Air Quality Monitoring in Jersey; Diffusion Tube Surveys, 2002

March 2003

Air Quality Monitoring in Jersey; Diffusion Tube Surveys, 2002

March 2003

Title	Air Quality Monitoring in Jersey; Diffusion Tube Surveys, 2002
Customer	Public Health Services, States of Jersey
Customer reference	
Confidentiality, copyright and reproduction	Restricted - Commercial This document has been prepared by AEA Technology plc in connection with a contract to supply goods and/or services and is submitted only on the basis of strict confidentiality. The contents must not be disclosed to third parties other than in accordance with the terms of the contract.
File reference	ED 46093001
Report number	AEAT/ENV/R/1411
Report status	Issue 1

netcen
Culham Science Centre
ABINGDON
Oxfordshire
OX14 3ED
Telephone 01235 463177
Facsimile 01235 463011

netcen is an operating division of AEA Technology plc
AEA Technology is certificated to BS EN ISO9001:(1994)

	Name	**Signature**	**Date**
Author	B Stacey A Loader		
Reviewed by	K Stevenson		
Approved by	G Dollard		

Executive Summary

Netcen (an operating division of AEA Technology Environment) has undertaken a programme of air quality monitoring on Jersey, on behalf of the Public Health Services and Planning and Environment Department of the States of Jersey. This report presents the results of the sixth consecutive year of monitoring, the period 3rd January 2002 to 3rd January 2003.

Diffusion tube samplers were used to monitor nitrogen dioxide (NO_2) at nineteen sites, sulphur dioxide (SO_2) at one site, and hydrocarbons at seven sites. Monitoring sites were selected to include areas likely to be affected by specific emission sources (such as petrol stations or the waste incinerator), as well as general background locations.

SO_2, NO_2 and hydrocarbon diffusion tubes were exposed for periods of 4 or 5 whole weeks, corresponding to the monthly exposure periods used in the UK NO_2 Network. The tubes were supplied and analysed by Harwell Scientifics Ltd, and changed by Technical Officers of Jersey's Environmental Health Section.

The highest annual mean of 25ppb was measured at the Weighbridge bus station site. Annual mean NO_2 concentrations at six of the seven kerbside and roadside sites in built-up areas were greater than the Limit Value of 21ppb, set by Directive 1999/30/EEC (to be achieved by 2010), and as an Objective by the UK Air Quality Strategy, to be achieved by 31 December 2005. Most of these exceedences were marginal, and after application of a correction factor for known diffusion tube bias, all sites were below 21ppb. However, given the uncertainty in diffusion tube measurements, exceedence cannot be ruled out, and further monitoring using more accurate automatic techniques is recommended.

By contrast, annual mean concentrations at urban and residential background sites were mostly well below 21ppb.

Ambient NO_2 concentrations at most sites have remained stable over the past three years. However, while NO_2 levels are not increasing, nor are they decreasing: the implication is that sites which currently approach or exceed the Limit Value and AQS Objective will continue to do so, unless action is taken.

SO_2 was measured at a single monitoring site, at Clos St Andre (near the Bellozanne Valley waste incinerator). The annual mean was 3.0ppb, slightly higher than the 2001 annual mean of 2.6ppb. However, concentrations remain low, and consistent with those measured by the more extensive surveys of earlier years.

Annual mean benzene concentrations were less than the UK Air Quality Strategy Objective of 5ppb (which applies to the running mean and is to be achieved by the end of 2003) at all sites, including those near petrol stations. However, the EC 2nd Daughter Directive annual mean Limit Value of 1.5ppb (which is to be achieved by 2010) was exceeded at Springfield Garage, which is located at a petrol station. Benzene concentrations at the four sites not associated with petrol stations were broadly similar to those measured at comparable sites in the UK.

Four of the hydrocarbon sites have been in operation since 1997. The six years' data from these four long-running hydrocarbon sites appear to show a decreasing trend in ambient concentrations of all the measured species except m+p xylene, which by contrast appears to be increasing at most sites.

Contents

Appendices

1 Introduction

1.1 BACKGROUND

Netcen, (an operating division of AEA Technology Environment), on behalf of the States of Jersey Public Health Services, has undertaken a further programme of air quality monitoring on the island of Jersey in 2002. This is the sixth in a series of extensive annual monitoring programmes that began in 1997.

The pollutants measured were nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and a range of hydrocarbon species (benzene, toluene, ethyl benzene and three xylene compounds), collectively termed BTEX. Average ambient concentrations were measured using passive diffusion tube samplers. NO_2 was measured at 19 sites on the island, SO_2 was measured at just one site (previous years' surveys having established that levels of SO_2 on Jersey are low), and BTEX at seven sites.

This report presents the results obtained in the 2002 survey, and compares the data from Jersey with relevant air quality Limit Values, Objectives and guidelines, data from selected UK monitoring stations and previous years' monitoring programmes.

1.2 OBJECTIVES

This survey follows on from those in the years 1997 to 2001[1,2,3,4,5]. The objective, as in the previous surveys, was to monitor at sites where pollutant concentrations were expected to be high, and compare these with background locations. The monitoring sites used were the same as those used in the 2000 and 2001 studies. These consisted of a mixture of some background sites investigated during previous studies, together with some locations where higher pollutant concentrations might be expected, such as roadside sites, or those close to specific emission sources.

2 Details of Monitoring Programme

2.1 POLLUTANTS MONITORED

2.1.1 NO_2

A mixture of nitrogen dioxide (NO_2) and nitric oxide (NO) is emitted by combustion processes. This mixture of oxides of nitrogen is termed NO_x. NO is subsequently oxidised to NO_2 in the atmosphere. NO_2 is an irritant to the respiratory system, and can affect human health. Ambient concentrations of NO_2 are likely to be highest in the most built-up areas, especially where traffic is congested, or buildings either side of the street create a "canyon" effect, impeding the dispersion of vehicle emissions. For consistency with previous years' reports, the units used for NO_2 in this report are parts per billion (ppb). To convert from ppb to microgrammes per cubic metre ($\mu g\ m^{-3}$) if required, the following relationship should be used:

1 $\mu g\ m^{-3}$ = 0.523 ppb for nitrogen dioxide at 293K (20°C) and 1013mb.

2.1.2 SO_2

Sulphur dioxide (SO_2) is formed during the combustion of fuels containing sulphur. The most significant source of this pollutant is fossil fuelled power generation, although diesel engines, domestic solid fuel burners and a number of chemical processes also produce SO_2.

SO_2 is a respiratory irritant, and is toxic at high concentrations. It is also damaging to ecosystems and a major precursor in the formation of acid rain. For consistency with previous years' reports, the units used for SO_2 in this report are parts per billion (ppb). To convert from ppb to microgrammes per cubic metre (μg m^{-3}) if required, the following relationship should be used:

1 μg m^{-3} = 0.376 ppb for sulphur dioxide at 293K (20°C) and 1013mb.

2.1.3 Hydrocarbons

There are many sources of hydrocarbon emissions. Methane, for example, is a naturally occurring gas, while xylene compounds are synthetic and used in many applications, for example as a solvent in paint. A range of hydrocarbons is found in vehicle fuel, and occur in vehicle emissions. In most urban areas, vehicle emissions would constitute the major source of hydrocarbons, in particular benzene. Also, there is the potential that they may be released to the air from facilities where fuels are stored or handled (such as petrol stations).

A wide range of hydrocarbons is emitted from both fuel storage and handling, and from fuel combustion in vehicles. It is not easy to measure all of these hydrocarbon species (particularly the most volatile) without expensive continuous monitoring systems. However, there are four moderately volatile species, all of which may be associated with fuels and vehicle emissions, which are easy to monitor using passive samplers. These are benzene, toluene, ethyl benzene and xylene. They are not the largest constituents of petrol emissions, but due to their moderate volatility they can be monitored by diffusion tubes. Diffusion tubes are available for monitoring this group of organic compounds, and are known as "BTEX" tubes.

(i) Benzene
Of the organic compounds measured in this study, benzene is the one of most concern, as it is a known human carcinogen; long-term exposure can cause leukaemia. It is found in petrol and other liquid fuels, in small concentrations. In urban areas, the major source is vehicle emissions. Benzene concentrations in ambient air are generally between 1 and 5 ppb. In this report, concentrations of benzene are expressed in parts per billion (ppb). To convert from ppb to microgrammes per cubic metre (μg m^{-3}) if necessary, the following relationship should be used:

1 μg m^{-3} = 0.307 ppb for benzene at 293K (20°C) and 1013mb.
(only applicable to benzene).

(ii) Toluene
Toluene is also found in petrol in small concentrations. Its primary use is as a solvent in paints and inks; it is also a constituent of tobacco smoke. It has been found to adversely affect human health. Typical ambient concentrations range from trace to 3.8 μg m^{-3} (1.0 ppb) in rural areas, up to 204 μg m^{-3} (54 ppb) in urban areas, and higher near industrial sources. There are no recommended limits for ambient toluene concentrations, although there are occupational limits for workplace exposure[6]: the occupational 8-hour exposure limit (OEL) is 50ppm (50,000ppb). The best estimate for the odour threshold of toluene has been reported[7] as 0.16ppm (160ppb).

(iii)ethyl benzene
Again, there are no limits for ambient concentration of ethyl benzene, although there are occupational limits relating to workplace exposure[6], of 100 ppm over 8 hours, and 125 ppm over 10 minutes. Ambient concentrations are highly unlikely to approach these levels.

(iv)xylene
Xylene exists in ortho (o), para (p) and meta (m) isomers. Occupational limits relating to workplace exposure, are 100 ppm over 8 hours, and 150 ppm over 10 minutes. Xylene, like toluene, can cause odour nuisance near processes (such as vehicle paint spraying), which emit it. Its odour threshold varies according to the isomer, but the best estimate for the odour threshold of mixed xylenes is 0.016ppm (16 ppb)[7].

2.2 AIR QUALITY LIMIT VALUES AND OBJECTIVES

2.2.1 World Health Organisation

In 2000, the World Health Organisation published revised air quality guidelines[8] for SO_2 and NO_2. These revised guidelines were set using currently available scientific evidence on the effects of air pollutants on health and vegetation. The WHO guidelines are advisory only, and do not carry any mandatory status. They are summarised in Appendix 1. There are WHO guidelines for ambient SO_2 (10-minute, 24-hour and annual means), and NO_2 (hourly and annual means) but not benzene.

2.2.2 European Community

Throughout Europe, ambient air quality is regulated by EC Directives. These set Limit Values, which are mandatory, and other requirements for the protection of human health and ecosystems. EC Daughter Directives covering SO_2, NO_2 and benzene [9,10] have been published in recent years. The Limit Values are summarised in Appendix 1.

2.2.3 UK Air Quality Strategy

The UK Air Quality Strategy (AQS) contains standards and objectives for a range of pollutants including SO_2, NO_2 and benzene[11]. These are also summarised in Appendix 1. Only those Objectives relating to the whole UK (as opposed to England, Wales, etc.) are applicable to Jersey, and the AQS does not at present have mandatory status in the States of Jersey.

2.3 METHODOLOGIES

The survey was carried out using diffusion tubes for SO_2, NO_2 and BTEX. These are "passive" samplers, i.e. they work by absorbing the pollutants direct from the surrounding air and need no power supply.

Diffusion tubes for SO_2 and NO_2 consist of a small plastic tube, approximately 7 cm long. During sampling, one end is "open" (or covered by a thin membrane in the case of SO_2) and the other closed. The closed end contains an absorbent for the gaseous species to be monitored, in this case SO_2 or NO_2. The tube is mounted vertically with the open (or membrane) end at the bottom. Ambient SO_2 or NO_2 diffuses up the tube during exposure, and is absorbed as sulphate or nitrite respectively. The average ambient pollutant concentration for the exposure period is calculated from the amount of pollutant absorbed.

BTEX diffusion tubes are different in appearance to SO_2 and NO_2 tubes. They are longer, thinner, and made of metal rather than plastic. These tubes are fitted at both ends with brass Swagelok fittings. A separate "diffusion cap" is supplied. Immediately before exposure, the Swagelok end fitting is replaced with the diffusion cap. The cap is removed after exposure, and is replaced with the Swagelok fitting. BTEX diffusion tubes are very sensitive to interference by solvents.

Diffusion tubes were prepared by Harwell Scientifics Ltd for AEA Technology, and supplied to local Technical Officers of Jersey's Public Health Services, who carried out the tube changing. The tubes were supplied in sealed condition prior to exposure. The tubes were exposed at the sites for a period of time. After exposure, the tubes were again sealed and returned to Harwell Scientifics for analysis. In this study, SO_2, NO_2 and BTEX tubes were exposed in 4- or 5- weekly batches, corresponding to the calendar of exposure periods used in the UK NO_2 Network.

The diffusion tube methodologies provide data that are accurate to $\pm$ 20% for SO_2, $\pm$ 25% for NO_2, and $\pm$ 20% for BTEX. The limits of detection are 0.4 ppb for SO_2, 0.2 ppb for NO_2 and 0.1 ppb for BTEX. It should be noted that tube results that are less than 10 x the limit of detection will have a higher level of uncertainty associated with them.

The Local Air Quality Management Technical Guidance LAQM.TG(03)[12] states that when using diffusion tubes for indicative NO_2 monitoring, correction should be made where applicable for any systematic bias (i.e. over-read or under-read compared to the automatic chemiluminescent technique, which is the reference method for NO_2). Harwell Scientifics state that their diffusion tubes typically exhibit a positive bias, and have provided a correction factor of 0.78. (This applies only to NO_2 diffusion tubes, not SO_2 or BTEX tubes). ***The NO_2 diffusion tube results in this report are uncorrected except where clearly specified.***

2.4 MONITORING SITES

Monitoring of NO_2 was started in 1999 with just 3 sites. During 2000, this was expanded to the present total of 19 sites. These same sites were used in 2002, and are shown in Table 1 and Figure 1.

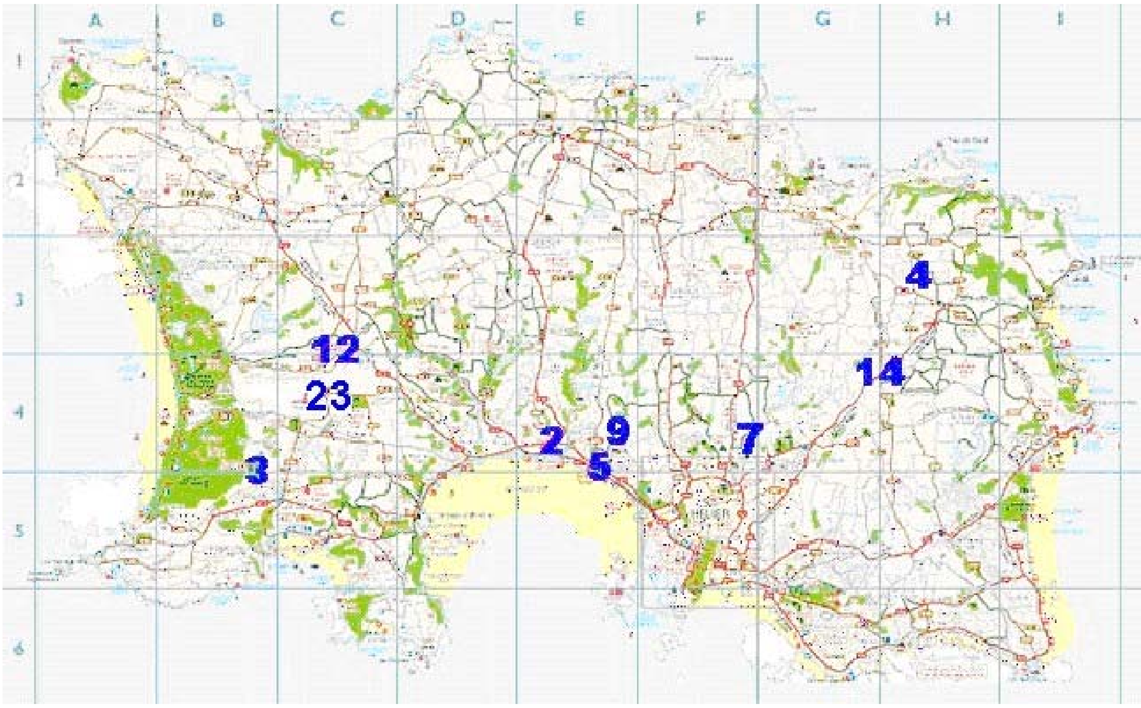
Table 1. NO_2 Monitoring Sites

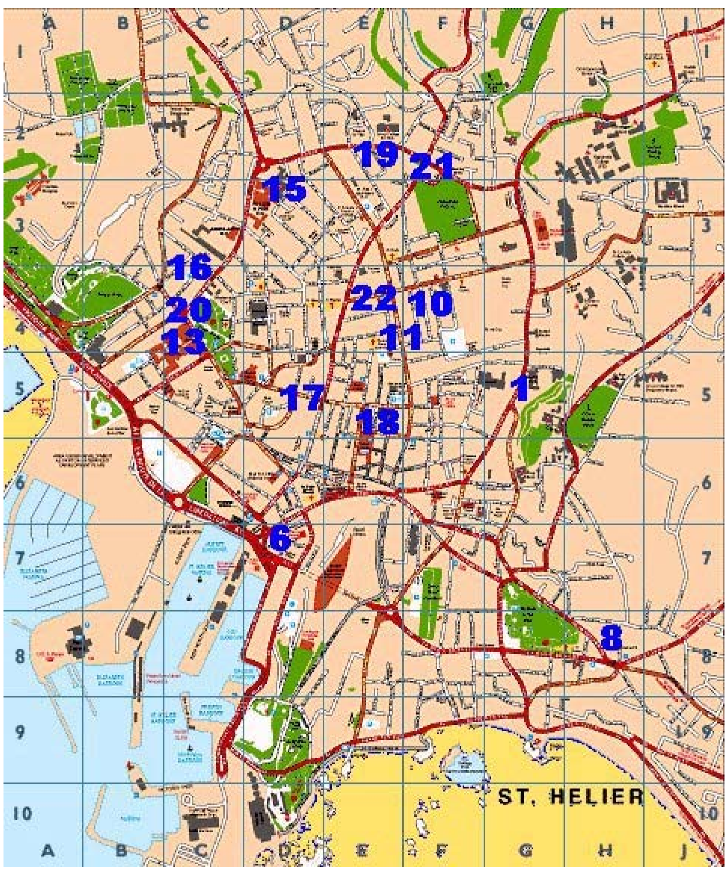
Site number	Site Name	Grid Reference	Description
N1	Le Bas Centre	658 489	Urban Background
N2	Mont Felard	629 501	Residential background, to SW of waste incinerator and 20m from busy road
N3	Les Quennevais	579 496	Residential Background
N4	Rue des Raisies	689 529	Rural Background
N5	First Tower	636 497	Kerbside on major road
N6	Weighbridge	651 483	Roadside at bus station near centre of St Helier
N7	Langley Park	660 501	Residential background
N8	Georgetown	661480	Kerbside on major road
N9	Clos St Andre	638 499	Residential area near Bellozanne Valley refuse Incinerator. Background
N10	L'Avenue et Dolmen	656 490	Urban background close to ring road
N11	Robin Place	656 489	Urban background
N12	Beaumont	597 516	Kerbside
N13	The Parade *	648 489	Roadside site at General Hospital
N14	Maufant	683 512	Background site in Maufant village
N15	Jane Sandeman	652 494	Urban background on housing estate
N16	Saville Street	648 492	Background
N17	Broad Street	652 486	Urban background
N18	Beresford Street	653 486	Urban background
N19	La Pouquelaye	654 496	Kerbside on St Helier ring road.

*The Parade site was moved to its current roadside location at the end of 2000.

Kerbside: less than 1m from kerb of a busy road.
Roadside: 1-5m from kerb of a busy road.
Background: > 50m from the kerb of any major road.

Note: all grid references are from OS 1:25000 Leisure Map of Jersey and are given to the nearest 100m.





Key:

1. Le Bas Centre
2. Mont Felard
3. Les Quennevais
4. Rue Des Raisies
5. First Tower
6. Weighbridge
7. Langley Park
8. Georgetown
9. Clos St Andre
10. L'Avenue et Dolmen
11. Robin Place
12. Beaumont
13. The Parade
14. Maufant
15. Jane Sandeman
16. Saville Street
17. Broad Street
18. Beresford Street
19. La Pouquelaye
20. Elizabeth Lane
21. Springfield Garage
22. Stopford Road
23. Airport

Figure 1. Site Locations

SO_2 monitoring has been carried out at just one site since 2000. Results from 1999 and earlier years, based on a total of 13 sites, indicated that SO_2 levels in Jersey were not likely to be high enough to constitute a problem. The single site at Clos St Andre was retained because it is in a residential area near the Bellozanne Valley waste incinerator (a potential source of SO_2).

Table 2. SO_2 Monitoring site

Site number	Site Name	Grid Reference	Description
S13	Clos St Andre	638 499	Residential area near Bellozanne Valley refuse incinerator.

BTEX hydrocarbons were monitored at a total of seven sites during 2002. Six of these were those used in 2001; these are shown in Table 3. The aim was to investigate sites likely to be affected by different emission sources, and compare these with background sites. The sites at Beresford Street and Le Bas Centre are intended to monitor hydrocarbon concentrations at an urban roadside and urban background location respectively. The Elizabeth Lane site is close to a paint spraying process, and the Springfield Garage site is located by a fuel filling station, both possible sources of hydrocarbon emissions. The Stopford Road site is located at a house between two petrol stations. (During the 1999 survey, this site was actually located inside the house to investigate reports of odours by residents; it was moved outdoors for the 2001 and 2002 studies). The Clos St Andre site is located near the Bellozanne Valley waste incinerator.

At the end of May 2002, monitoring ceased at the Stopford Road site, which was replaced by a new site at the Airport.

Table 3. BTEX Monitoring sites

Site number	Site Name	Grid Reference	Description
BTEX 1	Beresford Street	653 486	Urban Roadside
BTEX 2	Le Bas Centre	658 489	Urban Background
BTEX 3	Elizabeth Lane	648 491	Urban background near paint spraying process
BTEX 4	Springfield Garage	656 495	Urban background near fuel filling station
BTEX 6	Stopford Road (outdoors)	655 491	Outdoor urban background site, at house between two petrol stations.
BTEX 7	Clos St Andre	638 499	Residential area near Bellozanne Valley refuse incinerator.
BTEX 8	Airport	587 509	Jersey Airport, overlooking airfield

3 Results and Discussion

3.1 NITROGEN DIOXIDE

3.1.1 Summary of NO_2 Results

NO_2 diffusion tube results are presented in Table 4, and Figures 2 (kerbside and roadside sites) and 3 (background sites). Individual monthly mean NO_2 results ranged from 1.9ppb (in June at the rural Rue des Raisies site), to 32.1 ppb, (in October at the kerbside Weighbridge site, located in a bus station). Annual mean NO_2 concentrations ranged from 4.0 ppb (at Rue des Raisies) to 25.0ppb at Weighbridge.

3.1.2 Comparison with NO_2 Guidelines, Limit Values, and Objectives

Limit Values, AQS Objectives and WHO guidelines for NO_2 are shown in Appendix 1. These are based on the hourly and annual means. Because of the long sampling period of diffusion tubes, it is only possible to compare the results from this study against limits relating to the annual mean.

The WHO non-mandatory guideline[8] for NO_2 is that the annual mean should not exceed 21 ppb. The EC 1st Daughter Directive[9] contains Limit Values for NO_2 as follows:

- 105 ppb (200 $\mu g\ m^{-3}$) as an hourly mean, not to be exceeded more than 18 times per calendar year. To be achieved by 1 January 2010.
- 21 ppb (40 $\mu g\ m^{-3}$) as an annual mean, for protection of human health. To be achieved by 1 January 2010.
- There is also a limit for annual mean total oxides of nitrogen (NO_x), of 16 ppb (30 $\mu g\ m^{-3}$), for protection of vegetation (relevant in rural areas).

The UK Air Quality Strategy contains Objectives for NO_2, which are very similar to the EC Daughter Directive limits above: the only differences being the more stringent dates by which they must be attained (31 December 2005).

Annual mean NO_2 at six of the seven kerbside and roadside sites exceeded 21ppb; First Tower, Weighbridge, Georgetown, Beaumont, Broad Street and La Pouquelaye. In three of these cases, the annual mean was less than 22ppb. The seventh kerbside site, La Pouquelaye, had an annual mean NO_2 concentration greater than 19ppb, and was therefore very close to the EC Limit Value and AQS Objective.

As discussed in Section 2.3, Harwell Scientifics' NO_2 diffusion tubes typically overestimate NO_2 concentration. Harwell Scientifics have quantified this overestimation, by a series of field tests in 2002, and provided a bias correction factor of 0.78, to be applied to the annual mean NO_2 concentration. Applying this factor reduces the annual means at all sites to below the AQS Objective of 21ppb. The highest annual mean (at Weighbridge) is reduced from 26ppb (uncorrected) to 20ppb (bias corrected). However, given the uncertainty on diffusion tube measurements, it remains likely that some roadside and kerbside sites are currently "borderline" with respect to the Limit Value and AQS Objective for annual mean NO_2.

By contrast, the annual mean NO_2 concentrations at the 12 background sites were in most cases well below 21ppb. The 16ppb limit for protection of vegetation is only applicable at the one rural background site, Rue des Raisies, where the annual mean NO_2 concentration at this site was well within the limit.

Table 4. NO_2 Diffusion Tube Results 2002, Jersey. Concentrations in ppb.

Site / From - To:	3 Jan - 31 Jan 02	31 Jan - 26 Feb	26 Feb – 3 Apr	3 Apr - 30 Apr	30 Apr – 6 Jun	6 Jun - 3 Jul	3 Jul - 31 Jul	31 Jul - 4 Sep	4 Sep - 2 Oct	2 Oct - 30 Oct	30 Oct - 3 Dec	3 Dec 02 - 3 Jan 03	Average
Le Bas Centre	18.7	18.0	17.4	14.5	14.5	14.5	13.7	15.1	14.2	19.2	19.4	16.5	16.3
Mont Felard	13.7	12.8	14.8	12.6	12.0	10.9	12.1	14.5	12.3			16.6	13.2
Les Quennevais	6.8	4.5	5.8	5.3	3.3	2.4	4.4	6.1	7.5	6.2	5.1	9.3	5.6
Rue Des Raisies	5.1	4.6	4.3	2.8	2.3	1.9	2.6	3.8	3.8	4.7	4.2	7.4	4.0
First Tower	25.1	19.3	24.4	19.8	17.5	19.0	20.9	21.6	20.3	24.1	19.6	21.5	21.1
Weighbridge	29.6	28.5	27.6	25.4	21.7	30.0	26.9	24.1	10.1	32.1	21.0	23.1	25.0
Langley Park	14.3	13.1	11.9	8.7	6.8	7.0	8.1	6.8	9.8	11.4	11.8	13.4	10.3
Georgetown	23.0	19.4	24.5	23.3	17.9	17.0	18.4	21.5	21.8	24.0	23.1	26.2	21.7
Clos St.Andre	10.3	10.3	8.7	7.0	6.0	6.2	5.7	6.1	9.8	6.7	12.1	10.2	8.3
L'Avenue et Dolmen	15.3	15.1	13.4	10.8	9.1	6.2	10.0	8.8	2.8	14.8	14.4	14.9	11.3
Robin Place	20.6	19.2	16.1	14.1	12.1	12.6	13.4	13.2	15.5	18.6	17.6	17.8	15.9
Beaumont	22.2	20.1		22.6	19.7	19.5	21.1	25.3	21.9	22.3	22.0	23.2	21.8
The Parade	19.2	18.8	19.9	17.6	14.7	17.6	19.1	20.4	19.4	22.7	21.4	22.0	19.4
Maufant	6.8	6.3	5.4	4.9	3.4	3.2	4.0	4.9	4.1	6.0	4.9	8.1	5.2
Jane Sandeman	13.1	10.7	10.1	8.2	6.2	6.1	7.0	7.3	7.5	10.5	8.8	11.9	9.0
Saville Street	17.2	14.1	15.7	4.5	13.5			15.5		19.3	16.4	16.3	14.7
Broad Street	25.3	25.4	23.3	21.8	21.7	21.7	21.8	22.8	22.4	23.3	23.5	22.0	22.9
Beresford Street	20.1	20.3	20.1	16.2	16.6	15.2	15.7	16.9	14.9	22.0	21.0	19.1	18.2
La Pouquelaye	27.1	24.1	26.7	23.8	20.2	21.8	22.3	22.8	25.5	29.1	25.9	23.7	24.4

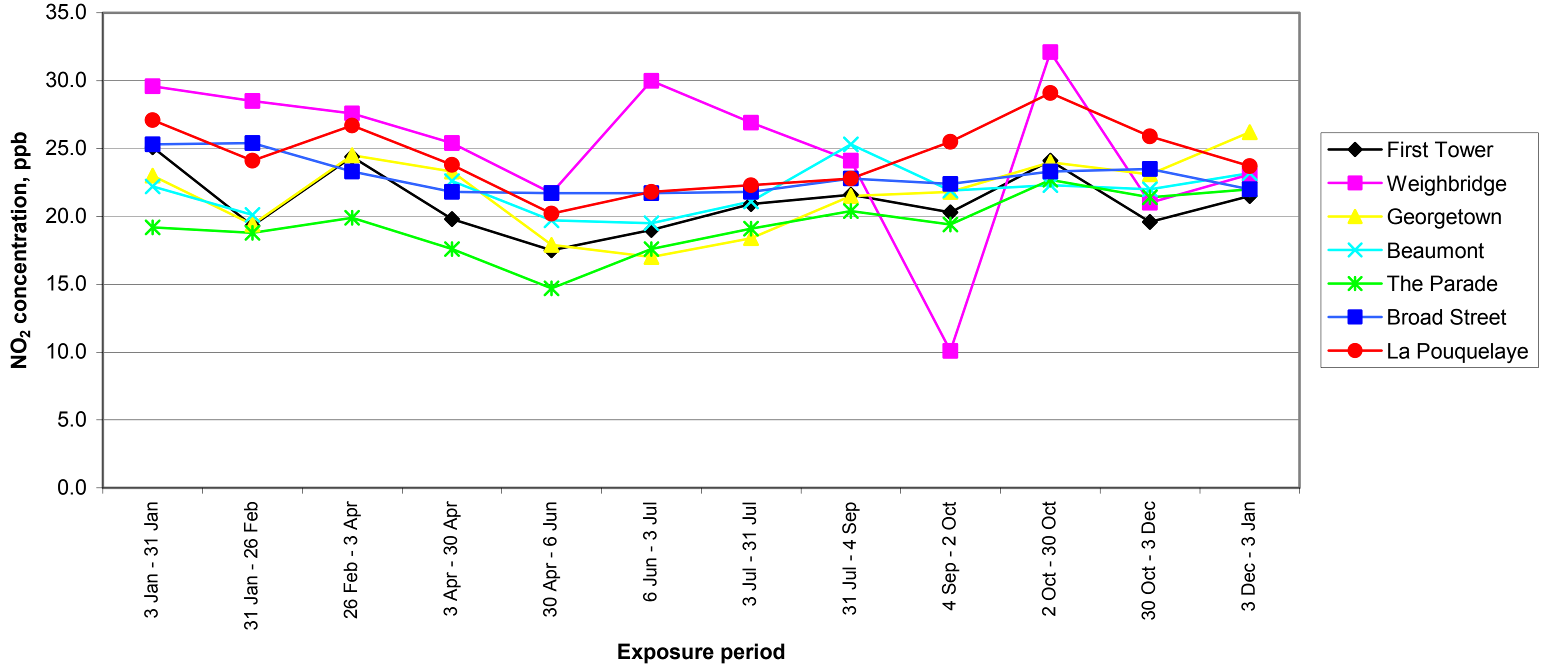


Figure 2. Monthly Mean Nitrogen Dioxide Concentrations at Roadside and Kerbside Sites, 2002

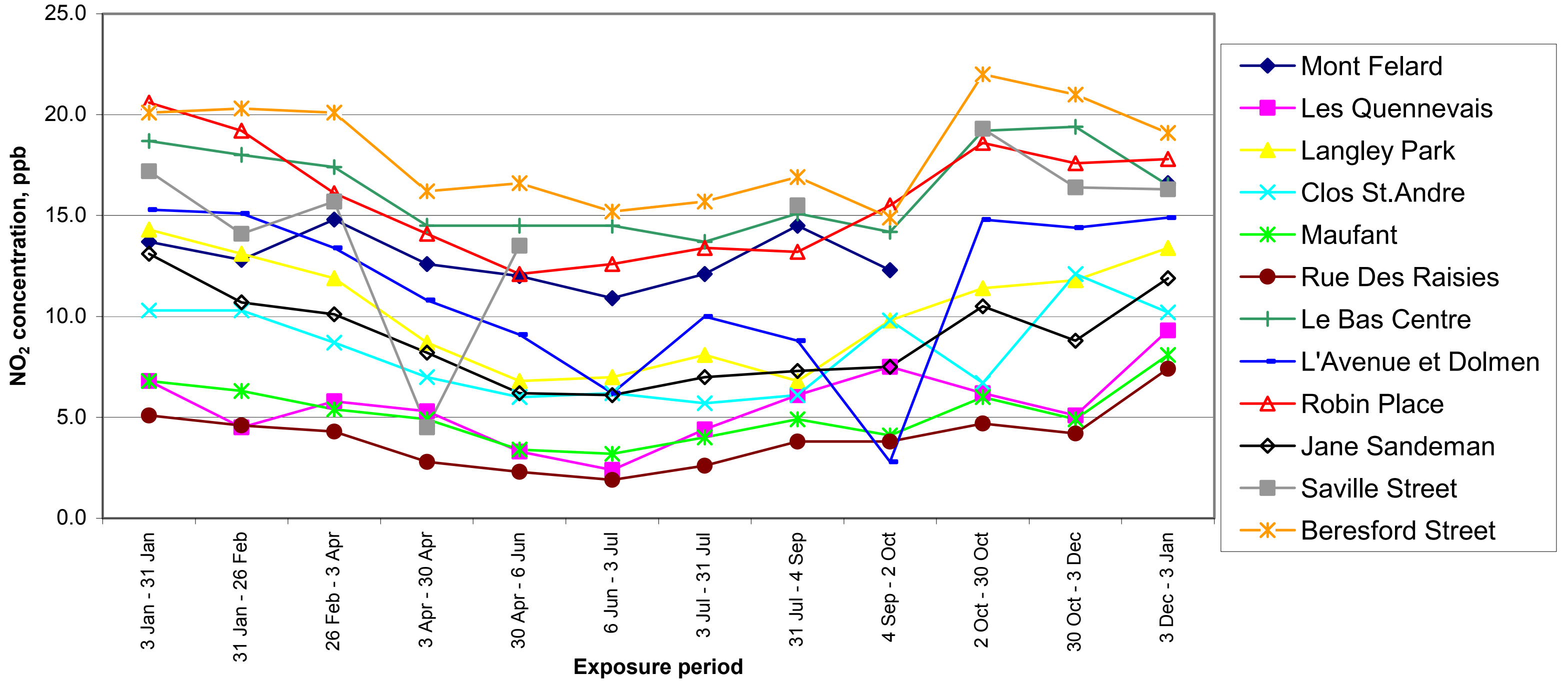


Figure 3. Monthly Nitrogen Dioxide concentrations at Background Sites, 2002

As well as having typically lower NO_2 concentrations, the urban background sites show slightly more seasonal variation than the roadside sites. This is likely to reflect the fact that the background sites are more affected by sources such as domestic heating, which increase during the winter. By contrast, NO_2 concentrations at the roadside sites are dominated by traffic emissions, which do not generally increase during winter.

3.1.3 Comparison with UK NO_2 data

The UK Nitrogen Dioxide Survey monitored this pollutant at around 1220 sites across the UK during 2002, using diffusion tubes. This survey concentrates on urban, not rural, areas. Sites are categorised as;

- Roadside, 1-5m from the kerb of a busy road
- Urban background, more than 50m from any busy road and typically in a residential area.

The national annual averages for 2002 are provisional at present, pending full data ratification. Estimated UK NO_2 Network averages for 2002 were 20 ppb for roadside sites and 11 ppb for urban background sites. These are consistent with the 200 averages for Jersey; 22 ppb for kerbside and roadside sites and 11 ppb for background sites.

Table 5 shows annual mean NO_2 concentrations measured at a selection of UK air quality monitoring stations using automatic (chemiluminescent) NO_2 analysers. The automatic data have been fully ratified. The sites used for comparison are as follows:

- Exeter Roadside – a roadside site in the centre of Exeter, Devon.
- Plymouth Centre - an urban non-roadside site, in the centre of a coastal city.
- Lullington Heath - a rural site on the South Coast of England near the town of Eastbourne.
- Harwell - a rural site in the south of England, within 10km of a power station.

Table 5 - Comparison of NO_2 in Jersey with UK Automatic Sites

Site	2002 Annual average NO_2, ppb
Exeter Roadside	20
Plymouth Centre	14
Lullington Heath	6
Harwell	8

The annual mean NO_2 concentrations measured at the kerbside and roadside sites in Jersey ranged from 19ppb to 25ppb. The annual mean at Exeter Roadside was therefore comparable with these. The Jersey urban background sites had annual mean NO_2 concentrations ranging from 9ppb to 18ppb, thus consistent with sites such as Plymouth Centre. Residential background sites well outside Jersey's larger towns (e.g. Les Quennevais, Clos St Andre, Maufant) had annual mean NO_2 ranging from 3.2ppb to 11ppb, and thus were more comparable with rural sites such as Lullington Heath and Harwell. The annual mean of 1.9ppb at the Jersey rural background site, Rue des Raisies, was considerably lower than that measured at either Harwell or Lullington Heath.

3.1.4 Comparison with Previous Years' Nitrogen Dioxide Results

Most of the sites have been operating for only three years, which is not long enough to identify trends. However, very little change has been observed at most of these sites over the past three years. 2002 annual mean concentrations at 13 of the 19 sites were within $\pm$ 1ppb of those measured during 2001, with no consistent pattern of increase or decrease. Of the other six sites, two increased and three decreased. This is similar to the pattern observed last year: very little change was apparent. Thus, it appears that those kerbside and roadside sites currently exceeding the Limit Value and Objective for the annual mean are likely to continue to do so, unless action is taken.

There are four sites that have been in operation since 1993, forming part of the UK Nitrogen Dioxide Network. Annual mean concentrations for these long-running sites are shown in Table 6 and Figure 4. These data show that NO_2 concentrations have remained relatively stable over the period, with a small decrease since the mid-1990s. The Beaumont site showed consistent increases between 1998 and 2001; however, the mean for 2002 at this site was lower.

Table 6 Annual mean NO_2 concentrations at Long-Term Sites

Site	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Beaumont (Kerbside)	-	23	25	24	No data	20	21	23	24	22
The Parade (Intermediate*)	16	16	16	16	No data	13	14	13	Site moved	-
Jane Sandeman (Background)	11	10	11	11	No data	9	9	8	9	9
Maufant (Background)	9	8	7	6	No data	5	6	5	5	5

**Intermediate sites were discontinued at the end of 2000. This site was replaced by a Roadside site, also at the Parade.*

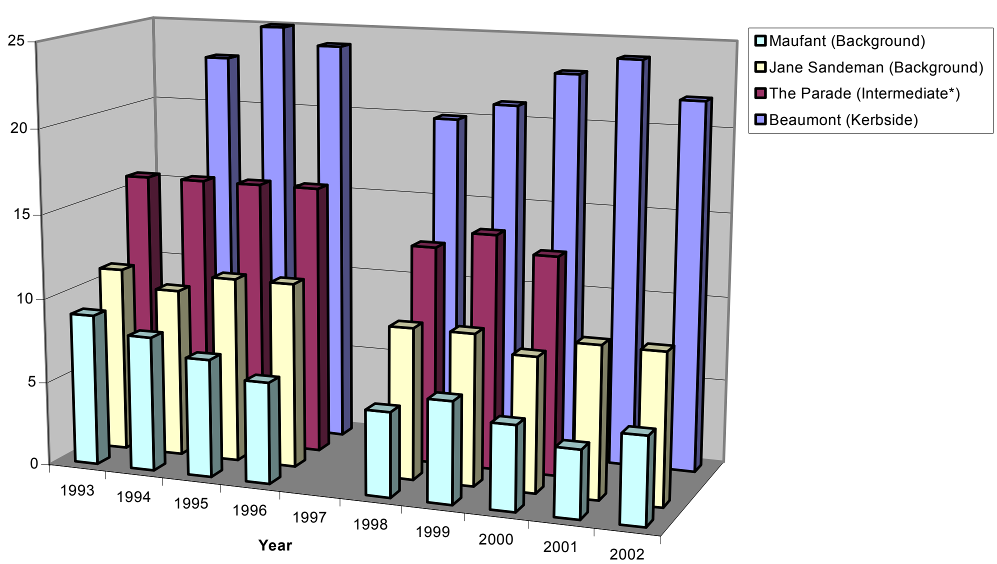


Figure 4. Trends in Annual Mean NO_2 Concentrations at Four Long-Term Sites

3.2 SULPHUR DIOXIDE

3.2.1 Summary of SO_2 Results

As from 2000, SO_2 monitoring has been carried out at single site, Clos St Andre. Previous year's monitoring had established that concentrations on Jersey are generally low. The monthly results for SO_2 at this site are shown in Table 7.

Ambient SO_2 concentrations at Clos St Andre were low during 2002: less than 3ppb during all but three months. The highest individual result was 11.2ppb (measured in October). This result is unusually high. Occasionally, spurious high results can be caused by damage to the membrane at the end of the diffusion tube, which allows particulate phase sulphate to enter the tube during exposure. However, the analyst did not find evidence of this, so this result must be treated as genuine.

The annual mean SO_2 concentration at Clos St Andre was 3.0ppb –slightly higher than the 2001 annual mean of 2.6ppb, but still low. The unusually high result for October is largely responsible for this apparent increase; if this result is rejected the annual mean is 2.2ppb.

3.2.2 Comparison with SO_2 Guidelines, Limit Values and Objectives

The guidelines, EC Limit Values and AQS objectives for SO_2 are presented in Appendix 1. However, most of the limits for SO_2 that relate to human health are based on short averaging periods, such as 15-minute, 1-hour or 24-hour means. Thus, diffusion tube data, based on much longer sampling periods, is not directly comparable with these. It is only possible to compare diffusion tube results with limits relating to longer periods, such as the annual mean.

The WHO has set a guideline of 17ppb for the annual mean. The 2001 annual mean SO_2 result for Clos St Andre was well within this value.

EC Directive 1999/30/EEC[9] (the first Daughter Directive) contains Limit Values for protection of human health, but these are based on the 1-hour and 24-hour mean. However, there is also a Limit Value of 8ppb for the annual (calendar year) and winter (October to March) mean SO_2 concentration, for the protection of ecosystems. This is only applicable in rural areas, and therefore strictly does not apply to Clos St Andre. However, the annual mean of 3.0ppb was well below this limit.

The UK Air Quality Strategy contains Objectives for SO_2 similar to those contained in the EC Directive above. Those set for protection of human health are based on the 15-minute, 1-hour and 24-hour means. There is also a limit of 8ppb for the annual (calendar year) and winter (October to March) mean SO_2 concentration, for the protection of ecosystems. Again, this is only applicable in rural areas but the Clos St Andre annual mean was well within this limit.

Table 7. SO_2 Diffusion Tube Results 2002, Jersey. Concentrations in ppb.

Site	From - To:	3 Jan - 31 Jan	31 Jan - 26 Feb	26 Feb - 3 Apr	3 Apr - 30 Apr	30 Apr - 6 Jun	6 Jun - 3 Jul	3 Jul - 31 Jul	31 Jul - 4 Sep	4 Sep - 2 Oct	2 Oct - 30 Oct	30 Oct - 3 Dec	3 Dec - 3 Jan	Average
Clos St.Andre		2.6	1.6	3.1	2.8	1.8	1.1	1.8	1.9	5.2	11.2	0.5	2.1	**3.0**

3.2.3 Comparison with UK SO_2 Data

Table 8 shows how the 2002 SO_2 data from Clos St Andre compares with a selection of UK air quality monitoring stations using automatic (UV fluorescence) SO_2 analysers. The automatic sites used for comparison are the same as used in the case of NO_2; the descriptions are given in section 3.1.3.

Table 8. Comparison of SO_2 at Clos St Andre with UK Sites

Site	Annual average SO_2, ppb
Diffusion Tubes	
Clos St Andre	3.0
UK Automatic Sites *(reported to nearest ppb)*	
Exeter Roadside	1
Plymouth Centre	2
Lullington Heath	1
Harwell	1

The annual mean SO_2 concentration at Clos St Andre this year is slightly higher than that measured at the Plymouth Centre urban site, and roadside or rural sites in the UK. However, as mentioned in Section 3.2.2, the Clos St Andre dataset for 2002 contained one uncharacteristically high measurement in October, which increased the average.

3.2.4 Comparison with Previous Years' SO_2 Results

The 2001 annual mean of 3.0ppb was consistent with the annual means measured in 2001 (2.6ppb), 2000 (2.2ppb), and 1999 (2.7ppb), at this site. It is slightly higher: the increase is not large and would only be a cause for concern if future year's monitoring indicates it is continuing to increase. Again, the apparent increase is largely due to the unusually high monthly average measured in October 2002.

3.3 HYDROCARBONS

3.3.1 Summary of Hydrocarbon Results

Results of the hydrocarbon survey for the seven sites are shown in Appendix 2, Tables A2.1 to A2.7 respectively. Graphical representations are shown in Figures 5 to 11.

The diffusion tube results show that average outdoor hydrocarbon concentrations in Jersey remain generally low. A summary of annual average hydrocarbon concentrations is shown in Table 9.

Table 9. Summary of Average Hydrocarbon Concentrations, Jersey, 2002

Site	Benzene, ppb	Toluene, ppb	Ethyl Benzene, ppb	m+p Xylene, ppb	o Xylene, ppb
Beresford Street	0.8	3.4	0.6	1.8	0.7
Le Bas Centre	0.6	2.1	0.4	1.3	0.5
Elizabeth Lane *(near paint spraying)*	0.5	2.9	0.5	1.4	0.4
Springfield Garage *(petrol station)*	1.7	9.6	1.4	4.3	1.6
Stopford Road *(petrol stations) Jan-May only*	1.1	6.8	1.2	3.8	1.4
Clos St Andre	0.3	0.7 *	0.2	0.5	0.2
Airport *(Jun-Dec only)*	0.3	0.4	0.1	0.2	0.1

**One outlying value rejected: July 2002.*

Highest average concentrations of benzene were found at Springfield Garage, followed by Stopford Road, as in previous years. However, average benzene concentrations were low - less than 3ppb at all sites. Springfield Garage showed some reduction compared with its 2001 mean benzene concentration of 2.1ppb.

Toluene concentrations were mostly less than 5ppb except at Springfield Garage, where monthly average concentrations ranged from 4.1ppb to 17ppb. At Clos St Andre, all monthly average toluene concentrations were less than 1ppb, with the exception of one unusually high value (21ppb) during July 2002. There was no obvious reason why such a high concentration should have occurred; it was suspected that the tube in question had become contaminated, and the result was therefore rejected.

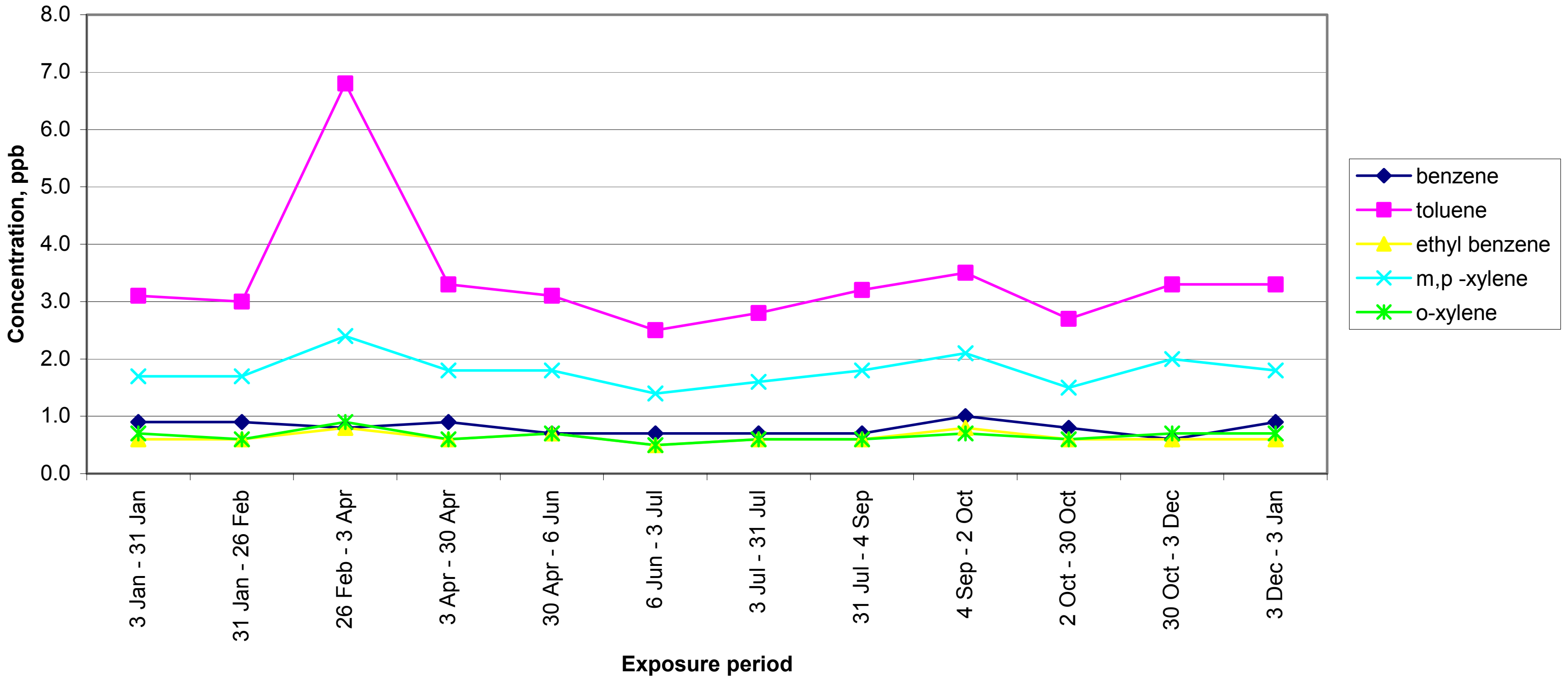


Figure 5. Monthly mean hydrocarbon concentrations at Beresford Street, 2002

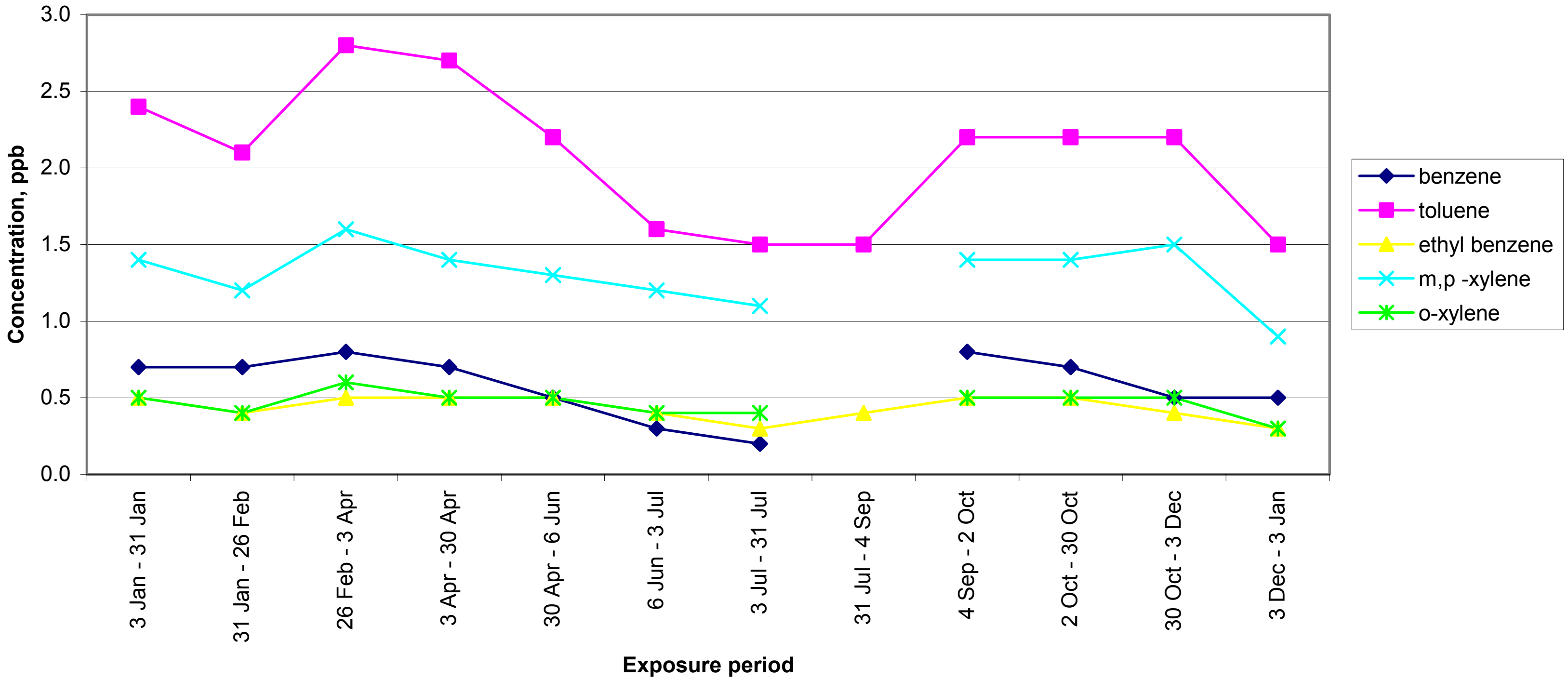


Figure 6. Monthly mean hydrocarbon concentrations at Le Bas Centre, 2002

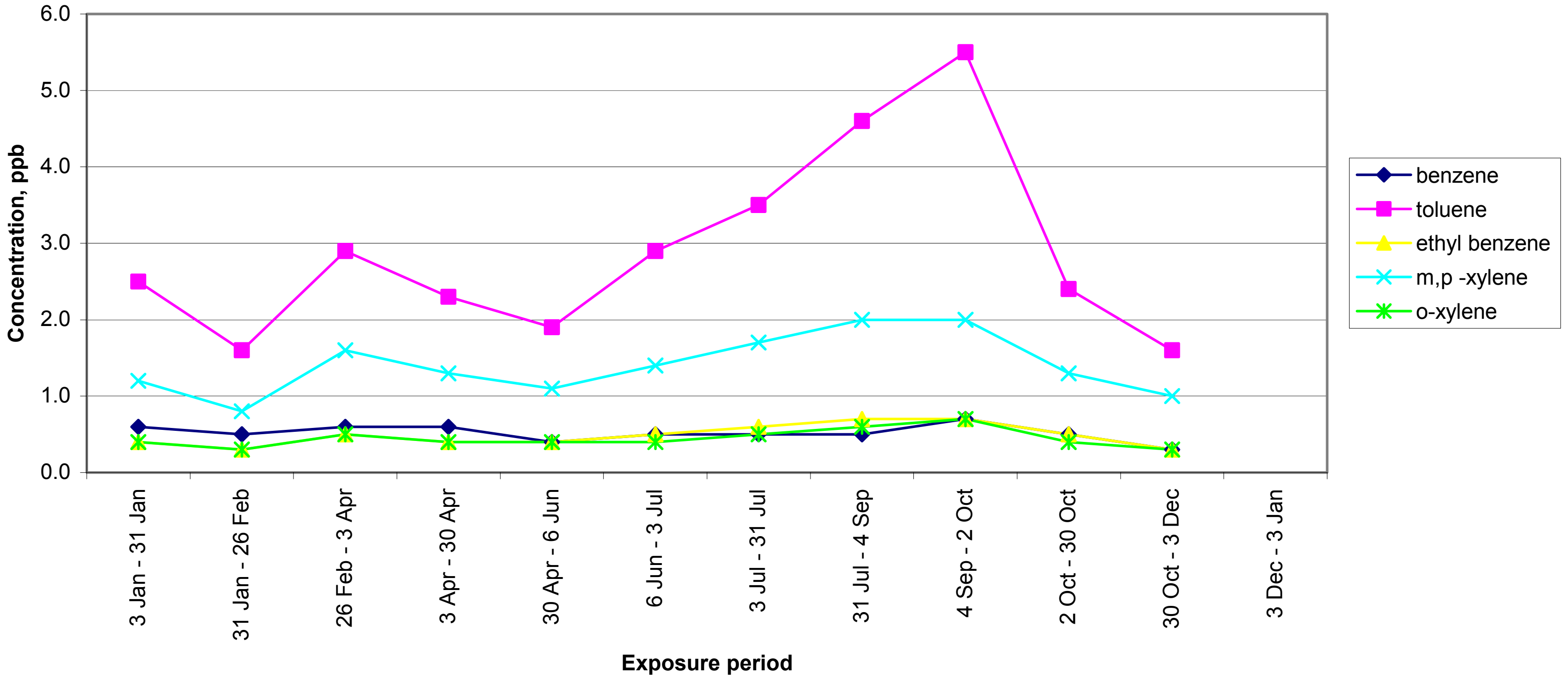


Figure 7. Monthly mean hydrocarbon concentrations at Elizabeth Lane, 2002

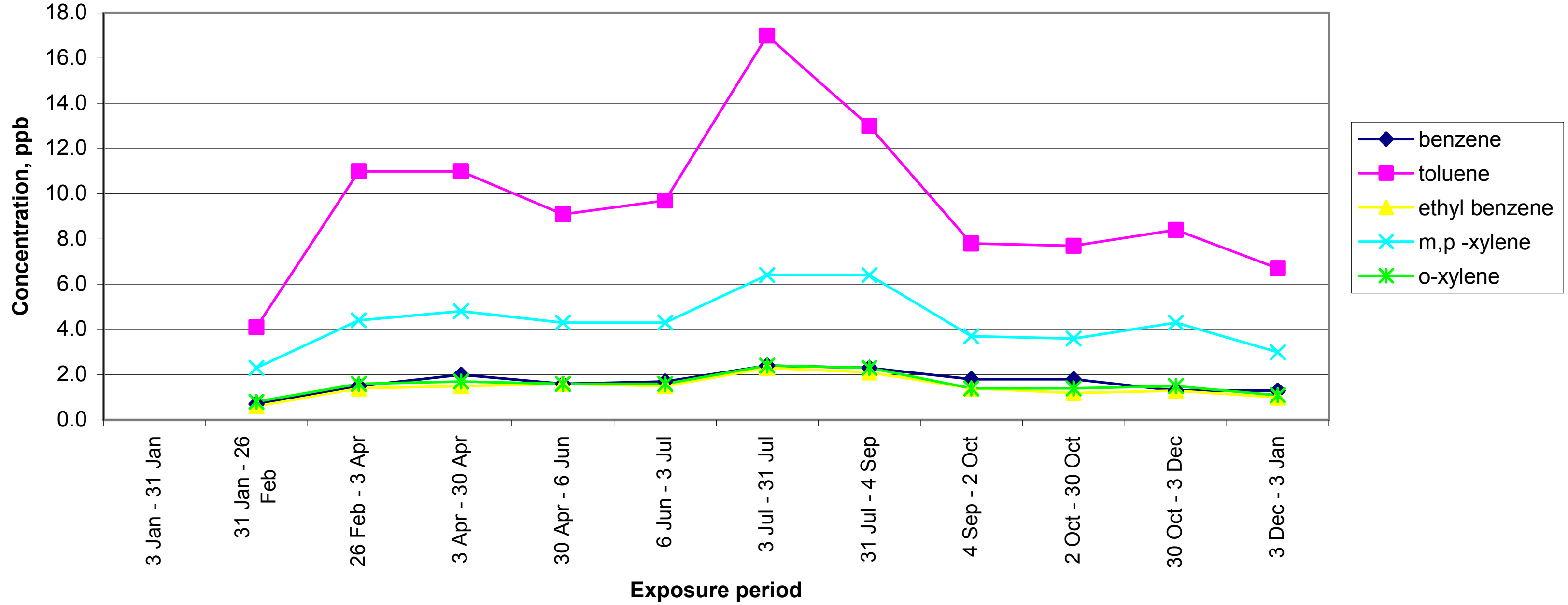


Figure 8. Monthly mean hydrocarbon concentrations at Springfield Garage, 2002

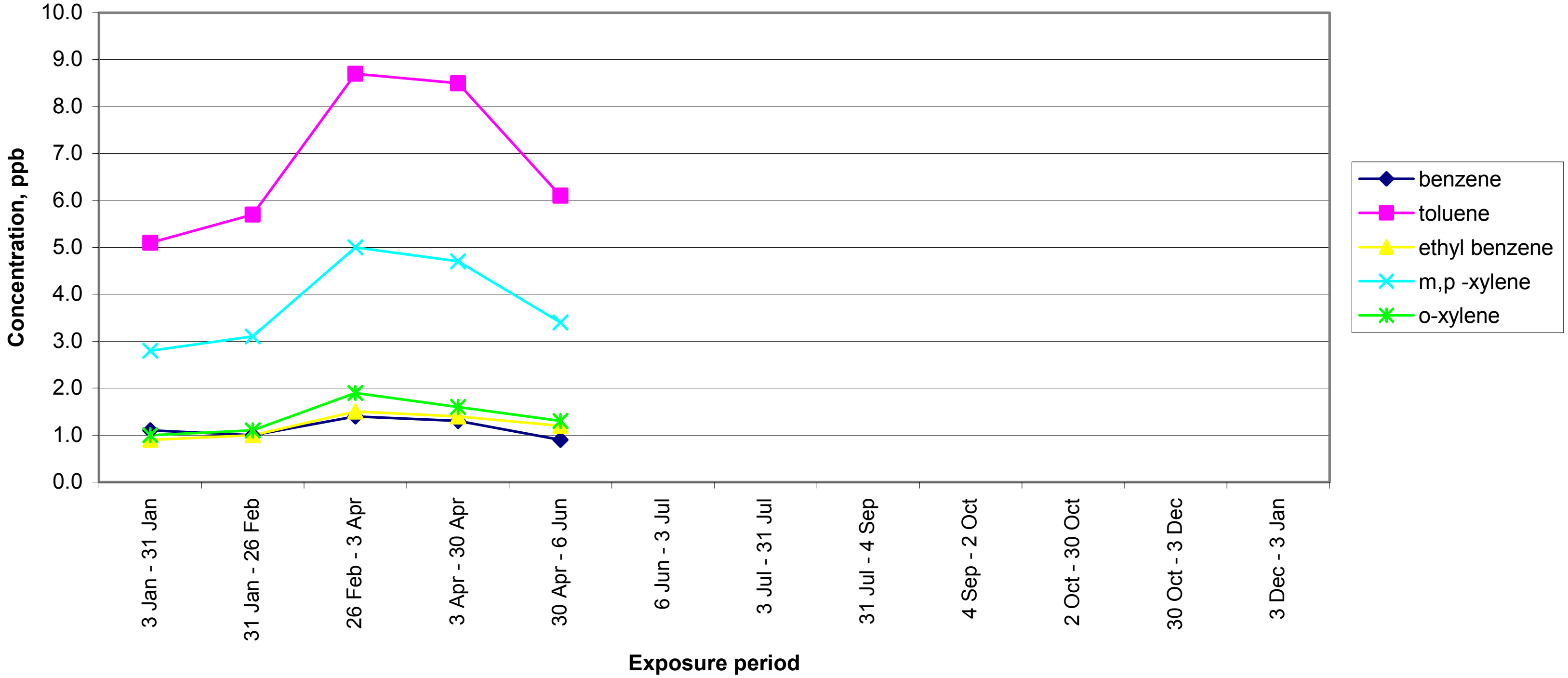


Figure 9. Monthly mean hydrocarbon concentrations at Stopford Road, 2002

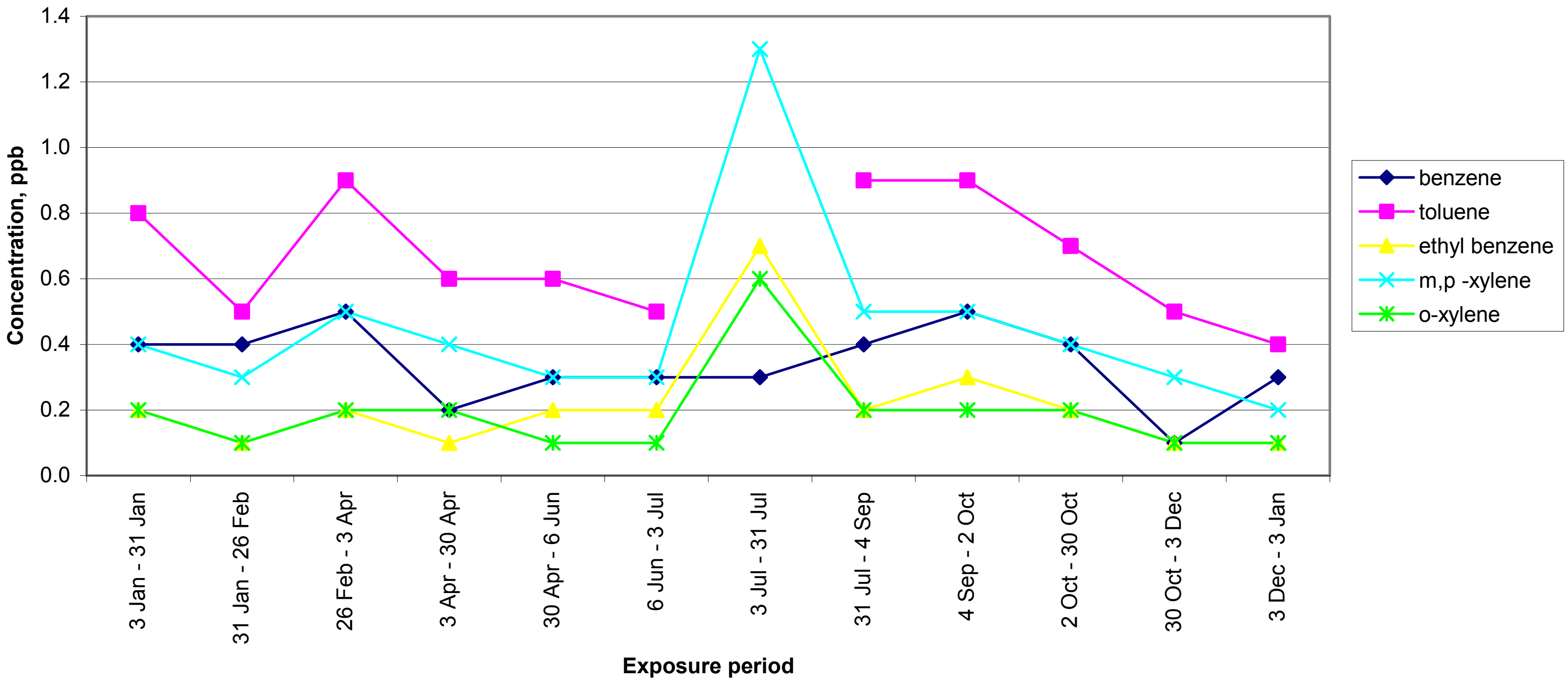


Figure 10. Monthly mean hydrocarbon concentrations at Clos St Andre, 2002

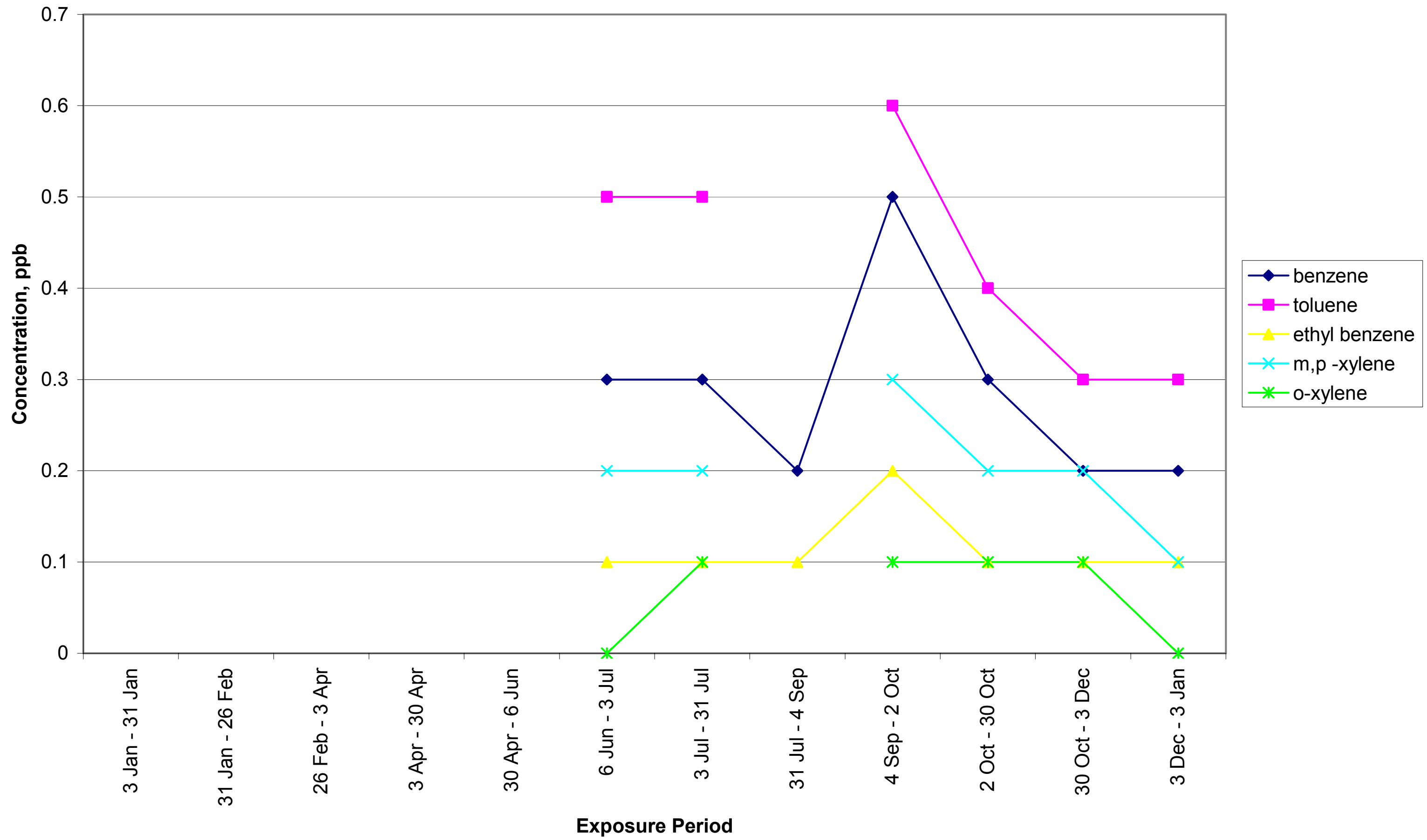


Figure 11. Monthly mean hydrocarbon concentrations at the Airport, 2002

3.3.2 Comparison with Hydrocarbon Guidelines, Limit Values and Objectives

Of the hydrocarbon species monitored, only benzene is the subject of any applicable air quality standards. The UK Air Quality Strategy sets an objective for the running annual mean of 5ppb, to be achieved by 31 December 2003, and applicable to the whole UK. (Tighter standards apply to England, Wales and Scotland). The annual mean benzene concentration (which can be considered a good indicator of the running annual mean) did not exceed 5ppb at any of the Jersey sites.

The EC 2nd Daughter Directive[10] sets a limit of 5μg m^{-3} (1.5ppb) to be achieved by 2010. This Limit Value was exceeded at Springfield Garage (a petrol station), where the annual mean benzene concentration was 1.7ppb. Monitoring was carried out for 5 months only at Stopford Road, before the site was re-located to Jersey Airport. However, the 5-month mean of 1.1ppb is sufficiently close to the Limit Value that exceedence at this site cannot be ruled out. At the new monitoring, Jersey Airport, monitoring was carried out from June to December 2002. The average of 0.3ppb for this period was well below the Limit Value.

3.3.3 Comparison with UK Data

Table 10 compares hydrocarbon data from the 2002 Jersey survey with a selection of automatic UK air quality monitoring stations, which measure hydrocarbons using pumped tube samplers. The sites used for comparison are:

- London Marylebone Road - an urban kerbside site, located on a major route into Central London. Heavy traffic, and surrounded by tall buildings.
- Cardiff East - a residential site to the east of the city.
- Edinburgh Medical School – a city centre site, in a street "canyon", with heavy traffic and tall buildings.
- Harwell - a rural site in the south of England, within 10km of a power station.

Note: the full 2002 dataset is not yet available for the automatic sites; only January to September data averages are available. Therefore, Table 2 compares these with January to September 2002 averages for each of the Jersey sites.

Table 10. Comparison with Hydrocarbon Concentrations at Other UK Sites, January to September 2002

Site	Benzene, ppb	Toluene, ppb	m+p Xylene, ppb
Jersey Diffusion Tube Sites: Jan – Sep 2002			
Beresford Street	0.8	*3.5*	1.8
Le Bas Centre	0.6	2.1	1.3
Elizabeth Lane *(near paint spraying)*	0.5	*3.1*	*1.5*
Springfield Garage *(petrol station)*	*1.8*	*10.3*	*4.6*
Stopford Road *(petrol stations) Jan-May only*	1.1	6.8	3.8
Clos St Andre	*0.4*	0.7	0.5
Airport *(Jun-Dec only)*	0.3	*0.5*	0.2
UK Automatic Sites: Jan – Sep 2002			
London Marylebone Road	1.2	4.4	2.5
Cardiff Centre	0.2	0.8	0.3
Edinburgh Medical School	0.2	0.7	0.4

Harwell	0.2	0.4	0.1

Highest hydrocarbon concentrations were measured at Springfield Garage and Stopford Road (where fuels are stored), and London Marylebone Road. Lower concentrations were measured at the background sites on Jersey; however, these sites had higher hydrocarbon levels that at Edinburgh or Cardiff (where hydrocarbon concentrations appear to have fallen since last year), or the rural site at Harwell. Hydrocarbon levels at Clos St Andre and the Airport were comparable with, although slightly higher than, the mean from the rural Harwell site over the same period. Concentrations at Elizabeth Lane were comparable to those at Beresford Street and Le Bas, despite the proximity of the paint spraying process.

3.3.4 Comparison with Previous Years' Hydrocarbon Results

Four sites (Beresford Street, Le Bas Centre, Elizabeth Lane and Springfield Garage) have been operating since 1997. The 2002 hydrocarbon concentrations were consistent with the previous year, and in some cases lower. Table 11 shows annual means for these sites, also Stopford Road (outdoor) and Clos St Andre. The Stopford Road site has not been included as a long-running site, as prior to 2000 it was located indoors.

Table 11. Comparison of Hydrocarbon Concentrations, Jersey, 1997 - 2002.

	benzene, ppb	toluene, ppb	Ethyl benzene, ppb	m+p xylene, ppb	o-xylene, ppb
Beresford Street					
1997	3.2	5.4	1.2	1.2	2.7
1998	2.5	4.9	0.9	1.0	2.3
1999	1.8	3.6	0.6	1.7	0.8
2000	0.9	3.7	0.8	2.3	0.9
2001	1.0	3.9	0.8	2.2	0.8
2002	0.8	3.4	0.6	1.8	0.7
Le Bas Centre					
1997	2.8	4.5	1.2	1.0	2.2
1998	2.3	4.2	0.7	0.9	1.9
1999	1.1	2.9	0.5	1.3	0.6
2000	0.9	3.3	0.7	1.9	0.7
2001	0.8	3.5	0.6	1.7	0.7
2002	0.6	2.1	0.4	1.3	0.5
Elizabeth Lane					
1997	1.9	4.4	1.4	1.7	2.2
1998	1.9	5.0	0.7	1.6	0.8
1999	1.0	3.3	0.5	1.2	0.6
2000	0.7	3.3	0.7	1.8	0.6
2001	0.7	4.1	0.7	2.0	0.8
2002	0.5	2.9	0.5	1.4	0.4
Springfield Garage					
1997	7.7	12.5	1.9	1.9	4.3
1998	7.7	12.3	1.5	1.7	4.3
1999	4.5	10.9	1.3	3.8	1.5
2000	1.6	9.2	1.8	5.0	2.0
2001	2.1	11.2	1.8	5.2	1.9
2002	1.7	9.6	1.4	4.3	1.6
Stopford Road Outdoor					
2000	1.2	8.4	1.8	5.3	2.2
2001	1.8	12.2	2.2	6.8	2.6
2002*	1.1	6.8	1.2	3.8	1.4
Clos St Andre					
2000	0.3	0.9	0.2	0.6	0.2
2001	0.4	1.2	0.3	0.6	0.3
2002	0.3	0.7	0.2	0.5	0.2

** 2002 data for Stopford Road based on 5 months data only.*

Figures 12 to 16 illustrate how annual mean concentrations of these hydrocarbons have changed over the years of monitoring.

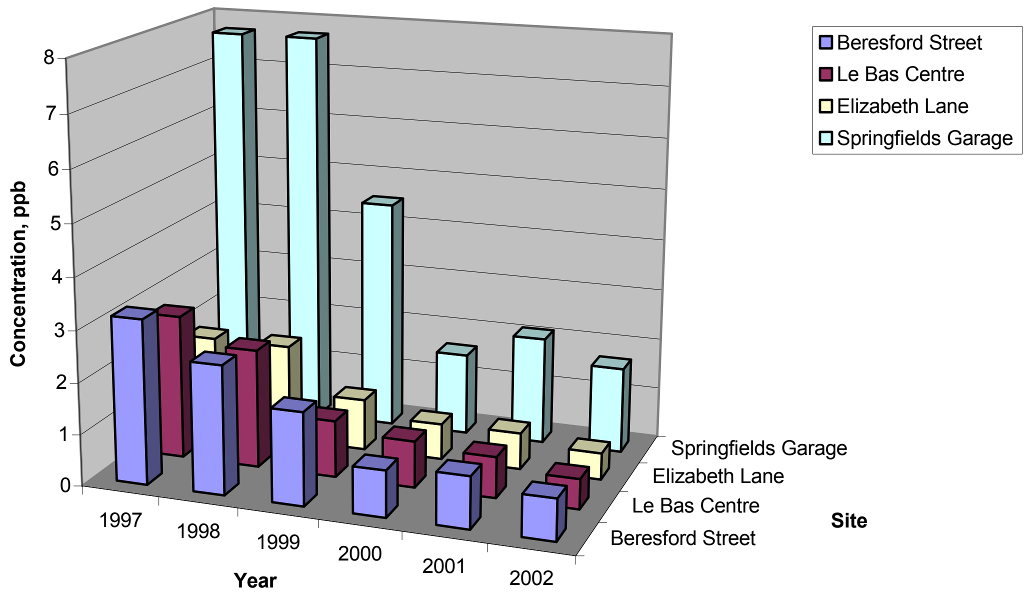


Figure 12. Trends in Benzene Concentration

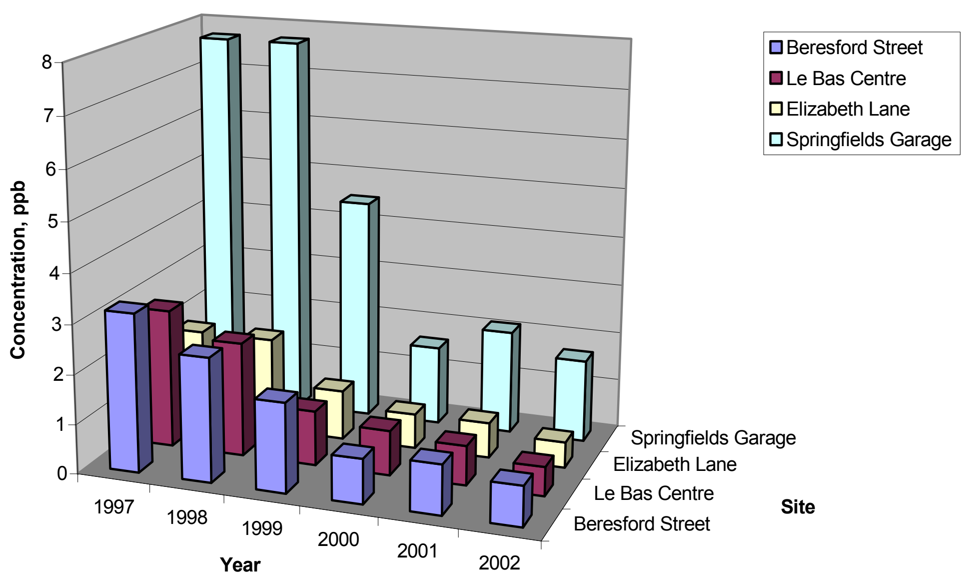


Figure 13. Trends in Toluene Concentration

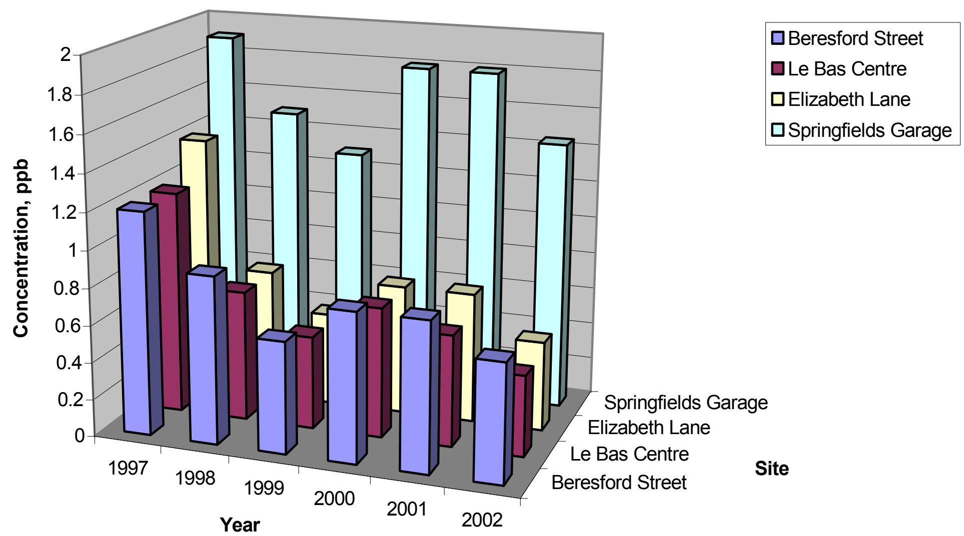


Figure 14. Trends in Ethylbenzene Concentration

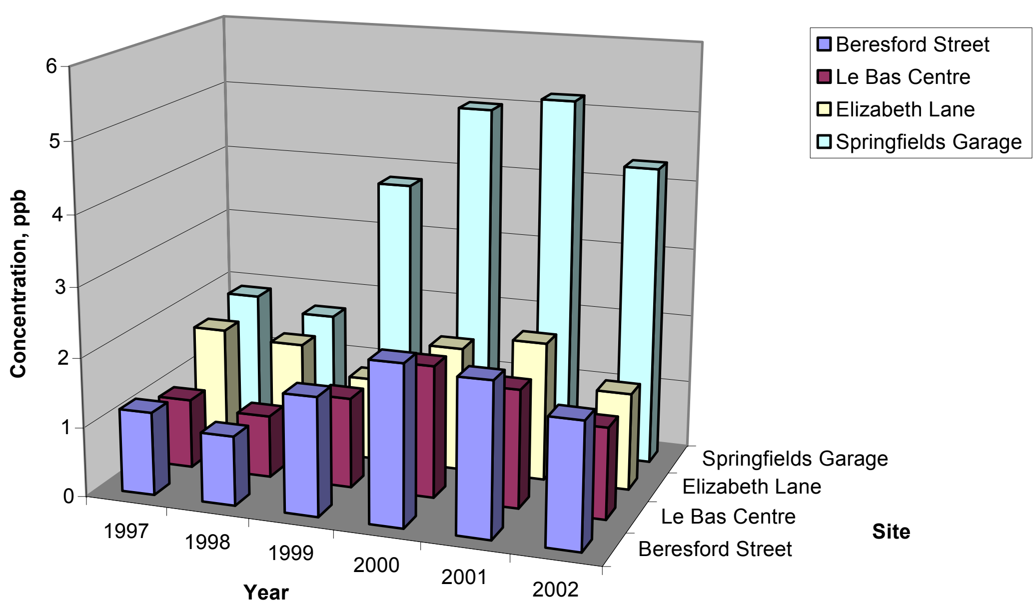


Figure 15. Trends in m+p- Xylene Concentration

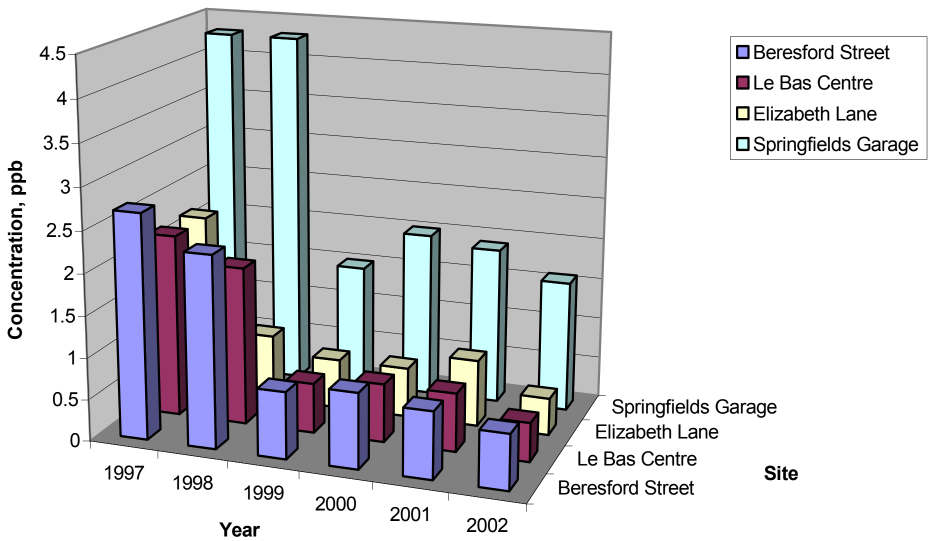


Figure 16. Trends in o-Xylene Concentration

Most hydrocarbon species appear to have decreased over the six years of monitoring, being in most cases lower now than in the late 1990s. Benzene in particular shows a marked drop in 2000: this is due to the maximum permitted benzene content of petrol sold in the UK being reduced from 2% in unleaded (5% in super unleaded), to 1% as of 1st January 2000. Only m+p xylene has shown an increase in recent years, at all sites except Elizabeth Lane.

4 Conclusions

- Netcen has undertaken a year-long diffusion tube monitoring study in Jersey during 2002, on behalf of the States of Jersey Public Health Services and Planning and Environment Department. This was the sixth such extended study, and continued from the end of the 2001 study, running from 3rd January 2002 to 3rd January 2003.
- Diffusion tubes were used to monitor NO_2 at 19 sites, and SO_2 at 1 site. Hydrocarbons (benzene, toluene, ethyl benzene and xylenes, collectively termed BTEX) were measured at 7 sites, including a new site at the Airport, which replaced the old site at Stopford Road, as of June 2002. The sites were located at a range of different locations on the island, and in most cases have been used since the 2000 study.
- All tubes were exposed for 4- or 5-week periods, in line with the "months" of the UK NO_2 Network calendar.

NO_2 results

- Annual mean NO_2 concentrations at six of the seven kerbside and roadside sites (First Tower, Weighbridge, Georgetown, Beaumont, Broad Street and La Pouquelaye) were above the EC Directive Limit Value and AQS Objective of 21ppb. Three of the sites exceeded by less than 1ppb. The sites have until 31st December 2005 to meet the AQS Objective.
- Applying the analytical laboratory's recommended correction factor for diffusion tube bias to these annual mean results reduces all of them to below 21ppb. However, given the uncertainty of $\pm$25% inherent in diffusion tube measurements, it is recommended that First Tower, Weighbridge, Georgetown, Beaumont, Broad Street and La Pouquelaye are at present considered "borderline" with respect to the EC Limit Value and AQS Objective.
- Annual mean NO_2 concentrations at all background sites were in most cases well below the Limit Value.
- Annual mean NO_2 concentrations at the 19 monitoring sites were very similar to those measured in 2001: within 1ppb of the 2001 average in many cases. Concentrations of this pollutant appear to be stable at most sites, having changed little in the years 2000-2002.
- Trends in NO_2 concentration were investigated using three long-running sites, which have operated since 1993 as part of the UK NO_2 Network. While NO_2 concentrations at the two urban background sites (Jane Sandeman and Maufant) have remained stable or decreased slightly. The kerbside site (Beaumont) showed an increasing trend until 2001, but in 2002 decreased slightly.
- One implication of the apparent stability of NO_2 concentrations, is that sites currently close to or above the Limit Value and AQS Objective of 21ppb for annual mean NO_2 concentration may remain so, unless action is taken to reduce urban roadside NO_2 levels.

SO_2 tube results

- The annual mean SO_2 concentration at the single site, Clos St Andre, was 3.0ppb. This is slightly higher than in the two previous years, possibly due to one unusually high result for October. However, it is still relatively low. Future monitoring should identify if there is any increasing trend.

Hydrocarbon tube results

- One site, Springfield Garage (near a petrol station), had an annual mean benzene concentration of 1.7ppb, which is greater than the EC 2nd Daughter Directive Limit Value of 1.5ppb (which is to be achieved by 2010). However, the annual mean was slightly lower than that measured in 2001.

- At Stopford Road, monitoring was carried out from January to May only. The average benzene concentration over this 5-month period was 1.1ppb: exceedence of the EC Limit Value can therefore not be ruled out.
- No sites had annual mean benzene concentrations greater than the UK Air Quality Strategy Objective of 5ppb, which is to be achieved by the end of 2003.
- Four of the BTEX sites (Beresford Street, Le Bas Centre, Elizabeth Lane, and Springfield Garage) have been in operation since 1997, and therefore yield some information on trends. Results from these sites appear to show a decreasing trend in BTEX hydrocarbon concentrations, with the exception of m+p xylene, which has increased at all sites except Elizabeth Lane.

5 Recommendations

1. Results of the diffusion tube survey indicate that most background locations in Jersey are likely to meet the UK Air Quality Strategy Objective for the annual mean NO_2 concentration by the end of 2005.
2. However, some kerbside and roadside locations are currently "borderline" with respect to this objective, and importantly there is no evidence of a downward trend. Measurements from diffusion tube surveys inevitably carry a high uncertainty, and are not sufficient on their own for determining compliance with Objectives and Directives. It is strongly recommended that the States of Jersey consider using a mobile automatic analyser, to investigate such sites further.
3. The series of diffusion tube surveys has proved very effective in providing information on spatial distribution of pollutant concentrations, and on trends. However, these data are retrospective, and they are unable to clearly highlight short-term pollution episodes. The States of Jersey should consider funding a permanent monitoring station, the results of which will offer the Island Government many advantages:

- Islanders can be provided with rapid information about air quality. Dissemination of this information could be helpful to people who are particularly sensitive to pollution exposure (e.g. asthma sufferers).
- The data from automatic analysers can be directly compared with data from EC Member States monitoring networks, subject to suitable data quality control procedures.
- Data can be used to monitor compliance with Objectives and Directives, and for determining policy.

6 Acknowledgements

AEA Technology Environment gratefully acknowledges the help and support of the staff of the States of Jersey Environmental Health Services, Planning, Environment and Public Services, in the completion of this monitoring study.

7 References

1. Air Quality Monitoring in Jersey; Diffusion Tube Surveys 1997. B Stacey, report no. AEAT-3071, March 1998.
2. Air Quality Monitoring in Jersey; Diffusion Tube Surveys 1998. B Stacey, report no. AEAT-5271, April 1999.
3. Air Quality Monitoring in Jersey; Diffusion Tube Surveys 1999. B Stacey, A Loader, report no. AEAT-EQ0191, March 2000.
4. Air Quality Monitoring in Jersey; Diffusion Tube Surveys 2000. J Lampert, B Stacey, report no. AEAT/ENV/R/ 0561, March 2001.
5. Air Quality Monitoring in Jersey; Diffusion Tube Surveys 2001. B Stacey, A Loader report no. AEAT/ENV/R/ 1033, March 2002.
6. EH40/97. Occupational Exposure Limits 1997. Health & Safety Executive. HMSO, ISBN 0-7176-1315-1.
7. Odour Measurement and Control - an update. Editors M Woodfield & D Hall. AEA Technology report AEA/CS/REMA/-038 ISBN 0 85624 8258. August 1994.
8. Guidelines for Air Quality, WHO, Geneva, 2000, WHO/SDE/OEH/00.02. www.who.int/peh/air/airqualitygd.htm
9. Council Directive 1999/30/EEC relating to Limit Values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air. 22 April 1999.
10. Council Directive 2000/69/EC relating to Limit Values for benzene and carbon monoxide in ambient air. 16 Nov 2000.
11. The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, Department of the Environment, Transport and the Regions. January 2000, ISBN 0 10 145482-1
12. Part IV of the Environment Act 1995 Local Air Quality Management. Technical Guidance LAQM.TG(03)
13. PORG (1993) Ozone in the United Kingdom 1993, Third Report of the UK Photochemical Oxidants Review Group, ISBN 0-7058-1683-4.

Appendices

CONTENTS

Appendix 1
Air Quality Standards

Air Pollution Guidelines Used in this Report.

UK and International Ambient Air Quality Limit Values, Objectives and Guidelines

Nitrogen Dioxide

Guideline Set By	Description	Criteria Based On	Value[1] / μgm^{-3} (ppb)
The Air Quality Strategy[2]	Objective for Dec. 31st 2005, for protection of human health	1-hour mean	200 (105) Not to be exceeded more than 18 times per calendar year.
Set in regulations[3] for all UK:	Objective for Dec. 31st 2005, for protection of human health	Annual mean	40 (21)
Not intended to be set in regulations:	Objective for Dec. 31st 2000, for protection of vegetation.	Annual mean NO_x (NO_x as NO_2)	30 (16)
European Community 1985 NO_2 Directive [4] Limit remains in force until fully repealed 01/01/2010.	Limit Value	Calendar year of data: 98%ile of hourly means.	200 (105)
1st Daughter Directive[5]	Limit Value for protection of human health. To be achieved by Jan. 1st 2010	1 hour mean	200 (105) not to be exceeded more than 18 times per calendar year
	Limit Value for protection of human health. To be achieved by Jan. 1st 2010	Calendar year mean	40 (21)
	Limit Value (total NO_x) for protection of vegetation. To be achieved by Jul. 19th 2001	Calendar year mean	30 (16)
World Health Organisation[6] **(Non-Mandatory Guidelines)**	Health Guideline	1-hour mean	200
	Health Guideline	Annual mean	40

(1) Conversions between $\mu g\ m^{-3}$ and ppb are as used by the EC, i.e. 1ppb NO_2 = 1.91 $\mu g\ m^{-3}$ at 20°C and 1013 mB.
(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1 & Addendum 2003.
(3) Air Quality (England) Regulations 2000 (SI 2000/928), Air Quality (Scotland) Regulations 2000 (SSI 2000/97), Air Quality (Wales) Regulations 2000 (SI 2000/1940 (W138)).
(4) Council Directive 85/203/EEC.
(5) Council Directive 1999/30/EC. Transposed into UK Air Quality Regulations in England by SI 2001/2315, in Scotland by SSI 2001/224, in Wales by SI 2001/2683 (W224), and by Statutory Rule 2002 (94) in Northern Ireland.
(6) WHO Guidelines for Air Quality WHO/SDE/OEH/00.02 (2000).

Sulphur Dioxide

Guideline Set By	Description	Criteria Based On	Value[1] / μgm^{-3} (ppb)
The Air Quality Strategy[2] **Set in regulations[3] for all UK.**	Objective for Dec. 31st 2005, for protection of human health.	15-minute mean	266 (100) Not to be exceeded > 35 times per calendar year.
	Objective for Dec. 31st 2004, for protection of human health	1-hour mean	350 (132) Not to be exceeded > 24 times per calendar year.
	Objective for Dec. 31st 2004, for protection of human health	24-hour mean	125 (47) Not to be exceeded > 3 times per calendar year.
Not intended to be set in regulations.	Objective for Dec. 31st 2000, for protection of vegetation.	Annual mean & winter (1st October – 31st March) mean	20 (8)
European Community Smoke & SO_2 Directive[4]	Limit Value	Pollution Year (median of daily values)	80 (30) if smoke[5] > 34 120 (45)if sm. <= 34
	Limit Value	Winter (median of daily values Oct-Mar)	130 (49)if sm. > 51 180 (68)if sm. <= 51
	Limit Value[6]	Pollution Year (98%ile of daily values)	250 (94)if sm. > 128 350 (131)if sm. <= 128
1st Daughter Directive[7]	Objective for Jan 1st 2005, for protection of human health	1-hour mean	350 (132) Not to be exceeded more than 24 times per calendar year.
	Objective for Jan 1st 2005, for protection of human health	Daily 24-hour mean	125 (47) Not to be exceeded more than 3 times per calendar year.
	Objective for Jul 19th 2001, for protection of vegetation.	Annual mean & winter (1st October – 31st March) mean	20 (8)
World Health Organisation[8] **(Non-Mandatory Guidelines)**	Health Guideline	10-minute mean	500
	Health Guideline	24-hour mean	125
	Health Guideline	Annual mean	50

(1) Conversions between $\mu g\ m^{-3}$ and ppb are as used by the EC, i.e. 1ppb SO_2 = 2.66 $\mu g\ m^{-3}$ at 20°C and 1013 mB.
(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1 & Addendum 2003.
(3) Air Quality (England) Regulations 2000 (SI 2000/928), Air Quality (Scotland) Regulations 2000 (SSI 2000/97), Air Quality (Wales) Regulations 2000 (SI 2000/1940 (W138)).
(4) Council Directive 80/779/EEC. Limit Values shown remain in force until fully repealed 1st Jan 2005.
(5) Limits for black smoke are given in $\mu g\ m^{-3}$ for the BS method as used in the UK. The limits stated in the EC Directive relate to the OECD method, where OECD = BS / 0.85.
(6) Member states must take all appropriate steps to ensure that three consecutive days do not exceed this Limit Value.
(7) Council Directive 1999/30/EC. Transposed into UK Air Quality Regulations in England by SI 2001/2315, in Scotland by SSI 2001/224, in Wales by SI 2001/2683 (W224), and by Statutory Rule 2002 (94) in Northern Ireland.
(9)WHO Guidelines for Air Quality WHO/SDE/OEH/00.02 (2000).

Benzene

Guideline Set By	Description	Criteria Based On	Value[1] / μgm^{-3} (ppb)
The Air Quality Strategy[2,3] **All UK**	Objective for Dec. 31st 2003	Running annual mean	16.25 (5)
England[4] & Wales[5] only:	Objective for Dec. 31st 2010	Annual mean	5 (1.54)
Scotland[6] & Northern Ireland	Objective for Dec. 31st 2010	Running annual mean	3.25 (1.0)
European Community 2nd Daughter Directive[8]	Limit Value. To be achieved by Jan 1st 2010	Annual calendar year mean	5 (1.5)

(1) Conversions between μg m^{-3} and ppb are those used by the EC, i.e. 1ppb benzene = 3.25 μg m^{-3} at 20°C and 1013 mB.
(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482-1 & Addendum 2003.
(3) Air Quality (England) Regulations 2000 (SI 2000/928), Air Quality (Scotland) Regulations 2000 (SSI 2000/97), Air Quality (Wales) Regulations 2000 (SI 2000/1940 (W138)).
(4) Air Quality (Amendment) (England) Regulations 2002 (SI 2002/3043)
(5) Air Quality (Amendment) (Wales) Regulations 2002 (SI 2002/3182 (W298))
(6) Air Quality (Amendment) (Scotland) Regulations 2002 (SI 2002/297)
(7) Council Directive 2000/69/EC. Transposed into UK Air Quality Regulations in England by SI 2002/3117, in Scotland by SSI 2002/556, in Wales by SI 2002/3183 (W299), and by Statutory Rule 2002 (357) in Northern Ireland.

Appendix 2
Hydrocarbon Results

Table A2.1 Monthly Hydrocarbon concentrations at Beresford Street (ppb)

Exposure period	benzene	toluene	ethyl benzene	m,p -xylene	o-xylene
3 Jan - 31 Jan	0.9	3.1	0.6	1.7	0.7
31 Jan - 26 Feb	0.9	3.0	0.6	1.7	0.6
26 Feb - 3 Apr	0.8	6.8	0.8	2.4	0.9
3 Apr - 30 Apr	0.9	3.3	0.6	1.8	0.6
30 Apr - 6 Jun	0.7	3.1	0.7	1.8	0.7
6 Jun - 3 Jul	0.7	2.5	0.5	1.4	0.5
3 Jul - 31 Jul	0.7	2.8	0.6	1.6	0.6
31 Jul - 4 Sep	0.7	3.2	0.6	1.8	0.6
4 Sep - 2 Oct	1.0	3.5	0.8	2.1	0.7
2 Oct - 30 Oct	0.8	2.7	0.6	1.5	0.6
30 Oct - 3 Dec	0.6	3.3	0.6	2.0	0.7
3 Dec - 3 Jan	0.9	3.3	0.6	1.8	0.7
Average	**0.8**	**3.4**	**0.6**	**1.8**	**0.7**

Table A2.2 Monthly Hydrocarbon concentrations at Le Bas Centre (ppb)

Exposure period	benzene	toluene	ethyl benzene	m,p -xylene	o-xylene
3 Jan - 31 Jan	0.7	2.4	0.5	1.4	0.5
31 Jan - 26 Feb	0.7	2.1	0.4	1.2	0.4
26 Feb - 3 Apr	0.8	2.8	0.5	1.6	0.6
3 Apr - 30 Apr	0.7	2.7	0.5	1.4	0.5
30 Apr - 6 Jun	0.5	2.2	0.5	1.3	0.5
6 Jun - 3 Jul	0.3	1.6	0.4	1.2	0.4
3 Jul - 31 Jul	0.2	1.5	0.3	1.1	0.4
31 Jul - 4 Sep		1.5	0.4		
4 Sep - 2 Oct	0.8	2.2	0.5	1.4	0.5
2 Oct - 30 Oct	0.7	2.2	0.5	1.4	0.5
30 Oct - 3 Dec	0.5	2.2	0.4	1.5	0.5
3 Dec - 3 Jan	0.5	1.5	0.3	0.9	0.3
Average	**0.6**	**2.1**	**0.4**	**1.3**	**0.5**

Table A2.3 Monthly Hydrocarbon concentrations at Elizabeth Lane (ppb)

Exposure period	benzene	toluene	ethyl benzene	m,p -xylene	o-xylene
3 Jan - 31 Jan	0.6	2.5	0.4	1.2	0.4
31 Jan - 26 Feb	0.5	1.6	0.3	0.8	0.3
26 Feb - 3 Apr	0.6	2.9	0.5	1.6	0.5
3 Apr - 30 Apr	0.6	2.3	0.4	1.3	0.4
30 Apr - 6 Jun	0.4	1.9	0.4	1.1	0.4
6 Jun - 3 Jul	0.5	2.9	0.5	1.4	0.4
3 Jul - 31 Jul	0.5	3.5	0.6	1.7	0.5
31 Jul - 4 Sep	0.5	4.6	0.7	2.0	0.6
4 Sep - 2 Oct	0.7	5.5	0.7	2.0	0.7
2 Oct - 30 Oct	0.5	2.4	0.5	1.3	0.4
30 Oct - 3 Dec	0.3	1.6	0.3	1.0	0.3
3 Dec - 3 Jan					
Average	**0.5**	**2.9**	**0.5**	**1.4**	**0.4**

Table A2.4 Monthly Hydrocarbon Concentrations at Springfield Garage (ppb)

Exposure period	benzene	toluene	Ethyl benzene	m,p -xylene	o-xylene
3 Jan - 31 Jan					
31 Jan - 26 Feb	0.7	4.1	0.6	2.3	0.8
26 Feb - 3 Apr	1.5	11.0	1.4	4.4	1.6
3 Apr - 30 Apr	2.0	11.0	1.5	4.8	1.7
30 Apr - 6 Jun	1.6	9.1	1.6	4.3	1.6
6 Jun - 3 Jul	1.7	9.7	1.5	4.3	1.6
3 Jul - 31 Jul	2.4	17.0	2.3	6.4	2.4
31 Jul - 4 Sep	2.3	13.0	2.1	6.4	2.3
4 Sep - 2 Oct	1.8	7.8	1.4	3.7	1.4
2 Oct - 30 Oct	1.8	7.7	1.2	3.6	1.4
30 Oct - 3 Dec	1.3	8.4	1.3	4.3	1.5
3 Dec - 3 Jan	1.3	6.7	1.0	3.0	1.1
Average	**1.7**	**9.6**	**1.4**	**4.3**	**1.6**

Table A2.5 Monthly Hydrocarbon Concentrations at Stopford Road (outdoor) (ppb)

Exposure period	benzene	toluene	ethyl benzene	m,p -xylene	o-xylene
3 Jan - 31 Jan	1.1	5.1	0.9	2.8	1.0
31 Jan - 26 Feb	1.0	5.7	1.0	3.1	1.1
26 Feb - 3 Apr	1.4	8.7	1.5	5.0	1.9
3 Apr - 30 Apr	1.3	8.5	1.4	4.7	1.6
30 Apr - 6 Jun	0.9	6.1	1.2	3.4	1.3
6 Jun - 3 Jul					
3 Jul - 31 Jul					
31 Jul - 4 Sep					
4 Sep - 2 Oct					
2 Oct - 30 Oct					
30 Oct - 3 Dec					
3 Dec - 3 Jan					
Average	**1.1**	**6.8**	**1.2**	**3.8**	**1.4**

Table A2.6 Monthly Hydrocarbon Concentrations at Clos St Andre (ppb)

Exposure period	benzene	toluene	ethyl benzene	m,p -xylene	o-xylene
3 Jan - 31 Jan	0.4	0.8	0.2	0.4	0.2
31 Jan - 26 Feb	0.4	0.5	0.1	0.3	0.1
26 Feb - 3 Apr	0.5	0.9	0.2	0.5	0.2
3 Apr - 30 Apr	0.2	0.6	0.1	0.4	0.2
30 Apr - 6 Jun	0.3	0.6	0.2	0.3	0.1
6 Jun - 3 Jul	0.3	0.5	0.2	0.3	0.1
3 Jul - 31 Jul	0.3	rejected	0.7	1.3	0.6
31 Jul - 4 Sep	0.4	0.9	0.2	0.5	0.2
4 Sep - 2 Oct	0.5	0.9	0.3	0.5	0.2
2 Oct - 30 Oct	0.4	0.7	0.2	0.4	0.2
30 Oct - 3 Dec	0.1	0.5	0.1	0.3	0.1
3 Dec - 3 Jan	0.3	0.4	0.1	0.2	0.1
Average	**0.3**	**0.7**	**0.2**	**0.5**	**0.2**

July 2002 Toluene mean of 21ppb was rejected.

Table A2.7 Monthly Hydrocarbon Concentrations at the Airport (ppb)

Exposure period	benzene	toluene	ethyl benzene	m,p -xylene	o-xylene
3 Jan - 31 Jan					
31 Jan - 26 Feb					
26 Feb - 3 Apr					
3 Apr - 30 Apr					
30 Apr - 6 Jun					
6 Jun - 3 Jul	0.3	0.5	0.1	0.2	0.0
3 Jul - 31 Jul	0.3	0.5	0.1	0.2	0.1
31 Jul - 4 Sep	0.2		0.1		
4 Sep - 2 Oct	0.5	0.6	0.2	0.3	0.1
2 Oct - 30 Oct	0.3	0.4	0.1	0.2	0.1
30 Oct - 3 Dec	0.2	0.3	0.1	0.2	0.1
3 Dec - 3 Jan	0.2	0.3	0.1	0.1	nd
Average	**0.3**	**0.4**	**0.1**	**0.2**	**0.1**