

Multi-Criteria Assessment of the Cutting-back of the A4 Exempt Route to the Hammersmith Flyover

by P Emmerson, J Francsics & P Abbott (TRL Limited)

Report Number PR T/100/03

UNPUBLISHED PROJECT REPORT

TRL Limited



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Version: 2a Draft (18/9/03)

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Prepared for: TfL, Street Management

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Executive Summary

This report sets out an assessment for one of the changes to the Exempt Network proposed by TRL in their recommendations report. It was proposed that the A4, between the A3220 and the Hammersmith Flyover (A219), should be excluded from the Exempt Network. An assessment of the impacts of the proposed change was made based on a survey (e-mail and fax) of current users of the route. The assessment considered a number of criteria, including changes in operating costs, working time, air quality (CO₂, NO_x, and PM10) and noise nuisance.

TRL initially recommended the proposed changes on efficiency grounds however the survey work undertaken as part of this pilot study has shown that this proposal, based on the survey travel pattern, would give rise to an increase rather than a decrease in operating costs. This is due to the fact that the proposed changes would result in an increase in lorry flows on the North Circular, the A40 and West Cross Route. In the light of the surveys and this assessment, the economic efficiency of this proposal is doubtful.

The study also highlighted a number of issues concerning the approach which need to be resolved before its use can be recommended more widely:

- Larger sample of routes are needed, on which to base the travel patterns, for confidence on the routing pattern on the Exempt Network prior to leaving it.
- There are possibly small differences between what the LLCS perceives as the 'best' route off the Exempt network from those using standard routing tools. In granting permit routes, the LLCS may take other aspects into account, but small differences in distances off the network should be accommodated if undue operating cost penalties result from a proposal (of course, virtually all the other proposals should lead to direct benefits to lorry operators with unknown environmental impacts).
- The simplified relationship between percentage change in residents with 'severely disturbed sleep' is not an ideal formulation for this work, where:
 - At night, HGVs may not be the major source of noise. (At the two Inner London sites of the 2003 Noise survey (Holland Road, and Seven Sisters Road) this was not the case. The consequent simplified relationship then breaks down when the current HGV flows tend to zero (or increase from zero)
 - The current formulation requires a base level of HGVs to be known. If they are known then usually a more detailed 3-way classification is available and a more accurate relationship can be adopted. There is very little available night-time HGV data for much of London.

1 Introduction

This report sets out an assessment for one of the changes to the Exempt Network proposed by TRL in their recommendations report. The report details the proposed change to the network and the likely effects as a result of this change. This is followed by an assessment of the impacts of the proposed change. Assessment is based on a survey (e-mail and fax) of current users of the route. The assessment itself considers a number of criteria, namely:

- Changes in operating costs
- Changes in working time
- Changes in air quality (CO₂, NO_x and PM10)
- Changes in noise nuisance.

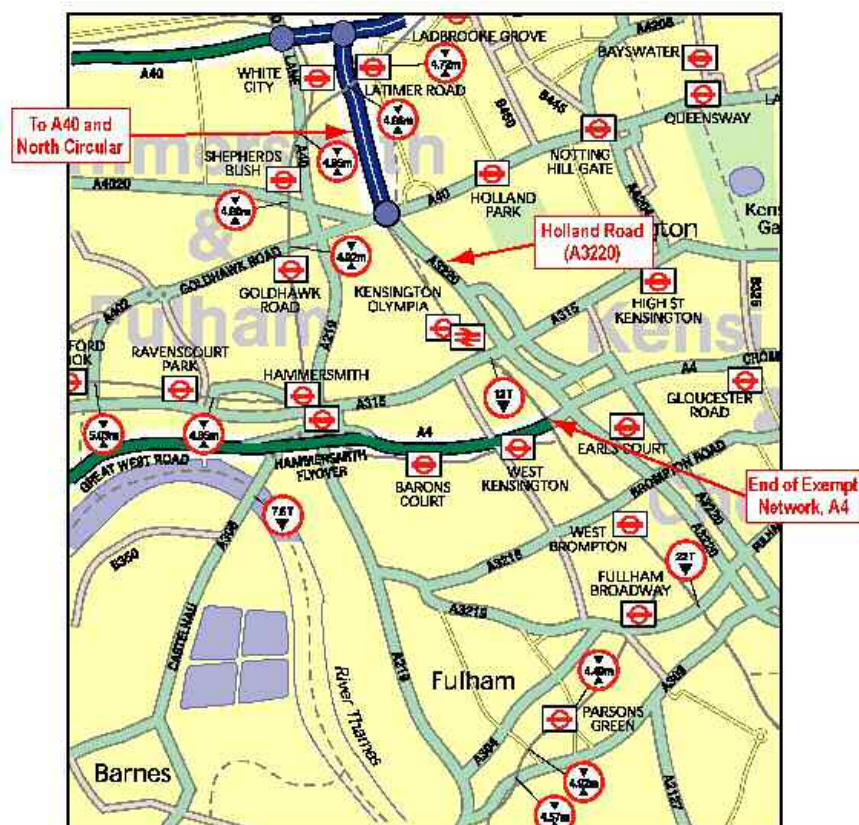
The assessment was devised as a pilot of an approach to assess the proposed changes to the Exempt Network. It is a pilot in two senses, firstly in that it is based on the pilot survey results, and secondly, it uses a new approach to assessing the impact of noise on residents that reflects current EU thinking and the practicality of data availability. This particular proposal was chosen as a pilot due to the ease with which goods vehicles could be surveyed and the relative ease involved in estimating the revised travel pattern of these goods vehicles, if the stretch of road were removed from the Exempt Network. The report concludes with an evaluation of the assessment approach.

2 Proposal

2.1 Outline

The proposal involves the exclusion of the A4, between the A3220 and the Hammersmith Flyover (A219), from the Exempt Network. The Exempt Network, along the A4 eastwards, currently finishes at the point indicated in Figure 2.1.

Figure 2.1: Map of Study Area



Drivers of HGVs, having passed over the Hammersmith Flyover, are unable to turn without leaving the Exempt Network. By excluding this section of the A4, drivers will not be forced to leave the network without a permit. The addition of roads allowing a turning movement under the flyover would allow HGVs to turn around at the Flyover. There is little industrial or commercial property on this part of the A4 so there will be little change to permit requirements. Complications arise from the fact that cutting back the A4 *may* lead the West Cross route becoming the closest ERN access for Central and South Kensington and Chelsea. Under Condition 5 the shortest distance to access/egress the Exempt Network should be used and differences between the new access point on the A4 and the West cross route will be small for quite a considerable area of west central London (the actual changes depend on the precise travel pattern). This could lead to re-assignment of lorries from the A4 to Holland Road. If this re-assignment were substantial, it is likely that there would be significant environmental impacts on the A4, Holland Road (A3220), North Circular and A40 (see Figure 2.1). When raised during the 1999/2000 review, Hammersmith & Fulham were in favour of the deletion but Kensington & Chelsea Borough were very much against this and this is still likely to be a sensitive issue. However, with travel and traffic data the quantitative assessment is relatively straightforward, compared with most potential changes.

2.2 Piloting issues

This proposal was identified as the most suitable for piloting the travel survey data collection procedure and the assessment methodology. This proposal was, in fact, used as a pilot for three different parts of the assessment.

1. Traffic survey - The fact that the proposal involved reducing the Exempt Network meant that one was only concerned with HGVs using the existing route, so the data collection requirements were relatively low. The other major proposals in Central London involved additions to the Exempt Network. With the assessment of these proposals, it is the HGVs using *other* routes that might transfer that need to be surveyed, making the survey a much greater proposition.
2. Noise issues – The assessment uses data from new noise surveys conducted in conjunction with this project. This sub-project aimed to compare results for 2003 with those from the original 1972 survey, and with particular reference to the lorry-ban review, obtain up to date information on night-time noise levels and traffic levels. The results of the noise survey project are detailed in TRL Report PR/SE/773/03 Abbott (2003). Importantly, work additional to the noise survey has related night-time noise *disturbance* to traffic levels. This is in line with current EU thinking but represent the first attempt in this country to estimate the impact of changes in HGV traffic levels on Night-time noise disturbance. See Appendix A for details.
3. Assessment procedures.

Previous reviews of the extent of the Exempt Network did not include any assessment of the costs and benefits (monetary or not) of any change. The assessment approach set out below sets out a multi-criteria assessment of the impact of the proposed change to the Exempt Network. The criteria assessed are:

- Changes in operating costs
- Changes in working time
- Changes in air quality (CO₂, NO_x, and particulates (PM₁₀))
- Changes in noise nuisance

In line with the LSDP Working Party recommendations no attempt has been made to weight these criteria to produce an overall cost-benefit assessment.

2.3 Data Availability

Apart from any political considerations the main problem with assessing this proposal is the lack of data. There is a TfL Inner Cordon at the end of A4 on Brompton Road, but information on the use (count or travel survey) of the affected stretch of the A4 is lacking (as is current HGV travel on the main alternative route – Holland Road). Any assessment of this proposal needed to collect data on both the lorry travel patterns in the area, and general HGV count data.

2.4 Data Collection

2.4.1 Travel survey

As section 2.3 pointed out, there is a lack of information on the patterns of HGV travel within Central London and an absence of relevant traffic data for this particular corridor until Brompton Road. To obtain this information, TRL took the approach of distributing e-mail and fax surveys to commercial vehicle operator members belonging to either the FTA or the RHA. A previous working paper (Emmerson, 2003) clarifies in detail the background as to why this approach was adopted. In addition to the surveys, the registration numbers of all HGVs were recorded during the traffic count survey so that they could be traced in the LLCS permit data-base. This element of the survey was carried out to provide some validation of the results in light of concerns that they could be biased by size of operators.

The survey asked vehicle operators to provide routeing information concerning trips using the A4 Talgarth Road during the lorry ban hours of operation over the period of a week. From this information it was hoped to be able to plot the travel patterns of these vehicles and to estimate which trips

would consequently be re-assigned to the West Cross route if the A4 (Talgarth Road) were omitted from the Exempt Network.

The survey questionnaires were sent out to vehicle operators in April 2003 and three weeks were allowed for the return of the routeing information.

From the completed surveys, only 10 different routes were identified, despite 141 HGVs being counted during one weekday night-period covered by the ban. Therefore, each route represented nearly 14 vehicles per night. In addition, the majority of these routes represented food/supermarket deliveries, which appear to be over represented. Because of the small numbers of routes obtained, the validation exercise was of limited use for the purpose for which it was intended, but it did result in shedding light on some other issues.

Permission was obtained from DVLA to get the owner of the 106 HGVs which were noted during the validation exercise and the type of vehicle checked. It was revealed that only 37 vehicles could be identified as HGVs possessing LLCS permits, and a further 51 vehicles had been mis-identified as HGVs (that is the noted registration number of the HGV referred to a non-HGV). This highlighted the difficulty of using manual identification of registration number plates on fast dual carriage-ways at night, even with adequate lighting. It also highlights the fact that approximately 20% of HGVs were running without a valid permit.

2.4.2 Traffic data

In addition to the travel survey, night-time classified traffic counts were undertaken on one night, firstly on Talgarth Road and secondly on Holland Road (in conjunction with a noise survey), the main alternative. There was no existing traffic data for either road and the whole A4 sector is short of classified data at night. The traffic results revealed that 141 HGVs used the A4 (Talgarth Road) for accessing Central London during the the night-time ban period. The comparable number for Holland Road was 82 HGVs. The variation in flows are plotted in Figures 2.2 (Talgarth Rd) and Figure 2.3 (Holland Road). In both figures it is noticeable that the number of HGVs during most of the night is very low (< 5 per 30 minutes) but there is a steep increase in HGVs from about 4 to 5am and the impact is noticeable by 6am. The effect is most noticeable eastbound (in-bound) on the A4 and northbound on Holland Road (outbound).

**A4 Talgarth Rd.
Half-hourly night-time flows by direction**

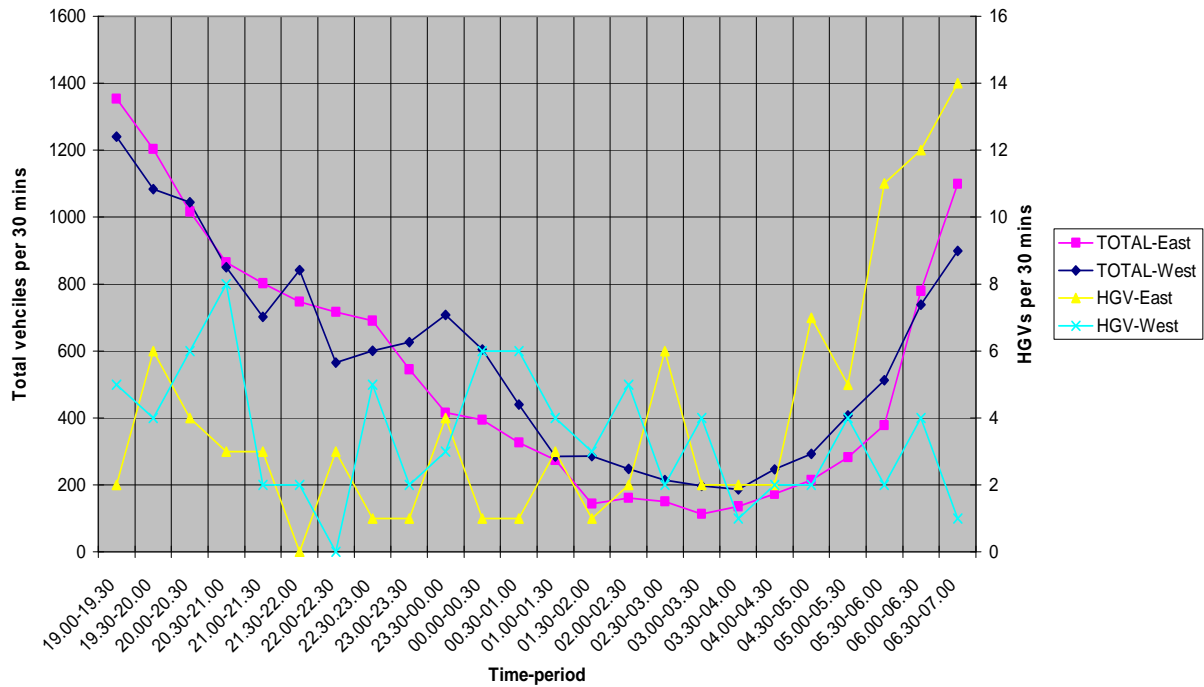


Figure 2.2: Night-time flows on A4 Talgarth Road

**Holland Road
Half-hourly night time flows**

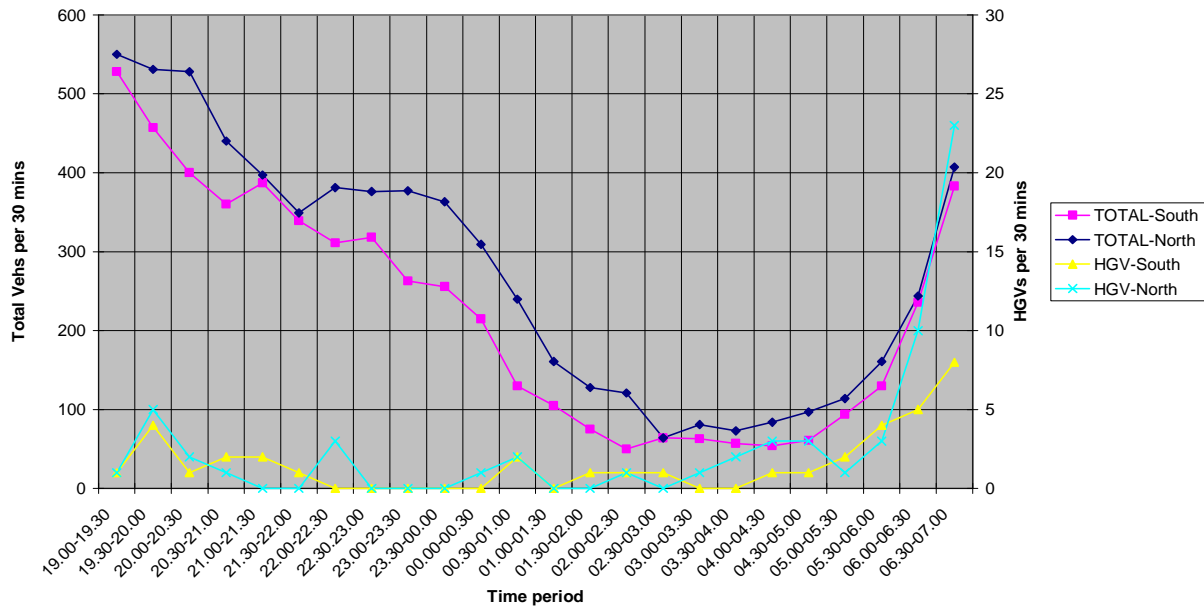


Figure 2.3: Night-time Flows on A3220 Holland Road

3 Assessment Methodology

3.1 Aims

The main aims for this part of the study were to:

- Pilot a number of different aspects of the assessment methodology; and
- Provide quantitative estimates of changes in a number of criteria that would be an aid to making a judgement on the merits of the proposed change to the Exempt Network. These criteria are set out in section 2.2 above.

To fulfil these aims, travel survey and traffic count data were collected (as set out in section 2.4 above).

3.2 Assessment approach

The approach to estimating the criteria was as follows:-

1. The routes obtained from the travel survey were plotted on a map and then for each route.
2. For each route, the total distance, time and costs were obtained, using Microsoft Autoroute and FTA operating cost per mile estimates, in order to determine costs for the current routes.
3. Each route was then tested in the situation where the A4 beyond the Hammersmith Flyover was omitted from the Exempt Network. Condition 5 was applied to each route to see if each route would need to use a different entry route. (Under Condition 5 the nearest entry point to the Exempt Network should normally be used). The alternative route tested in all cases was via the New Cross route from the Westway (although for other proposals there may be more than one alternative route). It was assumed that all journeys were made on an in-and-out basis, although the survey did show a few were part of a circuit of drop-offs.
4. Distance, costs and time of this alternative were costed in a similar fashion to the current route and used to derive the estimates for the different criteria.

3.2.1 Operating costs and working time

Changes in the operating costs were determined from the differences in the costs for routes that would alter, and factored up to a one year total. The values for the changes to drivers hours has been estimated using the DfT's TEN note which sets out the value of working time per type of vehicle to use in highway appraisal. The estimate was calculated in 1998 prices and upgraded to 2002 prices based on the change in GDP over the period.

3.2.2 Air Quality

The estimates of the changes in air quality emissions were obtained by using fixed emissions per kilometre, derived from the Department for Transport's (DfT) National Transport Model (based on year 2000, year 2002 version) and by using values for Inner London. The underlying equations are a function of speeds and the articulated/rigid vehicle split and derived from NETSEN data.

3.2.3 Noise impact

The estimation of the impact of the changes in noise for residents was not as straight forward as it was for other emissions. The adopted process had three separate stages. The impact of the change in the number of HGVs is translated into the change in night-time noise levels (*L_{night}* dB(A)). This was then used to estimate the change in the percentage change in 'highly sleep disturbed'. The combination of these two relationship is approximated as:

$$\% \text{ Change in highly sleep disturbed (\%HSD)} = A * 10 \text{LOG}((\text{Hafter}/\text{Hbefore}))$$

where : A is about 1.2% per dB(A) change in *L*_{night}

Hafter = number of heavies per period after

Hbefore = Number of heavies per period before

This is a simplified approach to what is a very complex problem and has the basic assumptions that:

1. At night the dominant noise source is from the heaviest vehicles.
2. The dose/response relationship is based on people's experience at home generally over long periods of time i.e. steady state conditions. Limited information is available about the dose/response relationship where noise changes over a relatively short period in terms of daytime levels. This information cannot easily be transferred to night-time conditions. However, it is likely that the relationship outlined above will underestimate people's response if the number of heavy vehicles is changed suddenly. The formulation is not ideal for the purposes of this study because it is based on a proportionate change, but for most roads in the area the total number of HGVs on the road at night is unknown. Appendix A sets out some of the background information behind these two stages.
3. The remaining information required is the number of residents affected. This is a difficult task as most sources of population data are not street based (e.g. the Census). Perhaps the most accurate method for the pilot case would be to use the electoral roll to estimate the number of electors registered to vote along each of the routes affected. Whilst this task is just about practical for the pilot area it is impractical for the larger proposals. There is also the need to see if particular addresses are in fact close enough to the road to be affected, inferring that a physical inspection of the routes would have to be carried out. After considering the alternatives it was decided to use as a factor, the length of frontage of residences that are affected by noise. After discussion with experts it was decided to include all residences within 20 metres of the road, including residences above shops and office. Residences were only excluded when there were physical barriers present, such as high walls. This was accomplished by videoing the main roads likely to be affected by an change in HGVs (those main roads in the sector of London bounded by Piccadilly, A40 (Hanger Lane), Chiswick (A406) and the A4.
4. The results were then tabulated by the number of frontage kilometres where a given change in percentage highly sleep disturbed was experienced.

4 Results

4.1 Changes in travel patterns

Of the ten routes surveyed, it was estimated that alteration would need to be made to five of them if Talgarth Road were removed from the Exempt Network (under Condition 5) and the Westway/Holland Road was used as an alternative access route. This equates to 50% of the HGV traffic, or 70 HGVs per night, being affected by the changes and required to switch routes. However the number of vehicles required to change their route proved to be very sensitive as to where the new end of the Exempt Network would be on the A4. If the end was sited another 100 yards to the western end of the Hammersmith flyover, it would result in all HGV traffic having to change routes. However, for the purposes of this study the original 50% will be assumed. The impact on the roads in West London is shown in Figure 4 below. The major change observed away from the two main roads is an increase of 42 HGVs using the North Circular.

4.2 Operator cost implications

Based on 50% of HGV traffic having to change access points, the change in costs for the operators has been estimated and is displayed in Table 4.1. It was assumed that the weekday night totals would be factored by 6 to give weekly totals. Table 4.1 shows that there would be significant changes to at least operating costs on average. In fact, of the 5 underlying routes that would be expected to change, one would benefit from the change whilst the other four would see increases of over 10% on all quantities. This is largely because half the routes surveyed came from the south-east using the South Circular, meaning that using the A40 instead of the A4 would increase journey distances.

Table 4.1: Impact of Change on Operator Costs

	Change	As percentage of current costs of all HGVs using Talgarth road
Distance (km per year)	55,429	5.2%
Time change (hours per year)	2,493	7.3%
Operating cost change £ per year	131,888	2.7%
Working time (£ per year)	35,446	7.3%

4.3 Air quality implications

The air quality impacts generally follow the distance impacts as they have been estimated on a per kilometre basis. The proposed change to the Exempt Network would lead to negative air quality emission impacts. The impacts of the proposal on air quality are shown in Table 4.2.

Table 4.2: Impact of Proposal on Air Quality

	Change
CO₂ emissions per year (tonnes per year-tailpipe)	+33,785
NO_x (tonnes per year)	+1,272
PM10 (tonnes per year)	+60

4.4 Noise implications

4.4.1 Impact on noise levels

The impact of the proposal on HGV flows is displayed in Appendix A. To estimate the impact that these changes will have on the night-time noise level, the simplified equation given in section 3.3.3 can be used. However, the form of the equation is such that it is the relative change in HGVs that impacts on residential disturbance. Of the network involved, little is known about the basic level of HGV noise. However, for a number of road links the base flows are unknown and for three of these, the impact of the change in HGVs has been calculated and is displayed in Table 4.3, based on the simplified equation.

Table 4.3: Illustrative Examples of the Impact of the Proposal on Night-Time Noise Disturbance

	A4 Talgarth Road	Holland Rd	A40 Western Avenue¹	A 406 Hanger Lane²
Current HGV night flow	141	82	356	374
'After' HGV night flow	70	138	426	430
% change in highly sleep disturbed	-3.65%	+2.71	+0.94%	0.73%

¹ based on 1999 data (2002 data now available)

² based on 2002 'VHGV' bin from TfL ATC site

It has been illustrated that the percentage change is quite small, even on the roads with the greatest absolute change (Holland Road and Talgarth Road). However, the simplified equation does have two major drawbacks. Firstly, it is based on the assumption that HGVs are the major source of night-time noise and therefore the equation is a function of a proportionate change, meaning that the equation is indeterminate when the estimated 'before' situation is zero (i.e. there are no HGVs). Secondly, the equation does not relate the absolute percentages already suffering from night-time disturbance.

4.4.2 Measuring residential frontages

The length of residential frontage was estimated using video surveys of the major roads involved and counting as residential frontage all building with residents (even if the lower floor(s) have another use) within 20 metres of the road and not screened by walls or thick vegetation. The videoing of Inner London streets was satisfactory, but problems with the videoing of the roads further out (A4, A406, and A40) means that the results on these routes are more approximate and based on additional evidence from Ordnance Survey 1:25,000 maps.

4.4.3 Impact of proposal on noise disturbance changes

The comprehensive estimation of the number of residents 'badly' affected by the proposed change has been adversely affected by the requirement for base situation HGV flows. It is possible to estimate the street frontage that would exhibit changes of greater than 2.5% in the number of 'severely' sleep disturbed residents, for those roads whose current HGV flows can be estimated. These are the A4 from Chiswick roundabout to Talgarth Road and the A40 (Western Avenue) from Hanger Lane to the West Cross route and down Holland Road. For other major roads affected, the

increase in the percentage with 'severely disturbed sleep' is much less. Estimates for the A406 North Circular between Chiswick and Hanger Lane are based on the TfL ATC count site which distinguishes 3 vehicle lengths and the longest bin will include bus and coaches as well as the goods vehicles over 18 tonnes (and a few under that weight). There are a number of roads where the percentage increase in 'severely disturbed sleep' residents is just below the 0.5% mark, notably Bayswater road and Kensington Gore. The impact on other roads, with no HGVs information cannot be gauged.

Table 4.4: Scale of Changes in the 'Severely Disturbed Sleep' Percentage

Scale of change in percentage severely sleep disturbed	Increase (km)	Decrease (Km)
0.5-2.5%	12.5	0.0
>2.5%	3.2	3.8

5 Conclusions

TRL initially recommended these proposed changes on efficiency grounds. It was anticipated that an increase in the demand for permits was unlikely and the net effects on the surrounding road network was expected to be small.

The survey work undertaken as part of this pilot study has shown that over half of the lorries would travel on the South Circular and none would take the North Circular route. This would imply that the proposed changes would result in an increase in lorry flows on the North Circular, the A40 and West Cross Route. As such, this proposal, based on the survey travel pattern, would give rise to an increased rather than a decrease in operating costs. In the light of the surveys and this assessment the economic efficiency of this proposal is doubtful.

The above conclusions are heavily based on the travel patterns of the 10 routes surveyed. It also highlights the need for a much higher sample of routes than 10 out of a daily average of 140 two-way HGVs vehicles per night. In this case, the whole operating cost and noise assessment is sensitive to:

- The true proportion of HGVs from the South Circular using the A4
- The precise point on the A4 at which to determine the Condition 5 ruling. In practice, the small differences in the distance travel from the Exempt Network to the destination may be sufficiently small for the LLCS permit to use the best of the two alternatives from the lorry operator's viewpoint.

6 Implications for Approach

Working through this assessment has highlighted a number of issues that need to be resolved before the approach can be recommended more widely:

1. There is a need for a large sample of routes on which to base the travel patterns, not so much for the travel patterns within Central London but for confidence on the routing pattern on the Exempt Network prior to leaving it.
2. There may be small differences between what the LLCS perceive as the 'best' route off the Exempt Network from that using standard routing tools. In granting permit routes the LLCS may take other aspects into account, but small differences in distances off the network should be accommodated if undue operating cost penalties result from a proposal (of course, virtually all the other proposals should lead to direct benefits to lorry operators with unknown environmental impact).
3. The simplified relationship between percentage change in residents with 'severely disturbed sleep' is not an ideal formulation for this work, where:
 - At night, HGVs may not be the major source of noise. (At the two Inner London sites of the 2003 Noise survey (Holland Road, and Seven Sisters Road) this was not the case. The consequent simplified relationship then breaks down when the current HGV flows tend to zero (or increase from zero)
 - The current formulation requires a base level of HGVs to be known. If they are known then usually a more detailed 3-way classification is available and a more accurate relationship can be adopted. For much of London there is very little data on night-time HGV movements.

Acknowledgements

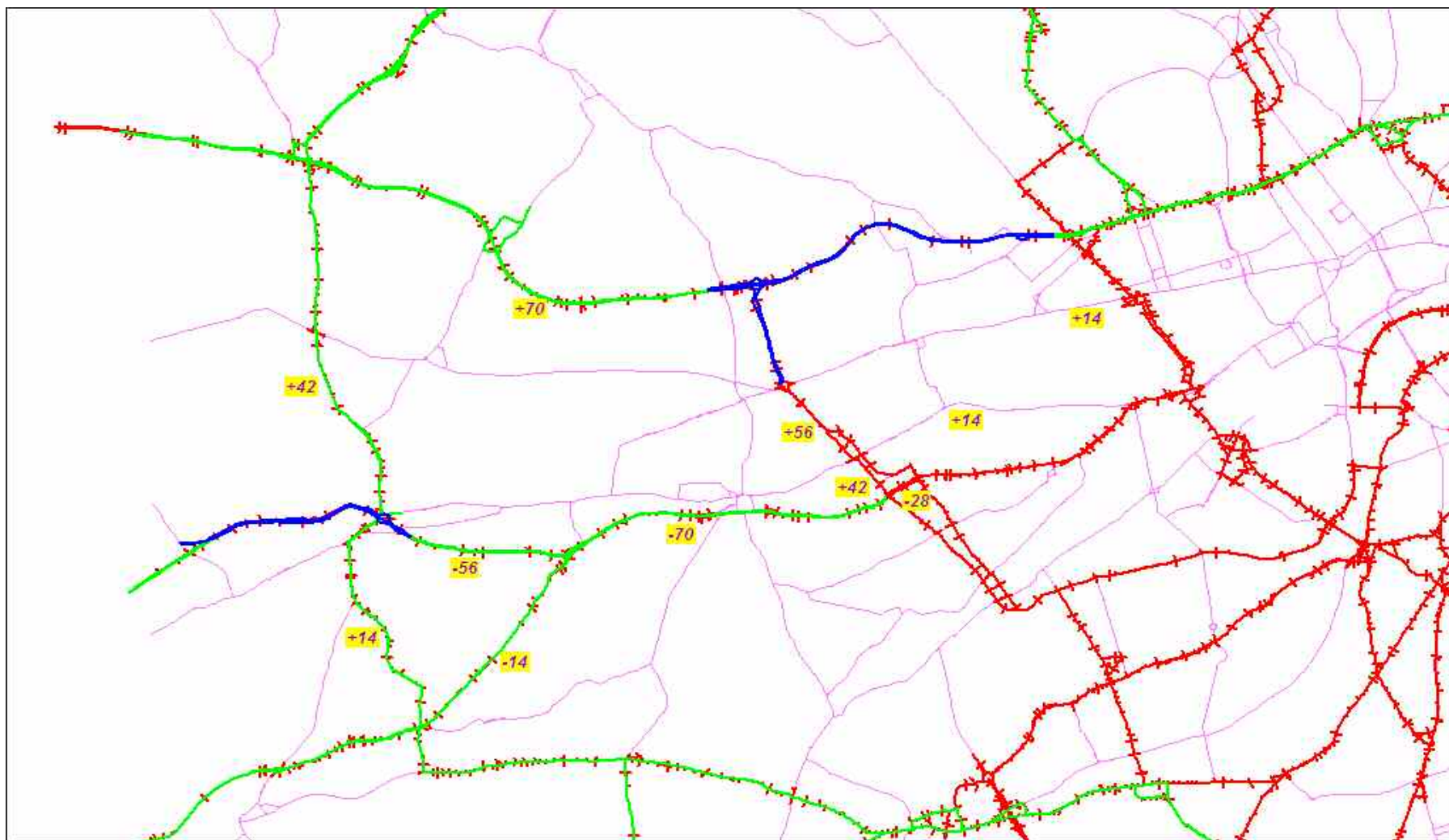
TRL acknowledges the support of the Freight Transport Association (FTA) and the Road Haulage Association (RHA) and the members of those organisations that responded to the survey.

References

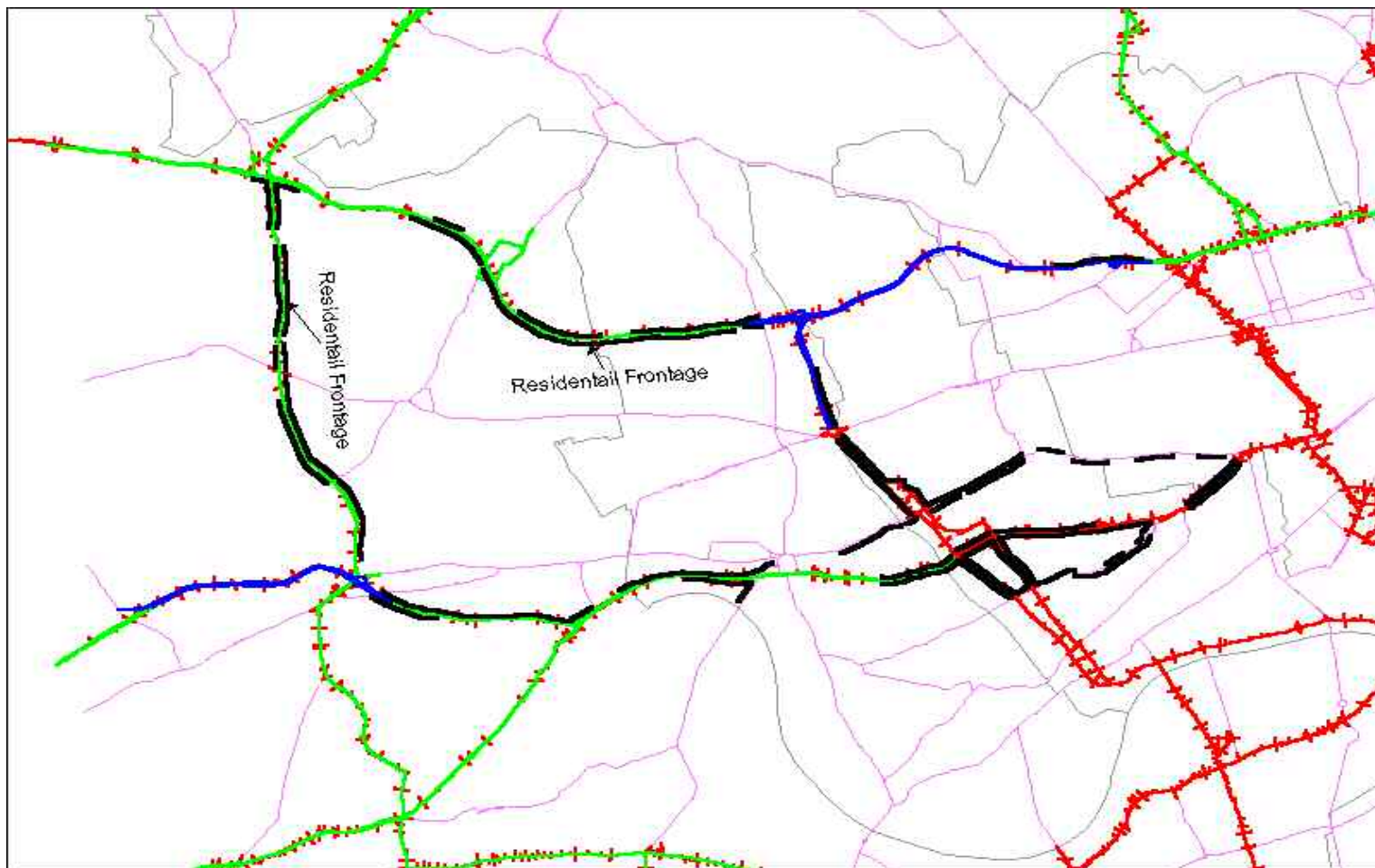
Abbot P (2003). Traffic noise in London - Estimated change in source noise over the past thirty years. TRL Unpublished Project Report, PR SE/773/03. (For Street Management, Transport for London), TRL, July 2003.

Emmerson P (2003) Review of the London Lorry Control Scheme: Recommendations Report Unpublished Project Report. TRL PR T/052/03. (For Street Management, Transport for London), TRL, May 2003.

Appendix A. Changes in night-time HGV flows from proposal



Appendix B. Extent of residential frontages in affected area



Appendix C. - Background to the Noise impact relationships

C.1 Introduction

Measures of the effects of transportation noise on people are described generally in terms of annoyance, sleep disturbance, and performance. Numerous surveys have been carried out to quantitatively measure the relationship between exposure and these effects. A comprehensive archive of this work has been published (Health Council of the Netherlands, 1997). A more limited exercise had been carried out by TRL for the Department of Transport when recommending the regulations for noise insulation for new railways (Department of Transport, 1991). More recently, preparations for a position paper on the relationship between the noise index, *L_{night}* dB(A), and sleep disturbance from transportation noise has been published (Miedema et al, 2003). The aim of this work carried out by the working group "Health and socio-economic aspects" was to make recommendations to the Noise Committee for revision to the recent EU Directive on the Assessment and Management of Environmental Noise. The following sections provide the dose/response relationship for sleep disturbance from night-time traffic noise as recommended in this recent report, the methodology used here to assess the change in sleep disturbance from changes in the night-time flow of heavy goods vehicles including the limitations in adopting this approach.

C.2 Dose/response relationship for sleep disturbance

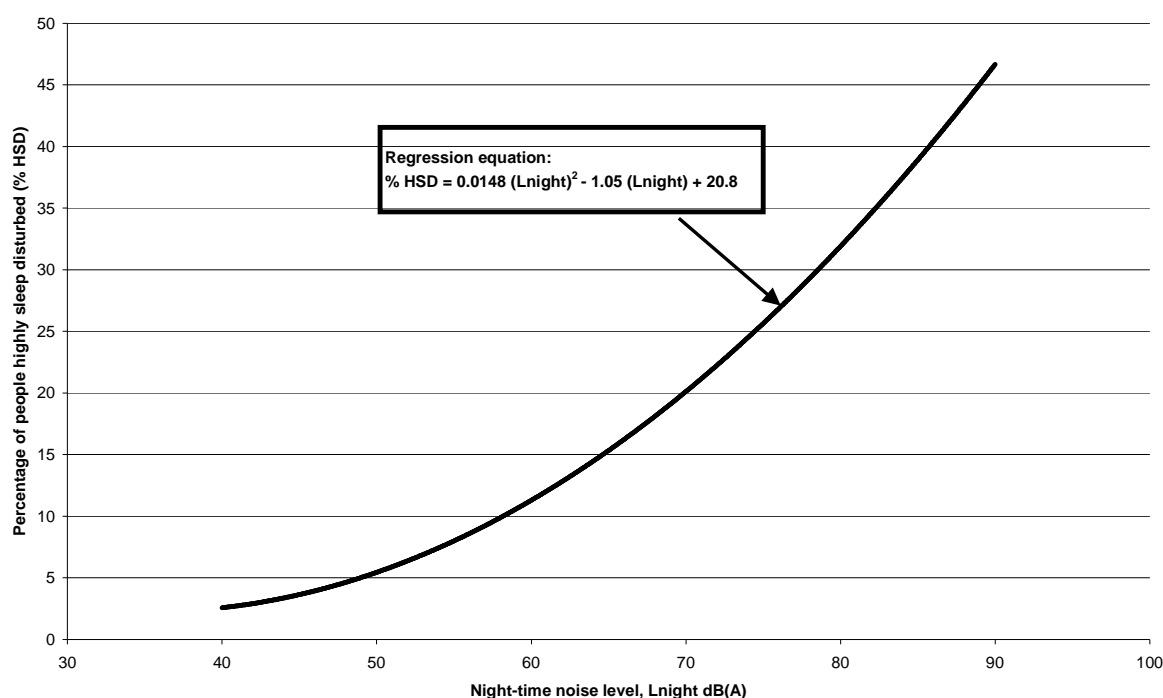


Figure A.1 Relationship between night-time noise, *L_{night}*, and a measure of sleep disturbance (% HSD)

Figure A.1 shows the recommended relationship between the percentage of people highly sleep disturbed (%HSD) and the incident noise from road traffic outside the most exposed façade of their home during the night-time period 23:00 to 07:00 (Miedema et al, 2003).

dB(A). For night-tim

This relationship was derived from a number of surveys carried out in different countries including the UK. The regression line shows that the change in %HSD with *L_{night}* varies from about 0.1% per dB(A) change in *L_{night}* at 40 dB(A) to 1.6% per dB(A) change in *L_{night}* at 90 e noise levels typical of

those measured recently in London as part of this work i.e about 75 dB(A), the rate of change in %HSD with *Lnight* is about 1.2% per dB(A) change in *Lnight*. For the purpose of this report this may be expressed as:

The rate of change in %HSD with *Lnight*, $A = 1.2\%$ per dB(A) A.1

By estimating the change in night-time noise levels due to changes in the night-time flow of heavies it is possible to use the above relationship to provide an estimate of the change in the percentage of people highly sleep disturbed. The following section describes the approach adopted to enable changes in night-time noise levels to be estimated.

C.3 Estimating change in night-time noise levels, *Lnight* dB(A), due to changes in heavy vehicle flows

Lnight is defined as the A-weighted average sound level over a year for the period 23:00 to 07:00 hours at the most exposed façade of a dwelling (European Communities, 2002). When the night-time noise is caused by separate events e.g. vehicle pass-bys, *Lnight* is the combined contribution of the individual sound exposure levels (*SEL*)¹ caused by these events averaged over the duration of the night-time period. Mathematically this may be expressed as:

$$L_{night} = 10 \text{ LOG } (\sum_i 10^{(SEL_i/10)} / 10512000) \quad \text{dB(A)} \quad \text{A.2}$$

Where 10512000 is the number of seconds in a year in the night period 23:00 to 07:00 hours and *SEL_i* is the sound exposure level of each individual noise event.

Equation A.1 can be simplified if we assume an average *SEL* value for all the N noise events that occur over the night-time period to give:

$$L_{night} = SEL + 10 \text{ LOG } N - 70.2 \quad \text{dB(A)} \quad \text{A.3}$$

If we further make the assumption that the dominant noise events during the night are from heavies we can estimate the change in *Lnight* from the following expression:

$$\text{Change in } L_{night} = 10 \text{ LOG } (\text{Hafter} / \text{Hbefore}) \quad \text{dB(A)} \quad \text{A.4}$$

Where *Hafter* = number of heavies per night-time period after

Hbefore = Number of heavies per night-time period before

C.4 Estimating the change in the % of people highly sleep disturbed

By combining equations A.1 and A.4 we have;

$$\% \text{ Change in highly sleep disturbed (\%HSD)} = A * 10 \text{ LOG } ((\text{Hafter} / \text{Hbefore})) \quad \text{A.5}$$

¹ The sound exposure level (*SEL*) is the level which if maintained constant over a period of 1 second would cause the same A-weighted sound energy to be received as the actual noise event.

which provides a simplistic measure in estimating the impact on sleep disturbance from changes in the night-time flow of heavy vehicles.

However, due to the simplistic approach of the method there are a number of issues that need to be clarified:

- In using the above formulation with respect to the London Lorry Control Scheme, differences in defining the start of the night-time period i.e 21:00 compared with 23:00 hours, will have only a small effect, providing the distribution of heavy vehicles across the night-time period is evenly distributed. (In fact the distribution of HGVs tends to higher between 5am and 7 am);
- It is assumed that the average *SEL* value for heavy vehicles does not change before and after the changes in night-time flows and that these pass-by noise events dominate overall traffic noise levels. Providing there are no significant changes in night-time flows from other vehicle categories this approach will overestimate the change in night-time noise level *L_{night}* and it is therefore likely to lead to an overestimation of the change in % of people highly sleep disturbed. To illustrate this problem section A5 describes the situation where the percentage of heavy vehicles in the traffic stream are low and compares the predicted change in % of people highly sleep disturbed based on the methodology described above with that where the noise from other vehicles in the traffic stream are taken into account.
- The dose/response relationship described in section A.2 is based on the results from surveys in which exposure has been approximately steady (Harland, 1977). However, some studies have measured nuisance changes associated with abrupt changes in traffic exposure (Griffiths and Raw, 1986) which may have more relevance to the type of scenario described in this report where changes in the exempt network would be introduced over a relatively short period of time. These studies have found that nuisance ratings change more than would be predicted from a relation between exposure and nuisance derived under "steady-state" conditions. The excess change in nuisance ratings appears to be more than simply a short-term effect with some studies showing the effects to persist for seven to nine years. Other studies have found little or no evidence of adaptation to traffic changes. Predictions using "steady-state" relations may therefore underestimate the impact where changes in night-time traffic flows are significantly altered over a relatively short time period.

C.5 Errors in the methodology when heavy vehicles flows are low

The methodology described in the previous section assumed that the pass-by noise events from heavy vehicles dominate overall traffic noise levels and that this is likely to lead to an overestimation of the change in % of people highly sleep disturbed. To illustrate this point the results of a noise survey carried out in Holland Road where traffic flows were also monitored will be examined (Abbott, 2003).

Table A.5.1 shows the predicted change in hourly noise levels, $L_{Aeq,1h}$ dB(A), after changes to the exempt network are introduced. Noise levels were derived from a noise model based on estimating vehicle noise levels (Noise Advisory Council, 1978). Using the traffic flow and composition of vehicles monitored during the noise survey carried out in Holland Road as input to the model, hourly noise levels during the period 21:00 to 07:00 hours were estimated to provide typical hourly noise levels prior to changes in the exempt network. This was repeated using the traffic flow and composition expected after introducing changes to the exempt network to derive the change in hourly noise levels.

Table A.5.1 Comparison of predicted changes in noise levels, *L_{night}*, in Holland Road

Time	Flow of heavy vehicles ¹		Predicted change in hourly noise levels
	(veh/h)		
	Before	After	$L_{Aeq,1h}$ dB(A)
21:00	3 (0.2)	6 (0.4)	0.0

22:00	3 (0.2)	6 (0.4)	0.0
23:00	0 (0.0)	0 (0.0)	0.0
00:00	5 (0.6)	9 (1.0)	0.1
01:00	1 (0.2)	2 (0.4)	0.0
02:00	3 (1.0)	6 (1.8)	0.2
03:00	3 (1.1)	6 (2.0)	0.2
04:00	8 (2.7)	15 (4.8)	0.4
05:00	10 (2.0)	19 (3.6)	0.3
06:00	46 (3.7)	85 (6.4)	0.6
<hr/>			
Total flow			
(21:00 - 07:00)	82 (1.0)	152 (1.9)	
Predicted change in <i>L_{night}</i>			0.2 (2.7) ²

¹Values in brackets are the flows of heavy vehicles expressed as a percentage of the total flow.

²Value in brackets is the predicted change in *L_{night}* assuming that the pass-by noise events from heavy vehicles dominate overall traffic noise levels.

The results in Table A.5.1 show that increasing the number of heavy vehicles during the night period 21:00 to 07:00 hours from 82 to 152 vehicles, the predicted change in the night-time noise level *L_{night}* would be 0.2 dB(A) compared with 2.7 dB(A) derived from the methodology assuming that the pass-by noise events from heavy vehicles dominate overall traffic noise levels. Although the number of heavy vehicles nearly doubled during the night-time period, the percentage of heavy vehicles in the traffic stream are very low, less than 2% and therefore do not contribute significantly to overall traffic noise levels. This example illustrates that the methodology used in this report will significantly overestimate changes in night time noise, *L_{night}*, where the percentage of heavy vehicles in the traffic stream are small.

C.6 References:

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