
Air Quality Monitoring in Jersey 2010



Report for States of Jersey

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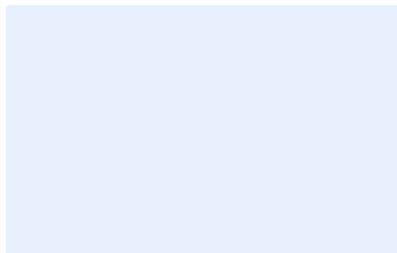
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Executive summary

This report presents the results for 2010 of an ongoing programme of air quality monitoring in Jersey, carried out by AEA on behalf of the Public Health Services and Planning and Environment Department of the States of Jersey.

An automatic monitoring station for nitrogen dioxide (NO₂) has been located in the Central Market, Halkett Place, St Helier since 2008. In addition, non-automatic diffusion tube samplers were used for indicative monitoring of nitrogen dioxide (NO₂) at 12 sites, and a suite of four hydrocarbons (benzene, toluene, ethylbenzene and xylenes) at a further six sites. Monitoring sites included areas likely to be affected by specific emission sources (such as petrol stations or the old waste incinerator which has since closed), as well as general background locations. The 2010 non-automatic monitoring programme continued a long-term survey that has operated in Jersey for the past 14 years.

NO₂ and hydrocarbon diffusion tubes were exposed for twelve periods approximating to calendar months. The tubes were supplied and analysed by Gradko International Ltd, and changed by Technical Officers of Jersey's Environmental Health Section.

The automatic monitoring site at Halkett Place met the EC Directive Limit Value (and AQS Objective) for both the 1-hour mean NO₂ concentration and the annual mean NO₂ concentration.

Annual mean concentrations of NO₂ at all twelve diffusion tube monitoring sites were within the EC Directive Limit Value, and were generally comparable with the previous year's results.

Data from long-running diffusion tube sites confirm that the decreasing trend in NO₂ concentration at urban roadside and kerbside sites, reported in 2009, has continued through 2010. NO₂ concentrations at residential and rural background sites do not appear to show a clear downward trend, but are already low.

The diurnal pattern in concentrations of oxides of nitrogen at Halkett Place showed a clear peak in the early morning (0700 – 0800). This is thought to reflect the early morning activity of market retailers arriving to set up for the day, and of daily refuse collections.

All six hydrocarbon monitoring sites met the EC Directive Limit Value for benzene (5 µg m⁻³ as an annual mean, to be achieved by 2010). This was the first full year of monitoring at the new Faux Bie site, which is located at the nearest relevant public exposure to a petrol station in Springfield. The annual mean benzene concentration at Faux Bie was 1.8 µg m⁻³: although this is the highest annual mean of all six sites, it is still well within the EC Limit Value.

Hydrocarbon concentrations at most sites have decreased over the duration of the survey. The Airport is the exception, showing no clear downward trend. However, levels there are already low.

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1 Introduction

1.1 Background

AEA, 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 2010. This is the fourteenth in a series of extensive annual monitoring programmes that began in 1997, and has since provided a long-term dataset of pollutant concentrations.

The pollutants measured were nitrogen dioxide (NO₂), and a range of hydrocarbon species (benzene, toluene, ethyl benzene and three xylene compounds). An automatic monitoring station at Halkett Place was used to monitor NO₂. This was supplemented by indicative monitoring of NO₂ using low cost passive samplers (Palmer type diffusion tubes) at 12 sites on the island. In addition, the suite of four hydrocarbons was monitored using "BTEX" diffusion tubes at six sites.

This report presents the results obtained in the 2010 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 2009^{1,2,3,4,5,6,7,8,9,10,11,12,13}. The objective, as in previous surveys, was to monitor at sites where pollutant concentrations were expected to be high, and compare these with background locations. The monitoring sites consisted of a mixture of urban and rural background sites, together with some locations where higher pollutant concentrations might be expected, such as roadside and kerbside sites, and some locations close to specific emission sources (such as the airport).

2 Details of Monitoring Programme

2.1 Pollutants Monitored

2.1.1 NO₂

A mixture of nitrogen dioxide (NO₂) and nitric oxide (NO) is emitted by combustion processes. This mixture of oxides of nitrogen is termed NO_x. NO is subsequently oxidised to NO₂ in the atmosphere. NO₂ is an irritant to the respiratory system, and can affect human health. Ambient concentrations of NO₂ are likely to be highest in the most built-up areas, especially where traffic is congested, or where buildings either side of the street create a “canyon” effect, impeding the dispersion of vehicle emissions. The units used for NO₂ concentration in this report are microgrammes per cubic metre (µg m⁻³). Some earlier reports in this series have used parts per billion (ppb): to convert from µg m⁻³ to ppb for comparison with the earlier reports if required, the following relationship should be used:

1 µg m⁻³ = 0.523 ppb for nitrogen dioxide at 293K (20°C) and 1013mb.

2.1.2 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 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 species associated with fuels and vehicle emissions which, though not the largest constituent of such emissions, are easy to monitor using passive samplers due to their moderate volatility. These are benzene, toluene, ethyl benzene and xylene. Diffusion tubes are available for monitoring this group of organic compounds, and are known as “BTEX” tubes (BTEX being an acronym for the compounds measured).

(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. In the UK, annual mean benzene concentrations in ambient air are typically less than 3 µg m⁻³. In this report, concentrations of benzene are expressed in microgrammes per cubic metre (µg m⁻³). Some earlier reports in the series used parts per billion (ppb): to convert to ppb to 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, and is also used as a solvent in paints and inks; it is also a constituent of tobacco smoke. There are no EU Limit Values for ambient toluene concentrations, although there are occupational limits for workplace exposure¹⁴, and a World Health Organisation (WHO) guideline, of 260 µg m⁻³ for the weekly mean.

The best estimate for the odour threshold of toluene has been reported as 0.16ppm ($613 \mu\text{g m}^{-3}$)¹⁵. The major concern associated with human exposure to toluene is its effect on the central nervous system: it is not believed to be carcinogenic¹⁶. Typical ambient concentrations are usually less than $5 \mu\text{g m}^{-3}$ in rural areas, and in the range 5-150 $\mu\text{g m}^{-3}$ in urban areas¹⁶.

In the present report, concentrations are expressed in microgrammes per cubic metre ($\mu\text{g m}^{-3}$). Some earlier reports in the series used parts per billion (ppb): to convert to ppb to if necessary, the following relationship should be used:

$1 \mu\text{g m}^{-3} = 0.261 \text{ ppb}$ for toluene at 293K (20°C) and 1013mb.

(only applicable to toluene).

(iii) Ethyl benzene

Again, there are no limits for ambient concentration of ethyl benzene, and although there are occupational limits relating to workplace exposure¹⁴, as discussed in previous reports in this series, they are several orders of magnitude higher than typical outdoor ambient concentrations.

(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 or $70 \mu\text{g m}^{-3}$)¹⁵.

In this report, concentrations of ethylbenzene and xylenes are expressed in microgrammes per cubic metre ($\mu\text{g m}^{-3}$). Some earlier reports in this series used parts per billion (ppb): to convert to ppb to if required, the following relationship should be used:

$1 \mu\text{g m}^{-3} = 0.226 \text{ ppb}$ for ethyl benzene or xylenes at 293K (20°C) and 1013mb.

(applicable to ethylbenzene, m-, p- and o-xylene).

2.2 Air Quality Limit Values and Objectives

This report compares the results of the monitoring survey with air quality Limit Values and Objectives applicable worldwide, in Europe and the UK. These are summarized in Appendix 1 and below.

2.2.1 World Health Organisation

In 2000, the World Health Organisation published revised air quality guidelines¹⁶ for pollutants including NO_2 . These 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 NO_2 concentrations (hourly and annual means), benzene and toluene.

The WHO non-mandatory guideline¹⁶ for NO_2 is that the annual mean should not exceed $40 \mu\text{g m}^{-3}$. For toluene, the WHO recommends a guideline value of 0.26 mg m^{-3} ($260 \mu\text{g m}^{-3}$) for the weekly mean.

2.2.2 European Community

Throughout Europe, ambient air quality is regulated by the EC Directive on Ambient Air Quality and Cleaner Air for Europe (2008/50/EC)¹⁷. This Directive (referred to as the Ambient Air Quality Directive) sets Limit Values, which are mandatory, and other requirements for the protection of human health and ecosystems. Both NO_2 and benzene are covered by this Directive. The States of Jersey have agreed to meet the EU health limits.

The Ambient Air Quality Directive¹⁷ contains Limit Values for NO₂ as follows:

- 200 µg m⁻³ as an hourly mean, not to be exceeded more than 18 times per calendar year. To have been achieved by 1st January 2010.
- 40 µg m⁻³ as an annual mean, for protection of human health. To have been achieved by 1st January 2010.
- There is also a limit for annual mean total oxides of nitrogen (NO_x), of 30 µg m⁻³, for protection of vegetation (relevant in rural areas only).

The same Directive¹⁷ also sets a limit of 5 µg m⁻³ for annual mean benzene, to be achieved by 2010.

2.2.3 UK Air Quality Strategy

The UK Air Quality Strategy (AQS) contains standards and objectives for a range of pollutants including NO₂ and benzene¹⁸. These are also summarised in Appendix 1. Only those Objectives relating to the whole UK (as opposed to specifically England, Wales, etc.) are applicable to Jersey, and the AQS does not at present have mandatory status in the States of Jersey.

The UK Air Quality Strategy's objectives for NO₂ are very similar to the EC Directive limits above: the only difference being that they had to be achieved by 31st December 2005.

The UK Air Quality Strategy¹⁸ sets the following objectives for benzene:

- 16.25 µg m⁻³ (for the running annual mean), to have been achieved by 31st December 2003
- 3.25 µg m⁻³ (for the calendar year mean in Scotland and Northern Ireland), to have been achieved by 31st December 2010.
- 5 µg m⁻³ (for the calendar year mean in England and Wales), to have been achieved by 31st December 2010.

Both the 2010 benzene objectives apply to specific parts of the UK only, so strictly speaking do not apply in Jersey. However, the objective of 5 µg m⁻³ applicable to England and Wales is the same as the EC Directive Limit Value, which is applicable in Jersey.

2.3 Methodologies

Oxides of nitrogen were monitored using a chemiluminescent analyser, located at the Central Market, Halkett Place, St Helier. This automatic monitoring site started operation in January 2008.

The chemiluminescent NO_x analyser provides a continuous output, proportional to the pollutant concentration. This output is recorded and stored every 10 seconds, and averaged to 15-minute average values by internal data loggers. The analyser is connected to a modem and interrogated by telephone to download the data to AEA. Data are downloaded daily and uploaded onto the publicly available website www.jerseymet.gov.je.

The automatic monitoring site at Halkett Place was supplemented by indicative monitoring, using diffusion tubes, for NO₂ and BTEX hydrocarbons. Diffusion tubes are "passive" samplers, i.e. they work by absorbing the pollutants direct from the surrounding air and need no power supply.

Palmes-type diffusion tubes were used for NO₂. These consist of a small plastic tube, approximately 7 cm long. During sampling, one end is open and the other closed. The closed end contains an absorbent for the gaseous species to be monitored, in this case NO₂. The tube is mounted vertically with the open end at the bottom. Ambient NO₂ diffuses up the tube during exposure, and is absorbed as nitrite. 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 NO₂ 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 and analysed by Gradko International Ltd. They were 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 set period of time. After exposure, the tubes were again sealed and returned to Gradko for analysis. The year was divided into twelve exposure periods approximating to calendar months. The duration of the exposure periods varied between four and five weeks.

Diffusion tubes are an indicative technique, and the results therefore have a greater uncertainty than those of more sophisticated automatic methods. The laboratory states that the margins of uncertainty on the diffusion tube analyses are typically $\pm 3.5\%$ for NO₂ and $\pm 9\%$ for BTEX hydrocarbons. However, uncertainties arising from the exposure phase also contribute to the overall uncertainty: it is usually estimated that the overall uncertainty on diffusion tube measurements is approximately $\pm 25\%$ for NO₂ and $\pm 25\%$ for BTEX hydrocarbons.

The limits of detection in ambient air depend on the tube uptake rate and the exposure time, and therefore vary to some extent from month to month. Typically the detection limit for NO₂ has been equivalent to an ambient concentration of $0.4 \mu\text{g m}^{-3}$, and the detection limit for benzene equivalent to around $0.05 \mu\text{g m}^{-3}$ (although the latter was higher this year).

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. In the case of the NO₂ sites, this is rarely a problem as ambient concentrations are above this threshold at all but the most rural locations. However, ambient concentrations of BTEX hydrocarbons are closer to the lower limit of detection using diffusion tubes: the non-urban sites have in the past regularly measured concentrations of $0.5 \mu\text{g m}^{-3}$ and less.

The UK Local Air Quality Management Technical Guidance LAQM.TG(09)¹⁹ states that when using diffusion tubes for indicative NO₂ 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 NO₂). By co-locating diffusion tubes with the automatic monitoring site at Halkett Place, it was possible to calculate a bias adjustment factor, which could then be applied to the annual mean diffusion tube measurements in this survey. The NO₂ diffusion tube results in this report are uncorrected except where clearly specified. BTEX diffusion tubes are not affected by the same sources of bias: the BTEX results have not been bias adjusted.

Each monthly batch of diffusion tubes was accompanied by a “travel blank” NO₂ and BTEX tube. These tubes were taken with the exposure tubes to the site, but were not exposed. They were returned to the site operator's premises, and were kept in a sealed bag in a cupboard. When the exposed tubes were collected, the “travel blank” tubes were taken by the operator to the site. The travel blanks were sent with the exposed tubes for analysis. The purpose of these tubes was to indicate if any contamination of the tubes had occurred. This was particularly relevant in the case of the BTEX tubes, which can easily be contaminated by exposure to solvents.

The travel blank results were not used to apply any correction to the results from the exposed tubes – only to highlight possible contamination issues.

2.4 Monitoring Sites

Automatic monitoring of oxides of nitrogen was carried out at the Central Market, Halkett Place, in St Helier (Figure 2-1). This site represents a roadside site where levels of NO₂ were expected to be high, and where members of the public are regularly exposed for periods of one hour or more.

Figure 2-1 Automatic NO_x Monitoring Site, Halkett Place, St Helier

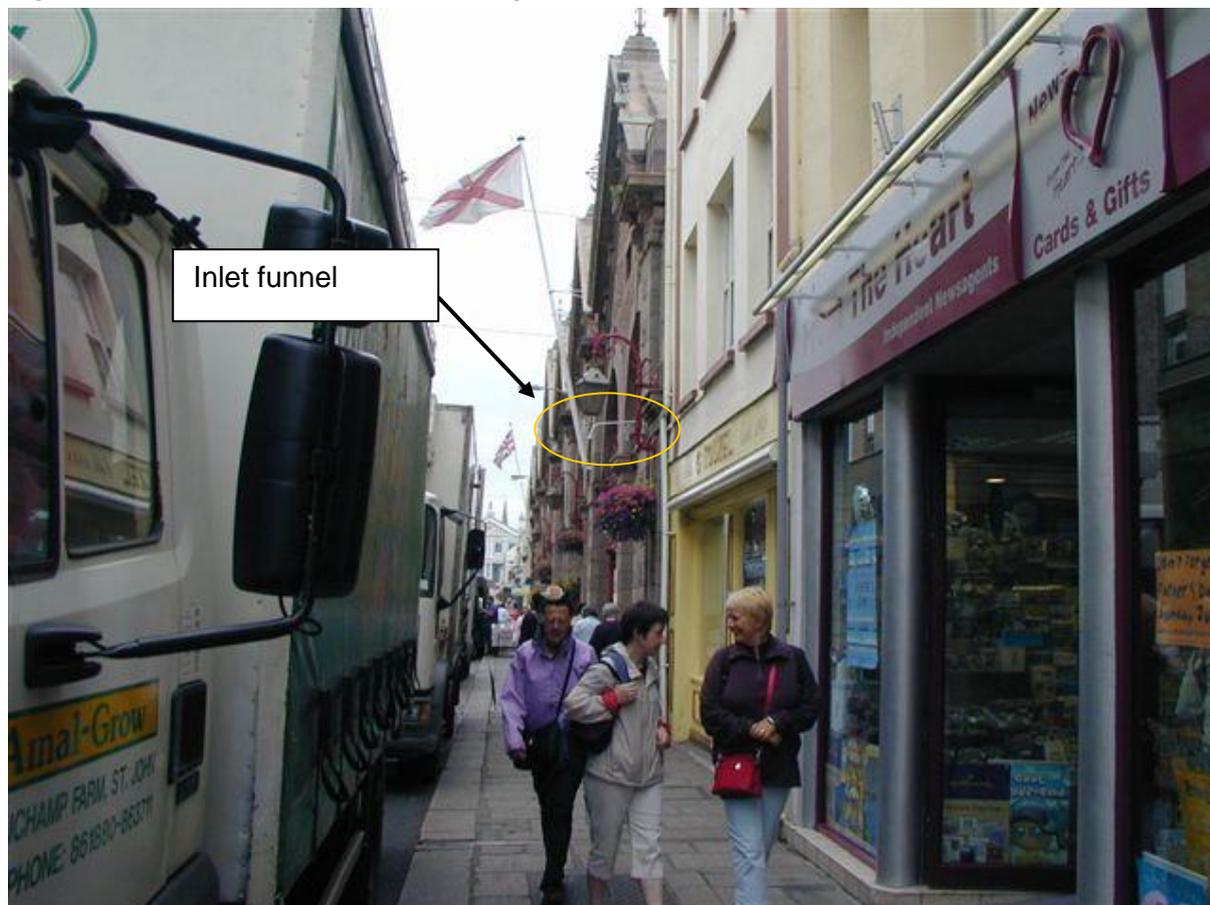


Figure 2-1 shows the location of the monitoring site. The inlet funnel (circled) is just visible as a white tube protruding from the building façade above the hanging basket just beyond the yellow shop front. It is at a height of about 5m.

Figure 2-2 shows the chemiluminescent NO_x analyser itself, which is located within the building. The analyser is calibrated monthly by the States of Jersey's Health Protection Team. Details of the calibration procedure, and an example of the calibration form used, are provided in Appendix 2.

As explained in section 2.3, diffusion tubes were also used to monitor NO₂ at twelve sites in a range of different environments around Jersey. Table 2-1 Table 2-1 NO₂ Monitoring Sites in Jersey lists the NO₂ diffusion tube sites, and Figures 2-3 and 2-4 show their locations.

Diffusion tubes were also co-located with the automatic monitoring site at Halkett Place, and the results of this co-located monitoring are used to assess the precision and accuracy of the diffusion tubes, relative to the automatic chemiluminescent analyser, which is defined within Europe as the reference method for NO₂. The tubes at this site are exposed in triplicate, to allow assessment of precision. All other diffusion tube sites are single tube sites.

Figure 2-2 Automatic NO_x Analyser at Halkett Place, St Helier

BTEX hydrocarbons were monitored at six sites during 2010. These sites are shown in Table 2-2. 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 Handsford Lane site is close to a paint spraying process – a potential source of hydrocarbon emissions, especially toluene and xylenes. This site replaced a similar site in Elizabeth Lane, which ceased operation when the process closed down in October 2003.

The Faux Bie site replaced the former Springfield Garage site at the beginning of June 2009. This was located at a fuel filling station, a potential source of hydrocarbon emissions including benzene. The old site was close to the forecourt: the new site is located at a nearby house, and is intended to be more representative of public exposure. As of December 2003, the fuel supplier has used vapour recovery when filling the tanks.

The Clos St Andre site is located near the site of the former Bellozane Valley waste incinerator (now closed), and the Airport site is located at Jersey Airport, overlooking the airfield.

Table 2-1 NO₂ Monitoring Sites in Jersey

Site Name	Grid Reference	Method	Description
Central Market, Halkett Place	653 486	Automatic analyser Diffusion tubes in triplicate	Central Market, Halkett Pl., St Helier
Le Bas Centre	658 489	Diffusion tube	Urban Background
Les Quennevais	579 496	Diffusion tube	Residential Background
Rue des Raisies	689 529	Diffusion tube	Rural Background
Weighbridge	651 483	Diffusion tube	Roadside at bus station near centre of St Helier
Georgetown	661 480	Diffusion tube	Kerbside on major road
Beaumont	597 516	Diffusion tube	Kerbside
The Parade *	648 489	Diffusion tube	Roadside site at General Hospital
Broad Street	652 486	Diffusion tube	Urban background
Union Street	653 486	Diffusion tube	Kerbside in St Helier – corner of Union St. & New St.
New Street	653 485	Diffusion tube	Kerbside in St Helier
Liberation Station	652 485	Diffusion tube	Kerbside opposite entrance to new bus station

**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.

Figure 2-3 Site Locations Outside St Helier

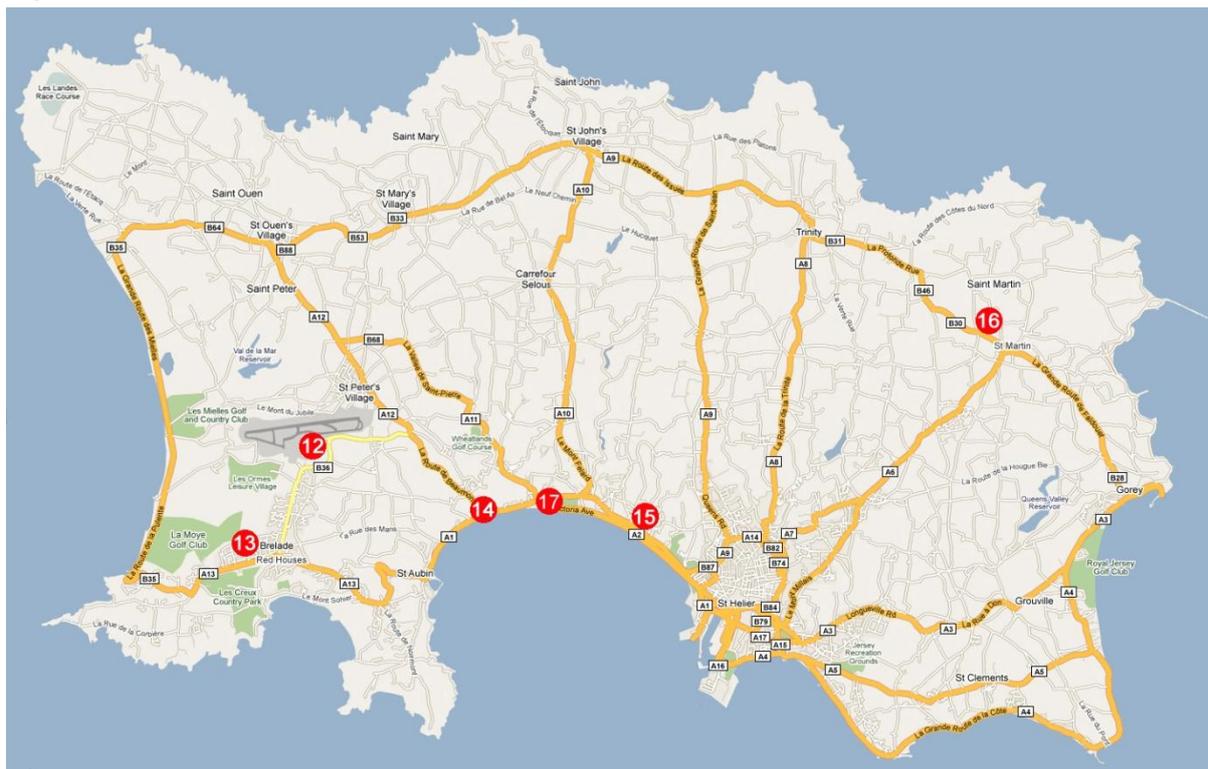
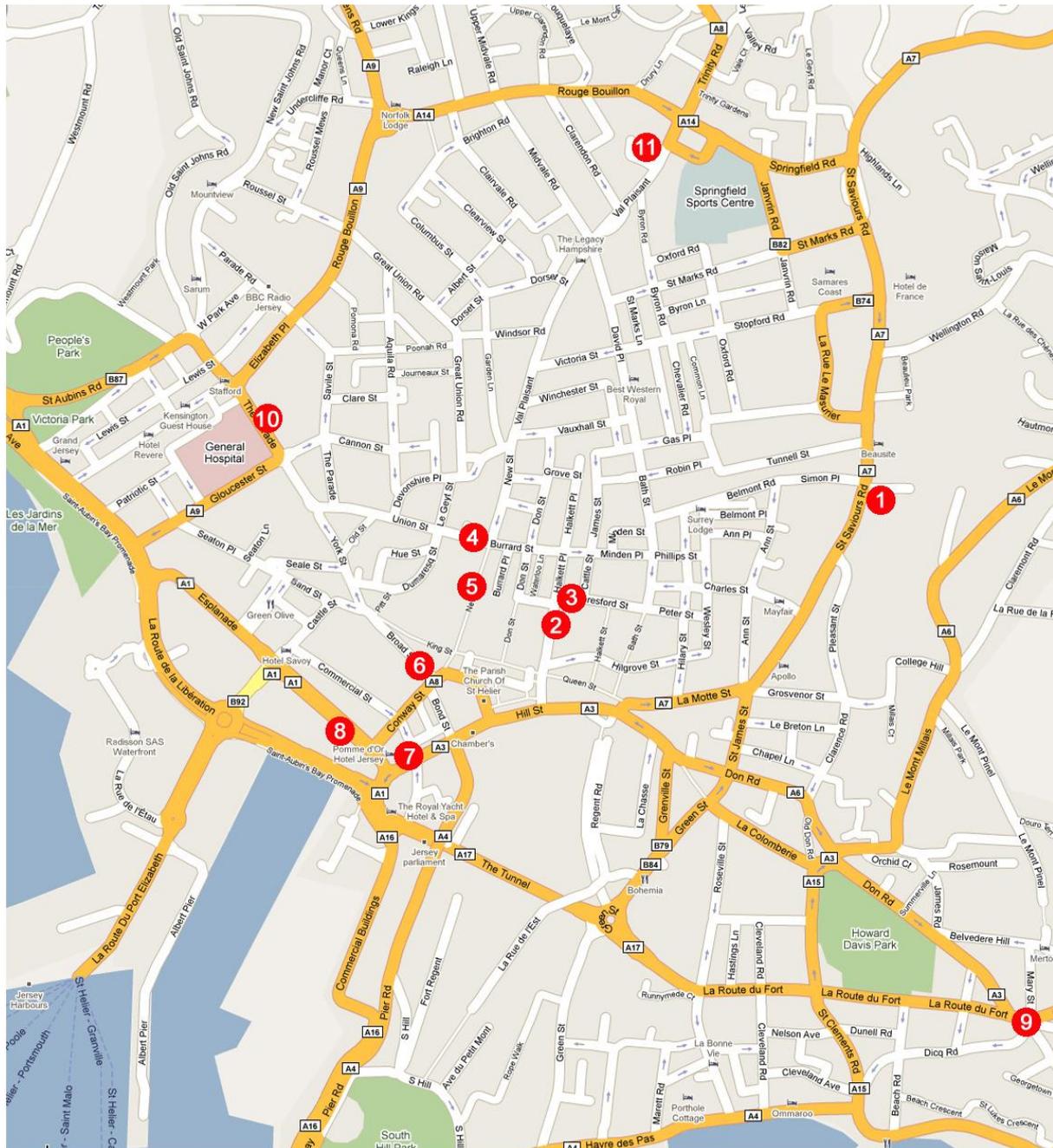


Figure 2-4 Sites in St Helier town



Key:

1	Le Bas Centre	NO ₂ , BTEX	10	The Parade	NO ₂
2	Central Market	NO ₂ , (diffusion tube and automatic)	11	Faux Bie	BTEX
3	Beresford Street	NO ₂ , BTEX	12	Airport	BTEX
4	Union Street	NO ₂	13	Les Quennevais	NO ₂
5	New Street	NO ₂	14	Beaumont	NO ₂
6	Broad Street	NO ₂	15	Clos St Andre	BTEX
7	Weighbridge	NO ₂	16	Rue Des Raisies	NO ₂
8	Liberation Station	NO ₂	17	Handsford Lane	BTEX
9	Georgetown	NO ₂			

Table 2-2 BTEX Diffusion Tube Monitoring sites

Site Name	Grid Reference	Description
Beresford Street	653 486	Urban Roadside
Le Bas Centre	658 489	Urban Background
Faux Bie	658 495	Urban background near fuel filling station
Clos St Andre	638 499	Residential area near site of former Bellozanne Valley refuse incinerator (now closed).
Airport	587 509	Jersey Airport, on arrivals hall building overlooking car park.
Handsford Lane	633 499	Urban background near a paint spraying process.

2.5 Calendar of Diffusion Tube Exposure Periods

The calendar of exposure periods used for the NO₂ and BTEX diffusion tubes is shown in Table 2-3. They were intended to approximate to calendar months, while allowing for the tubes to be changed on a consistent day of the week.

Table 2-3 Diffusion Tube Exposure Periods

Month	Start Date	End Date
January	05/01/2010	03/02/2010
February	03/02/2010	02/03/2010
March	02/03/2010	31/03/2010
April	31/03/2010	27/04/2010
May	27/04/2010	02/06/2010
June	02/06/2010	30/06/2010
July	30/06/2010	04/08/2010
August	04/08/2010	01/09/2010
September	01/09/2010	29/09/2010
October	29/09/2010	03/11/2010
November	03/11/2010	01/12/2010
December	01/12/2010	05/01/2011

3 Quality Assurance and Data Capture

3.1 Quality Assurance And Quality Control

A full intercalibration audit of the Jersey Halkett Place air quality monitoring site takes place annually. In addition to instrument and calibration standard checking, the air intake sampling system is cleaned and all other aspects of site infrastructure are checked.

Following the instrument and calibration gas checking, and the subsequent scaling and ratification of the data, the overall accuracy and precision figures for the pollutants monitored at Jersey can be summarised as in Table 3-1. These are given in ppb, the “native” unit of the automatic data.

Table 3-1 Estimated Accuracy and Precision of the Data Presented

Pollutant	Precision	Accuracy %
NO	±5 ppb	±15%
NO ₂	±5 ppb	±15%

3.2 Data Capture

Overall data capture statistics for the monitoring site are given in Table 3-2. A data capture rate of 90% or greater for ratified data is recommended in the Defra Technical Guidance LAQM.TG(09)¹⁹.

Table 3-2 Jersey Halkett Place - Data Capture Statistics 2009

Site	NO	NO ₂	NO _x
Jersey Halkett Place	65.7 %	65.7 %	65.7 %

The Halkett Place site did not achieve the data capture target of 90%: there were two significant gaps in the data set, as shown in Table 3-3:

Table 3-3 Data Gaps 2010

Pollutant	Period	No. of Days	Reason
All	8 th – 30 th April	22	Pump failure (pump replaced on 30 th Apr.)
All	10 th Jun – 26 th Aug	77	Analyser sent off for service by contractor (SupportingU). Contractor did not return it for 6 weeks.

4 Results and Discussion

4.1 Presentation of Results

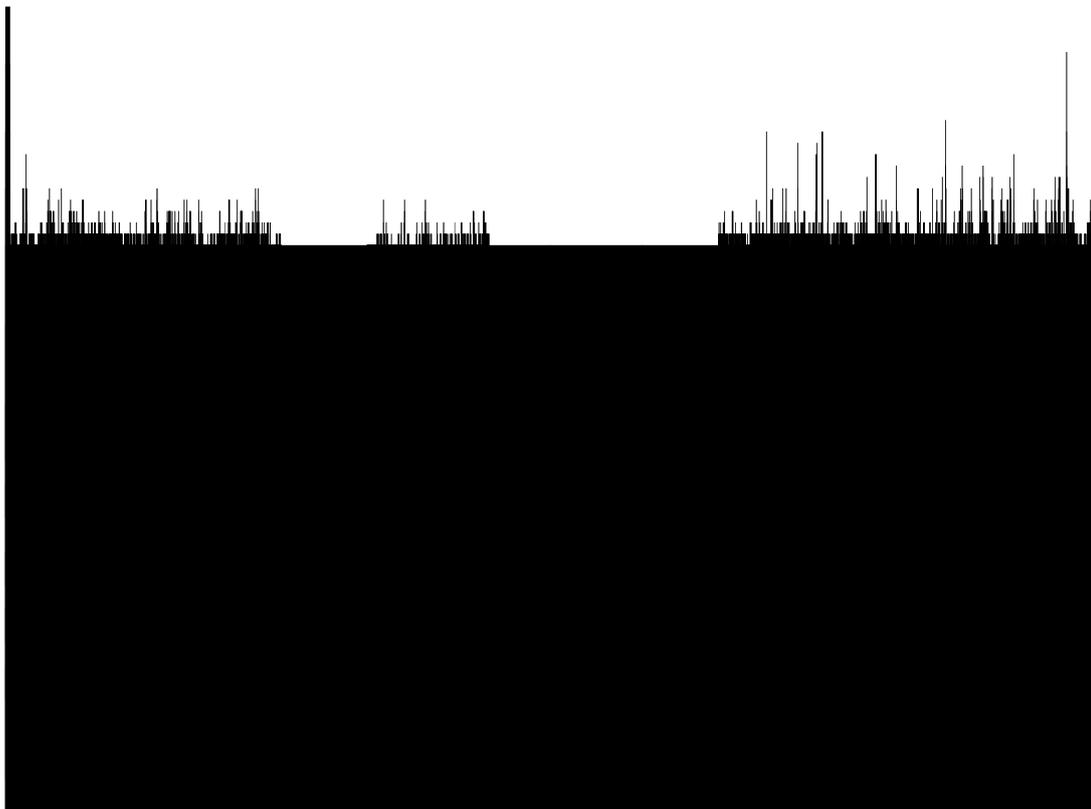
4.1.1 Automatic NO₂ Monitoring Results

Table 4-1 shows the key statistics for oxides of nitrogen measured by the automatic analyser at Halkett Place. Figure 4-1 shows timeseries plots of hourly mean NO, NO₂ and NO_x concentrations.

Table 4-1 Oxides of Nitrogen: Air Quality Statistics for 2010

POLLUTANT	NO µg m ⁻³	NO ₂ µg m ⁻³	NO _x µg m ⁻³
Maximum 15-minute mean	585	273	1079
Maximum hourly mean	323	139	590
Maximum running 8-hour mean	125	81	260
Maximum running 24-hour mean	73	59	163
Maximum daily mean	70	58	157
Average	17	29	54
Data capture	65.7 %	65.7 %	65.7 %

Figure 4-1 Time series plots of hourly mean pollutant concentrations at Halkett Place, 2010



4.1.2 NO₂ Diffusion Tube Results

NO₂ diffusion tube results are presented in Table 4-2 and Figure 4-2. Although reported by the analyst to two decimal places, the monthly mean results reported here have been rounded to the nearest integer, in view of the estimated uncertainty of $\pm 25\%$ on diffusion tube measurements. (There are two exceptions - Les Quennevais and Rue des Raisies – where concentrations are typically less than $10 \mu\text{g m}^{-3}$: these sites' results are given to one decimal place).

Individual monthly mean NO₂ results ranged from $4.0 \mu\text{g m}^{-3}$ (in August at the rural Rue des Raisies site), to $61 \mu\text{g m}^{-3}$ (in November, at the roadside Liberation Station site). The latter result was higher than typical results at Liberation Station, but there was no obvious reason to believe it was spurious.

One tube went missing from a site: December's tube at Les Quennevais.

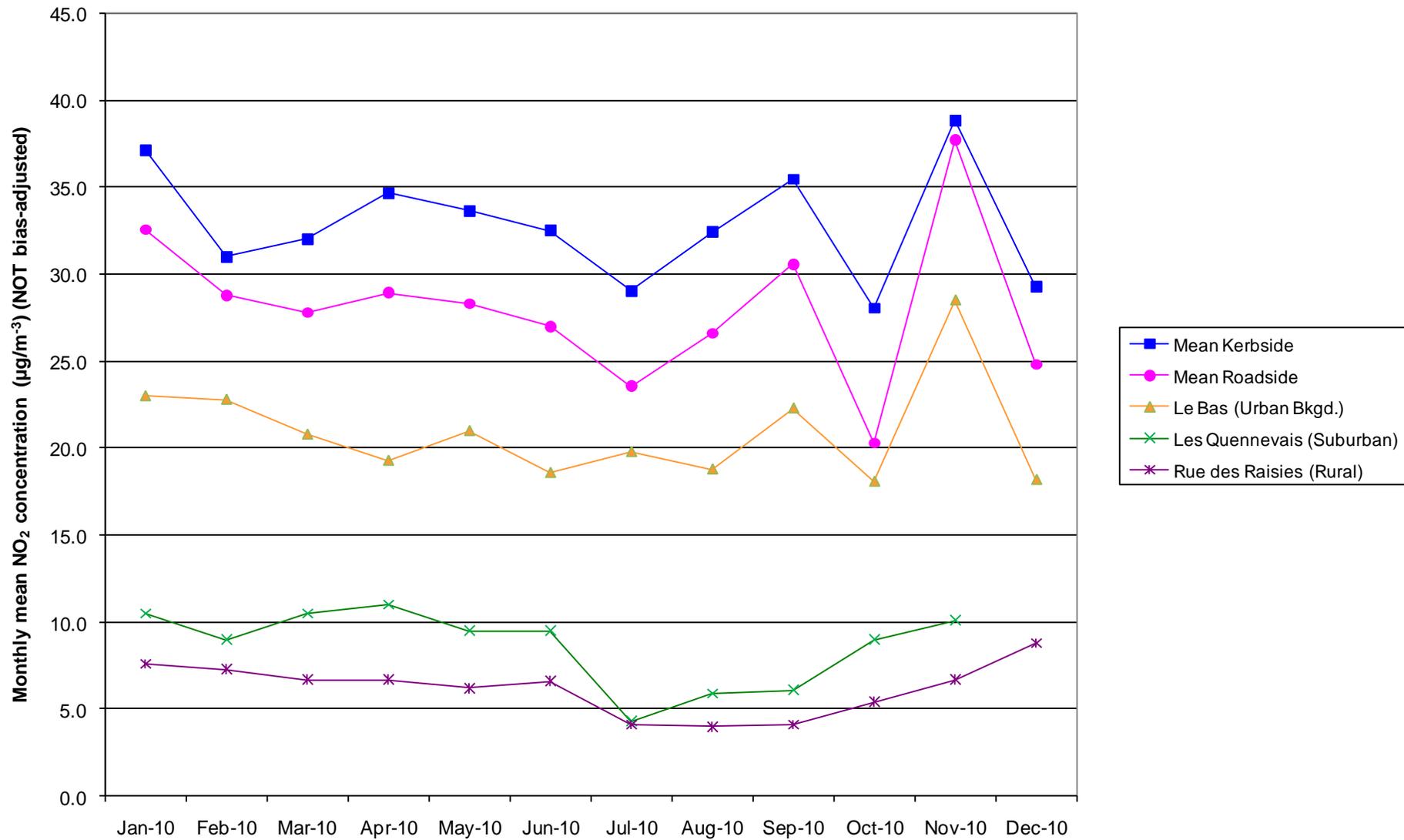
Results from the Halkett Place site (where diffusion tubes are co-located with an automatic analyser) were used to calculate a bias adjustment factor of 0.93 - see Appendix 3. Annual mean NO₂ concentrations (after application of this bias adjustment factor) ranged from $5.8 \mu\text{g m}^{-3}$ (at the rural Rue des Raisies site) to $33 \mu\text{g m}^{-3}$ at the kerbside Weighbridge and Beaumont sites in the centre of St Helier. The latter two sites, especially Weighbridge, have historically produced relatively high results.

Table 4-2 NO₂ Diffusion Tube Results 2010, Jersey. Concentrations (rounded) in µg m⁻³

Site	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Annual Mean µg m ⁻³	Annual mean x BAF µg m ⁻³
Beaumont (K)	41	31	30	42	38	39	29	30	37	28	45	38	36	33
Broad Street (K)	36	34	34	30	32	29	32	37	37	29	36	22	32	30
Georgetown (K)	38	32	35	41	33	38	28	28	34	32	39	32	34	32
The Parade (K)	31	25	28	26	24	22	22	27	29	24	32	25	26	24
Weighbridge(K)	39	33	32	35	41	35	35	40	40	28	43	30	36	33
Halkett Place tube 1	35	33	32	30	31	31	27	27	34	26	35	26	-	-
Halkett Place tube 2	36	30	32	30	32	31	27	25	34	28	35	26	-	-
Halkett Place tube 3	38	30	30	32	41	31	25	28	35	27	35	26	-	-
Halkett Place mean (R)	36	31	31	31	35	31	26	27	34	27	35	26	31	29
Liberation Station (R)	37	30	28	38	32	33	26	31	40	10	61	30	33	30
New Street (R)	25	24	21	18	19	17	15	19	18	19	20	19	19	18
Union Street (R)	32	31	32	30	28	27	28	31	31	26	35	25	30	27
Le Bas Centre(UB)	23	23	21	19	21	19	20	19	22	18	29	18	21	19
Les Quennevais (S)	10.5	9.0	10.5	11.0	9.5	9.5	4.3	5.9	6.1	9.0	10.1	* n/a	8.7	8.1
Rue des Raisies (Ru)	7.6	7.3	6.7	6.7	6.2	6.6	4.1	4.0	4.1	5.4	6.7	8.8	6.2	5.8

December tube at Les Quennevais was missing, presumed stolen.

Figure 4-2 Comparison of Annual Mean Nitrogen Dioxide Concentrations at All Jersey Sites, 2010 (NOT Bias Adjusted)



4.1.3 Precision and Accuracy of NO₂ Diffusion Tubes

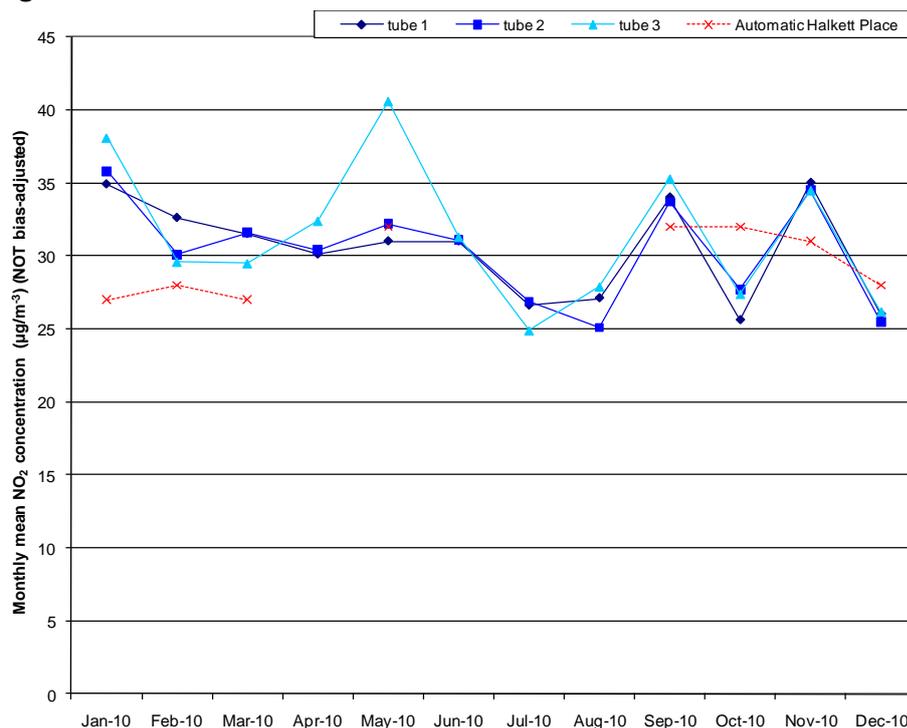
Diffusion tubes are an indicative monitoring technique: although they are economical and easy to use, they do not give the same level of precision and accuracy as more expensive automatic monitoring methods. For this reason, as explained in section 2.3 above, the Local Air Quality Management Technical Guidance LAQM.TG(09)¹⁹ states that when using diffusion tubes for indicative NO₂ 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 NO₂.

This is usually done by co-locating diffusion tubes with a chemiluminescent analyser and comparing the results of the two methods. The co-location site in this study was Halkett Place. By exposing diffusion tubes in triplicate at this site, it was possible to compare their precision and accuracy with that of the automatic monitor, and to calculate a “bias adjustment factor” which could be applied to the annual mean NO₂ concentrations measured at the other diffusion tube sites, in order to correct for any “bias”.

The mean NO₂ concentration as measured by the diffusion tubes was 32 µg m⁻³, compared to 30 µg m⁻³ as measured by the reference automatic method (excluding months for which data capture was less than 75%). The “bias adjustment factor” calculated for the whole year was 0.93. (Note: the annual mean of 30 µg m⁻³ from the automatic analyser used here is slightly different from the value of 29 µg m⁻³ reported above, because the former is the mean of the eight months with at least 75% data capture).

Exposing tubes in triplicate allowed an investigation of diffusion tube precision. Precision may be expressed in terms of the coefficient of variation (CV) of the three replicate measurements. This parameter, also known as the relative standard deviation, is the standard deviation expressed as a percentage of the mean. For diffusion tubes exposed in triplicate, the CV is usually expected to be within 10% on average. This is based purely on experience of what a competent laboratory is typically able to achieve, although it can be affected by conditions at the site. It is not uncommon for diffusion tube precision to occasionally be poor; this is not a cause for concern if the precision over the rest of the year is consistently good. At Central Market, the CV of the monthly tube triplets ranged from <1% to 15%, with a mean of 5%. There was one month when this value was particularly high. In May, the three results were 31 µg m⁻³, 32 µg m⁻³ and 41 µg m⁻³. However, none have been rejected from the dataset.

Figure 4-3 shows the monthly mean NO₂ concentrations, as measured by diffusion tubes and by the automatic analyser, at Halkett Place. (Monthly means from the automatic analyser for April, June, July and August have been excluded due to low data capture). In the months which do have good data capture however, agreement between the two methods was good.

Figure 4-3 Co-location Results at Halkett Place

4.2 Comparison with NO₂ Guidelines, Limit Values, and Objectives

Limit Values, AQS Objectives and WHO guidelines for NO₂ are shown in Appendix 1. These are based on the hourly and annual means.

The WHO non-mandatory guideline¹⁶ for NO₂ is that the annual mean should not exceed 40 µg m⁻³ NO₂. The Ambient Air Quality Directive¹⁷ contains Limit Values for NO₂ as follows:

- 200 µg m⁻³ as an hourly mean, not to be exceeded more than 18 times per calendar year. To have been achieved by 1st January 2010.
- 40 µg m⁻³ as an annual mean, for protection of human health. To have been achieved by 1st January 2010.
- There is also a limit for annual mean total oxides of nitrogen (NO_x), of 30 µg m⁻³, for protection of vegetation (relevant in rural areas).

The UK Air Quality Strategy¹⁸ contains Objectives for NO₂, which are very similar to the EC Directive limits above: the only difference being that they had to be achieved by 31st December 2005.

The 1-hour mean at the Halkett Place automatic monitoring site remained below 200 µg m⁻³ throughout 2010. Therefore this site meets the hourly mean EC Directive Limit Value and AQS Objective for this parameter. The annual mean concentration of 29 µg m⁻³ as measured by the automatic analyser at Halkett Place is well within the EC Limit Value of 40 µg m⁻³.

Because of the long sampling period of diffusion tubes, it is only possible to compare the results from the diffusion tube sites in this study against limit values relating to the annual mean. Annual mean NO₂ concentrations did not exceed 40 µg m⁻³ at any sites in 2010. Therefore, all diffusion tube sites met the Limit Value for annual mean NO₂ concentration.

The highest annual mean concentration of $33 \mu\text{g m}^{-3}$ (after bias adjustment) was measured at Weighbridge, an urban kerbside site in the centre of St Helier that has recorded some of Jersey's highest annual mean NO_2 concentrations throughout previous years of this survey.

The $30 \mu\text{g m}^{-3}$ limit for protection of vegetation is only applicable at rural sites, and is therefore only relevant to Rue des Raisies. The annual mean NO_2 concentration of $5.8 \mu\text{g m}^{-3}$ at this rural site was well within the Limit Value.

4.3 Diurnal and Seasonal Variation in NO_2 Concentration

4.3.1 Diurnal variation in NO_2 concentration at Halkett Place

Figure 4-4 shows how concentrations of nitrous oxide (NO), nitrogen dioxide (NO_2) and total oxides of nitrogen (NO_x) typically varied over the course of the day during 2010, as measured by the automatic monitor at Halkett Place.

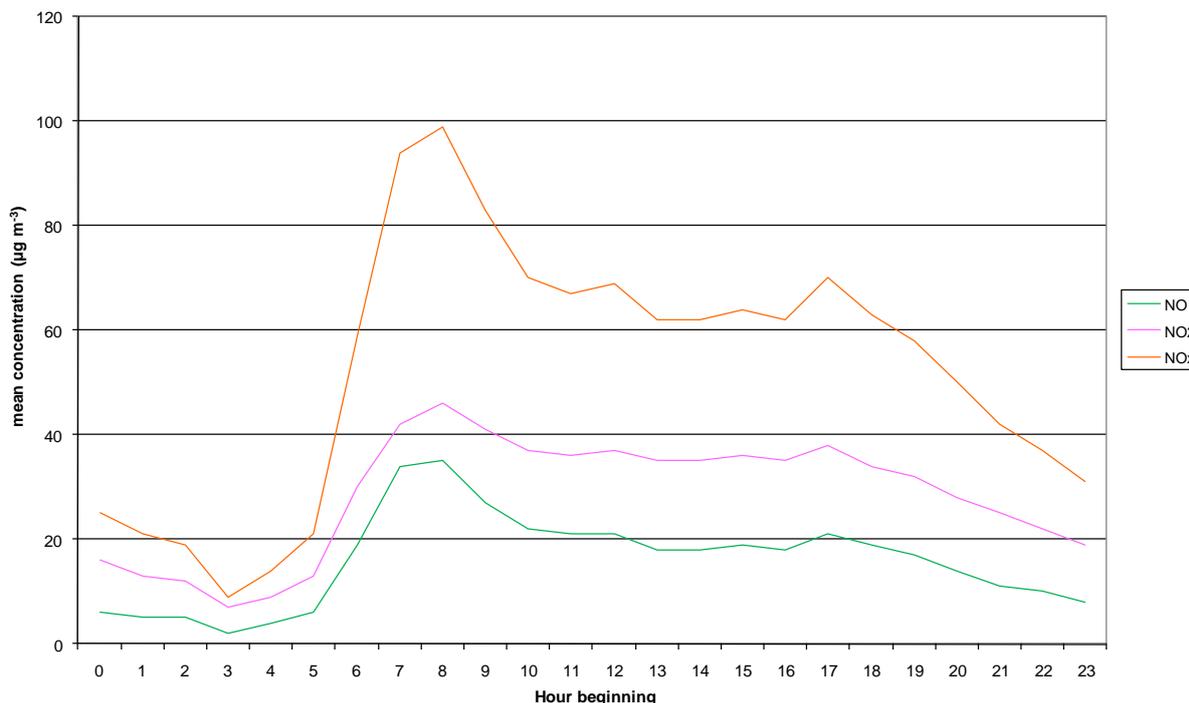
The curve for NO (which is a primary pollutant, i.e. directly emitted from source, and arises from road vehicles and other combustion sources) shows a sharp morning peak at 0700 - 0800. Concentrations then decrease during the late morning, remaining on a "plateau" for the rest of the afternoon, before concentrations begin to fall again at around 1800. There is barely any afternoon or evening rush-hour peak.

For NO_2 , which has both primary (directly emitted) and secondary (due to oxidation of NO) components, there is also an early morning peak, decreasing to a plateau through the rest of the morning and afternoon. There is a small peak at the time of the afternoon rush hour, but it is much less pronounced than that observed in the morning.

Based on AEA's experience with data from the Automatic Urban and Rural Network, the morning peak in NO and NO_2 is typical for urban sites, reflecting the increased levels of these pollutants associated with morning rush-hour traffic. However, at Halkett Place it is particularly early and particularly sharp. This may be explained by the fact that there is a market at Halkett Place every day except Sundays: the peak coincides with the time at which the market traders arrive and set up for the day. In addition, a skip lorry arrives at this time to collect the previous day's refuse. It is believed that vehicle emissions from these activities are responsible for the distinctive morning pattern at Halkett Place.

Halkett Place does not exhibit a substantial afternoon or evening rush-hour peak (as observed at many roadside AURN sites). This is unusual for an urban site: in the afternoon, concentrations of oxidising agents, particularly ozone, in the atmosphere tend to increase, leading to enhanced oxidation of NO to NO_2 . This typically causes the afternoon NO_2 peak at many urban sites to be higher than the morning NO_2 peak. However, this is not the case at Halkett Place. The likely reason is that there is no afternoon traffic "rush hour" in this area. Most traffic is associated with the market and with shoppers, and occurs during the morning - afternoons are relatively quiet.

Figure 4-4 Diurnal variation in concentrations of NO, NO₂ and total NO_x at Halkett Place, 2010

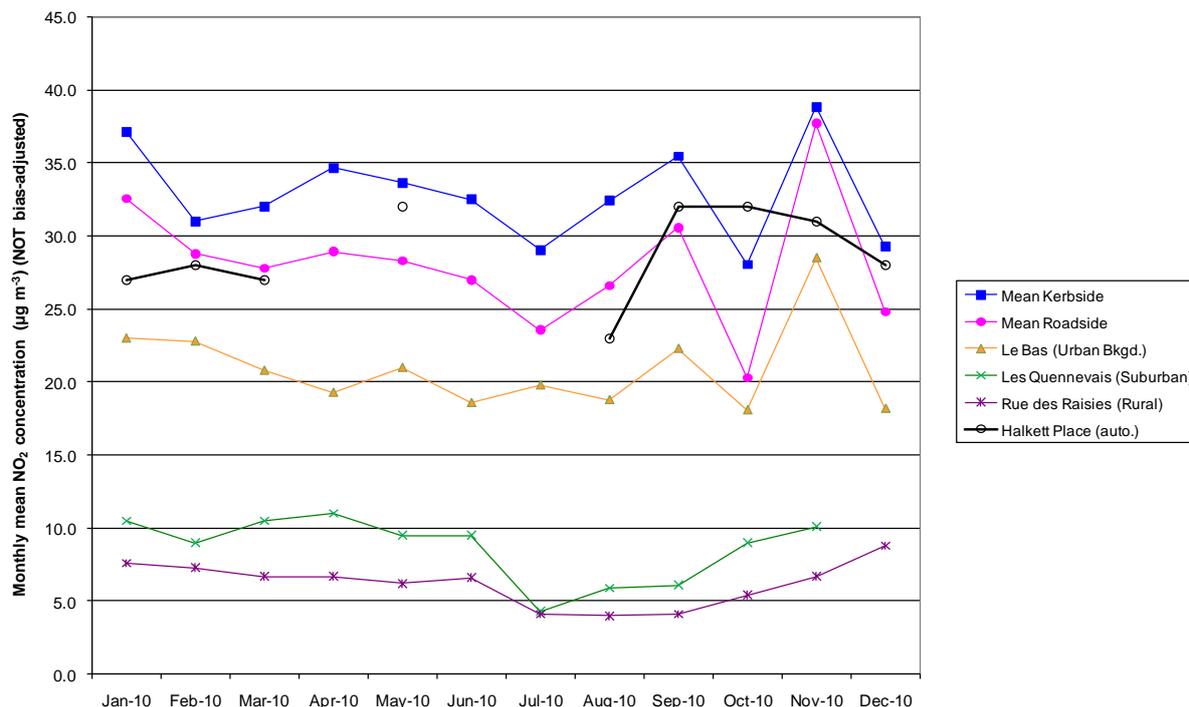


4.3.2 Seasonal variation in NO₂ concentration

Figure 4-5 shows the monthly mean NO₂ concentrations measured at the diffusion tube sites and at Halkett Place. This shows the mean of the five kerbside sites, mean of the four roadside sites, and the monthly means measured at the single urban background site (Le Bas Centre), urban residential site (Les Quennevais) and rural site (Rue des Raisies). Monthly means (based on the same periods as the diffusion tube exposures) are also shown for the Halkett Place automatic site.

The typical pattern in urban areas is for NO₂ concentrations to be generally higher in the winter and lower in the summer. However, the sites in Jersey did not show any clear seasonal pattern. (The previous year’s data also showed no clear seasonal pattern).

Figure 4-5 Monthly mean NO₂ concentrations (NOT bias adjusted) at Diffusion Tube sites and Halkett Place



4.3.3 Comparison with UK NO₂ data

Table 4-3 compares the annual NO₂ concentration measured at Halkett Place with those measured at a selection of UK air quality monitoring stations using automatic (chemiluminescent) NO₂ 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.
- Brighton Roadside – a roadside site in the coastal city of Brighton, Sussex.
- Brighton Preston Park – an urban background site in Brighton.
- Southend on Sea – an urban background site in the coastal town of Southend, Essex.
- Harwell - a rural site in the south of England, within 10km of a power station.
- Yarner Wood – a rural moorland site in Devon.

Table 4-3 Comparison of NO₂ in Jersey with UK Automatic Sites

Site	2010 Annual mean NO ₂ concentration, µg m ⁻³
Exeter Roadside	40
Brighton Roadside	34
Brighton Preston Park	22
Southend on Sea	23
Harwell	11.7
Yarner Wood	4.9
Halkett Place (auto.)	29

After bias adjustment, the annual mean NO₂ concentrations measured at the kerbside and roadside sites in Jersey (rounded to the nearest integer) ranged from 18 to 33 µg m⁻³. The annual means at Exeter Roadside and Brighton Roadside (34 µg m⁻³ and 40 µg m⁻³ respectively) were just above this range, and both were higher than the annual mean of 29 µg m⁻³ measured by the automatic analyser at Halkett Place. The Jersey urban background site at Le Bas Centre had a (bias adjusted) annual mean NO₂ concentration of 19 µg m⁻³; a little lower than the annual means from the urban background sites in Southend and Brighton Preston Park. The residential background site at Les Quennevais had a bias-adjusted annual mean NO₂ concentration of 8 µg m⁻³: this is comparable with Harwell. The bias-adjusted annual mean of 5.8 µg m⁻³ at the Jersey rural background site, Rue des Raisies was comparable with that measured at Yarner Wood, the rural moorland site in Devon.

4.3.4 Trends in Nitrogen Dioxide at Long-Running Sites

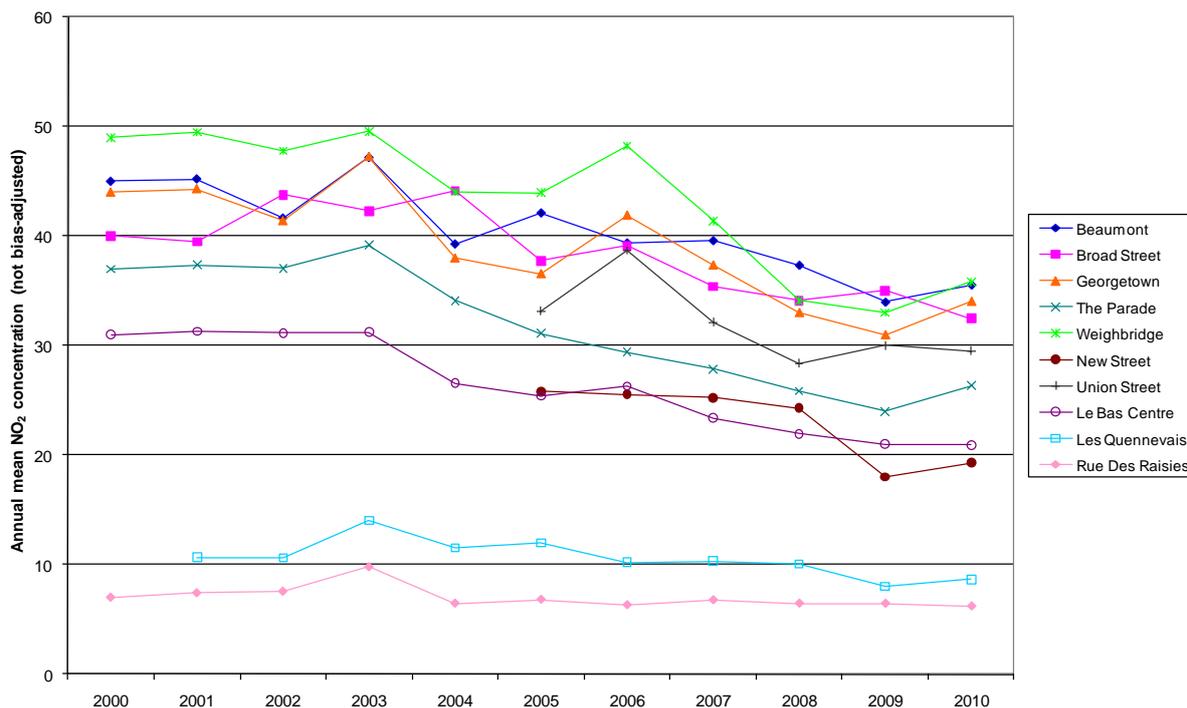
There are ten sites in the survey which have been in operation since 2005 or earlier, and therefore have five or more years' data. The annual mean NO₂ concentrations are shown in Table 4-4 and illustrated in Figure 4-6. These data are not adjusted for diffusion tube bias; prior to 2002 there was no reliable information on which to carry out bias adjustment, so for consistency, unadjusted data are used in this section.

Annual mean NO₂ concentrations at the kerbside, roadside and urban background sites (Weighbridge, Georgetown, Beaumont, the Parade, Broad Street, and Le Bas) gave cause for concern in the early years of the study (2000 to 2003). Many were above the EC Directive Limit Value of 40 µg m⁻³, and there was no sign of concentrations decreasing. However, from 2004 onwards, concentrations began to decrease, and all are now comfortably within the Limit Value.

Table 4-4 Annual mean NO₂ concentrations at Diffusion Tube Sites, µg m⁻³ (not bias adjusted)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Beaumont	45	45	42	47	39	42	39	40	37	34	36
Broad Street	40	39	44	42	44	38	39	35	34	35	32
Georgetown	44	44	41	47	38	37	42	37	33	31	34
The Parade	37	37	37	39	34	31	29	28	26	24	26
Weighbridge	49	49	48	50	44	44	48	41	34	33	36
New Street						26	26	25	24	18	19
Union Street						33	39	32	28	30	30
Le Bas Centre	31	31	31	31	27	25	26	23	22	21	21
Les Quennevais		11	11	14	12	12	10	10.3	10.1	8.0	8.7
Rue Des Raisies	7	7	8	10	6	7	6	6.8	6.5	6.4	6.2

Figure 4-6 Annual Mean NO₂ Concentrations (not adjusted for diffusion tube bias).



In general, annual mean concentrations in 2010 were consistent with those in 2009. The downward trend observed at roadside and kerbside sites between around 2003 and 2009 appears to have flattened off in the past two years.

As highlighted in the 2009 report, New Street showed a substantial decrease in 2009. This is thought to be due to a reduction in traffic flow: New Street is now open to access traffic only. By contrast, Union Street was reported to be carrying a greater quantity of traffic, which may possibly have accounted for the observed increase in NO₂ concentration in 2009.

4.4 Hydrocarbons

Full monthly results of the hydrocarbon survey for the six sites are shown in Appendix 4, Tables A4.1 to A4.7. A summary of annual average hydrocarbon concentrations is shown in Table 4-5.

Each batch of tubes was accompanied by a travel blank, whose purpose is explained in section 2.3. These were analysed alongside the exposed tubes, and the results (expressed as equivalent concentrations) have been included in Table 4-5. Travel blank tubes would normally be expected to give consistently lower results compared with exposed tubes, and ideally be at or below the limit of detection (equivalent to an ambient concentration of 0.10-0.12 µg m⁻³ assuming a four week exposure period, or 0.08-0.10 µg m⁻³ for a five week exposure period, depending on the hydrocarbon species).

While the travel blank levels of xylenes were consistently low during 2010, this was not the case for benzene, toluene and ethylbenzene, as some blanks were higher than would be expected.

Table 4-5 Summary of Average Hydrocarbon Concentrations ($\mu\text{g m}^{-3}$), Jersey, 2010

Site	Benzene	Toluene	Ethylbenzene	m+p Xylene	o Xylene
Beresford Street	1.4	4.7	1.1	3.5	1.5
Le Bas Centre	1.0	3.6	0.9	2.5	1.2
Handsford Lane (paint spraying)	0.8	2.6	2.0	7.1	2.5
Faux Bie (Houses near petrol station)	1.8	6.7	1.4	4.0	1.6
Clos St Andre	0.5	1.3	0.6	1.2	0.7
Airport	0.6	1.6	0.3	0.7	0.5
Travel Blanks (equivalent concentration)	0.37	0.23	0.19	0.09 (< LoD)	0.07 (< LoD)
Limit of detection concentration equivalent (assuming 4 week exposure)	0.12	0.10	0.11	0.11	0.11
Limit of detection concentration equivalent (assuming 5 week exposure)	0.10	0.08	0.09	0.09	0.09

Full data capture was not achieved: missing results are as follows. The November and December 2010 tubes went missing from the Beresford Street site (presumed stolen). The January tube from Handsford Lane, and the October tube from the Airport, arrived back at the laboratory without their end caps, and had therefore been unsealed and still sampling throughout the return journey. Results of these tubes have therefore been rejected. The results from the September tube at Faux Bie were also discarded: levels of all hydrocarbon species were reported as being less than the limit of detection. These results were thought unlikely to be genuine and more likely the result of a faulty tube.

An unusually high toluene concentration was measured at the Airport site in November. This has not been rejected as there is no evidence that it is not genuine.

The site at Faux Bie (which is at the nearest housing to a petrol station) measured highest annual mean concentrations of both benzene and toluene. It is likely that evaporation of these compounds from fuel is the cause. However, 2010 was the first full year of data from this site, so it is not yet possible to say whether these concentrations are typical. It should be noted that hydrocarbon concentrations at this site are much lower than those measured at the former Springfield Garage site which it replaced in 2009. Monitoring is based on a 4-weekly exposure period, so it is not possible to compare the results directly with the WHO guideline value for toluene, of $260 \mu\text{g m}^{-3}$ for the weekly mean.

As in previous years, the Handsford Lane site (near a paint spraying process) measured highest levels of xylenes. However, benzene and toluene concentrations at Handsford Lane

were lower than those at Beresford Street or Le Bas; the nearby paint spraying process is not a significant source of benzene or toluene.

The Airport site, and Clos St Andre, which are in rural surroundings, recorded the lowest annual mean concentrations of all the BTEX hydrocarbons.

Graphical representations of monthly mean hydrocarbon concentrations are shown in Figures 4-7 to 4-12. All six figures use an identical y-axis, for ease of comparison

Figure 4-7 Monthly mean hydrocarbon concentrations at Beresford Street, 2010

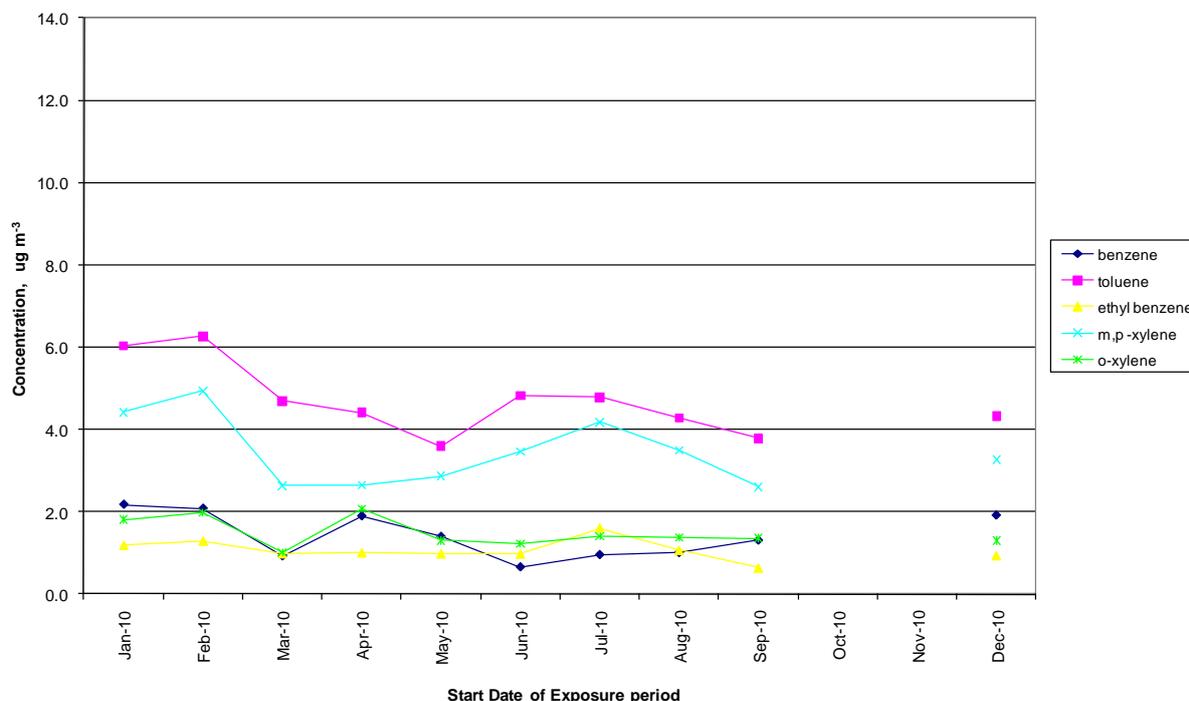


Figure 4-8 Monthly mean hydrocarbon concentrations at Le Bas Centre, 2010

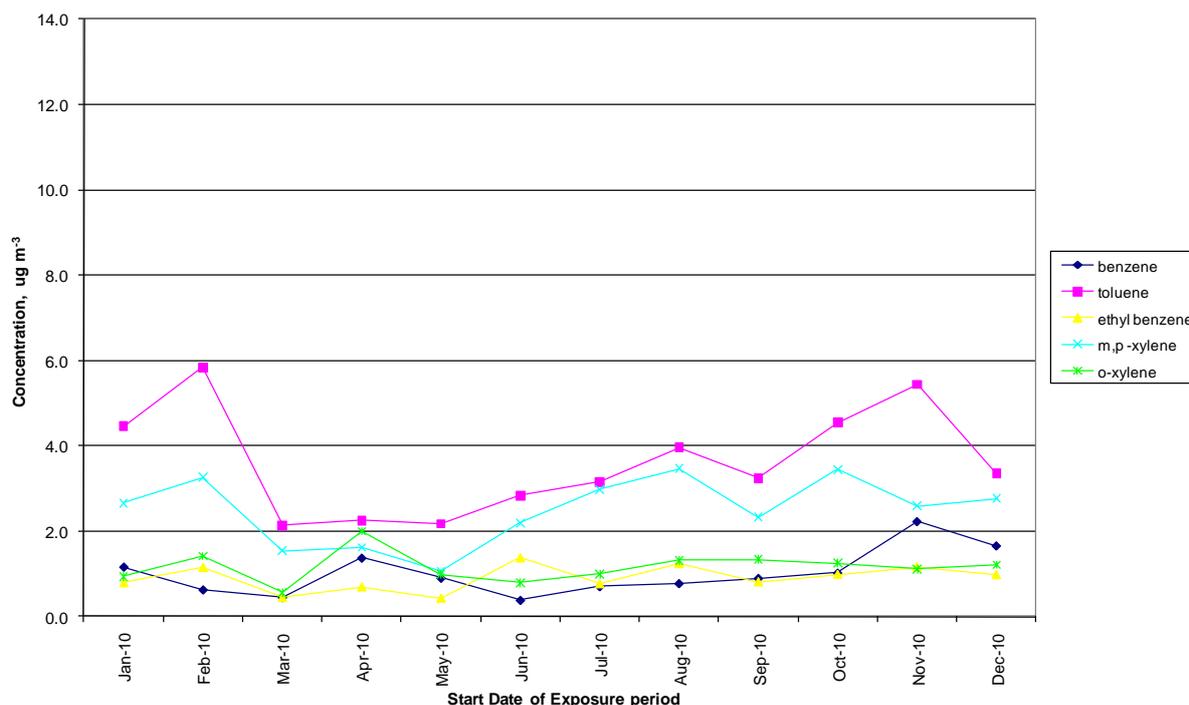


Figure 4-9 Monthly mean hydrocarbon concentrations at Handsford Lane, 2010

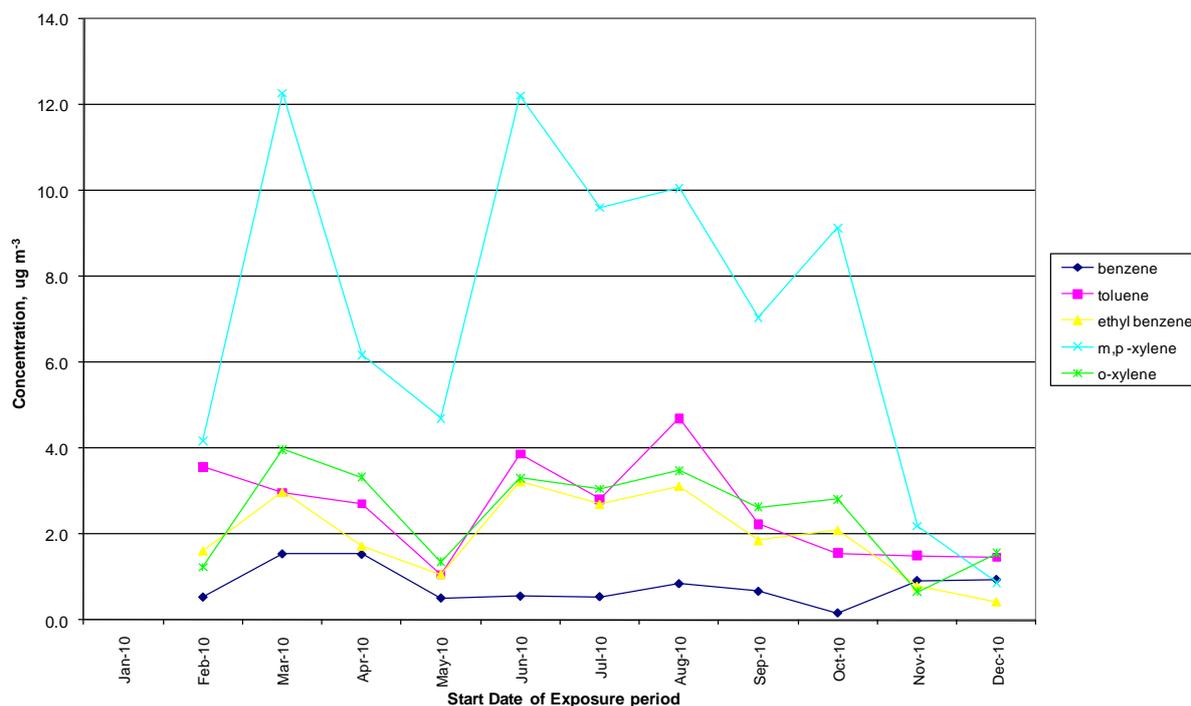


Figure 4-10 Monthly mean hydrocarbon concentrations at Faux Bie, 2010

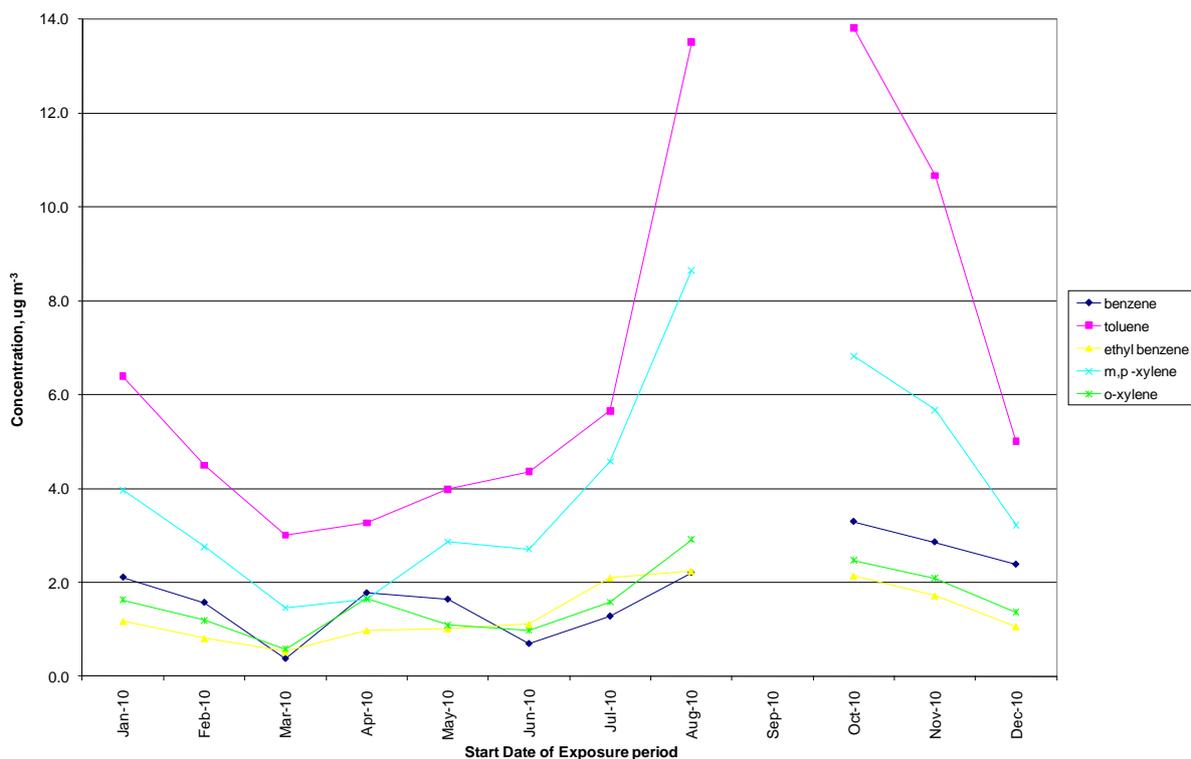


Figure 4-11 Monthly mean hydrocarbon concentrations at Clos St Andre, 2010

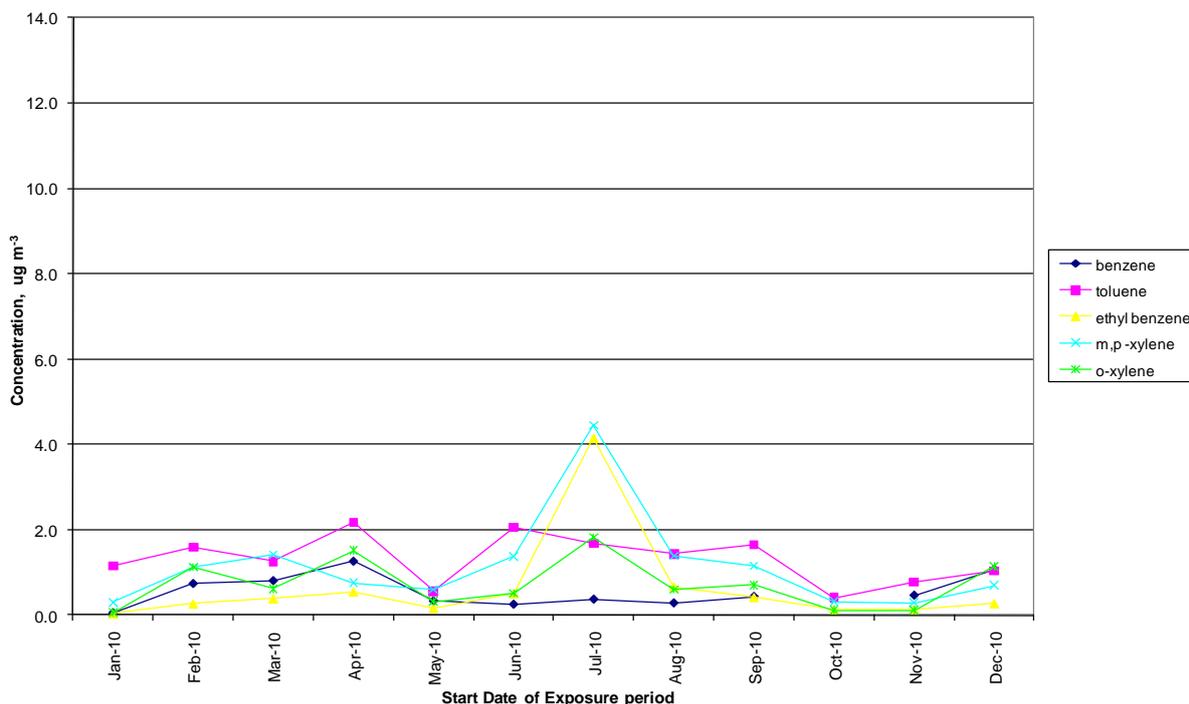
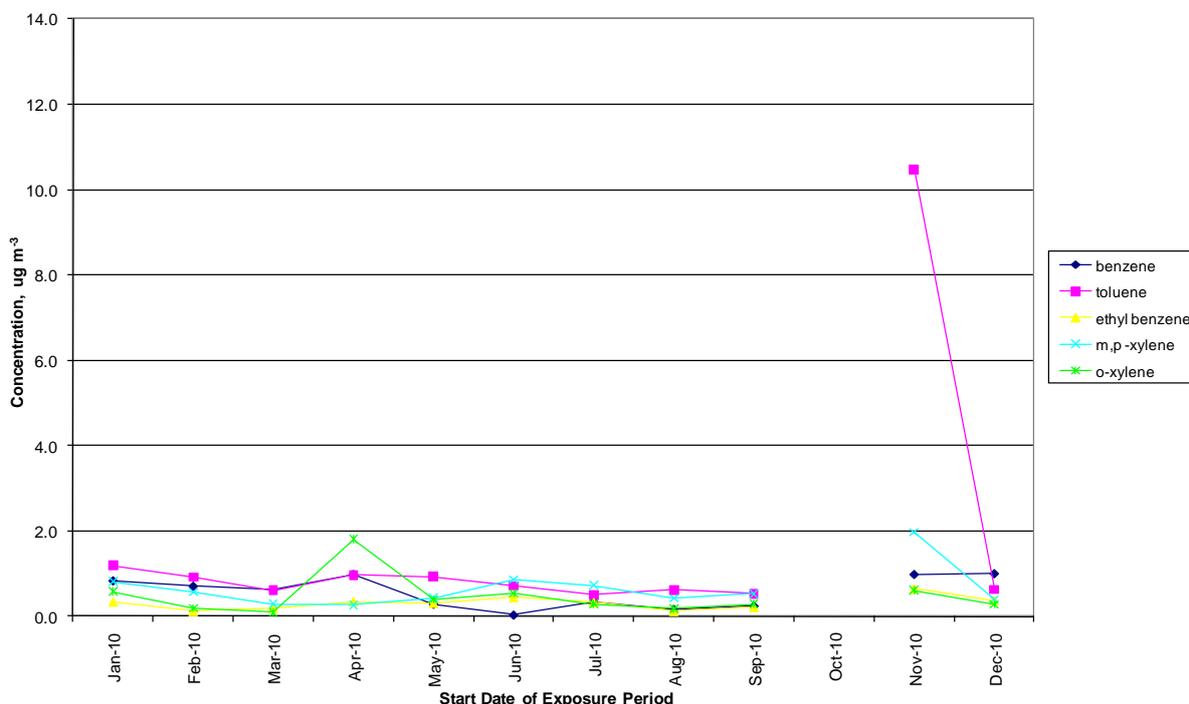


Figure 4-12 Monthly mean hydrocarbon concentrations at the Airport, 2010



4.4.1 Comparison With Limit Values and Objectives

Of the hydrocarbon species monitored, only benzene is the subject of any applicable air quality standards. The EC Directive on Ambient Air Quality and Cleaner Air for Europe¹⁷ sets a limit of 5 $\mu\text{g m}^{-3}$ for annual mean benzene, to be achieved by 2010. All sites met this limit in 2010.

The UK Air Quality Strategy¹⁸ sets the following objectives for benzene:

- 16.25 $\mu\text{g m}^{-3}$ (for the running annual mean), to have been achieved by 31st December 2003
- $\mu\text{g m}^{-3}$ (for the calendar year mean), to have been achieved by 31st December 2010 in England and Wales. This is the same as the EC Limit Value.
- 3.25 $\mu\text{g m}^{-3}$ (for the calendar year mean), to have been achieved by 31st December 2010 in Scotland and Northern Ireland.

These AQS Objectives are not at present mandatory in Jersey.

The annual mean benzene concentration (which can be considered a good indicator of the running annual mean) was well within the 2003 Objective of 16.25 $\mu\text{g m}^{-3}$ at all the Jersey sites. The calendar year mean benzene concentration was below 3.25 $\mu\text{g m}^{-3}$ at all Jersey sites. Therefore these sites meet the tightest AQS objectives for benzene (those applying to Scotland and Northern Ireland).

4.4.2 Comparison with UK Benzene Data

Benzene is measured throughout the UK, by the Non-Automatic Hydrocarbons Network. This network uses the pumped-tube sampler, which is defined within Europe as the reference method. Annual mean concentrations from the pumped-tube sites ranged from 0.3 $\mu\text{g m}^{-3}$ (at the urban background site Oxford St Ebbes) to 1.8 $\mu\text{g m}^{-3}$ (at Killingholme, in an industrial area of Humberside).

Table 4-6 compares benzene data from the Jersey sites, with four sites in the Non-Automatic Hydrocarbon Network:

- Plymouth – an urban background site in the coastal city of Plymouth, Devon
- Southampton – a roadside site in the city of Southampton
- Birmingham Roadside 2 – a roadside site beside the Stratford Road, a major route into the city centre.
- Killingholme – site with rural surroundings but in a generally industrial area between Grimsby and Hull in Humberside.

It is important to note that the Non-Automatic Hydrocarbon Network uses a different measurement technique to the Jersey sites. Therefore this comparison should be treated as *indicative only*.

Table 4-6 Comparison with Benzene Concentrations at Other UK Sites, 2010

Site	2010 Annual Mean Benzene, $\mu\text{g m}^{-3}$
Jersey Sites	
Beresford Street	1.4
Le Bas Centre	1.0
Handsford Lane (paint spraying process)	0.8
Faux Bie (petrol station)	1.8
Clos St Andre	0.5
Airport	0.6
Mainland UK sites	
Plymouth	0.6
Southampton	0.8
Birmingham Roadside 2	1.3
Killingholme	1.8

The annual mean benzene concentration at Jersey’s traffic-related urban sites (Beresford Street and Le Bas Centre) was typically higher than the UK Network urban centre sites such as Southampton and Plymouth, and closer to that at roadside sites such as Birmingham Roadside 2. The annual mean benzene concentration at Faux Bie (near the petrol station) was the same as that reported from the Killingholme site.

Prior to 2006 it was reported that benzene levels at Clos St Andre and the Airport were lower than typical UK urban levels. However, UK urban levels appear to have decreased at a greater rate than those at the above two Jersey sites, and there are now several UK mainland sites (such as Plymouth) with annual mean benzene concentrations comparable to those at Clos St Andre and the Airport. However, the difference in measurement techniques should be borne in mind when making any comparisons.

4.4.3 Comparison with Previous Years' Hydrocarbon Results

Figure 4-13 to Figure 4-17 show how annual mean hydrocarbon concentrations at the six Jersey sites have changed over the years of monitoring. These data are also provided in tabular form in Appendix 4. The graphs do not show the former sites at Springfield Garage (closed 2009) and Elizabeth Lane (closed 2003).

Annual mean levels of hydrocarbons in 2010 were comparable with those measured in 2009 and recent years. It is important to remember that pollutant concentrations are expected to show considerable year-to-year variation, due to meteorological and other factors. Year-to-year changes are therefore of less importance than the observation of long-term trends, which are discussed below.

Figure 4-13 Trends in Benzene Concentration

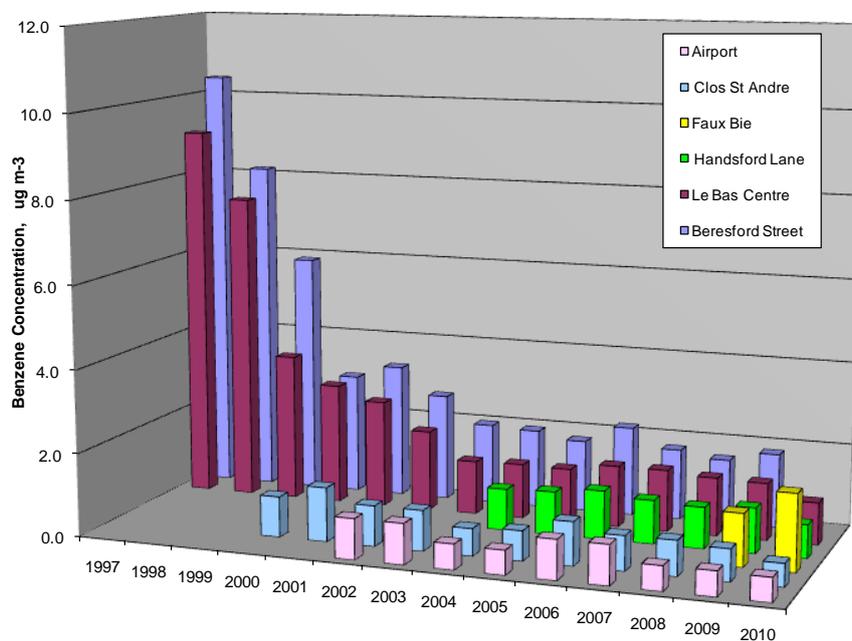


Figure 4-14 Trends in Toluene Concentration

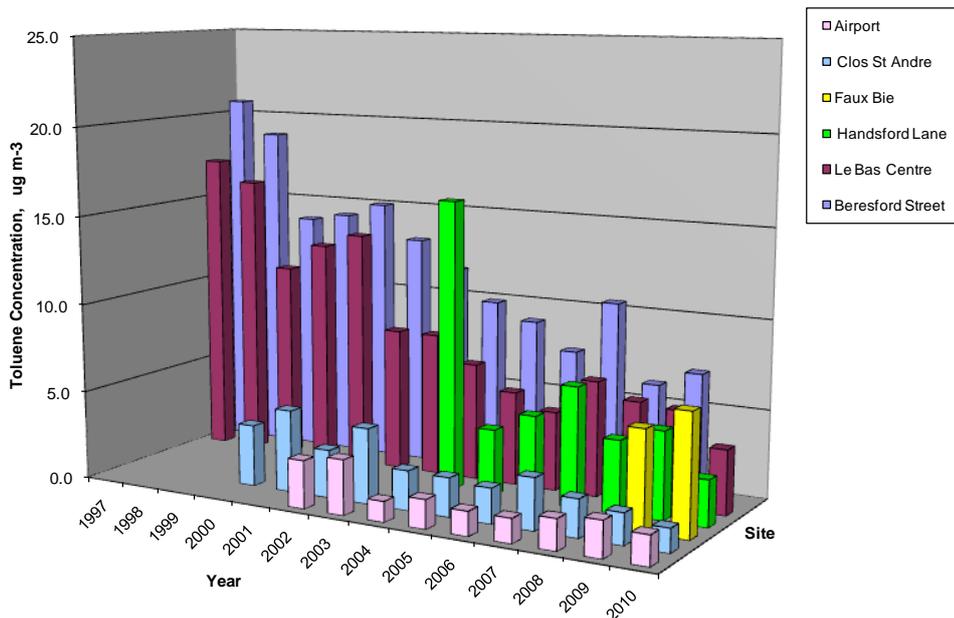


Figure 4-15 Trends in Ethylbenzene Concentration

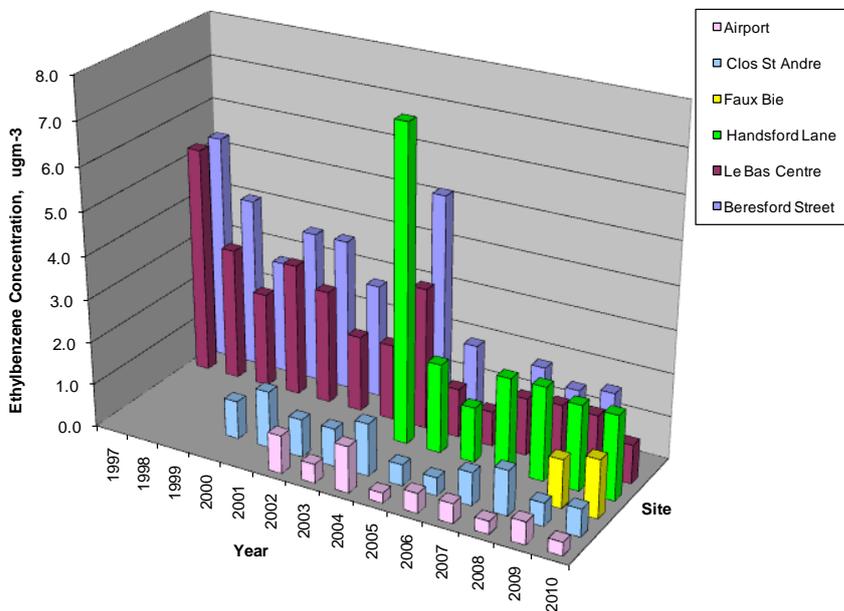


Figure 4-16 Trends in m+p- Xylene Concentration

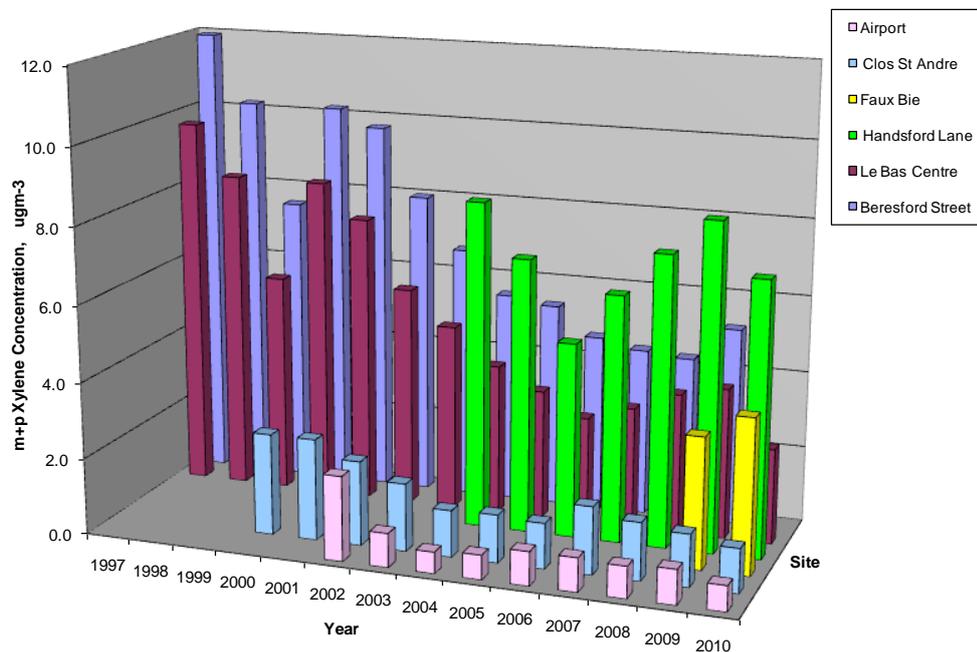
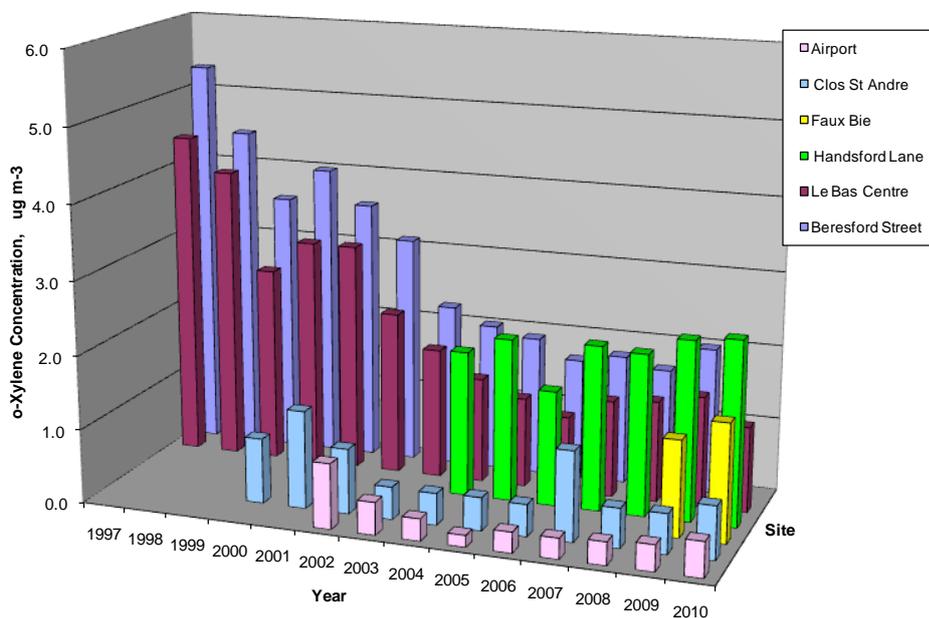


Figure 4-17 Trends in o-Xylene Concentration



Most hydrocarbon species appear to have decreased over the ten years of monitoring, being in most cases lower now than in the late 1990s. Key observations include:

- Benzene showed a marked drop in 2000 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. Concentrations have remained stable (with small fluctuations) since around 2004.

- Toluene concentrations show a downward trend over the earlier years of the survey (1997-2004), which appears to have resumed in the most recent years.
- Ethylbenzene concentrations have generally decreased, despite an unexplained increase in 2004. The high annual mean measured at Handsford Lane in 2004 does not appear to be typical of the site.
- Concentrations of m+p xylene, and of o-xylene, are now generally lower than in the early years of the survey. However, at Handsford Lane (near the paint spraying process), concentrations of m+p xylene appear to have risen year-on-year since 2006, after having decreased in the early years of monitoring at this site.
- The Airport site does not appear to show a clear downward trend in any hydrocarbon concentrations: however, levels there are already low.

5 Conclusions

AEA has continued the ongoing air quality monitoring programme in Jersey during 2010, on behalf of the States of Jersey Public Health Services. 2010 was the fourteenth year of monitoring. Oxides of nitrogen were monitored at one automatic monitoring station, located in a roadside position at the Central Market, Halkett Place in St Helier. This was supplemented by diffusion tubes for indicative monitoring of NO₂ at 12 sites around the island. Diffusion tubes were also co-located (in triplicate) with the automatic site at Halkett Place.

Hydrocarbons (benzene, toluene, ethyl benzene and xylenes, collectively termed BTEX) were measured at six sites, also using diffusion tubes. The sites were located at a range of different locations on the island, and two have been in operation since 1997. Conclusions of the monitoring programme were as follows:

5.1 NO₂ results

1. The maximum hourly mean NO₂ concentration at the Halkett Place automatic monitoring station was 139 µg m⁻³. The EC Directive Limit Value (and AQS Objective) for 1-hour mean NO₂ concentration of 200 µg m⁻³, with 18 exceedences permitted per calendar year; as the maximum hourly mean reported by this site was well within this value, Halkett Place easily met the Limit Value and Objective.
2. The annual mean NO₂ concentration at Halkett Place was 29 µg m⁻³, as measured by the automatic analyser. This is well within the EC Directive Limit Value and AQS Objective of 40 µg m⁻³ for annual mean NO₂.
3. Diffusion tubes exposed in triplicate alongside the automatic analyser showed good agreement with the reference method, giving an annual mean of 32 µg m⁻³.
4. Annual mean NO₂ concentrations at all 12 diffusion tube monitoring sites were within the EC Limit Value, and were generally comparable with previous year's results.
5. The diurnal variation in concentrations of oxides of nitrogen at Halkett Place is generally typical of an urban site, but with a particularly early (and sharp) morning rush-hour peak. This is thought to be due to the early morning traffic associated with the market.
6. Monthly mean NO₂ concentrations at the diffusion tube sites show no clear seasonal pattern.
7. Annual mean NO₂ concentrations at kerbside and roadside are lower than in the earlier years of the survey, although the decreasing trend observed since around 2003 appears to have flattened off. Concentrations of this pollutant at the urban background, residential and rural sites are stable, and well below the Limit Value and AQS Objective.

5.2 Hydrocarbon diffusion tube results

8. Annual mean benzene concentrations at all five sites were well within the EC Directive Limit Value of 5 µg m⁻³ (which is to be achieved by 2010).

9. The first full year's data from the Faux Bie site (which replaced the old Springfield Garage site during 2009) gave an annual mean benzene concentration of $1.8 \mu\text{g m}^{-3}$.
10. Annual mean concentrations of BTEX hydrocarbons were comparable with those measured in recent years.
11. Two of the sites (Beresford Street and Le Bas Centre) have been in operation since 1997. These two sites show a decreasing trend in all BTEX hydrocarbons, but particularly benzene, in the early years of the survey. This is attributed to legislation reducing the maximum permitted benzene content of petrol sold in the UK, as of 2000.

It is recommended that the monitoring programme be continued. Since the old waste incinerator at Clos St Andre has closed, States of Jersey may wish to consider re-locating this monitoring site.

If there is concern about exposure of residents at Faux Bie to toluene, it may be useful to carry out a short-term monitoring study with exposure periods of one week, for comparison with the WHO non-mandatory guide value of $260 \mu\text{g m}^{-3}$ as a one-week mean. However, it is not expected to be a problem.

6 Acknowledgements

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Appendices

Appendix 1: Air Quality Limit Values, Objectives and Guidelines

Appendix 2: Calibration Procedures for Automatic Analyser

Appendix 3: Nitrogen Dioxide Diffusion Tubes; Bias Adjustment Factor

Appendix 4: BTEX Diffusion Tubes: Monthly Dataset and Annual Means 1997-2010

Appendix 1 – Air Quality Limit Values, Objectives and Guidelines

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⁾ / $\mu\text{g m}^{-3}$ (ppb)
The Air Quality Strategy⁽²⁾	Objective for Dec. 31 st 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. 31 st 2005, for protection of human health	Annual mean	40 (21)
Not intended to be set in regulations:	Objective for Dec. 31 st 2000, for protection of vegetation.	Annual mean NO _x (NO _x as NO ₂)	30 (16)
European Community 1985 NO₂ Directive⁽⁴⁾ Limit remains in force until fully repealed 01/01/2010.	Limit Value	Calendar year of data: 98 th ile of hourly means.	200 (105)
ED Directive on Ambient Air Quality and Cleaner Air for Europe ⁽⁵⁾	Limit Value for protection of human health. To be achieved by Jan. 1 st 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. 1 st 2010	Calendar year mean	40 (21)
	Limit Value (total NO _x) for protection of vegetation. To be achieved by Jul. 19 th 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 $\mu\text{g m}^{-3}$ and ppb are as used by the EC, i.e. $1\text{ppb NO}_2 = 1.91 \mu\text{g m}^{-3}$ at 20°C and 1013 mB.

(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007, The Stationery Office, ID 5611194 07/07.

(3) Air Quality Regulations 2007 (SI 2007/64), Air Quality Standards (Wales) Regulations 2007 (Welsh SI 2007 717 (W63)), Air Quality Standards (Scotland) Regulations 2007 (SSI 2007 No. 182), Air Quality Standards (Northern Ireland) Regulations 2007 (Statutory Rule 2007 No. 265)

(4) Council Directive 85/203/EEC.

(5) Council Directive 2008/50/EC.

(6) WHO Air Quality Guidelines for Europe (2000).

Benzene

Guideline Set By	Description	Criteria Based On	Value ⁽¹⁾ / $\mu\text{g m}^{-3}$ (ppb)
The Air Quality Strategy^(2,3) All UK England⁽⁴⁾ & Wales⁽⁵⁾ only: Scotland⁽⁶⁾ & Northern Ireland	Objective for Dec. 31 st 2003	Running annual mean	16.25 (5)
	Objective for Dec. 31 st 2010	Annual mean	5 (1.54)
	Objective for Dec. 31 st 2010	Running annual mean	3.25 (1.0)
ED Directive on Ambient Air Quality and Cleaner Air for Europe ⁽⁸⁾	Limit Value. To be achieved by Jan 1 st 2010	Annual calendar year mean	5 (1.5)

(1) Conversions between $\mu\text{g m}^{-3}$ and ppb are those used by the EC, i.e. 1ppb benzene = $3.25 \mu\text{g m}^{-3}$ at 20°C and 1013 mB.

(2) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007, The Stationery Office, ID 5611194 07/07.

(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 2008/50/EC.

Toluene

Guideline Set By	Description	Criteria Based On	Value ⁽¹⁾ / $\mu\text{g m}^{-3}$ (ppb)
World Health Organisation⁽⁸⁾ (Non-Mandatory Guideline)	Health Guideline	1-week mean	$260 \mu\text{g m}^{-3}$ or 0.26 mg m^{-3}

(8) WHO Air Quality Guidelines for Europe (2000).

Appendix 2 – Calibration Procedures for Automatic Analyser

Appendix 3 – Nitrogen Dioxide Diffusion Tubes; Bias Adjustment Factor

The precision and accuracy of the diffusion tubes in this study were quantified by exposing them in triplicate alongside the automatic NO_x analyser at Halkett Place. The percentage by which the diffusion tubes over-or under-estimate with respect to the automatic chemiluminescent analyser (defined within the European Community as the reference method for NO₂) is calculated as follows:

Percentage bias $B = 100 \times (D-C)/C$

- where D = the average NO₂ concentration as measured using diffusion tubes and C is the average NO₂ concentration as measured using the automatic analyser.

The diffusion tube annual mean concentrations measured at the other (non-co-located) sites can be adjusted for the diffusion tube over/under-read, by application of a bias adjustment factor, calculated as follows:

Bias adjustment factor = C/D (where D and C are the annual mean NO₂ concentrations as measured using diffusion tubes and the automatic analyser respectively, as above).

These calculations were carried out using a spreadsheet tool developed by AEA: see Figure A3.1 below. This spreadsheet shows the diffusion tube concentrations to 1 decimal place as reported by the analyst – but given the uncertainty on diffusion tube measurements it is only considered valid to report to the nearest integer in the report, except at the sites with lowest concentrations.

(Note – the annual mean calculated by the spreadsheet for the automatic monitor is shown as $30 \mu\text{g m}^{-3}$ rather than the reported value of $29 \mu\text{g m}^{-3}$: this is because the spreadsheet shows the mean of the 12 monthly means with acceptable data capture (at least 70%), rather than the mean of the complete hourly dataset. This makes a negligible difference to the bias adjustment factor).

Appendix 4 - BTEX Diffusion Tubes: Monthly Dataset and Annual Means 1997-2010

Table A4.1 Monthly mean Hydrocarbon Concentrations, $\mu\text{g m}^{-3}$ – Beresford Street

Start Date	benzene	toluene	ethyl benzene	m,p -xylene	o-xylene
5-Jan-10	2.2	6.0	1.2	4.4	1.8
3-Feb-10	2.1	6.3	1.3	4.9	2.0
2-Mar-10	0.9	4.7	1.0	2.6	1.0
31-Mar-10	1.9	4.4	1.0	2.6	2.1
27-Apr-10	1.4	3.6	1.0	2.9	1.3
2-Jun-10	0.7	4.8	1.0	3.5	1.2
30-Jun-10	1.0	4.8	1.6	4.2	1.4
4-Aug-10	1.0	4.3	1.1	3.5	1.4
1-Sep-10	1.3	3.8	0.6	2.6	1.4
29-Sep-10	-	-	-	-	-
3-Nov-10	-	-	-	-	-
1-Dec-10	1.9	4.3	0.9	3.3	1.3
Average	1.4	4.7	1.1	3.5	1.5

October & November 2010 tubes went missing from site.

Table A4.2 Monthly mean Hydrocarbon Concentrations, $\mu\text{g m}^{-3}$ – Le Bas Centre

Start Date	benzene	toluene	ethyl benzene	m,p -xylene	o-xylene
5-Jan-10	1.2	4.5	0.8	2.7	0.9
3-Feb-10	0.6	5.8	1.1	3.3	1.4
2-Mar-10	0.4	2.1	0.4	1.5	0.6
31-Mar-10	1.4	2.2	0.7	1.6	2.0
27-Apr-10	0.9	2.2	0.4	1.1	1.0
2-Jun-10	0.4	2.8	1.4	2.2	0.8
30-Jun-10	0.7	3.2	0.8	3.0	1.0
4-Aug-10	0.8	4.0	1.2	3.5	1.3
1-Sep-10	0.9	3.2	0.8	2.3	1.3
29-Sep-10	1.0	4.5	1.0	3.4	1.2
3-Nov-10	2.2	5.4	1.2	2.6	1.1
1-Dec-10	1.7	3.3	1.0	2.8	1.2
Average	1.0	3.6	0.9	2.5	1.2

Table A4.3 Monthly mean Hydrocarbon Concentrations, $\mu\text{g m}^{-3}$ – Handsford Lane

Start Date	benzene	toluene	ethyl benzene	m,p -xylene	o-xylene
5-Jan-10	-	-	-	-	-
3-Feb-10	0.5	3.6	1.6	4.2	1.2
2-Mar-10	1.6	3.0	3.0	12.3	4.0
31-Mar-10	1.5	2.7	1.7	6.2	3.3
27-Apr-10	0.5	1.1	1.1	4.7	1.4
2-Jun-10	0.6	3.9	3.2	12.2	3.3
30-Jun-10	0.5	2.8	2.7	9.6	3.1
4-Aug-10	0.8	4.7	3.1	10.1	3.5
1-Sep-10	0.7	2.2	1.9	7.0	2.6
29-Sep-10	0.2	1.6	2.1	9.1	2.8
3-Nov-10	0.9	1.5	0.8	2.2	0.7
1-Dec-10	0.9	1.5	0.4	0.9	1.6
Average	0.8	2.6	2.0	7.1	2.5

Jan 2010 tube returned with cap missing.

Table A4.4 Monthly mean Hydrocarbon Concentrations, $\mu\text{g m}^{-3}$ – Faux Bie

Start Date	benzene	toluene	ethyl benzene	m,p -xylene	o-xylene
5-Jan-10	2.1	6.4	1.2	4.0	1.6
3-Feb-10	1.6	4.5	0.8	2.8	1.2
2-Mar-10	0.4	3.0	0.5	1.5	0.6
31-Mar-10	1.8	3.3	1.0	1.6	1.7
27-Apr-10	1.6	4.0	1.0	2.9	1.1
2-Jun-10	0.7	4.4	1.1	2.7	1.0
30-Jun-10	1.3	5.7	2.1	4.6	1.6
4-Aug-10	2.2	13.5	2.2	8.7	2.9
1-Sep-10	< LOD	< LOD	< LOD	< LOD	< LOD
29-Sep-10	3.3	13.8	2.1	6.8	2.5
3-Nov-10	2.9	10.7	1.7	5.7	2.1
1-Dec-10	2.4	5.0	1.1	3.2	1.4
Average	1.8	6.7	1.4	4.0	1.6

Sep 2010 results all < LOD: considered suspect and rejected.

Table A4.5 Monthly mean Hydrocarbon Concentrations, $\mu\text{g m}^{-3}$ – Clos St Andre

Start Date	benzene	toluene	ethyl benzene	m,p -xylene	o-xylene
5-Jan-10	0.0	1.2	0.0	0.3	0.1
3-Feb-10	0.7	1.6	0.3	1.1	1.1
2-Mar-10	0.8	1.3	0.4	1.4	0.6
31-Mar-10	1.3	2.2	0.5	0.8	1.5
27-Apr-10	0.3	0.6	0.2	0.6	0.3
2-Jun-10	0.2	2.1	0.5	1.4	0.5
30-Jun-10	0.4	1.7	4.2	4.4	1.8
4-Aug-10	0.3	1.4	0.7	1.4	0.6
1-Sep-10	0.4	1.7	0.4	1.1	0.7
29-Sep-10	< LOD	0.4	0.1	0.3	0.1
3-Nov-10	0.5	0.8	0.1	0.3	0.1
1-Dec-10	1.1	1.0	0.3	0.7	1.1
Average	0.5	1.3	0.6	1.2	0.7

Table A4.6 Monthly mean Hydrocarbon Concentrations, $\mu\text{g m}^{-3}$ – Airport

Start Date	benzene	toluene	ethyl benzene	m,p -xylene	o-xylene
5-Jan-10	0.8	1.2	0.3	0.8	0.6
3-Feb-10	0.7	0.9	0.1	0.6	0.2
2-Mar-10	0.6	0.6	0.2	0.3	0.1
31-Mar-10	1.0	1.0	0.3	0.3	1.8
27-Apr-10	0.3	0.9	0.3	0.4	0.4
2-Jun-10	0.0	0.7	0.4	0.9	0.5
30-Jun-10	0.3	0.5	0.3	0.7	0.3
4-Aug-10	0.2	0.6	0.1	0.4	0.2
1-Sep-10	0.2	0.5	0.2	0.5	0.3
29-Sep-10	-	-	-	-	-
3-Nov-10	1.0	10.5	0.6	2.0	0.6
1-Dec-10	1.0	0.6	0.4	0.4	0.3
Average	0.6	1.6	0.3	0.7	0.5

Sep 2010 tube returned with cap missing.

Table A4.7 Comparison of Hydrocarbon Concentrations, Jersey, 1997 - 2010.

	benzene, $\mu\text{g m}^{-3}$	toluene, $\mu\text{g m}^{-3}$	ethylbenzene $\mu\text{g m}^{-3}$	m+p xylene, $\mu\text{g m}^{-3}$	o-xylene, $\mu\text{g m}^{-3}$
Beresford Street					
1997	10.4	20.7	5.3	11.9	5.3
1998	8.1	18.8	4.0	10.2	4.4
1999	5.9	13.8	2.7	7.5	3.5
2000	2.9	14.2	3.5	10.2	4.0
2001	3.3	14.9	3.5	9.7	3.5
2002	2.6	13.0	2.7	8.0	3.1
2003	2.0	11.5	2.2	6.6	2.2
2004	1.9	9.8	5.1	5.5	2.0
2005	1.7	8.9	1.8	5.3	1.9
2006	2.2	7.4	1.3	4.6	1.6
2007	1.7	10.4	1.7	4.4	1.8
2008	1.6	6.1	1.4	4.3	1.6
2009	1.8	6.9	1.5	5.2	2.0
2010	1.4	4.7	1.1	3.5	1.5
Le Bas Centre					
1997	9.1	17.2	5.3	9.7	4.4
1998	7.5	16.1	3.1	8.4	4.0
1999	3.6	11.1	2.2	5.7	2.7
2000	2.9	12.6	3.1	8.4	3.1
2001	2.6	13.4	2.7	7.5	3.1
2002	2.0	8.0	1.8	5.7	2.2
2003	1.3	8.0	1.8	4.9	1.8
2004	1.3	6.6	3.3	3.9	1.4
2005	1.3	5.3	1.1	3.4	1.2
2006	1.5	4.4	0.8	2.8	1.0
2007	1.5	6.5	1.3	3.2	1.3
2008	1.4	5.6	1.4	3.7	1.4
2009	1.4	5.4	1.4	3.9	1.5
2010	1.0	3.6	0.9	2.5	1.2
Handsford Lane					
2004	1.0	16.1	7.3	8.5	2.0
2005	1.0	3.7	2.1	7.1	2.2
2006	1.2	4.8	1.3	5.1	1.6
2007	1.1	6.7	2.2	6.4	2.2
2008	1.0	4.0	2.2	7.6	2.2
2009	1.1	4.9	2.0	8.5	2.4
2010	0.8	2.6	2.0	7.1	2.5

	benzene, $\mu\text{g m}^{-3}$	toluene, $\mu\text{g m}^{-3}$	ethylbenzene $\mu\text{g m}^{-3}$	m+p xylene, $\mu\text{g m}^{-3}$	o-xylene, $\mu\text{g m}^{-3}$
Faux Bie					
2009	1.3	5.5	1.1	3.4	1.3
2010	1.8	6.7	1.4	4.0	1.6
Clos St Andre					
2000	1.0	3.4	0.9	2.7	0.9
2001	1.3	4.6	1.3	2.7	1.3
2002	1.0	2.7	0.9	2.2	0.9
2003	1.0	4.2	0.9	1.8	0.4
2004	0.7	2.2	1.2	1.2	0.4
2005	0.7	2.2	0.5	1.3	0.5
2006	1.0	2.0	0.4	1.2	0.4
2007	0.8	2.9	0.8	1.8	1.2
2008	0.8	2.1	1.0	1.5	0.5
2009	0.8	1.7	0.5	1.4	0.5
2010	0.5	1.3	0.6	1.2	0.7
Airport					
2002	1.0	2.7	0.9	2.2	0.9
2003	1.0	3.1	0.4	0.9	0.4
2004	0.6	1.1	1.1	0.6	0.3
2005	0.6	1.6	0.2	0.6	0.2
2006	1.0	1.4	0.5	0.9	0.3
2007	1.0	1.4	0.5	0.9	0.3
2008	0.6	1.7	0.3	0.8	0.3
2009	0.6	2.0	0.5	0.9	0.4
2010	0.6	1.6	0.3	0.7	0.5



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