hill Lane junction with York Way**

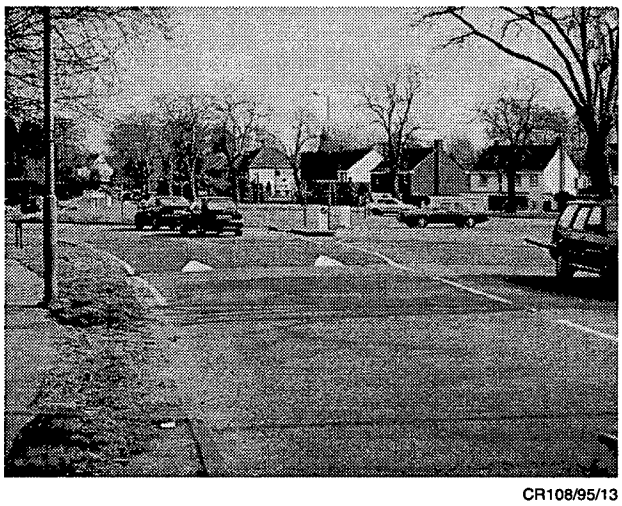

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**Fig. 2c Hump at the approach to Guildford Road roundabout at eastern end of Wych Hill Lane**

CR108/95/3

**Fig. 2d Hump at the approach to Triggs Lane roundabout at western end of Wych Hill Lane**

Junction 4 of the M3 motorway via Prospect Avenue and the A325 Farnborough Road.

Mayfield Road is 1300 yards long and there is a speed limit of 30 mph along the entire length of the road. There are 10 side road junctions with residential access roads (not shown on Fig 3). The frontages along the road include residential dwellings with and without front drives, a shopping precinct and a school. Off-street parking was well catered for at the western end of the road but there was less space available for off-street parking at the eastern end of the road.

Mayfield Road is a bus route and it is also an important route for the three emergency services.

The carriageway width varied between 6 metres and 10 metres and site lines were good for the entire length of the road, which encouraged fast speeds. Excessive speeds were considered by the police and Council to be a major problem along Mayfield Road. The 85th percentile speeds were about 37 mph before the traffic calming measures were installed.

The scheme consists of seventeen flat-top humps, nominally 100 mm high, with 1:15 ramp gradients. The humps are approximately 75 metres apart and have a plateau length of 4.5 metres. They were designed in consultation with the bus company to be sufficient to accommodate the wheel base of the mini and midi-buses which use the road.

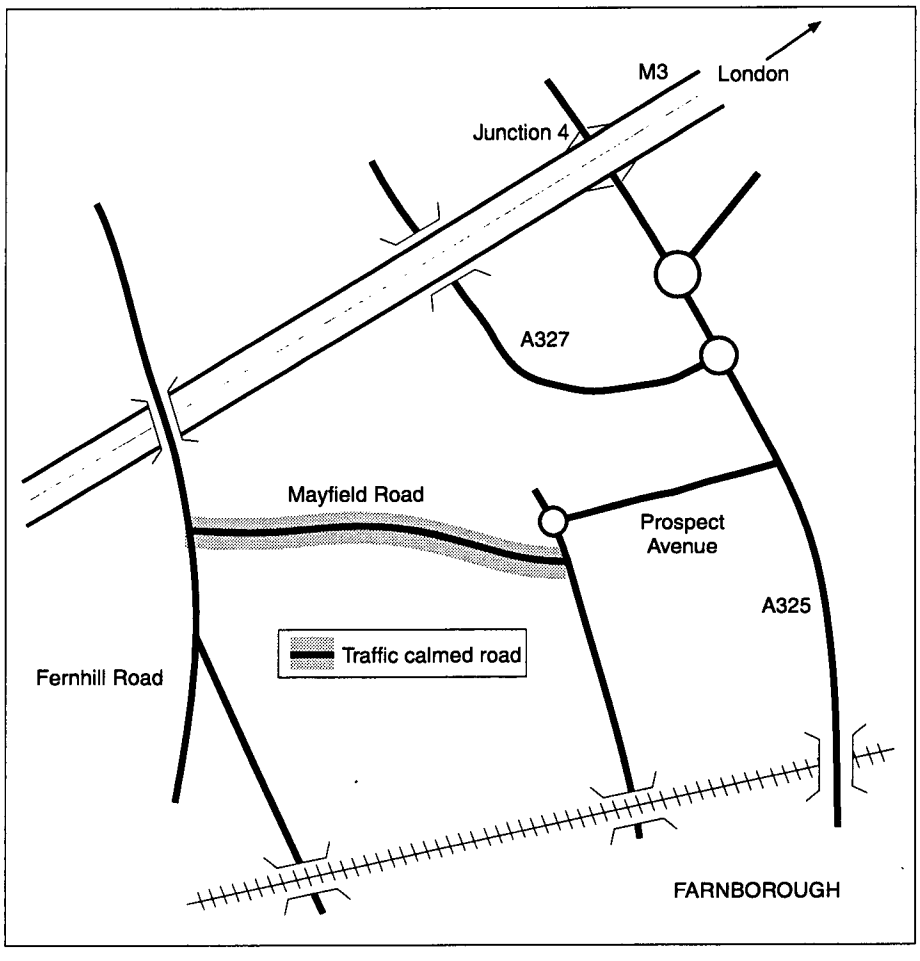


**Fig 3 Location of scheme on Mayfield Road, Farnborough**

The flat-top humps outside Mayfield County Junior School and Totland shopping precinct were combined with a narrowing of the carriageway by 1.5 metres (See Fig 4a).

The parking along the road has been reorganised so that there are more 'official' parking bays along Mayfield Road, but some vehicles are still parked on the footway. Fig 4b shows vehicles parked in one of the new bays (right hand side of photograph) and a vehicle parked on the footway (left hand side of photograph).

At the eastern end of Mayfield Road the first hump has been combined with a central island, to assist pedestrians crossing the road, and 'keep left' bollards to improve the visual presence near the junction (See Fig 4c). At the western end a mini-roundabout was added (See Fig 4d) to assist drivers, particularly at peak times, turning right out of Mayfield Road into Fernhill Road. The work was completed in August 1992.

## 2.3 DEDWORTH ROAD AREA, WINDSOR

The Dedworth Road scheme is situated approximately 2 miles due west of Windsor castle and 2.5 miles south of Junction 6 of the M4 motorway (see Fig 5). It is bounded by the A308 and the River Thames to the north and the A355 to the east. Dedworth Road (B3024) forms the southern boundary with the B3383 to the west as shown in Fig 6.

The Dedworth area, which has a 30 mph speed limit, is mainly residential and it contains a number of cul-de-sacs and minor roads which are not shown in Fig 6. The roads are relatively wide and on-street parking is not a problem. The area is served by bus routes along Dedworth Road and there are also services along Ruddlesway and Smiths Lane.

The Dedworth Road area traffic calming scheme was completed in September 1993 in advance of a supermarket opening in November 1993. The location of the new supermarket and the traffic calmed roads is shown in Fig 6.

A variety of traffic calming measures were used which included new roundabouts, kerb alignments, pedestrian refuge islands, new road markings and road humps. The types of measures installed and general views of the scheme are shown in Fig 7. The scheme was completed in September 1993 but some remedial work was identified which included ensuring that all of the humps were within the correct height tolerances.

**Fig. 4a Flat-top hump outside Mayfield County Junior School looking west along Mayfield Road**

**Fig. 4b Parking along Mayfield Road, 50 metres east of Totland Close looking west**

**Fig. 4c Eastern end of Mayfield Road looking east showing flat-top humps and central island**

**Fig. 4d Western end of Mayfield Road looking west to roundabout with Fernhill Road**

Berkshire County Council had previous experience of using flat-top humps to successfully traffic calm a fairly busy road (1991, Crowthorne High Street, 17,000 vehicles per day before calming). Flat-top humps and mini-roundabouts were used again as the main speed reducing measures on the Dedworth Road. The flat-top humps used on Dedworth Road were similar to those used in Crowthorne High street and were designed to reduce overall traffic speeds without causing too much difficulty for buses and emergency vehicles.

On Dedworth Road, ten 75 mm high flat-top humps were installed; five with 3 metre plateaux & 1:10 gradients and five with 6 metre plateaux & 1:13 gradients. A further two 50 mm high round-top humps, four new roundabouts, pedestrian refuges and road markings were also installed

On Smiths Lane, two 75 mm high flat-top humps with 3 metre plateaux & 1:10 gradients, three 75 mm high and eight 50 mm high round-top humps were installed.

On Gallys Road, four 75 mm high and eleven 50 mm high round-top humps were installed.

On Ruddlesway, three 75 mm high and seven 50 mm high round-top humps were installed.

On Smiths Lane, Gallys Road and Ruddlesway the roads have 75 mm high humps at each end of the road and also at strategic points along the road such as road junctions and schools. The less severe 50 mm high humps were then used to fill in the gaps between the 75 mm high humps.

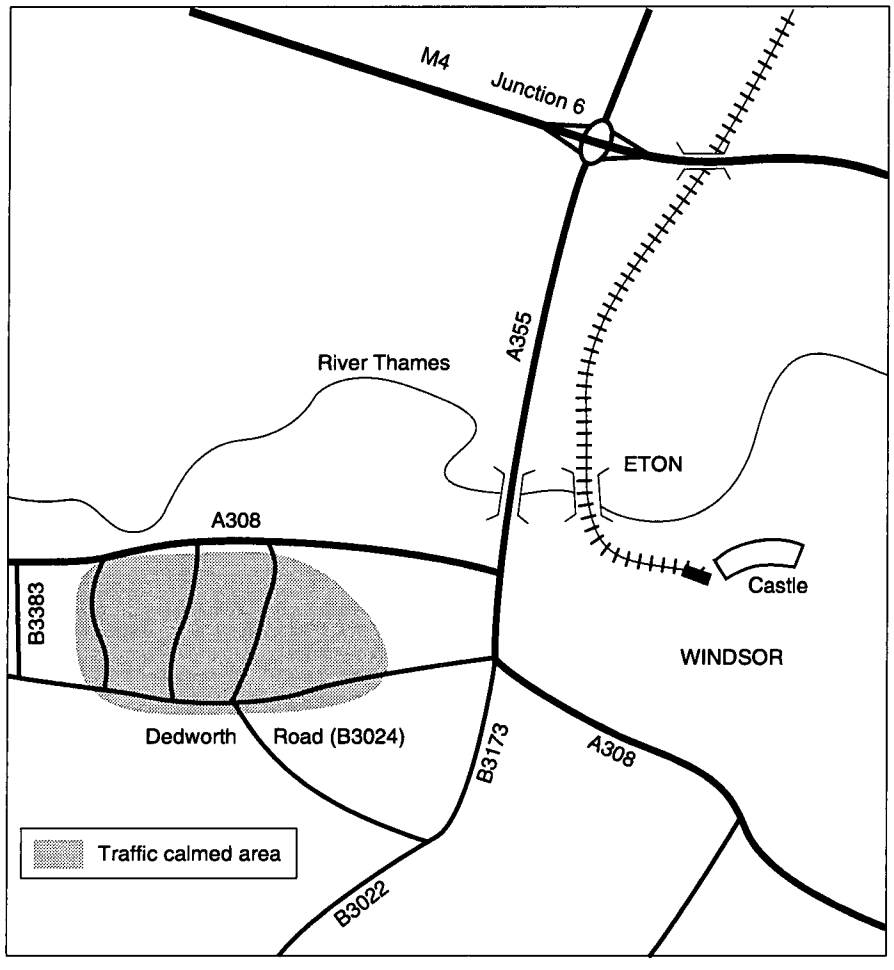


**Fig. 5 Location of Dedworth Road Area, Windsor**

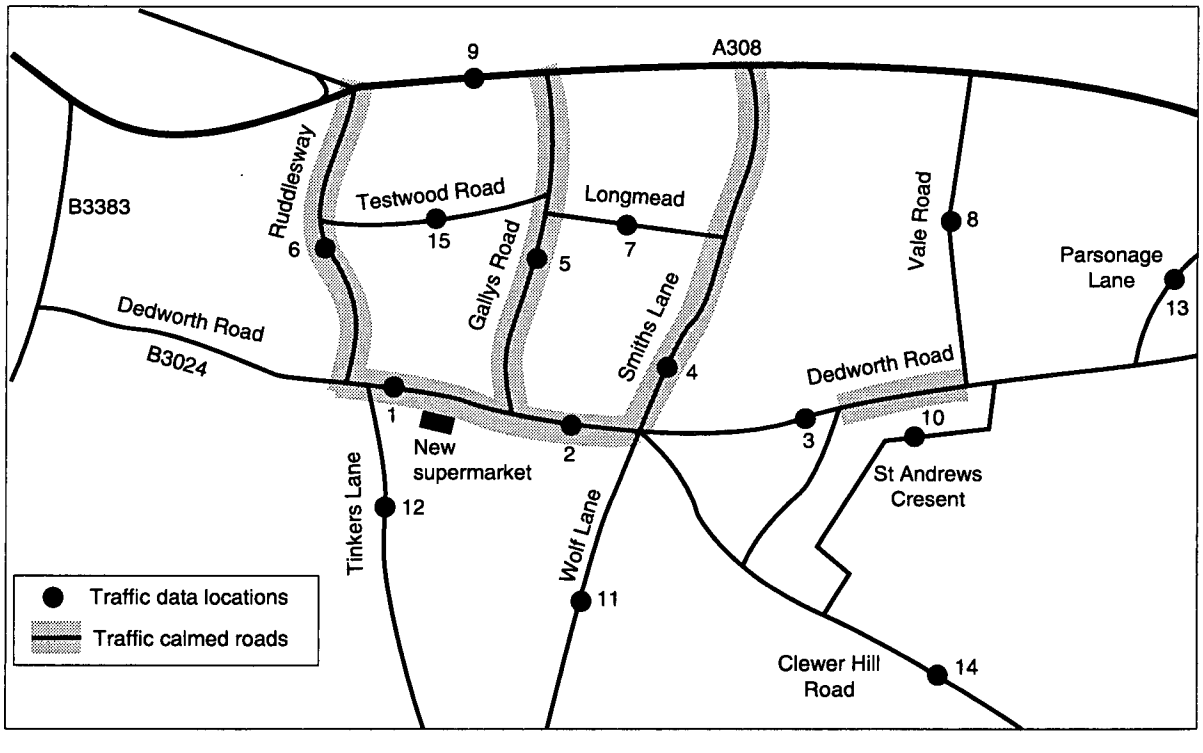


**Fig. 6 Traffic data locations, Dedworth Road Area**

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**Fig. 7a Uncalmed section of Dedworth Road, looking west from location 3**

CR107/95/8

**Fig. 7b Uncalmed section of Dedworth Road, looking east from Smiths Lane roundabout**

CR107/95/12

**Fig. 7c Location no. 1 looking eastbound along Dedworth Road showing an 8.0 metre flat-top table with central island close to the new supermarket**

CR107/95/4

**Fig. 7d Vale Road junction looking westbound along Dedworth Road showing a 4.5 metre flat-top table with central island**

CR107/95/17

**Fig. 7e Round-top humps on Gallys Road looking southbound from location no. 5**

CR107/95/15

**Fig. 7f Round-top humps on Ruddlesway looking southbound from location no. 6**

## 2.4 NORTH WATFORD SCHEMES

The North Watford schemes formed part of the Feet First/ A Step Ahead initiative. This was set up in 1992 by Transport 2000 and Local Authority Associations (Association of County Councils, the Association of District Councils and the Association of Metropolitan Authorities) to promote traffic management schemes that make the environment more friendly to pedestrians.

The opening, on 29th July 1993, of a new link road from Watford Town Centre to Junction 5 on the M1 motorway, provided an opportunity for the Local Highway Authority to reduce rat-running and the volume of heavy goods vehicles on nearby roads. Non-essential traffic here was causing environmental disbenefits for the residents and potential accidents.

The location of the two North Watford schemes is shown in Figs 8 and 9. Scheme 1 is situated to the north, and Scheme 2 to the south of the new M1 link road. Hertfordshire County Council coordinated the installation of the two schemes but the Borough of Watford and Hertsmere Borough Council designed and installed schemes 1 and 2 respectively.

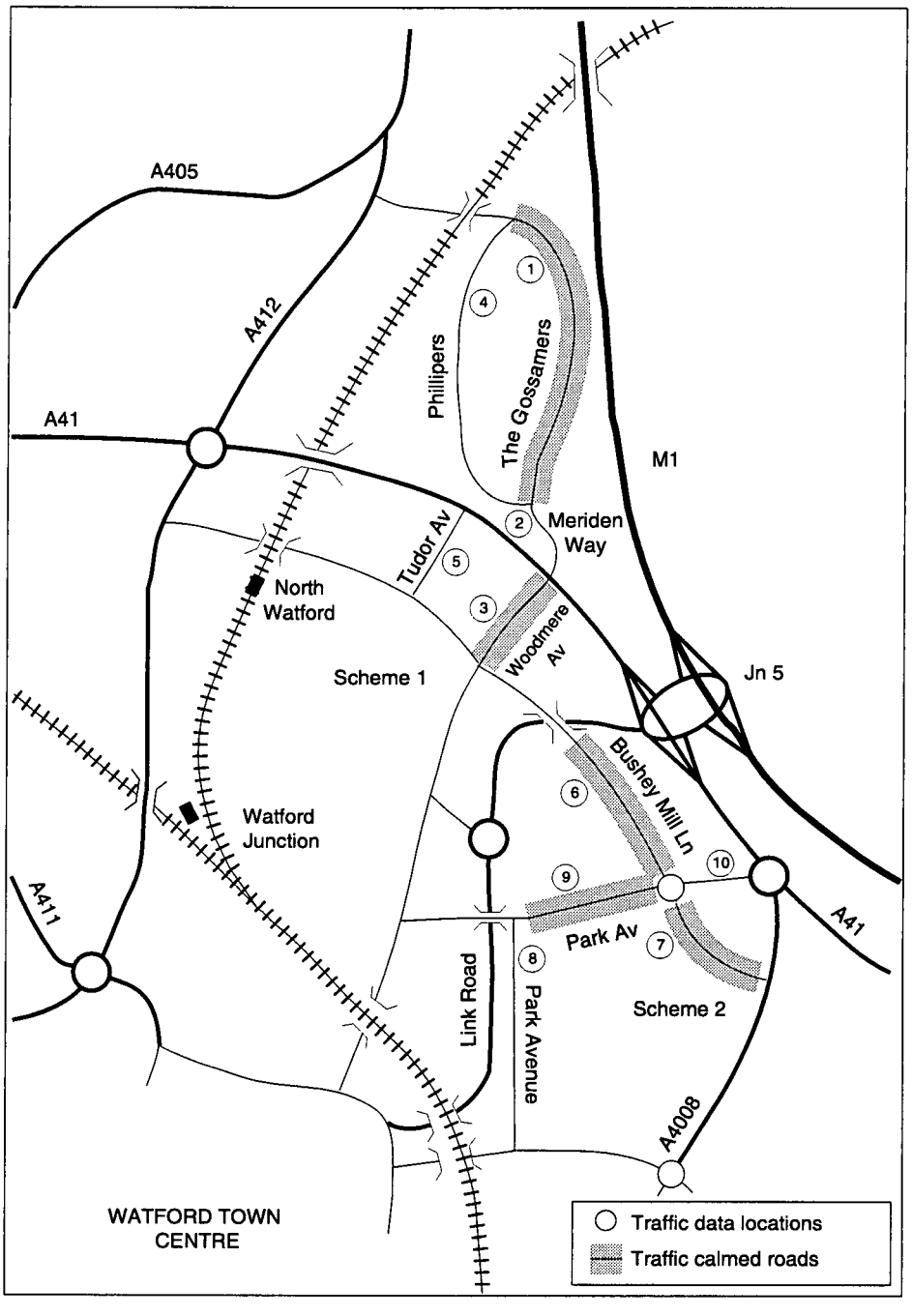


**Fig 8 Location of North Watford schemes**

Fig. 9a Bus gate on Woodmere Avenue looking towards A41 (Before)


Fig. 9b Flat-top humps on Woodmere Avenue looking towards A41 (After)

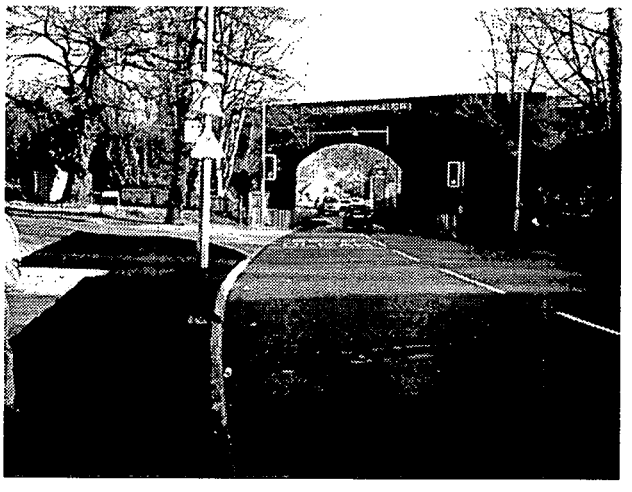

Fig. 9c One way signals on The Gossamers at Garston bridge

Fig. 9d Humped zebra crossing on The Gossamers outside no. 120

Fig. 9e Flat-top humps on Bushey Mill Lane outside no. 423

Fig. 9f Chicane on Bushey Mill Lane outside nos. 457/459, looking south

Photographs courtesy of Hertfordshire County Council

There was a high incidence of rat-running in the area, with drivers in the Scheme 1 area using Woodmere Avenue/ Meriden Way/The Gossamers to avoid delays on the A412 and A41. The A412 carries 30,000 vehicles per day, which is partly due to the fact that North Watford has a high car ownership. This has lead to a declining bus service network. In 1990 (DOT, 1991) Hertfordshire had a car ownership rate of 491 cars/1,000 people which was the second highest behind Berkshire at 493 cars/1,000 people.

Fig 9a shows a 'before' photograph of Woodmere Avenue in Scheme 1. The photograph is looking north-east towards the A41 and it shows an existing bus only arrangement down the centre of the road for assisting buses approaching the junction. The road is long, wide and straight. This has lead to speeding which has resulted in a deterioration of the local environment for the residents.

The traffic calming measures were installed between October 1993 and April 1994. The main traffic calming measures used to slow the traffic, to the 30 mph speed limit, were flat-top road humps. These humps were 75 mm high with 1:15 on/off gradients and 6 metre long plateaux. They were designed to slow cars and to reduce problems of discomfort and delay for bus passengers and the emergency services which occurred at previous schemes which used 100 mm high flat-top humps with steeper on/off gradients.

The roads chosen for traffic calming were the main rat-running routes. In Scheme 1, there were a total of 9 flat-top humps, made of red asphalt, installed along Woodmere Avenue and The Gossamers at spacings of approximately 140 metres (see Fig 9b). There was also a set of one-way working signals, with carriageway narrowing and a new footway, installed at the railway bridge at the northern end of the Gossamers to slow traffic approaching the scheme (see Fig 9c). A new humped zebra crossing was installed at the southern end outside No. 120 to assist pedestrians (see Fig 9d). There were no humps installed on Meriden Way or on the potential parallel routes of Phillipers and Tudor Avenue.

In Scheme 2, there were 23 flat-top humps, constructed in pavoir blocks, installed on Park Avenue and Bushey Mill Lane (see Fig 9e) at spacings of approximately 70 metres. A set of two one-way working chicanes, 125 metres apart, with cycle bypasses were also installed on a trial basis in Bushey Mill Lane (see Fig 9f). Central islands with an illuminated bollard were used prior to the first chicane encountered, to give drivers additional warning of the chicanes ahead.

# 3. TRAFFIC SPEEDS

'Before' and 'after' speed measurements were made at all of the sites by either 200 radar readings or a week of automatic equipment readings. The 95% confidence limits for speed measurements with 200 radar readings are approximately plus or minus 1 mph, with about 6000 automatic readings they are approximately plus or minus 0.15 mph. Overall differences between 200 'before' and 200 'after' speed measurements that are greater than about 1.5 mph are likely to be statistically significant at the 1% level. Whilst large speed reductions are likely to be mainly due to the traffic calming measures, small differences in speed of up to 3 mph may be due to differences in factors such as in time of day, seasonal differences or weather. These factors were minimised for the comparisons by using the same method for both 'before' and 'after' measurements and where possible the same time of day and weather conditions. Automatic equipment can be susceptible to unforseen events during unattended periods.

## 3.1 SPEED CHANGES AT INDIVIDUAL SCHEMES

### 3.1.1 Wych Hill Lane, Woking

'Before' and 'after' speed measurements were taken in August 1991 and June 1993 on Wych Hill Lane by Woking BC using a radar gun at the same position. Drivers were not aware that their speeds were being measured because the operators were on a bank which was partially concealed from the road. The results of these measurements are given in Table 1.

The results in Table 1 show that the two way 'before' and 'after' 85th percentile vehicle speeds were reduced, below the 30 mph speed limit, from 40 to 28 mph (see Fig 10) and mean speeds from 35.1 to 23.3 mph respectively, giving an overall statistically significant reduction (at the 1% level) of 12 mph due to the flat-top humps.

Automatic speed/flow measurement tubes were laid across the road for 1 week in February 1995 to check that vehicle speeds were still at the same level as in June 1993. Unfortunately it was not possible to locate the tubes in exactly the same position as the radar speed measurement results in Table 1. The measurement location was approximately 60 metres further along the road but the results indicated that, for the same time of day, vehicle speeds were similar to the June 1993 speeds.

### 3.1.2 Mayfield Road, Farnborough

Speed measurement data was obtained by Hampshire County Council and analysed at TRL. The data was collected by the Local Authority using a radar gun to record the speeds of individual free flowing vehicles and the drivers were unaware that they were being measured.

The 'before' and 'after' speed data was obtained on a week day in November 1991 and in May 1993 (9 months after installation) respectively at the same four locations. The

## TABLE 1

Vehicle speeds on Wych Hill Lane (radar measurements)

| Vehicle direction | Vehicle speed (mph) Before (B) Mean | 85% | After (A) Mean | 85% | Difference (A) - (B) Mean | 85% |
|---|---|---|---|---|---|---|
| Eastbound (Downhill) | 35.8 | 40 | 25.0 | 28 | -10.8 | -12 |
| Westbound (Uphill) | 34.4 | 39 | 21.6 | 28 | -12.8 | -11 |
| Overall | 35.1 | 40 | 23.3 | 28 | -11.8 | -12 |

Notes. (B) 1991, (A) 1993

vehicle speeds were measured in each direction, but the results showed that the directional speed differences were small and therefore only the two-way speeds have been used. Table 2 gives the 'before' and 'after' 85th percentile and maximum speeds for each site.

The 85th percentile speeds given in Table 2 show that, on average, the speeds between the 100 mm high flat-top humps were reduced, below the 30 mph speed limit, by 13 mph from 37 mph to 24 mph (see Fig 10). Maximum speeds had been reduced, on average, by 16 mph from 45 mph to 29 mph. 85th percentile speeds between humps spaced at 135 metres were about 2 mph faster than between humps spaced at 75 metres. These speed reductions are all statistically significant at the 1% level.

### 3.1.3 Dedworth Road area, Windsor

'Before' and 'after' traffic speeds were measured at 8 sites (sites 1 to 8 in Fig 6). Measurements of speeds were taken using automatic speed monitoring tubes laid across the road. 'Before' speeds were measured for 7 days in 1990 and 'after' speeds were measured for 7 days in October 1994.

Table 3 gives the 'before', and 'after' 85th percentile speeds for the 7 day period at sites 1 to 8. The vehicle speeds were taken for each direction, but the speed difference due to direction was 1 mph or less, and therefore only the 2-way speeds have been used. The 85th percentile 'before' speeds ranged from 35 to 39 mph. The speed limit on these roads was 30 mph.

The 85th percentile speeds given in Table 3 and Fig 10 show that on average, at sites where humps were installed, the speeds were reduced by 13 mph (statistically significant at the 1% level) to levels below the 30 mph speed limit. There was also a small non statistically significant reduction of 2 mph on the roads with no measures.

On Dedworth Road, the 85th percentile speeds were reduced by 14 mph (38 mph to 24 mph) at Site 1 and by 10 mph (38 mph to 28 mph) at Site 2. Sites 1 and 2 were both located between 75 mm high flat-top humps. The uncalmed section (hatching only) of Dedworth Road (Site 3), which is 375 metres long, showed an 8 mph reduction at a point approximately 50 metres west of the new roundabout (See Fig 7a).

At about 25 mph, the 'after' 85th percentile speeds measured between the 50 mm high round-top humps on Gallys Road (60 metre separation) and Ruddlesway (40 metre separation), are about 6 mph lower than the overall average

## TABLE 2

Before and after maximum and 85th percentile speeds (mph) between the humps

| Site number | Vehicle speeds (mph) Before (B) 85% | Max | After (A) 85% | Max | Dif (A-B) 85% | Max | Hump spacing (metres) |
|---|---|---|---|---|---|---|---|
| 1 | 38 | 45 | 26 | 30 | -12 | -15 | 135 |
| 2 | 38 | 46 | 24 | 28 | -14 | -18 | 72 |
| 3 | 36 | 43 | 23 | 30 | -13 | -13 | 75 |
| 4 | 37 | 47 | 24 | 28 | -13 | -19 | 75 |
| Overall | 37.3 | 45.3 | 24.3 | 29.0 | -13.0 | -16.3 | (89) |

## TABLE 3

Before and after 85th percentile speeds (both directions)

| Site No. | Road Name | Type of measure | Vehicle speeds (mph) Before(B) | After(A) | Difference (A) - (B) |
|---|---|---|---|---|---|
| 1 | Dedworth Rd | Humps | 38 | 24 | -14 |
| 2 | Dedworth Rd | Humps | 38 | 28 | -10 |
| 3 | Dedworth Rd | None * | 38 | 30 | - 8 |
| 4 | Smiths Lane | Humps | 39 | 20 | -19 |
| 5 | Gallys Road | Humps | 35 | 25 | -10 |
| 6 | Ruddlesway | Humps | 37 | 24 | -13 |
| 7 | Longmead | None | 36 | 33 | - 3 |
| 8 | Vale Road | None | 38 | 37 | - 1 |
| Average 1,2,4,5 & 6 | | Humps | 37 | 24 | -13 |
| Average 7 - 8 | | None | 37 | 35 | - 2 |

* Note. Between calmed section of Dedworth Road (hatching only)

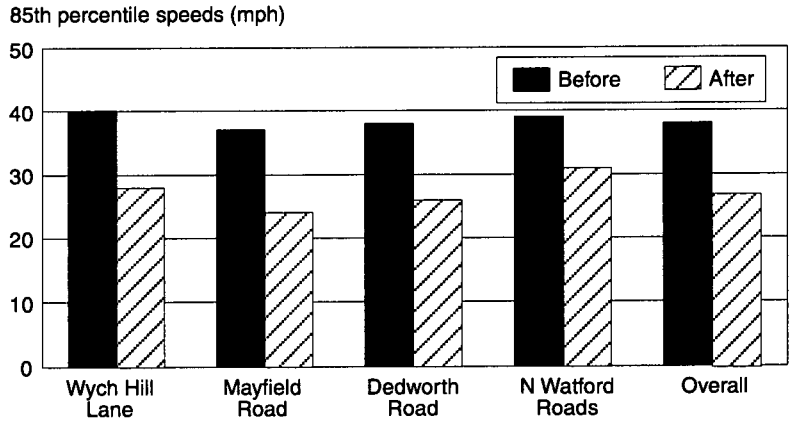


**Fig 10 Speed changes for all four distributor roads**

value found by Webster (1994) in a study of 7 sites which had only 50 mm high round-top humps (31 mph at an average spacing of 70 metres). Although the speeds on Gallys Road and Ruddlesway were measured between 50 mm high humps, the presence of 75 mm high humps on these roads may have influenced drivers to travel at lower speeds.

The 'after' monitoring at sites 10 to 15 (see Fig 6) on uncalmed roads were monitored to determine if the speeds were acceptable for the type of road. The speeds were relatively high in Wolf Lane, Tinkers Lane and Clewer Hill Road (Sites 11, 12 and 14) where the 85th percentile speeds were approximately 8 mph above the speed limit. The County have installed, since the above measurements were taken, 'Kill your Speed' signs in these three roads and also in Vale Road (see Table 3) which had similar after speeds which are 7 mph above the speed limit.

The 85th percentile speeds on St Andrews Crescent, Parsonage Close and Testwood Road (Sites 10, 13 and 15) were closer to the speed limit (3 mph above, 3 mph above and 1 mph below the speed limit respectively) and 'Kill your Speed' signs were not considered to be necessary.

### 3.1.4 North Watford schemes

'Before' and 'after' traffic speeds were measured at 5 sites in Scheme 1 and 5 sites in Scheme 2 (see Fig 8). The ten sites were chosen so that an estimate of the speed reduction could be determined along the roads where traffic calming measures were installed, as well as some adjacent roads which did not contain any speed reducing features.

The speeds were measured mid-way between two humps using automatic speed monitoring tubes laid across the road. 'Before' speeds were measured over a 7 day period in

## TABLE 4

'Before' and 'after' vehicle speeds (7 day averages)

| Site No. | Road Name | Type of measure | Vehicle speeds (mph) Before(B) Mean | Before(B) 85% | After(A) Mean | After(A) 85% | Difference (A) - (B) Mean | Difference (A) - (B) 85% |
|---|---|---|---|---|---|---|---|---|
| 1 | The Gossamers | Humps | 35.6 | 41.7 | 28.4 | 33.7 | -7.2 | -8.0 |
| 2 | Meriden Way | None | 32.2 | 37.6 | 33.2 | 39.7 | 1.0 | 2.1 |
| 3 | Woodmere Av. | Humps | 33.9 | 40.0 | 26.0 | 31.2 | -7.9 | -8.8 |
| 4 | Phillipers | None | 21.8 | 27.6 | 23.0 | 28.9 | 1.2 | 1.3 |
| 5 | Tudor Avenue | None | 34.2 | 41.4 | 32.7 | 39.5 | -1.5 | -1.9 |
| 6 | Bushey Mill | Humps | 31.0 | 36.9 | 23.2 | 28.5 | -7.8 | -8.4 |
| 7 | Bushey Mill | Chicane | 35.6 | 42.0 | 25.2 | 30.2 | -10.4 | -11.8 |
| 8 | Park Avenue | None | 36.5 | 43.5 | 37.3 | 44.0 | 0.8 | 0.5 |
| 9 | Park Avenue | Humps | 31.7 | 37.8 | 25.7 | 30.9 | -6.0 | -6.9 |
| 10 | Park Avenue | None | 35.4 | 42.0 | 34.8 | 41.7 | -0.6 | -0.3 |
| Overall | | Humps | 33.1 | 39.1 | 25.8 | 31.1 | -7.2 | -8.0 |
| Overall | | None | 32.0 | 38.4 | 32.2 | 38.8 | 0.2 | 0.4 |

June/July 1993 and 'after' speeds were measured for a 7 day period June/July 1994.

Table 4 gives the 'before' and 'after' mean and 85th percentile speeds for the 7 day period at each site. Mean 'before' speeds on the traffic calmed roads were between 31 and 36 mph. 85th percentile 'before' speeds were between 37 and 42 mph, about 6 mph higher than mean speeds.

The schemes were designed to minimise the number of humps used thus striking a balance between the speed reduction of cars and the discomfort of road users, especially bus passengers. The 85th percentile speeds on roads with humps were generally reduced to levels slightly above the 30 mph limit.

The mean and 85th percentile speeds between the humps on The Gossamers (site 1), Woodmere Avenue (site 3), Bushey Mill Lane (Site 6) and Park Avenue (Site 9), were reduced by about 7 mph to an average of about 26 mph and 31 mph respectively (see Fig 10). This speed reduction was statistically significant at the 1% level. The hump spacings at the measurement sites were 130 metres, 150 metres, 46 metres and 90 metres respectively.

At Bushy Mill Lane (site 7), which had two chicanes spaced at 125 metres apart, the mean and 85th percentile speeds were reduced by 10 mph and 12 mph respectively to 25 and 30 mph. Radar speed measurements at the chicane gave mean and 85th percentile speeds of 19 and 21 mph respectively. It should be noted that the chicanes only allowed one-way working (see Fig 9f) so some of the vehicles will have stopped to allow traffic in the opposite direction to pass.

Drivers approaching the first of the two chicanes (from either direction) have to give way to vehicles leaving the chicanes. Thus on approaching the second chicane they have priority over oncoming vehicles

There has been concern expressed that traffic speeds might increase on uncalmed roads within a traffic calmed area. The uncalmed roads (see Fig 8) of Meriden Way (site 2), Phillipers (site 4), Tudor Avenue (site 5) and Park Avenue (sites 8 and 10) gave mean and 85th percentile 'after' speeds which were all within 2 mph of the 'before' speeds; and were not statistically significantly different from them. Further speed reductions were thought to be necessary on Tudor Avenue and therefore humps have recently been added to compliment the humps in the parallel road of Woodmere Avenue.

## 3.2 OVERALL SPEED CHANGES

On the four distributor roads studied (see Fig 10), the 85th percentile speeds between the humps were reduced to levels below or near the 30 mph speed limit. The 85th percentile speeds were reduced by 11 mph from an average of 38 mph to an average of 27 mph, and mean speeds by 10 mph from an average of 34 mph to an average of 24 mph respectively. The average spacing between the humps for all of the schemes was 90 metres.

At the chicane site, mean speed between the chicanes was reduced by 10 mph from 35 mph to 25 mph and 85th

percentile speed was reduced by 12 mph from 42 mph to 30 mph.

Additional speed measurements were carried out at Dedworth Road, Windsor and the North Watford schemes on roads surrounding the distributor roads. The results show that there are generally no large increases in speed when drivers were outside the calmed sections of the distributor roads.

In the Dedworth Road scheme, the uncalmed residential roads within the calmed area showed a reduction in 85th percentile speed of 2 mph.

In the Watford schemes, the sections of distributor roads and adjacent residential roads without traffic calming measures, showed a slight (less than 0.5 mph) overall increase in mean and 85th percentile speeds and all of the 'after' speeds for the roads without traffic calming measures were within 2 mph of the 'before' speeds.

# 4. TRAFFIC FLOWS

Traffic calming can lead to reduced flows (Webster, 1993) as well as reduced speeds monitored in section 3.

## 4.1 FLOW CHANGES AT INDIVIDUAL SCHEMES

### 4.1.1 Wych Hill Lane, Woking

Peak morning vehicle 'before' flows were taken manually by Woking BC on Tuesday 29th October 1991. Automatic counters were laid across the road for 1 week in February 1995 to obtain the 'after' vehicle speeds and these were also used to obtain the 'after' vehicle flows. A comparison between the 'before' and 'after' peak flows is given in Table 5. The 'after' flow was 12,000 vehicles per day using Wych Hill Lane compared with an estimate of 20,000 vehicles per day 'before' the traffic calming was installed, giving an estimated reduction of 40% reduction. In the 'after' period, 11,040 (92%) of the vehicles were cars or light vans.

The 'before' and 'after' vehicle flows for the morning peak period (8.00 to 9.00) are given in Table 5.

The results in Table 5 show that the morning peak 2-way flow was reduced from 1869 vehicles/hour to 661 vehicles/hour (a reduction of 65%). It can be assumed that a high proportion of the flow reduction can be attributed to the introduction of the traffic calming scheme. However, there is likely to be some uncertainty in the size of the reduction, as the flows along Wych Hill Lane can vary considerably, particularly during the rush hour. If the traffic in the town builds up, the congestion causes traffic to divert along Wych Hill Lane. It is worth noting that 12,000 vehicles per day still use Wych Hill Lane, therefore it remains an important east/west route for traffic.

### 4.1.2 Mayfield Road, Farnborough

Traffic flows on Mayfield Road were measured by Hampshire County Council for a 7 day period in November 1991 and for a 7 day period in May 1993, 9 months after the scheme was installed. The data was recorded using automatic tube counters laid across the road at a position midway along Mayfield Road. The output from the traffic counters was analysed at TRL.

Table 6 gives the 'before' and 'after' flows for an average week day, an average weekend day and an average day. Changes in flow in the morning and evening peak hours are also given. Before the traffic calming scheme was introduced, the average weekday daily flow on Mayfield Road was about 8,425 vehicles per day and the average weekend daily flow was 6,855 vehicles per day. Average peak hour flows were about 900 vehicles per hour in the morning peak and 660 vehicles per hour in the evening peak.

The results in Table 6 show that the average daily (Monday to Friday period) traffic flow was reduced by 28% whereas the Saturday and Sunday flows were 27% and 8% respectively. The Sunday flow was smaller than the other days and

## TABLE 5

Vehicle flows along Wych Hill Lane

| Period of day | Direction | Number of vehicles Before (B) | After (A) | Difference (A) - (B) |
|---|---|---|---|---|
| 8.00 - 9.00 | Eastbound | 999 | 263 | - 736 (-74%) |
| 8.00 - 9.00 | Westbound | 870 | 398 | - 472 (-54%) |
| 8.00 - 9.00 Overall | Two-way | 1869 | 661 | - 1208 (-65%) |

## TABLE 6

Summary of 24 hour and peak hour flow measurements before and after installation.

| Day of the week | Number of vehicles in given time period | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 24 hours | | | AM peak hour | | | PM peak hour | | |
| | Before | After | %Dif | Before | After | %Dif | Before | After | %Dif |
| Mon-Fri | 8425 | 6037 | -28% | 904 | 545 | -40% | 659 | 494 | -25% |
| Sat | 7690 | 5580 | -27% | - | - | - | - | - | - |
| Sun | 6019 | 5549 | - 8% | - | - | - | - | - | - |

may suggest that most of the observed average reduction in daily flow is for through traffic not requiring local access.

Many morning peak hour drivers may have been discouraged from using Mayfield Road. The average flows at weekday peak periods, morning peak (8.00 - 9.00) and evening peak (17.00 - 18.00) were reduced by 40% and 25% respectively.

Some change in traffic flow might be due to seasonal differences or the effect of the construction of the new M3 Minley interchange and the new section of the Farnborough bypass, but it is likely that a substantial part of the change would be due to the traffic calming scheme. A study carried out at TRL of a large number of schemes have shown that the average change in daily traffic flow following the introduction of 75 mm high humps was a reduction of about 25 per cent.

### 4.1.3 Dedworth Road area, Windsor

Traffic flow measurements were undertaken at the same time and in the same positions as the speed measurements so that a limited assessment could be made of any traffic transfer in the area. 'Before' and 'after' traffic flows were measured at 9 sites (sites 1 to 9 in Fig 6) in 1990 and 1994 (after the schemes had been installed). Some of the measured changes in the traffic flows may be due to seasonal differences or the opening of a new supermarket, but the broad pattern of changes on traffic calmed and uncalmed roads is likely to be unaffected.

The flow results, given in Table 7, are 7 day averages for each site with flows/day for each direction combined to give the overall 2-way flows. Before the traffic calming scheme was introduced, the traffic flows (vehicles/day) were about 11,500 on Dedworth Road, 2,000 to 4,000 on the other traffic calmed roads, 1,000 to 3,000 on adjacent uncalmed roads and 16,000 on the uncalmed A308.

Flows on Dedworth Road were reduced by 30% to 7,575 vehicles per day on western section and by only 5% to 11,100 on the central and eastern sections. This smaller reduction may be due to traffic generated by the opening of the new supermarket. There was an overall reduction of 13% in vehicle flows for the three monitoring points.

Flows on the other traffic calmed roads, Smiths Lane, Ruddlesway and Gallys Road were reduced by 34% (1,350 vehicles/day), 21% (900 vehicles/day) and 1% respectively.

Flows on the adjacent uncalmed roads; Longmead and Vale Road increased by 9% (50 vehicles/day) and 35% (950 vehicles/day) respectively. The indications are that some traffic has transferred from the calmed Smiths Lane to the uncalmed Vale Road.

The flow on Maidenhead Road (A308) increased by 3% (429 vehicles/day) to 16,780 vehicles/day. The small size of the increase may be due to the fact that, at key junctions, the saturation capacity has been reached at peak times, reducing the attractiveness of the A308 as an alternative route.

Overall the flows were reduced by 15% (1,141 vehicles/day) at the sites on the calmed roads and increased by 7% (493 vehicles/day) at sites on the uncalmed roads.

### 4.1.4 North Watford schemes

Traffic flow measurements were undertaken in the North Watford Schemes so that a limited assessment could be made of any traffic transfer to adjacent roads.

The traffic flow measurements in the 'before' and 'after' periods were taken at the same time and in the same positions as the speed measurements, which are described in section 3. The 'before' and 'after' 7-day average traffic flows for each site are given in Table 8. The 'before' flows on The Gossamers/Meriden Way/Woodmere Avenue route were 7,000 - 8,000 vehicles/day. On Tudor Avenue site 5, Bushey Mill Lane sites 6 and 7, and Park Avenue sites 8 - 10, flows were between 3,000 and 8,000 vehicles/day. Flows on the adjacent road of Phillipers were 1,000 vehicles/day.

## TABLE 7

Before and after vehicle flows/day (calmed & uncalmed roads)

| Site No. | Road Name | Direction | Average vehicle flow/day on each road Before | After | Difference | % Diff |
|---|---|---|---|---|---|---|
| **CALMED ROADS** | | | | | | |
| 1 | Dedworth Rd | 2 Way | 11000 | 7575 | -3425 | -31 |
| 2 | Dedworth Rd | 2 Way | 11000 | 10350 | -650 | - 6 |
| 3 | Dedworth Rd | 2 Way | 12400 | 11900 | -500 | - 4 |
| **Overall Dedworth Rd** | | | 11467 | 9942 | -1525 | -13 |
| 4 | Smiths Lane | 2 Way | 4000 | 2650 | -1350 | -34 |
| 5 | Gallys Road | 2 Way | 1775 | 1750 | -25 | - 1 |
| 6 | Ruddlesway | 2 Way | 4250 | 3350 | -900 | -21 |
| **UNCALMED ROADS** | | | | | | |
| 7 | Longmead | 2 Way | 1125 | 1225 | 100 | 9 |
| 8 | Vale Road | 2 Way | 2700 | 3650 | 950 | 35 |
| 9 | Maidenhead Road (A308) | 2 Way | 16351 | 16780 | 429 | 3 |
| Overall Calmed | | | 7404 | 6263 | -1141 | -15 |
| Overall Uncalmed | | | 6725 | 7218 | 493 | 7 |

## TABLE 8

'Before' and 'after' vehicle 2-way flows/day (7 day averages)

| Site No. | Road Name | Type of measure | Average vehicle flow/day on each road Before | After | Diff | % Dif |
|---|---|---|---|---|---|---|
| 1 | The Gossamers | Humps | 7338 | 5925 | -1413 | -19 |
| 2 | Meriden Way | None | 8496 | 7636 | -860 | -10 |
| 3 | Woodmere Av. | Humps | 8326 | 5058 | -3268 | -39 |
| 4 | Phillipers | None | 1306 | 1461 | 155 | 12 |
| 5 | Tudor Avenue | None | 3615 | 3296 | - 319 | - 9 |
| 6 | Bushey Mill | Humps | 5598 | 3754 | -1844 | -33 |
| 7 | Bushey Mill | Chicane | 4202 | 3297 | -905 | -22 |
| 8 | Park Avenue | None | 6580 | 5884 | -696 | -11 |
| 9 | Park Avenue | Humps | 8308 | 3834 | -4474 | -54 |
| 10 | Park Avenue | None | 6994 | 3643 | -3351 | -48 |
| Overall | | Humps | 7393 | 4643 | -2750 | -37 |
| Overall | | None | 5398 | 4384 | -1014 | -19 |

Flows were reduced on the four roads with humps, by between 19% and 54% with an average reduction of 37% overall.

The flows on the roads which had no humps were reduced overall by 19%. Flow on Meriden Way (site 2), the route between The Gossamers and Woodmere Avenue, was reduced by 10%. Flow on Phillipers (site 4), which is an alternative to The Gossamers, increased by 12% (155 vehicles) overall. However, this overall increase was mainly due to a 30% increase in the northbound traffic, indicating that some northbound drivers may have diverted. Flow on Tudor Avenue (site 5) showed a reduction of 9% (319 vehicles). This road has had humps added since the 'after' surveys were carried out.

The changes in flow cannot be solely attributed to the presence of the humps; delays caused by the new one-way working traffic signals at the railway bridge may also have encouraged traffic to divert from the Gossamers/Meriden Way/Woodmere avenue route.

Traffic flows were reduced on Bushy Mill Lane at Site 7 (chicanes) by 22%. Bushey Mill Lane is used by cyclists going to the local schools and therefore the reduction in flow on the road could prove to be beneficial. There are cycle bypasses at the chicane locations.

Park Avenue (Site 8) showed no difference northbound, but a decrease of 22% southbound, giving the overall reduction of 11%.

## 4.2 OVERALL FLOW CHANGES

Traffic flows on the traffic calmed distributor roads were reduced by between 13% and 40% at the four schemes in this study see Fig 11.

The flows on Wych Hill Lane were estimated to have reduced by 40% to 12,000 vehicles per day.

The flows on Mayfield Road were reduced overall by 26% (7976 to 5902 vehicles per day). The traffic flows along Mayfield Road may have been affected by the construction of the M3 Minley interchange and the new section of the Farnborough by-pass, but this could not be quantified.

Dedworth Road showed an overall reduction of 13% in vehicle flows for the three monitoring points. Flows on adjacent calmed roads were reduced by up to 34% (1350 vehicles per day) whereas on uncalmed roads traffic flows increased by up to 35% (950 vehicles per day). The indications are that some traffic has transferred from the calmed Smiths Lane to the uncalmed Vale Road.

At North Watford the vehicle flows were reduced by between 19% and 54%, with an average of 37%, on roads with traffic calming measures. There was evidence of northbound traffic transference onto the Phillipers which had no measures installed.

The results from this study suggest that flat-top humps with 1:10 to 1:15 ramp gradients can be used as the main speed reducing measure on urban local distributor roads and town centres carrying flows of 8,000 to 17,000 vehicles per day, but there is likely to be some transfer of traffic onto alternative routes. These results are similar to those from Crowthorne High Street (Mackie and Webster 1995) and Borehamwood High Street (Hopper and Cannon, 1994), which both carried 17,000 vehicles per day before calming.

# 5. ACCIDENTS

The number of personal injury accidents along Wych Hill Lane, Mayfield Road, Dedworth Road and the North Watford distributor roads were monitored for 36 months in the 'before' and 17, 28, 13 and 17 months in the 'after' periods respectively. The North Watford roads were com-

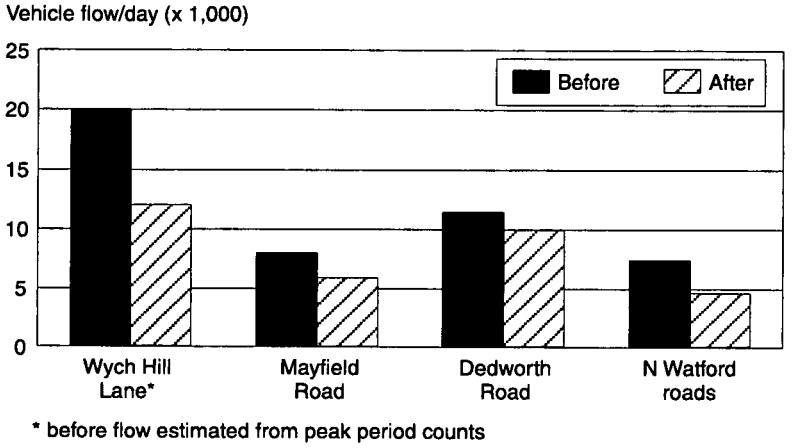


**Fig 11 Flow changes for all four distributor roads**

bined for schemes 1 & 2. All of the personal injury accident data, which contained no fatal accidents, is given in Table 9.

The accident frequencies along Wych Hill Lane, Mayfield Road, Dedworth Road and the North Watford distributor roads have all been reduced by 39%, 61%, 7% and 47% respectively giving an overall reduction of 32% (26.0 to 17.8 accidents per year).

The accident numbers are small and although the change is encouraging it is not statistically significant. More time will be required to ascertain the long term effect on accidents of the scheme, however the results are consistent with those which showed that reductions in speed are related to reductions in accidents (Finch et al, 1994).

# 6. REACTIONS TO THE SCHEMES

## 6.1 BEFORE INSTALLATION

All of the Local Authorities consulted widely, (emergency services, the bus companies and the public), before the schemes were installed. The police, fire service and ambulance service had no objections to the schemes but it was noted that the ambulance service placed a higher priority on the journey leaving the traffic calmed area with an injured person, whereas the fire service were generally only concerned with access into the area. The bus companies were not generally in favour of the schemes but they were prepared to run their buses over the flat-top humps while they monitored the effect on their services.

The residents were generally in favour of the schemes but the possibility of noise from the humps was expressed as a concern by some residents.

A code of practice, which sets out arrangements for consulting on proposals to introduce traffic calming schemes, has been issued (DOT, 1994) since these schemes were installed.

## 6.2 AFTER INSTALLATION

### 6.2.1 Emergency services

The consultation generally continues after implementation on a regular basis, to ensure that the schemes continue to work satisfactorily. The police are particularly in favour of the schemes because the reduced speeds are expected to give fewer accidents and hence save their time. The fire and ambulance services generally had no major objections to the schemes since installation.

### 6.2.2 Bus operators

The bus operators have not complained to any of the Local Authorities since the schemes were installed, which indicates that they are prepared to accept running their buses along the traffic calmed roads with 'bus friendly' flat-top humps.

### 6.2.3 Residents

Detailed public attitude studies were not carried out, however a short postal questionnaire of the Mayfield Road area was carried out by the Local Authority to assess the residents views of the scheme, but very few comments were received. Some residents wanted the scheme to be extended to take in some of the surrounding roads.

The Local Authorities in the other areas received a few comments from the residents.

Some residents living in non-calmed roads in the Wych Hill Lane area asked "Can we have humps like those in Wych Hill Lane".

Some residents living in the Dedworth Road area scheme were concerned that drivers were avoiding the humps by using uncalmed residential roads to the south of Dedworth

## TABLE 9

'Before' and 'after' accidents at the schemes

| | Before | | | | After | | | |
|---|---|---|---|---|---|---|---|---|
| Site name | Serious | Slight | Total | Accs/yr | Serious | Slight | Total | Accs/yr |
| Wych Hill Lane | 1 | 6 | 7 | 2.3 | 0 | 2 | 2 | 1.4 |
| Mayfield Road | 2 | 8 | 10 | 3.3 | 1 | 2 | 3 | 1.3 |
| Dedworth Road | 0 | 33 | 33 | 11.0 | 0 | 11 | 11 | 10.2 |
| N Watford roads | 3 | 25 | 28 | 9.3 | 1 | 6 | 7 | 4.9 |
| Total all schemes | 6 | 72 | 78 | 26.0 | 2 | 21 | 23 | 17.8 |

Road. Investigations by the Local Authority showed that any increase in traffic is likely to be small, because journey times would be twice as long using the alternative route compared with using the Dedworth Road.

There were initially comments from some residents who live in the North Watford Scheme 1 that they preferred the humps made of blocks as used in Scheme 2 rather than the red asphalt humps in their roads. The red colour, which was thought to be too strong, has toned down in the time since installation and therefore the colour now blends in much better with the surroundings. The one-way working chicanes were not popular initially because some drivers did not fully understand the standard priority signs (See Fig 9f) which were used at the chicanes. The residents who have one of the chicanes outside their house do not like the chicane because their access is slightly restricted and also the available space for on road parking is reduced.

Noise and vibration near humps were also commented on by some residents. The change in noise levels is likely to be influenced by changes in traffic speed, traffic volume and the proportion of heavy vehicles in the traffic stream. TRL has carried out research and produced a report (Abbott et al, 1995) of a noise study at speed cushion sites in York which shows that overall day-time traffic noise has been reduced by 4 dB(A) alongside the cushions and also between the cushions.

The reactions to the schemes indicate that they are generally working well and causing few problems.

# 7. SUMMARY AND CONCLUSIONS

## 7.1 MEASURES INSTALLED

All of the four schemes studied had flat-top humps as the main speed reducing measure which were designed to slow cars and to reduce problems of discomfort and delay for bus passengers and the emergency services. The humps were 75 mm high with on/off ramps of 1:15 at two sites, 75 mm high with 1:10 or 1:13 on/off ramps at one site and 100 mm high with 1:15 on/off ramps at the other site. The plateaux lengths varied from 3 metres for humps between junctions to 22 metres for humps at junctions.

Chicanes were used at one site and a variety of additional measures were used at all sites which included; new roundabouts, kerb alignments, pedestrian islands, new road markings and humped zebra crossings.

## 7.2 SPEEDS

On the four distributor roads studied (see Fig 10), the 85th percentile speeds between the humps were reduced to levels below or near the 30 mph speed limit. The 85th percentile speeds were reduced by 11 mph from an average of 38 mph to an average of 27 mph, and mean speeds by 10 mph from an average of 34 mph to an average of 24 mph respectively. The average spacing between the humps for all of the schemes was 90 metres.

At the chicane site, mean speed between the chicanes was reduced by 10 mph from 35 mph to 25 mph and 85th percentile speed was reduced by 12 mph from 42 mph to 30 mph.

Additional speed measurements were carried out at Dedworth Road, Windsor and the North Watford schemes on roads surrounding the distributor roads. The results show that there are generally no large increases in speed when drivers were outside the calmed sections of the distributor roads.

In the Dedworth Road scheme, the uncalmed residential roads within the calmed area showed a reduction in 85th percentile speed of 2 mph.

In the Watford schemes, the sections of distributor roads and adjacent residential roads without traffic calming measures, showed a slight (less than 0.5 mph) overall increase in mean and 85th percentile speeds and all of the 'after' speeds for the roads without traffic calming measures were within 2 mph of the 'before' speeds.

## 7.3 FLOWS

Traffic flows on the traffic calmed distributor roads were reduced by 13% to 40% at the four schemes in this study see Fig 11.

The flows on Wych Hill Lane were estimated to have reduced by 40% to 12,000 vehicles per day.

The flows on Mayfield Road were reduced overall by 26% (7976 to 5902 vehicles per day). The traffic flows along Mayfield Road may have been affected by the construction of the M3 Minley interchange and the new section of the Farnborough by-pass, but this could not be quantified.

Dedworth Road showed an overall reduction of 13% in vehicle flows for the three monitoring points. Flows on adjacent calmed roads were reduced by up to 34% (1350 vehicles per day) whereas on uncalmed roads traffic flows increased by up to 35% (950 vehicles per day). The indications are that some traffic has transferred from the calmed Smiths Lane to the uncalmed Vale Road.

At North Watford the vehicle flows were reduced by between 19% and 54%, with an average of 37%, on roads with traffic calming measures. There was evidence of northbound traffic transference onto the Phillipers which had no measures installed.

The results from this study suggest that flat-top humps with 1:10 to 1:15 ramp gradients can be used as the main speed reducing measure on urban local distributor roads and town centres carrying flows of 8,000 to 17,000 vehicles per day, but there is likely to be some transfer of traffic onto alternative routes. These results are similar to those from Crowthorne High Street (Mackie and Webster 1995) and Borehamwood High Street (Hopper and Cannon, 1994), which both carried 17,000 vehicles per day before calming.

## 7.4 ACCIDENTS

The accident frequencies along Wych Hill Lane, Mayfield Road, Dedworth Road and the North Watford distributor roads have all been reduced by 39%, 61%, 7% and 47% respectively giving an overall reduction of 32% (26.0 to 17.8 accidents per year).

The accident numbers are small and although the change is encouraging it is not statistically significant. More time will be required to ascertain the long term effect on accidents of the scheme.

## 7.5 REACTIONS TO THE SCHEMES

Reactions to the schemes have been favourable at all of the schemes, particularly from the residents and the police. The fire brigade and ambulance services have generally supported the schemes. The bus companies were often concerned before the schemes were installed, but it appears that they have accepted the schemes when implemented.

The reactions to the schemes from the residents were generally favourable, but the chicanes were unpopular because of restricted access and loss of parking space with residents who had a chicane outside their house. It took time for drivers to understand how to use the one-way working chicane properly with regard to the priority signing, but there has been only one slight injury accident because a driver failed to give way.

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