Standardised Traffic Inputs for the Operational Street Pollution Model (OSPM)

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Data sheet

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Abstract: A method has been developed for generation of standardised traffic input parameters for the Operational Street Pollution Model (OSPM) developed at the National Environmental Research Institute (NERI). The model requires as inputs: street configuration data, meteorological data, emission factors and traffic data. In many cases detailed traffic data (hour by hour) will not be available for a specific street and therefore standard profiles for variation in traffic has been developed.

Keywords: Generation of traffic inputs, temporal variation, OSPM, street air pollution model.

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Contents

Preface

The Operational Street Pollution Model (OSPM) was developed at the National Environmental Research Institute (NERI) for calculations of pollution levels in urban streets. The OSPM is a comprehensive and useful model tool for traffic planners and for different types of assessment studies.

The model requires as input street configuration data, emission factors and on an hourly basis data about meteorology, urban background concentrations and traffic. In many cases detailed traffic data will not be available for a specific street and therefore standard profiles for variation in traffic has to be applied.

The present report describes the generation og such standard profiles from traffic data provided by the Danish Road Directorate.

The generated traffic profiles will be used in the "Childhood Cancer Project" under the Danish National Environmental Research Programme, and in the authors Ph.D. study concerning human exposure modelling.

1 Introduction

1.1 The questionnaire of the Childhood Cancer Project

Childhood Cancer Project

The Childhood Cancer Project is an epidemiological study of 7,500 Danish children investigating the relationship between development of cancer and exposure to traffic air pollution during the childhood of the children (Raaschou-Nielsen et al. 1996).

Questionnaire

Questionnaires were issued to the municipalities to provide part of the required input data for the OSPM about the surrounding street and traffic environment of the children's home address. A copy of the questionnaire is presented in Appendix B.

The questionnaires give information about the Average Daily Traffic (ADT), the fraction of heavy traffic, the driving speed and the road authority of the streets in question (state, county or municipality). ADT is the total traffic load on a road during a year divided by 365.

1.2 Traffic Inputs for the Operational Street Pollution Model

OSPM

The OSPM calculates hourly pollution concentrations in urban streets. For these calculations static data (concerning the street configuration and emissions factors) and dynamic data (meteorology, urban background levels and traffic data) are needed as input. (Hertel and Berkowicz, 1989a,b,c; Berkowicz et al., 1997). A short description of the OSPM is presented in Vignatti et al. (1997) together with the calculation procedure for exposure calculations for the Childhood Cancer Project.

OSPM requires the traffic load on a hourly basis during the year for the vehicle categories: passenger cars incl. small vans (0-2 ton), vans incl. small lorries (light duty vehicles < 3.5 ton) and lorries (heavy duty vehicles > 3.5 ton).

The traffic loads at the children's addresses are given for a specific year. Very little information is available about the change over the years in the seasonal, weekly and diurnal variation of traffic and it is assumed that the temporal variation is the same from year to year.

To obtain information about the temporal variation of traffic, the Danish Road Directorate was requested to provide a traffic data set for 1994 with hourly values for various vehicle and road categories. The data was delivered as Excel spreadsheet files.

Scope

The scope of the present report is to generate the additional street and traffic input data which is not included in the questionnaire. These inputs include the street width, the temporal variation of traffic and cold starts.

Street Data — The street width is determined for different types of roads from the literature.

Traffic Data — Traffic parameters are used to estimate emissions applying emission factors for the different vehicle categories. The OSPM requires traffic data hour by hour for different vehicle categories (passenger cars, vans, lorries) and their mean travel speed. The temporal variation is divided into the diurnal variation on working days, Saturdays and Sundays with a separate diurnal variation during the holiday month of July.

Cold Starts — The OSPM also requires an estimate of the fraction of cold started petrol powered passenger cars which has been obtained from the literature.

2 Temporal Variation of Traffic

This chapter describes the method for generating the appropriate seasonal, weekly and diurnal variation of the various vehicle catagories.

2.1 Methodology

The methodology for estimating the temporal variation in traffic is illustrated in Figure 2.0.

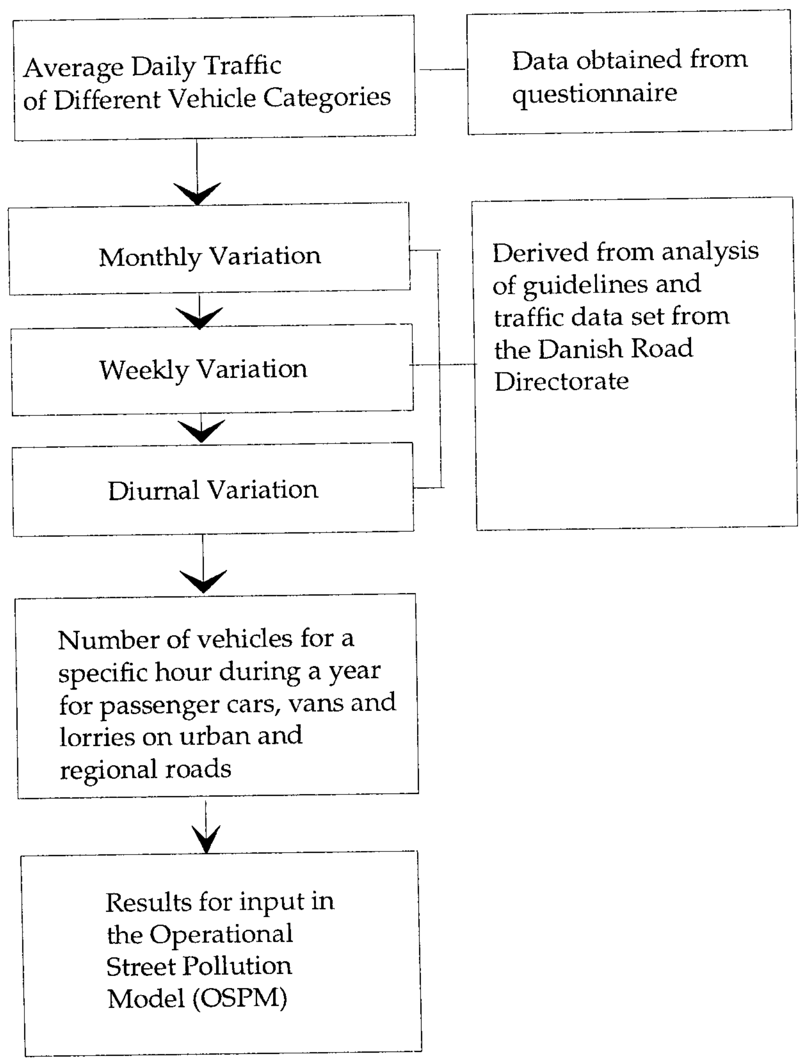

Figure 2.0 Diagram to illustrate the methodology for estimation of the temporal variation in traffic.

Obtained Traffic Information from the Road Directorate

The temporal variation of traffic is derived from two sources: a traffic data set from 1994 generated by the Road Sector Information System (VIS) and the report "Guidelines for Traffic Counts" both from the Danish Road Directorate.

The Danish Road Directorate operates about 80 permanent and 120 mobile traffic counting stations on the Danish road network with registration of the total traffic load on hourly basis. The majority of stations are located on the main roads and only a few on urban streets. To obtain information about the traffic loads of the various traffic categories periodic manual traffic counts are carried out. The traffic performance (km travelled) on the road network is modelled based on these measurements.

The traffic is classified in seven categories:

- home-work place traffic
- urban/local traffic
- regional traffic
- long-distant traffic
- moderate holiday traffic
- pronounced holiday traffic
- summer land traffic.

Traffic Data Set

The vehicle categories in the data set are:

- passenger cars incl. small vans and motorcycles < 2 tonnes
- vans and small lorries 2-3.5 tonnes
- lorries > 3.5 tonnes.

The road categories are:

- motorways
- other main roads
- urban streets.

Data from the Road Directorate includes the hourly traffic performance (km travelled) each day during the year for each road category and for each vehicle category.

The Road Directorate includes motorcycles in the category "passenger cars". Motorcycles are not included in the OSPM traffic input file. However, the numbers of motorcycles are insignificant and do not affect emission estimates. Otherwise, the categories correspond to the categories needed for the OSPM. In the category "vans and lorries" between 2 and 3.5 ton the majority of vehicles will be vans.

Busses are included in the category for vehicles with a weight above 3.5 tonnes. No attempt has been made to estimate the number of busses, since it will depend on the specific road.

The questionnaire provides information about the road authority (state, county or municipality). Motorways and other main roads will be either state or county roads and urban streets will usually be municipality roads but no clear distinction can be made based on the road authority. The speed limit on motorways, other main roads and urban streets is 110 km/h, 80 km/h and 50 km/h, respectively. The questionnaire only provides a rough categorisation of the speed at higher speeds since all speeds above 65 km/h are pooled. Therefore, no distinction can be made between motorways and other main roads. The length of the motorway system is short compared to other main roads and motorways are usually located at a distance of houses, therefore, we have assumed that all main roads are 80 km/h roads.

Representativeness

The Road Directorate has selected representative permanent traffic counting stations for the categories: motorways, other main roads, and urban streets. For the motorways one station for each of the seven traffic groups were selected. However, the data from motorways were not used for the above reasons. For other main roads one representative station from the category "regional traffic" was selected (Køgebugtmotorvejen at Ølby, Road 10, km 35.100) and for urban streets one representative station from the category "urban/local traffic" was selected (Motorringvejen at Husum, Road 3, km 44.820).

Both stations selected to represent main roads and urban streets are located on motorways. However, the Road Directorate has selected the stations based on an assessment of their representativity for the temporal variation in traffic. The data represents the best judgement of the Road Directorate for the temporal variation in traffic for the type of roads in question based on the available permanent stations. The measurement of the Road Directorate is likely to be biased towards the main road network and there is no central authority that systematicly collect data on the temporal variation of low trafficked urban streets. A few municipalities collect information on the temporal variation of traffic on selected busy streets.

The Road Directorate has provided the temporal variation of the national traffic performance (traffic times length) of 1994 for the three vehicle categories and three road categories. The traffic performance is derived by assuming that the temporal variation in the national traffic performance is equal to the traffic performance at the selected representative permanent stations. Therefore, the data simply reflects the temporal variation at the selected stations.

In the data set the Road Directorate has assumed the same diurnal variation for the various vehicle categories. However, there is a distinct difference in the temporal variation of passenger cars compared to vans and lorries.

For the diurnal variation in the number of passenger cars the diurnal variation in total traffic is used, since passenger cars constitutes the majority of the traffic. The diurnal variation in vans and lorries has be based on "Guidelines for Traffic Counts" (Vejdirektoratet 1995).

Guidelines for Traffic Counts

The Danish Road Directorate has issued guidelines to the municipalities and counties for manual traffic counts (Vejdirektoratet, 1995). Based on traffic counts a few hours during 6-18 of a working day it is possible to extrapolate to diurnal traffic, from diurnal traffic to weekly traffic, and from weekly traffic to ADT. The guidelines are based on statistical analysis of the various traffic counts carried out by the Road Directorate. Extrapolations are possible for various vehicle categories, among others, passenger cars, vans and lorries.

The material is useful to generate the temporal variation in traffic, since our approach is the exact opposite, we have ADT and we aim at extrapolating seasonal, weekly and diurnal variations. The quidelines do not provide information of the diurnal variation during the evening and night (18-6) on working days and no information is given on the diurnal variation in traffic on Saturdays and Sundays.

The "Guidelines for traffic counts" have been used to generate the seasonal and weekly variation in the various vehicle categories and the diurnal variation in the number of vans and lorries. However, the diurnal variation of vans and lorries from 12 to 6 has been assumed to be similar to that of passenger cars.

2.2 Average Daily Traffic

The questionaire gives ADT and the fraction of heavy vehicles, but OSPM requires the number of passenger cars, vans and lorries.

The fraction of traffic performance for passenger cars, vans and lorries is the same for urban streets (50 km/h) and other main roads (80 km/h) in the traffic data set from the Road Directorate, namely 82%, 11% and 7% respectively.

This implies that the number of passenger cars, vans and lorries as ADT is calculated in the following way:
N_PasCars = (ADT-N_Lorries) x 0.88
N_Vans = (ADT-N_Lorries) x 0.12
N_Lorries = ADT x F_Heavy.

Where:
F_Heavy is the fraction of heavy vehicles of ADT
N_Vans is the number of vans
N_PasCars is the number of passenger cars
N_Lorries is the number of lorries

Especially urban roads with very low traffic are likely to carry less vans and lorries than indicated above.

2.3 Monthly Variation

The monthly variation in the various vehicle categories on urban and regional roads is based on the "Guidelines for traffic counts" (Vejdirektoratet 1995), and visualized in Figure 2.1 (the values are given in Table 1 in Appendix A). The original data is given on a weekly basis as a factor by which weekly traffic is multiplied to give ADT. In Figure 2.1 the opposite factor but on monthly basis is given. The monthly factor times ADT gives the mean diurnal traffic for a specific month.

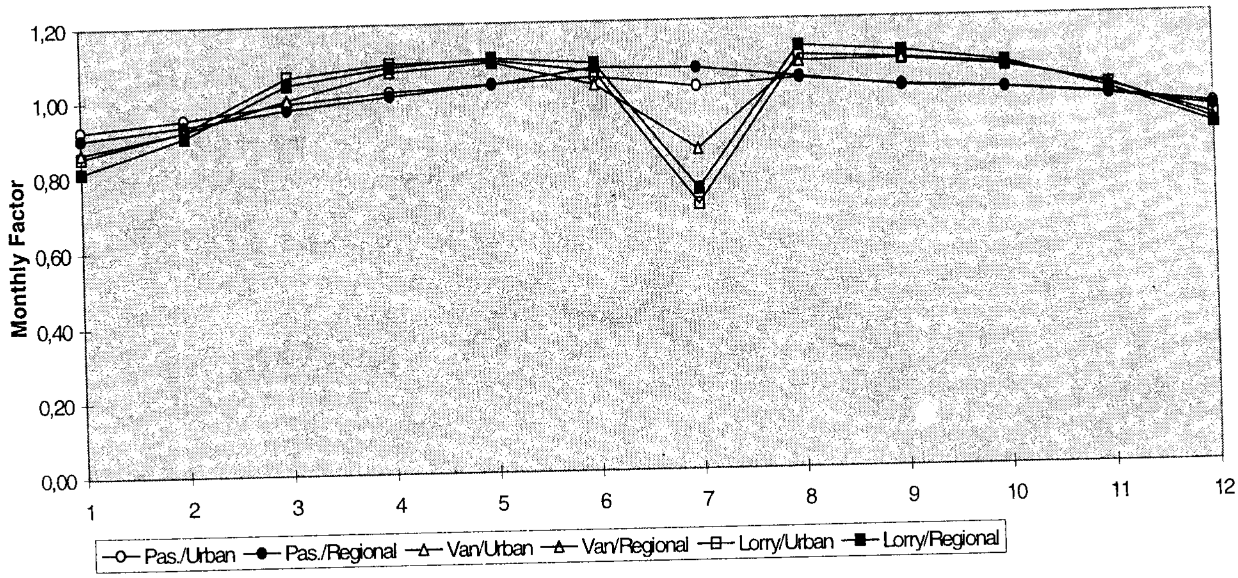

Figure 2.1 The seasonal variation in passenger cars, vans and lorries on urban and regional roads. The monthly factor times ADT gives the mean diurnal traffic for a specific month.

There are only minor differences between urban and regional roads for the various vehicle categories. For vans and lorries there is a seasonal variation with lower levels during winther months and higher levels during spring and autumn with a minimum in July. A minimum in July is not seen for passenger cars probably because an increase in holiday traffic neutralizes the decrease in home - workplace traffic. The relatively low amount of vans and lorries in July is probably due to holiday leaves. Sligthly higher traffic levels during spring and autumn compared to winther is probably due to the weather conditions that affect outdoor economic and social activities.

To limit the number of calculations, only the marked difference in the monthly variation of july will be taken into account, see Table 2.1.

Table 2.1 Traffic reduction in July compared to Average Daily Traffic (%)

Vehicle Category	Urban roads	Regional roads
Passenger cars	0	0
Vans	14	14
Lorries	29	25

The reduction in traffic for July for vans and lorries should in principle increase traffic during other months to keep the annual traffic constant. However, the increase for the other months is neglectable.

The monthly variation is calculated in the following way:
N_PasCars = N_PasCars
N_Vans_July = 0.86 x N_Vans
N_Vans_Not July = N_Vans
N_Lorries_Urban_july = 0.71 x N_Lorries
N_Lorries_Urban_Not July = N_Lorries
N_Lorries_Regional_July = 0.75 x N_Lorries
N_Lorries_Regional_Not July = N_Lorries.

Where urban and regional refer to urban and regional roads, respectively. July refers to the month of July and Not July refers to all other months than July.

2.4 Weekly Variation

Table 2.2 shows the weekly distribution of traffic for the various vehicle categories generated from Vejdirektoratet (1995). This reference gives factors on how to extrapolate from working days (Monday through Friday) to an average weekday (Monday through Sunday). The factors that have been used to generate distribution of traffic over the week.

Based on Vejdirektoratet (1995) it is only possible to derive the fraction of traffic during the week-end (Saturday and Sunday). The traffic data set from 1994 showed almost the same traffic levels on Saturdays and Sundays for all traffic. Therefore traffic loads are assumed semilar for Saturdays and Sundays. However, for vans and lorries there may be a difference between Saturdays and Sundays because their is little commercial activities on Sundays. There is almost no difference between urban and regional roads and the weekly variation is assumed to the same for both types of roads.

Table 2.2 The Weekly Distribution of Traffic (%)

Vehicle Category	Working days	Saturdays	Sundays	All
Passenger Cars	75	12.5	12.5	100
Vans	89	5.5	5.5	100
Lorries	97	1.5	1.5	100

The number of passenger cars are only sligthly lower during Saturdays and Sundays compared to a working day. For vans and lorries almost all traffic is on working days. Assuming that the percentage of passenger cars, vans and lorries are 82%, 11% and 7%, respectively, about 78% of the total load of traffic is on working days and about 22% is during the weekend. This implies that traffic levels are about 30% lower on weekends compared to working days.

However, much larger difference in traffic during working days and weekends may be seen. For the traffic data set of 1994 levels during weekends are about half of the levels during working days, see Appendix A, Figure 1A and 1B. However, the traffic counting station that is an indicator for urban roads is likely to be dominated by home - workplace traffic.

Based on the figures in Table 2.2 a weekly factor has been derived in a way that the number of passenger cars, vans or lorries on either working days, Saturdays or Sundays can be calculated on the basis on the previously estimated mean diurnal traffic for passenger cars, vans or lorries during July and other months, see Table 2.3. For example, the weekly factor for vans during working days is derived in the following way: (89%*7)/5=1.25. The weekly variation during July and other months is assumed to be similar.

Table 2.3 Weekly Factors for Various Vehicle Categories

Vehicle Category	Working days	Saturdays	Sundays
Passenger cars	1.05	0.875	0.875
Vans	1.25	0.385	0.385
Lorries	1.36	0.105	0.105

E.g. the number of vans on a working day in July is 1.25 times the mean diurnal number of vans in July estimated in section 2.3.

2.5 Diurnal Variation

Weekly Variation

Passenger Cars

The diurnal variation of passenger cars on urban roads broken down by working days, Saturdays and Sundays during the year (except July) is shown in Figure 2.2. Hour number one is from 0000 to 0100.

The diurnal variation of passenger cars is based on analysis of the traffic data set from 1994 provided by the Road Directorate. The data set covers total traffic including passenger cars, vans and lorries. However, passenger cars constitute about 80 % of total traffic loads therefore the diurnal variation of total traffic will be close to the diurnal variation of passenger cars.

There is a marked difference between the diurnal variation on working days, Saturdays and Sundays. During working days there are distrinct rush hours in the morning and afternoon due to home - workplace traffic. A similar diurnal variation is seen for various permanent traffic counting stations in Copenhagen, see Figure 2 in Appendix A. The weekend traffic is more levelled out and dominated by traffic directed to shopping and social activities.

Variation on working days

The difference in the diurnal variation for working days was analysed for total traffic on urban roads. The diurnal variation on Mondays, Tuesdays, Wednesdays and Thursdays was almost identical, see Figure 3 in Appendix A. Fridays had a slightly different diurnal variation with a more smooth and earlier afternoon rush hour peak than the other working days. This minor difference has not been taken into account and the diurnal variation of all working days has been assumed to be the same.

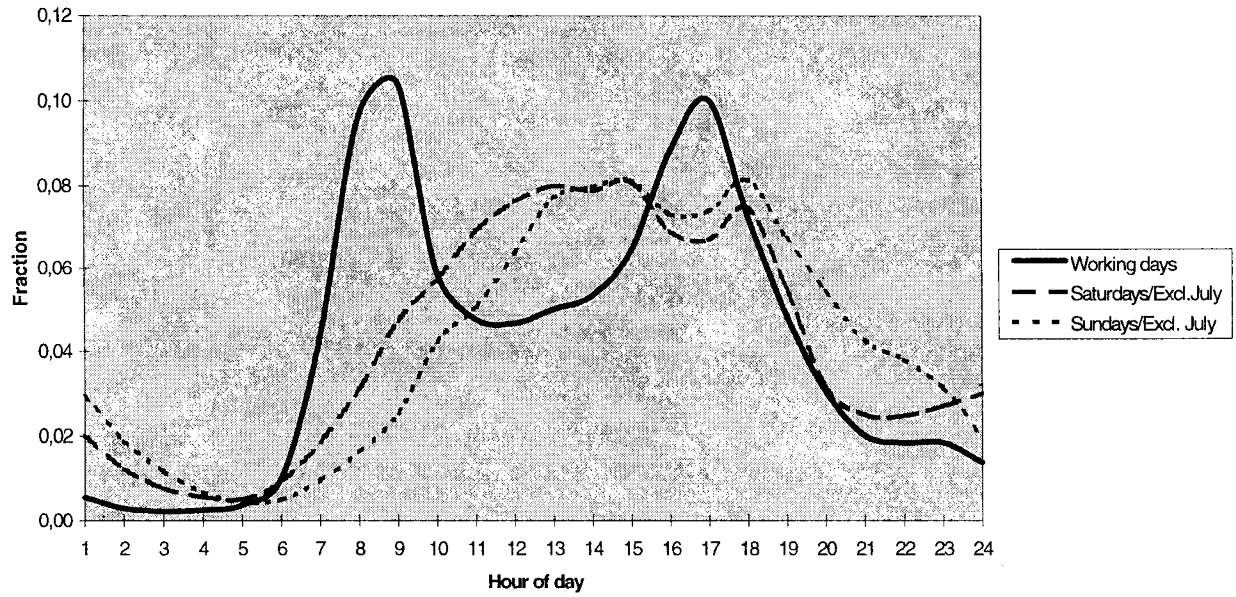

Figure 2.2 The diurnal variation in passenger cars on urban roads on working days, Saturdays and Sundays during the year (except July).

Monthly Variation

For working days the difference between the diurnal variation of July and the rest of the year is illustrated in Figure 2.3 for passenger cars. The difference is relatively small. The holiday month of July has less pronounced rush hours; and traffic around noon, in the evening and during the night is slightly higher. The largest difference is found during the morning rush hours where July has about 15% less traffic than the rest of the months.

For Saturdays and Sundays the difference between July and the rest of the year is shown in Figure 2.4 and 2.5, respectively. During the weekend there is a clear difference in the diurnal variation between July and the rest of the year. From noon to about seven o'clock in the evening traffic is less during July compared to the rest of the year and traffic is also higher during the evening.

Urban and Regional Roads

The difference between the diurnal variation on urban and regional roads is shown in Figures 2.6, 2.7 and 2.8 for working days, Saturdays and Sundays, respectively. The difference is relatively small. The largest difference is found during the morning rush hours on working days where regional roads have about 30% less traffic than urban roads.

The figures of the diurnal variation in passenger cars during working days, Saturdays and Sundays during July and the rest of the year are given in Appendix A, Table 2.

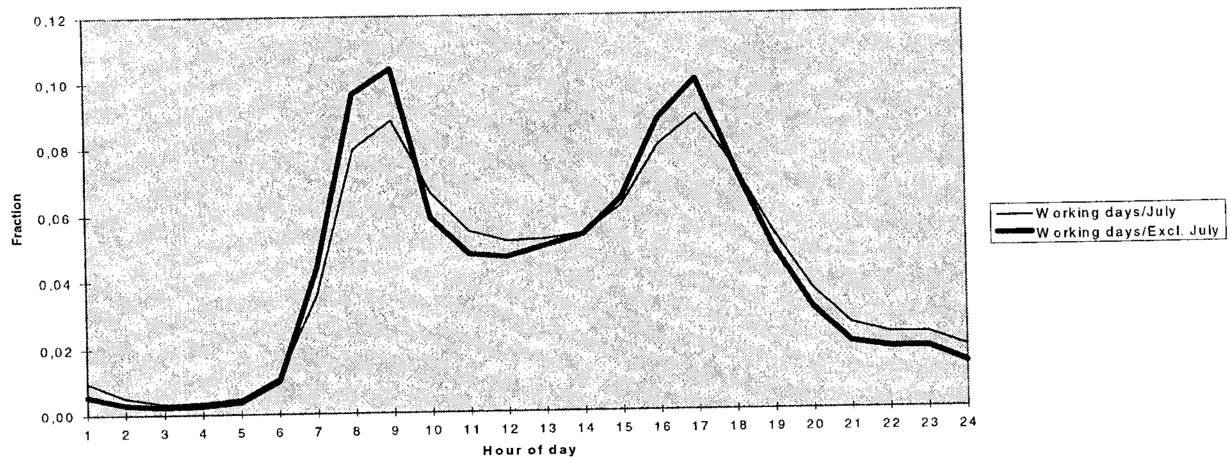

Figure 2.3 Diurnal variation in passenger cars on urban roads during working days in July and the rest of the year.

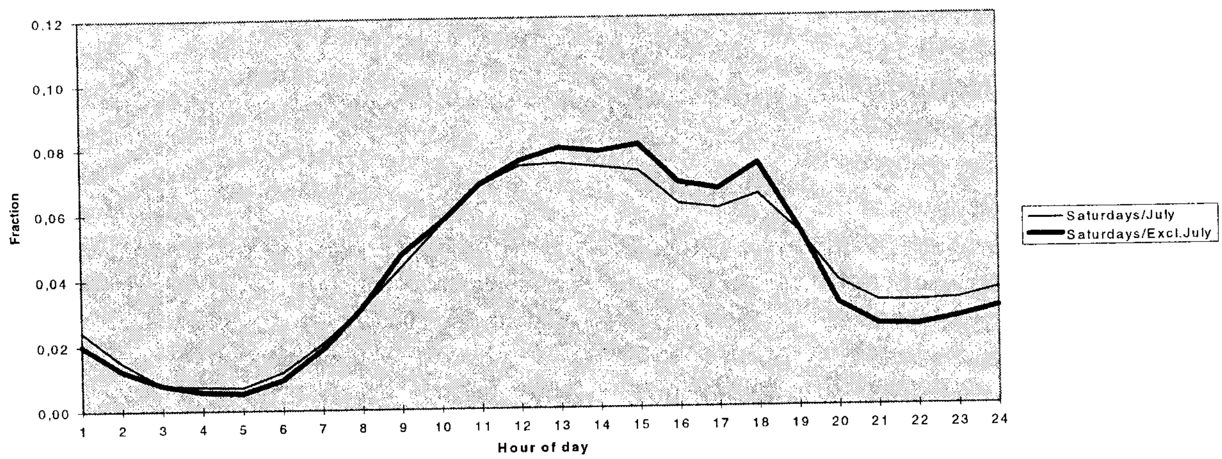

Figure 2.4 Diurnal variation in passenger cars on urban roads during Saturdays in July and the rest of the year.

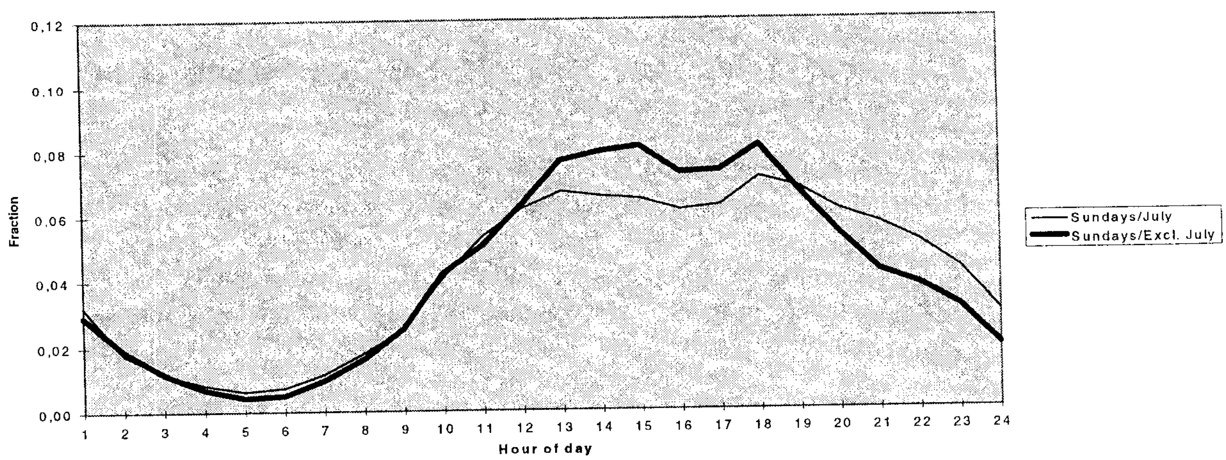

Figure 2.5 Diurnal variation in passenger cars on urban roads during Sundays in July and the rest of the year.

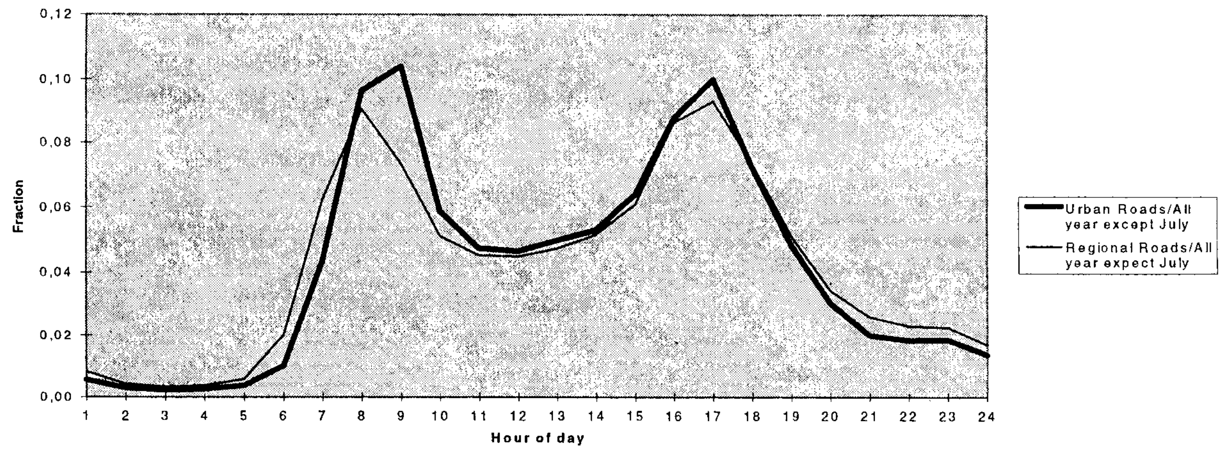

Figure 2.6 The difference between the diurnal variation on urban and regional roads for passenger cars during working days.

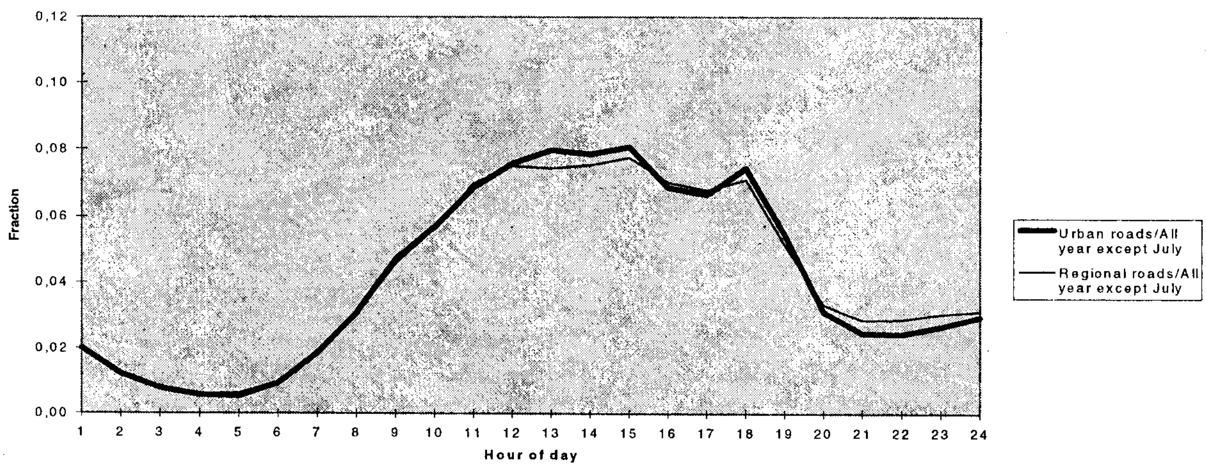

Figure 2.7 The difference between the diurnal variation on urban and regional roads for passenger cars during Saturdays.

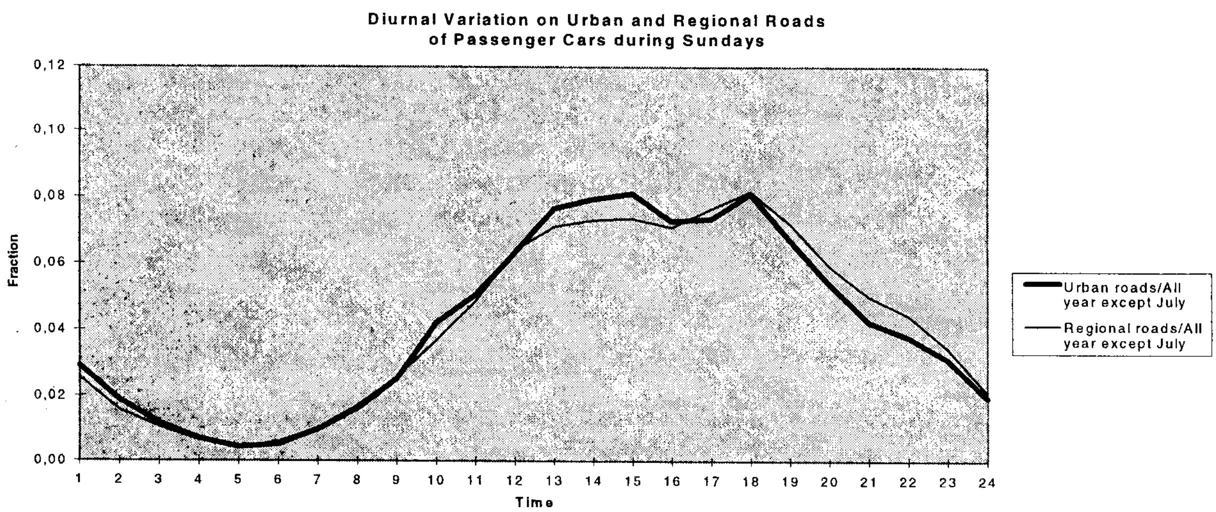

Figure 2.8 The difference between the diurnal variation on urban and regional roads for passenger cars during Sundays.

Weekly Variation

Vans and lorries

The diurnal variation in number of vans and lorries on urban roads is shown in Figure 2.9 including the diurnal variation in passenger cars as a reference.

The diurnal variation of vans and lorries is based on "Guidelines for traffic counts" (Vejdirektoratet 1995). The guidelines only cover working days during 6-18. For vans and lorries on urban and regional roads the traffic load within this period is in the range of 82% to 94%. To obtain the diurnal variation from 18-6 it is assumed that the diurnal variation of vans and lorries is similar to that of passenger cars. The diurnal variation during Saturdays and Sundays is definitely different from working days. However, the traffic loads are very low for vans and lorries during Saturdays and Sundays, and it is simply assumed that the diurnal variation of vans and lorries is the same every day of the week.

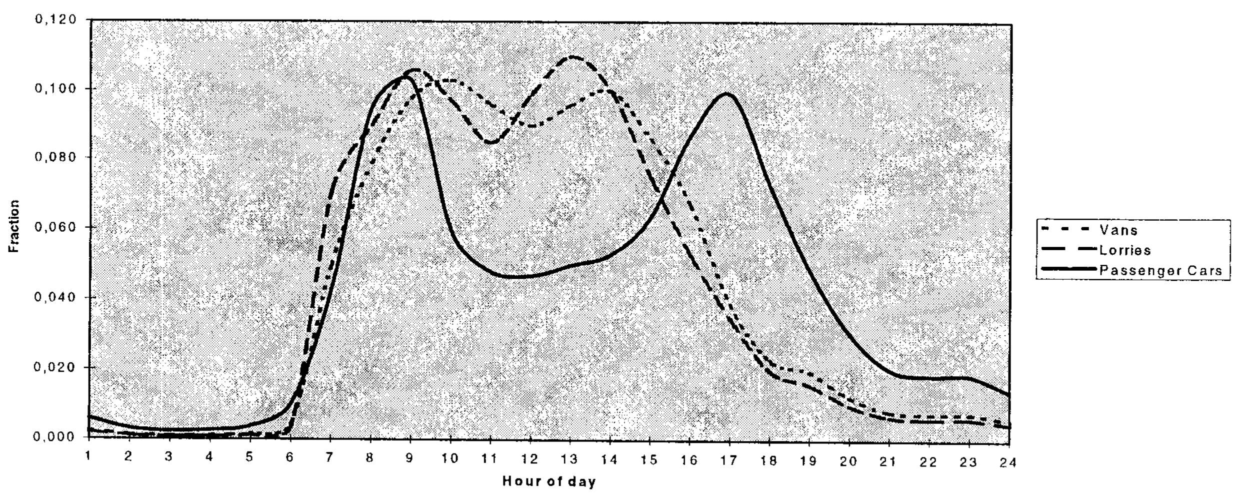

Figure 2.9 Diurnal variation in passenger cars, vans and lorries on urban roads during working days. For vans and lorries the diurnal variation from 18-6 is assumed to be similar to that of passenger cars.

The diurnal variation in the number of vans and lorries is relatively equal and considerably different from the diurnal variation in passenger cars. The morning rush hours appear a little later and the afternoon rush hours very early compared to that of passenger cars. There is more traffic during the day and less during the late afternoon and evening. The main part of the traffic appears during normal working hours.

Urban and Regional Roads

The difference between the diurnal variation in vans and lorries on urban and regional roads is shown in Figures 2.10 and 2.11.

There is a marked difference between the diurnal variation on urban and regional roads for both vans and lorries. On regional roads there are no clear rush hours and more traffic is carried out during the evening. The more even diurnal variation in vans and lorries on regional roads is due to more long-distance traffic.

2.6 An Example of the Calculation Procedure

The following is an example of the calculation procedure for estimating the temporal variation in traffic.

On the assumption that an urban road has an ADT of 10.000 vehicles of which 10% are lorries, we want to determine the load of passenger cars on Saturdays in July between 10 and 11 o'clock.

ADT of Various Vehicle Categories and monthly Variation

ADT of the various vehicle categories are given below based on section 2.2 and section 2.3:

Table 2.4 ADT og Various Vehicle Categories and Monthly Variation

Vehicle Category	Traffic Load All Year	Traffic Load in July
Passenger cars	7,920	7,920
Vans	1,080	929
Lorries	1,000	710
Total	10,000	9,559

Weekly Variation

Based on section 2.4 the traffic loads on the various days of the week during July are:

Table 2.5 Weekly Variation

Vehicle Category	Working days	Saturdays	Sundays	Mean Day of Week
Passenger cars	8,316	6,930	6,930	7,920
Vans	1,116	358	358	929
Lorries	966	75	75	710
Total	10,443	7,363	7,363	9,559

Diurnal Variation

In Table 2 in Appendix A the fraction of passenger cars of the diurnal traffic load on urban roads on Saturdays in July between 10 and 11 o'clock is 0.068 or 471 passenger cars.

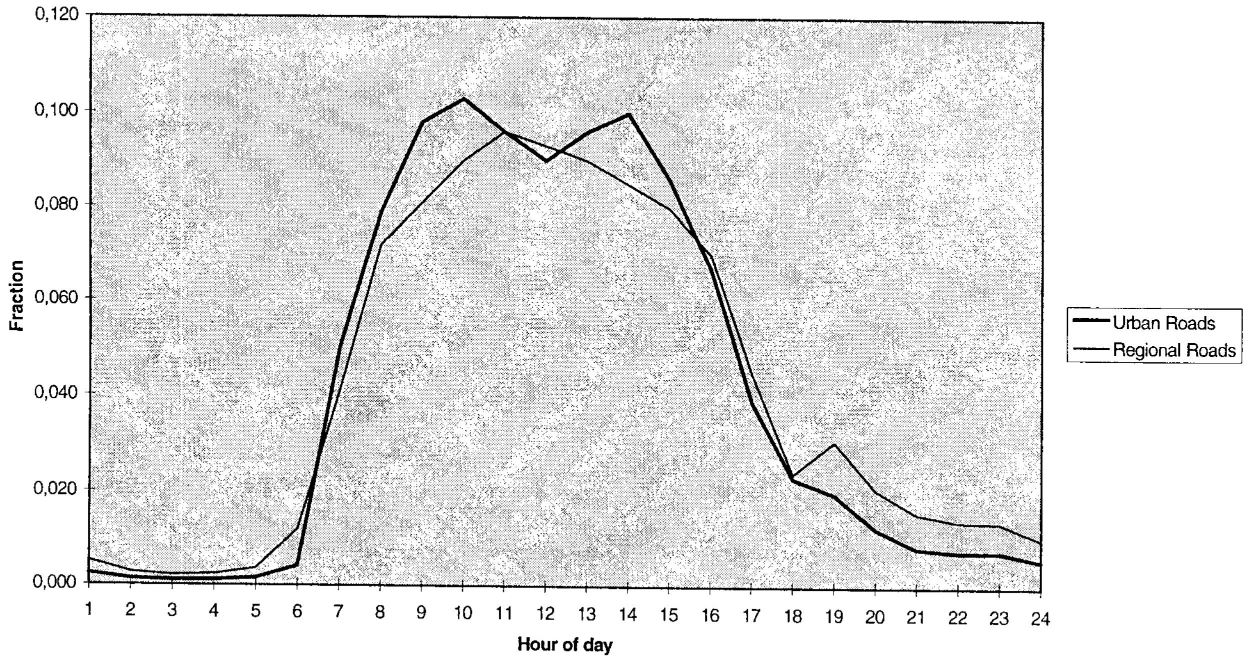

Figure 2.10 Difference between the diurnal variation in vans during working days on urban and regional roads.

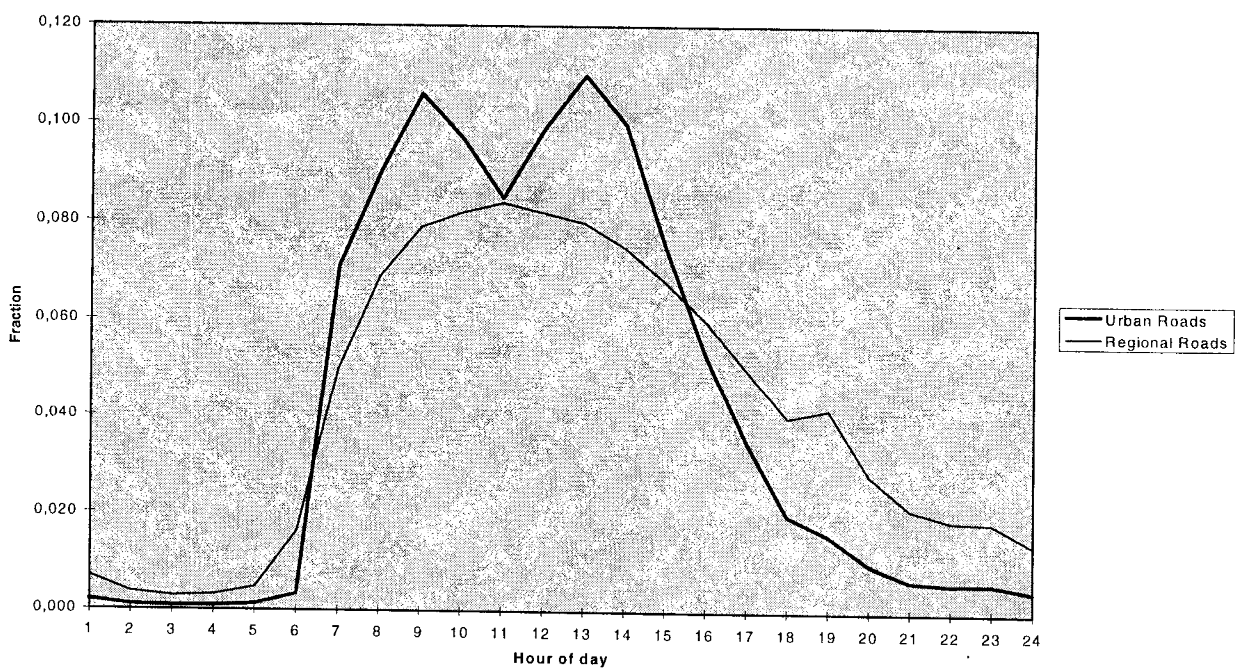

Figure 2.11 Difference between the diurnal variation in lorries during working days on urban and regional roads.

3 Diurnal Variation in Cold Started Passenger Cars

The percentage of cold started petrol powered passenger cars is one of the input parametres that is used to estimate traffic emissions in the OSPM model. A cold started vehicle is defined as an engine that has been running for less than 2.5 minutes and it has not been operating the last 2 hours before starting.

In the Childhood Cancer Project we have information on the type of street (state, county or municipality), ADT and speed. The diurnal variation in cold started passenger cars has to be derived from these parameters.

Data Assessment

Only few studies have been carried out concerning cold start for different Danish road types. The few studies have been summarized by the Danish Road Directorate (Vejdirektoratet, 1994b). A summary of studies based on postcard questionnaires given to drivers at selected streets in three middle-sized cities in Denmark (Roskilde, Køge and Hillerød) is shown in Table 3.1.

Table 3.1 Percentage of Cold Started Petrol Powered Passenger Cars in Different Streets during 7-11 and 14-18 on Working days

Type of Road:	ADT	No. of streets	7-8	8-9	9-10	10-11	14-15	15-16	16-17	17-18
Through roads / Arterial roads	8.000-10.000	5	8	5	2	3	7	5	9	5
City centre streets	7.000-9.000	3	11	14	7	8	9	7	12	5
Residential Streets	1.500-3.000	4	51	36	28	33	-		-	-
Street in industrial zone	1.000-4.000	4	-		-	-	30	41	51	38

The studies only cover working days during 7-11 and 14-18. It is not possible to derive a monthly or weekly variation from the data. Since the data is limited, the uncertainty concerning the variation in cold starts is large. It seems as the percentage of cold starts is higher during morning and afternoon rush hours than outside rush hours. Furthermore, low traffic streets in residential areas have a high percentage of cold starts.

Results

For municipality streets with less than 3.000 ADT we will assume that the cold starts are as for residential streets, and for municipality streets with more than 3.000 ADT we will assume that cold starts are as an average of through roads and city centre streets.

For state and county roads with low speed (less than 65 km/h) cold starts are assumed to be similar to urban conditions with more than 3.000 ADT.

For speeds above 65 km/h on state and county roads no cold starts are assumed since the roads are likely to be in rural settings. The assumptions are summarized in Table 3.2.

Table 3.2 Diurnal Variation of Cold Starts (%)

Type of Road	Within Rush Hours (7-8 & 16-17)	Outside Rush Hours (18-6 & 9-15)
Municipality roads (ADT< 3.000)	50	30
Municipality roads (ADT> 3.000)	10	6
County and state roads (speed < 65 km/h)	10	6
County and state roads (speed > 65 km/h)	0	0

4 Estimation of Street Width

The width of the carriageway is an importent input parameter for OSPM. In the model it is assumed that the traffic emission is uniformly distributed over the width of the street. In the following the width of the carriageway is estimated in a way that it is possible to generate the excepted width from the available information in the questionnaire.

4.1 Rural Areas

The Danish Road Directorate has established guidelines for design of roads in rural areas (Vejdirektoratet, 1981). In Table 4.1 the width of the carriageway has been related to the Average Daily Traffic based on these guidelines and these associations will be used to estimated the width of the carriageway for the state and county roads.

Table 4.1 The expected width of the carriage in rural areas as a function of the Average Daily Traffic (ADT).

Average Daily Traffic (ADT)	Expected Width of Carriageway in Rural Areas (meters)
0 < ADT <= 7,000	6
7,000 < ADT <= 11,000	8
11,000 < ADT <= 18,000	11
18,000 < ADT	18

Note: For ADT between 7,000 and 18,000 the carriageway is incl. the edge and for ADT above 18,000 the carriageway is incl. the edge and the centre strip.

4.2 Urban Areas

In the design guidelines for urban areas the width of a street is not simply related to ADT due to the many local conditions that determines the design of urban streets (Vejdirektoratet 1991a and 1991b).

The relationship between ADT and the width of the carriageway has been established empericly based on 34 representative urban streets in Denmark based on a study carried out by the Danish Road Directorate (Vejdirektoratet 1994a). In the study, eight representative cities were selected based on city size and location, and streets of different type and traffic intensity were selected. Traffic intensity varies from 1,675 to 46,170 in 1992.

Figure 4.1 shows that there is a fair association between ADT and the width of the carriageway.

An emperical association will be used for municipality streets and the linear expression is:

$$\text{Width} = 6.5 + 3.0 \times 10^{-4} * \text{ADT}.$$

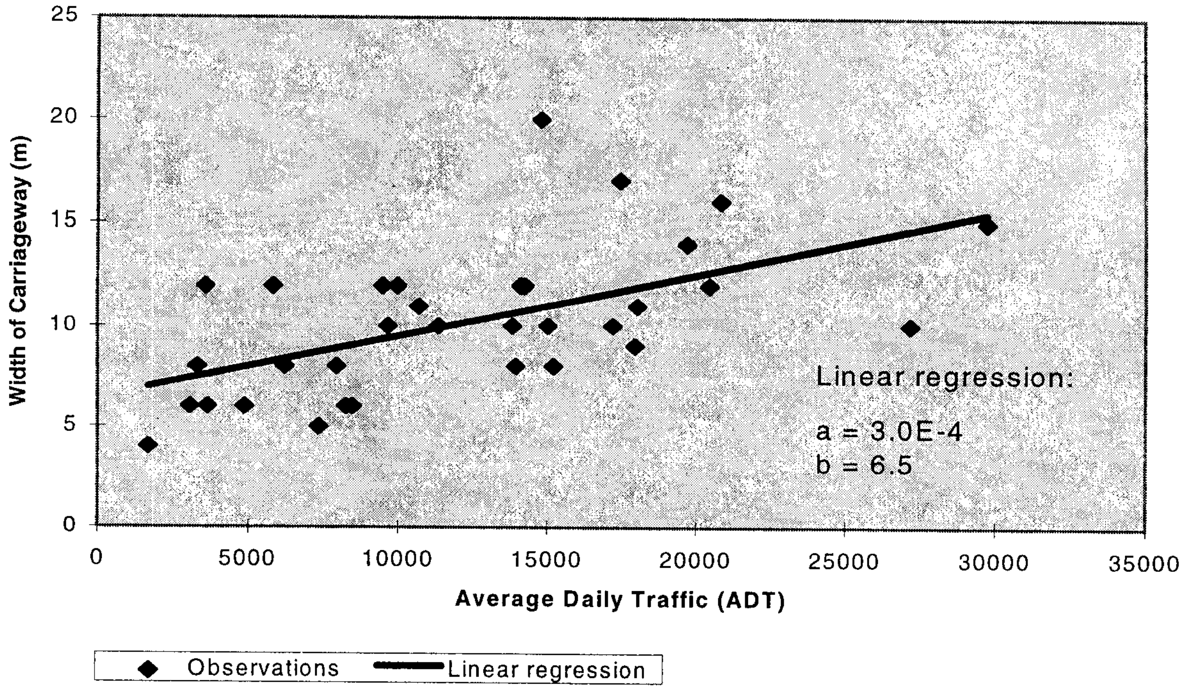

Figure 4.1 Relationship between average daily traffic and the width of a carriageway in urban areas based on 33 representative streets in Denmark (Vejdirektoratet 1994).

5 Evaluation of Standardised Input Parameters

In this chapter the procedure for generating traffic data is evaluated by comparison with traffic data from three urban streets where fixed monitor stations are located. The same streets were used for a sensitivity analysis of the procedure for generation input parameters for OSPM (Vignati et al., 1997).

Comparison is performed for the generated distribution of vehicle categories, and the weekly and diurnal variation in traffic. Furthermore, the generation of street width and number of cold starts are evaluated.

In the following the generated standard input parameters are termed predicted inputs (although empirically derived) and compared to data from the three streets.

5.1 Test sites

The three streets used for the validation are not necessary representative of the streets in the Childhood Cancer Study but they represent three examples of urban streets where detailed traffic and air quality data is available. The streets carry a high traffic load with relatively much bus traffic compared to most urban streets.

The three streets are: Vesterbro in Aalborg, Jagtvej and H.C. Andersens Boulevard in Copenhagen. All streets are urban street canyons with different street configuration. Traffic data were obtained from the Danish Road Directorate, the Municipality of Aalborg and the Municipality of Copenhagen.

Vesterbro has an ADT of 32,600 and four lanes. The total traffic load is measured continuously on an hourly basis and data exists from the period May to September 1994. The distribution of traffic into passenger cars, vans and lorries has been estimated based on a two hour visual traffic count carried out on a working day.

Jagtvej has an ADT of about 24,600 and the street has two wide lanes. A campaign measurement of the traffic on an hourly basis was carried out during April 1994 to May 1995. The traffic counting equipment separates the traffic in short and long vehicles and in combination with one visual traffic count the vehicle distribution has been established.

H.C. Andersens Boulevard has an ADT of about 47,500 and the street has six lanes. The street is the most heavily trafficked urban street in Denmark with average working day traffic of about 60,000 vehicles. No continuous traffic counts have been carried out due to the wide street layout and the traffic loads and distribution of traffic in vehicle categories are based on one visual traffic count during a working day.

5.2 Vehicle Categories

Table 5.1 shows a comparison between the predicted and the observed distribution of traffic for the three streets.

Table 5.1 Comparison between predicted and observed distribution of traffic for the three streets (%)

Street	ADT	Passenger cars	Vans	Lorries	All
Predicted	-	82	11	7	100
Vesterbro	32,600	88	7	6	100
Jagtvej	24,600	89	9	3	100
H.C. Andersens Boulevard	47,500	84	9	7	100

Table 5.1 shows a good agreement between predicted and observed distribution of traffic. The relative difference between the predicted and observed distribution of traffic is largest for vans and lorries.

5.3 Weekly Distribution of Traffic

To derive the temporal variation of traffic the first step has been to derive the weekly distribution of traffic. Table 5.2 shows a comparison between predicted and observed weekly distributions of traffic.

Table 5.1 Comparison between predicted and observed weekly distribution of traffic for the three streets (%)

Vehicle Category	Working days	Saturdays	Sundays	All
Passenger Cars:				
Predicted	75	12.5	12.5	100
Vesterbro	79	11	10	100
Jagtvej	76	12	12	100
H.C. Andersens Boulevard	90	5	5	100
Vans:				
Predicted	89	5.5	5.5	100
Vesterbro	76	12	12	100
Jagtvej	77	12	11	100
H.C. Andersens Boulevard	92	4	4	100
Lorries:				
Predicted	97	1.5	1.5	100
Vesterbro	82	10	9	100
Jagtvej	88	6	5	100
H.C. Andersens Boulevard	96	2	2	100

Table 5.1 shows generally a fair agreement between predicted and observed weekly distributions of traffic. It is predicted that the share of traffic on Saturdays and Sundays is the same for all streets and all vehicle categories which is in good agreement with the observed weekly distribution for Jagtvej which is the only street where continuous measurements have been carried out according to vehicle categories. For the two other streets the weekly distribution of vans and lorries is predicted based on visual traffic counts carried out on working days and the uncertainty on these predictions are large.

5.4 Diurnal Variation of Traffic

Standardised diurnal variation of traffic have been generated for passenger cars, vans and lorries on urban and rural roads for working days, Saturdays and Sundays during July and the rest of the year.

The validation test has been limited to passenger cars on working days, Saturdays and Sundays and for vans and lorries on working days during the rest of the year (excl. July).

Passenger Cars
Comparisons between predicted and observed diurnal variations for passenger cars on working days, Saturdays and Sundays are given in Figure 5.1, 5.2 and 5.3, respectively. There is generally a good agreement between predicted and observed diurnal variation for passenger cars.

For Vesterbro the presented diurnal variation is total traffic but as passenger cars constitute the majority of traffic the diurnal variation of total traffic and the diurnal variation of passenger will be close to one another. For Jagtvej the diurnal variation is based on continuous measurement of short vehicles which is a good proxy for passenger cars. For H.C. Andersens Boulevard the diurnal variation is based on a single day of visual traffic counts but it is still in good agreement with the predicted diurnal variation.

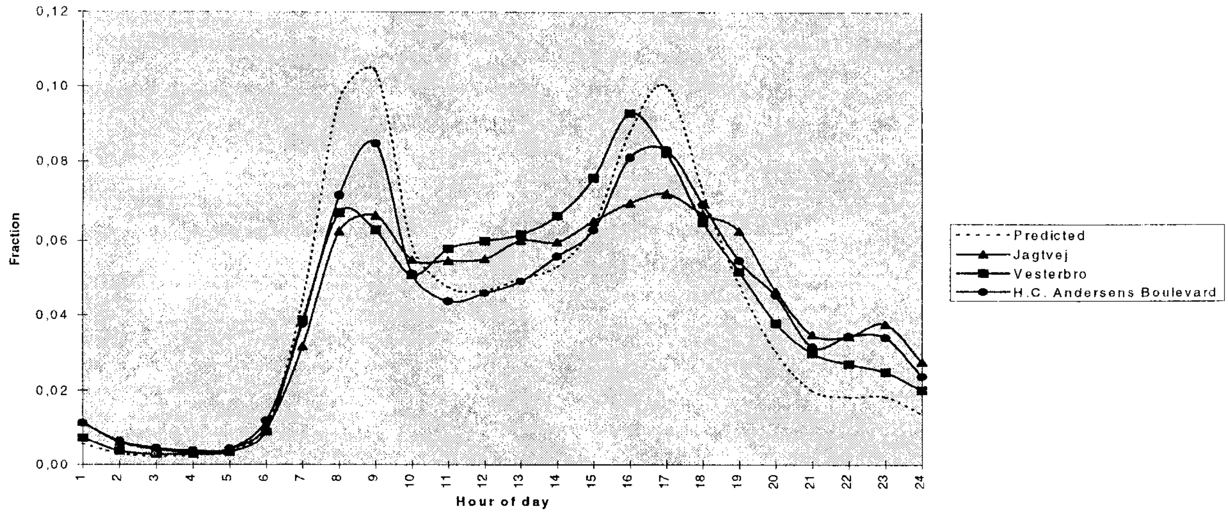

Figure 5.1 Comparison between predicted and observed diurnal variation of passenger cars on urban roads during working days (excl. July).

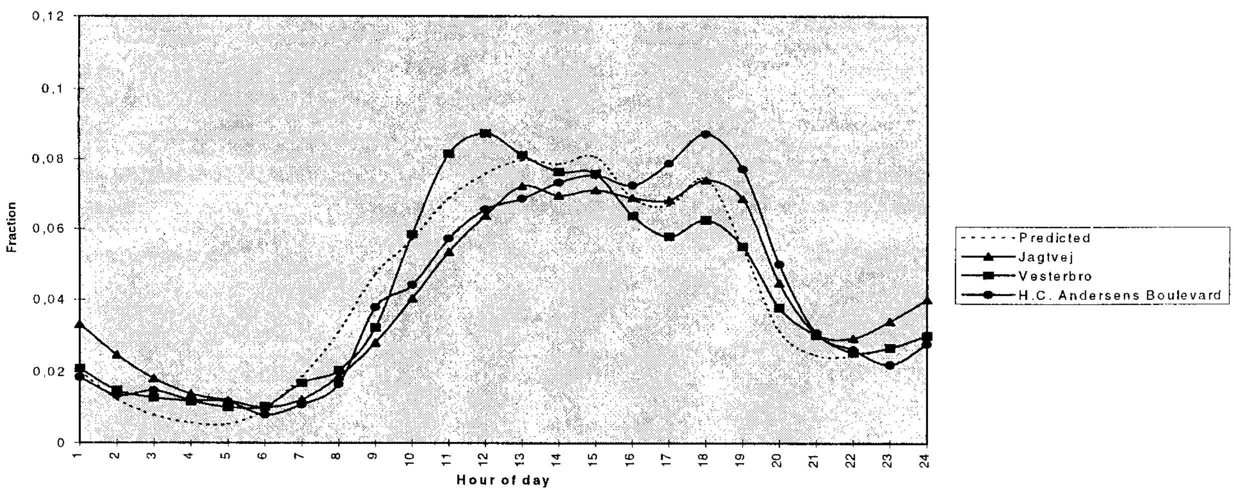

Figure 5.2 Comparison between predicted and observed diurnal variation of passenger cars on urban roads during Saturdays (excl. July).

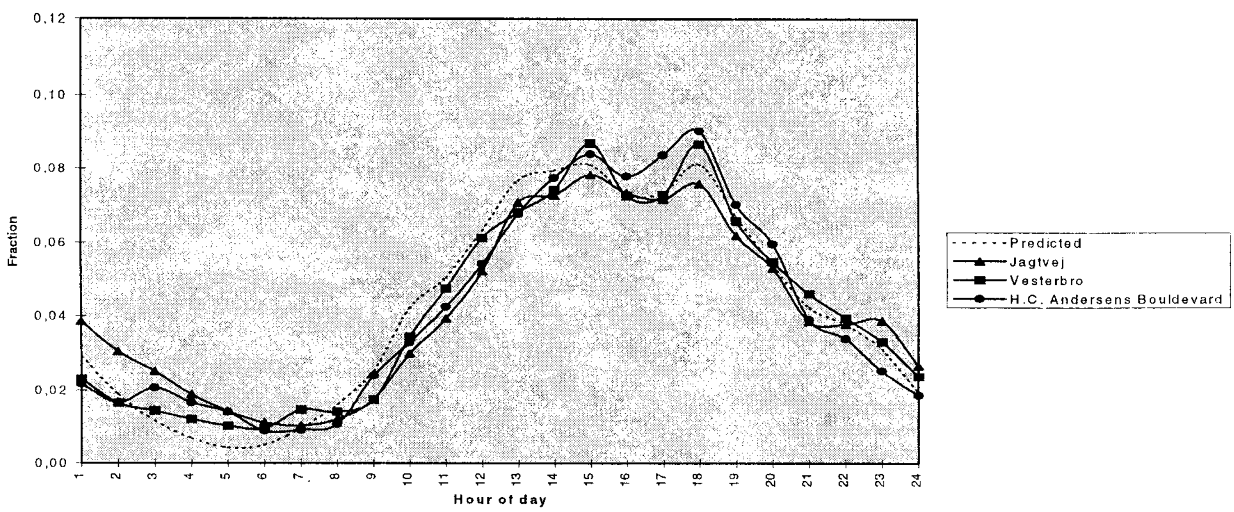

Figure 5.3 Comparison between predicted and observed diurnal variation of passenger cars on urban roads during Sundays (excl. July).

Vans

In Figure 5.4 a comparison between predicted and observed diurnal variations for vans on working days is shown. Generally the agreement between predicted and observed diurnal variation is poor to fair depending on the street in question.

There is a fair agreement between predicted and observed diurnal variation for Jagtvej which is the only street where continuous measurements of traffic have taken place. However, the diurnal variation of vans is not measured directly because the traffic counting method only measures short and long vehicles. The short vehicles are both passenger cars and vans and the distribution of passenger cars and vans has been determined by visual traffic counts. The agreement for Vesterbro is poor because the diurnal variation of vans simple has been generated as a fraction of passenger cars which is a rough estimate. The agreement for H.C. Andersens Boulevard is also poor because it is based one visual traffic count.

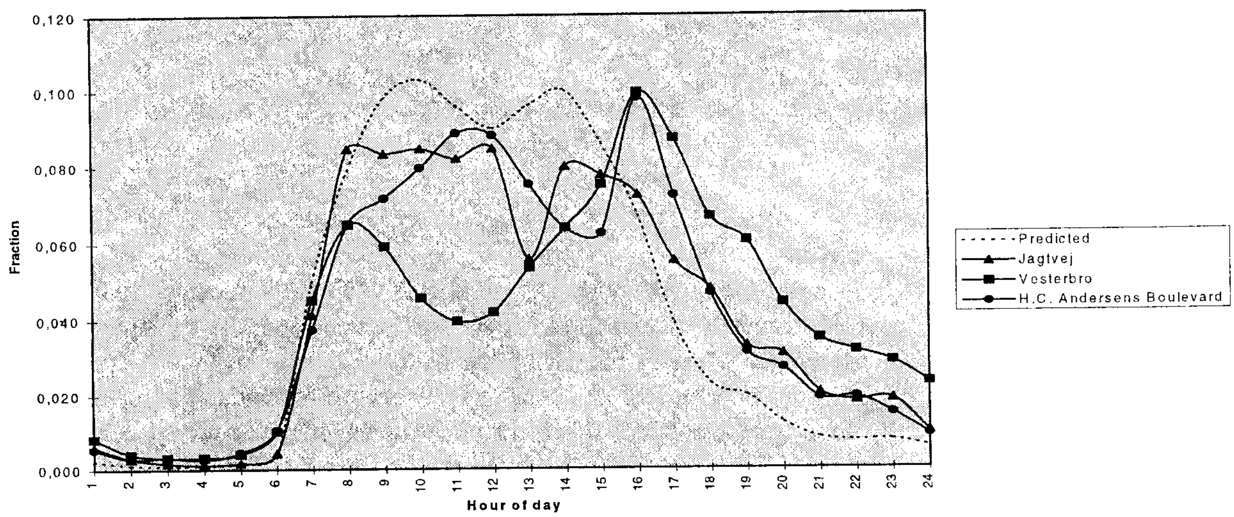

Figure 5.4 Comparison between predicted and observed diurnal variation of vans on urban roads during working days (excl. July).

Lorries

In Figure 5.5 a comparison between predicted and observed diurnal variations for lorries on working days is shown. Generally the agreement between predicted and observed diurnal variation is poor to fair depending on the street in question.

There is a fair agreement between predicted and observed diurnal variation for Jagtvej which is the only street where continuous measurements of heavy traffic (as long vehicles) has taken place. The agreement for Vesterbro is poor because the diurnal variation of lorries simple has been generated as a fraction of all vehicles based on one visual traffic count. For H.C. Andersens Boulevard the agreement is also poor as the diurnal variation is based on one visual traffic count.

The impact on emissions of a poor or fair diurnal variation of vans and lorries is minor as vans and lorries constitute a minor fraction of all vehicles.

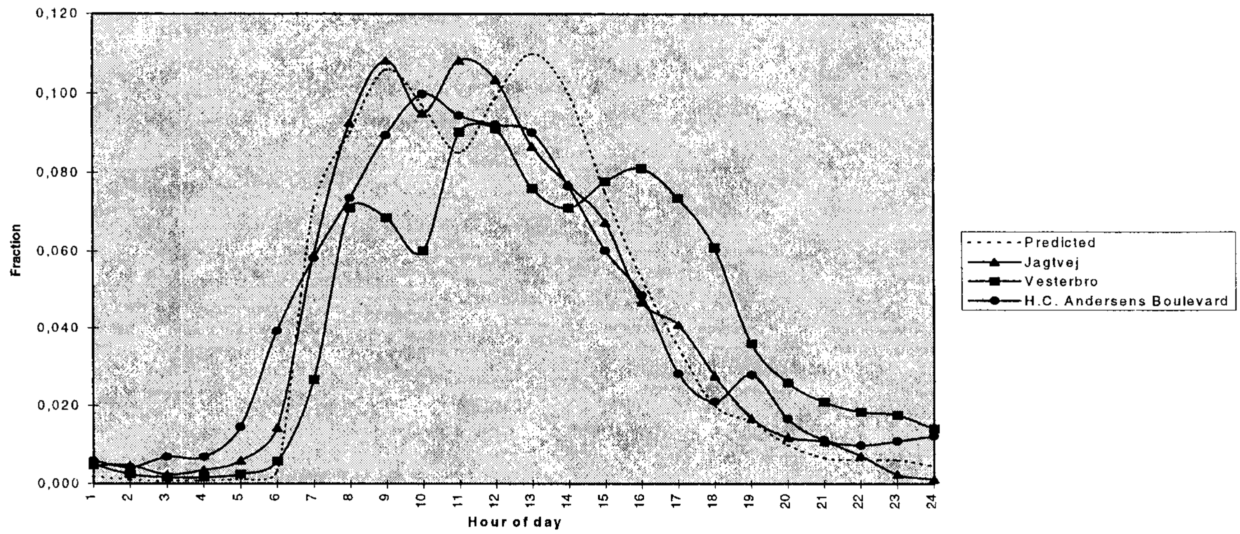

Figure 5.5 Comparison between predicted and observed diurnal variation of lorries on urban roads during working days (excl. July).

Buses

A comparison between the predicted diurnal variation for lorries and the observed diurnal variation for buses is given in Figure 5.6. The observed diurnal variation for buses is quite different from that of lorries. Bus traffic is obviously determined by the bus routes that serve the street and the fraction of bus traffic is lower during normal working hours and higher in the evening when compared to lorry traffic. The diurnal variation of heavy traffic (lorries and buses) is influenced by the distinct diurnal variation of buses, see Figure 5.7.

In the questionnaire of the Childhood Cancer Project the fraction of heavy traffic is given. However, it has not been possible to determine whether or not the street in question carries bus traffic. Therefore we have assumed that the streets do not carry bus traffic and the diurnal variation of heavy traffic has been assumed to be similar to that of lorries.

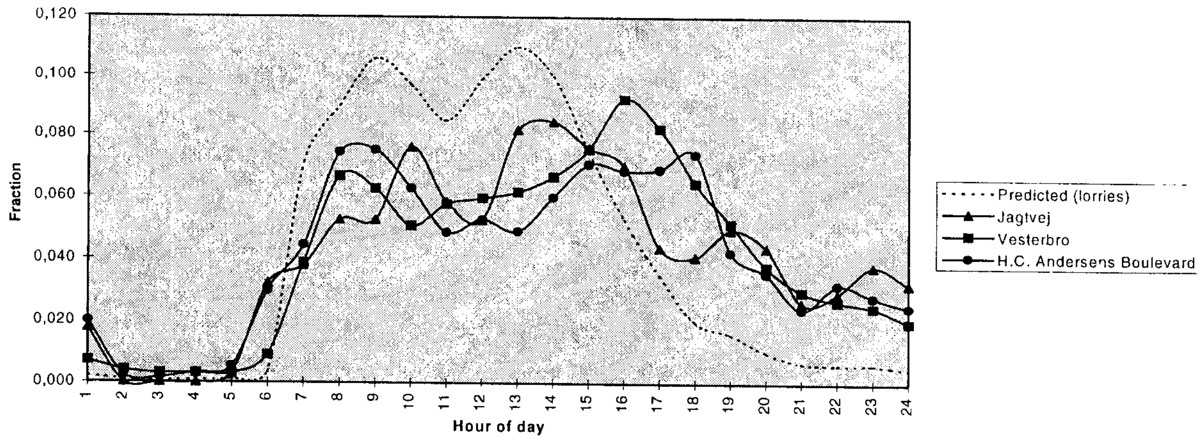

Figure 5.6 Comparison between predicted diurnal variation for lorries and observed diurnal variation of buses

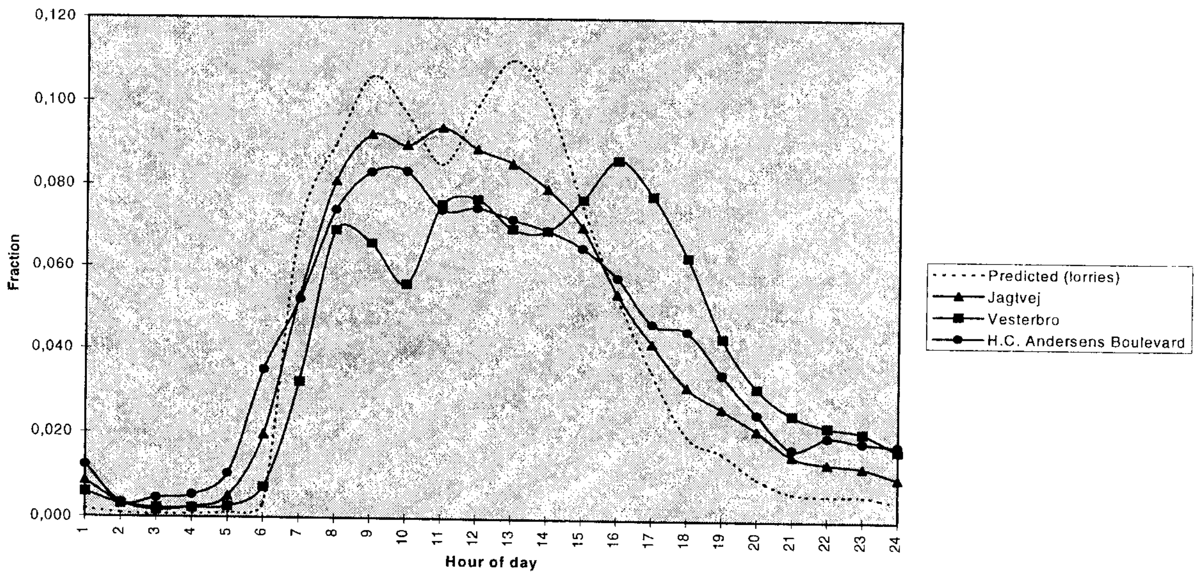

Figure 5.7 Comparison between predicted (lorries) and observed diurnal variation of heavy traffic (lorries and buses) on urban roads during working days (excl. July).

5.5 Width of the Carriageway

The width of the carriageway is one of the input parameters that has been generated. The width has been established empirically based on 33 streets as a linear relationship depending on ADT where the width = $6.5 + 3.0 \times 10^{-4} \times$ ADT. The relationship is fair as the regression coefficient (r^2) is 0.33 (33 per cent of the variance in the width can be explained by the variance in ADT) and the standard deviation is 2.9 meters (if the deviation is a normal distribution the probability of the width being within +/- 2.9 meters of the predicted width is 68 per cent).

5.6 Cold Starts

The diurnal variation of cold starts for passenger cars has also been established empirically based on all available Danish data. It has not been possible to compare the generated input parameters with other data.

Instead a small sensitivity analysis has been carried out to illustrate the impact on the emission of changes in the assumed fraction of cold starts. For urban roads with less than 3,000 vehicles a day the fraction of cold starts has been estimated to 50 per cent during rush hours. In the sensitivity analysis it is assumed that this fraction is 25 per cent or 75 per cent and the impact on CO emissions has been calculated. CO emissions are among the most sensitive emissions to changes in the fraction of cold starts.

A hypothetical road is assumed with a vehicle distribution of passenger cars, vans and lorries of 82, 11 and 7 per cent, respectively. The fraction of passenger cars with catalyst is assumed to be 35 per cent. CO emission factors are based on a study carried out by the Danish Road Directorate (Vejdirektoratet 1992) and the ratio between hot and cold conditions is also based on a study by the Road Directorate (Vejdirektoratet 1994b).

Table 5.2 CO emission factors at 50 km/h for average vehicles in 1991 based on Vejdirektoratet (1992) and Vejdirektotatet (1994b)

Vehicle category	Hot Condition	Cold Condition	Hot/Cold Ratio
Passenger cars without catalyst	22	68	1/3.5
Passenger cars with catalyst	5,5	48	1/15
Vans	9,3	9,3	1/1
Lorries	3,0	2,0	1/1

During cold condition the CO emission is about 3.5 times higher for passenger cars without catalyst and about 15 times higher for passenger cars with catalyst.

The results are given in Table 5.3.

Table 5.3 Sensitivity analysis of the impact on CO emission to changes in the fraction of cold starts

Fraction of Cold Starts (per cent):	CO Emission Index:
25	67
50	100
75	133

Table 5.3 shows that changes in the assumption of cold starts have a major influence on the CO emissions. A 50 per cent lower cold start fraction (from 50 to 25) decreases emissions by 33 per cent and a 50 per cent higher cold start fraction (from 50 to 75) increase emissions by 33 percent.

For NO_x emissions only passenger cars with catalyst are influenced by cold start with a hot/cold ratio of 3.5 according to Vejdirektotatet (1994b). Therefore, the impact of changes in the assumed cold start fraction is much lower for NO_x emissions than for CO emissions.

6 Summary and Future Research Needs

6.1 Summary

The purpose of this report has been to supplement the traffic and street information in the questionnaires of the Childhood Cancer Project to fit the requirements of the Danish Operational Street Pollution Model (OSPM). Since the model requires traffic inputs on an hourly basis which often will not be available a standardised temporal variation of traffic including monthly, weekly and diurnal variations has been generated. Additionally, the temporal variation of cold starts has been generated and the width of the street has been estimated for certain street configurations.

Method and Data

The temporal variation of traffic is derived empirically from two sources: a traffic data set from 1994 generated from the Road Sector Information System (VIS) and the report "Guidelines for Traffic Counts" (Vejdirektoratet 1995) both from the Danish Road Directorate.

The traffic data set includes the national traffic performance (km travelled) on the main road network broken down by vehicle categories (passenger cars, vans and lorries) and the temporal variation of traffic based on stationary traffic counting stations measuring the total traffic load. One station has been selected to represent each of the follwing types for traffic: urban (50 km/h) and regional (80 km/h). In the following this source is referred to as the traffic data set.

The Danish Road Directorate has issued guidelines to the municipalities and counties for manual traffic counts. Based on traffic counts a few hours during 6-18 of a working day it is possible to extrapolate to diurnal traffic, from diurnal traffic to weekly traffic, and from weekly traffic to ADT (Average Daily Traffic). The guidelines are based on statistical analysis of the various traffic counts carried out by the Road Directorate. Extrapolations are possible for various vehicle categories, among others, passenger cars, vans and lorries. The material is useful to generate the temporal variation in traffic, since our approach is the exact opposite, we have ADT and we aim at extrapolating to monthly, weekly and diurnal variations. The guidelines do not provide information of the diurnal variation during the evening and night (18-6) on working days and no information is given on the diurnal variation in traffic on Saturdays and Sundays. In the following this source is referred to as the guidelines.

Standard temporal variations have been set up to be able to generate hourly traffic inputs from limited available information from the municipalities (Average Daily Traffic (ADT) and fraction of heavy traffic).

The temporal varation of traffic was generated in the following way:
- distribution of traffic into vehicle categories (passenger cars, vans and lorries)
- monthly variation
- weekly variation
- diurnal variation.

Additionally, the following has been set up:
- the diurnal variation in cold started passenger cars
- the excepted width of a given type of road.

Results

Distribution of traffic

Based on the traffic data set a formula has been established to transform ADT and the fraction of heavy vehicles into the vehicle categories: passenger cars, vans and lorries. The questionnaire does not provide information on buses and it is very difficult to predict the number of buses because it is very specific for the street in question, therefore, buses are included in lorries. Furthermore, the type of roads were limited to two catagories (urban and regional) due to limited information in the questionnaire.

Monthly variation

An analysis of the monthly variation of traffic based on the guidelines showed that there is only a minor difference between urban and regional roads for the various vehicle categories. For vans and lorries there was a distinct minimum in July which was not seen for passenger cars. To limit the number of calculations, only the marked difference in the monthly variation of july have be taken into account for vans and lorries. Hence, the year has been divided in two categories: July and the rest of the year.

Weekly variation

The weekly variation is based on the guidelines and it is only possible to derive the percentage of traffic during the week-end (Saturday and Sunday). The traffic data set from 1994 showed almost the same traffic levels on Saturdays and Sundays for all traffic. Therefore traffic amounts are assumed similar for Saturdays and Sundays. However, for vans and lorries there may be a difference between Saturdays and Sundays because their is little commercial activities on Sundays. There is almost no difference between urban and regional roads and the weekly variation is assumed to the same for both types of roads. The number of passenger cars are only sligthly lower during Saturdays and Sundays compared to a working day. For vans and lorries almost all traffic is on working days which implies that total traffic load is about 30% lower on weekends compared to working days.

Diurnal variation

The analysis of the diurnal variation showed a marked difference between the diurnal variation on working days, Saturdays and Sundays. The diurnal variation among working days was minor. During working days there are distrinct rush hours in the morning and afternoon due to home - workplace traffic. The weekend traffic is more levelled out and dominated by traffic directed to shopping and social activities.

For working days there is a relatively small difference in the diurnal variation for passenger cars between July and the rest of the year. The holiday month of July has less pronounced rush hours, and traffic around noon, in the evening and during the night is slightly higher. The largest difference is found during the morning rush hours where July has about 15% less traffic than the rest of the months.

For Saturdays and Sundays there is a clear difference in the diurnal variation between July and the rest of the year. From noon to about seven o'clock in the evening traffic is less during July compared to the rest of the year and traffic is also higher during the evening.

The difference between the diurnal variation on urban and regional roads is relatively small. The largest difference is found during the morning rush hours on working days where regional roads have about 30% less traffic than urban roads.

Standardised diurnal variations have been set up for passenger cars, vans and lorries for urban and regional roads broken down by working days, Saturdays and Sundays and for July and the rest of the year.

Cold starts

Limited data was available to support a standardised diurnal variation of cold started passenger cars (Vejdirektoratet 1994a, 1994b).

The fraction of cold starts was determined to be depending on the type of street, ADT, speed and time of day (rush hours/outside rush hours).

Width of street

For municipality roads (urban setting) an empirical linear expression based on 33 representative streets (Vejdirektoratet 1994a) was established to predict the width of the carriageway depending on ADT. For state and county roads (rural settings) the width of the carriageway has been related to ADT based on the road design guidelines of the Danish Road Directorate (Vejdirektoratet 1981).

Evaluation and validation

An evaluation of the generated traffic inputs was carried out to test the predicted inputs against observations. The evaluation covered the distribution of vehicle categories, the weekly distribution of traffic and the diurnal variation of traffic.

Predicted traffic input was compared to traffic data from three urban streets where fixed monitor stations are located: H.C. Andersens Boulevand, Jagtvej and Vesterbro. The three streets used for the validation are not necessary representative of the streets in the Childhood Cancer Study but they represent three examples of urban streets where detailed traffic and air quality data is available. The streets carry a high traffic load with relatively much bus traffic compared to most urban streets.

Distribution of vehicle categories

There is a good agreement between predicted and observed distribution of traffic (passenger cars, vans and lorries). The relative difference between the predicted and observed distribution of traffic is largest for vans and lorries.

Weekly variation

Generally, a fair agreement between predicted and observed weekly distributions of traffic was observed. It is predicted that the share of traffic on Saturdays and Sundays is the same for all streets and all vehicle categories which is in good agreement with the observed weekly distribution for the only street where continuous measurements have been carried out according to vehicle categories. For the two other streets the weekly distribution of vans and lorries is predicted based on manual traffic counts carried out on working days and the uncertainty on these predictions are large.

Diurnal variation

For the diurnal variation the validation test has been limited to passenger cars on working days, Saturdays and Sundays and for vans and lorries on working days during the rest of the year (excl. July).

There is generally a good agreement between predicted and observed diurnal variation for passenger cars on all days. For vans and lorries the agreement between predicted and observed diurnal variation is poor to fair depending on the street in question. The impact on emissions of a poor or fair diurnal variation of vans and lorries is minor as vans and lorries constitute a minor fraction of all vehicles.

A comparison between the predicted diurnal variation for lorries and the observed diurnal variation for buses was carried out. The observed diurnal variation for buses is quite different from that of lorries. Bus traffic is obviously determined by the bus routes that serve the street and the fraction of bus traffic is lower during normal working hours and higher in the evening when compared to lorry traffic. Hence, the diurnal variation of heavy traffic (lorries and buses) is influenced by the distinct diurnal variation of buses. In the questionnaire of the Childhood Cancer Project the fraction of heavy traffic is given. However, it has not been possible to determine whether or not the street in question carries bus traffic. Therefore we have assumed that the streets do not carry bus traffic and the diurnal variation of heavy traffic has been assumed to be similar to that of lorries.

Street width

The width of the carriageway is one of the input parameters that has been generated as a linear expression depending on ADT. The linear dependence is fair.

Cold starts

The diurnal variation of cold starts for passenger cars has also been established empirically based on all (although limited) available Danish data. It has not been possible to compare the generated input parameters with other data.

Instead a sensitivity analysis has been carried out for CO emissions which is one of the most sensitive pollutants to cold starts and a worst case situation has been selected by choosing an urban road during rush hours. CO emission from both passenger cars with and without catalysts is influenced by cold starts. Distribution of passenger cars, vans and lorries is assumed to be be 82, 11 and 7 per cent, respectively, and the fraction of passenger cars with catalyst is assumed to be 35 per cent. A 50 per cent lower cold start fraction (from 50 to 25) decreases emissions by 33 per cent and a 50 per cent higher cold start fraction (from 50 to 75) increase emissions by 33 per cent. The relationship between cold starts and emissions is linear but not proportional.

For NO_x emissions only passenger cars with catalyst are influenced by cold starts with a lower hot/cold ratio than CO, therefore, the impact of changes in the assumed cold start fraction is much lower for NO_x emissions than for CO emissions.

6.2 Future Research Needs

Diurnal variation of traffic and distribution of traffic

Most of the traffic counting stations operated by the Danish Road Directorate or by the municipalities count total traffic on heavy trafficked roads and some devide traffic in two categories based on vehicle length (short and long vehicles). A comprehensive study should be carried out to analyse differences in the diurnal variation for different types of roads. The present study was based on a few counting stations located on busy roads, but future studies with more stations would provide more reliable data. Particularly, the diurnal variation of vans and lorries during the night and during week-ends and the diurnal variation of traffic on low trafficked roads need more attention. A future study should also include an analysis of the distribution of traffic (passenger cars, vans, lorries, buses) on different types of roads. The data of the temporal variation of total traffic is already available from the Danish Road Directorate and the municipalities but it needs to be supplemented by counting stations on low trafficked roads. To determine the distribution of traffic by traditional manual traffic counts would be very costly for a comprehesive study due to the high cost of labour. A possible method could be based on video recording and subsequent analysis or some kind of automatic image analysis.

Diurnal variation of cold starts

A study of the diurnal variation in cold starts for passenger cars should be carried out as there is only limited data available to predict the diurnal variation of cold starts. So far the fraction of cold starts has been measured by stopping selected vehicles e.g. in intersections with traffic lights and handing the drivers a post card with questions to return. The method is costly and an interference to traffic, and a study based on this method would have to be very limited in the number of streets selected and time covered. However, presently there is no other available method to apply.

Acknowledgements

The present work is part of the author's Ph.D. study about human exposure modelling to traffic air pollution funded by the Danish Transport Council and the Danish Research Academy. Traffic counts used to generate traffic profiles have been obtained from the Danish Road Directorate.

For evaluation of the standardised traffic profiles comparisons were carried out between predicted profiles and traffic profiles from three specific streets. Data were obtained from the Danish Road Directorate, the Municipality of Copenhagen and the Municipality of Aalborg.

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Appendix A: Temporal Variation in Traffic

Contents

Table 1 Monthly Variation of Traffic

Monthly Factor (ADT * Monthly Factor = Monthly Diurnal Traffic)						
	Passenger Cars		Vans		Lorries	
Month	Urban Roads	Regional Roads	Urban Roads	Regional Roads	Urban Roads	Regional Roads
1	0.92	0.90	0.87	0.87	0.85	0.81
2	0.95	0.94	0.92	0.92	0.92	0.91
3	0.99	0.98	1.00	1.00	1.06	1.04
4	1.02	1.01	1.07	1.07	1.09	1.08
5	1.04	1.04	1.09	1.09	1.10	1.11
6	1.05	1.08	1.03	1.03	1.06	1.09
7	1.02	1.07	0.86	0.86	0.71	0.75
8	1.04	1.04	1.08	1.08	1.10	1.13
9	1.02	1.02	1.09	1.09	1.09	1.11
10	1.01	1.01	1.06	1.06	1.07	1.08
11	0.99	0.98	1.01	1.01	1.01	1.00
12	0.96	0.95	0.91	0.91	0.93	0.90

Monthly Factor (ADT * Monthly Factor = Monthly Diurnal Traffic)						
	Passenger Cars		Vans		Lorries	
Month	Urban Roads	Regional Roads	Urban Roads	Regional Roads	Urban Roads	Regional Roads
July	1.02	1.07	0.86	0.86	0.71	0.75
All year except July	1.00	0.99	1.01	1.01	1.03	1.02

Table 2 Diurnal Variation in Number of Passenger Cars (Fraction)

Urban Roads						
	July			All Year except July		
Hour	Working days	Saturdays	Sundays	Working days	Saturdays	Sundays
1	0.010	0.025	0.032	0.006	0.020	0.029
2	0.005	0.015	0.018	0.003	0.012	0.019
3	0.003	0.008	0.012	0.002	0.008	0.012
4	0.004	0.007	0.008	0.003	0.006	0.007
5	0.005	0.007	0.006	0.004	0.005	0.004
6	0.011	0.012	0.007	0.010	0.009	0.005
7	0.036	0.020	0.012	0.044	0.019	0.010
8	0.079	0.031	0.018	0.096	0.031	0.016
9	0.088	0.043	0.025	0.104	0.047	0.025
10	0.066	0.056	0.041	0.059	0.057	0.042
11	0.054	0.068	0.053	0.047	0.069	0.051
12	0.051	0.074	0.062	0.047	0.076	0.063
13	0.052	0.075	0.067	0.050	0.080	0.077
14	0.053	0.074	0.066	0.053	0.079	0.079
15	0.062	0.072	0.065	0.064	0.081	0.081
16	0.080	0.062	0.062	0.088	0.069	0.073
17	0.089	0.061	0.063	0.100	0.067	0.074
18	0.073	0.065	0.071	0.072	0.074	0.081
19	0.053	0.054	0.068	0.048	0.055	0.067
20	0.036	0.038	0.061	0.030	0.031	0.054
21	0.026	0.032	0.057	0.020	0.025	0.042
22	0.023	0.032	0.051	0.018	0.024	0.038
23	0.022	0.032	0.043	0.018	0.027	0.031
24	0.018	0.035	0.030	0.014	0.030	0.019
Regional Roads						
	July			All Year except July		
Hour	Working days	Saturdays	Sundays	Working days	Saturdays	Sundays
1	0.013	0.024	0.030	0.008	0.019	0.026
2	0.007	0.013	0.017	0.004	0.012	0.016
3	0.005	0.009	0.011	0.003	0.008	0.010
4	0.005	0.007	0.008	0.004	0.006	0.006
5	0.008	0.010	0.008	0.006	0.006	0.004
6	0.019	0.012	0.008	0.020	0.010	0.006
7	0.053	0.022	0.013	0.062	0.020	0.010
8	0.070	0.032	0.019	0.091	0.030	0.017
9	0.060	0.043	0.026	0.073	0.046	0.026
10	0.051	0.056	0.040	0.051	0.057	0.037
11	0.054	0.073	0.055	0.045	0.070	0.049
12	0.053	0.080	0.064	0.045	0.075	0.064
13	0.052	0.075	0.066	0.047	0.074	0.071
14	0.053	0.071	0.063	0.052	0.075	0.073
15	0.059	0.069	0.061	0.061	0.078	0.074
16	0.079	0.063	0.060	0.086	0.070	0.071
17	0.084	0.060	0.063	0.093	0.068	0.077
18	0.069	0.059	0.069	0.074	0.071	0.082
19	0.054	0.050	0.070	0.051	0.052	0.072
20	0.041	0.039	0.062	0.034	0.033	0.059
21	0.032	0.033	0.061	0.026	0.029	0.050
22	0.029	0.033	0.054	0.023	0.029	0.044
23	0.028	0.035	0.043	0.023	0.031	0.035
24	0.022	0.032	0.028	0.017	0.031	0.021

Table 3 Diurnal Variation of Vans and Lorrries

	Vans		Lorries	
Hour	All Days Urban Roads	All Days Regional Roads	All Days Urban Roads	All Days Regional Roads
1	0.002	0.005	0.002	0.007
2	0.001	0.003	0.001	0.004
3	0.001	0.002	0.001	0.003
4	0.001	0.002	0.001	0.003
5	0.002	0.004	0.001	0.005
6	0.004	0.012	0.003	0.016
7	0.050	0.041	0.071	0.050
8	0.079	0.072	0.090	0.069
9	0.098	0.081	0.106	0.079
10	0.103	0.090	0.097	0.082
11	0.096	0.096	0.085	0.084
12	0.090	0.093	0.099	0.082
13	0.096	0.090	0.110	0.080
14	0.100	0.085	0.100	0.075
15	0.086	0.080	0.075	0.068
16	0.067	0.070	0.053	0.060
17	0.039	0.045	0.035	0.050
18	0.023	0.024	0.020	0.040
19	0.020	0.031	0.016	0.042
20	0.012	0.021	0.010	0.028
21	0.008	0.016	0.007	0.021
22	0.008	0.014	0.006	0.019
23	0.008	0.014	0.006	0.019
24	0.006	0.010	0.005	0.014

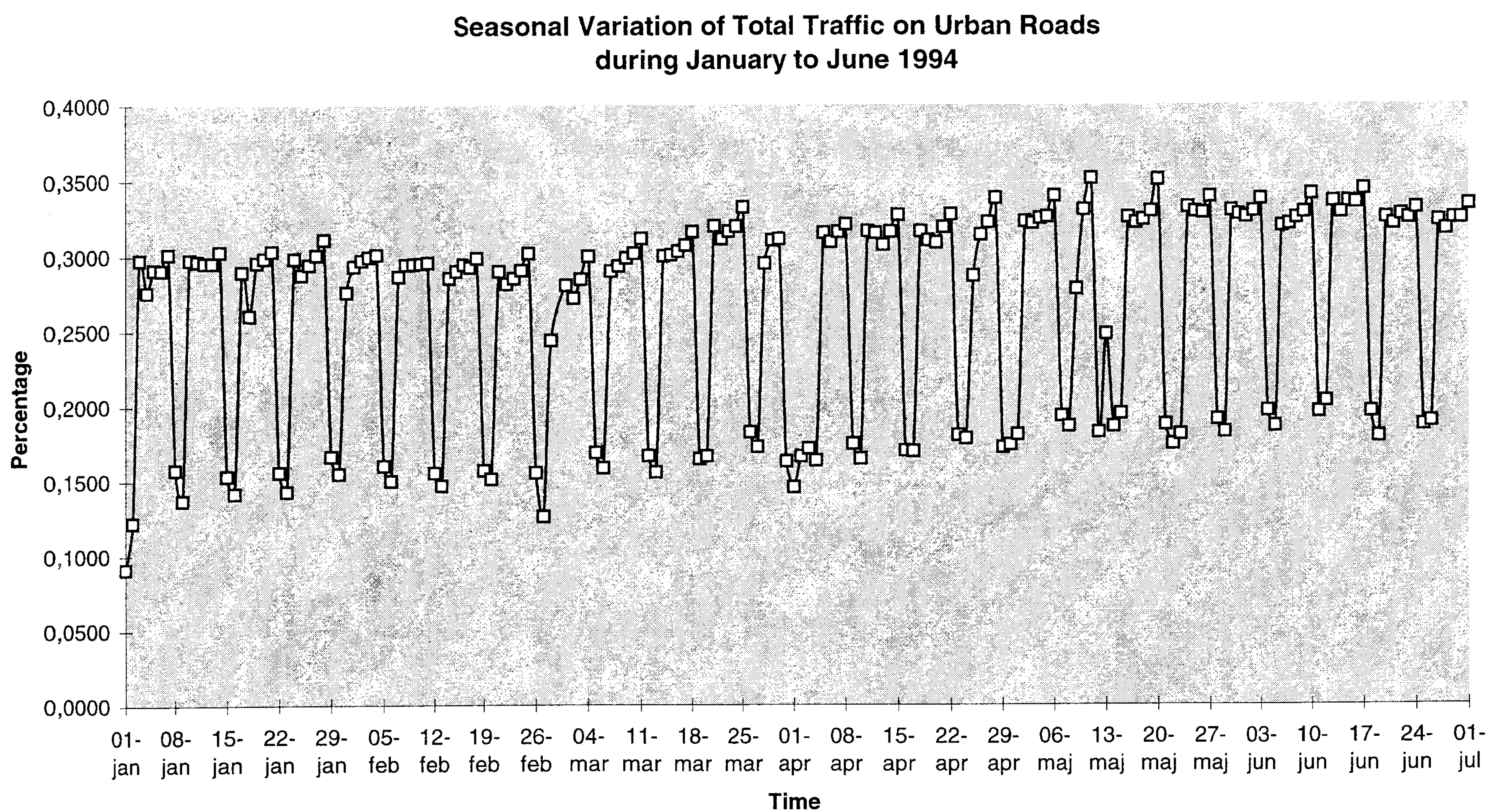


Figure 1A Time serie of the daily traffic. Traffic on Saturdays and Sundays is about half of the traffic on weekdays. Note that the starting date is on a Saturday (1st of January).

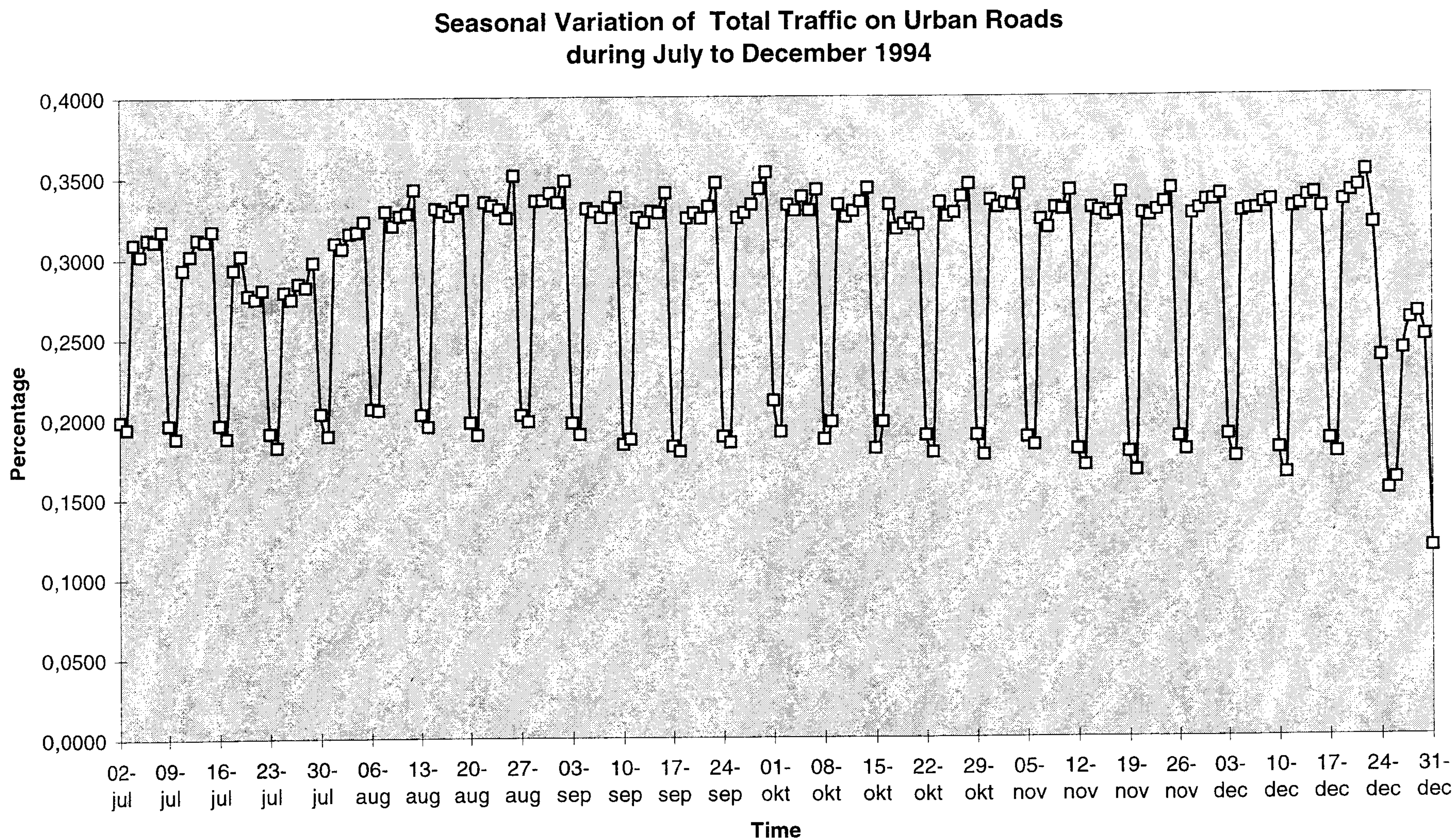


Figure 1B Time serie of the daily traffic. Traffic on Saturdays and Sundays is about half of the traffic on weekdays. Note that the starting date is on a Saturday (2nd of July).

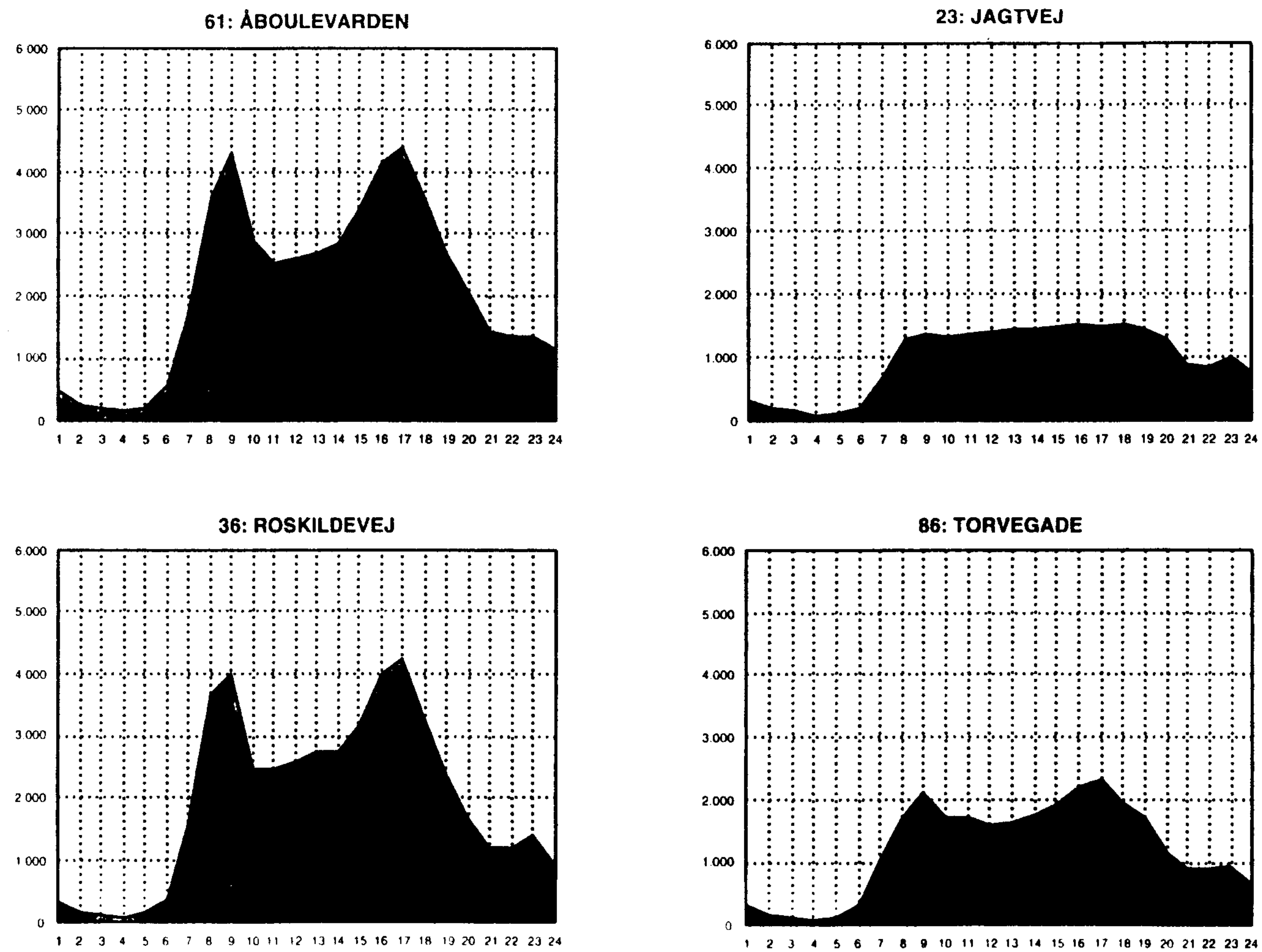


Figure 2 The diurnal variation in number of vehicles during working days on selected roads in Copenhagen in 1994 x-axis refer to hour of day and y-axis to number of vehicles (Københavns Kommune 1995).

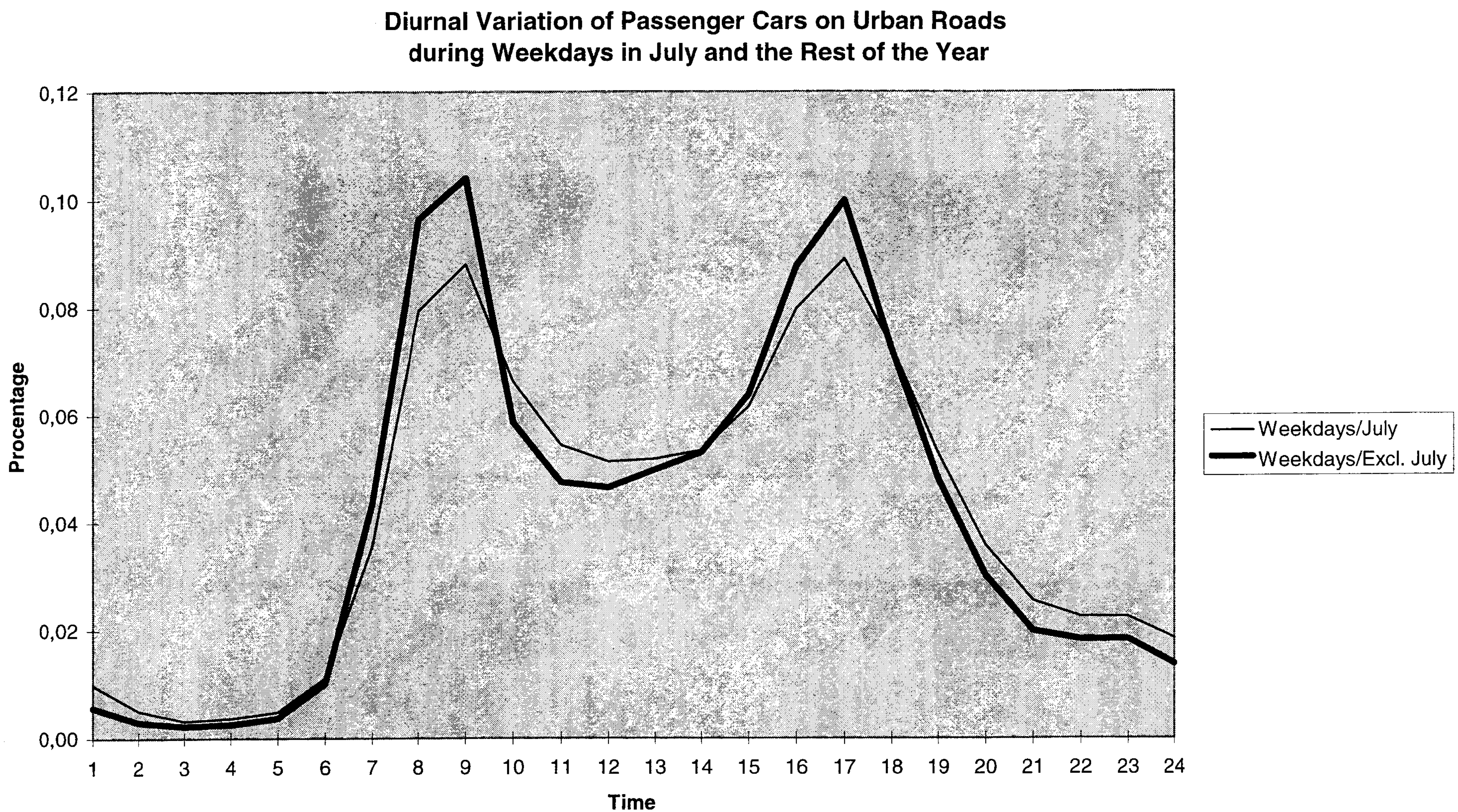


Figure 3 Diurnal variation of passenger cars on urban roads during weekdays in July and the rest of the year.

Appendix B: The Questionnaire

The address ___________________________

The time period ___________________________

(This part is filled out by the Danish Cancer Society)

The questions below refer to the middle of the time period considered.

If there have been major traffic changes during the period please indicate this in question No. 10.

For all questions you are requested to make the best judgement when precise information is not available.

1. Was the type of road mentioned on the front page , a

1) ___ municipality street or private street
2) ___ county road, give county number ___, administrative road number ___, and kilometric position at address
3) ___ state road, give administrative number ___ and kilometric position at address ___.

Note: If it is a county or state road and the municipality does not have traffic figures, go to question No. 4. If the municipality has traffic data, or these can be estimated, you are requested to answer question No. 2 and No. 3 for county and state roads.

2. How much traffic was there on the street at the address?

___ vehicles/day (Average Daily Traffic)

The Average Daily Traffic is the annual average for all 365 days for traffic in both directions. Please indicate if the figure is given in other terms than the Average Daily Traffic.

3. How much heavy traffic (buses and vans over 3500 kg) did the street carry?

The exact fraction of heavy traffic was ___ %

If the exact fraction is not known, you are requested to use your best judgement to choose one of the below options

1) ___ Almost no heavy traffic (less than 1% of traffic)
2) ___ Small fraction (1-4% of traffic)
3) ___ Moderate fraction (5-8% of traffic)
4) ___ Large fraction (9% of traffic or more)

4. What was the actual mean speed at the address?

If the actual speed cannot be estimated, use the speed limit as a basis for an estimate. Unsteady driving patterns due to e.g. traffic lights lowers the mean driving speed.

1) ___ 00-35 km/h
2) ___ 35-45 km/h
3) ___ 45-55 km/h
4) ___ above 65 km/

5. Which of the below road surroundings suits best the address: (A-E) ___.

A A house in an open street. The house can be situated close to or far from the street. There may be other houses nearby.

What was the distance from the facade of the address house to the furthest road edge on the furthest driving lane?

About ___ m

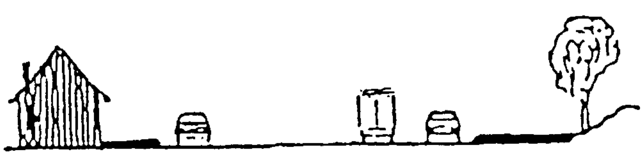
B Low scattered houses. Choose the one which fits best.

1) ___ A row of low houses on one side of the street. Almost no houses on the other side.
2) ___ Villas on both sides with space (gardens) in between.
3) ___ Low houses with open front areas (parking lots, gardens etc.)

What was the distance from the facade of the address house to the furthest road edge on the furthest driving lane?
Approximate distance ___ m

How high are the houses at the address side of the street?
___ storeys

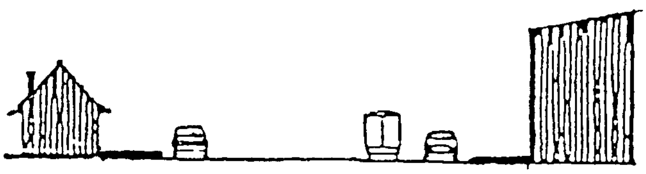
How high are the houses on the other side of the street (if no houses write 0)?
___ storeys



C Low houses on one side of the street and high houses on the other side of the street.

What was the distance between the house facades?
Approximately ___ m

How high are the houses on the other side of the street?
___ storeys

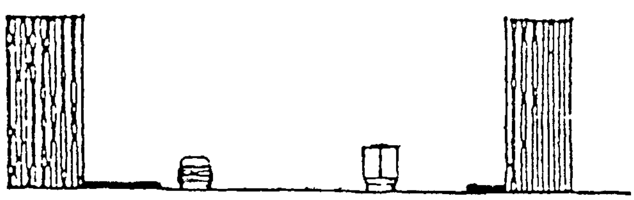


D High houses on both sides of the street

What was the distance between the house facades?
Approximately ___ m

How high are the houses on the address side of the street?
___ storeys

How high are the houses on the other side of the street?
___ storeys

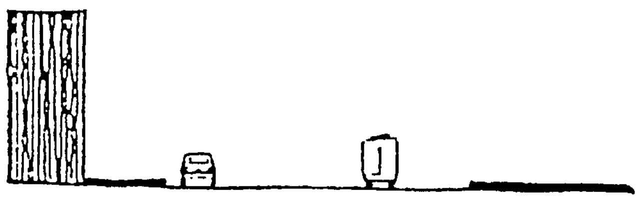


E High houses on one side of the street. Almost no houses on the other side.

What was the distance from the address house facade to the furthest road edge on the furthest driving lane?
Approximately ___ m

How high is the address house?
___ storeys

Was the address side
1) ___ *On the side of the street with high houses*
2) ___ *A single house on the other side*



6. Was there within 50 m from the address a cross road, which had more traffic than the street at which the address is located?
1) ___ *Yes*
2) ___ *No*

If yes, how many vehicles were on this street? (If there were several cross roads, answer for the most trafficked)
1) ___ *0-2,000 vehicles/day*
2) ___ *2,000-5,000 vehicles/day*
3) ___ *5,000-10,000 vehicles/day*
4) ___ *10,000-15,000 vehicles/day*
5) ___ *more than 15,000 vehicles/day*

7. How was the traffic in the quarter around the address? (Within 300 m around the address)
1) ___ *Rural area or other, where almost no other streets than the one with the address*
2) ___ *Urban areas with residential or low speed streets, or other streets with low traffic intensity (only local traffic)*
3) ___ *Urban traffic, however without heavily trafficked streets (below 10,000 vehicles/day)*
4) ___ *Heavy urban traffic, where one or more of the streets were heavily trafficked (above 10,000 vehicles/day)*
5) ___ *Other*

8. How was the main part of the houses in the quarter around the address? (Within 300 m around the address)

1) ___ *No or almost no houses*
2) ___ *Low density built-up areas (e.g. villages, small towns and residential neighbourhoods)*
3) ___ *Semi-dense built-up areas (e.g. 2-3 storey buildings in central areas in middle-sized cities)*
4) ___ *Scattered multi-storey buildings (e.g. Gellerup-Parken in Aarhus)*
5) ___ *Dense built-up areas (e.g. 4-6 storey buildings with street in between, e.g. "Bro-kvartererne" in Copenhagen)*

9. How many inhabitants had the city in which the address was situated? (A city is a coherent built-up area. If almost all of the municipality is urban area, the municipality is regarded as one city. Copenhagen and Frederiksberg Municipalities are regarded as one city),

1) ___ *The address was located within a urban area (go to question No. 10)*
2) ___ *Less than 2,000 inhabitants (go to question No. 10)*
3) ___ *2,000-20,000 inhabitants (go to question 10)*
4) ___ *20,000-40,000 inhabitants*
5) ___ *40,000-80,000 inhabitants*
6) ___ *80,000-150,000 inhabitants*
7) ___ *More than 150,000 inhabitants*

If the city had more than 20,000 inhabitants:

What was the distance (direct line) from the address to the centre of the city? *Approximately* ___ *km.*

What was the distance (direct line) from the address to a larger area without built-up area, e.g. forest, field or water? *Approximately* ___ *km.*

A larger area has to be at least 1 x 1 km^2 e.g. Horsens Fjord, Jægersborg Dyrehave, Hareskov at Værløse, Vest-amager and Utterslev Mose at Copenhagen. The following are **not** large enough: Sports stadium, parks and smaller lakes (e.g. Damhussøen at Rødovre).

10. Are there special conditions, which you think should be mentioned?

If there have been major traffic changes during the period given on the front page, please indicate what has happened and when it happened ______________________________

____

____

Thank you for your help.

11. This questionnaire has been filled out

by ______________________ / Institution ______________________

National Environmental Research Institute

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NERI's tasks are primarily to conduct research, collect data, and give advice on problems related to the environment and nature.

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