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The Measurement of Benzene Concentrations in the Vicinity of Petrol Stations

September 2000

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Executive Summary

A programme of measurements of the benzene concentrations in air in the vicinity of eighteen petrol stations has been conducted on behalf of the Department of the Environment Transport and the Regions, the National Assembly of Wales, the Scottish Executive and the Department of Environment in Northern Ireland. Benzene concentrations were determined using Chromosorb 106 diffusion tubes, exposed in triplicate. The survey was carried out over twelve months at 18 petrol stations. Three of the petrol stations had a throughput of petrol significantly in excess of 1000 m³/annum. The other fifteen petrol stations had a throughput of petrol of less than 1000 m³/annum.

The highest concentrations of benzene, of the order of 5 to 6 ppb as an annual mean, were recorded at a petrol station in Marylebone Road, London. The results indicated that evaporative emissions of benzene and motor vehicle exhaust emissions contributed approximately equal amounts of benzene at this roadside location. At all of the other sites benzene concentrations were in the range 0.45 to 3.3 ppb and the contribution from evaporative emissions ranged from zero to about 1.2 ppb.

Roadside benzene monitoring, undertaken as part of this survey, indicated that locations with similar traffic numbers will experience higher ambient concentrations of benzene where the traffic speed is low or variable. Locations close to traffic lights or pedestrian crossings are typical examples. Measurements at such a location in Bristol indicated that the measured concentrations could be elevated by at least 50% compared to locations with a free flow of traffic.

In addition, diffusion tubes were exposed at four of the UK Hydrocarbon Network monitoring sites for comparison purposes. The results of these comparisons indicated that there was a difference of 0 to 1.0 ppb between the sets of results, which was dependent on the site at which sampling occurred.

The predicted decrease in emissions of benzene from motor vehicle emissions has been used to calculate likely benzene concentrations in the future. The calculated concentrations have been compared with the Air Quality Standard of 5 ppb for benzene to be achieved by 31 December 2003.

The petrol station in Marylebone Road is the only site at which the calculated benzene concentration will approach the Air Quality Standard.

The calculated concentrations have also been compared with the proposed EU limit of 5 µg/m³ (1.54 ppb) to be met by 1 January 2010. The calculated concentration will not meet the limit value at the Marylebone Petrol Station by 1 January 2010 unless additional measures are taken to reduce ambient benzene concentrations. For all other stations in this survey the estimated concentrations at the beginning of January 2002 and beginning of January 2010 will meet the respective EU limit values.

Contents

| | | |
|----------|---|----------|
| 1 | Introduction | 1 |
| 2 | Monitoring programme | 3 |
| 2.1 | OBJECTIVES OF THE STUDY | 3 |
| 2.2 | INITIAL SELECTION OF SUITABLE PETROL STATIONS | 3 |
| 2.3 | RESULT OF THE PRELIMINARY SURVEY OF PETROL STATIONS | 3 |
| 2.4 | MODIFIED REQUIREMENTS FOR PETROL STATION SELECTION | 4 |
| 2.5 | SELECTED PETROL STATIONS | 4 |
| 2.6 | DIFFUSION TUBES | 4 |
| 2.6.1 | Analysis of the collected samples | 5 |
| 2.6.2 | Diffusion tube blanks | 5 |
| 3 | Results and Discussion | 6 |
| 3.1 | DIFFUSION TUBE RESULTS | 6 |
| 3.1.1 | Reproducibility | 6 |
| 3.1.2 | Blanks | 6 |
| 3.2 | RESULTS FROM THE PETROL STATIONS | 6 |
| 3.2.1 | Stations with a throughput greater than 1000 m ³ /annum | 6 |
| | I. Marylebone Road Service station, Marylebone Road, London. | 6 |
| | II. Hagley Road Petrol Station, Hagley Road, Birmingham | 7 |
| | III. Star Service Station, 106 – 114 Gloucester Road, Bristol | 8 |
| 3.2.2 | Petrol Stations with a throughput less than 1000 m ³ /annum | 10 |
| | I. St Quentin Petrol Station, off Dalgarno Gardens, North Kensington. | 10 |
| | II. New Road Service Station, New Road, Croxley Green. | 10 |
| | III. Cecil Road Petrol Station, Cecil Road, Watford. | 11 |
| | IV. Rickmansworth Service Station, Victoria Close, Rickmansworth. | 12 |
| | V. Biggerstaffs Petrol Station, Dimmock's Lane, Sarrat. | 12 |
| | VI. Aston Lane Petrol Station, Aston Lane, Birmingham. | 13 |
| | VII. Billesley Lane Petrol Station, Billesley Lane, Birmingham. | 14 |
| | VIII. Reddicap Heath Petrol Station, Reddicap Heath Road, Birmingham. | 15 |
| | IX. Grove Road Petrol Station, Grove Road, Birmingham. | 15 |
| | X. Redland Road Petrol Station, Redland Road, Bristol. | 16 |
| | XI. Hampton Road Petrol Station, Hampton Road, Bristol. | 17 |
| | XII. Wick Road Petrol Station, Wick Road, Bristol. | 18 |
| | XIII. Dawson Street Petrol Station, Dawson Street, Oxford. | 19 |
| | XIV. Queen Street Service Station, Queen Street, Newbury. | 19 |
| | XV. Grove Service Station, Grove, Oxfordshire. | 20 |
| 3.2.3 | Assessment of the data from the measurement programme | 21 |
| 3.3 | RESULTS OF DIFFUSION TUBE EXPOSURE AT SELECTED SITES IN THE UK HYDROCARBON NETWORK. | 23 |
| 3.3.1 | Marylebone Road | 23 |

| | | |
|----------|--|-----------|
| 3.3.2 | Birmingham | 24 |
| 3.3.3 | Bristol | 25 |
| 3.3.4 | Harwell | 25 |
| 3.3.5 | Comparison of diffusion tubes and automatic analysers. | 26 |
| 4 | Future Trends in Benzene Concentrations | 28 |
| 4.1 | PREDICTED CHANGES IN THE EMISSION OF BENZENE FROM MOTOR VEHICLES. | 28 |
| 4.2 | CHANGES TO BENZENE CONCENTRATIONS IN PETROL AND INFLUENCE ON EVAPORATIVE EMISSIONS | 29 |
| 4.3 | AQS OF 5 PPB FOR BENZENE | 29 |
| 4.3.1 | Marylebone Road petrol station | 29 |
| 4.4 | EU PROPOSED DIRECTIVE FOR BENZENE OF 5 µg/m ³ (1.5 PPB) | 30 |
| 5 | Conclusions | 32 |

Appendices

| | |
|------------|--|
| Appendix 1 | List of selected petrol stations and Hydrocarbon Network sites |
| Appendix 2 | Concentrations measured at each location |
| Appendix 3 | Graphs of measured concentrations at each site |
| Appendix 4 | Maps of sampling locations |

1 Introduction

Benzene is one of a range of hydrocarbons present in the atmosphere at trace levels. It is an atmospheric pollutant that may have both a direct and indirect effect on human health. It is a genotoxic carcinogen and is involved in the production of secondary photochemical pollutants such as ozone.

In 1994, the Expert Panel on Air Quality Standards (EPAQS) recommended an Air Quality Standard for benzene in the United Kingdom of 5 ppb as a running annual mean (RAM). The Air Quality Strategy (AQS) has set a standard for benzene of 5 parts per billion (ppb) expressed as a running annual mean (RAM) to be achieved by 31 December 2003.

The European Commission has adopted a Proposal for a Directive which will, for the first time, set European Union (EU) limit values for benzene in air. The proposal sets a limit value of $5 \mu\text{g}/\text{m}^3$ (approximately 1.5 ppb) to be met by 1 January 2010. A margin of tolerance of 100% or $5 \mu\text{g}/\text{m}^3$ has been specified for the time of entry into force of the Directive, reducing on 1 January 2003 and every 12 months thereafter by equal annual percentages to reach 0% by 1 January 2010.

Measurements made by the UK Hydrocarbon Network at thirteen sites in the UK indicate that only at one site, Marylebone Road London, does the RAM approach the specified AQS of 5 ppb for benzene.

The source of most of the benzene observed at the UK Hydrocarbon Network sites is motor vehicle exhaust. However, earlier measurements of benzene on petrol station forecourts and in the vicinity of petrol stations have suggested that concentrations in the vicinity of petrol stations could be influenced by emissions of petrol vapour.

There are two occasions when the emission will be most significant. The first is when the road tanker delivers the fuel to the station, termed Stage 1. Vapour above the petrol stored in the underground tanks is forced through the tank vents as the tank is filled. Historically this vapour was vented to atmosphere. Recent legislation for Stage 1 controls has required that petrol stations should fit a vapour recovery system to prevent the vapour being discharged to the atmosphere at the petrol station. The timetable and requirement is dependent on the quantity of petrol sales over a 12-month period. Legislation allows Member States to exempt service stations with a throughput below 500 m^3 "where the service station is located in a geographic area or on a site where vapour emissions are unlikely to contribute significantly to environmental or health problems" if they are within a derogated area. For the UK, only specific areas of the Highlands and Islands of Scotland are derogated areas for the purpose of the legislation.

The Stage 1 vapour recovery process involves the installation of an additional pipe from the tanker during the fuel dispensing process. The vapour from the underground tanks is recovered into the tanker creating a closed loop during the dispensing of the petrol from the delivery tanker to the underground tanks.

The second occasion when significant vapour emission can occur is when petrol is dispensed into motor vehicle petrol tanks, termed Stage 2. Again the emission is due to the displacement of vapour from the tank by the petrol. There are no legal obligations on petrol stations, at present, that require the fitting of Stage 2 vapour recovery equipment. A limited number of larger, newer petrol stations are fitted with Stage 2 vapour recovery equipment.

It is believed that the total emission of vapour during Stage 1 and Stage 2 are similar. The basis of this assumption is that the total volume of vapour displaced during Stage 1 and Stage 2 is similar. However, other factors may influence the emission e.g. the vapour pressure of benzene at the time of emission that will be dependent on the temperature of the petrol, the quantity of petrol spillage during both stages. During the period covered by the measurement programme, the concentration of benzene was higher in unleaded petrol than in leaded and higher in super-unleaded than in ordinary unleaded. The maximum concentration allowed in all cases being 5%. From 1 January 2000, legislation required that the maximum benzene content of all petrol, unleaded and super-unleaded is 1%.

The total benzene emissions in the UK, on a year by year basis, have been compiled in National Atmospheric Emission Inventory (NAEI) reports. An assessment has been made of the emissions of benzene for future years. The prediction indicates that the quantity of emitted benzene will fall year by year due to the increasing percentage of cars fitted with catalytic converters.

Chromosorb 106 diffusion tubes have been used in this study to measure the long term average concentrations in the vicinity of a number of petrol stations. The selected sites consisted of three petrol stations with petrol throughputs of significantly greater than 1000 m³/annum and fifteen with a throughput of less than 1000 m³/annum.

2 Monitoring programme

2.1 OBJECTIVES OF THE STUDY

The objectives of the study were:

- Determine how the concentration of benzene in ambient air is influenced by the presence of petrol stations.
- Determine the factors that are likely to influence the concentration of benzene in the vicinity of petrol stations and the magnitude of the change in concentration. Factors to be investigated to include; the presence or not of Stage 1 vapour recovery, petrol throughput, and size of the petrol station.
- To estimate how the concentrations are likely to change in the future and whether current or future air quality objectives are likely to be breached due to the presence of petrol stations.

2.2 INITIAL SELECTION OF SUITABLE PETROL STATIONS

During the early phase of the programme the requirements for the selection of petrol stations were:

- The selected petrol stations to have residential properties within 10 m of the boundary.
- The diffusion tube location should be at a distance representative of the nearest residential property or a property within 10 m of the boundary, given that it might not be possible to sample on the residential property.
- The petrol stations should have a range of petrol throughput. Petrol stations with greater than 1000m³/annum were legally obliged to fit Stage 1 vapour recovery (Stage 1) by 31 December 1998.
- The selected petrol stations should be a mixture of those fitted with Stage 1 and those not fitted with Stage 1, if possible.

2.3 RESULT OF THE PRELIMINARY SURVEY OF PETROL STATIONS

Petrol stations in London, Birmingham and Bristol were selected with a range of throughputs; some fitted with Stage 1, some not. Only one station with a throughput of less than 1000 m³/annum but fitted with Stage 1 was identified in the preliminary survey. This station was located in Bristol and had undergone a refurbishment. Stage 1 had been installed during the refurbishment. Stations with a throughput of less than 1000 m³/annum but greater than 500 m³/annum have to fit Stage 1 vapour recovery before 31 December 2001. Petrol stations with a throughput of less than 500 m³/annum are legally obliged to fit Stage 1 by 31 December 2004 except those that qualify for derogation. Due to the cost of fitting Stage 1, petrol station owners have generally not yet fitted Stage 1 recovery where the throughput is less than 1000 m³/annum. It is likely that they will wait until close to the deadline date. All stations with throughput of less than 100 m³/annum are exempt from the requirement to fit Stage 1 controls.

2.4 MODIFIED REQUIREMENTS FOR PETROL STATION SELECTION

A meeting was held to discuss the finding of the preliminary survey. The requirements for petrol station selection were changed. The revised requirements were:

- The selected petrol stations to have residential properties within 10 m of the boundary.
- The diffusion tube location should be at a distance representative of the nearest residential property or a property within 10 m of the boundary, given that it might not be possible to sample on the residential property.
- Three petrol stations should have a petrol throughput of significantly greater than 1000 m³/annum. The petrol stations should be located in London, Birmingham and Bristol.
- The remainder of the selected stations should have throughputs of less than 1000 m³/annum and cover as wide a range of type of station as possible. These should include petrol stations with and without a canopy, with and without Stage 1 vapour recovery and if possible, other criteria that might influence the concentration of benzene emitted at petrol stations.

2.5 SELECTED PETROL STATIONS

The revised requirements for the selection of petrol stations meant that there were insufficient numbers of suitable petrol stations available as a result of the preliminary survey. More petrol stations in London, Birmingham and Bristol were assessed. A number of petrol stations with throughput of less than 1000 m³/annum were assessed. One further petrol station with a throughput of less than 1000 m³/annum and with Stage 1 controls already fitted was found - the Reddicap Heath petrol station in Birmingham.

Eighteen petrol stations were chosen for the survey described in this report. The chosen petrol stations covered a range of throughput, from about 180 m³/annum to about 3500 m³/annum. Four monitoring locations were chosen in the vicinity of each petrol station. Two monitoring sites were at least 50m from the boundary of the petrol station in an attempt to measure the concentrations likely to be encountered due to the emissions from the vehicle traffic travelling on the road. The other two sites were within 10m of the boundary of the petrol station and were chosen to be as representative as possible of the concentrations present at the nearest residential property. The selected petrol stations are listed in Appendix 1; the list includes names, addresses, grid references, whether or not Stage 1 vapour recovery was fitted and the range of petrol throughput. Maps of the sites and sampling locations are given in Appendix 4.

Monitoring was also conducted at four UK Hydrocarbon Network sites, to allow comparison of the results generated using the two measurement techniques.

For purposes of traceability each petrol station was assigned a code, the four monitoring locations in the vicinity of each petrol station were assigned a number from 1 to 4. Therefore, for example at the Marylebone Road petrol station the four sampling locations were MRP1, MRP2, MRP3 and MRP4.

2.6 DIFFUSION TUBES

Diffusion tubes filled with Chromosorb 106, conforming to the design required for analysis using a Perkin Elmer ATD400, were selected for this survey. Tubes were exposed in triplicate

at each sampling location, mounted in robust holders to reduce the likelihood of damage or theft. A small number of holders were stolen or removed but not enough to significantly affect the data capture. Diffusion tube holders were usually mounted on lampposts at a height of about 3m. At the UK Hydrocarbon Network sites, the tubes were mounted as close to the sample line inlet as possible, but not so close that the uptake rate might be affected by the flow of air into the inlet.

The exposure periods for each set of triplicate tubes were typically 14 days. Sets of tubes were exposed at each sampling location for a 52-week period, corresponding to 26 sets of results.

Tubes were stored in a fridge containing a tray of activated charcoal from the time of receipt to despatch and from return from the site to delivery to the analyst to minimise the likelihood of benzene uptake during storage.

2.6.1 Analysis of the collected samples

The contents of the tubes were desorbed using a Perkin Elmer ATD400 and analysed using a mass spectrometer. Analytical Services Group, AEA Technology, now Harwell Scientifics (part of the Atesta Group), undertook the analyses. The analytical procedure reported the mass of the analyte in ng per tube for benzene, toluene, ethylbenzene, m-xylene and p-xylene as the sum of the individual components, and o-xylene. The results for the benzene concentrations are reported here, the results for the other components are not reported.

An uptake rate of 1.6 was used to generate the average benzene concentration for each exposure period.

2.6.2 Diffusion tube blanks

At least one set of 3 tubes was used as a blank for each journey where tubes were exposed and retrieved. Use of the data from the diffusion tube blanks is discussed in Section 3.1.2.

3 Results and Discussion

3.1 DIFFUSION TUBE RESULTS

3.1.1 Reproducibility

In general the results from the triplicate exposures were very close. Most of the results of the analysis indicated that the standard deviation of the three measurements was less than 10%. However, a standard deviation of up to 20% was considered to be acceptable. A limited number of triplicate analyses gave results with standard deviation greater than 20%. In most of the cases, one of the results of the triplicate analysis was the cause of the higher than usual standard deviation, often the lowest value of the set of three. In most cases, the low value for benzene was not evident in the results for other components, which often agreed well for all three members of the triplicate. Where one of the results was responsible for a standard deviation of greater than 20%, the result was removed from the calculation of the mean for the exposure period. A small number of results for triplicate analyses had standard deviations greater than 40%, no two individual results agreeing within 20%. In this case all three results were removed from the data set and, as a result no mean value was generated.

The average concentrations for each sampling location are given in Tables A2.1, A2.2, A2.3, A2.4, A2.5, A2.6 and A2.7 (Appendix 2).

3.1.2 Blanks

A minimum of one set of three unexposed tubes or blanks was maintained for each journey corresponding to tube exposures. The reported blank values ranged from 5 ng to 18 ng with the majority being of the order of 10 ng. A 10 ng loading was equivalent to about 0.3 ppb of benzene over a 2 week sampling period. Overall reproducibility for any set of 3 blank tubes tended to be very good, the standard deviation being better than 20%. The average value for each set of blanks was subtracted from the equivalent average for each sampling location.

3.2 RESULTS FROM THE PETROL STATIONS

The results for each of the monitoring periods for each site are given in Tables A2.1 to A2.7, Appendix 2 and plotted in Figures A3.1 to A3.18, Appendix 3. Maps of each sampling location are given in Figures A4.1 to A4.18, Appendix 4. The monitoring locations at each site are marked on the maps with the selected code.

3.2.1 Stations with a throughput greater than 1000 m³/annum

I. Marylebone Road Service station, Marylebone Road, London.

The averages of the measured concentrations over the monitoring period, in the vicinity of the Marylebone Road Service station, Marylebone Road, London, are given in Table 3.1 below. The data for each individual monitoring period are presented in Table A2.1, Appendix 2 and

plotted in Figure A3.1, Appendix 3. Figure A4.1 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.1. Mean of the measured concentrations for the sampling locations in the vicinity of the Marylebone Road Service station, Marylebone Road, London; 9 September 1998 to 9 September 1999. Fitted with Stage 1 vapour recovery prior to commencement of the monitoring survey.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| MRP1 | 3.58 |
| MRP2 | 5.46 |
| MRP3 | 4.80 |
| MRP4 | 1.43 |

- MRP1 – On a lamp post in Marylebone Road, approximately 60m East of the petrol station.
- MRP2 – On the boundary of the petrol station adjacent to Marylebone Road.
- MRP3 – On the boundary of the petrol station adjacent to Gloucester Road.
- MRP4 – On a lamp post in Gloucester Road, approximately 50m North of the petrol station.

It is clear from the results that the benzene concentrations are significantly higher in Marylebone Road than in Gloucester Road. The presence of the petrol station does appear to contribute to the observed benzene concentrations. MRP1 and MRP2, the two sampling locations in Marylebone Road indicate that the enhancement due to the presence of the petrol station is of the order of 2 ppb. Given that the petrol station was fitted with Stage 1 vapour recovery prior to commencement of the monitoring survey, the observed enhancement is probably due primarily to the Stage 2 emissions.

The results for locations in Gloucester Road, MRP3 and MRP4 indicate that the enhancement is more pronounced. However, it is likely that location MRP3 was subject to the influence of both Marylebone Road and Gloucester Road. Location MRP4 was probably, therefore, not representative of the traffic 'background' at MRP3. The increased distance of MRP3 from Marylebone Road probably accounts for the slightly lower observed concentration than those observed at MRP2.

II. Hagley Road Petrol Station, Hagley Road, Birmingham

The averages of the measured concentrations over the monitoring period, in the vicinity of the Hagley Road Petrol Station, Hagley Road, Birmingham, are given in Table 3.2 below. The data for each individual monitoring period are presented in Table A2.2, Appendix 2 and plotted in Figure A3.2, Appendix 3. Figure A4.2 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.2. Mean of the measured concentrations for the sampling locations in the vicinity of the Hagley Road Petrol Station, Hagley Road, Birmingham; 2 September 1998 to 2 September 1999. Fitted with Stage 1 vapour recovery prior to commencement of the monitoring survey.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| HG1 | 0.76 |
| HG2 | 0.86 |
| HG3 | 0.45 |
| HG4 | 0.69 |

- HG1 – On a lamp post in Trevanie Avenue, about 5m East of the petrol station.
- HG2 – On a lamp post in Trevanie Avenue, about 10m East of the petrol station.
- HG3 – On a lamp post, about 50m South of the petrol station.
- HG4 – On a lamp post about 70m North of the petrol station.

The concentrations reported for locations in the vicinity of this petrol station were amongst the lowest of those reported for the locations in Birmingham even though this was a petrol station with a relatively high throughput (>1000 m³/annum, believed to be about 3000 m³/annum).

This petrol station was chosen because it had been a source of an odour complaint from a resident in Trevanie Road, to the Local Authority (LA), before the start of the monitoring campaign described in this report. The complaints were received prior to the fitting of Stage 1 vapour control. Representatives from the Environmental Protection Unit (EPU), part of the LA, had responded to the odour complaint and confirmed that the petrol odour had been particularly strong on the adjoining property at the time of petrol delivery to the petrol station. After the fitting of Stage 1 no further odour complaints had been received by the LA.

There were no residential properties within 10 m of the petrol station in Hagley Road but a residential property in Trevanie Avenue bordered on to the Petrol Station. Sampling locations were therefore selected in Trevanie Avenue. The general background in Trevanie Avenue would be expected to be lower than that in Hagley Road due to the lower traffic flow. The influence, if any, of the petrol station would be easier to observe the lower the background.

The observed background, measured at locations HG3 and HG4, was low. The two sampling locations close to the petrol station, HG1, within 5 m and HG2, approximately 10 m from the boundary, showed evidence of only a small enhancement when compared to the background values. Although anecdotal, the fitting of Stage 1 vapour recovery at this petrol station appears to have reduced the emissions associated with the Stage 1 process.

The observed concentrations at this site were well within the AQS for benzene of 5 ppb.

III. Star Service Station, 106 – 114 Gloucester Road, Bristol

The averages of the measured concentrations over the monitoring period, in the vicinity of Star Service Station, 106 – 114 Gloucester Road, Bristol, are given in Table 3.3 below. The data for each individual monitoring period are presented in Table A2.3, Appendix 2 and plotted in

Figure A3.3, Appendix 3. Figure A4.3 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.3. Mean of the measured concentrations for the sampling locations in the vicinity of Star Service Station, 106 – 114 Gloucester Road, Bristol; 21 August 1998 to 20 August 1999. Stage 1 vapour recovery was installed on or about 1 December 1998.

| Sampling Location | Average Concentration(ppb) | | |
|-------------------|----------------------------|------------------|-----------------------|
| | Whole period | Prior to Stage 1 | After fitting Stage 1 |
| JGL1 | 1.95 | 2.12 | 1.87 |
| JGL2 | 2.32 | 2.73 | 2.13 |
| JGL3 | 3.25 | 5.13 | 2.37 |
| JGL4 | 2.08 | 2.44 | 1.92 |

- JGL1 – On a lamp post about 100 m NNE of the petrol station.
- JGL2 – On a lamp post about 10 m to the East of the boundary of the petrol station.
- JGL3 – On a lamp post about 1 m to the East of the boundary of the petrol station.
- JGL4 – On a lamp post about 80 m South of the petrol station.

The most significant aspect of the data for this site is the relative change in concentrations observed for sampling location JGL3, compared to the 3 other locations, at the beginning of December 1998 (see Figure A3.3). Location JGL3 was about 1 m from the boundary of the petrol station and approximately 4 m from the vent pipes for the underground tanks. Sampling location JGL2 was about 10m from the boundary of the petrol station and about 15 m from the vent pipes.

At the beginning of the measurement programme, Stage 1 vapour recovery was not fitted at this petrol station. Stage 1 was fitted early in December 1998. The effect of fitting Stage 1 is clearly apparent from the averages in Table 3.3 and in Fig A3.3. Prior to the fitting of Stage 1 the reported concentrations for JGL3 were significantly higher than the concentrations at the other three locations. After the fitting of Stage 1 the concentrations at all four sampling locations were highly comparable.

The fact that all four sites have similar reported concentrations after the fitting of Stage 1 is somewhat unexpected. The emissions from Stage 1 and Stage 2 are believed to be of similar magnitude. The observed concentrations would be expected to drop after fitting Stage 1 but the effect of Stage 2 emissions should still have been observed. The fact that there seems to be only limited evidence of Stage 2 emissions for this site may reflect the fact that the petrol station has a large forecourt and therefore, a fairly dispersed source for the Stage 2 emissions. The petrol pumps were 5 to 20 m from sampling location JGL3, the effect of Stage 2 emissions may well have been reduced by the greater distance than for the Stage 1 source.

The assessment of likely exposure to benzene from evaporative emissions at any petrol station should therefore, involve careful consideration of the likely Stage 1 and Stage 2 emission sources, their proximity to the sampling location and the layout and extent of the petrol pumps.

3.2.2 Petrol Stations with a throughput of less than 1000 m³/annum of petrol

I. St Quentin Petrol Station, off Dalgarno Gardens, North Kensington.

The averages of the measured concentrations over the monitoring period, in the vicinity of St Quentin Petrol Station, off Dalgarno Gardens, North Kensington, are given in Table 3.4 below. The data for each individual monitoring period are presented in Table A2.1, Appendix 2 and plotted in Figure A3.4, Appendix 3. Figure A4.4 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.4. Mean of the measured concentrations for the sampling locations in the vicinity of the St Quentin Petrol Station, off Dalgarno Gardens; 21 October 1998 to 6 October 1999. Not fitted with Stage 1 vapour recovery.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| STQ1 | 0.95 |
| STQ2 | 1.88 |
| STQ3 | 0.89 |
| STQ4 | 0.86 |

- STQ1 - On a lamp post about 50 m NNW of the petrol station.
- STQ2 - On a drain pipe about 4 m to the West of the petrol station.
- STQ3 - On a sign post about 20 m to the SW of the petrol station.
- STQ4 - On a lamp post about 100 m WSW of the petrol station.

Location STQ2 was about 4 m from the petrol pumps, which were situated on a plinth forming part of the boundary to the petrol station. Due to the limited availability of suitable sampling locations for the tube holders, location STQ3 was about 20 m from the boundary.

The average concentration at location STQ2 was approximately 1 ppb higher than the mean for the 2 'background' locations. Location STQ3 gave a value that falls between the two values for STQ1 and STQ4 and therefore, appears not to be influenced by any emissions from the petrol station.

The presence of the petrol station does appear to influence the ambient benzene concentration in the immediate vicinity. The observed concentrations were well within the AQS for benzene of 5 ppb.

II. New Road Service Station, New Road, Croyley Green.

The averages of the measured concentrations over the monitoring period, in the vicinity of New Road Service Station, New Road, Croyley Green, are given in Table 3.5 below. The data for each individual monitoring period are presented in Table A2.1, Appendix 2 and plotted in Figure A3.5, Appendix 3. Figure A4.5 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.5 Mean of the measured concentrations for the sampling locations in the vicinity of the New Road Service Station, New Road, Croxley Green; 23 September 1998 to 9 September 1999. Not fitted with Stage 1 vapour recovery.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| NEW1 | 0.66 |
| NEW2 | 0.75 |
| NEW3 | 0.70 |
| NEW4 | 0.79 |

- NEW1 – On a lamp post about 40 m to the East of the petrol station.
- NEW2 – On a lamp post about 12 m to the East of the petrol station.
- NEW3 – On a lamp post about 10 m to the West of the petrol station.
- NEW4 – On a lamp post about 100 m to the West of the petrol station.

All the measured concentrations were similar, no obvious correlation with distance from the petrol station being evident. All the observed concentrations were well within the AQS for benzene of 5 ppb.

III. Cecil Road Petrol Station, Cecil Road, Watford.

The averages of the measured concentrations over the monitoring period, in the vicinity of Cecil Road Petrol Station, Cecil Road, Watford, are given in Table 3.6 below. The data for each individual monitoring period are presented in Table A2.1, Appendix 2 and plotted in Figure A3.6, Appendix 3. Figure A4.6 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.6. Mean of the measured concentrations for the sampling locations in the vicinity of the Cecil Road Petrol Station, Cecil Road, Watford; 9 September 1998 to 9 September 1999. Not fitted with Stage 1 vapour recovery.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| WCR1 | 0.85 |
| WCR2 | 0.76 |
| WCR3 | 0.84 |
| WCR4 | 0.75 |

- WCR1 - On a lamp post about 100 m to the East of the petrol station.
- WCR2 - On a lamp post about 5 m to the East of the petrol station.
- WCR3 - On a telegraph post about 10 to the South of the petrol station.
- WCR4 - On a lamp post about 50 m to the West of the petrol station.

All the mean values are similar with no obvious correlation of benzene concentration with distance from the petrol station being evident. The observed concentrations were well within the AQS for benzene of 5 ppb.

IV. Rickmansworth Service Station, Victoria Close, Rickmansworth.

The averages of the measured concentrations over the monitoring period, in the vicinity of Cecil Road Petrol Station, Cecil Road, Watford, are given in Table 3.7 below. The data for each individual monitoring period are presented in Table A2.1, Appendix 2 and plotted in Figure A3.7, Appendix 3. Figure A4.7 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.7. Mean of the measured concentrations for the sampling locations in the vicinity of the Rickmansworth Service Station, Victoria Close, Rickmansworth; 23 September 1998 to 9 September 1999. Not fitted with Stage 1 vapour recovery.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| RCK1 | 0.83 |
| RCK2 | 1.02 |
| RCK3 | 1.00 |
| RCK4 | 0.98 |

- RCK1 – On a lamp post about 30 m SSE of the petrol station.
- RCK2 – On a lamp post about 2 m to the East of the petrol station.
- RCK3 – On a lamp post about 12 m NNE of the petrol station.
- RCK4 – On a lamp post about 100 m NNE of the petrol station.

Most 'background' locations in this study were 50 m or more from the boundary. Location RCK1, one of the background locations for the Rickmansworth Service Station was about 30m from the petrol station, the selected location being the most suitable given the limited availability of suitable locations to the SSE.

The average concentrations were similar. The largest difference being 0.19 ppb, between RCK1, a background and RCK2, the location closest to the boundary. The results indicate that the benzene concentrations were only elevated to a small extent due to the presence of the petrol station.

The observed concentrations were well within the AQS for benzene of 5 ppb.

V. Biggerstaffs Petrol Station, Dimmock's Lane, Sarrat.

The averages of the measured concentrations over the monitoring period, in the vicinity of Biggerstaffs Petrol Station, Dimmock's Lane, Sarrat, are given in Table 3.8 below. The data for each individual monitoring period are presented in Table A2.1, Appendix 2 and plotted in Figure A3.8, Appendix 3. Figure A4.8 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.8. Mean of the measured concentrations for the sampling locations in the vicinity of the Biggerstaffs Petrol Station, Dimmock's Lane, Sarrat; 23 September 1998 to 9 September 1999. Not fitted with Stage 1 vapour recovery.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| SR1 | 0.57 |
| SR2 | 0.72 |
| SR3 | 0.75 |
| SR4 | 0.45 |

- SR1 – On a telegraph post about 100 m SE of the petrol station.
- SR2 – On a lamp post about 2m SE of the petrol station.
- SR3 – On a lamp post about 2m WNW of the petrol station.
- SR4 – On a lamp post about 50 WNW of the petrol station.

Locations SR2 and SR3 were both about 2 m from the boundary placed either side of the garage forecourt.

The results indicate that the benzene concentrations were elevated by about 0.2 ppb due to the presence of the petrol station. The observed concentrations were well within the AQS for benzene of 5 ppb.

VI. Aston Lane Petrol Station, Aston Lane, Birmingham.

The averages of the measured concentrations over the monitoring period, in the vicinity of Aston Lane Petrol Station, Aston Lane, Birmingham, are given in Table 3.9 below. The data for each individual monitoring period are presented in Table A2.2, Appendix 2 and plotted in Figure A3.9, Appendix 3. Figure A4.9 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.9. Mean of the measured concentrations for the sampling locations in the vicinity of the Aston Lane Petrol Station, Aston Lane, Birmingham; 2 September 1998 to 2 September 1999. Not fitted with Stage 1 vapour recovery. The Petrol station ceased trading 21/12/98

| Sampling Location | Average Concentration(ppb) | | |
|-------------------|----------------------------|------------------|---------------|
| | Whole period | Prior to Closure | After Closure |
| AL1 | 1.25 | 1.49 | 1.14 |
| AL2 | 1.18 | 1.43 | 1.06 |
| AL3 | 1.24 | 1.42 | 1.15 |
| AL4 | 1.81 | 2.13 | 1.66 |

- AL1 – On a lamp post about 2 m to the NE of the petrol station.
- AL2 – On a lamp post about 1 m to the South of the petrol station.
- AL3 – On a lamp post about 50 m SSW of the petrol station.
- AL4 – On a lamp post about 80 m NNE of the petrol station.

Sampling locations AL1 and AL2 were within 1 to 2 m of the boundary but approximately 10 to 15 m from the petrol pumps. During the process of selection of the sampling locations in the vicinity of the Aston Lane Petrol Station an odour that was believed to be due to petrol evaporation was detected from time to time.

The mean concentrations at locations AL1, AL2 and AL3 were all similar, whereas the concentrations at AL4 were elevated by about 0.55 ppb. The concentrations at AL4 were elevated relative to the other sampling locations on a fairly consistent basis see Figure A3.9, Appendix 3. It was observed that a car was parked immediately below sampling location AL4 on most occasions when tubes were changed. This fact was noted as the car was parked partly on the pavement restricting access to the sampling location on a number of occasions. A potential source of benzene was therefore within 3m of sampling location AL4. This might account for the elevated values observed at location AL4.

The petrol station ceased trading on 21 December 1998. The presence of the petrol station made no apparent difference to the ambient levels of benzene both before and after trading ceased. The odour detected during site selection may therefore have been an isolated incident or possibly not due to petrol evaporation.

The observed concentrations were well within the AQS for benzene of 5 ppb.

VII. Billesley Lane Petrol Station, Billesley Lane, Birmingham.

The averages of the measured concentrations over the monitoring period, in the vicinity of Billesley Lane Petrol Station, Billesley Lane, Birmingham, are given in Table 3.10 below. The data for each individual monitoring period are presented in Table A2.2, Appendix 2 and plotted in Figure A3.10, Appendix 3. Figure A4.10 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.10. Mean of the measured concentrations for the sampling locations in the vicinity of the Billesley Lane Petrol Station, Billesley Lane, Birmingham; 2 September 1998 to 2 September 1999. Not fitted with Stage 1 vapour recovery.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| BL1 | 1.16 |
| BL2 | 1.10 |
| BL3 | 1.06 |
| BL4 | 0.82 |

- BL1 – On lamp post about 1 m to the South of the petrol station.
- BL2 – On a lamp post about 2 m West of the petrol station.
- BL3 – On a lamp post about 50 m ESE of the petrol station.
- BL4 – On a lamp post about 50 m West of the petrol station.

Sampling locations BL1 and BL2 were within 1 to 2 m of the boundary and within 10m of the petrol pumps.

The mean benzene concentrations at locations BL1 and BL2 were slightly elevated compared to BL3 and BL4 but only by 0.1 to 0.3 ppb.

The observed concentrations were well within the AQS for benzene of 5 ppb.

VIII. Reddicap Heath Petrol Station, Reddicap Heath Road, Birmingham.

The averages of the measured concentrations over the monitoring period, in the vicinity of Reddicap Heath Petrol Station, Reddicap Heath Road, Birmingham, are given in Table 3.11 below. The data for each individual monitoring period are presented in Table A2.2, Appendix 2 and plotted in Figure A3.11, Appendix 3. Figure A4.11 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.11. Mean of the measured concentrations for the sampling locations in the vicinity of the Reddicap Heath Petrol Station, Reddicap Heath Road, Birmingham; 2 September 1998 to 2 September 1999. Fitted with Stage 1 vapour recovery prior to commencement of monitoring.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| RH1 | 1.88 |
| RH2 | 0.85 |
| RH3 | 0.80 |
| RH4 | 0.85 |

- RH1 – On a telephone post about 1 m to the SE of the petrol station.
- RH2 – On a lamp post about 10 m to the SW of the petrol station.
- RH3 – On a lamp post about 40 m SSW of the petrol station.
- RH4 – On a lamp post about 80 m NNE of the petrol station.

Sampling location RH1 was approximately 1 m from the boundary of the petrol station and within about 5 m of the petrol pumps. RH2 was about 10 m from the boundary of the petrol station and about 25 m from the petrol pumps.

The mean concentrations measured at locations RH2, RH3 and RH4 exhibit very similar values. The mean benzene concentration at RH1 was however, about 1 ppb higher than at the other 3 locations. It is likely that the proximity of the sampling point to the pumps is the reason for the enhanced benzene concentrations.

The observed concentrations were well within the AQS for benzene of 5 ppb.

IX. Grove Road Petrol Station, Grove Road, Birmingham.

The averages of the measured concentrations over the monitoring period, in the vicinity of Grove Road Petrol Station, Grove Road, Birmingham, are given in Table 3.12 below. The data for each individual monitoring period are presented in Table A2.2, Appendix 2 and plotted in Figure A3.12, Appendix 3. Figure A4.12 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.12. Mean of the measured concentrations for the sampling locations in the vicinity of the Grove Road Petrol Station, Grove Road, Birmingham; 2 September 1998 to 2 September 1999. Not fitted with Stage 1 vapour recovery.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| GR1 | 0.56 |
| GR2 | 0.60 |
| GR3 | 0.50 |
| GR4 | 0.45 |

- GR1 – On a lamp post about 2 m to the West of the petrol station.
- GR2 – On a lamp post about 5 m to the South of the petrol station.
- GR3 – On a lamp post about 100 m NE of the petrol station.
- GR4 – On a lamp post about 40 m ESE of the petrol station.

Sampling locations GR1 was within 2 m of the boundary of the petrol station but about 20 to 25 m from the petrol pumps and the Stage 1 vents. Location GR2 was about 5m from the boundary and about 6m from the vents for the Stage 1 emissions.

All the mean benzene concentrations measured in the vicinity of Grove Road petrol station were well below 1 ppb. There is slight evidence that the presence of the petrol station may have contributed to the concentration of benzene in the vicinity but only by about 0.1 ppb.

The observed concentrations were well within the AQS for benzene of 5 ppb.

X. Redland Road Petrol Station, Redland Road, Bristol.

The averages of the measured concentrations over the monitoring period, in the vicinity of Redland Road Petrol Station, Redland Road, Bristol, are given in Table 3.13 below. The data for each individual monitoring period are presented in Table A2.3, Appendix 2 and plotted in Figure A3.13, Appendix 3. Figure A4.13 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.13. Mean of the measured concentrations for the sampling locations in the vicinity of the Redland Road Petrol Station, Redland Road, Bristol; 4 September 1998 to 20 August 1999. Not fitted with Stage 1 vapour recovery.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| JRR1 | 1.27 |
| JRR2 | 0.85 |
| JRR3 | 1.97 |
| JRR4 | 1.81 |

- JRR1 – On a lamp post about 60 m NW of the petrol station.
- JRR2 – On a sign post about 0.5 m NW of the petrol station.
- JRR3 – On a lamp post about 12 m NE of the petrol station.
- JRR4 – On a lamp post about 50 m to the East of the petrol station.

Locations JRR1, JRR2 and JRR4 were all at very similar distances from the edge of the road, JRR2 being located about 1m higher than JRR1 and JRR4 for reasons of security. JRR1 was next to a section of Redland Road with a gradient, the gradient reducing significantly in the vicinity of the petrol station and JRR4. JRR2 was next to an open, grassed area. It is possible that location JRR2 may have been better ventilated than the other locations. Location JRR4 was within about 5 m of a zebra crossing where road traffic would have been decelerating and accelerating.

Location JRR3 gave rise to the highest concentrations, however, JRR2 gave rise to the lowest concentrations. JRR1 and JRR4 showed a difference of about 0.5 ppb. The interpretation of the results from the vicinity of Redland Road petrol station is not simple, the immediate vicinity possibly being of too complex in nature. JRR4 may have exhibited higher concentrations than JRR1 due to the proximity of a zebra crossing. JRR2 may have been better ventilated than the other locations and hence subject to lower benzene concentrations.

The observed concentrations were well within the AQS for benzene of 5 ppb.

XI. Hampton Road Petrol Station, Hampton Road, Bristol.

The averages of the measured concentrations over the monitoring period, in the vicinity of Hampton Road Petrol Station, Hampton Road, Bristol, are given in Table 3.14 below. The data for each individual monitoring period are presented in Table A2.3, Appendix 2 and plotted in Figure A3.14, Appendix 3. Figure A4.14 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.14. Mean of the measured concentrations for the sampling locations in the vicinity of the Hampton Road Petrol Station, Hampton Road, Bristol; 21 August 1998 to 20 August 1999. Fitted with Stage 1 vapour recovery prior to commencement of the monitoring survey.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| JHR1 | 1.30 |
| JHR2 | 1.35 |
| JHR3 | 1.23 |
| JHR4 | 2.02 |

- JHR1 – On a lamp post about 70 m SSE of the petrol station.
- JHR2 – On a lamp post about 10 m to the East of the petrol station
- JHR3 – On a lamp post about 10 m ENE of the petrol station.
- JHR4 – On a lamp post about 100 m NNW of the petrol station.

Sampling location JHR4 was within about 5 m of a zebra crossing and about 15 m from a small crossroads.

The mean benzene concentrations observed at JHR1, JHR2 and JHR3 were relatively consistent. The mean concentration observed at location JHR4 was however, approximately 0.7 ppb higher than observed at the other locations.

It does not appear that the Hampton Road station influences the benzene concentrations at about 10 m from the boundary. Considering location JHR4, it is possible that the presence of the zebra crossing and possibly the road junction may result in elevated benzene concentrations. Road traffic will have to slow down and possibly stop when the pedestrian crossing is in use. The traffic will then accelerate after passing the pedestrian crossing. The road traffic will spend more time in the vicinity of the pedestrian crossing than at the other sites. The speed will also vary by a greater extent, possibly contributing to higher emissions in the vicinity of the pedestrian crossing.

The observed concentrations were well within the AQS for benzene of 5 ppb.

XII. Wick Road Petrol Station, Wick Road, Bristol.

The averages of the measured concentrations over the monitoring period, in the vicinity of Wick Road Petrol Station, Wick Road, Bristol, are given in Table 3.15 below. The data for each individual monitoring period are presented in Table A2.3, Appendix 2 and plotted in Figure A3.15, Appendix 3. Figure A4.15 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.15. Mean of the measured concentrations for the sampling locations in the vicinity of the Wick Road Petrol Station, Wick Road, Bristol; 21 August 1998 to 20 August 1999. Not fitted with Stage 1 vapour recovery.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| JWR1 | 1.24 |
| JWR2 | 1.01 |
| JWR3 | 0.94 |
| JWR4 | 1.10 |

- JWR1 – On a lamp post about 70 m to the South of the petrol station.
- JWR2 – On a telephone post about 10m ESE of the petrol station.
- JWR3 – On a lamp post about 10 m ENE of the petrol station.
- JWR4 – On a lamp post about 70 m to the North of the petrol station.

Sampling locations JWR2 and JWR3 were about 10m from the boundary of the petrol station and about 15 m from the petrol pumps.

The mean benzene concentrations at all sampling locations did not vary by more than 0.3 ppb. Location JWR1 exhibiting the highest concentration. The presence of the petrol station did not appear to contribute to the observed benzene concentration 10 m from the boundary.

The observed concentrations were well within the AQS for benzene of 5 ppb.

XIII. Dawson Street Petrol Station, Dawson Street, Oxford.

The averages of the measured concentrations over the monitoring period, in the vicinity of Dawson Street Petrol Station, Dawson Street, Oxford, are given in Table 3.16 below. The data for each individual monitoring period are presented in Table A2.4, Appendix 2 and plotted in Figure A3.16, Appendix 3. Figure A4.16 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.16. Mean of the measured concentrations for the sampling locations in the vicinity of the Dawson Street Petrol Station, Dawson Street, Oxford; 21 October 1998 to 21 October 1999. Not fitted with Stage 1 vapour recovery.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| OOD1 | 2.10 |
| OOD2 | 1.07 |
| OOD3 | 1.32 |
| OOD4 | 1.26 |

- OOD1 – On a lamp post about 40 m NW of the petrol station.
- OOD2 – On a lamp post about 8 m to the West of the petrol station.
- OOD3 – On a lamp post about 10m SW of the petrol station.
- OOD4 – On a lamp post about 60 m SE of the petrol station.

The mean benzene concentrations measured at locations OOD1 and OOD4 may not have represented a reasonable ‘background’ for the petrol station. The road traffic was probably significantly higher near to locations OOD1 and OOD4 than at OOD2 and OOD3. As a result no firm conclusions can be drawn on the effect of the petrol station had on the observed concentrations.

The observed concentrations were well within the AQS for benzene of 5 ppb.

XIV. Queen Street Service Station, Queen Street, Newbury.

The averages of the measured concentrations over the monitoring period, in the vicinity of Queen Street Service Station, Queen Street, Newbury, are given in Table 3.17 below. The data for each individual monitoring period are presented in Table A2.5, Appendix 2 and plotted in Figure A3.17, Appendix 3. Figure A4.17 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.17. Mean of the measured concentrations for the sampling locations in the vicinity of the Queen Street Service Station, Queen Street, Newbury; 6 November 1998 to 6 October 1999. Not fitted with Stage 1 vapour recovery.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| NBY1 | 0.82 |
| NBY2 | 1.32 |
| NBY3 | 1.10 |
| NBY4 | 0.91 |

- NBY1 – On a lamp post about 50 m to the East of the petrol station.
- NBY2 – On a lamp post about 3 m to the East of the petrol station.
- NBY3 – On a lamp post about 8m to the South of the petrol station.
- NBY4 – On a lamp post about 50 m to the West of the petrol station.

The mean benzene concentrations were highest at the location closest to the petrol station, NBY2, about 0.2 ppb lower at the next closest location, NBY3, and a further 0.2 to 0.3 ppb lower at distances that should represent the 'background' for Queens Road. At a distance of about 3m from the boundary, the benzene concentration was elevated by 0.4 to 0.5 ppb.

The observed concentrations were well within the AQS for benzene of 5 ppb.

XV. Grove Service Station, Grove, Oxfordshire.

The averages of the measured concentrations over the monitoring period, in the vicinity of Grove Service Station, Grove, Oxfordshire, are given in Table 3.18 below. The data for each individual monitoring period are presented in Table A2.6, Appendix 2 and plotted in Figure A3.18, Appendix 3. Figure A4.18 is a map of the area surrounding the petrol station with an indication of the sampling locations.

Table 3.18. Mean of the measured concentrations for the sampling locations in the vicinity of the Grove Service Station, Grove, Oxfordshire; 4 September 1998 to 17 September 1999. Not fitted with Stage 1 vapour recovery.

| Sampling Location | Average Concentration (ppb) |
|-------------------|-----------------------------|
| OGR1 | 0.79 |
| OGR2 | 0.74 |
| OGR3 | 1.34 |
| OGR4 | 0.52 |

- OGR1 – On a lamp post about 50 m to the South of the petrol station.
- OGR2 – On a lamp post about 8 m to the East of the petrol station.
- OGR3 – On a lamp post about 2 m NE of the petrol station.
- OGR4 – On a lamp post about 50 m to the North of the petrol station.

Sampling location OGR1 was about 8 m from a set of traffic lights.

The benzene concentrations observed at OGR3, the location closest to the petrol station, were consistently higher than at the other three locations, see Figure A3.21, Appendix 3. Sampling location OGR1 may have been influenced by the presence of the traffic lights where vehicle speeds will be more variable. The mean benzene concentration observed at location OGR4, may represent a better 'background' concentration than that at OGR1. The benzene concentration at a distance of 2 m from the petrol station was elevated by 0.6 to 0.8 ppb.

The observed concentrations were well within the AQS for benzene of 5 ppb.

3.2.3 Assessment of the data from the measurement programme

In this programme, petrol stations were chosen with a number of selection criteria, e.g. with and without canopy, varying size of canopy, possible ventilation characteristics. The overall average benzene concentrations found at the station are summarised, in relation to these features, in Table 3.19.

In general, the data do not show any strong correlation with these features. However, the following observations can be made in relation to the incidence of measured concentrations above the general background concentrations:

- Fitting Stage 1 vapour recovery can significantly reduce the measured benzene concentrations. The measurements at the Gloucester Road petrol station, Bristol, show this quite clearly.
- The proximity of the petrol pumps and/or the Stage 1 vents to the boundary or sampling location may have a significant effect.
- The enhancement of the benzene concentration seems to fall off quite rapidly in a relatively short distance. The concentrations were only significantly enhanced when the sampling location was within 5 m of the boundary. The range of enhancement varied from 0 to 2 ppb.
- The roadside monitoring away from the immediate vicinity of petrol stations shows the importance of the traffic speed to benzene concentrations. Where traffic flow may be interrupted e.g. at a pedestrian crossing or at traffic lights, the observed concentration may well be higher, possibly of the order of 50% higher than for an uninterrupted section of the same road.
- Benzene concentrations may be elevated to a small extent, due to petrol evaporation from a parked vehicle in close proximity of the sampling point. The age of the vehicle may be an important factor.

Table 3.19. Summary table of results of the measured concentrations in the vicinity of petrol stations

| Station Name | City/Town | Petrol Throughput (m ³ /yr) | Stage 1 fitted | Canopy | Other features | Average Concentration close to station (ppb) | Average Concentration at a distance from station (ppb) |
|-------------------------------|--------------------|--|----------------|-------------|--|--|--|
| Marylebone Road | London | >1000 | Yes | Yes | High Traffic flow | 5.1 | 2.5 |
| Hagley Road | Birmingham | >1000 | Yes | Yes | | 0.81 | 0.57 |
| Star Service Station | Bristol | >1000 | Fitted Dec1998 | Yes | High traffic flow | 2.79 | 2.02 |
| St Quentin | London | <1000 | No | Partial | Small road, light traffic. | 1.39 | 0.91 |
| New Road | Croxley Green | <1000 | No | No | | 0.73 | 0.73 |
| Cecil Road | Watford | <500 | No | No | Low traffic flow | 0.8 | 0.8 |
| Rickmansworth Service Station | Rickmansworth | <1000 | No | Yes | | 1.01 | 0.91 |
| Biggerstaffs Petrol Station | Sarrat | <1000 | No | No | | 0.74 | 0.51 |
| Aston Lane | Birmingham | <1000 | No | Yes (Small) | Stopped Trading 21/12/99 | 1.22 | 1.53 |
| Billesley Lane | Birmingham | <1000 | No | No | | 1.13 | 0.94 |
| Reddicap Heath | Birmingham | <=1000 | Yes | Yes (Small) | Close to edge of the urban conurbation | 1.37 | 0.83 |
| Grove Road | Birmingham | <1000 | No | Yes (Small) | | 0.58 | 0.48 |
| Redland Road | Bristol | <1000 | No | Yes (Small) | | 1.41 | 1.54 |
| Hampton Road | Bristol | <=1000 | Yes | Yes (Small) | | 1.29 | 1.66 |
| Wick Road | Bristol | <1000 | No | No | | 0.98 | 1.17 |
| Dawson Street | Oxford | <1000 | No | No | | 1.20 | 1.68 |
| Queen Street | Newbury | <1000 | No | No | | 1.21 | 0.87 |
| Grove Service Station | Grove, Oxfordshire | <1000 | No | No | | 1.04 | 0.66 |

3.3 RESULTS OF DIFFUSION TUBE EXPOSURE AT SELECTED SITES IN THE UK HYDROCARBON NETWORK.

Sets of tubes were exposed in triplicate at UK Hydrocarbon Network sites. The sites were those at Marylebone Road, London, Birmingham, Bristol and Harwell. The letter codes assigned to the UK Hydrocarbon Network sites were M – Marylebone Road site, B – Birmingham, J – Bristol and H – Harwell.

The results of the analysis of tubes exposed at the UK Hydrocarbon Network sites and the data generated by the automatic analysers are plotted graphically in Appendix 3. The results from the automatic analysers were taken from the data presented on the WEB pages of the National Archive. The average of the reported concentrations during the period corresponding to the sampling period used for the diffusion tubes was calculated for the comparison.

3.3.1 Marylebone Road

The sampling inlet for the PE/ATD400 automatic hydrocarbon monitor was approximately 2.5 m above ground level and extended approximately 30 cm from the cabin towards Marylebone Road. The label MHC refers to the data generated by the PE/ATD400 and displayed on the web pages of the National Archive. The labels MDT1 and MDT2 refer to two sampling locations on the monitoring cabin at Marylebone Road and the respective data sets. The tubes corresponding to MDT1 and MDT2 were mounted on the rails fixed to the cabin roof. Both MDT1 and MDT2 were therefore, 30 cm further from the roadside than the PE/ATD400 sampling inlet. Location MDT1 was approximately 0.75 m from the PE/ATD400 sampling inlet, location MDT2 was approximately 1.5 m from the PE/ATD400 sampling inlet.

The measured concentrations at the Marylebone Road AUN site using tubes and the Perkin Elmer/ATD 400 automatic analyser (PE/ATD400) are compared in Table 3.20 below. The data for each individual monitoring period are presented in Table A2.1, Appendix 2. The data for each individual period are plotted in Figure A3.19, Appendix 3.

Table 3.20. Comparison of the overall mean reported for diffusion tubes and the PE/ATD400 at the Marylebone Road AUN monitoring site; 9 September 1998 to 9 September 1999.

| Monitoring method | Concentration (ppb) |
|-------------------|---------------------|
| PE/ATD (MHC) | 3.17 |
| Tubes (MDT1) | 2.77 |
| Tubes (MDT2) | 2.60 |

Figure A3.19 is a plot of the concentrations as reported by the diffusion tubes and the automatic analyser. The agreement is good for most of the first 5 months of the monitoring period. The following 6 exposure periods display similar profiles but with an offset of about 1 ppb, the diffusion tubes giving results that are lower than the PE/ATD. The agreement then improved for two of the exposure periods but became somewhat erratic for the last 5 weeks of

monitoring. During the last 5 weeks the data reported for the PE/ATD had some large gaps. The generated 2 week averages are not therefore, necessarily representative of the average of the 2 week period.

The overall means given in Table 3.20 show moderately good agreement. Both sets of tubes agree well but underread by about 0.4 ppb when compared to the PE/ATD. Most of the underread is probably due to the relatively consistent underread during the 3 months from February to April 1999 and some of the later data when data capture for the PE/ATD was low.

3.3.2 Birmingham

The sampling inlet for the VOCAIR automatic hydrocarbon monitor was approximately 3.5 m above ground level and extended approximately 1.5m above the roof of the cabin. The label BHC refers to the data generated by the VOCAIR at the Birmingham site. The labels BDT1 and BDT2 refer to two sampling locations on the monitoring cabin at the Birmingham site and the respective data sets. Diffusion tubes were installed at location BDT1 at an earlier time than at location BDT2. A single set of triplicate tubes, BDT1, was fixed to the inlet for the VOCAIR approximately 30 cm below the cowling. The second and third sets were stolen. No further tubes were exposed until a protective cage had been installed. Two sets of triplicate tubes, BDT1 and BDT2, were installed after the security of the site had been improved.

The mean of the measured concentrations at the Birmingham UK Hydrocarbon Network site using tubes and the Chrompack VOCAIR analyser (VOCAIR) are compared in Table 3.21 below. The data for each individual monitoring period are presented in Table A2.2, Appendix 2.

Table 3.21. Comparison of the mean concentrations for diffusion tubes and the VOC-AIR at the Birmingham Hydrocarbon Network site. Tubes corresponding to BDT1 were exposed for the periods 2 September 1998 to 16 September 1998 and 11 November 1998 to 2 September 1999. Tubes corresponding to BDT2 were exposed for the period 24 November 1998 to 2 September 1999.

| Monitoring method | Concentration (ppb) |
|-------------------|---------------------|
| VOCAIR (BHC) | 0.91 |
| Tubes (BDT1) | 0.46 |
| VOCAIR (BHC) | 0.87 |
| Tubes (BDT2) | 0.37 |

The data for each individual period are plotted in Figure A3.20, Appendix 3. Inspection of Figure A3.20 suggests that the agreement, in terms of measured concentration, is poor with the VOCAIR average result approximately twice as high as the diffusion tube result. The difference was about 1 ppb for the early period of the monitoring but closer to 0.3 ppb from the beginning of February 1999 to the end of the monitoring period. The agreement for the two techniques is relatively good in terms of the trends in concentrations.

3.3.3 Bristol

The configuration of the inlet system for the automatic analyser at Bristol is similar to that at Birmingham. The single set of triplicate tubes was fixed to the sampling inlet for the VOCAIR approximately 30 cm below the cowling. The label JHC refers to the data generated by the VOCAIR at Bristol and extracted from the web pages of the National Archive. The label JDT1 refers to the location and the data for the location of the triplicate samples.

The mean of the measured concentrations at the Bristol UK Hydrocarbon Network site using tubes and the Chrompack VOC-AIR analyser are compared in Table 3.22 below. The data for each individual monitoring period are presented in Table A2.3, Appendix 2. The data for each individual period are plotted in Figure A3.21, Appendix 3.

Inspection of Figure A3.21 indicates that the reported results compare well in terms of the observed trends but display a relatively constant offset making the VOCAIR result almost twice as high as the diffusion tube result. Unlike the results for the comparison at the Birmingham site, the difference between the two sets of results, the offset, remained relatively constant over the monitoring period. The difference between the two mean values being 0.44 ppb with the tubes reporting results lower than the VOCAIR.

Table 3.22. Comparison of the mean concentrations for diffusion tubes and the VOC-AIR at the Bristol Hydrocarbon Network site; 21 August 1998 to 20 August 1999.

| Monitoring method | Concentration (ppb) |
|-------------------|---------------------|
| VOCAIR (JHC) | 0.91 |
| Tubes (JDT1) | 0.47 |

3.3.4 Harwell

The configuration of the inlet system for the automatic analyser at Harwell is similar to that at Birmingham and Bristol, however, the inlet is about 4.5m above ground level, compared to 3.5 m at the other sites. The tubes were fixed to the sampling inlet line about 3m above ground level, approximately 1.2m below the sampling inlet for the VOCAIR. The label HHC refers to the averages of the data reported using a VOCAIR for the periods corresponding to the exposure periods of the tubes at the Harwell site. HDT1 and HDT2 refer to the sampling location and the corresponding data for the exposure periods. Location HDT2 was installed after sampling had commenced at location HDT1. The first exposure period at location HDT2 corresponded to the third exposure period for HDT1.

The decision to install tubes at the Harwell site was made after a number of results had been received for the comparison at the UK Hydrocarbon Network site at Bristol. The Harwell site is classified as a rural site, the concentrations being the lowest reported by the UK Hydrocarbon Network. The comparison of the results of the measurements at the Harwell site was considered a good test of the diffusion tubes. The comparison at the Harwell site covers less than six months.

The mean of the measured concentrations at the Harwell UK Hydrocarbon Network site, using tubes and the Chrompack VOC-AIR analyser (VOCAIR) are compared in Table 3.23. The data for each individual monitoring period are presented in Table A2.4, Appendix 2. The data for each individual period are plotted in Figure A3.22, Appendix 3.

Table 3.23. Comparison of the mean concentrations for diffusion tubes and the VOC-AIR at the Harwell Hydrocarbon Network site. Tubes corresponding to HDT1 were exposed for the period, 24 March 1998 to 2 September 1999. Tubes corresponding to HDT2 were exposed for the period, 23 April 1998 to 2 September 1999.

| Monitoring method | Concentration (ppb) |
|-------------------|---------------------|
| VOCAIR (HHC) | 0.22 |
| Tubes (HDT1) | 0.09 |
| VOCAIR (HHC) | 0.21 |
| Tubes (HDT2) | 0.10 |

Inspection of Figure A3.22 indicates that the agreement with respect to the observed profile is reasonable but that there is an offset of about 0.1 ppb. The reported results for diffusion tubes being lower than the results for the VOCAIR.

3.3.5 Comparison of diffusion tubes and automatic analysers.

The comparison of the results reported for the diffusion tubes and the automatic analysers in terms of the observed trends appear to be relatively good. In terms of the measured values there is a significant difference in the results produced by the two techniques. The results generated by the tubes are lower than those produced by the automatic analysers. Although the difference or offset is relatively consistent for extended periods of measurement at each site, the offset varies significantly from site to site. The offset in the reported benzene concentrations varies from about 0.1 at the Harwell site to nearly 1 ppb for a period at the Birmingham site. The offset appears to be relatively constant although a step change from 1 ppb to about 0.3 ppb is apparent in the data set for the Birmingham site. The measurements suggest that the difference is an offset and not proportional to the measured concentration. The discrepancy does not therefore, appear to be due to either the uptake rate for the diffusion tubes or the calibration factor for the automatic analysers.

Analysis of the data does not suggest an obvious reason for the discrepancy. Possible reasons for this include:

- A system 'blank' or possible co-elution for the automatic analysers. A system 'blank' is unlikely as the measured concentrations were often lower than the apparent discrepancy at the site in question. A co-elution is also unlikely given that the discrepancy appears to be constant for a number of consecutive exposure periods.
- A contamination of the tube 'blanks' during transportation or storage. This is very unlikely as data was also available for toluene, ethylbenzene and the xylene for the blanks. Whereas the

benzene 'blank' was often of the order of 10 ng, the toluene, ethylbenzene and xylene blanks were of the order of 1 to 2 ng. If 'blanks' were in some way contaminated then the other components would be expected to be elevated in a similar way.

The analytical procedure is unlikely to have contributed to the discrepancy as tubes were analysed in batches. Each batch contained tubes from a selection of the sites whereas the discrepancy appeared to be relatively constant at each individual site.

Given that the reason for the observed discrepancy cannot be easily deduced the measured concentrations in the vicinity of petrol stations should be considered to be an underestimate of up to 1.0 ppb. The highest observed discrepancy for an extended period was of the order of 1 ppb at the Birmingham site.

The blank level observed in this study, of about 10 ng, equivalent to about 0.3 ppb for an exposure period of 2 weeks, tended to be very consistent. Measured concentrations of less than 0.5 ppb above the blank value should be used with caution if obtained using a single diffusion tube. In this study the exposure of tubes and blanks in triplicate gave consistent results within each set of triplicates adding some confidence to the measured values. Measurement of concentrations of benzene below 0.5 ppb will require blank levels significantly lower than observed in this study.

The diffusion tubes as used in this study gave results that were consistently lower than measured by the both types of automatic analyser, the VOCAIR and the Perkin-Elmer ATD400. The differences appeared to vary with time and from site to site. No clear conclusion could be drawn from the results obtained in this study.

4 Future Trends in Benzene Concentrations

4.1 PREDICTED CHANGES IN THE EMISSION OF BENZENE FROM MOTOR VEHICLES.

A projection of the emission of benzene from motor vehicles in the UK has been made by the National Atmospheric Emission Inventory (NAEI)^{1,2}. The projection is plotted in Figure 4.1, as total emission of benzene, from motor vehicles, in kT/annum versus calendar year. Assuming that the measured concentrations of benzene measured at roadside locations is primarily due to the emissions from motor vehicles, the future changes in the concentrations at the monitoring locations can be estimated from the NAEI predictions.

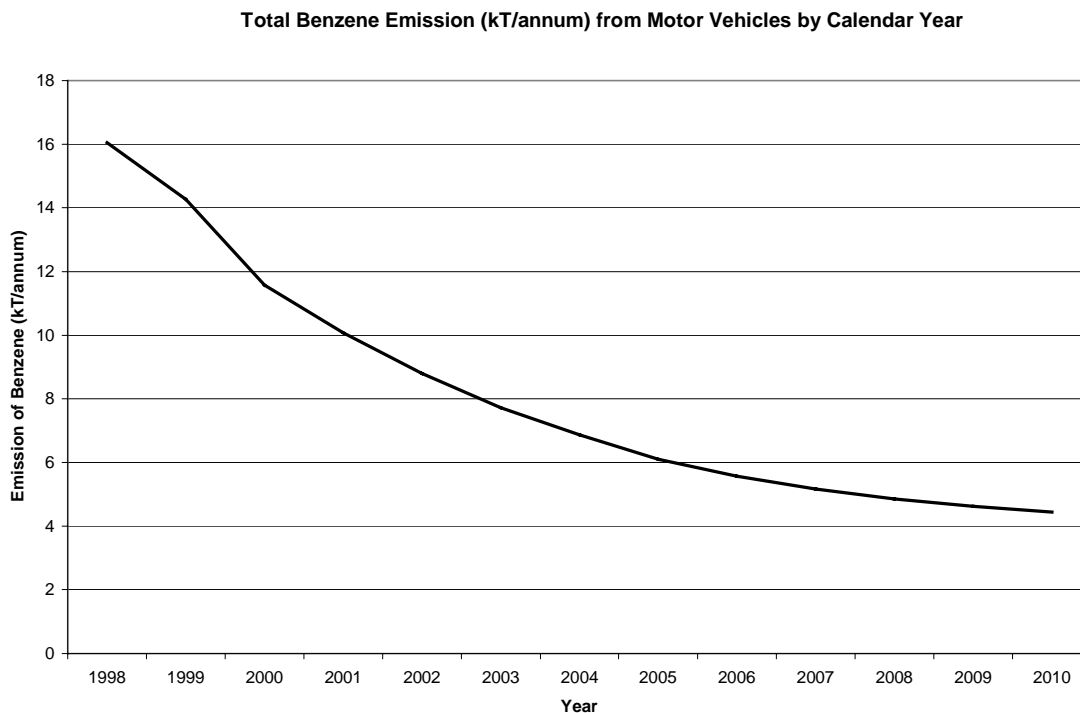


Figure 4.1. Predicted total emission of benzene, exhaust and evaporative, from motor vehicles by calendar year in the UK.

1

The monitoring in this study commenced during mid 1998 and continued through to mid 1999. Taking the average value for 1998 and 1999, the total emission of benzene from motor vehicles was about 15.2 kT/annum in the UK.

1 Goodwin, J.W.L. et al, (1999), UK Emissions of Air Pollutants 1970 – 1997

2 Murrells, T.P. (2000), "UK Road Transport Emission Projections. The assumptions used and results of the 1997 National Atmospheric Emission Inventory Base Projections". AEAT Technology Report AEAT – 5953, January 2000

4.2 CHANGES TO BENZENE CONCENTRATIONS IN PETROL AND INFLUENCE ON EVAPORATIVE EMISSIONS

The upper limit for benzene concentrations in petrol, to the end of December 1999 was 5% by weight. In practice the average benzene concentration in petrol during early 1999 was about 2%. From the beginning of January 2000 the upper limit for the benzene concentration in petrol was reduced to 1%. Data on the concentration of benzene in all types of petrol are not available as yet, therefore, a concentration of 1% has been assumed. From the beginning of 2000 the benzene concentration in petrol should have been reduced to a maximum of 50% of the concentration in 1998/1999.

As a result of the change in the concentration of benzene in petrol, the concentration of benzene in the atmosphere due to evaporative emission should reduce by the same factor. Assuming no further changes to upper limits of benzene concentration in petrol, changes to evaporative emissions from motor vehicles and evaporative emissions from petrol stations, the future concentrations of benzene in the atmosphere due to evaporative emissions should reduce to a maximum of 50% of the concentration in 1998/1999.

The likely changes to benzene concentrations in the atmosphere, discussed in sections 4.1 and 4.2 above, can be used to estimate the future benzene concentration at the monitoring locations described in this study. The predicted values can be compared to air quality standards.

4.3 AQS OF 5 PPB FOR BENZENE

Assuming that the measured benzene concentrations in this study were underestimated by 1 ppb, any reported average value of 4 ppb or greater indicates that the sampling location was subject to benzene concentrations that exceed the AQS of 5 ppb. In this study only measurements made in the vicinity of the Marylebone road petrol station gave rise to values that exceeded 4 ppb. Measured concentrations at all other petrol stations were below 4 ppb. Assuming the measured concentrations were underestimated by 1 ppb the concentrations at all other petrol stations would be below the AQS of 5 ppb for benzene.

It is clear from this study that motor vehicles contribute a significant percentage of the measured benzene concentrations. Given the target date of 31 December 2003 for the achievement of the AQS of 5 ppb for benzene, the likely change in emissions of benzene from motor vehicle sources should be taken into consideration. The projection of benzene emitted by motor vehicles indicates that the emissions of benzene from motor vehicles will be reduced to about 50% of their present values, by the end of December 2003. The predicted emissions of benzene are expected to continue to fall beyond the end of December 2003.

4.3.1 Marylebone Road petrol station

The benzene concentration was measured at one background location in Marylebone Road, with an average of about 3.6 ppb. Assuming a consistent underestimation of 1 ppb, the value becomes 4.6 ppb. The predicted decrease in benzene emissions indicate that the benzene from motor vehicles will decrease to less than 50 % of their 1998/99 values by the end of December 2003. Should the contribution from motor vehicles reduce by 50%, the highest concentration

of benzene observed at the kerbside of Marylebone Road would be reduced to about 2.3 ppb by the end of December 2003.

At the Marylebone Petrol Station, the remainder of the observed benzene, about 2 ppb may well originate from emissions due to evaporation during the Stage 2 process and exhaust emissions. Stage 1 vapour recovery is already fitted at the Marylebone petrol station therefore, emissions from the Stage 1 process should be relatively low. Stage 2 emissions should be proportional to the benzene content of petrol. As discussed above the benzene concentration in petrol should reduce by at least 50% from 1998/99 to 2003. The contribution arising from Stage 2 emissions should therefore, decrease from 2 ppb to 1 ppb at the Marylebone petrol station from January 2000.

The estimated total benzene concentration in the atmosphere at the Marylebone Road petrol station will be $(2.3 + 1.0) = 3.3$ ppb at the end of December 2003. This will be well within the AQS of 5 ppb. This is based on the assumption that the quantity of petrol contributing to the Stage 2 emission does not increase by the end of December 2003.

Although the value of 3.3 ppb would meet the AQS for benzene of 5 ppb, uncertainties in the predicted reduction of emissions and measurement techniques add an element of uncertainty. The predicted total emission from motor vehicles continues to decrease to 2010 and hence, the estimated concentrations will continue to fall after the end of December 2003.

The measured concentrations at all the other locations in this study were significantly lower than measured concentrations at the Marylebone Petrol Station. Assuming the same rate of decrease of benzene concentrations, all other sites will meet the AQS of 5 ppb for benzene by 31 December 2003.

4.4 EU PROPOSED DIRECTIVE FOR BENZENE OF 5 µg/m³ (1.5 PPB)

The European Commission has adopted a Proposal for a Directive which will for the first time set European Union (EU) limit values for benzene. The proposal sets a limit value of 5 µg/m³ (approximately 1.54 ppb) to be met by 1 January 2010. A margin of tolerance of 100% or 5 µg/m³ has been specified for the time of entry into force of the Directive, reducing on 1 January 2003 and every 12 months thereafter by equal annual percentages to reach 0% by 1 January 2010.

Although the date has not been specified, the time required for the approval and ratification may mean that 2 years will pass before the Directive comes into force. Choosing 1 January 2002 as a possible date, the 100% margin of tolerance permitted under the Directive with respect to the limit value will be about 3.0 ppb (10 µg/m³).

Considering the results for the Marylebone Road petrol station. The measured value at the 'background' site in Marylebone road was about 3.6 ppb during 1998/99. Allowing for a potential underestimation of 1 ppb using the tubes a 'background' concentration of 4.6 ppb is assumed. Applying the predicted reduction in motor vehicle emission of benzene to the concentration of 4.6 ppb will result in a reduction to 66% by 1 January 2002, i.e. 3.1 ppb. The evaporative component, 2 ppb in 1998/99, is assumed to reduce to 1 ppb, due to the change in

limit value for benzene in petrol. At the beginning of January 2002 the predicted concentrations at the Marylebone site will be $(3.1 + 1.0) = 4.1$ ppb ($13.3 \mu\text{g}/\text{m}^3$), about 1.1 ppb above the limit value.

By 1 January 2010 the limit value will be 1.54 ppb ($5 \mu\text{g}/\text{m}^3$). The predicted decrease in motor vehicle emissions indicates that the emissions in 2010 will be 31% of their 1999 value. Applying this factor to the measured concentration, the expected concentration in 2010 will be of the order of $(1.4 + 1.0) = 2.4$ ppb, exceeding the limit by about 0.9 ppb. This calculation is based on predicted changes to the vehicle emissions and a halving of the contribution from evaporative emission at the petrol station.

In 2010, the Stage 2 emissions at the Marylebone petrol station will contribute an estimated 1 ppb to the average ambient concentration of benzene, see section 4.3.1 above. Should Stage 2 vapour recovery be installed, and be 100% efficient, then the contribution from Stage 2 emissions will be completely eliminated. The predicted average concentration of benzene will, as a result, fall by 1 ppb to 1.4 ppb in 2010. The predicted concentrations may just meet the EU limit value of 1.5 ppb ($5 \mu\text{g}/\text{m}^3$). It should be noted that there are considerable uncertainties in the predicted emissions which could significantly change the estimated concentrations. There are also uncertainties in the measured values obtained using the diffusion tubes. Should the underestimation be greater than 1 ppb, for example 1.5 ppb, then the predicted concentrations in 2010 will be 1.58 ppb which would just exceed the EU limit value.

For all other petrol stations in this study, the measured concentrations were significantly lower than at the Marylebone road petrol station. The Star Service station in Bristol exhibited the highest concentrations of the remaining petrol stations. Assuming an underestimation of 1 ppb, the average concentration in the vicinity of the petrol station would be about 3.4 ppb and about 2.0 ppb at the background locations. Applying the predicted reductions the highest concentrations will fall to $(1.32 + 0.7) = 2.02$ ppb at the beginning of 2002, about 1.0 ppb below the EU margin of tolerance of 3 ppb and $(0.61 + 0.7) = 1.31$ ppb at the beginning of 2010, which is just below the limit value of 1.5 ppb.

As noted above, that there are uncertainties in the emission predictions and in the measurements which, given the closeness of the predicted results to the relevant standards, may have a significant effect on these conclusions.

The results of the measurements at all remaining petrol stations were all lower than the values at the Star Service station. The estimated concentrations for the beginning of 2003 and beginning of 2010 are therefore, all below the respective EU limit values.

5 Conclusions

A programme of measurements of the benzene concentrations in air in the vicinity of eighteen petrol stations has been conducted on behalf of the Department of the Environment, Transport and the Regions, the National Assembly for Wales, the Scottish Executive and the Department of Environment in Northern Ireland. Benzene concentrations were determined using Chromosorb 106 diffusion tubes, exposed in triplicate. The survey was carried out over twelve months at 18 petrol stations. Three of the petrol stations had a throughput of petrol significantly in excess of 1000 m³/annum. The other fifteen petrol stations had a throughput of petrol of less than 1000 m³/annum.

The results of this study show that the presence of petrol stations can have a significant influence on the measured concentration of benzene in the immediate vicinity of the station and in some cases at the nearest residential property.

The factors that appear to contribute most to the enhancement of benzene concentrations in the vicinity of petrol stations are:

- The distance from the petrol pumps to the point of measurement. Small petrol station with pumps close to the boundary may have a greater influence than larger petrol stations with pumps at a greater distance from the boundary.
- Petrol throughput, the greater the throughput the greater the enhancement.

Diffusion tubes, as used in this study, underestimated the ambient concentrations relative to the concentrations measured by automatic instrumentation in the UK Hydrocarbon Network by up to 1 ppb. The underestimation varied from site to site and with time at some of the sites. Taking account of this possible underestimation, the data were further analysed to assess likely compliance with the forthcoming EU Directive on Benzene.

Predicted decreases in the emissions from motor vehicles and fuel evaporation will result in a significant decrease in the concentrations in the vicinity of petrol stations in future years. The predicted concentrations are likely to meet the Air Quality Strategy standard of 5 ppb (16.25 µg/m³) by 2003, but may exceed the EU limit values of 1.5 ppb (5 µg/m³) at one of the petrol stations, the Marylebone Road petrol station, assuming there are no further measures adopted to reduce emissions of benzene. The concentrations at the Star Service Station in Bristol are estimated to fall to 1.32 ppb (4.3 µg/m³), which will be below, but relatively close to the EU limit value.

The installation of Stage 2 vapour recovery would probably reduce the predicted values to below the EU limit value for the Marylebone Road station and further reduce the concentrations at the Star Service Station.

Appendices

CONTENTS

| | |
|------------|--|
| Appendix 1 | List of selected petrol stations and Hydrocarbon Network sites |
| Appendix 2 | Concentrations measured at each location |
| Appendix 3 | Graphs of measured concentrations at each site |
| Appendix 4 | Maps of sampling locations |

Appendix 1

List of Selected Petrol Stations and Hydrocarbon Network sites

London

1) Marylebone Road AUN Monitoring Site.

- Commenced monitoring 9 September 1998
- Kerbside site for air quality monitoring, including hydrocarbons
- Grid Reference: TQ 281 820

2) Marylebone Road Petrol Station, junction of Marylebone Road and Gloucester Place.

- Under residential flats
- Throughput $>1000\text{m}^3/\text{annum}$ (Approx. $3500\text{m}^3/\text{annum}$)
- Commenced monitoring 9 September 1998
- Stage 1 vapour recovery
- Grid Reference: TQ 278 820

3) Cecil Road Garage, Cecil Road, Watford

- No canopy
- Throughput <500m³/annum (Approx. 180 m³/annum, based on quoted throughput for 1997)
- Commenced monitoring 9 September 1998
- No Stage 1 vapour recovery
- Grid Reference: TQ 108 982

4) New Road Service Station, New Road, Croxley Green

- No Canopy
- Throughput <1000m³/annum
- Commenced Monitoring 23 September 1998
- No Stage 1 vapour recovery
- Grid Reference: TQ 073 955

5) Rickmansworth Service Station, Victoria Close, Rickmansworth

- Canopy
- Throughput <1000m³/annum
- Commenced monitoring 23 September 1998
- No Stage 1 vapour recovery
- Grid Reference: TQ 057 948

6) St Quentin Garage, off Dalgarno Gardens, North Kensington.

- Partial Canopy
- Throughput <1000m³/annum
- Commenced monitoring 21 October 1998
- No Stage 1 vapour recovery
- Grid Reference: TQ 232 819

Birmingham

1) Birmingham East Monitoring Site, Ward End School

- Commenced monitoring 2 September 1998
- AUN and Hydrocarbon monitoring site
- Grid Reference: SP 115 889

2) Hagley Service Station, Trevanie Avenue, Birmingham

- Large Station with canopy

- Throughput >1000m³/annum(Approx. 4000m³/annum)
- Commenced monitoring 2 September 1998
- Stage 1 vapour recovery fitted.
- Grid Reference: SP 002 849

3) Aston Lane Service Station, Aston Lane, Birmingham.

- Small canopy
- Throughput <1000m³/annum
- Commenced monitoring 2 September 1998
- No Stage 1 vapour recovery
- Stopped trading 21 December 1998
- Grid Reference: SP 076 907

4) Billesley Lane, Birmingham

- No Canopy
- Throughput <1000m³/annum
- Commenced monitoring 2 September 1998
- No Stage 1 vapour recovery
- Grid Reference: SP 083 824

5) Grove Road, Birmingham

- Small Canopy
- Throughput <1000m³/annum
- Commenced monitoring 2 September 1998
- No Stage 1 vapour recovery
- Grid Reference: SP 068 810

6) Reddicap Heath Road, Birmingham

- Small Canopy
- Throughput <1000m³/annum although close to 1000m³/annum
- Commenced monitoring 2 September 1998
- Stage 1 vapour recovery fitted.
- Grid Reference: SP 145 959

Bristol

1) Bristol Hydrocarbon Monitoring Site, Jubilee Street, Bristol.

- Commenced monitoring 21 August 1998
- AUN and Hydrocarbon monitoring site
- Grid Reference: ST 599 729

2) Texaco, Gloucester Road, Bristol

- Large Station with canopy
- Throughput >1000m³/annum
- Commenced monitoring 21 August 1998
- Stage 1 vapour recovery fitted during December 1998.
- Grid Reference: ST 590 754

3) Wick Road, Bristol.

- No Canopy
- Throughput <1000m³/annum
- Commenced monitoring 21 August 1998
- No Stage 1 vapour recovery
- Grid Reference: ST 617 712

4) Hampton Road, Bristol

- Small Canopy
- Throughput <1000m³/annum although close to 1000m³/annum
- Commenced monitoring 21 August 1998
- Stage 1 vapour recovery fitted.
- Grid Reference: ST 579 743

5) Redland Road, Bristol

- Small Canopy
- Throughput <1000m³/annum
- Commenced monitoring 4 September 1998
- No Stage 1 vapour recovery
- Grid Reference: ST 579 749

Suburban**London**

Biggerstaffs Garage, Dimmocks Lane, Sarrat

- No Canopy
- Throughput <1000m³/annum
- Commenced monitoring 23 September 1998
- No Stage 1 vapour recovery
- Grid Reference: TQ 046 992

Oxford

Dawson Street, Oxford

- No Canopy
- Throughput <1000m³/annum
- Commenced monitoring 22 October 1998
- No Stage 1 vapour recovery
- Grid Reference: SP 528 060

Newbury

Davies & Co. Queens Road, Newbury

- No Canopy
- Throughput <1000m³/annum
- Commenced monitoring 6 November 1998
- No Stage 1 vapour recovery
- Grid Reference: SU 476 666.

Rural

Grove

Grove Garage, Grove, Oxfordshire

- No Canopy
- Throughput <1000m³/annum
- Commenced monitoring 18 September 1998
- No Stage 1 vapour recovery
- Grid Reference: SU 402 895

Harwell

- UK Hydrocarbon Network Site
- Grid Reference: SU 467 861

Appendix 2

Concentrations measured at each location

OMRPVMMN=fèèi É=N

^b^=qÉÀÜàçãÓó

OMRPVMMN=fèèì É-N

| Location Code | Date Exposed | 09/09/98 | 23/09/98 | 07/10/98 | 21/10/98 | 04/11/98 | 18/11/98 | 02/12/98 | 16/12/98 | 30/12/98 | 14/01/99 | 28/01/99 | 10/02/99 | 24/02/99 | 10/03/99 | 28/03/99 | 08/04/99 | 21/04/99 | 05/05/99 | 19/05/99 | 03/06/99 | 17/06/99 | 30/06/99 | 15/07/99 | 28/07/99 | 10/08/99 | 24/08/99 | 09/09/99 | 22/09/99 | 06/10/99 | | | |
|----------------|--------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|--|--|--|
| Date Retrieved | 23/09/98 | 07/10/98 | 21/10/98 | 04/11/98 | 18/11/98 | 02/12/98 | 16/12/98 | 30/12/98 | 14/01/99 | 28/01/99 | 10/02/99 | 24/02/99 | 10/03/99 | 28/03/99 | 08/04/99 | 21/04/99 | 05/05/99 | 19/05/99 | 03/06/99 | 17/06/99 | 30/06/99 | 15/07/99 | 28/07/99 | 10/08/99 | 24/08/99 | 09/09/99 | 22/09/99 | 06/10/99 | 21/10/99 | | | | |
| Mid Date | 16/09/98 | 30/09/98 | 14/10/98 | 28/10/98 | 11/11/98 | 25/11/98 | 09/12/98 | 23/12/98 | 06/01/99 | 21/01/99 | 03/02/99 | 17/02/99 | 03/03/99 | 19/03/99 | 02/04/99 | 14/04/99 | 28/04/99 | 12/05/99 | 26/05/99 | 10/06/99 | 23/06/99 | 07/07/99 | 21/07/99 | 03/08/99 | 17/08/99 | 01/09/99 | 15/09/99 | 29/09/99 | 13/10/99 | | | | |
| Days Exposure | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 15 | 14 | 13 | 14 | 14 | 18 | 11 | 13 | 14 | 14 | 15 | 14 | 13 | 15 | 13 | 13 | 14 | 16 | 13 | 14 | 15 | | | | |
| MRP1 | 3.91 | 4.88 | 6.98 | 3.09 | 4.37 | 4.93 | 2.76 | 2.39 | 2.75 | 2.54 | 5.19 | 3.58 | 2.84 | 3.45 | 2.80 | 4.96 | 3.16 | 2.54 | ** | 3.02 | | 2.87 | 3.38 | 3.66 | 3.24 | 2.69 | | | | | | | |
| MRP2 | 6.44 | 8.02 | 9.23 | 4.82 | 6.33 | 7.40 | 4.27 | 3.70 | 4.47 | 4.89 | 5.67 | 4.17 | 4.00 | 4.27 | 4.00 | 6.41 | 5.40 | 4.77 | ** | 4.71 | | 6.08 | 6.06 | 7.21 | 4.06 | 4.62 | | | | | | | |
| MRP3 | 5.99 | 6.42 | 7.96 | 3.67 | 5.29 | 7.75 | 4.31 | 3.78 | 4.06 | 4.84 | 3.51 | 2.55 | 2.08 | 2.98 | 4.27 | 4.92 | 5.40 | 5.07 | ** | 3.72 | 5.12 | 5.55 | 4.64 | 7.72 | 3.71 | 4.64 | | | | | | | |
| MRP4 | 1.60 | 1.16 | 1.86 | 1.29 | 2.12 | 1.80 | 1.56 | 1.41 | 1.26 | 1.88 | 1.48 | 1.13 | 0.93 | 1.40 | 1.32 | 1.49 | 1.53 | 1.34 | ** | 1.38 | 0.91 | 1.15 | 1.15 | 2.08 | 0.96 | 1.48 | | | | | | | |
| WCR1 | 0.53 | 0.84 | 0.41 | 1.16 | 1.72 | 1.68 | 0.71 | 0.67 | 0.48 | 1.14 | 0.99 | 0.99 | 0.59 | 1.51 | 0.88 | 0.11 | 0.64 | 0.61 | ** | 0.73 | 0.48 | 0.48 | 0.56 | 1.06 | 1.01 | 0.87 | | | | | | | |
| WCR2 | 0.53 | 0.96 | 0.38 | 0.87 | 1.61 | 1.51 | 0.77 | 0.60 | 0.36 | 0.84 | 0.69 | 0.93 | 0.64 | 1.34 | 0.57 | 0.36 | 0.44 | 0.58 | ** | 0.58 | -0.15 | 0.41 | 0.62 | 0.85 | 0.90 | 0.80 | | | | | | | |
| WCR3 | 0.32 | 0.47 | 0.56 | 0.83 | 1.50 | 1.89 | 1.01 | 0.91 | 0.51 | 1.12 | 1.11 | 0.93 | 0.70 | 1.35 | 0.84 | 0.50 | 0.34 | 0.66 | ** | 0.61 | -0.08 | 0.58 | 0.69 | 0.92 | 0.89 | 0.85 | | | | | | | |
| WCR4 | 0.48 | 0.78 | 1.23 | 0.55 | 1.53 | 1.83 | 0.71 | 0.58 | 0.46 | 0.71 | 1.03 | 0.78 | 0.50 | 1.33 | 0.57 | 0.37 | 0.43 | 0.46 | ** | 0.64 | -0.43 | 0.33 | 0.50 | 0.76 | 0.67 | 0.67 | | | | | | | |
| SR1 | * | 0.65 | 1.23 | 0.55 | 0.96 | 1.12 | 0.45 | 0.23 | 0.36 | 0.74 | 0.77 | 0.15 | 0.29 | 0.77 | 0.58 | | 0.52 | 0.38 | ** | 0.46 | 0.33 | 0.36 | 0.53 | 0.61 | 0.38 | 0.63 | | | | | | | |
| SR2 | * | 0.67 | 1.45 | 0.60 | 1.08 | 1.48 | 0.70 | 0.56 | 0.24 | 0.55 | 0.96 | 0.54 | 0.35 | 1.14 | 0.45 | 0.53 | 0.57 | 0.36 | ** | 0.59 | 0.78 | 0.43 | 0.87 | 0.82 | 0.69 | 0.93 | | | | | | | |
| SR3 | * | 0.54 | 1.33 | 0.50 | 1.19 | 1.55 | 0.71 | 0.83 | 0.37 | 0.52 | 0.92 | 0.64 | 0.53 | 1.03 | 0.62 | 0.55 | 0.78 | 0.44 | ** | 0.72 | 0.55 | 0.48 | 0.87 | 0.89 | 0.78 | 0.76 | | | | | | | |
| SR4 | * | 0.29 | 0.90 | 0.32 | 0.62 | 0.99 | 0.18 | 0.63 | 0.07 | 0.44 | 0.69 | 0.54 | 0.35 | 0.79 | 0.44 | 0.34 | 0.31 | 0.13 | ** | 0.43 | 0.17 | 0.24 | 0.43 | 0.42 | 0.50 | 0.52 | | | | | | | |
| RCK1 | * | 0.30 | 0.60 | 0.63 | 1.47 | 2.11 | 1.00 | 1.18 | 0.55 | 0.76 | 0.85 | 1.26 | 0.75 | 1.65 | 0.55 | 0.15 | 0.58 | 0.47 | ** | 0.60 | 0.47 | 0.54 | 0.71 | 0.82 | 1.02 | 0.80 | | | | | | | |
| RCK2 | * | 0.90 | 0.97 | 0.69 | 1.76 | 2.80 | 0.95 | 1.33 | 0.68 | 1.21 | 0.98 | 1.46 | 0.90 | 1.53 | 0.09 | 0.51 | | 0.77 | ** | 0.63 | 0.54 | 0.76 | 0.83 | 1.33 | 1.02 | 0.83 | | | | | | | |
| RCK3 | * | 0.72 | 0.85 | 0.98 | 2.05 | 2.48 | 1.16 | 1.25 | 0.73 | 0.91 | 1.04 | 1.40 | 0.89 | 1.34 | 0.12 | 0.88 | | 0.81 | ** | 0.73 | 0.57 | 0.65 | 0.78 | 1.13 | 0.57 | 0.95 | | | | | | | |
| RCK4 | * | 0.62 | 1.01 | 0.41 | 1.91 | 2.22 | 1.26 | 1.29 | 0.75 | 1.02 | 1.05 | 1.51 | 0.90 | 1.38 | 0.76 | 0.89 | 0.42 | 0.81 | ** | 0.86 | 0.71 | 0.77 | 0.61 | 0.98 | 0.49 | 0.85 | | | | | | | |
| NEW1 | * | 0.34 | 0.53 | 0.42 | 1.44 | 1.34 | 0.83 | 0.65 | 0.41 | 0.80 | 0.91 | 1.00 | 0.52 | 1.01 | 0.66 | 0.44 | 0.44 | 0.57 | ** | 0.60 | 0.40 | 0.51 | 0.37 | 0.71 | 0.34 | 0.57 | | | | | | | |
| NEW2 | * | 0.68 | 0.80 | 0.34 | 1.57 | 1.59 | 0.63 | 1.06 | 0.51 | 0.96 | 0.99 | 0.88 | 0.55 | 1.15 | 0.80 | 0.43 | 0.56 | 0.56 | ** | 0.53 | 0.56 | 0.61 | 0.43 | 0.72 | 0.36 | 0.62 | | | | | | | |
| NEW3 | * | 0.88 | 0.50 | 0.43 | 1.37 | 1.25 | 0.61 | 0.85 | 0.35 | 0.92 | 0.98 | 0.74 | 0.56 | 0.99 | 0.88 | 0.06 | 0.49 | 0.55 | ** | 0.51 | 0.58 | 0.54 | 0.42 | 0.81 | 0.33 | 0.64 | | | | | | | |
| NEW4 | * | 0.71 | 0.68 | 0.73 | 1.48 | 1.55 | 0.84 | 0.86 | 0.43 | 1.05 | 1.05 | 1.03 | 0.58 | 1.30 | 0.88 | 0.04 | 0.58 | 0.45 | ** | 0.70 | 0.41 | 0.53 | 0.43 | 0.87 | 0.32 | 0.74 | | | | | | | |
| STQ1 | * | * | * | 1.40 | 2.19 | 1.94 | 1.06 | 1.03 | 0.69 | 1.35 | 1.36 | 0.97 | 0.76 | 1.31 | 0.89 | 0.40 | 0.27 | 0.52 | ** | 0.79 | 0.74 | 0.70 | 0.38 | 0.96 | 0.33 | 1.14 | ** | 0.69 | | | | | |
| STQ2 | * | * | * | 0.76 | 1.83 | 2.70 | 2.69 | 1.78 | 1.80 | 3.46 | 2.94 | 1.54 | 1.47 | 1.91 | 1.20 | 0.91 | 0.84 | 2.27 | ** | 1.90 | 1.41 | 1.75 | 2.17 | 2.63 | 0.63 | 1.92 | ** | 2.78 | | | | | |
| STQ3 | * | * | * | 0.65 | 1.30 | 2.05 | 1.12 | 1.01 | 0.85 | 1.39 | 1.43 | 0.76 | 0.72 | 1.03 | 0.86 | 1.17 | 0.47 | 0.71 | ** | 0.75 | 0.62 | 0.61 | 0.77 | 0.38 | 0.23 | 1.07 | ** | 0.60 | | | | | |
| STQ4 | * | * | * | 0.71 | 1.12 | 2.03 | 0.77 | 0.82 | 0.72 | 1.13 | 1.95 | 0.63 | 0.78 | 1.17 | 0.69 | 0.32 | | 0.75 | ** | 0.59 | 0.77 | 0.52 | 0.75 | 0.82 | 0.17 | 1.04 | ** | 0.69 | | | | | |
| MDT1 | 2.58 | 2.03 | 4.71 | 3.62 | 3.73 | 3.73 | 3.31 | 2.99 | 2.32 | 4.96 | 2.76 | 2.66 | 2.04 | 2.42 | 2.48 | 2.19 | 1.53 | 2.33 | ** | 2.65 | 2.58 | 2.28 | 2.23 | 3.11 | 1.55 | 2.47 | | | | | | | |
| MDT2 | 2.62 | 1.33 | 4.77 | 2.93 | | 3.68 | 3.15 | 2.85 | 2.39 | 4.90 | 2.74 | 2.55 | 2.08 | 2.27 | 2.49 | 1.49 | 1.40 | 2.27 | ** | 2.45 | 2.50 | 2.08 | 2.23 | 3.05 | 1.69 | 2.40 | | | | | | | |
| MHC @ (PE/ATD) | 2.82 | 3.11 | 3.89 | 3.71 | 3.76 | 3.17 | 3.69 | 3.09 | 2.77 | 4.51 | 2.38 | 3.38 | 2.98 | 3.19 | 3.24 | 2.99 | 2.09 | 2.34 | 2.47 | 3.01 | 2.64 | 3.76 | 1.41 | 2.79 | 4.55 | 3.90 | 3.28 | 4.29 | | | | | |

* - Sampling programme not yet established at this location
 ** - Results not received from Analysts
 S - Sampling programme completed.
 # - Tubes and tube holders stolen. In some instances tubes were not replaced until a more robust or additional security was installed.
 @ - Average concentrations reported for the automatic analysers are included for comparison.

Table A2.1 Benzene concentrations (ppb) reported using Chromosorb 106 tubes, exposed in the vicinity of petrol stations in and around London and at the Marylebone AUN site.

OMRPVMMN=fèèì É-N

| Date Exposed | 02/09/98 | 16/09/98 | 30/09/98 | 14/10/98 | 28/10/98 | 11/11/98 | 24/11/98 | 09/12/98 | 22/12/98 | 06/01/99 | 20/01/99 | 03/02/99 | 17/02/99 | 03/03/99 | 17/03/99 | 31/03/99 | 14/04/99 | 28/04/99 | 12/05/99 | 26/05/99 | 09/06/99 | 23/06/99 | 09/07/99 | 21/07/99 | 04/08/99 | 18/08/99 | | |
|----------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|--|--|
| Date Retrieved | 16/09/98 | 30/09/98 | 14/10/98 | 28/10/98 | 11/11/98 | 24/11/98 | 09/12/98 | 22/12/98 | 06/01/99 | 20/01/99 | 03/02/99 | 17/02/99 | 03/03/99 | 17/03/99 | 31/03/99 | 14/04/99 | 28/04/99 | 12/05/99 | 26/05/99 | 09/06/99 | 23/06/99 | 09/07/99 | 21/07/99 | 04/08/99 | 18/08/99 | 02/09/99 | | |
| Mid Date | 09/09/98 | 23/09/98 | 07/10/98 | 21/10/98 | 04/11/98 | 17/11/98 | 01/12/98 | 15/12/98 | 29/12/98 | 13/01/99 | 27/01/99 | 10/02/99 | 24/02/99 | 10/03/99 | 24/03/99 | 07/04/99 | 21/04/99 | 05/05/99 | 19/05/99 | 02/06/99 | 16/06/99 | 01/07/99 | 15/07/99 | 28/07/99 | 11/08/99 | 25/08/99 | | |
| Days Exposure | 14 | 14 | 14 | 14 | 14 | 13 | 15 | 13 | 15 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 16 | 12 | 14 | 14 | 15 | | |
| Location Code | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RH1 | 3.04 | 4.21 | 2.68 | 1.43 | 1.40 | 2.88 | 1.59 | 1.47 | 0.70 | 1.47 | 2.04 | 1.49 | 0.75 | 2.64 | 1.70 | 1.59 | 1.82 | 2.07 | | 1.19 | 1.88 | 1.96 | 1.70 | 2.26 | 1.29 | 1.83 | | |
| RH2 | # | # | # | # | # | # | # | 1.41 | 0.98 | 0.36 | 1.33 | 0.67 | 0.42 | 1.37 | 0.92 | 0.89 | 0.88 | 0.80 | | | | | 0.43 | 0.58 | 0.80 | | | |
| RH3 | 3.16 | 0.77 | 0.47 | 0.51 | 0.80 | 1.84 | 1.30 | 0.68 | 0.52 | 0.74 | 1.21 | 0.87 | 0.32 | 1.25 | 0.81 | 0.58 | 0.43 | 0.58 | | 0.42 | 0.74 | 0.39 | 0.42 | 0.39 | 0.16 | 0.65 | | |
| RH4 | # | # | # | # | # | # | # | 0.86 | 0.60 | 0.88 | 1.44 | 0.84 | 0.71 | 1.23 | 1.15 | 1.55 | 0.86 | 0.77 | | 0.75 | 0.87 | 0.46 | 0.66 | 0.50 | 0.42 | 0.67 | | |
| AL1 | 3.57 | 0.46 | 0.29 | 1.04 | 1.40 | 2.08 | 1.47 | 1.57 | 1.03 | 1.42 | 2.18 | 2.09 | 0.99 | 1.69 | 1.37 | 2.13 | 0.85 | 0.72 | | 0.80 | 0.90 | 0.53 | 0.76 | 0.67 | 0.44 | 0.80 | | |
| AL2 | 2.26 | 1.54 | 0.73 | 0.88 | 1.17 | 1.81 | 2.05 | 0.97 | 0.87 | 1.01 | 1.73 | 1.83 | 0.84 | 1.53 | 1.44 | 1.90 | 0.87 | 0.82 | | 0.79 | 0.65 | 0.49 | 0.70 | 0.98 | 0.65 | 0.87 | | |
| AL3 | 1.52 | 1.13 | 0.61 | 0.96 | 1.20 | 2.04 | 2.54 | 1.37 | 1.73 | 1.11 | | 2.00 | 0.67 | 1.68 | 1.32 | 2.21 | 0.93 | 0.86 | | 0.93 | 0.88 | 0.59 | 0.78 | 1.25 | 0.62 | 0.85 | | |
| AL4 | 1.29 | 1.40 | 1.12 | 1.38 | 1.79 | 4.08 | 3.47 | 2.52 | 1.14 | 1.95 | | 2.75 | 1.19 | 2.27 | 2.36 | 3.03 | 1.54 | 1.33 | | 1.34 | 1.38 | 0.94 | 1.15 | 1.64 | 1.21 | 1.29 | | |
| BL1 | 2.80 | 1.85 | 0.76 | 0.84 | 1.10 | 1.86 | 1.69 | 1.29 | 0.75 | 0.79 | | 1.47 | 0.70 | 1.27 | 1.01 | 1.44 | 0.91 | 0.43 | | 0.69 | 1.17 | 0.91 | 0.74 | 1.19 | 0.77 | 1.31 | | |
| BL2 | 1.75 | 0.80 | 1.21 | 0.77 | 0.93 | 3.68 | 1.33 | 1.09 | 0.66 | 0.64 | | 1.33 | 0.66 | 1.29 | 1.75 | 0.82 | 0.70 | 0.87 | | 0.60 | 1.16 | 0.57 | 0.64 | 1.26 | 0.87 | 0.89 | | |
| BL3 | 1.53 | 1.01 | 0.47 | 1.04 | 1.20 | 2.41 | 1.79 | 1.56 | 0.87 | 0.74 | | 1.40 | 0.75 | 1.07 | 1.42 | 0.80 | 0.79 | 0.89 | | 0.63 | 0.98 | 0.69 | 0.81 | 0.92 | 0.76 | 1.01 | | |
| BL4 | 0.74 | 0.66 | 0.60 | 0.74 | 0.87 | 1.50 | 1.95 | 1.29 | 0.61 | 0.57 | | 1.00 | 0.58 | 1.01 | 1.28 | 0.58 | 0.59 | 0.76 | | 0.48 | 0.70 | 0.40 | 0.45 | 0.88 | 0.67 | 0.74 | | |
| GR1 | 0.89 | 0.21 | 0.35 | 0.50 | 0.58 | 1.26 | 1.42 | 0.91 | 0.23 | 0.34 | | 0.71 | 0.37 | 0.60 | 0.49 | 0.29 | 0.37 | 0.58 | | 0.36 | 0.50 | 0.31 | 0.21 | 0.72 | 0.64 | 0.49 | | |
| GR2 | 0.82 | 0.95 | 0.62 | 0.34 | 0.44 | 1.40 | 1.70 | 0.81 | 0.16 | 0.38 | | 0.77 | 0.33 | 0.63 | 0.47 | 0.25 | 0.28 | 0.76 | | 0.37 | 0.19 | 0.54 | 0.22 | 0.65 | 0.64 | 0.69 | | |
| GR3 | 0.42 | 0.46 | 0.50 | 0.35 | 0.48 | 1.09 | 1.19 | 0.88 | 0.21 | 0.47 | | 0.68 | 0.32 | 0.72 | 0.45 | 0.39 | 0.54 | 0.48 | | 0.05 | 0.31 | 0.41 | 0.36 | 0.16 | 0.34 | 0.57 | | |
| GR4 | 1.85 | 1.07 | 0.43 | 0.28 | 0.35 | 0.64 | 0.51 | 0.32 | 0.31 | 0.33 | | 0.55 | 0.32 | 0.57 | 0.50 | 0.26 | 0.59 | 0.42 | | 0.11 | 0.30 | 0.33 | 0.35 | 0.30 | | 0.17 | | |
| HG1 | 1.33 | 1.20 | 1.06 | 0.35 | 0.45 | 0.64 | 0.64 | 0.83 | 0.33 | 0.73 | 0.85 | 0.91 | 0.47 | 1.11 | 0.91 | 0.54 | 1.15 | 0.86 | | 0.54 | 0.60 | 0.72 | 0.67 | 0.42 | 0.94 | 0.90 | | |
| HG2 | 2.31 | 0.75 | 0.47 | 0.50 | 0.64 | 0.97 | 0.70 | 0.97 | 0.46 | 0.59 | 0.82 | 1.44 | 0.69 | 1.30 | 0.78 | 1.04 | 0.92 | 0.63 | 0.54 | 1.02 | 1.00 | 0.79 | 0.29 | 0.95 | 0.85 | 0.98 | | |
| HG3 | 0.84 | 0.50 | 0.27 | 0.20 | 0.40 | 1.56 | 0.56 | 0.37 | 0.27 | 0.33 | 0.31 | 0.57 | | 0.62 | 0.37 | 0.17 | 0.44 | 0.40 | 0.44 | 0.44 | 0.38 | 0.31 | 0.16 | 0.46 | 0.51 | 0.45 | | |
| HG4 | 1.10 | 0.53 | 0.54 | 0.46 | 0.85 | 0.35 | 1.07 | 0.82 | 0.32 | 0.55 | 0.89 | 1.16 | | 0.73 | 0.89 | 0.69 | 0.87 | 0.87 | | 0.81 | 0.52 | 0.28 | 0.65 | 0.69 | 0.72 | | | |
| BDT1 | 0.71 | # | # | # | # | 1.29 | 0.77 | 0.70 | 0.20 | 0.43 | 0.74 | 0.75 | 0.30 | 0.58 | 0.59 | | 0.32 | 0.36 | | -0.01 | 0.26 | 0.42 | 0.22 | 0.02 | 0.18 | 0.41 | | |
| BDT2 | * | * | * | * | * | * | 0.72 | 0.56 | 0.39 | 0.44 | 0.82 | 0.73 | 0.27 | 0.60 | 0.32 | | 0.33 | 0.27 | | 0.10 | 0.20 | 0.37 | 0.21 | 0.06 | 0.14 | 0.31 | | |
| BHC @ (VOCAIR) | 0.74 | 1.38 | 0.77 | 0.88 | 1.06 | 1.97 | 2.25 | 1.41 | 1.18 | 1.31 | 3.68 | 1.14 | 0.49 | | 0.79 | 0.65 | 0.80 | 0.62 | 0.40 | 0.52 | 0.54 | 0.56 | 0.37 | 0.37 | 0.67 | 0.82 | | |

- * - Sampling programme not yet established at this location
- ** - Results not received from Analysts
- S - Sampling programme completed.
- # - Tubes and tube holders stolen. In some instances tubes were not replaced until a more robust or additional security was installed.
- @ - Average concentrations reported for the automatic analysers are included for comparison.

Table A2.2 Benzene concentrations (ppb) reported using Chromosorb 106 tubes, exposed in the vicinity of petrol stations and the Hydrocarbon Network site, in Birmingham.

OMRPVMMN=fèèì È=N

| | Date Exposed | 21/08/98 | 04/09/98 | 18/09/98 | 02/10/98 | 16/10/98 | 29/10/98 | 16/11/98 | 27/11/98 | 11/12/98 | 23/12/98 | 11/01/99 | 22/01/99 | 09/02/99 | 19/02/99 | 05/03/99 | 19/03/99 | 07/04/99 | 16/04/99 | 29/04/99 | 14/05/99 | 28/05/99 | 11/06/99 | 25/06/99 | 12/07/99 | 23/07/99 | 06/08/99 |
|----------------|----------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | Date Retrieved | 04/09/98 | 18/09/98 | 02/10/98 | 16/10/98 | 29/10/98 | 16/11/98 | 27/11/98 | 11/12/98 | 23/12/98 | 11/01/99 | 22/01/99 | 09/02/99 | 19/02/99 | 05/03/99 | 19/03/99 | 07/04/99 | 16/04/99 | 29/04/99 | 14/05/99 | 28/05/99 | 11/06/99 | 25/06/99 | 12/07/99 | 23/07/99 | 06/08/99 | 20/08/99 |
| | Mid Date | 28/08/98 | 11/09/98 | 25/09/98 | 09/10/98 | 22/10/98 | 07/11/98 | 21/11/98 | 04/12/98 | 17/12/98 | 01/01/99 | 16/01/99 | 31/01/99 | 14/02/99 | 26/02/99 | 12/03/99 | 28/03/99 | 11/04/99 | 22/04/99 | 06/05/99 | 21/05/99 | 04/06/99 | 18/06/99 | 03/07/99 | 17/07/99 | 30/07/99 | 13/08/99 |
| | Days Exposure | 14 | 14 | 14 | 14 | 13 | 18 | 11 | 14 | 12 | 19 | 11 | 18 | 10 | 14 | 14 | 19 | 9 | 13 | 15 | 14 | 14 | 14 | 17 | 11 | 14 | 14 |
| Location Code | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| JWR1 | | 1.72 | 0.95 | 1.54 | 0.99 | 0.54 | 1.20 | 1.73 | 2.73 | 1.91 | 1.06 | 1.77 | 1.09 | 2.84 | 1.03 | 2.11 | 0.80 | 1.96 | 0.84 | 0.65 | 1.01 | 0.81 | 0.75 | 0.57 | 0.25 | 0.81 | 0.63 |
| JWR2 | | 1.07 | 1.04 | 0.90 | 0.61 | 0.39 | 1.12 | 0.74 | 2.04 | 1.52 | 1.25 | 1.78 | 1.22 | 2.23 | 0.80 | 1.49 | 0.89 | 1.70 | 0.77 | 0.58 | 0.63 | 0.66 | 0.47 | 0.50 | 0.58 | 0.66 | 0.60 |
| JWR3 | | 1.05 | 0.75 | 1.57 | 0.48 | 0.41 | 1.01 | 1.13 | 1.97 | 1.27 | 1.12 | 1.47 | 1.26 | 2.02 | 0.89 | 1.43 | 0.58 | 1.53 | 0.29 | 0.46 | 0.44 | 0.65 | 0.47 | 0.39 | 0.74 | 0.45 | 0.60 |
| JWR4 | | 0.63 | 0.85 | 0.85 | 1.04 | 0.40 | 1.26 | 1.92 | 1.97 | 1.53 | 1.10 | 1.35 | 1.42 | 2.37 | 0.96 | 1.91 | 0.90 | 1.65 | 0.34 | 0.75 | 0.71 | 0.68 | 0.92 | 0.59 | 0.75 | 0.80 | 0.95 |
| JGL1 | | 0.72 | 1.43 | 2.18 | 1.66 | 1.08 | 2.11 | 3.14 | 4.62 | 2.72 | 1.79 | 3.03 | 2.71 | 2.68 | 1.46 | 2.83 | 1.81 | 2.76 | 1.55 | 1.44 | 1.26 | 1.28 | 1.42 | 1.09 | 1.32 | 1.24 | 1.25 |
| JGL2 | | 1.49 | 2.03 | 2.67 | 2.56 | 1.51 | 2.80 | 3.45 | 5.30 | 3.16 | 2.02 | 2.88 | 2.96 | 1.39 | 1.26 | 3.50 | 1.93 | 2.82 | 1.84 | 2.01 | 1.92 | 1.85 | 1.88 | 1.50 | 1.98 | 1.74 | 1.74 |
| JGL3 | | 5.94 | 4.66 | 4.17 | 4.12 | 4.53 | 4.84 | 6.30 | 6.46 | 2.64 | 2.30 | 1.90 | 3.32 | 2.79 | 1.31 | 3.50 | 1.87 | 2.85 | 2.03 | 1.67 | 1.88 | 2.51 | 2.12 | 2.95 | 2.32 | 2.28 | |
| JGL4 | | 1.19 | 1.08 | 4.17 | 1.73 | 1.02 | 2.04 | 3.66 | 4.66 | 2.74 | 2.03 | 1.60 | 2.66 | 1.97 | 1.16 | 3.06 | 1.81 | 2.07 | 2.01 | 1.96 | 1.51 | 1.59 | 1.59 | 1.69 | 1.35 | 2.39 | 1.46 |
| JRR1 | * | 0.74 | 2.61 | 1.55 | 0.68 | 1.21 | 2.01 | 2.78 | 1.18 | 1.01 | 0.86 | 1.67 | 1.19 | 0.75 | 2.36 | 0.98 | 1.27 | 1.03 | 0.74 | 1.23 | | 1.03 | 0.85 | 0.92 | 1.02 | 0.87 | |
| JRR2 | * | 0.46 | 1.08 | 0.68 | 0.68 | 0.49 | 1.48 | 1.82 | 1.22 | 0.95 | 0.86 | 1.60 | 1.43 | 0.71 | 1.52 | 0.62 | 0.49 | 0.62 | 0.67 | 0.38 | 0.66 | 0.53 | 0.50 | 0.70 | 0.61 | 0.58 | |
| JRR3 | * | 1.30 | 3.12 | 1.97 | 1.54 | 1.43 | 4.16 | 3.79 | 2.72 | 1.70 | 2.10 | 1.25 | 2.36 | 1.60 | 2.77 | 1.35 | 1.69 | 1.70 | 1.61 | 1.30 | 1.74 | 1.03 | 1.70 | 1.69 | 2.09 | 1.55 | |
| JRR4 | * | 0.92 | 2.70 | 1.90 | 1.14 | 1.48 | 3.04 | 4.03 | 1.85 | 1.45 | 1.77 | 2.64 | 2.44 | 1.20 | 3.04 | 1.49 | 1.97 | 1.40 | 1.18 | 1.40 | 1.47 | 1.75 | 1.19 | 1.25 | 1.48 | 1.10 | |
| JHR1 | 0.60 | # | # | # | # | 1.11 | 3.05 | 3.60 | 1.21 | 0.68 | 1.69 | 1.70 | 2.01 | 0.87 | 2.09 | 0.96 | 1.50 | 0.70 | 0.64 | 0.84 | 0.85 | 0.94 | 0.88 | 0.92 | 1.10 | 0.75 | |
| JHR2 | 0.57 | 0.77 | 1.38 | 1.10 | 1.17 | 1.25 | 2.90 | 1.79 | 1.89 | 0.72 | 1.70 | 1.77 | 0.87 | 0.91 | 4.97 | 0.83 | 1.54 | 0.94 | 1.00 | 1.00 | 0.96 | 0.99 | 1.02 | 0.80 | 1.25 | 0.88 | |
| JHR3 | 0.88 | 0.45 | 2.43 | 1.03 | 0.76 | 1.25 | 2.11 | 1.51 | 1.55 | 0.68 | 1.31 | 1.49 | 1.79 | 0.25 | 4.44 | 0.95 | 0.66 | 1.08 | 0.68 | 1.09 | 0.83 | 1.08 | 1.02 | 0.58 | 1.28 | 0.81 | |
| JHR4 | 1.82 | 1.25 | 2.44 | 4.16 | 1.63 | 2.30 | 3.38 | 0.75 | 2.56 | 1.19 | 2.88 | 3.10 | 3.05 | 1.28 | 5.25 | 1.24 | 2.22 | 0.89 | 0.90 | 1.53 | 1.61 | 1.59 | 1.39 | 1.73 | 1.34 | 1.17 | |
| JDT1 | 0.47 | 0.33 | 0.53 | 0.53 | 0.15 | 0.45 | 1.16 | 1.46 | 0.68 | 0.60 | 0.59 | 0.13 | 1.14 | 0.25 | 0.52 | 0.27 | 0.84 | 0.36 | 0.17 | 0.26 | 0.14 | 0.12 | 0.13 | 0.25 | | 0.11 | |
| JHC @ (VOCAIR) | 0.91 | 0.51 | 1.22 | 0.95 | 0.55 | 0.93 | 1.83 | 2.18 | 1.08 | 0.77 | 0.93 | 0.92 | 1.58 | 0.61 | 1.25 | 0.79 | 0.73 | 0.84 | 0.65 | 0.58 | 0.67 | 0.56 | 0.47 | 0.80 | 0.59 | 0.52 | |

- * - Sampling programme not yet established at this location
- ** - Results not received from Analysts
- \$ - Sampling programme completed.
- # - Tubes and tube holders stolen. In some instances tubes were not replaced until a more robust or additional security was installed.
- @ - Average concentrations reported for the automatic analysers are included for comparison.

Table A2.3 Benzene concentrations (ppb) reported using Chromosorb 106 tubes, exposed in the vicinity of petrol stations and at the Hydrocarbon Network site, in Bristol.

| | 21/10/98 | 04/11/98 | 02/12/98 | 16/12/98 | 30/12/98 | 14/01/99 | 28/01/99 | 10/02/99 | 24/02/99 | 10/03/99 | 28/03/99 | 08/04/99 | 21/04/99 | 05/05/99 | 19/05/99 | 03/06/99 | 17/06/99 | 30/06/99 | 15/07/99 | 28/07/99 | 10/08/99 | 24/08/99 | 09/09/99 | 22/09/99 | 06/10/99 |
|----------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Date Exposed | 04/11/98 | 02/12/98 | 16/12/98 | 30/12/98 | 14/01/99 | 28/01/99 | 10/02/99 | 24/02/99 | 10/03/99 | 28/03/99 | 08/04/99 | 21/04/99 | 05/05/99 | 19/05/99 | 03/06/99 | 17/06/99 | 30/06/99 | 15/07/99 | 28/07/99 | 10/08/99 | 24/08/99 | 09/09/99 | 22/09/99 | 06/10/99 | 21/10/99 |
| Date Retrieved | 28/10/98 | 18/11/98 | 09/12/98 | 23/12/98 | 06/01/99 | 21/01/99 | 03/02/99 | 17/02/99 | 03/03/99 | 19/03/99 | 02/04/99 | 14/04/99 | 28/04/99 | 12/05/99 | 26/05/99 | 10/06/99 | 23/06/99 | 07/07/99 | 21/07/99 | 03/08/99 | 17/08/99 | 01/09/99 | 15/09/99 | 29/09/99 | 13/10/99 |
| Mid Date | 14 | 28 | 14 | 14 | 15 | 14 | 13 | 14 | 14 | 18 | 11 | 13 | 14 | 14 | 15 | 14 | 13 | 15 | 13 | 13 | 14 | 16 | 13 | 14 | 15 |
| Days Exposure | | | | | | | | | | | | | | | | | | | | | | | | | |
| Location Code | | | | | | | | | | | | | | | | | | | | | | | | | |
| OOD1 | 2.49 | 2.86 | 2.52 | 2.06 | 2.52 | 2.41 | 4.09 | 3.14 | 2.28 | 3.10 | 2.34 | 1.12 | 1.64 | 1.71 | ** | 1.32 | | 1.21 | 0.97 | 1.58 | 0.96 | 1.77 | ** | 2.11 | ** |
| OOD2 | 0.85 | 1.52 | 1.13 | 1.02 | 1.43 | 1.01 | 1.48 | 1.32 | | 1.69 | 1.13 | 0.57 | 1.07 | 1.03 | ** | 0.79 | | 0.86 | 0.38 | 0.98 | 0.51 | 1.15 | ** | 1.43 | ** |
| OOD3 | 1.41 | 1.55 | 1.33 | 1.21 | 1.59 | 1.24 | 2.25 | 1.87 | 1.70 | 1.71 | 1.51 | 0.78 | 1.26 | 0.97 | ** | 1.11 | 1.35 | 1.07 | 0.80 | 1.30 | 0.53 | 1.00 | ** | 1.58 | ** |
| OOD4 | 1.24 | 1.86 | 1.69 | 1.26 | 1.53 | 1.48 | 2.41 | 1.80 | 1.46 | 1.91 | 1.47 | 0.60 | 1.00 | 1.22 | ** | 0.76 | 0.95 | 0.73 | 0.76 | 0.96 | 0.50 | 0.92 | ** | 1.25 | ** |

- * - Sampling programme not yet established at this location
- ** - Results not received from Analysts
- \$ - Sampling programme completed.
- # - Tubes and tube holders stolen. In some instances tubes were not replaced until a more robust or additional security was installed.

Table A2.4 Benzene concentrations (ppb) reported using Chromosorb 106 tubes, exposed in the vicinity of Dawson Street Petrol Station, Oxford.

| | 06/11/98 | 19/11/98 | 27/11/98 | 11/12/98 | 23/12/98 | 11/01/99 | 22/01/99 | 09/02/99 | 19/02/99 | 05/03/99 | 19/03/99 | 07/04/99 | 16/04/99 | 29/04/99 | 14/05/99 | 27/05/99 | 11/06/99 | 25/06/99 | 12/07/99 | 23/07/99 | 06/08/99 | 20/08/99 | 03/09/99 | 17/09/99 | 06/10/99 | 21/10/99 |
|----------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Date Exposed | 19/11/98 | 27/11/98 | 11/12/98 | 23/12/98 | 11/01/99 | 22/01/99 | 09/02/99 | 19/02/99 | 05/03/99 | 19/03/99 | 07/04/99 | 16/04/99 | 29/04/99 | 14/05/99 | 27/05/99 | 11/06/99 | 25/06/99 | 12/07/99 | 23/07/99 | 06/08/99 | 20/08/99 | 03/09/99 | 17/09/99 | 06/10/99 | 21/10/99 | 04/11/99 |
| Date Retrieved | 12/11/98 | 23/11/98 | 04/12/98 | 17/12/98 | 01/01/99 | 16/01/99 | 31/01/99 | 14/02/99 | 26/02/99 | 12/03/99 | 28/03/99 | 11/04/99 | 22/04/99 | 06/05/99 | 20/05/99 | 03/06/99 | 18/06/99 | 03/07/99 | 17/07/99 | 30/07/99 | 13/08/99 | 27/08/99 | 10/09/99 | 26/09/99 | 13/10/99 | 28/10/99 |
| Mid Date | 13 | 8 | 14 | 12 | 19 | 11 | 18 | 10 | 14 | 14 | 19 | 9 | 13 | 15 | 13 | 15 | 14 | 17 | 11 | 14 | 14 | 14 | 14 | 19 | 15 | 14 |
| Days Exposure | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Location Code | | | | | | | | | | | | | | | | | | | | | | | | | | |
| NBY1 | 1.34 | 1.12 | 1.43 | 0.93 | 0.44 | 0.69 | 0.95 | 1.57 | 0.60 | 1.67 | 0.57 | 0.80 | 0.51 | 0.43 | 0.57 | 0.73 | 0.62 | 0.62 | 0.63 | 0.87 | 0.61 | 0.57 | 0.69 | 0.75 | ** | ** |
| NBY2 | 2.25 | 1.90 | 1.17 | 1.48 | 0.74 | 0.81 | 1.32 | 3.08 | 0.90 | 2.06 | 0.95 | 1.68 | 0.59 | 0.71 | 1.24 | 1.38 | 1.14 | 1.02 | 1.79 | 0.97 | 1.06 | 1.19 | 1.15 | 1.15 | ** | ** |
| NBY3 | 1.53 | 2.75 | 1.62 | 2.09 | 0.93 | 0.96 | 0.98 | 1.65 | 1.06 | 1.56 | 0.99 | 1.14 | 0.47 | 0.84 | 0.64 | 0.61 | 0.90 | 0.72 | 0.58 | 0.52 | 0.67 | 0.95 | 0.88 | 1.28 | ** | ** |
| NBY4 | 0.92 | 1.95 | 1.58 | 1.09 | 0.53 | 0.61 | 0.76 | 2.14 | 0.80 | 2.01 | 0.69 | 1.25 | 0.32 | 0.35 | 0.77 | 0.43 | 0.93 | 0.42 | 0.79 | 0.38 | 0.62 | 0.81 | 0.86 | 0.85 | ** | ** |

- * - Sampling programme not yet established at this location
- ** - Results not received from Analysts
- \$ - Sampling programme completed.
- # - Tubes and tube holders stolen. In some instances tubes were not replaced until a more robust or additional security was installed.
- @ - Average concentrations reported for the automatic analysers are included for comparison.

Table A2.5 Benzene concentrations (ppb) reported using Chromosorb 106 tubes, exposed in the vicinity of the Davies and Co Petrol Station, Queen Street Newbury.

| Date Exposed | 04/09/98 | 18/09/98 | 02/10/98 | 16/10/98 | 29/10/98 | 16/11/98 | 27/11/98 | 11/12/98 | 23/12/98 | 11/01/99 | 26/01/99 | 09/02/99 | 19/02/99 | 05/03/99 | 19/03/99 | 07/04/99 | 16/04/99 | 29/04/99 | 14/05/99 | 27/05/99 | 11/06/99 | 25/06/99 | 12/07/99 | 23/07/99 | 06/08/99 | 20/08/99 | 03/09/99 |
|----------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Date Retrieved | 18/09/98 | 02/10/98 | 16/10/98 | 29/10/98 | 16/11/98 | 27/11/98 | 11/12/98 | 23/12/98 | 11/01/99 | 26/01/99 | 09/02/99 | 19/02/99 | 05/03/99 | 19/03/99 | 07/04/99 | 16/04/99 | 29/04/99 | 14/05/99 | 27/05/99 | 11/06/99 | 25/06/99 | 12/07/99 | 23/07/99 | 06/08/99 | 20/08/99 | 03/09/99 | 17/09/99 |
| Mid Date | 11/09/98 | 25/09/98 | 09/10/98 | 22/10/98 | 07/11/98 | 21/11/98 | 04/12/98 | 17/12/98 | 01/01/99 | 18/01/99 | 02/02/99 | 14/02/99 | 26/02/99 | 12/03/99 | 28/03/99 | 11/04/99 | 22/04/99 | 06/05/99 | 20/05/99 | 03/06/99 | 18/06/99 | 03/07/99 | 17/07/99 | 30/07/99 | 13/08/99 | 27/08/99 | 10/09/99 |
| Days Exposure | 14 | 14 | 14 | 13 | 18 | 11 | 14 | 12 | 19 | 15 | 14 | 10 | 14 | 14 | 19 | 9 | 13 | 15 | 13 | 15 | 14 | 17 | 11 | 14 | 14 | 14 | 14 |
| Location Code | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OGR1 | 0.25 | 0.98 | 0.65 | 0.40 | 0.20 | 1.37 | 0.68 | 0.92 | 0.48 | 0.80 | 1.07 | 1.22 | 0.62 | 1.00 | 3.28 | 0.66 | 0.38 | 0.47 | 0.74 | 0.43 | 0.61 | 0.67 | 0.72 | 0.90 | 0.52 | 0.78 | 0.54 |
| OGR2 | 0.19 | | 0.72 | 0.39 | 0.15 | 1.44 | 0.89 | 0.57 | 0.54 | 0.65 | 0.96 | 1.21 | 0.66 | 1.08 | 3.34 | 0.55 | 0.40 | 0.17 | 0.63 | 0.50 | 0.54 | 0.55 | 0.71 | 0.68 | 0.67 | 0.50 | 0.53 |
| OGR3 | 0.81 | 0.81 | 1.83 | 1.07 | 0.61 | 2.69 | 1.92 | 1.43 | 0.92 | 1.04 | 1.34 | 2.22 | 0.91 | 1.72 | 3.99 | 1.62 | 0.79 | 0.76 | 0.80 | 0.92 | 1.00 | 1.17 | 1.57 | 1.08 | 0.88 | 1.19 | 1.24 |
| OGR4 | 0.24 | 0.63 | 0.72 | 0.34 | 0.06 | 1.38 | 1.52 | 0.73 | 0.45 | 0.53 | 0.64 | 0.90 | 0.24 | 0.95 | 0.22 | 0.38 | 0.20 | 0.35 | 0.26 | 0.34 | 0.32 | 0.47 | 0.40 | 0.51 | 0.41 | 0.43 | 0.41 |

- * - Sampling programme not yet established at this location
- ** - Results not received from Analysts
- \$ - Sampling programme completed.
- # - Tubes and tube holders stolen. In some instances tubes were not replaced until a more robust or additional security was installed.

Table A2.6 Benzene concentrations (ppb) reported using Chromosorb 106 tubes, exposed in the vicinity of Grove Service Station, Grove, Oxfordshire.

| Date Exposed | 24/03/99 | 12/04/99 | 23/04/99 | 13/05/99 | 26/05/99 | 08/06/99 | 21/06/99 | 07/07/99 | 20/07/99 | 05/08/99 | 20/08/99 | 02/09/99 | 17/09/99 | 14/10/99 | 28/10/99 |
|----------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Date Retrieved | 12/04/99 | 23/04/99 | 13/05/99 | 26/05/99 | 08/06/99 | 21/06/99 | 07/07/99 | 20/07/99 | 05/08/99 | 20/08/99 | 02/09/99 | 17/09/99 | 14/10/99 | 28/10/99 | 11/11/99 |
| Mid Date | 02/04/99 | 17/04/99 | 03/05/99 | 19/05/99 | 01/06/99 | 14/06/99 | 29/06/99 | 13/07/99 | 28/07/99 | 12/08/99 | 26/08/99 | 09/09/99 | 30/09/99 | 21/10/99 | 04/11/99 |
| Days Exposure | 19 | 11 | 20 | 13 | 13 | 13 | 16 | 13 | 16 | 15 | 13 | 15 | 27 | 14 | 14 |
| Location Code | | | | | | | | | | | | | | | |
| HDT1 | 0.19 | 0.11 | 0.04 | -0.10 | 0.05 | 0.17 | 0.11 | 0.00 | 0.12 | 0.07 | 0.20 | | | | |
| HDT2 | | | 0.03 | -0.02 | 0.07 | 0.14 | 0.07 | 0.21 | 0.11 | 0.07 | 0.19 | | | | |
| HHC @ (VOCAIR) | 0.29 | 0.25 | 0.29 | 0.20 | 0.18 | 0.17 | 0.21 | 0.19 | | 0.17 | 0.30 | 0.31 | 0.19 | 0.40 | 0.27 |

- * - Sampling programme not yet established at this location
- ** - Results not received from Analysts
- \$ - Sampling programme completed.
- # - Tubes and tube holders stolen. In some instances tubes were not replaced until a more robust or additional security was installed.

Table A2.7 Benzene concentrations (ppb) reported using Chromosorb 106 tubes, exposed at the Harwell Hydrocarbon Network site.

OMRPVMMN=fèèì É=N

^b^=qÉÀÛàçãÖó

Appendix 3

Graphs of measured concentrations at each site

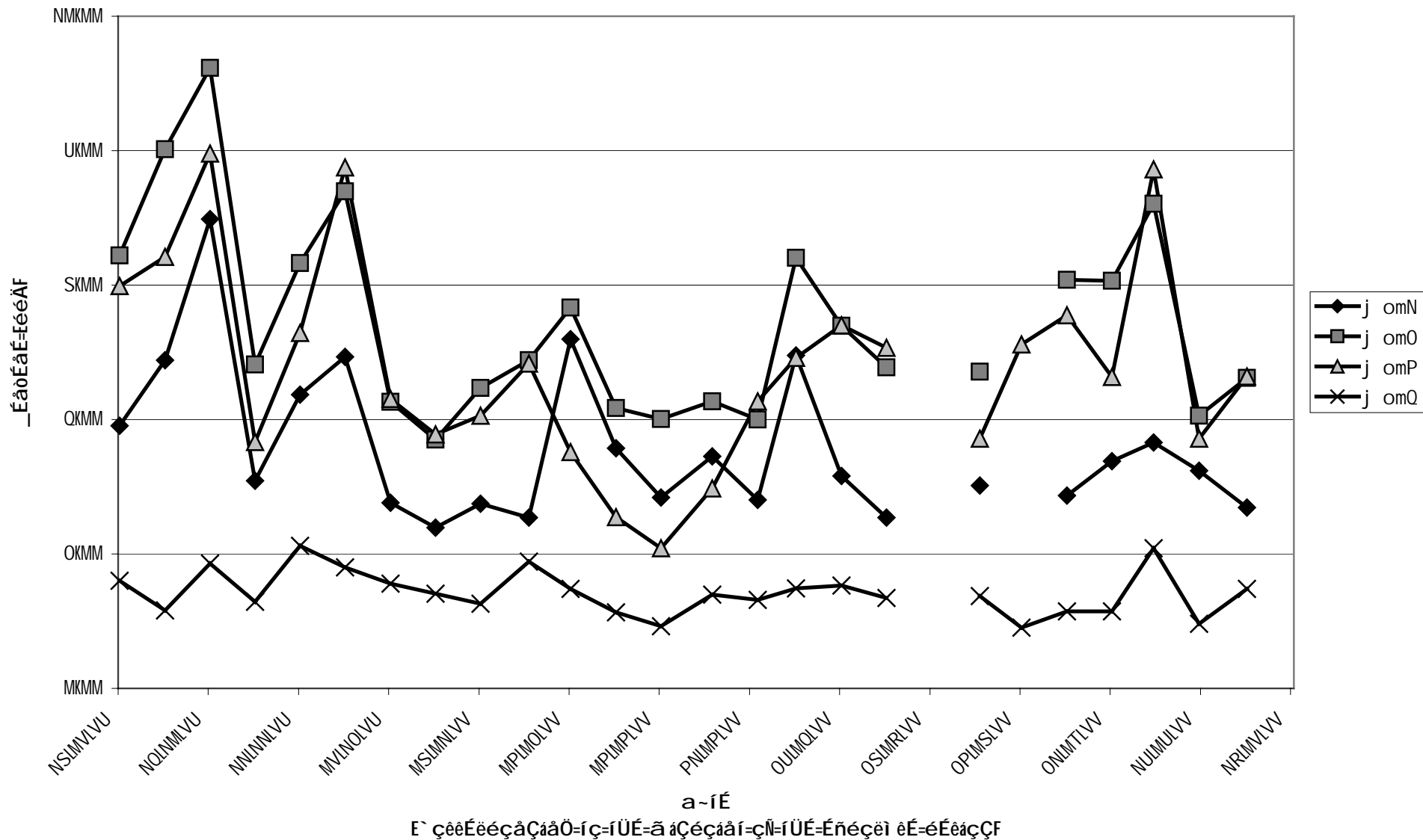


Figure A3.1 Measured benzene concentrations in the vicinity of Marylebone Road petrol station, Marylebone Road, London.

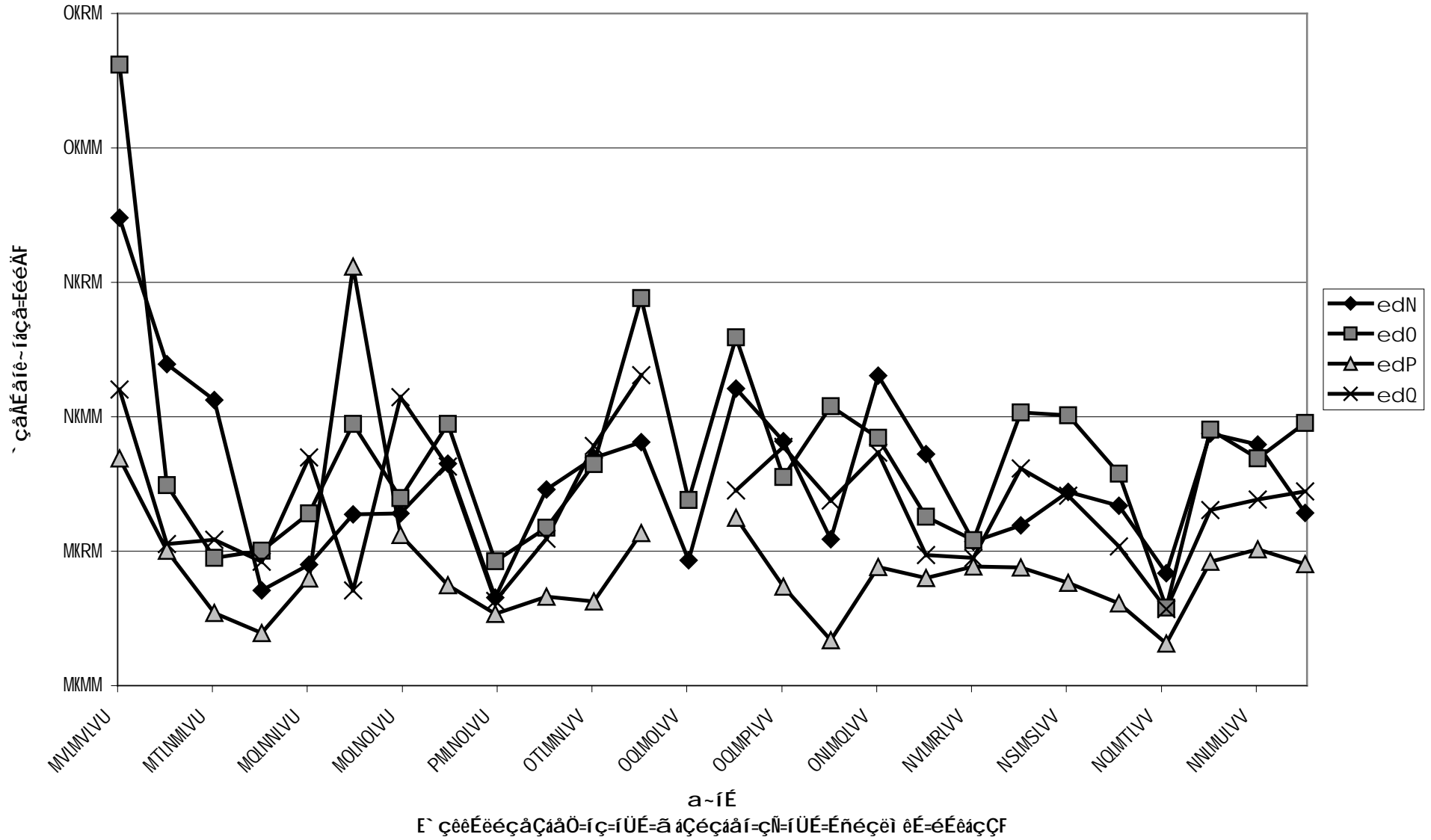


Figure A3.2 Measured benzene concentrations in the vicinity of Hagley Road petrol station, Hagley Road, Birmingham.

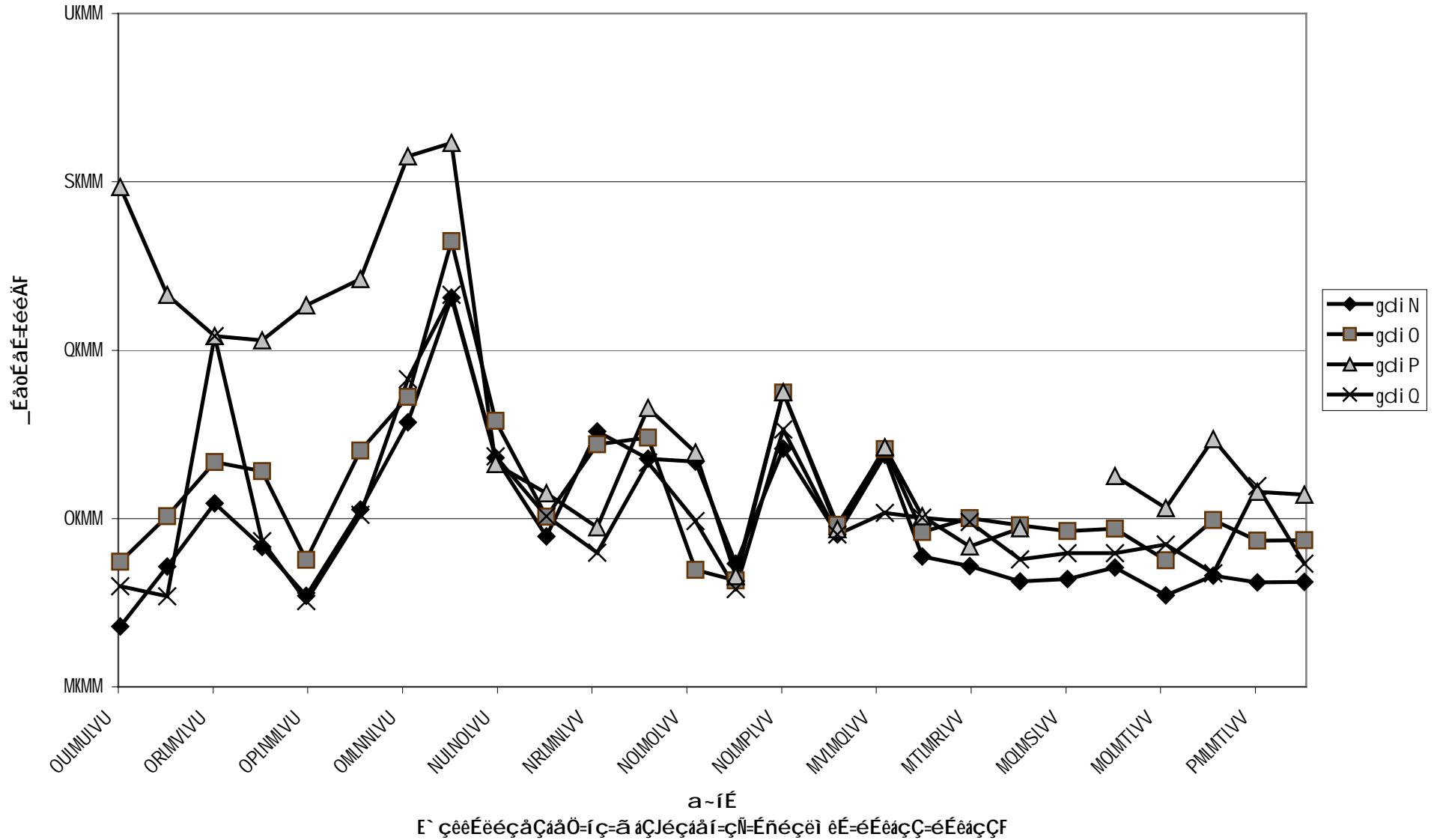


Figure A3.3 Measured benzene concentrations in the vicinity of Star Service Station, Gloucester Road, Bristol.

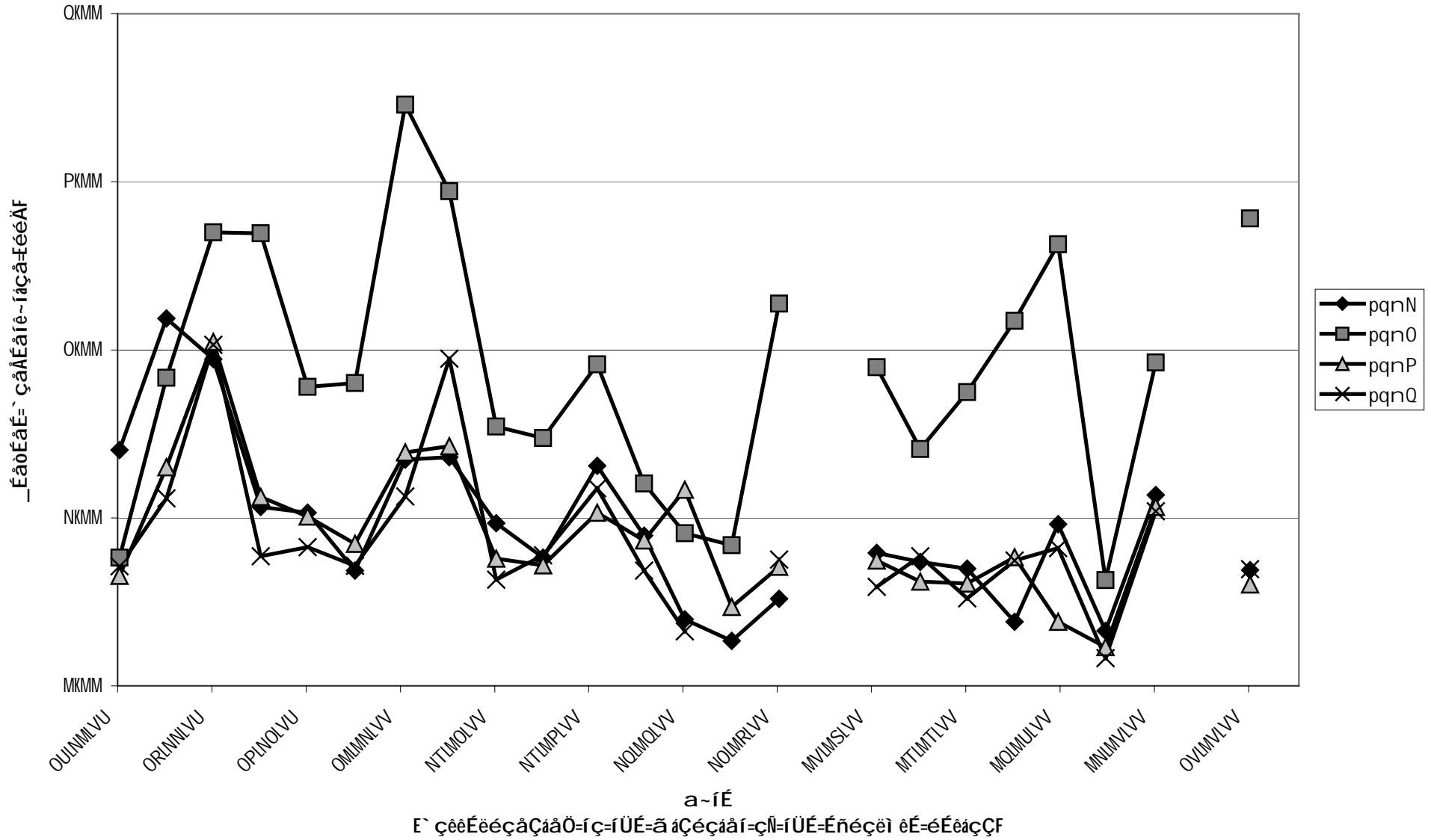


Figure A3.4 Measured benzene concentrations in the vicinity of St. Qentins Petrol Station, North Kensington

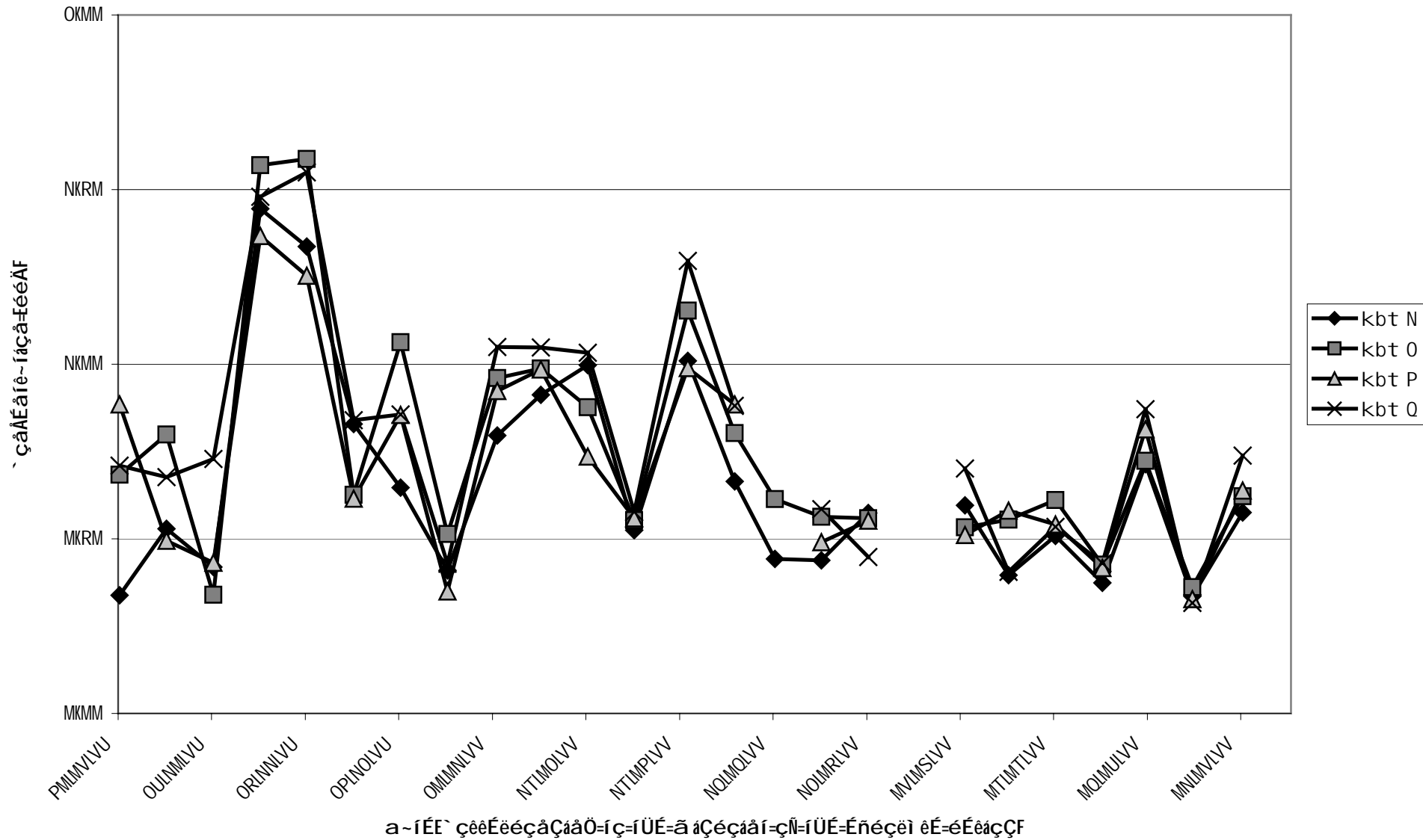


Figure A3.5 Measured benzene concentrations in the vicinity of New Road Service Station, New Road,

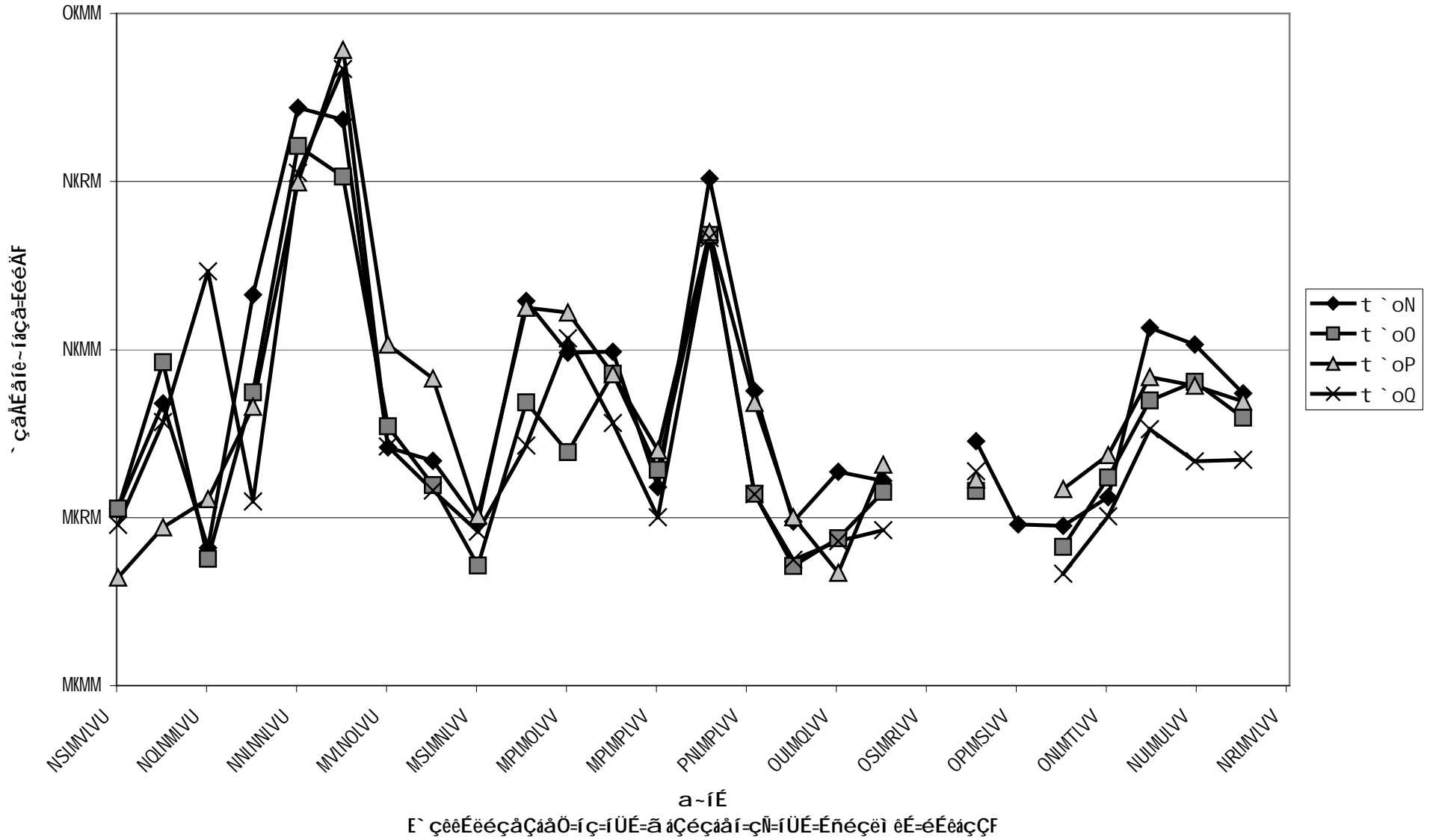


Figure A3.6 Measured benzene concentrations in the vicinity of Cecil Road petrol station, Cecil Road, Watford.

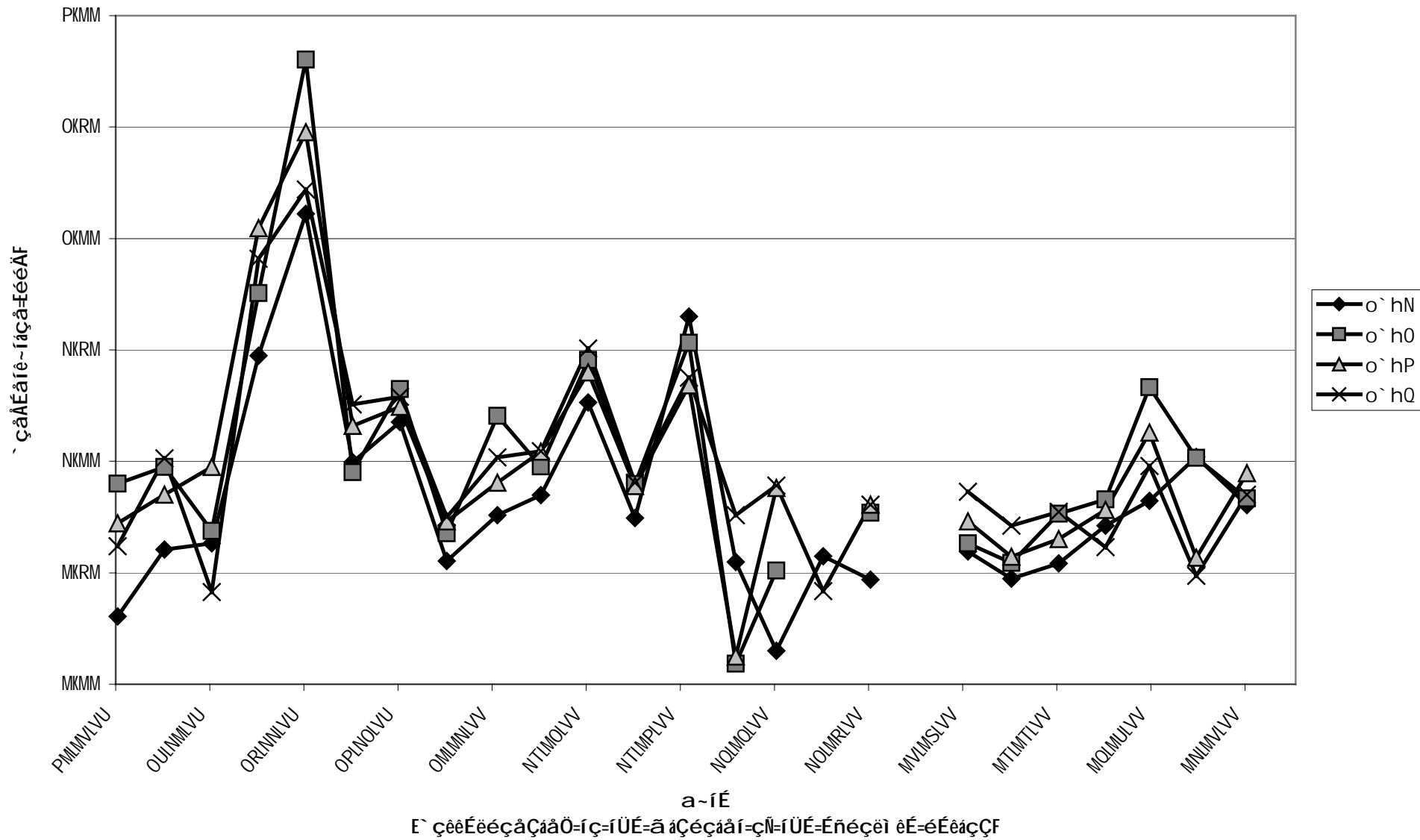


Figure A3.7 Measured benzene concentrations in the vicinity of Rickmansworth Service Station, Rickmansworth,

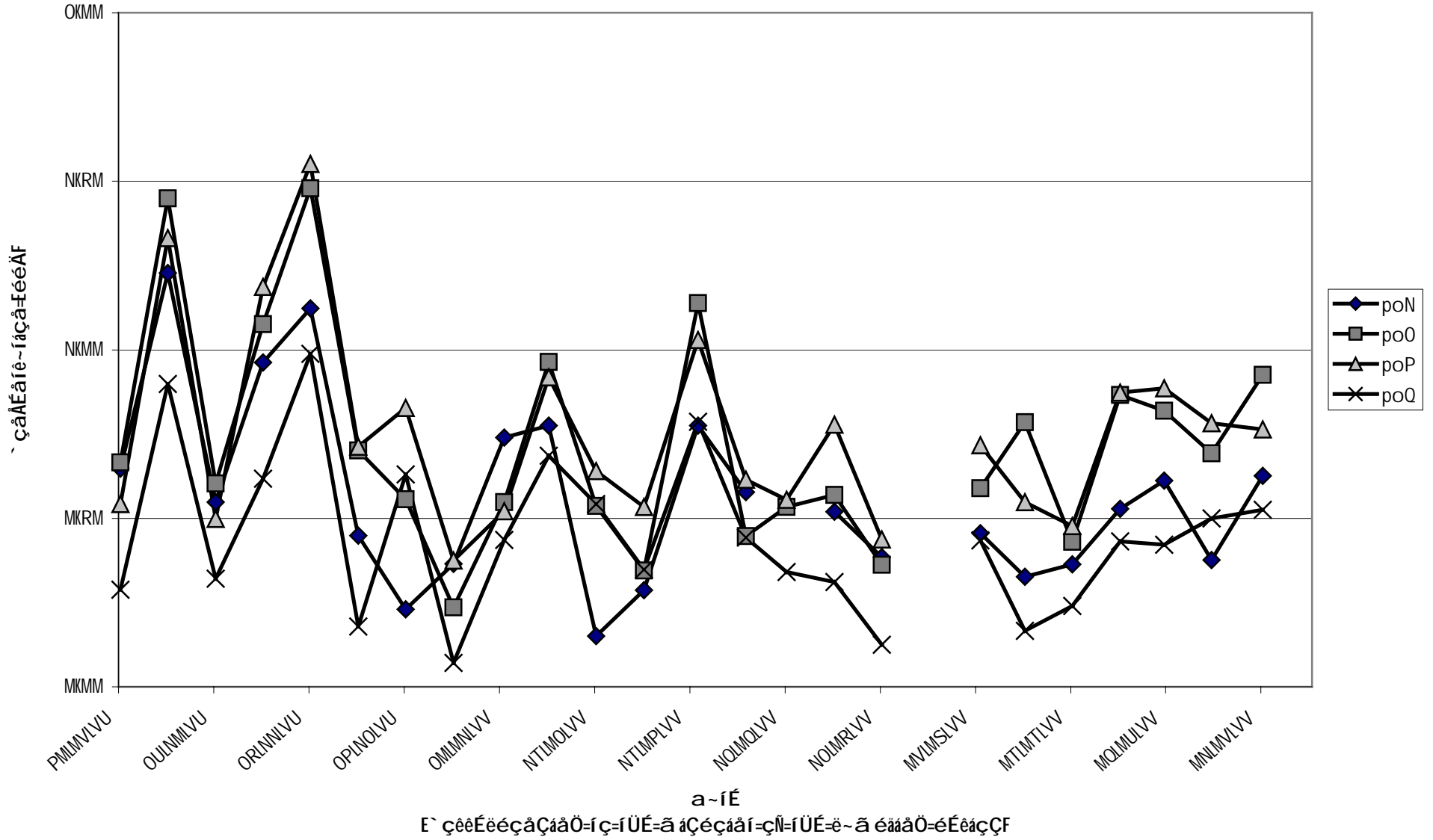


Figure A3.8 Measured benzene concentrations in the vicinity of Biggerstaffs Petrol Station, Sarrat,

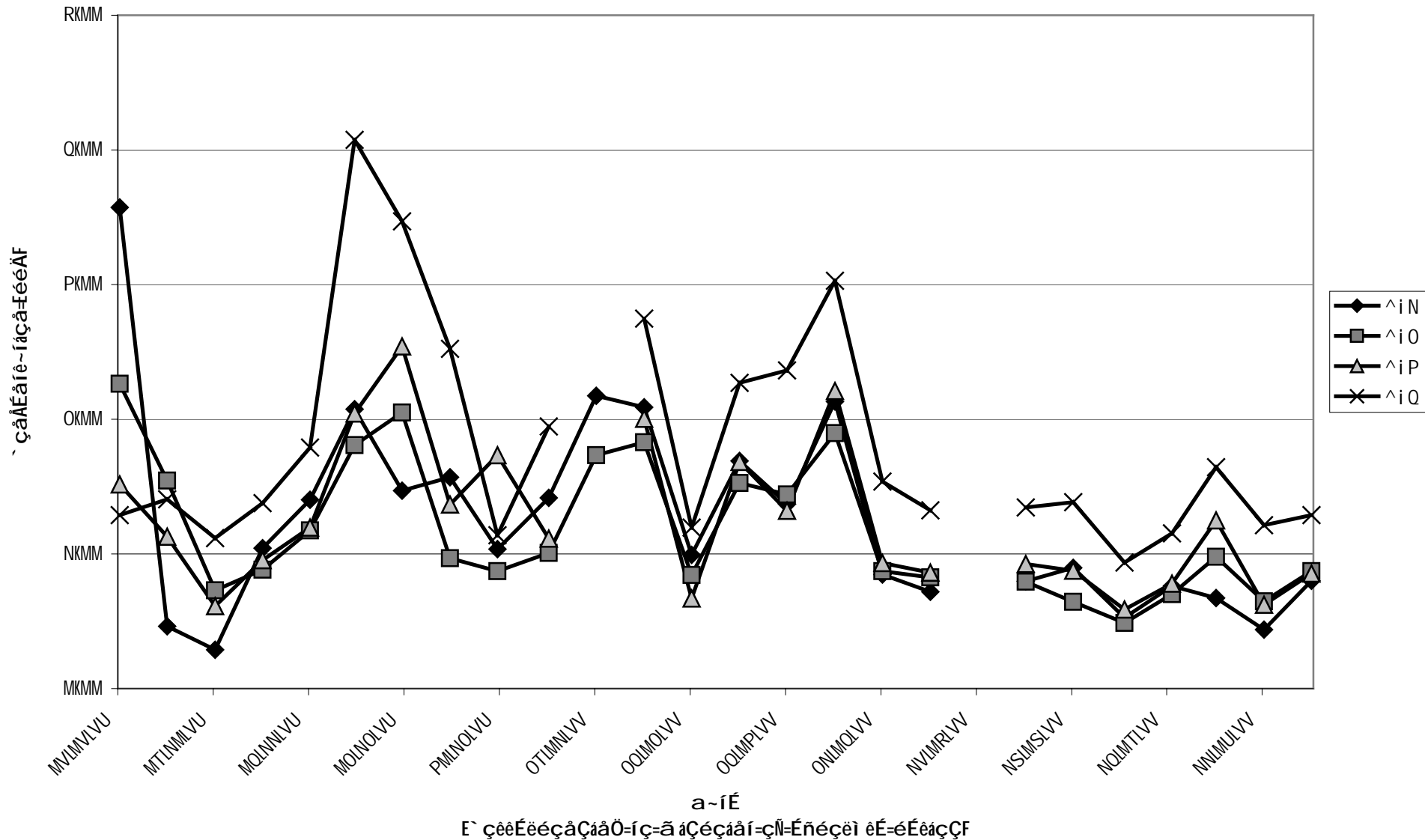


Figure A3.9 Measured benzene concentrations in the vicinity of Aston Lane Petrol Station, Aston Lane, Birmingham.

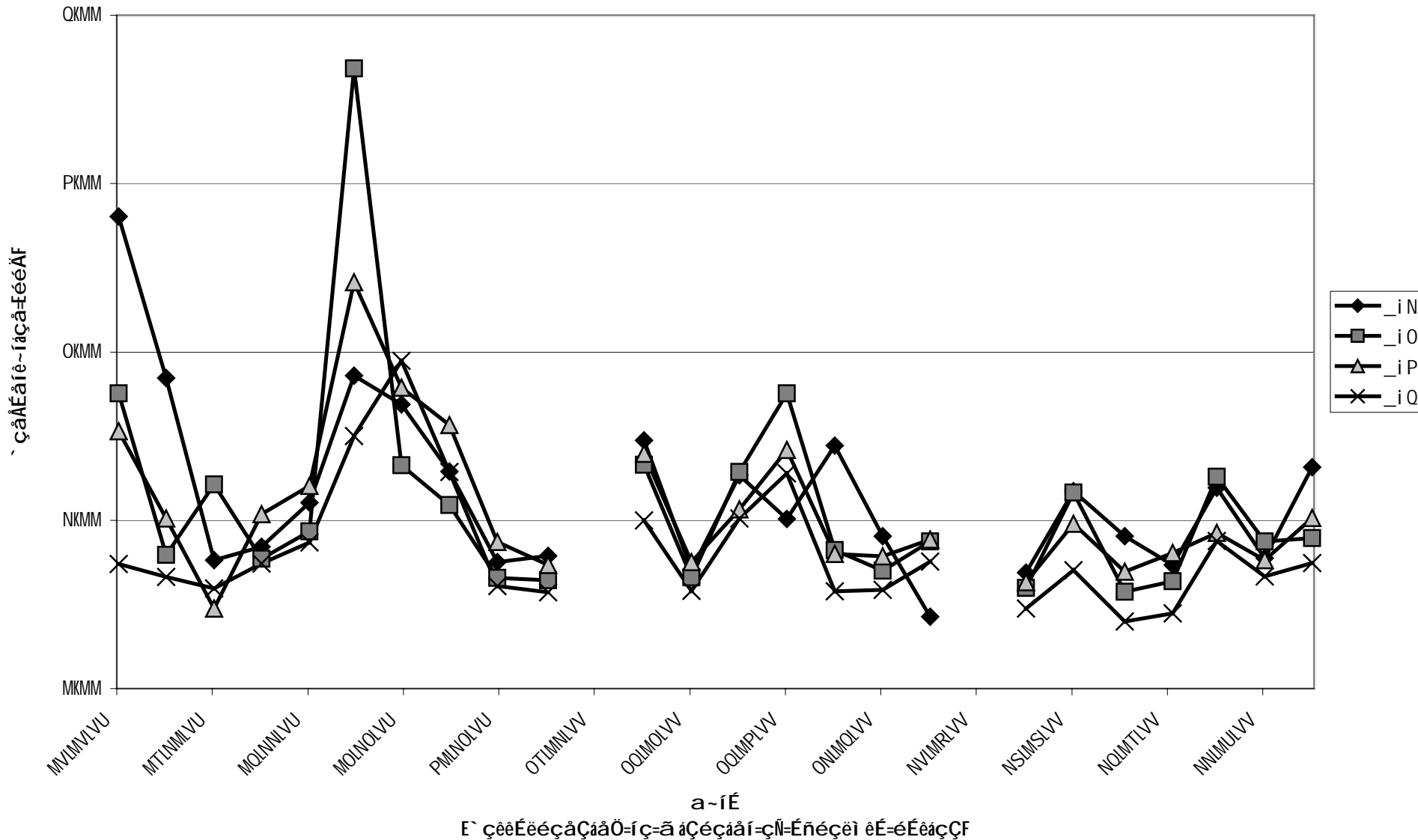


Figure A3.10 Measured benzene concentrations in the vicinity of Billesley Lane Petrol Station, Billesley Lane, Birmingham.

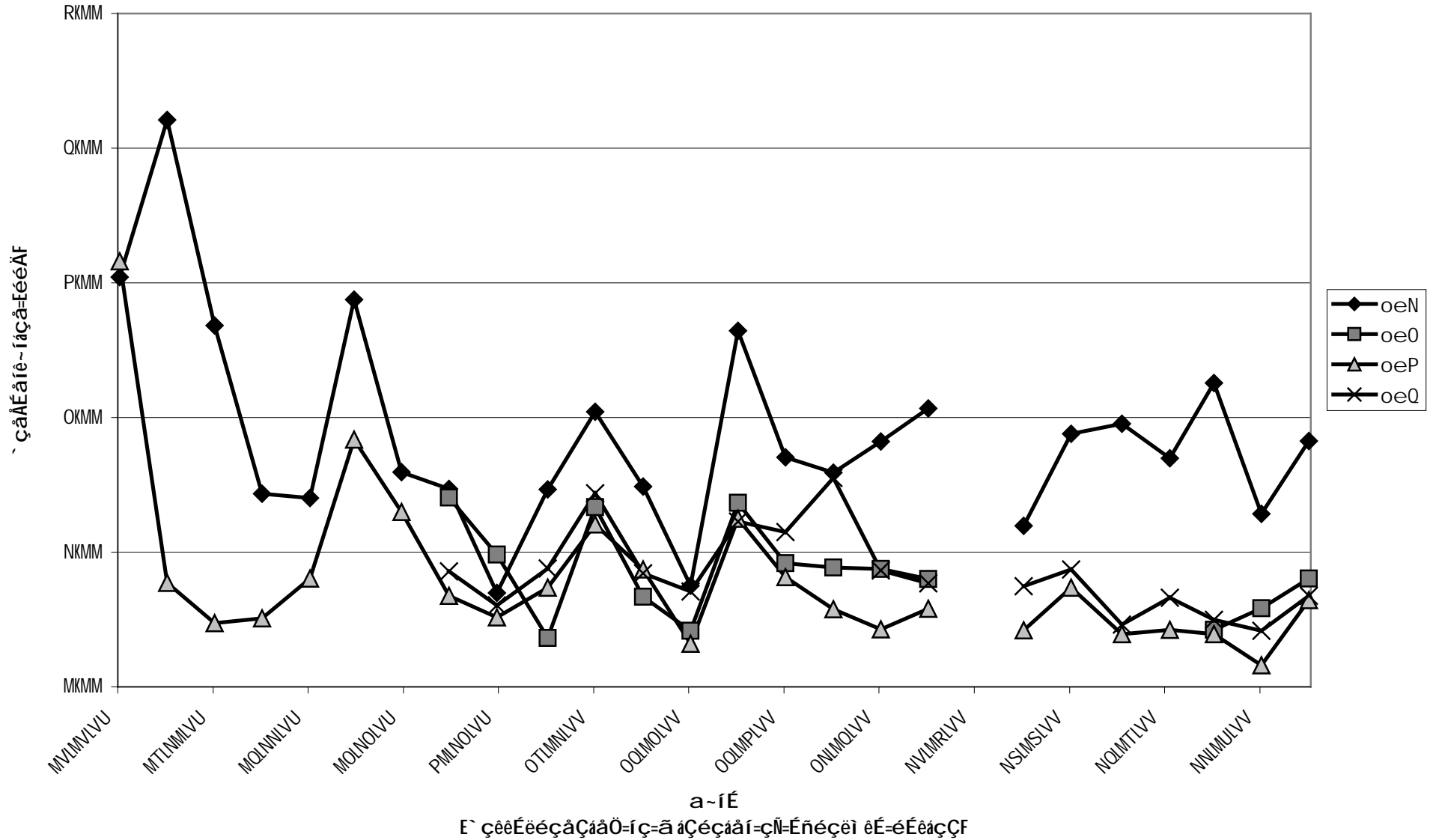


Figure A3.11 Measured benzene concentrations in the vicinity of Reddicap Heath Petrol Station, Reddicap Heath Road, Birmingham.

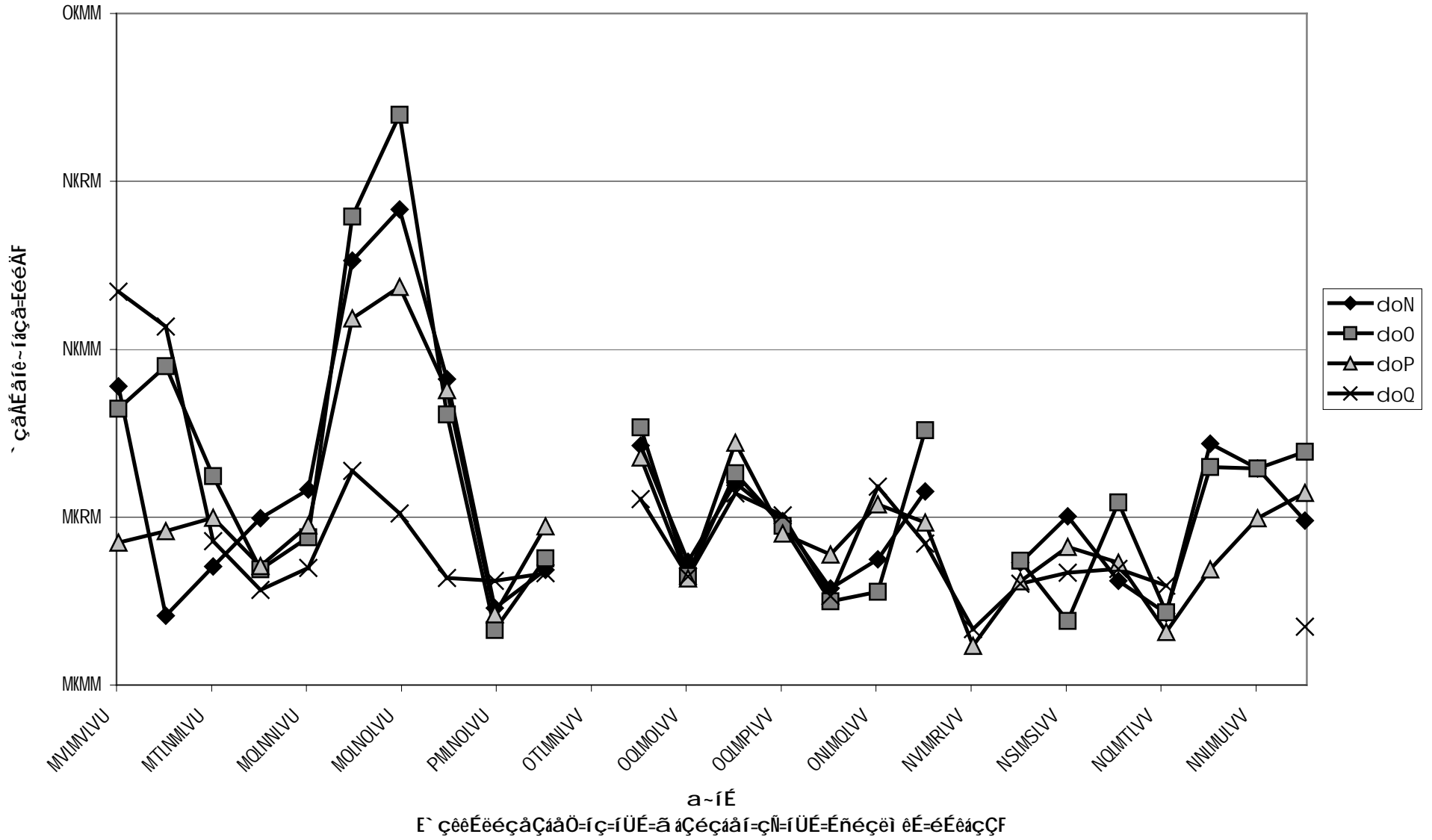


Figure A3.12 Measured benzene concentrations in the vicinity of Grove Road Petrol station, Grove Road, Birmingham.

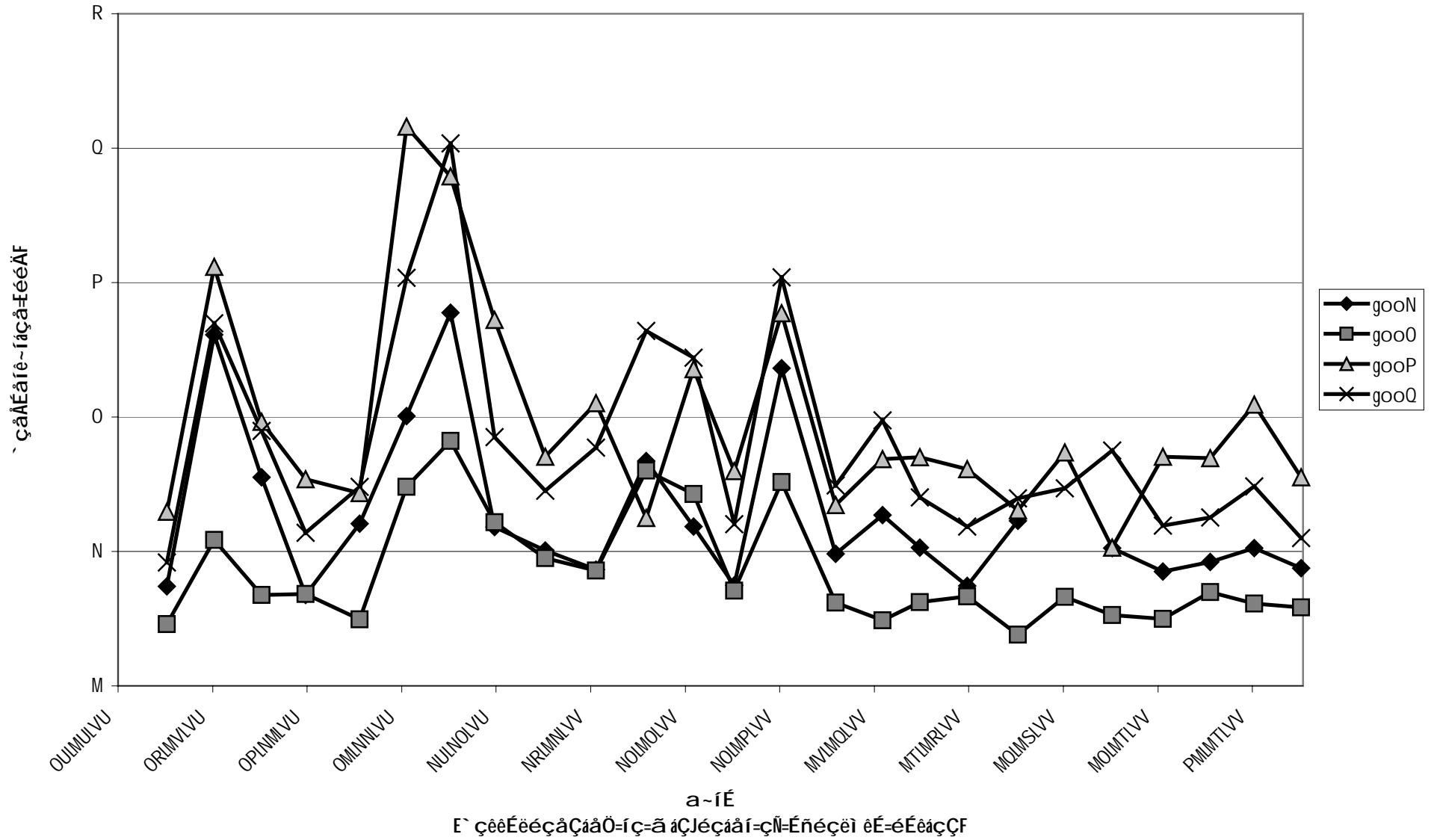


Figure A3.13 Measured benzene concentrations in the vicinity of Redland Road Petrol Station, Redland Road, Bristol.

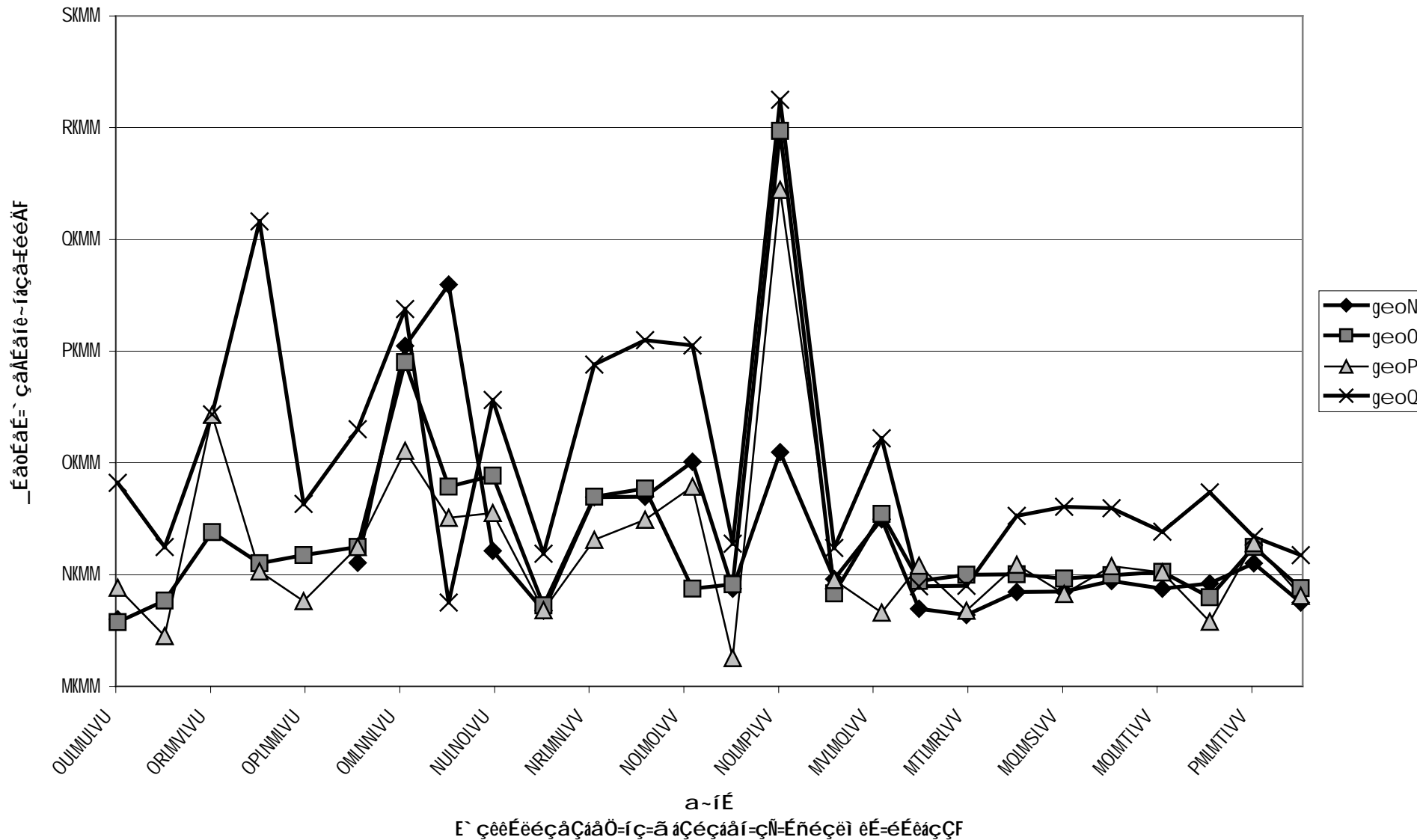


Figure A3.14 Measured benzene concentrations in the vicinity of Hampton Road Service Station, Hampton Road, Bristol.

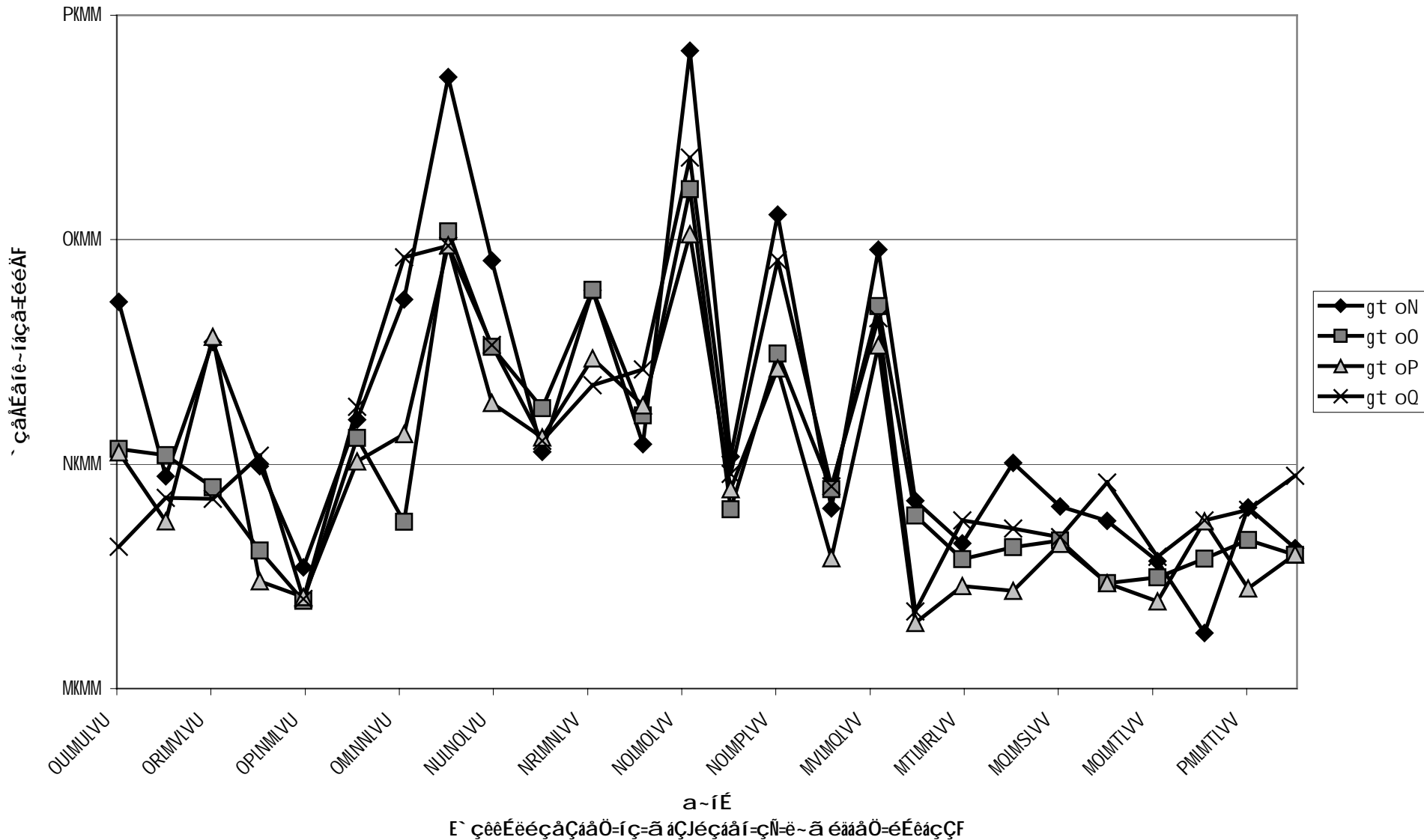


Figure A3.15 Measured benzene concentrations in the vicinity of Wick Road Petrol Station Wick Road, Bristol

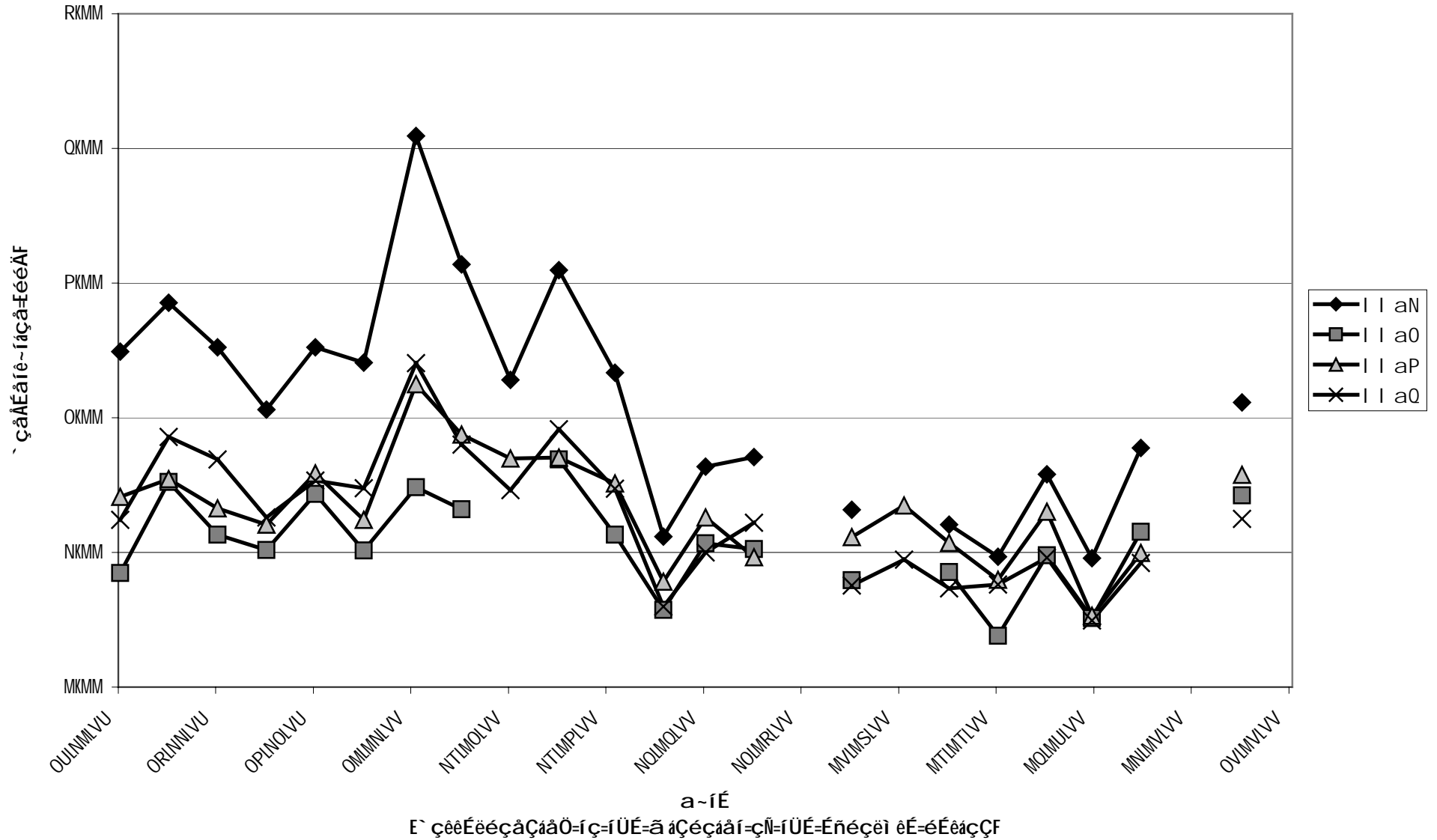


Figure A3.16 Measured benzene concentrations in the vicinity of Dawson Street Petrol Station, Dawson Street, Oxford.

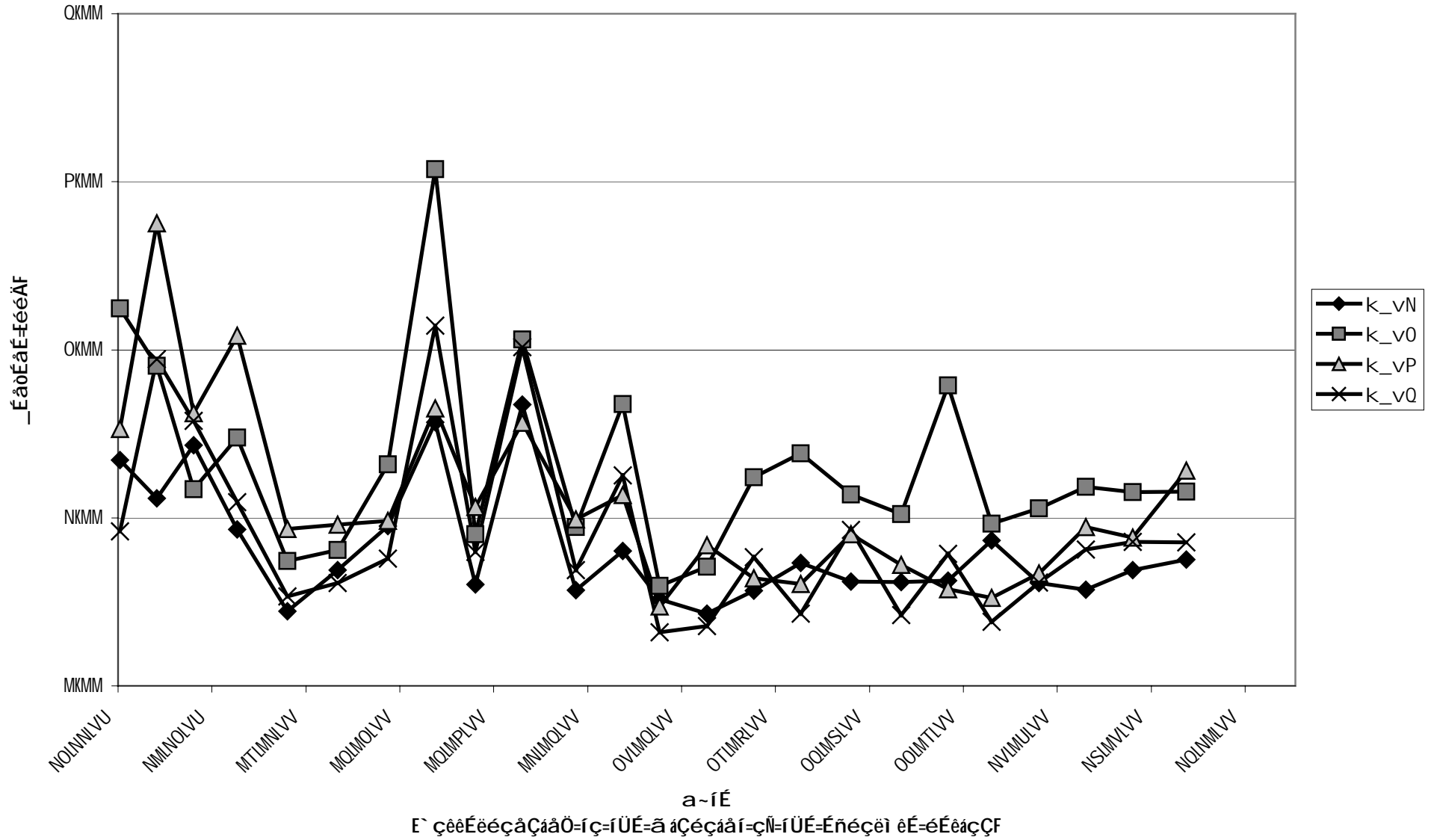


Figure A3.17 Measured benzene concentrations in the vicinity of Davies and Co. Garage, Queens Street, Newbury.

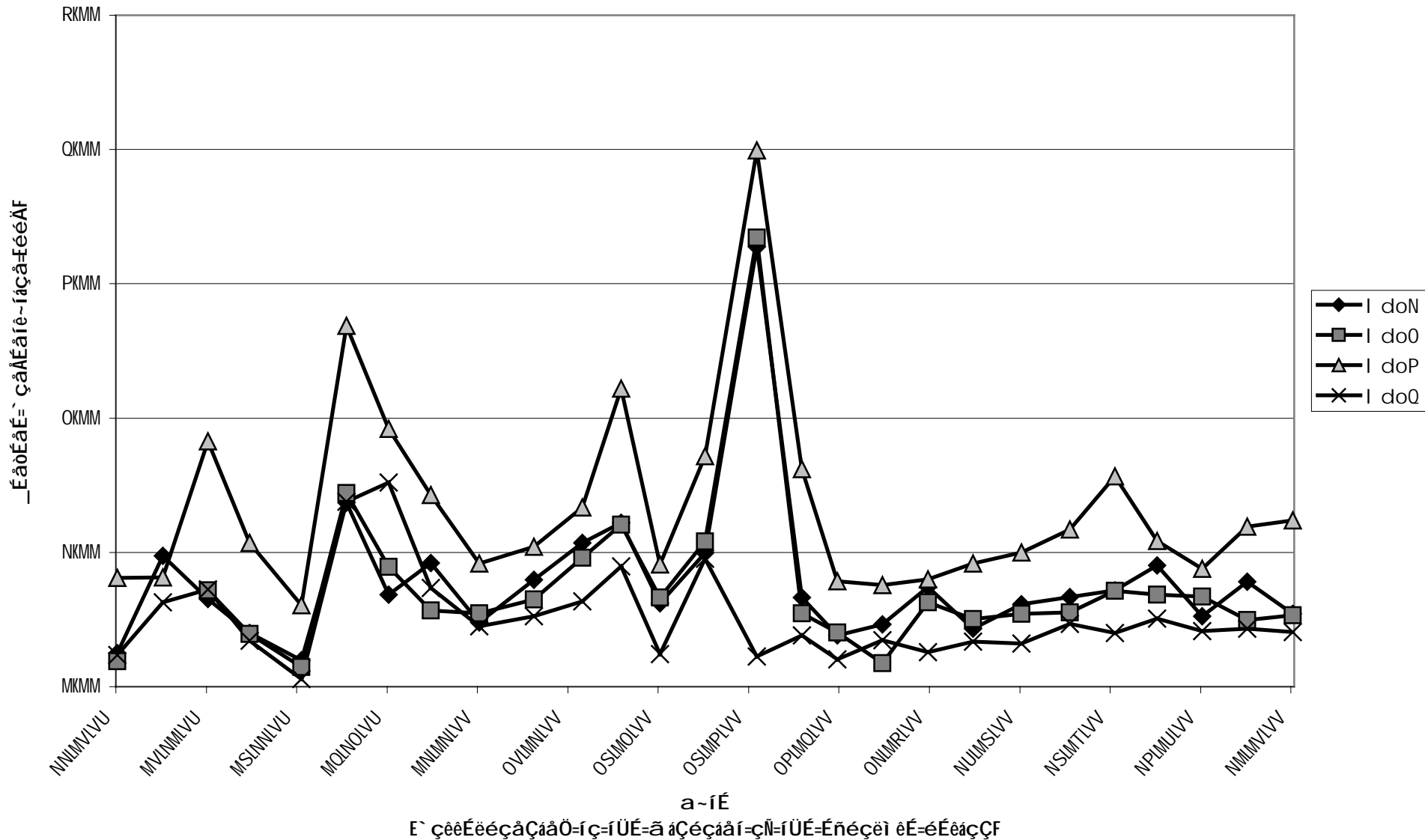


Figure A3.18 Measured benzene concentrations in the vicinity of Grove Service Station, Grove, Oxfordshire.

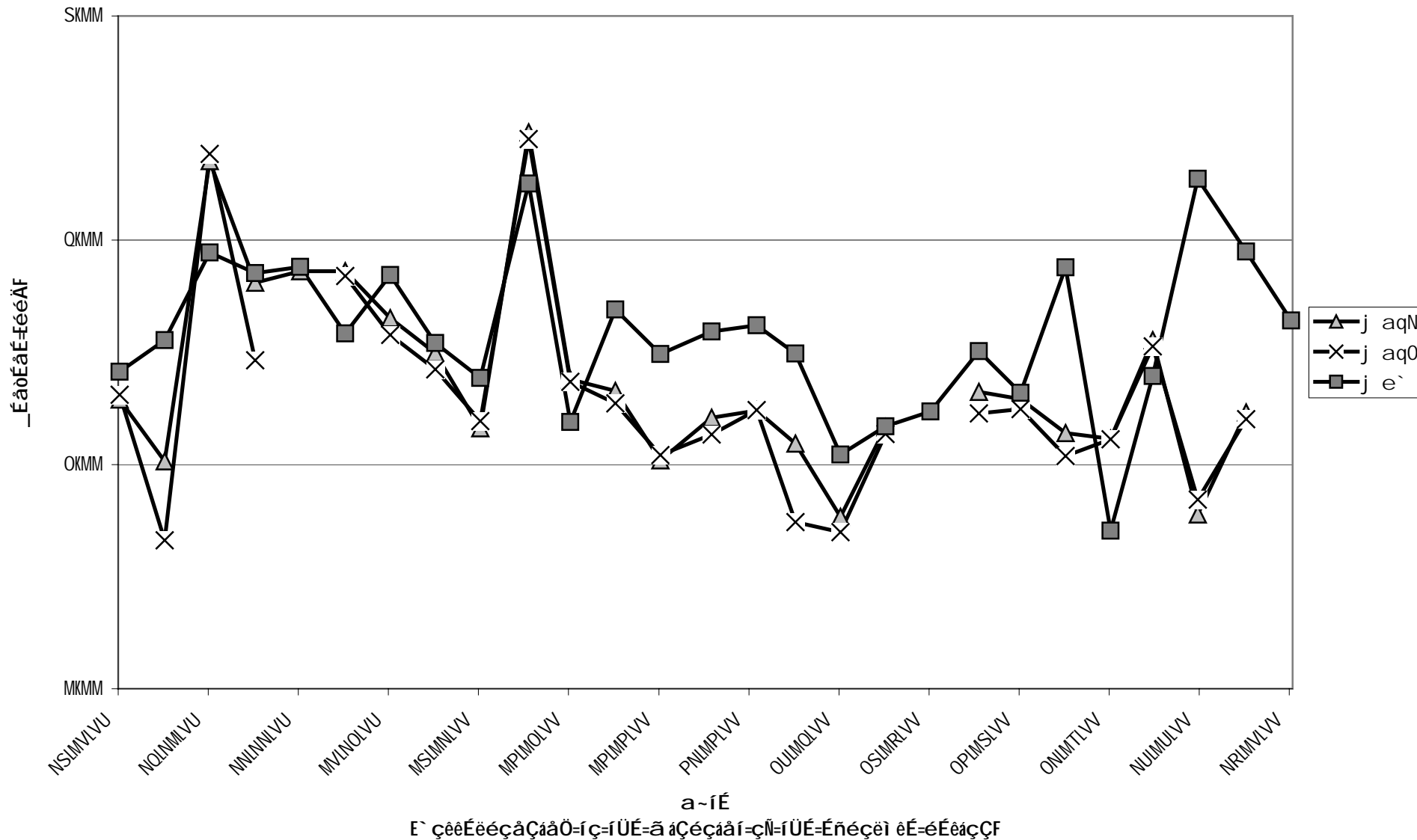


Figure A3.19 Comparison of the measured concentrations at the Marylebone Road AUN site, using Chromosorb 106 diffusion tubes (MDT1 & MDT2) and a Perkin Elmer ATD/400 automatic analyser (MHC).

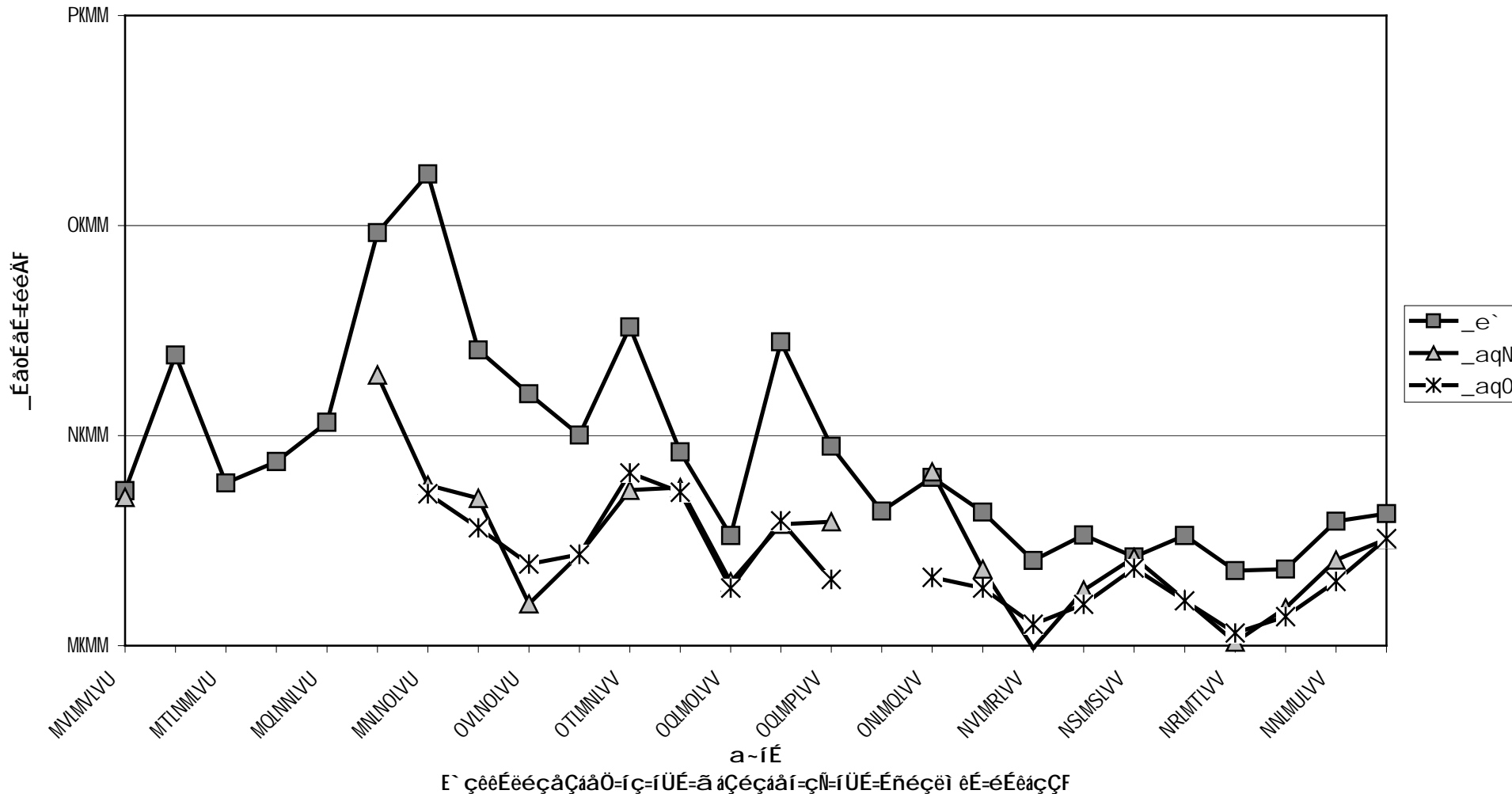


Figure A3.20 Comparison of the measured concentrations at the Birmingham Hydrocarbon Network site , using Chromosorb 106 diffusion tubes (BDT1 and BDT2) and a Chrompack VOC-AIR analyser (BHC).

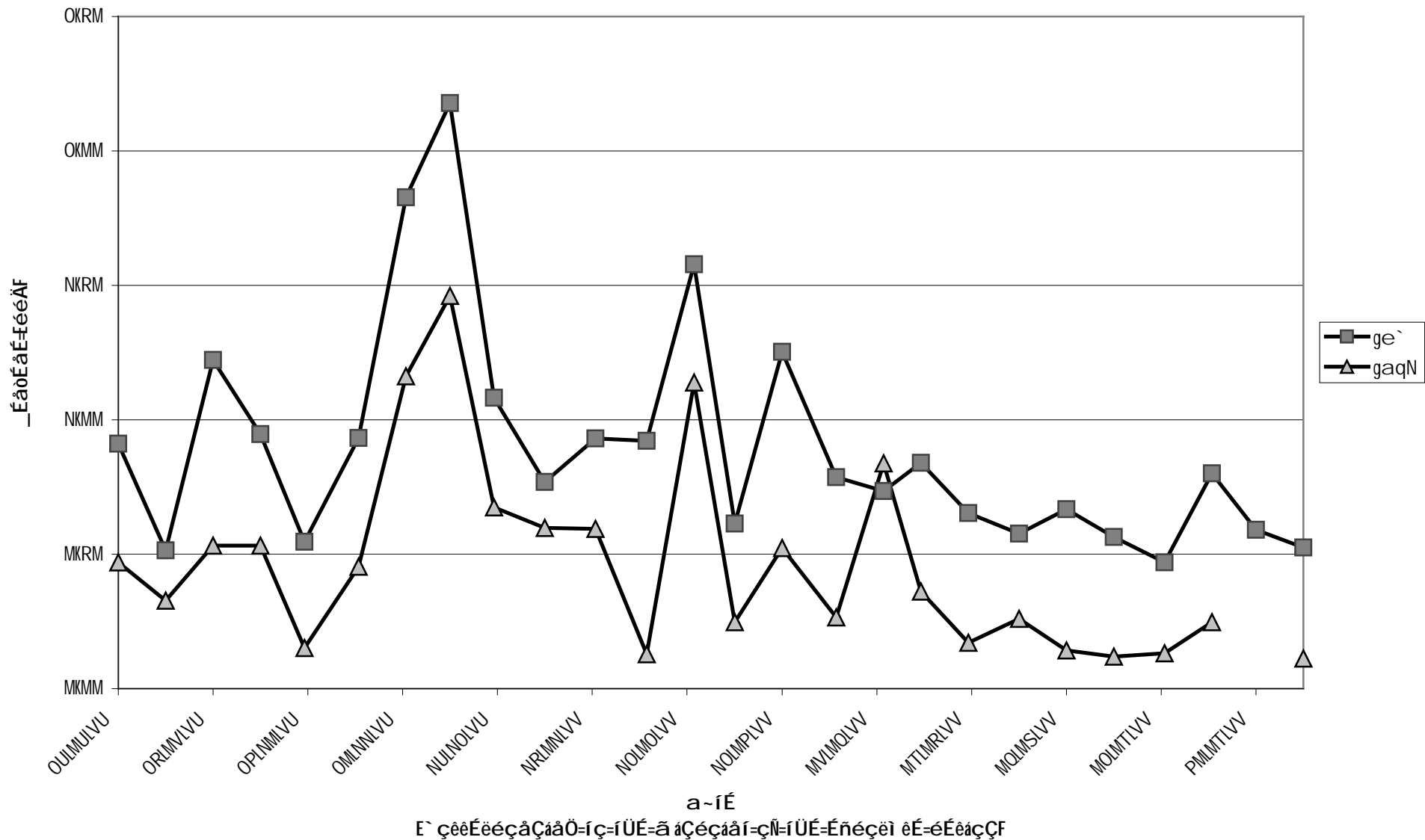


Figure A3.21 Comparison of the measured concentrations at the Bristol Hydrocarbon Network site , using Chromosorb 106 diffusion tubes (JDT1) and a Chrompack VOC-AIR analyser (JHC).

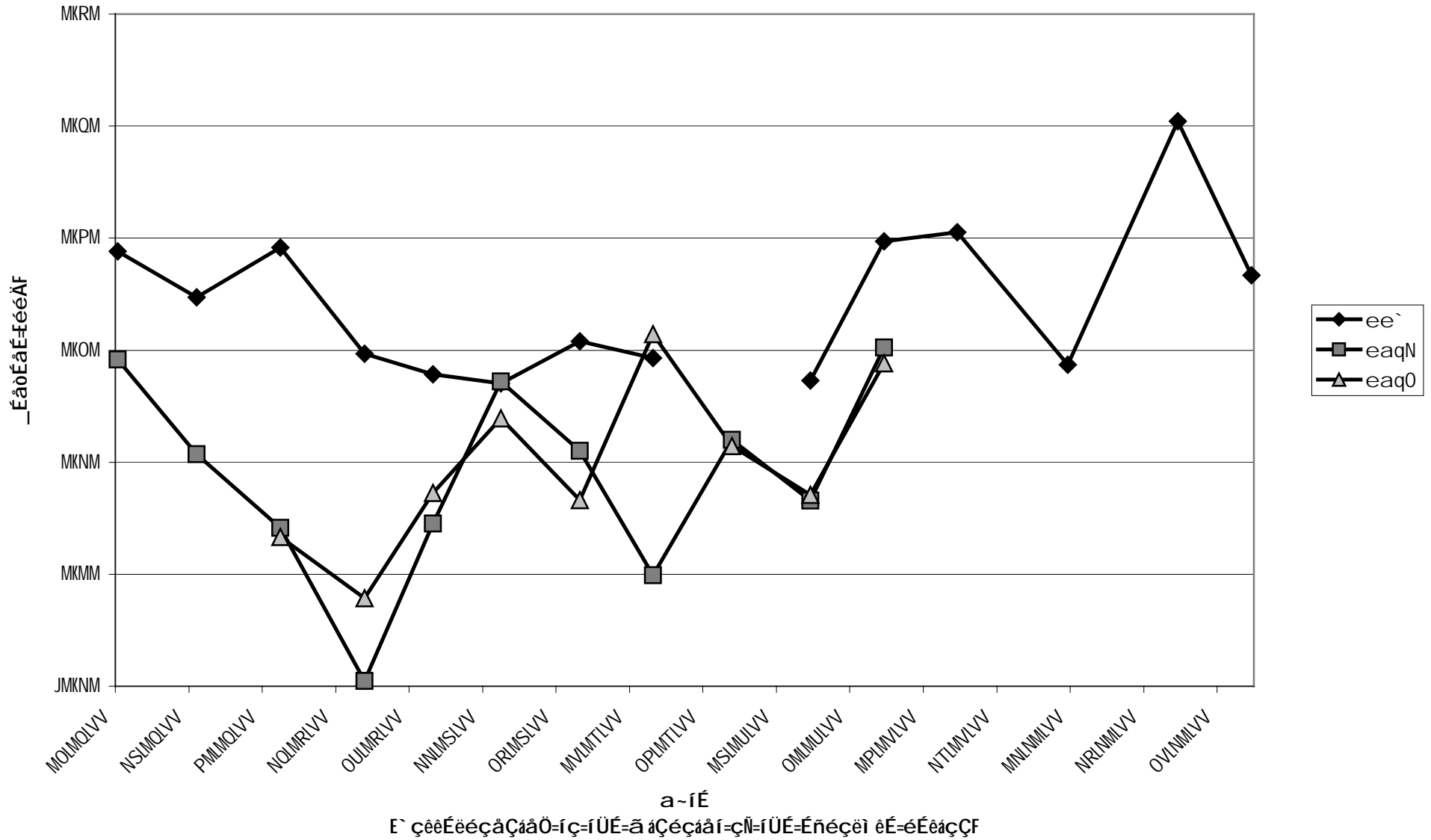


Fig A3.22 Comparison of the measured concentrations at the Harwell Hydrocarbon Network site , using Chromosorb 106 diffusion tubes and a Chrompack VOC-AIR analyser.

OMRPVMMN=fèèi É=N

^b^=qÉÄÜâçãçÖö

Appendix 4

Maps of sampling locations

OMRPVMMN=fèèì É=N

^b^=qÉÀÜäçîçÖó

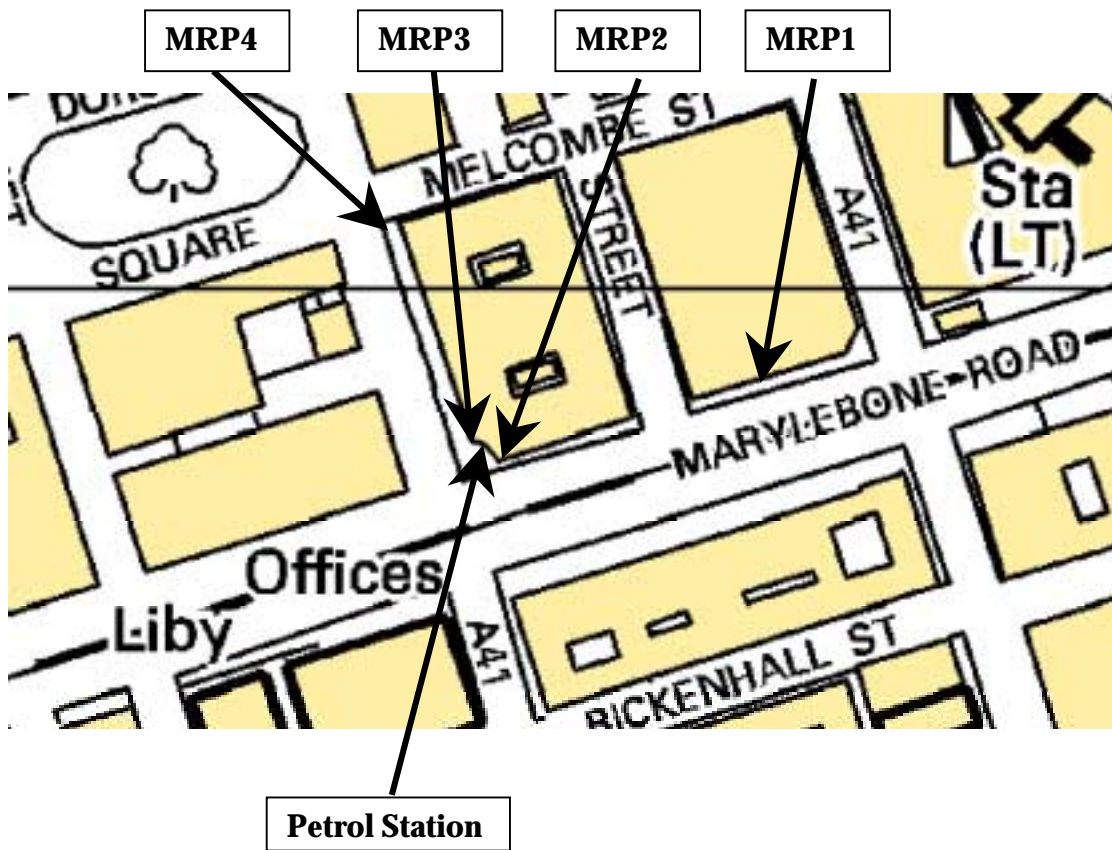


Fig A4.1 Location of diffusion tube sites in the vicinity of the Marylebone Road Petrol Station, London

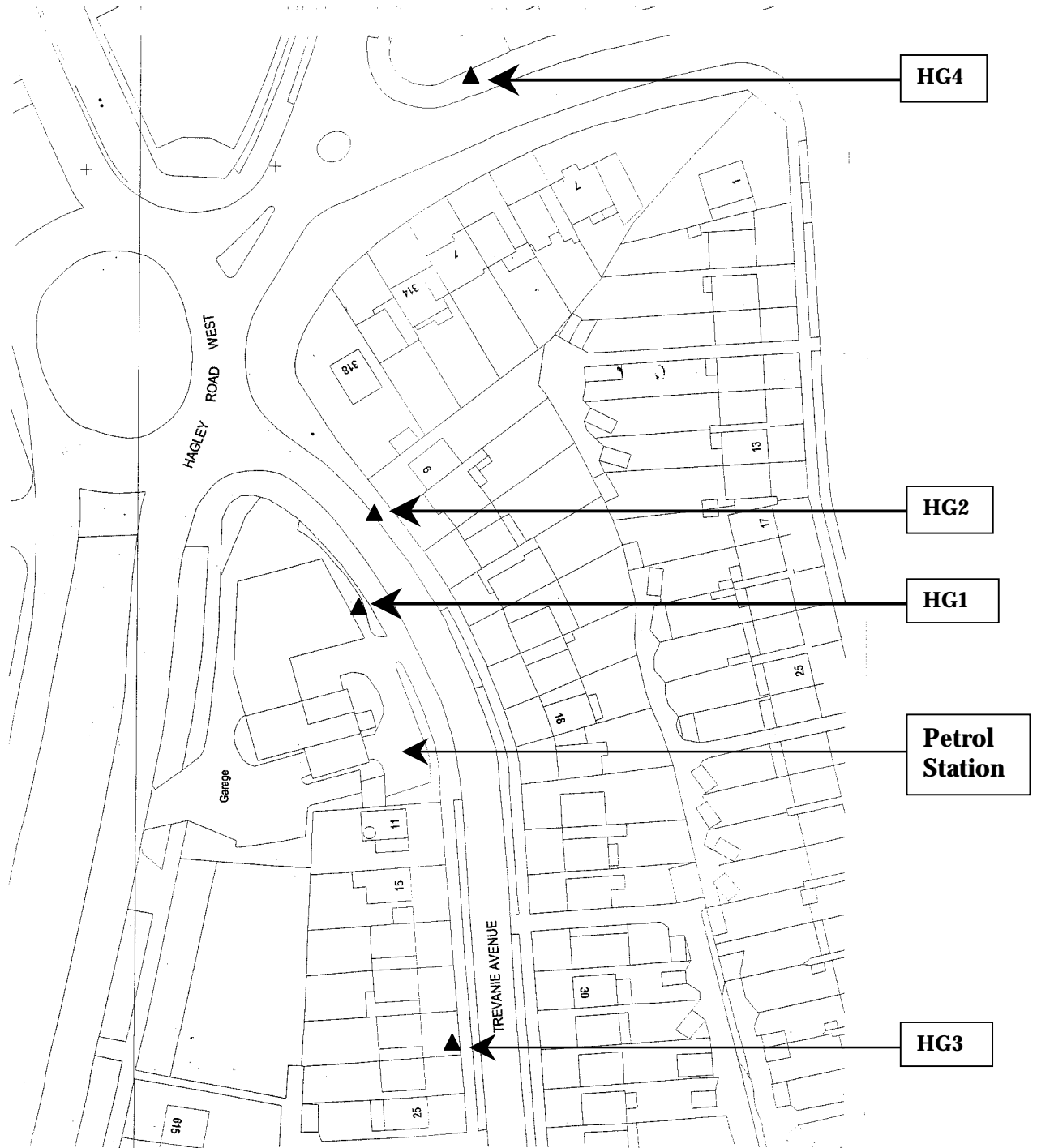


Fig A4.2 Location of diffusion tube sites in the vicinity of the Hageley Road Petrol Station, Hageley Road, Birmingham



Figure A4.3 Location of diffusion tube sites in the vicinity of the Gloucester Road Petrol Station, Bristol

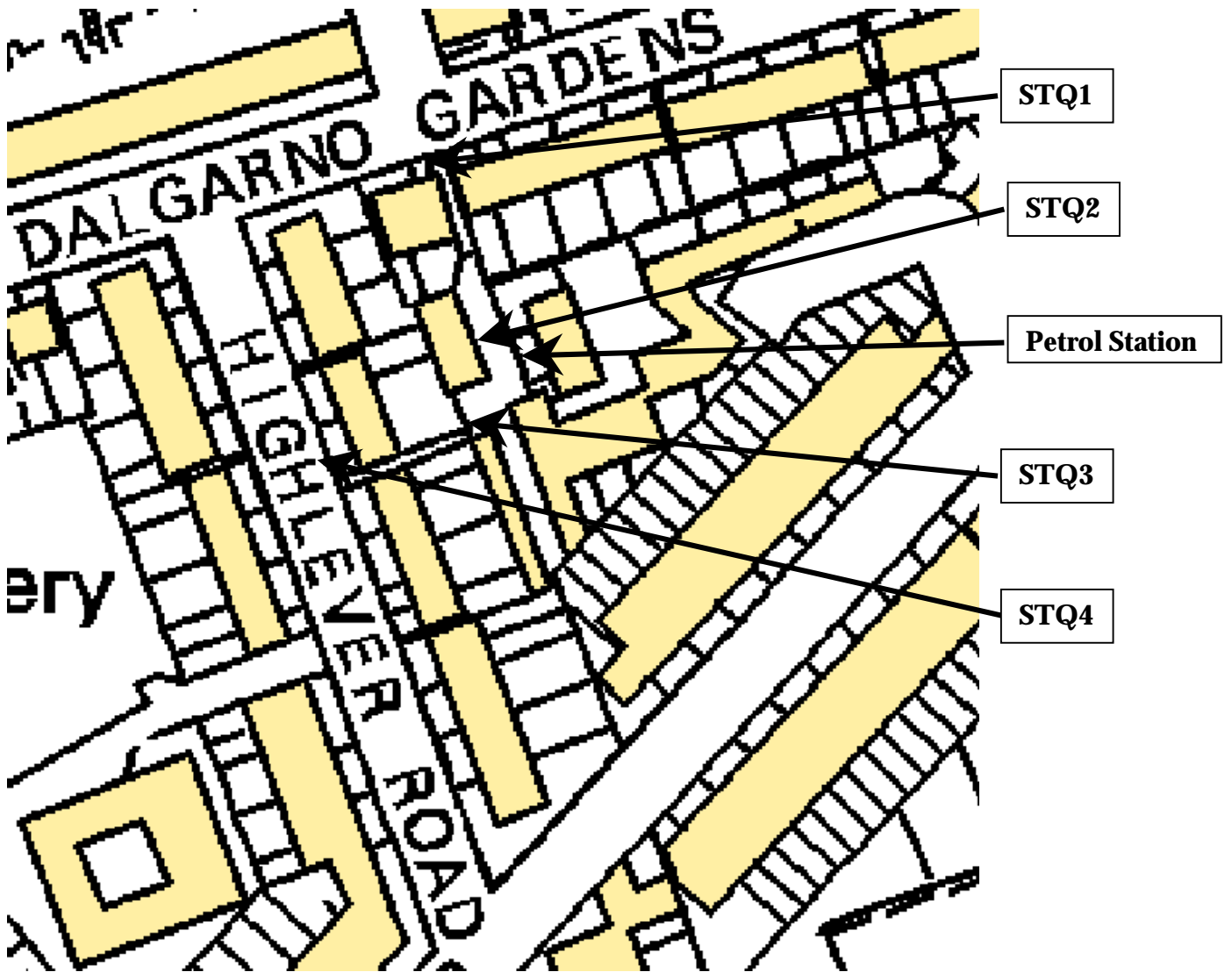


Figure A4.4 Location of diffusion tube sites in the vicinity of the St. Quentin Petrol Station, off Dalgarno Gardens, North Kensington, London

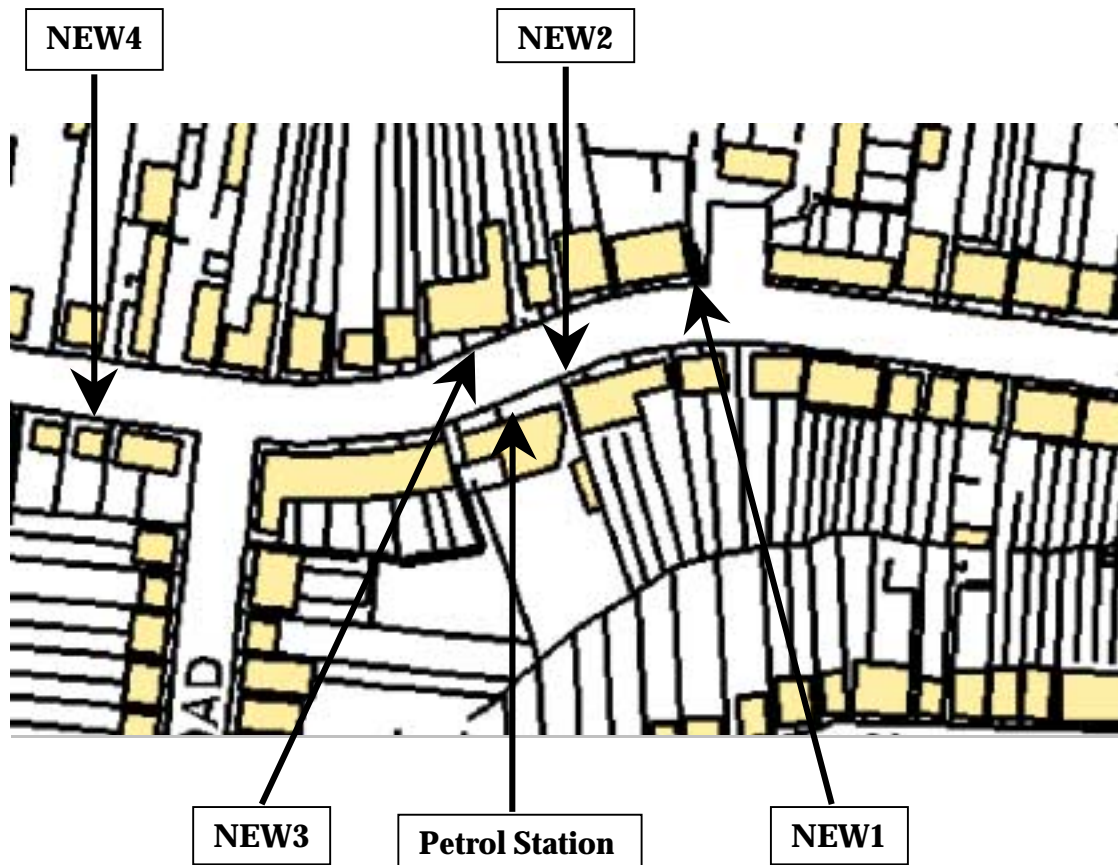


Figure A4.5 Location of diffusion tube sites in the vicinity of the New Road Service Station, New Road, Croxley Green.

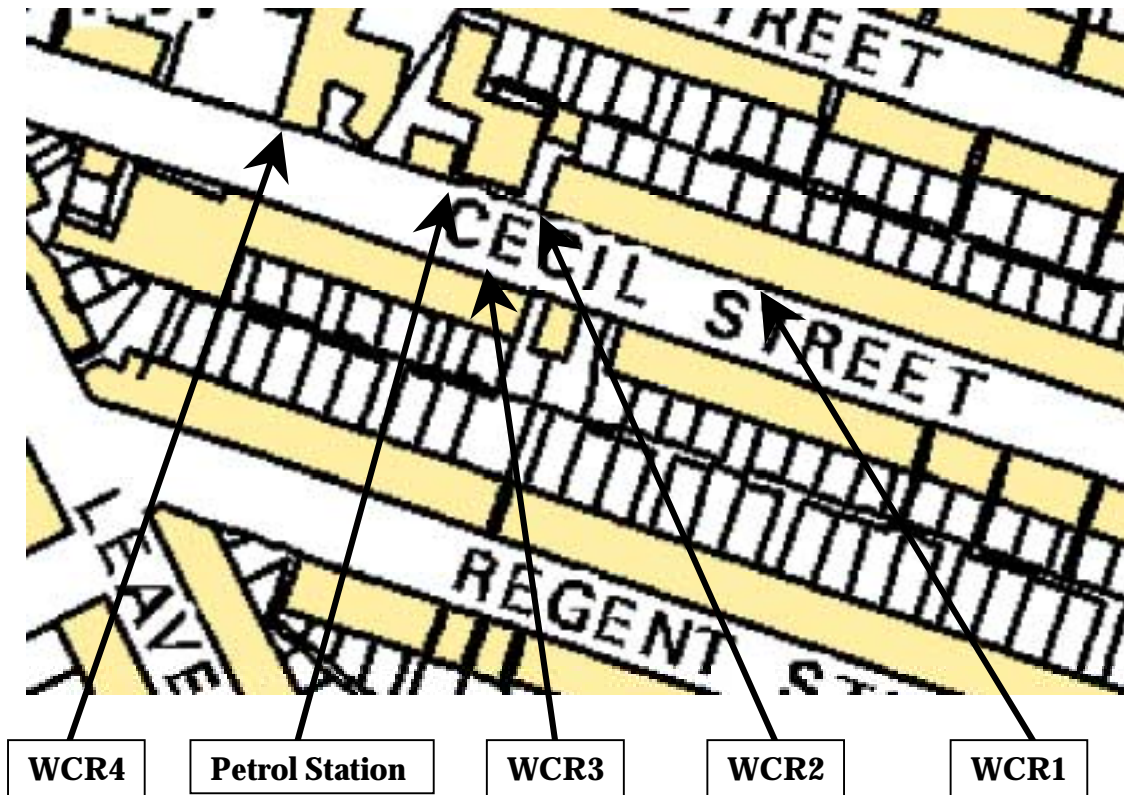


Figure A4.6 Location of diffusion tube sites in the vicinity of the Cecil Street Petrol Station, Cecil Street, Watford

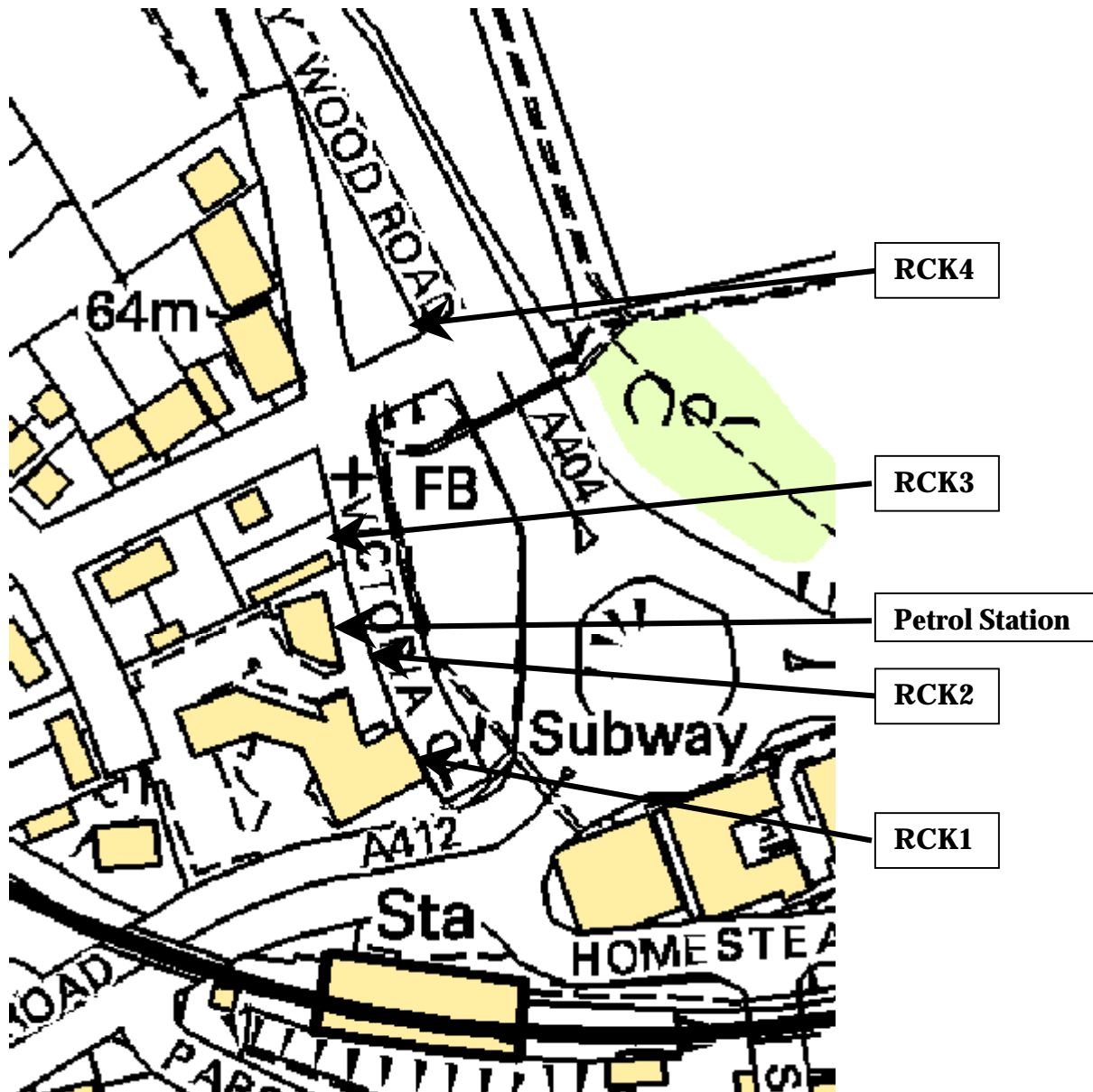


Figure A4.7 Location of diffusion tube sites in the vicinity of the Rickmansworth Service Station, Victoria Close, Rickmansworth.

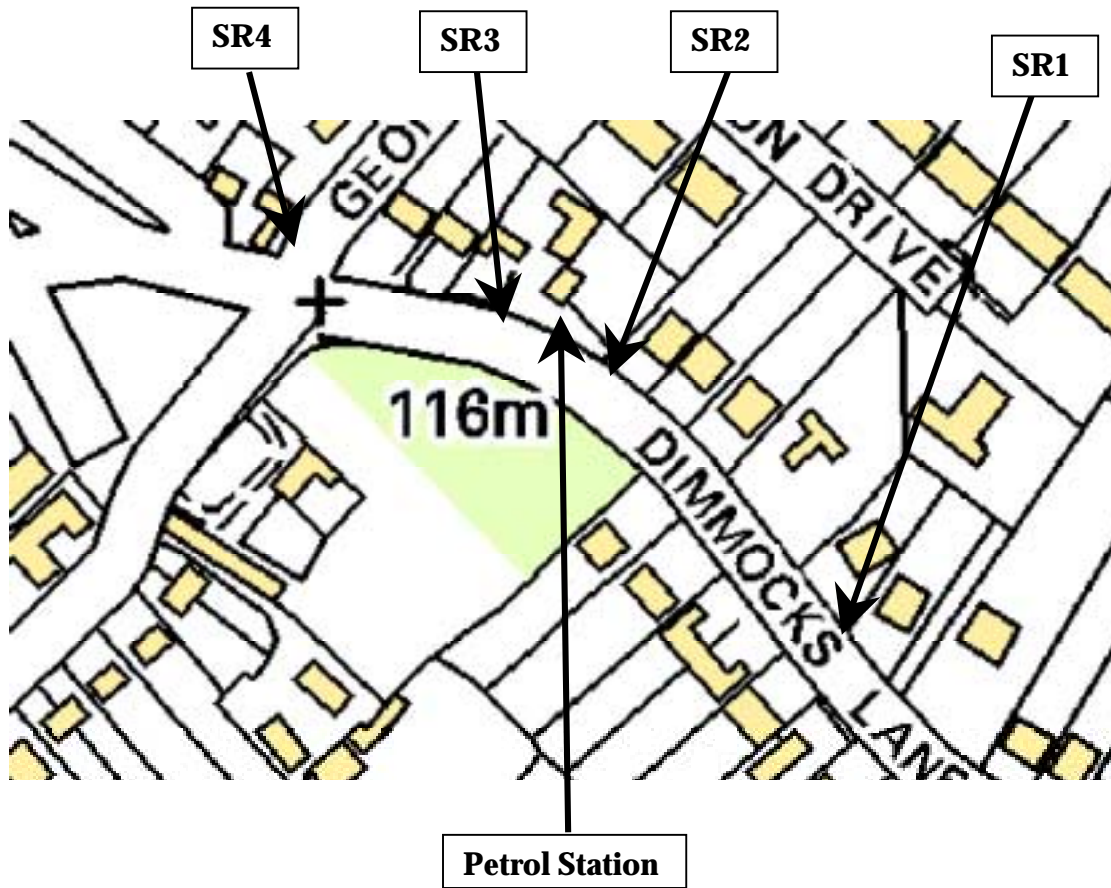


Figure A4.8 Location of diffusion tube sites in the vicinity of the Biggerstaffs Petrol Station, Dimmock's Lane, Sarrat.

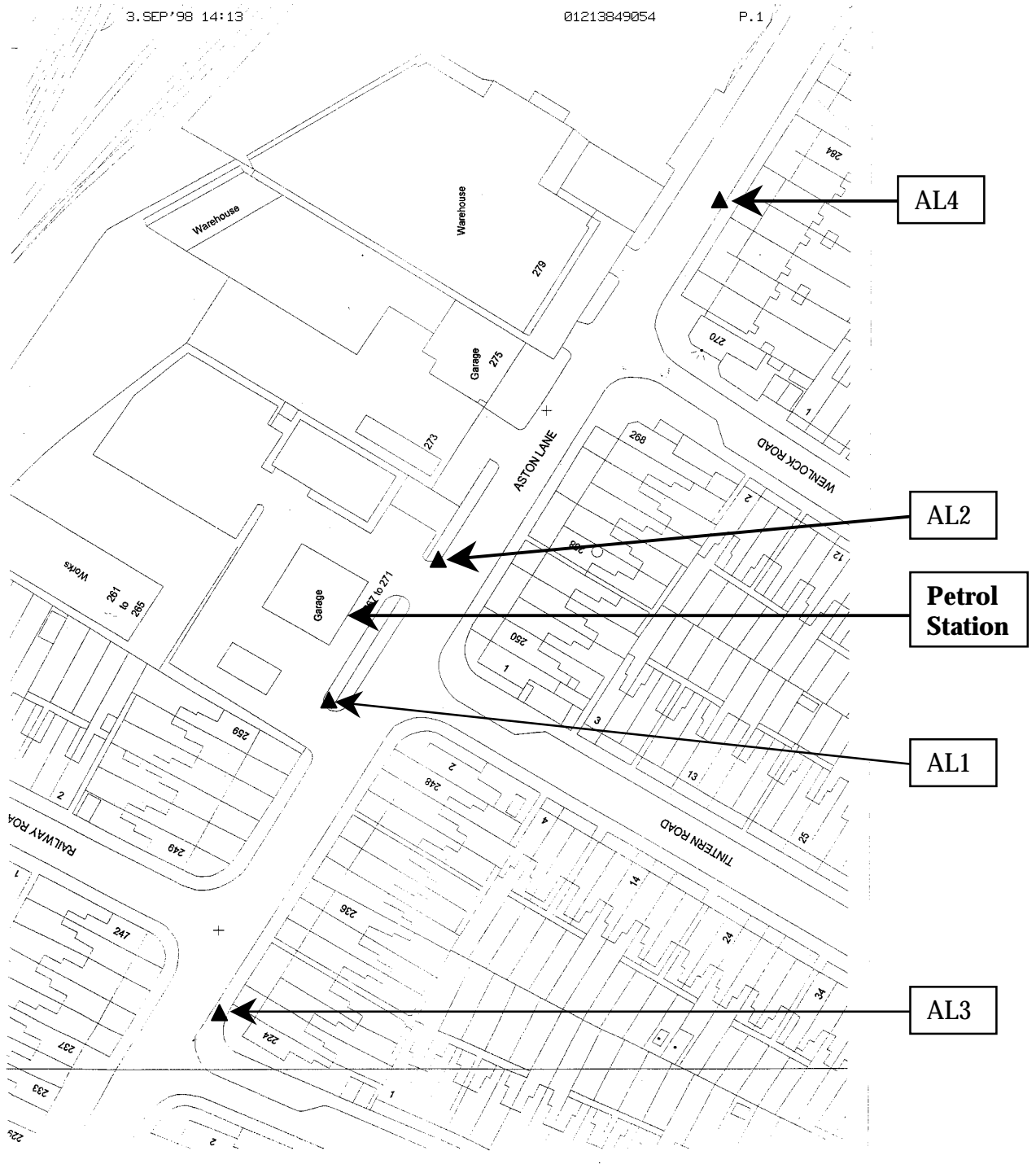


Figure A4.9 Location of diffusion tube sites in the vicinity of the Aston Lane Petrol Station, Aston Lane, Birmingham.

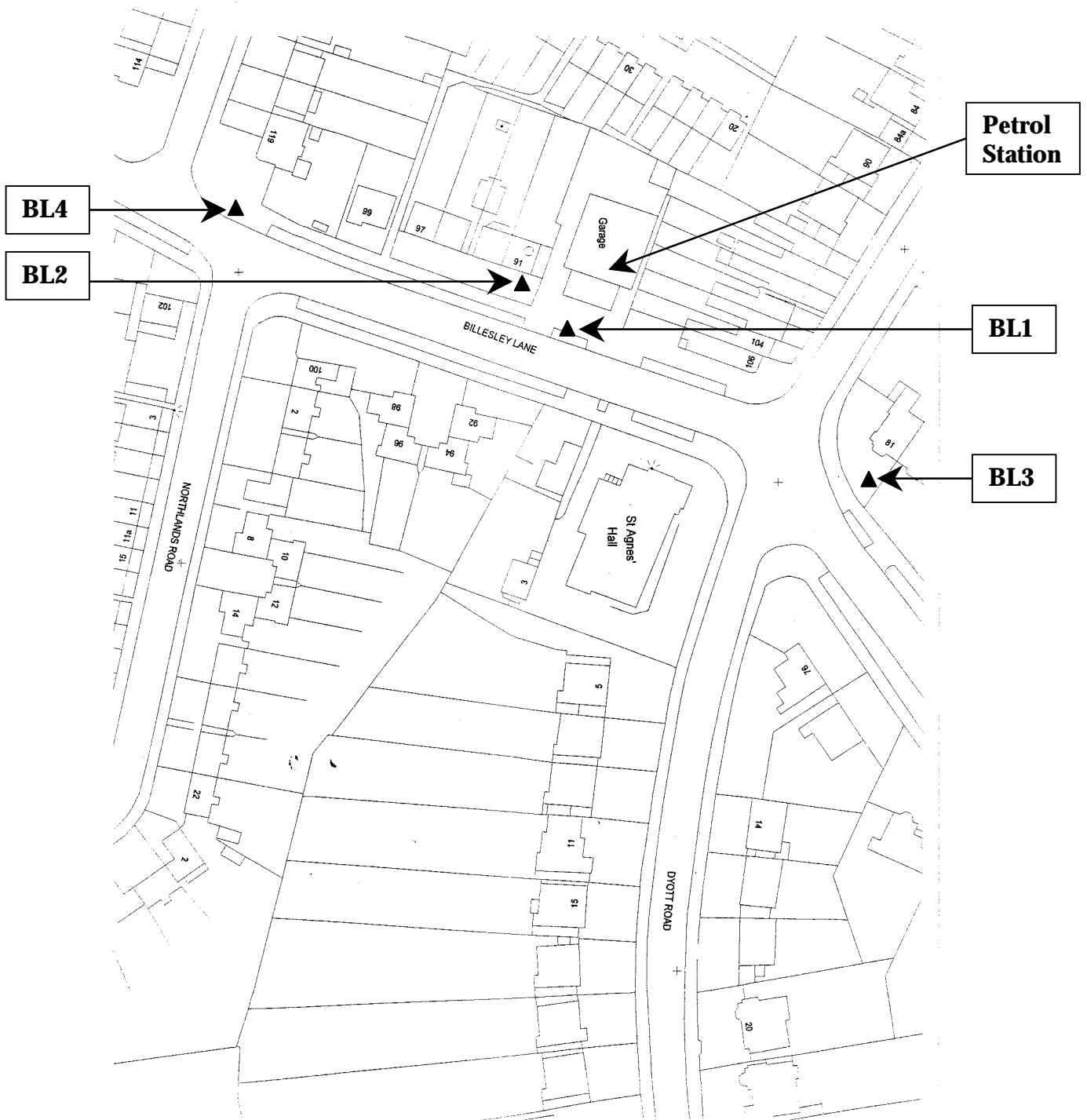


Figure A4.10 Location of diffusion tube sites in the vicinity of the Billesley Lane Petrol Station, Billesley Lane, Birmingham.

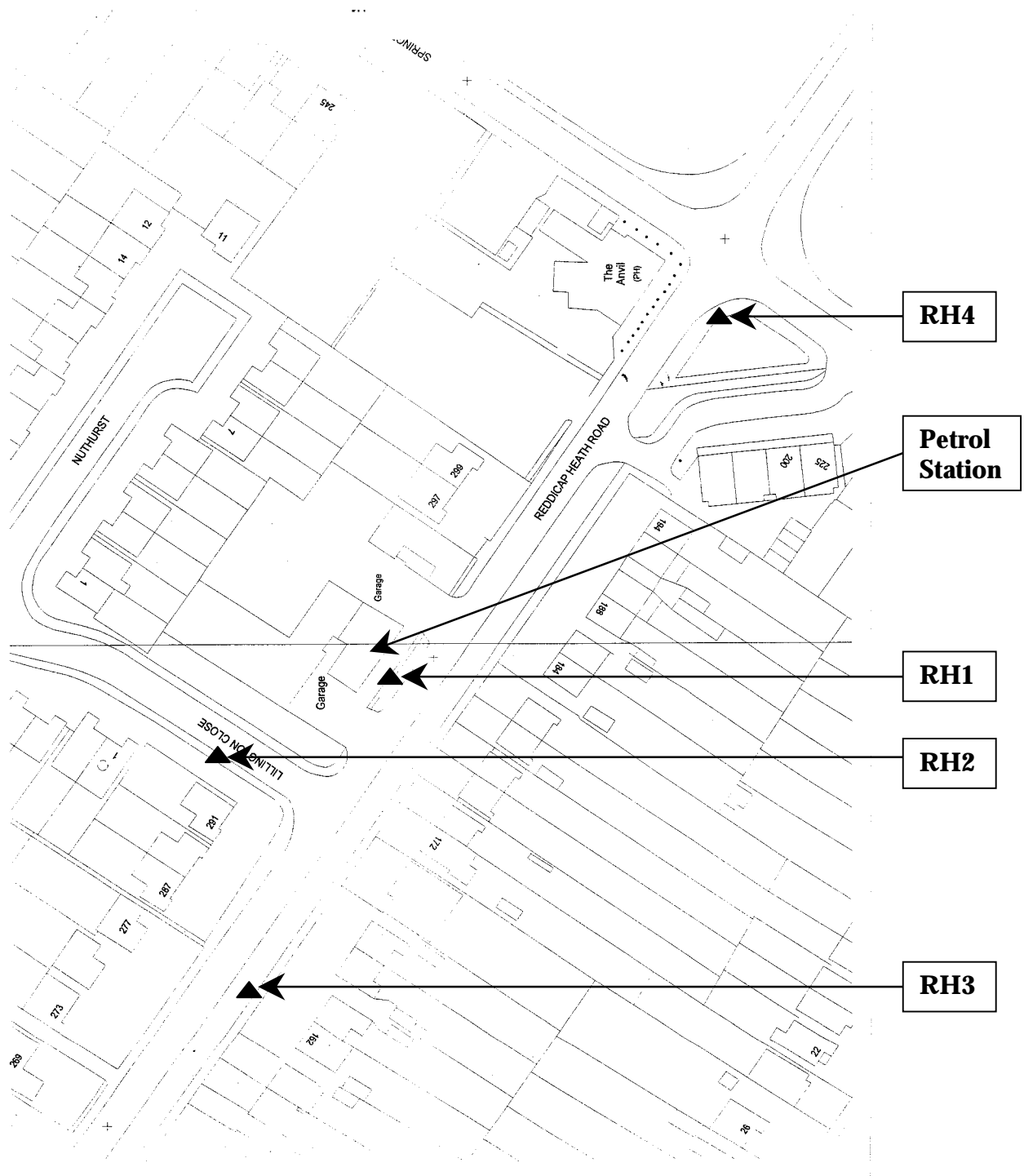


Figure A4.11 Location of diffusion tube sites in the vicinity of the Reddicap Heath Petrol Station, Reddicap Heath, Birmingham.

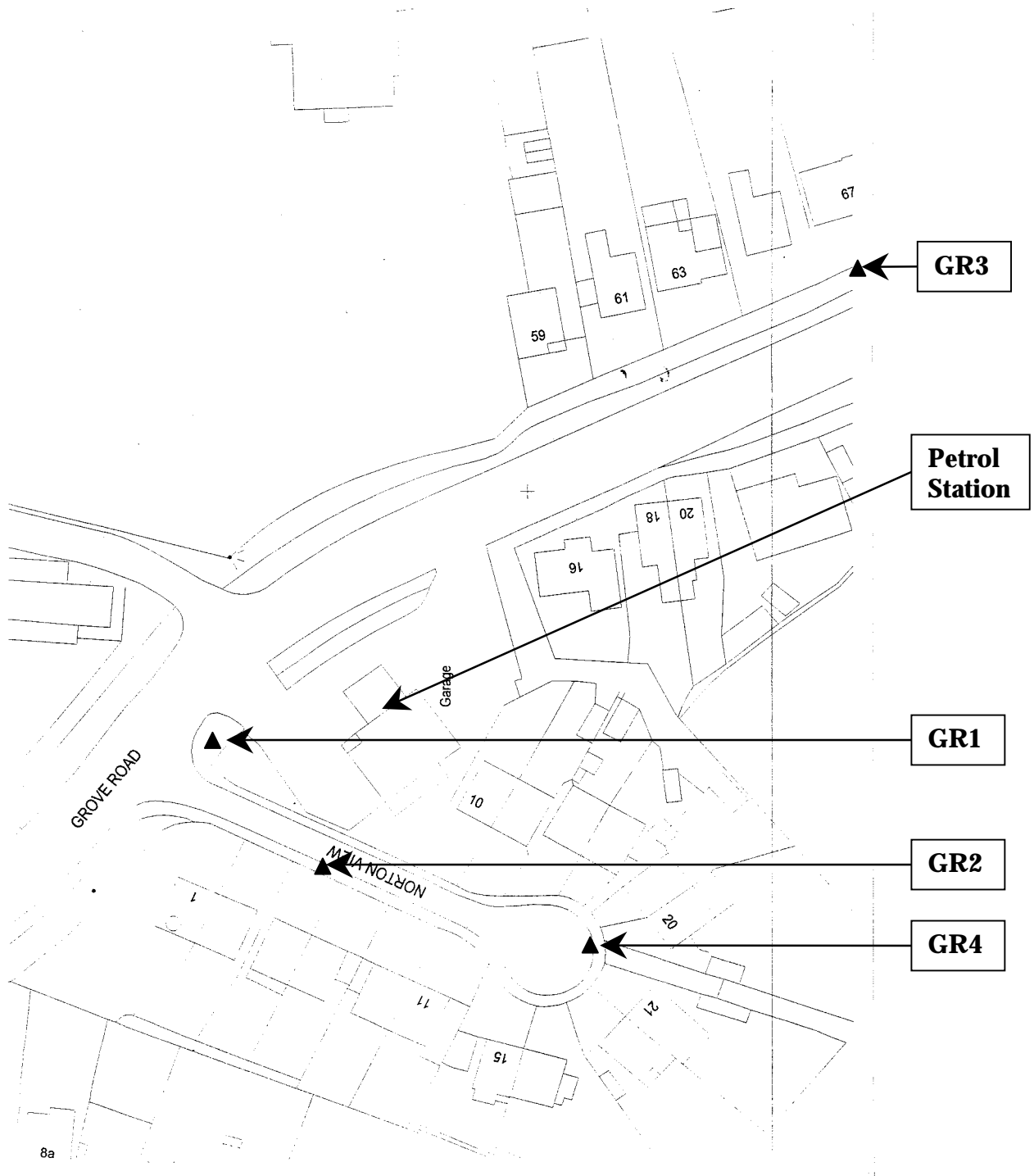


Figure A4.12 Location of diffusion tube sites in the vicinity of the Grove Road Petrol Station, Grove Road, Birmingham.

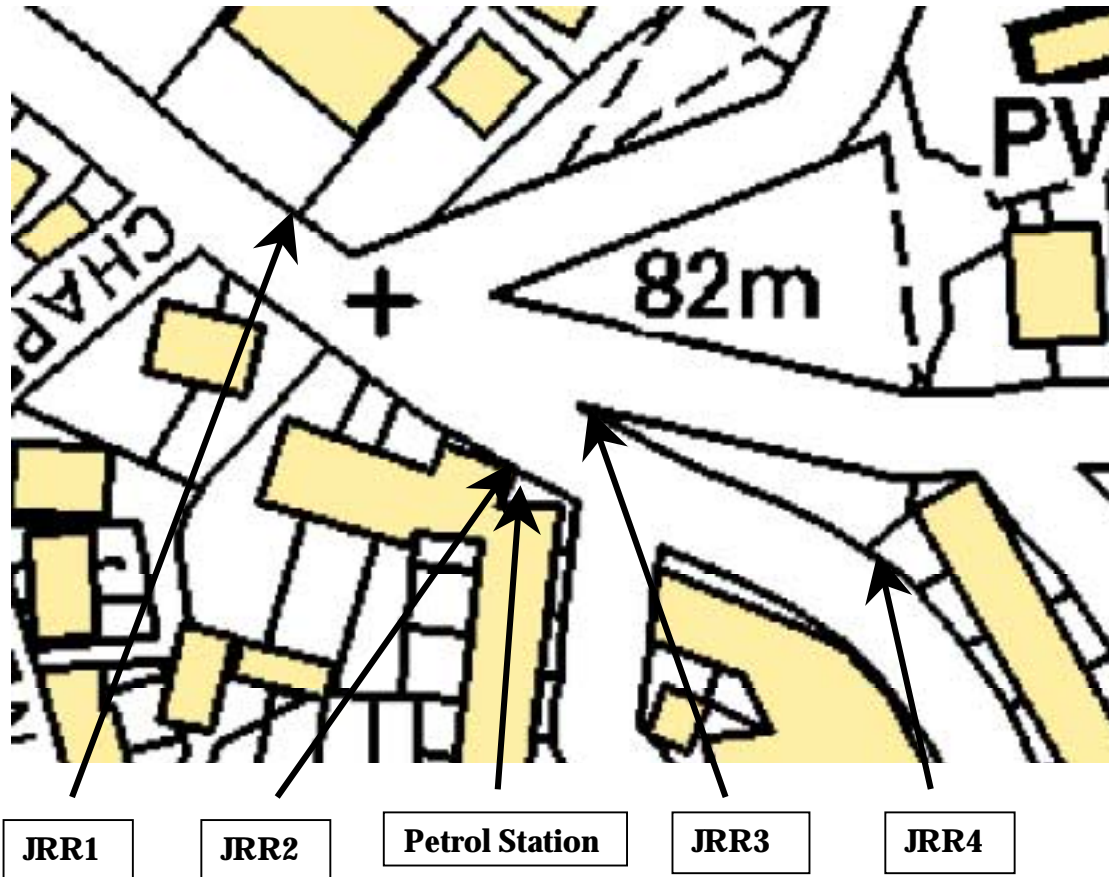


Figure A4.13 Location of diffusion tube sites in the vicinity of the Redland Road Petrol Station, Redland Road, Bristol.

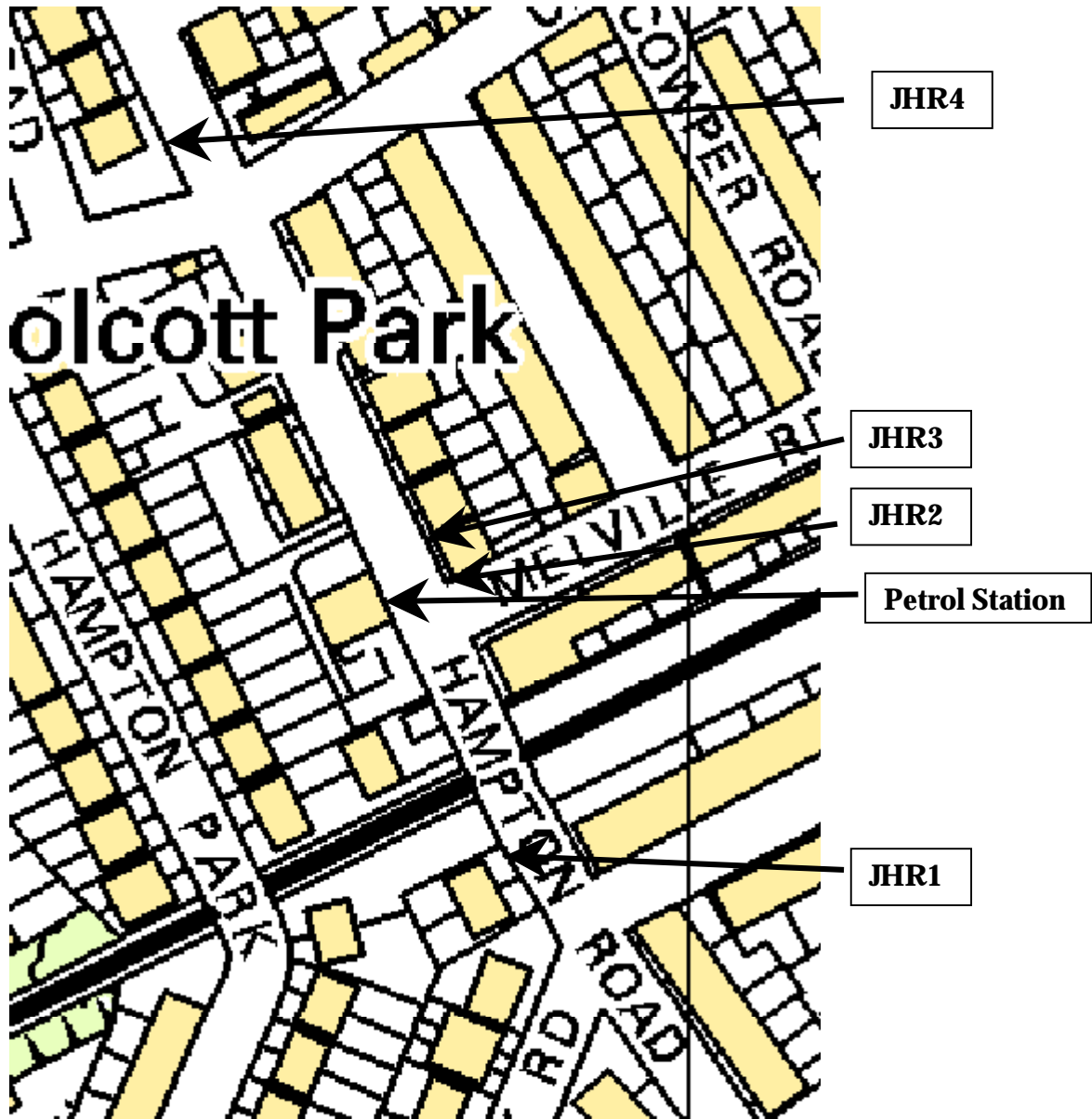


Figure A4.14 Location of diffusion tube sites in the vicinity of the Hampton Road Petrol Station, Hampton Road, Bristol.

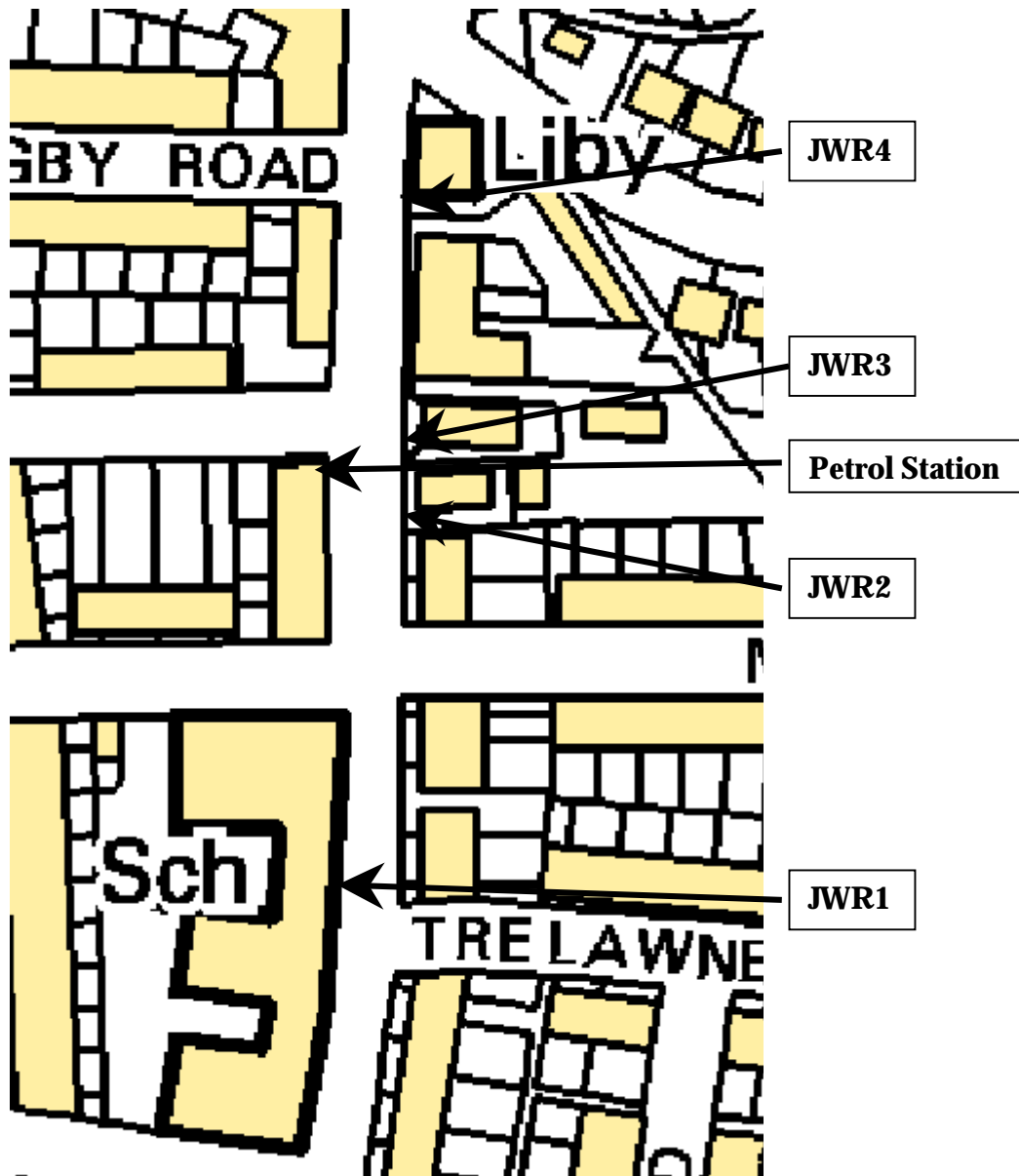


Figure A4.15 Location of diffusion tube sites in the vicinity of the Wick Road Petrol Station, Wick Road, Bristol.



Figure A4.16 Location of diffusion tube sites in the vicinity of the Dawson Street Petrol Station, Dawson Street, Oxford.

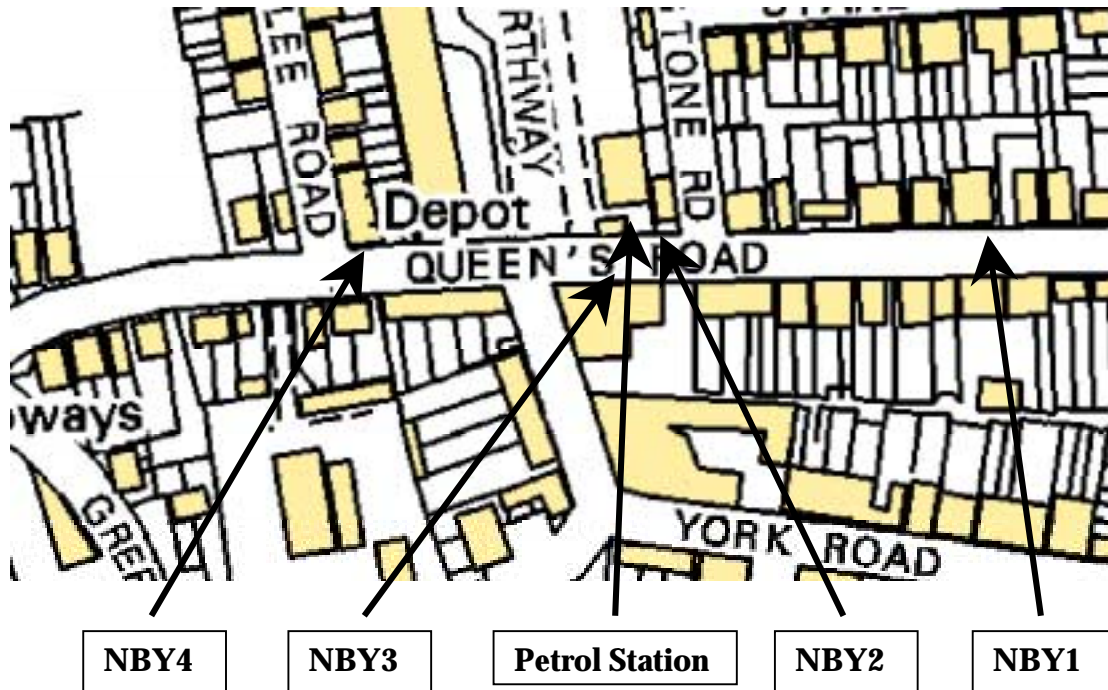


Figure A4.17 Location of diffusion tube sites in the vicinity of the Queen Street Service Station, Queen Street, Newbury.

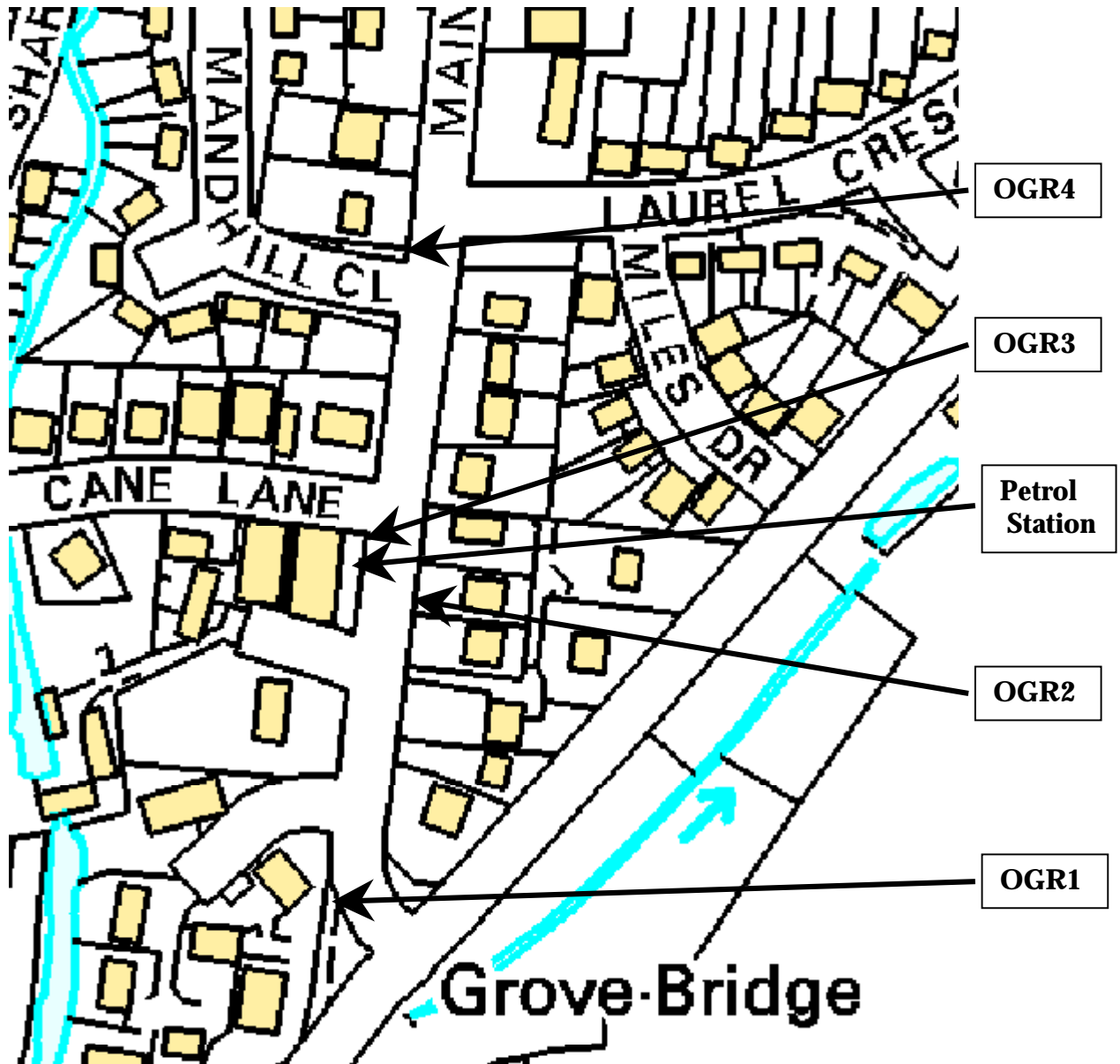


Figure A4.18 Location of diffusion tube sites in the vicinity of the Grove Service Station, Grove, Oxfordshire.

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