

Air quality monitoring in Jersey 2012



Report for States of Jersey

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Executive summary

This report presents the results for 2012 of an ongoing programme of air quality monitoring in Jersey, carried out by Ricardo-AEA on behalf of the Environmental Health Department of the States of Jersey.

An automatic monitoring station for nitrogen dioxide (NO₂) was located in the Central Market, Halkett Place, St Helier. 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 a petrol station and a paint-spraying process), as well as general background locations. The 2012 non-automatic monitoring programme continued a long-term survey that has operated in Jersey since 1997.

One hydrocarbon monitoring site was re-located in March 2012. The Jersey Airport site was moved to Route de l'Hermitte, near the northern perimeter fence in October 2011. This was moved again in March 2012 to the Airport Fence.

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. Annual means were generally comparable with the previous year's results, with most showing a decrease on concentrations measured in 2011.

The diurnal pattern in concentrations of oxides of nitrogen at Halkett Place was similar to that observed in previous years. It showed a clear peak in the early morning (07:00 to 09:00), and very little afternoon rush-hour peak. 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). The maximum annual mean benzene concentration was 0.8 µg m⁻³, measured at Halkett Place and Faux Bie Terrace. Faux Bie represents the nearest relevant public exposure to a petrol station.

Hydrocarbon concentrations at most sites have decreased since monitoring started.

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1 Introduction

1.1 Background

This report describes a programme of air quality monitoring undertaken by Ricardo-AEA, on behalf of the States of Jersey Public Health Services, on the island of Jersey in 2012. This is the sixteenth consecutive year in which an annual monitoring programme has been carried out: the first was undertaken in 1997. This ongoing monitoring programme has provided a long-term dataset of pollutant concentrations.

The pollutants measured were nitrogen dioxide (NO₂), and a range of hydrocarbon species (benzene, toluene, ethylbenzene and three xylene compounds). NO₂ was measured by an automatic monitor situated at Halkett Place, St Helier. This was supplemented by indicative monitoring of NO₂ at 12 other locations on the island, using low cost passive samplers (Palmer type diffusion tubes). The suite of hydrocarbon species was monitored using "BTEX" diffusion tubes at six sites.

This report presents the results obtained in the 2012 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 2011¹⁻¹⁵. 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 NO_x

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 micrograms per cubic metre (µg m⁻³). The earliest 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 293 K (20 °C) and 1013 mb.

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 solvents 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, ethylbenzene 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).

2.1.2.1 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 micrograms per cubic metre (µg m⁻³). Some earlier reports in the series used parts per billion (ppb): to convert to ppb, if necessary, the following relationship should be used:

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

2.1.2.2 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 exposure¹⁶, 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 0.16 ppm (613 $\mu\text{g m}^{-3}$)¹⁷. The major concern associated with human exposure to toluene is its effect on the central nervous system: it is not believed to be carcinogenic¹⁸. 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 areas¹⁸.

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

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

2.1.2.3 Ethyl benzene

Again, there are no limits for ambient concentration of ethylbenzene, and although there are occupational limits relating to workplace exposure¹⁶, as discussed in previous reports in this series, they are several orders of magnitude higher than typical outdoor ambient concentrations.

2.1.2.4 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 0.016 ppm (16 ppb or 70 $\mu\text{g m}^{-3}$)¹⁷.

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

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

2.2.1 World Health Organisation

In 2000, the World Health Organisation published revised air quality guidelines¹⁸ for pollutants including NO₂. 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 NO₂ concentrations (hourly and annual means), benzene and toluene.

The WHO non-mandatory guideline¹⁸ for NO₂ 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)¹⁹. This Directive (referred to as the Air Quality Directive) sets limit values, which are mandatory, and other requirements for the protection of human health and ecosystems. Both NO₂ and benzene are covered by this Directive. The States of Jersey have agreed to meet the EU health limits.

The Air Quality Directive¹⁹ 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 Directive¹⁹ also sets a limit of 5 µg m⁻³ for annual mean benzene, to have been achieved by 2010. Having achieved the limit values by the due dates, Member States must maintain compliance in future years.

2.2.3 UK Air Quality Strategy

The UK Air Quality Strategy (AQS)²⁰ contains standards and objectives for a range of pollutants including NO₂ and benzene. 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 Strategy²⁰ 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 Monitoring methodologies

2.3.1 Automatic methods

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 Ricardo-AEA. Data are downloaded daily and uploaded onto the publicly available website www.jerseymet.gov.je

2.3.2 Diffusive sampling of NO₂ and hydrocarbons

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.

2.3.2.1 *NO₂ diffusion tubes*

Palmer-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 (in this case NO₂) to be monitored. 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.

2.3.2.2 *BTEX diffusion tubes*

BTEX diffusion tubes are different in appearance from 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.

2.3.2.3 *Preparation and analysis*

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.

The UK Local Air Quality Management Technical Guidance LAQM.TG(09)²¹ states that when using diffusion tubes for indicative NO₂ monitoring, correction should be made where applicable for any systematic bias (ie 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 as NO₂ diffusion tubes, therefore 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.

Gradko also retained one tube from each batch, in a sealed bag in their premises, as a "laboratory blank".

The travel blank results for NO₂ were not used to apply any correction to the results from the exposed tubes – only to highlight possible contamination issues. BTEX results were blank corrected using the travel blank, or the laboratory blank where the analyst judged this to be appropriate.

2.3.2.4 *Calendar of diffusion tube exposure periods*

The calendar of exposure periods used for the NO₂ and BTEX diffusion tubes is shown in Table 2-1. They were intended to approximate to calendar months, while allowing for the tubes to be changed on a consistent day of the week.

Table 2-1: Diffusion tube exposure periods

Month	Start date	End date
January	04/01/2012	01/02/2012
February	01/02/2012	29/02/2012
March	29/02/2012	28/03/2012
April	28/03/2012	25/04/2012
May	25/04/2012	30/05/2012
June	30/05/2012	27/06/2012
July	27/06/2012	01/08/2012
August	01/08/2012	29/08/2012
September	29/08/2012	26/09/2012
October	26/09/2012	31/10/2012
November	31/10/2012	29/11/2012
December	29/11/2012	02/01/2013

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 NO_2 were expected to be high, and where members of the public are regularly exposed for periods of one hour or more. 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 4 metres.

Figure 2-1: Automatic NO_x monitoring site, Halkett Place, St Helier

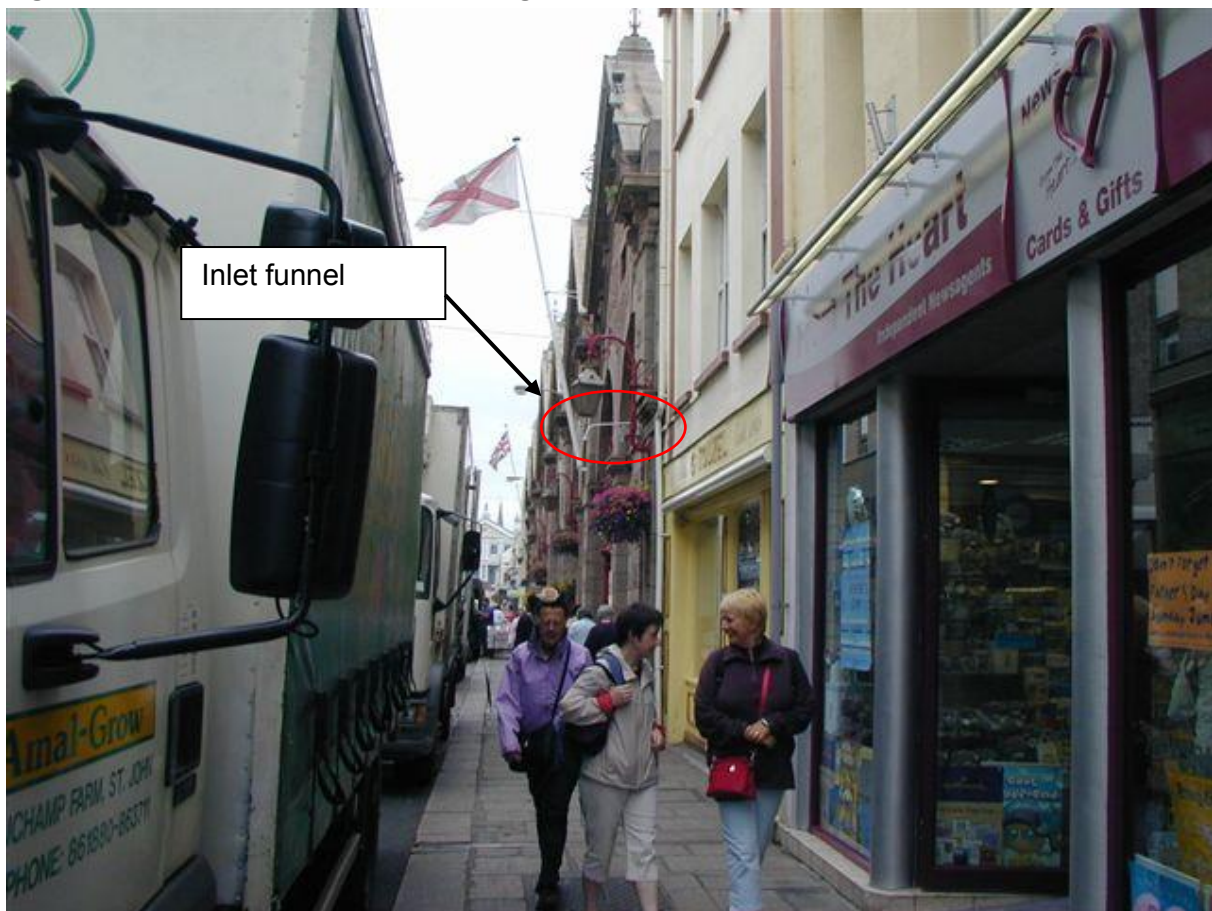


Figure 2-2 shows the chemiluminescent NO_x analyser itself, which is located within the building. The analyser is calibrated monthly by the States of Jersey's Environmental Health Team. Details of the calibration procedure, and an example of the calibration form used, are provided in Appendix 2.

Figure 2-2: Automatic NO_x analyser at Halkett Place, St Helier



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 2-2 lists the NO₂ diffusion tube sites, and Figure 2-3 and Figure 2-4 show their locations.

Table 2-2: NO₂ monitoring sites in Jersey

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

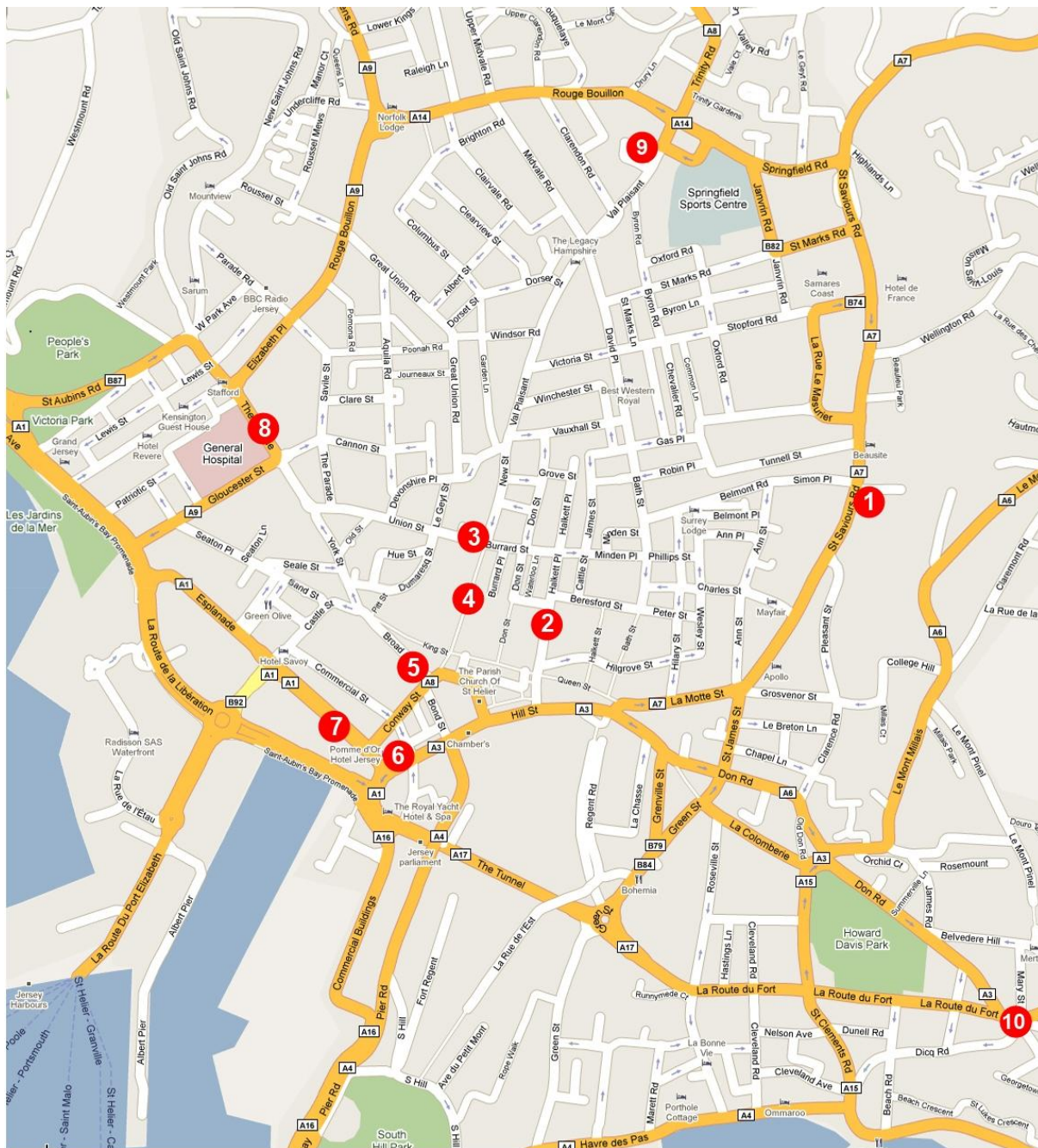
Kerbside: less than 1 m from kerb of a busy road.

Roadside: 1 – 5 m from kerb of a busy road.

Background: > 50 m 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 100 m.

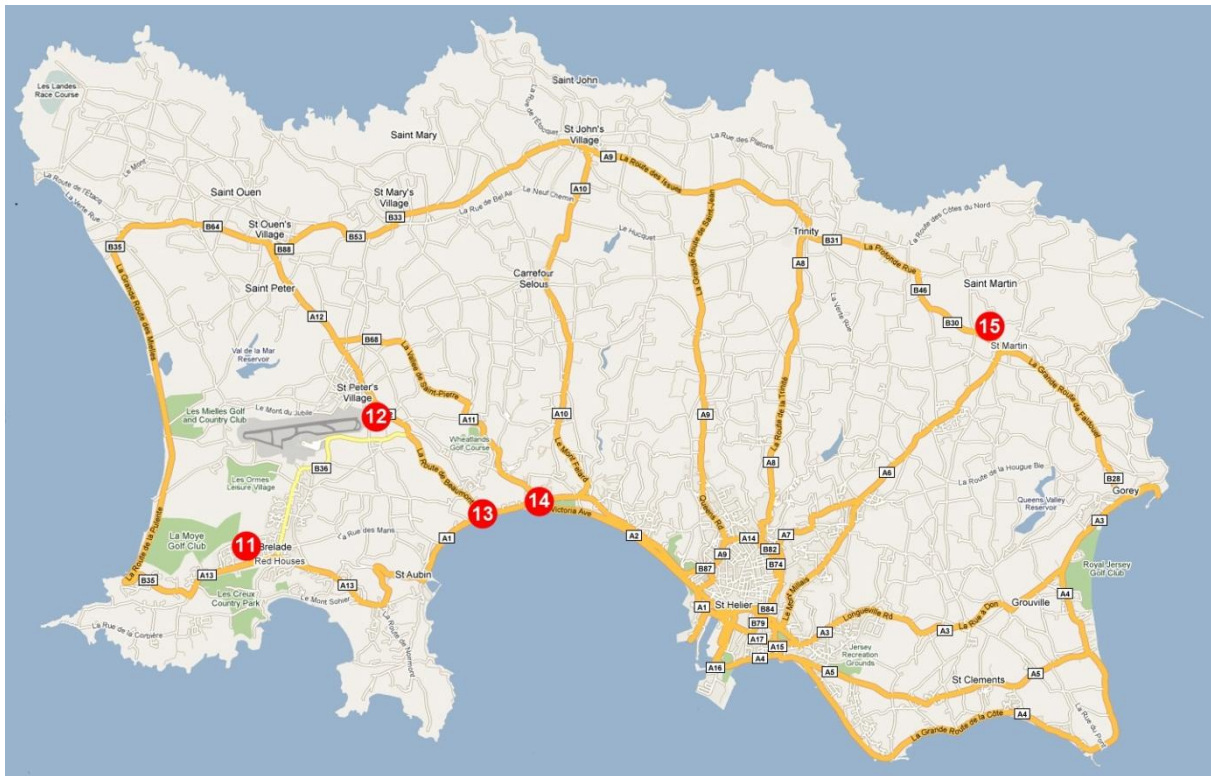
Figure 2-3: Site locations in St Helier town



Key:

Number	Site name	Pollutants	Number	Site name	Pollutants
1	Le Bas Centre	NO ₂ , BTEX	6	Weighbridge	NO ₂
2	Halkett Place (Central Market)	NO ₂ , BTEX, automatic NO _x (and automatic PM ₁₀ – locally managed)	7	Liberation Station	NO ₂
3	Union Street	NO ₂	8	The Parade	NO ₂
4	New Street	NO ₂	9	Faux Bie	BTEX
5	Broad Street	NO ₂	10	Georgetown	NO ₂

Figure 2-4: Site locations outside St Helier



Key:

Number	Site name	Pollutants	Number	Site name	Pollutants
11	Les Quennevais	NO ₂	14	Hansford Lane	BTEX
12	Airport Fence (replaced La Route de l’Hermitte)	BTEX	15	Rue Des Raisies	NO ₂
13	Beaumont	NO ₂			

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 use single tubes.

BTEX hydrocarbons were monitored at six sites during 2012. These sites are shown in Table 2-3. The aim was to investigate sites likely to be affected by different emission sources, and compare these with background sites.

Table 2-3: BTEX diffusion tube monitoring sites

Site name	Grid reference	Description
Halkett Place	653 486	Urban roadside. Replaced Beresford Street in September 2011
Le Bas Centre	658 489	Urban background
Faux Bie	658 495	Urban background near fuel filling station
Hansford Lane	633 499	Urban background near a paint spraying process
Route de l'Hermitte	592 512	Replaced by the Airport Fence site in March 2012
Airport Fence	512 598	Replaced the Route de l'Hermitte site in March 2012, following a previous relocation from the original Jersey Airport site in October 2011

Le Bas Centre was intended to monitor hydrocarbon concentrations at an urban background location.

Hansford Lane was close to a paint spraying process. This is a potential source of hydrocarbon emissions, especially toluene and xylenes.

The Faux Bie site is located near a fuel filling station, a potential source of hydrocarbon emissions including benzene. The monitoring site is at a nearby house, and is intended to represent public exposure to emissions from the filling station. The fuel supplier uses a vapour recovery system to reduce emissions when filling the storage tanks, and has done so since December 2003.

The Airport Fence site was introduced as a replacement to the original Jersey Airport location. In October 2011, monitoring was moved to La Route de l'Hermitte in St Peter village, close to the northern perimeter fence of the airfield. The site was moved again to its current location.

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 shown 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)²¹. The Halkett Place site achieved the data capture target of 90 %, with no major gaps in the data set.

Table 3-2: Jersey Halkett Place - Data capture statistics 2012

Site	NO	NO ₂	NO _x
Jersey Halkett Place	93.6 %	93.6 %	93.6 %

3.3 Diffusion tube uncertainty and detection limits

Diffusion tubes are an indicative technique, with greater uncertainty than more sophisticated automatic methods. The reported margins of uncertainty on the analysis only were typically ± 5.2 % to ± 7.8 % for NO₂ and ± 9.6 % to ± 10.3 % 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 ± 25 % for NO₂ and BTEX hydrocarbons.

The limits of detection in ambient air depend partly on the exposure time, and therefore vary to some extent from month to month. Typically the detection limit for NO₂ in 2012 was equivalent to an ambient concentration of 0.34 µg m⁻³ assuming an exposure period of 28 days. For hydrocarbons, the limit of detection varied from 1.83 ng to 5 ng (total mass on tube). This equated to ambient concentrations ranging from 0.1 to 0.3 µg m⁻³. **The laboratory advises that results lower than 10 times the limit of detection will have a higher level of uncertainty. In the case of the NO₂ sites, ambient concentrations are well above this threshold. However, for BTEX hydrocarbons at Jersey, this was the case for the majority of measurements. The BTEX hydrocarbon measurements are therefore likely to have overall uncertainty greater than ± 25 % and should be treated as indicative only.**

4 Results and discussion

4.1 Presentation of results

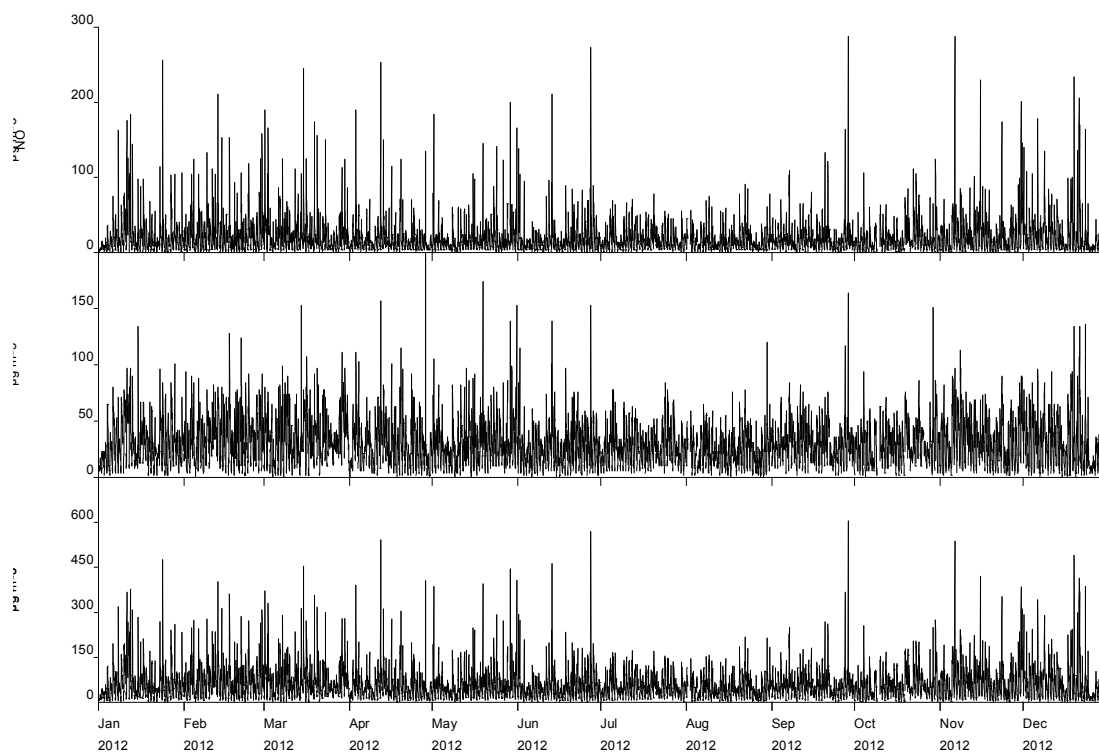
4.1.1 Automatic NO₂ monitoring results

Table 4-1 shows the key statistics for oxides of nitrogen measured by the automatic analyser at Halkett Place. Figure 4-1 shows time series plots of hourly mean NO, NO₂ and NO_x concentrations. The purpose of these plots is to illustrate how concentrations of these pollutant species varied on a short-term timescale, and throughout the year. It also illustrates that there were no major gaps in the dataset.

Table 4-1: Oxides of nitrogen - air quality statistics for 2012

Pollutant	NO $\mu\text{g m}^3$	NO ₂ $\mu\text{g m}^3$	NO _x $\mu\text{g m}^3$
Maximum 15-minute mean	639	500	1,270
Maximum hourly mean	288	199	604
Maximum running 8-hour mean	139	95	306
Maximum running 24-hour mean	80	64	179
Maximum daily mean	77	63	173
Average	20	30	60
Data capture	93.6 %	93.6 %	93.6 %

Figure 4-1: Time series plots of hourly mean pollutant concentrations at Halkett Place, 2012



4.1.2 NO₂ diffusion tube results

NO₂ diffusion tube results are presented in Table 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.

There were no data for February because of an error in the analysis. Those for July were also rejected because of a faulty batch of diffusion tubes. In September, the result for Rue des Raisies looked unusually high whilst the result for Georgetown appeared unusually low. Because these results appear anomalous, they have both been rejected. (One possibility is that the results for these sites have been accidentally interchanged: however there is no evidence to confirm this, hence the decision to reject the data).

Individual monthly mean NO₂ results ranged from $3.6 \mu\text{g m}^{-3}$ (in August at the rural Rue des Raisies site), to $44 \mu\text{g m}^{-3}$ (in March at the kerbside Beaumont site).

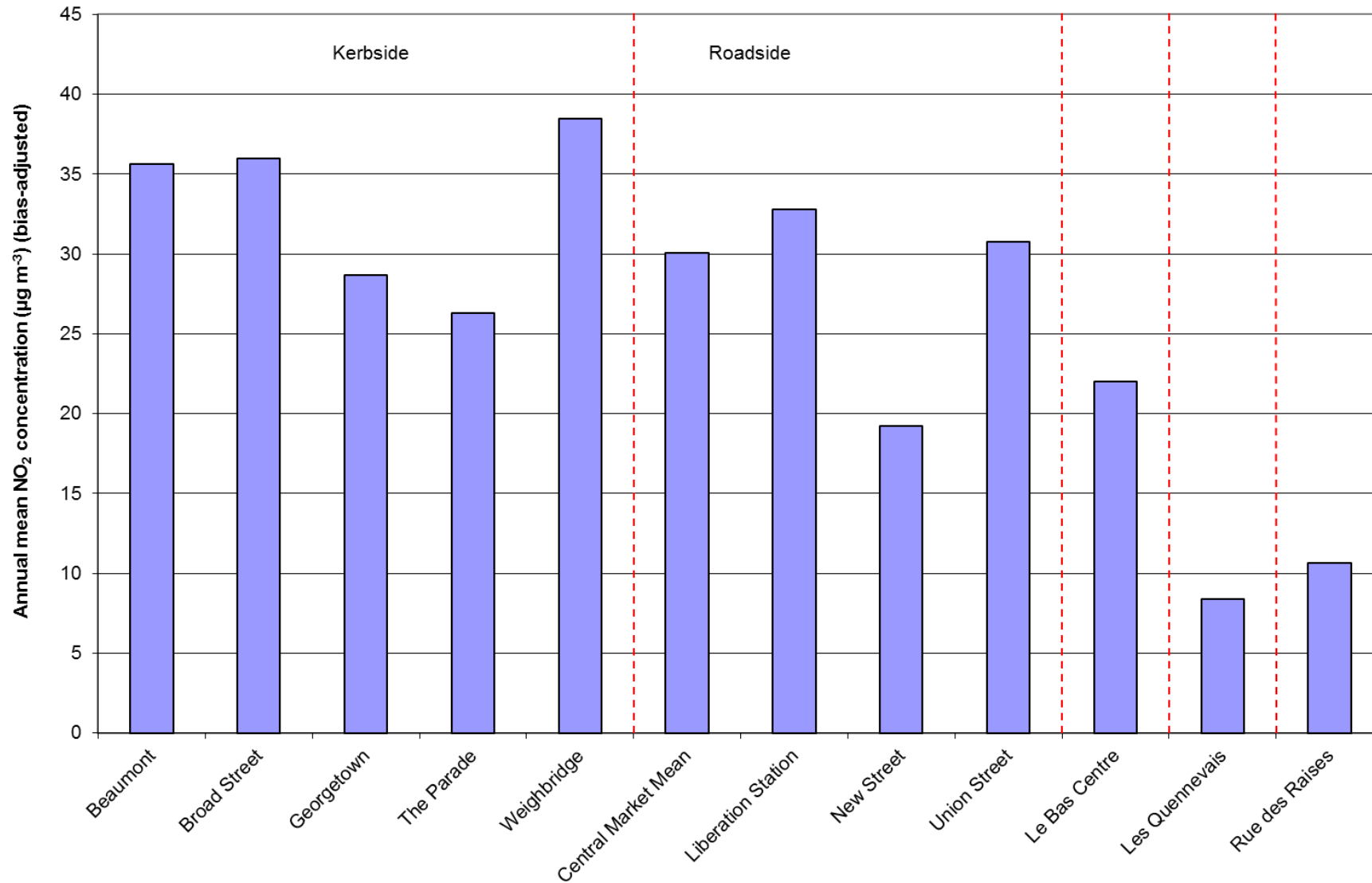
Results from the Halkett Place site (where diffusion tubes are co-located with an automatic analyser) were used to calculate a bias adjustment factor of 1.1 - see Appendix 3. Annual mean NO₂ concentrations (after application of this bias adjustment factor) ranged from $8 \mu\text{g m}^{-3}$ (at the suburban Les Quennevais site) to $38 \mu\text{g m}^{-3}$ at the Weighbridge site, a kerbside location which has produced relatively high results in the past.

Table 4-2: NO₂ diffusion tube results 2012, Jersey. Concentrations (rounded) in µg m⁻³

Site	Jan 12	Feb 12	Mar 12	Apr 12	May 12	Jun 12	Jul 12	Aug 12	Sep 12	Oct 12	Nov 12	Dec 12	Annual mean µg m ⁻³	Annual mean x BAF µg m ⁻³
Beaumont (K)	39	No data	44	33	30	25	No data	30	34	27	28	31	32	36
Broad Street (K)	33	No data	35	26	33	34	No data	37	29	29	36	32	32	36
Georgetown (K)	17	No data	43	27	29	21	No data	29	No data	24	33	32	28	31
The Parade (K)	25	No data	31	21	21	18	No data	23	22	23	25	26	24	26
Weighbridge (K)	37	No data	41	27	34	26	No data	37	32	38	40	34	35	38
Halkett Place tube 1	32	No data	35	27	26	24	No data	23	28	27	26	27	-	-
Halkett Place tube 2	32	No data	35	23	27	23	No data	23	28	24	23	28	-	-
Halkett Place tube 3	28	No data	35	26	26	24	No data	25	26	25	26	29	-	-
Halkett Place mean (R)	31	No data	35	25	27	24	No data	24	27	25	25	28	27	30
Liberation Station (R)	36	No data	38	30	27	23	No data	30	39	25	26	23	30	33
New Street (R)	22	No data	24	15	15	14	No data	15	13	19	20	16	17	19
Union Street (R)	32	No data	35	23	28	22	No data	27	26	29	26	31	28	31
Le Bas Centre (UB)	24	No data	26	19	18	18	No data	17	19	21	24	13	20	22
Les Quennevais (S)	8.9	No data	14.2	7.6	7.4	4.4	No data	5.6	4.9	7.2	8.0	7.4	8	8
Rue des Raisies (Ru)	9.3	No data	12.8	4.7	5.0	3.6	No data	4.3	No data	7.0	6.7	5.7	6.6	7.3

K = kerbside, R = roadside, UB = urban background, S = suburban, Ru = rural.

Figure 4-2: Comparison of annual mean NO₂ concentrations at all Jersey sites, 2012 (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)²¹ 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.

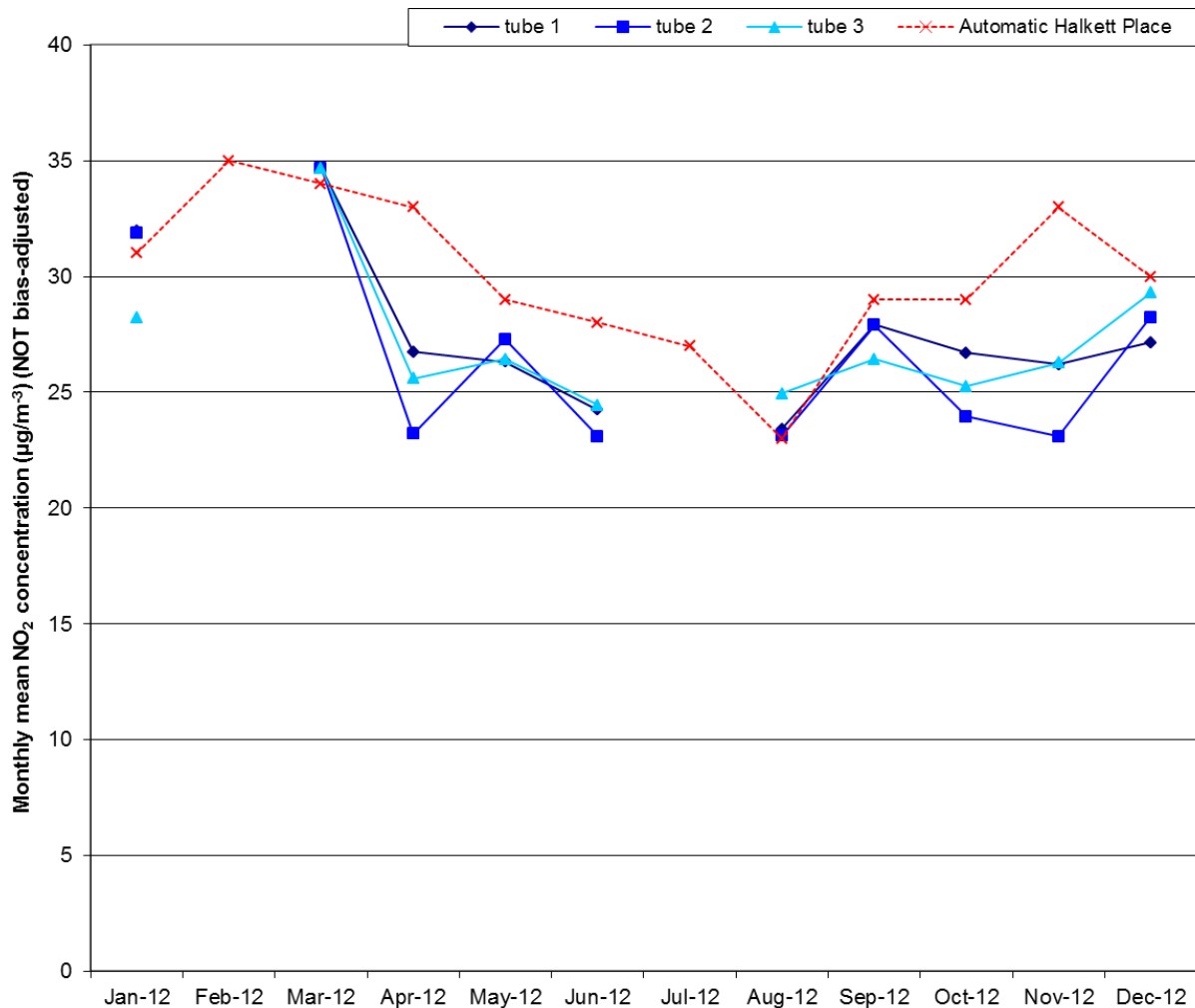
This is usually done by co-locating diffusion tubes with a chemiluminescent analyser and comparing the results of the two methods. The co-location site in this study was Halkett Place. By exposing diffusion tubes in triplicate at this site, it was possible to compare their precision and accuracy with 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 27 µg m⁻³ and by the reference automatic method was 30 µg m⁻³, i.e. the diffusion tubes were under-reading by 10% compared to the reference method. This is unusual: in previous years the diffusion tubes at Halkett Place have typically over-read relative to the automatic analyser. The “bias adjustment factor” calculated for the whole year was 1.1. The automatic monitor achieved at least 89.3 % data capture in each month.

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. At Halkett Place, the CV of the monthly tube triplets ranged from 2 % to 7 %, with a mean of 5 %. This is a good result.

Figure 4-3 shows the monthly mean NO₂ concentrations, as measured by diffusion tubes and by the automatic analyser, at Halkett Place. 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 guideline¹⁸ for NO₂ is that the annual mean should not exceed 40 µg m⁻³ NO₂. The Air Quality Directive¹⁸ 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 Strategy²⁰ 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 2012. Therefore this site met the EC Directive limit value and AQS objective for this parameter. The annual mean concentration of 30 µg m⁻³ as measured by the automatic analyser at Halkett Place was 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 of the sites in 2012. Therefore, all diffusion tube sites met the limit value for annual mean NO₂ concentration.

The highest annual mean concentration of 38 µg m⁻³ (after bias adjustment) was measured at Weighbridge, an urban kerbside site in the centre of St Helier. This is consistent with results from previous years at this site, which has recorded some of Jersey's highest annual mean NO₂ concentrations.

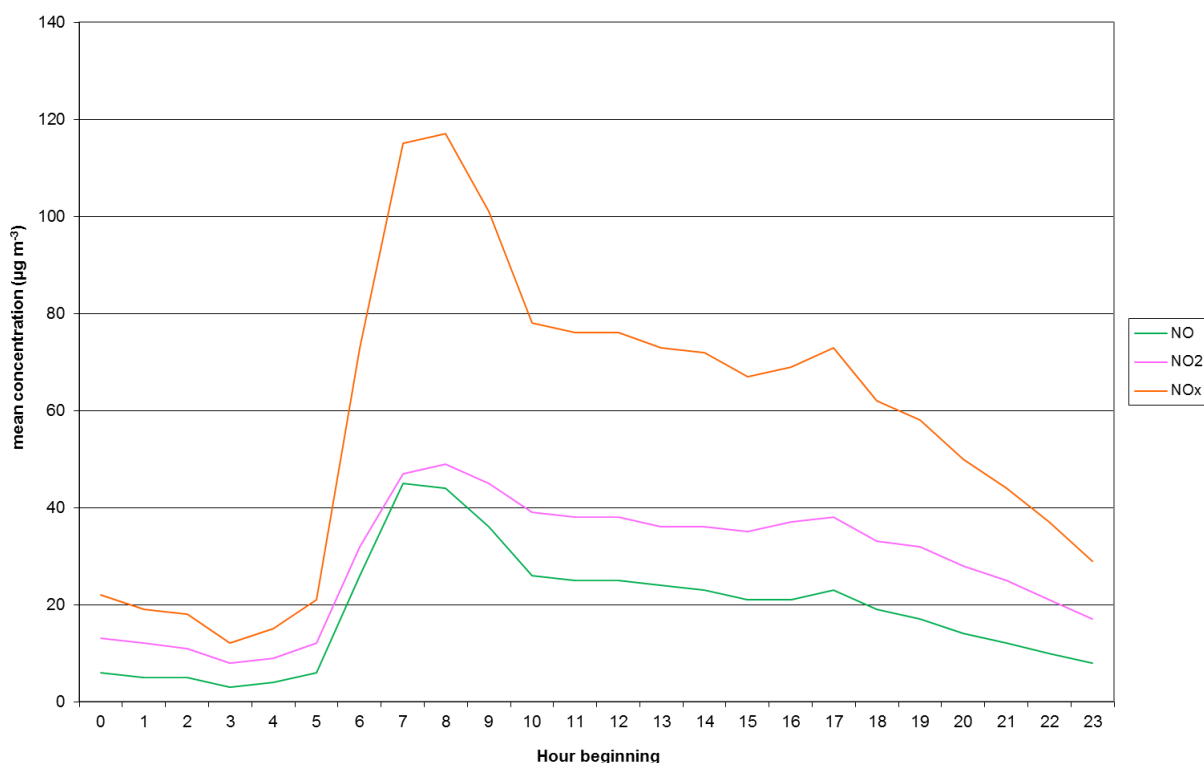
The 30 µg m⁻³ limit for protection of vegetation is only applicable at rural sites, and is therefore only relevant to Rue des Raisies. The annual mean NO₂ concentration of 7.3 µg m⁻³ at this rural site was well within the limit value.

4.3 Diurnal and seasonal variation in NO₂ concentration

4.3.1 Diurnal variation in NO₂ concentration at Halkett Place

Figure 4-4 shows how concentrations of nitrous oxide (NO), nitrogen dioxide (NO₂) and total oxides of nitrogen (NO_x) typically varied over the course of the day during 2012, as measured by the automatic monitor at Halkett Place.

Figure 4-4: Diurnal variation in concentrations of NO, NO₂ and total NO_x at Halkett Place, 2012



The curve for NO, which is a primary pollutant (ie directly emitted from source, and arises from road vehicles and other combustion sources), shows a sharp morning peak between 07:00 and 08:00. Concentrations then decrease during the late morning, remaining on a “plateau” for the rest of the afternoon, before they begin to fall again at around 17:00. There is barely any afternoon or evening rush hour peak.

For NO₂, 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.

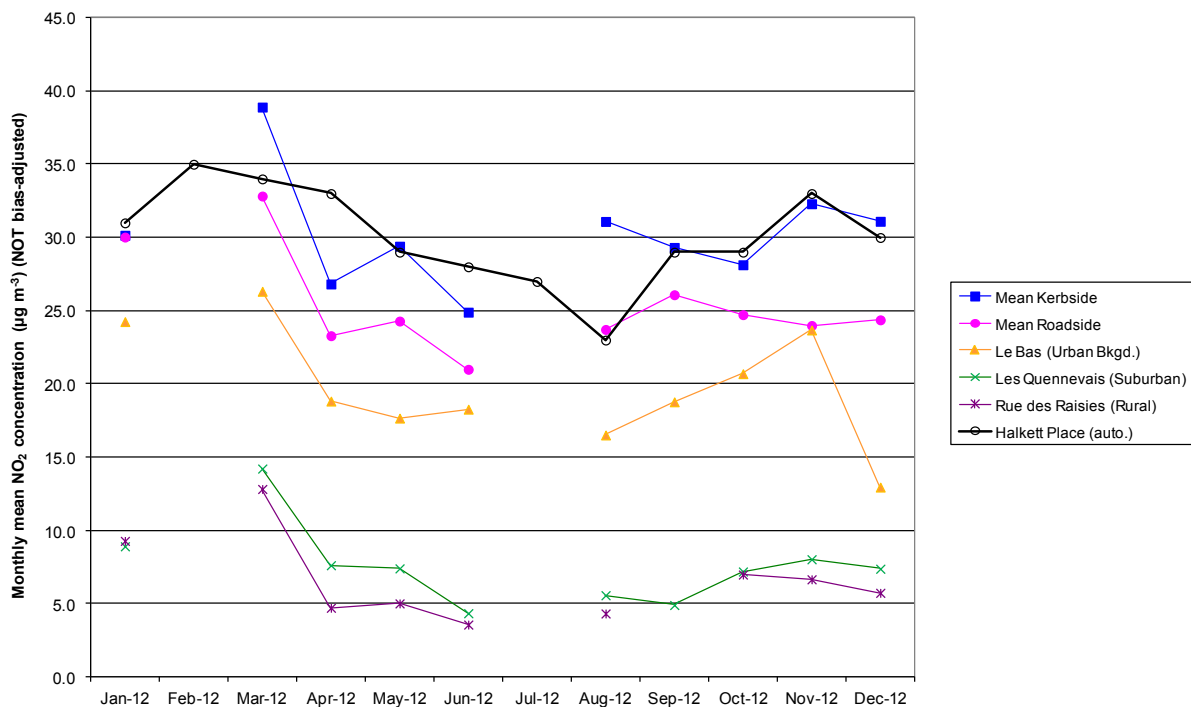
Based on Ricardo-AEA's experience with data from the Automatic Urban and Rural Network (AURN), the morning peak in NO and NO₂ is typical for urban sites, reflecting the increased levels of these pollutants associated with morning rush hour traffic. However, at Halkett Place it is particularly early and 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 in the atmosphere (particularly ozone) tend to increase, leading to enhanced oxidation of NO to NO₂. This typically causes the afternoon NO₂ peak at many urban sites to be higher than the morning NO₂ 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.

4.3.2 Seasonal variation in NO₂ concentration

Figure 4-5 shows 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 – with the anomalous September result excluded). Monthly means (based on the same periods as the diffusion tube exposures) are also shown for the Halkett Place automatic site.

Figure 4-5: Monthly mean NO₂ concentrations (NOT bias adjusted) at diffusion tube sites and Halkett Place



The typical pattern in UK urban areas is for NO₂ concentrations to be generally higher in the winter and lower in the summer. However, the sites in Jersey have not shown any consistent seasonal pattern. The highest monthly mean for the diffusion tubes was recorded at the kerbside sites in March 2012. The highest monthly mean recorded by the automatic analyser was in February 2012.

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 in the national Automatic Urban and Rural Network using automatic (chemiluminescent) NO₂ analysers. The automatic data have been fully ratified. The sites used for comparison are listed below.

- Brighton Preston Park – an urban background site in Brighton, Sussex.
- Exeter Roadside – a roadside site in the centre of Exeter, Devon.
- Lullington Heath – a rural site in East Sussex.
- Plymouth Centre – an urban centre site in the coastal city of Plymouth, Devon.
- Yarner Wood – a rural moorland site in Devon.

Table 4-3: Comparison of NO₂ in Jersey with UK automatic sites

Site	2012 Annual mean NO ₂ concentration, µg m ⁻³
Brighton Preston Park	16
Exeter roadside	33
Lullington Heath	9
Plymouth Centre	25
Yarner Wood	4.3
Halkett Place (automatic)	30

After bias adjustment, the annual mean NO₂ concentrations measured at the kerbside and roadside sites in Jersey (rounded to the nearest integer) ranged from 19 to 38 µg m⁻³. The annual means at Exeter Roadside and Plymouth Centre (33 µg m⁻³ and 25 µg m⁻³ respectively) were within this range. The mean concentration measured at Exeter Roadside was higher than the annual mean of 30 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 22 µg m⁻³, comparable with the annual means from the urban background site in 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 a similar to the rural Lullington Heath site. The bias-adjusted annual mean of 7.3 µg m⁻³ at the Jersey rural background site, Rue des Raisies was lower than that measured at Lullington Heath, but higher than the more remote Yarner Wood site in Devon.

4.3.4 Trends in NO₂ at long-running sites

There are ten sites in the survey which have been in operation since 2005 or earlier and therefore have eight 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 as there was no reliable information on which to carry out bias adjustment prior to 2002. Therefore, for consistency, unadjusted data are used in this section. (The anomalous September 2012 results for Georgetown and Rue des Raisies have been excluded).

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). Several exceeded the EC Directive limit value of $40 \mu\text{g m}^{-3}$, and there was no sign of concentrations decreasing. However, from 2004 onwards, concentrations began to decrease, and all are now within the limit value, after application of the bias adjustment factor.

Table 4-4: Annual mean NO₂ concentrations at diffusion tube sites, $\mu\text{g m}^{-3}$ (not bias adjusted)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Beaumont (K)	45	45	42	47	39	42	39	40	37	34	36	37	32
Broad Street (K)	40	39	44	42	44	38	39	35	34	35	32	36	32
Georgetown (K)	44	44	41	47	38	37	42	37	33	31	34	33	28
The Parade (K)	37	37	37	39	34	31	29	28	26	24	26	24	24
Weighbridge (K)	49	49	48	50	44	44	48	41	34	33	36	39	35
Halkett Place (R)											31	30	27
Liberation Station (R)											33	34	30
New Street (R)						26	26	25	24	18	19	19	17
Union Street (R)						33	39	32	28	30	30	32	28
Le Bas Centre (UB)	31	31	31	31	27	25	26	23	22	21	21	22	20
Les Quennevais (S)		11	11	14	12	12	10	10.3	10.1	8.0	8.7	10.4	8
Rue Des Raisies (Ru)	7	7	8	10	6	7	6	6.8	6.5	6.4	6.2	7.0	6.6

K = kerbside, R = roadside, UB = urban background, S = suburban, Ru = rural.

Figure 4-6: Annual mean NO₂ concentrations (not adjusted for diffusion tube bias)

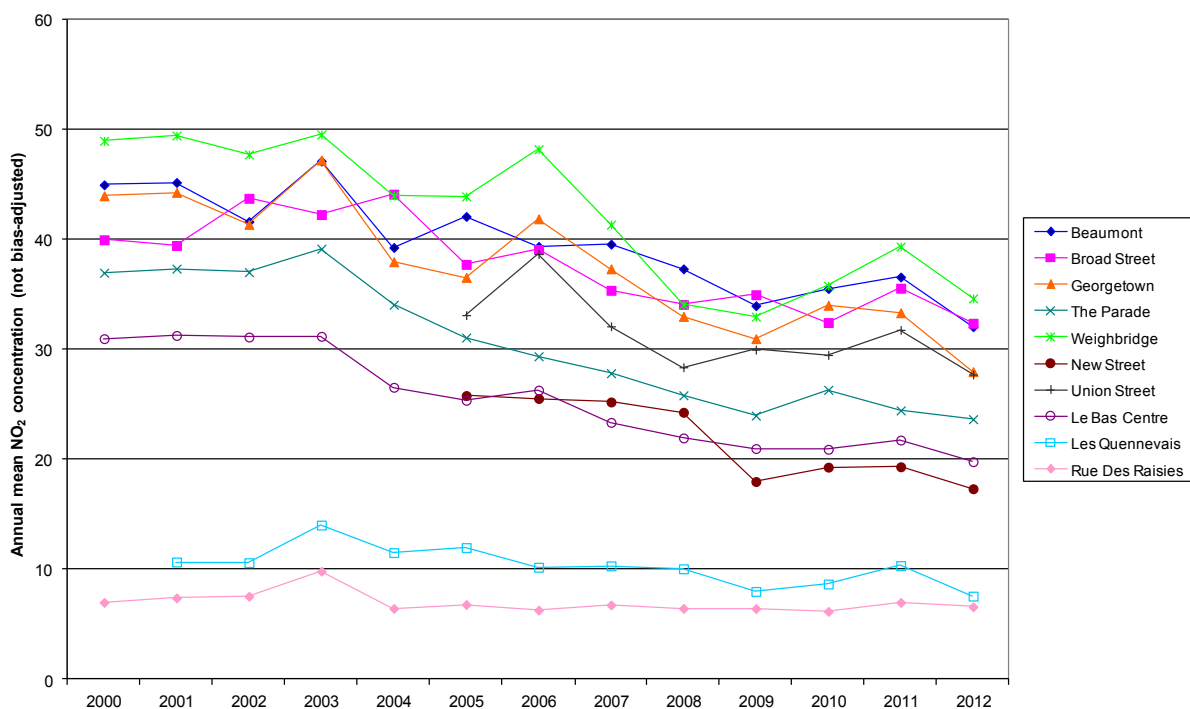


Figure 4-6 illustrates how annual mean concentrations remained stable from 2000 to 2003, then typically decreased between 2003 and 2009. However, this downward trend appears to have flattened off after 2009.

Annual mean concentrations in 2012 were generally lower than those measured in 2011. This reflects trends seen in the UK.

Annual mean NO₂ concentrations at kerbside and roadside sites were lower than those recorded in previous years. Concentrations of NO₂ at the urban background, residential and rural sites remain stable with a continuing decrease in concentrations at le Bas Centre (urban background).

A report in 2007 by the Air Quality Expert Group (AQEG)²² highlighted the fact that NO₂ concentrations in the UK were no longer decreasing. They attributed this to:

- i. An increased proportion of diesel cars on the road.
- ii. Use of pollution control devices (such as catalytically regenerative traps) on buses - these reduce the overall NO_x emissions but increase the proportion emitted as NO₂.
- iii. Increasing background concentration of O₃, which promotes the oxidation of emitted NO to NO₂.

4.4 Hydrocarbons

Full monthly results of the hydrocarbon survey for the six BTEX sites are shown in Appendix 4, Tables A4-1 to A4-6. A summary of annual average hydrocarbon concentrations is shown in Table 4-5 (excluding La Route de l'Hermitte, which was only operational for two months). There were numerous instances throughout the year when the reported results were less than the limit of detection. Where this was the case, the value was treated as equal to the half limit of detection for the purposes of calculating the annual mean.

Travel blank values are included in Appendix 4, Table A4-7. These would usually be expected to give consistently lower results than the exposed tubes. However, this was not always the case in 2012. Travel blank results were frequently comparable to exposed tube results or even higher. This was also the case in 2010 and 2011.

Table 4-5: Summary of average hydrocarbon concentrations (µg m⁻³), Jersey, 2012

Site	Benzene	Toluene	Ethyl benzene	m+p xylene	o xylene
Le Bas Centre	0.6	3.0	0.8	1.9	0.7
Halkett Place	0.8	3.1	0.8	2.0	0.8
Faux Bie	0.8	4.5	0.7	2.3	0.8
Hansford Lane	0.3	1.1	0.7	2.3	0.8
Airport Fence (March – December 2012)	0.2	0.6	0.4	0.4	0.2
Travel blank	0.2	0.2	0.2	0.1	0.1

Peaks in all hydrocarbon concentrations were measured at Le Bas Centre in August.

High annual mean concentrations of both toluene and, to a lesser extent, ethyl benzene were measured at Faux Bie, which is at the nearest housing to a petrol station. This was also the case in 2010 and 2011. It is likely that the evaporation of these compounds from fuel, as it is stored or dispensed, is the cause.

As in previous years, the Hansford Lane site (near a paint spraying process) measured relatively high levels of xylenes. The paint spraying process is not a significant source of benzene or toluene and the concentrations of these two hydrocarbons were lower at Hansford Lane than at Le Bas.

Graphical representations of monthly mean hydrocarbon concentrations are shown in Figure 4-7 to Figure 4-11. All five figures use identical y-axes, for ease of comparison.

Figure 4-7: Monthly mean hydrocarbon concentrations at Le Bas Centre, 2012

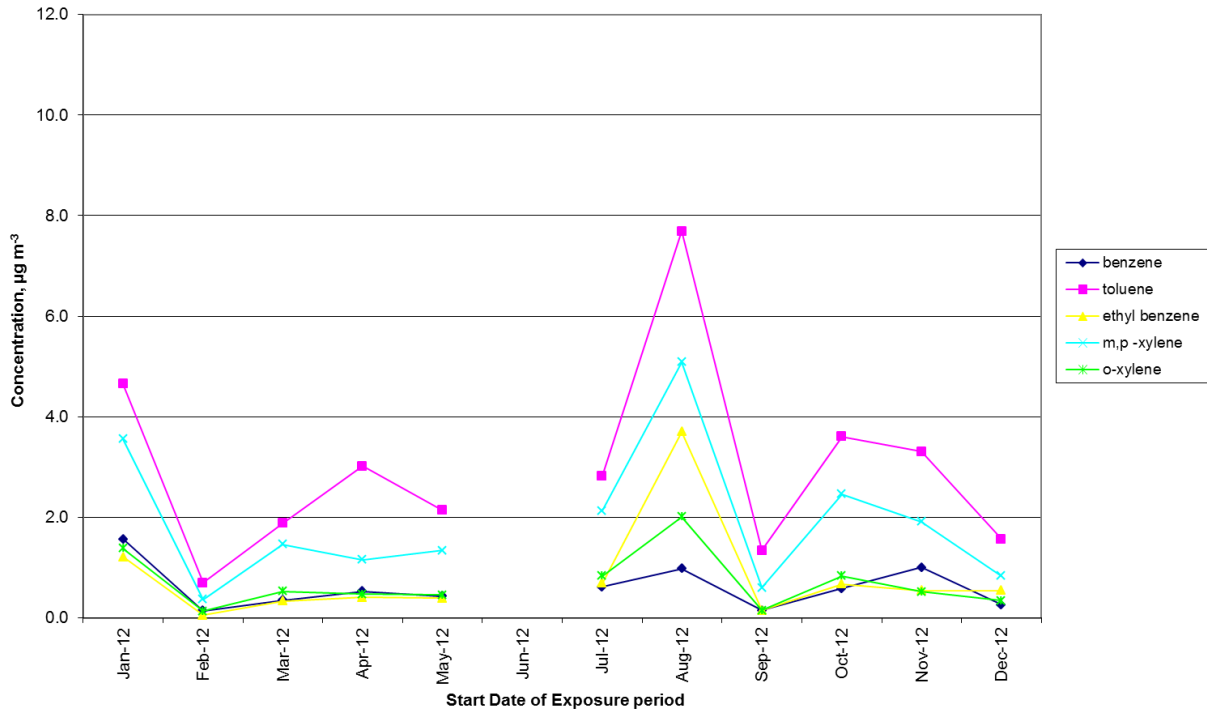


Figure 4-8: Monthly mean hydrocarbon concentrations at Faux Bie, 2012

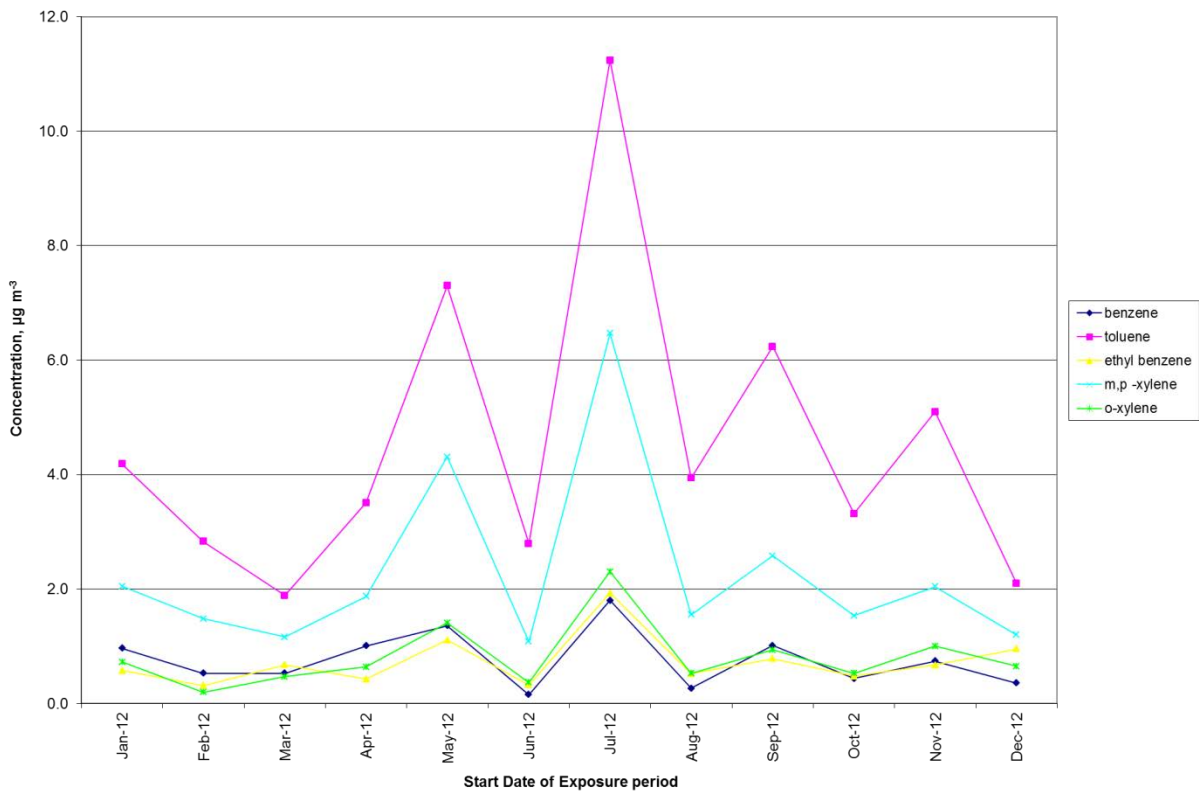


Figure 4-9: Monthly mean hydrocarbon concentrations at Hansford Lane, 2012

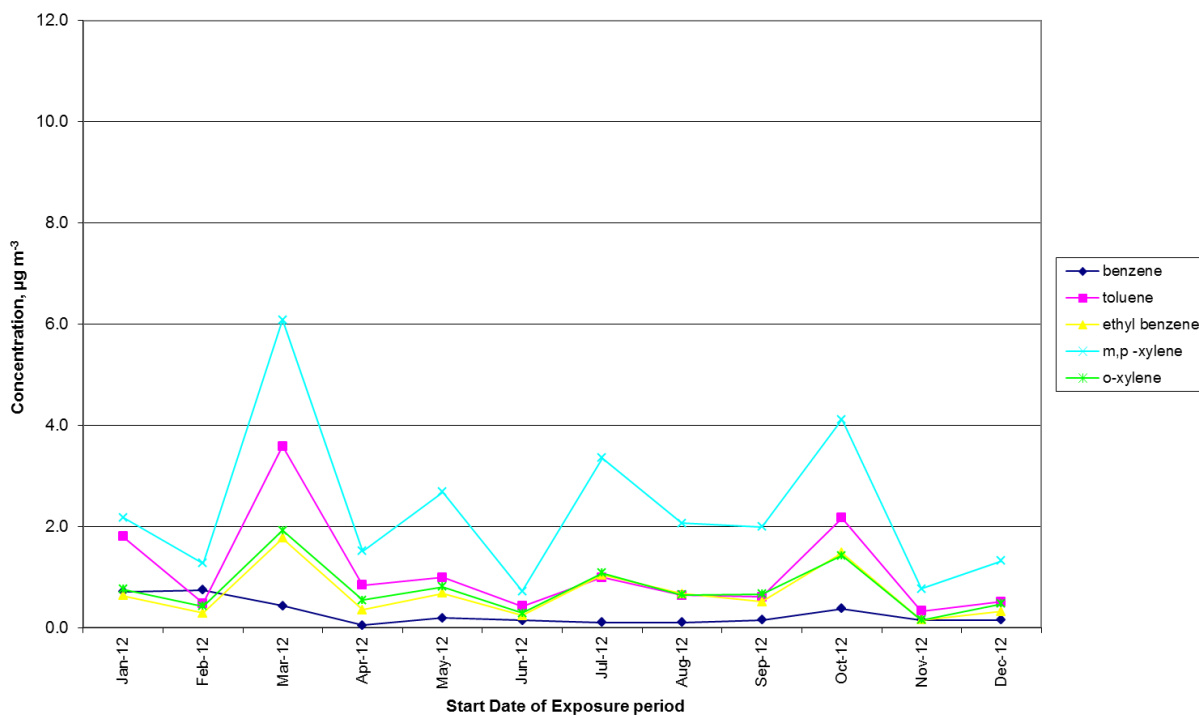


Figure 4-10: Monthly mean hydrocarbon concentrations at Airport Fence (March to December 2012)

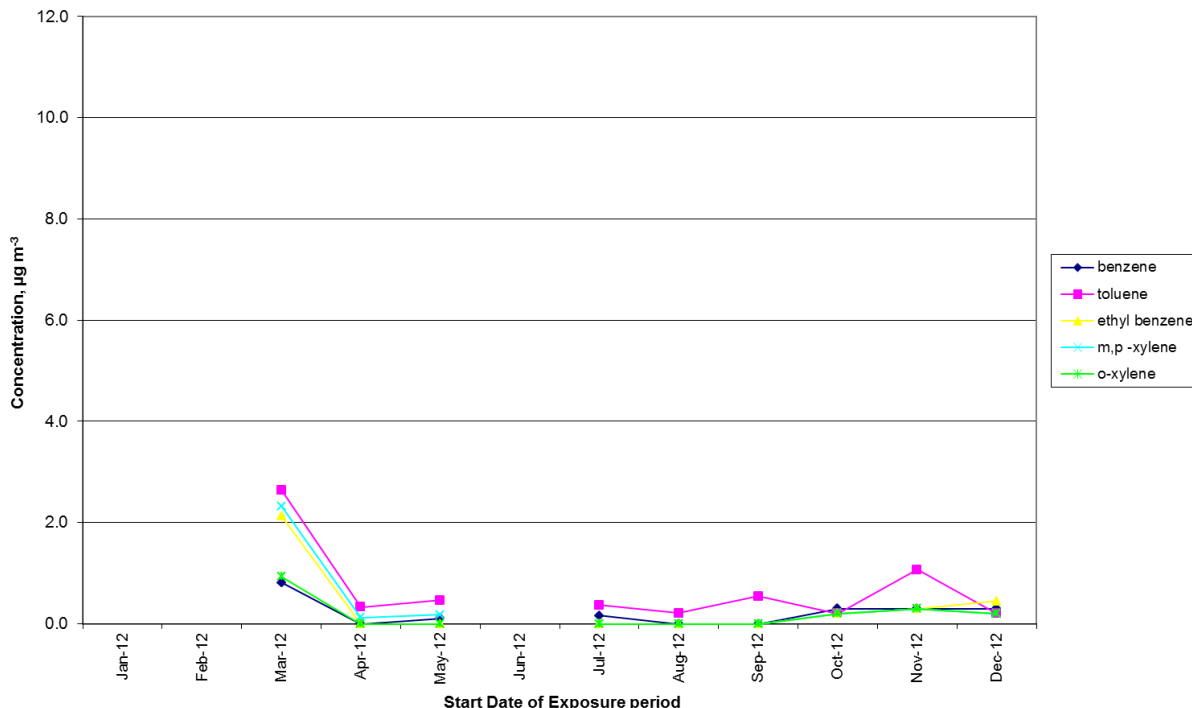
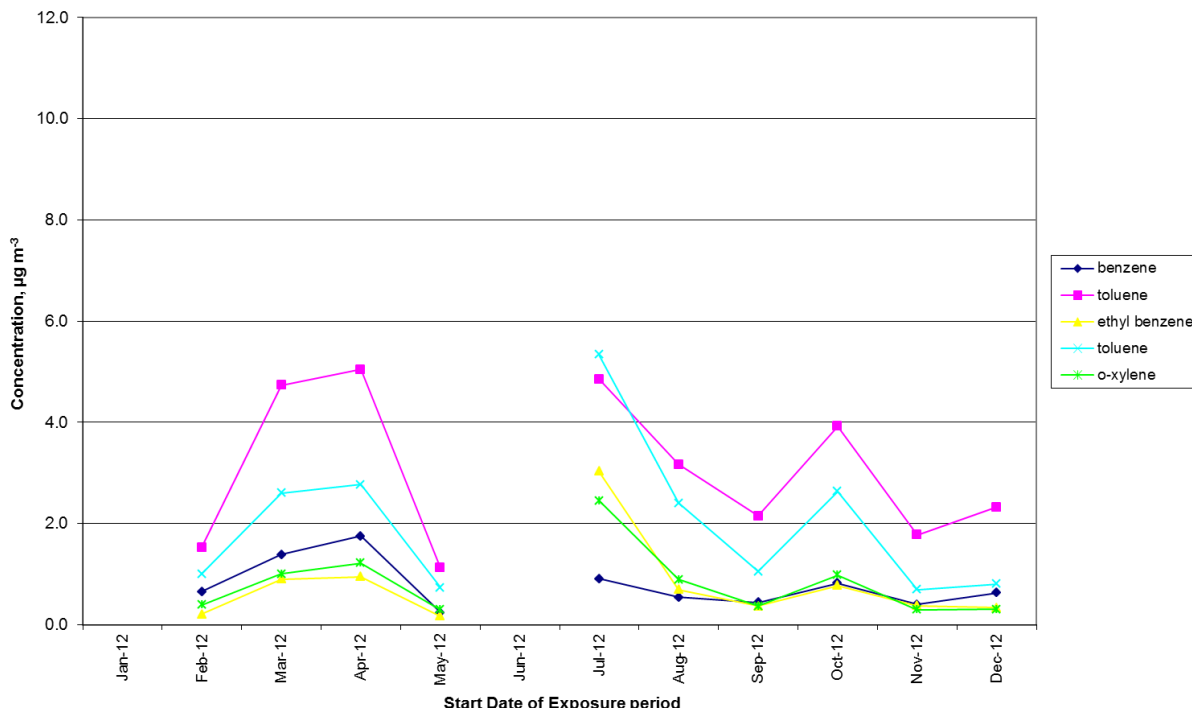


Figure 4-11: Monthly mean hydrocarbon concentrations at Halkett Place, 2012



Of the five sites, the Airport Fence site recorded the lowest concentrations of all the BTEX hydrocarbons. This replaced a new site at La Route de l’Hermitte on the northern perimeter of the airfield. Measured hydrocarbon concentrations at La Route de l’Hermitte were very low in 2011, frequently dropping below the detection limit. This was believed unlikely to be

representative of air quality around the terminal, and relocation was being considered to move the site closer to the terminal.

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 Europe¹⁹ 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 2012, though La Route de l’Hermite was only in operation for two months (the minimum data capture necessary to calculate a representative annual mean is 75%).

The UK Air Quality Strategy²⁰ 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.
- $5 \mu\text{g m}^{-3}$ (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 at urban sites throughout the UK, by the Non-Automatic Hydrocarbon Network. This network uses the pumped-tube sampler, which is defined within Europe as a reference method.

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

- Birmingham Tyburn Roadside – a roadside site alongside a major route into Birmingham city centre.
- Grangemouth – an industrial site near an oil refinery in central Scotland.
- Plymouth Centre – an urban centre site in the coastal city of Plymouth, Devon.
- Southampton Centre – an urban centre site in the coastal city of Southampton.

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. In future years it may be worth considering installing a pumped-tube sampler at key sites.

Table 4-6: Comparison with benzene concentrations at other UK sites, 2012

Jersey sites	2012 annual mean benzene, $\mu\text{g m}^{-3}$
Le Bas Centre	0.6
Halkett Place	0.8
Faux Bie (petrol station)	0.8
Airport Fence	0.2
Hansford Lane (paint spraying process)	0.3
Mainland UK sites	2012 annual mean benzene, $\mu\text{g m}^{-3}$

Birmingham Tyburn Roadside	0.8
Grangemouth	2.1
Plymouth Centre	0.6
Southampton centre	0.7

The annual mean benzene concentration at Jersey’s urban background site (Le Bas Centre) was similar to those measured at the UK Network urban centre sites at Southampton and Plymouth, but lower than the annual mean at Birmingham Tyburn Roadside. The annual mean benzene concentration at Faux Bie (near the petrol station) was close to that measured at Birmingham Tyburn Roadside, but lower than that at the industrial Grangemouth site.

4.4.3 Comparison with previous years’ hydrocarbon results

Figure 4-12 to Figure 4-16 show how annual mean hydrocarbon concentrations at the five 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 site at La Route de l’Hermite, which closed in February 2012.

Annual mean levels of hydrocarbons in 2012 were generally comparable with those measured in the previous two 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 4-12: Trends in benzene concentrations

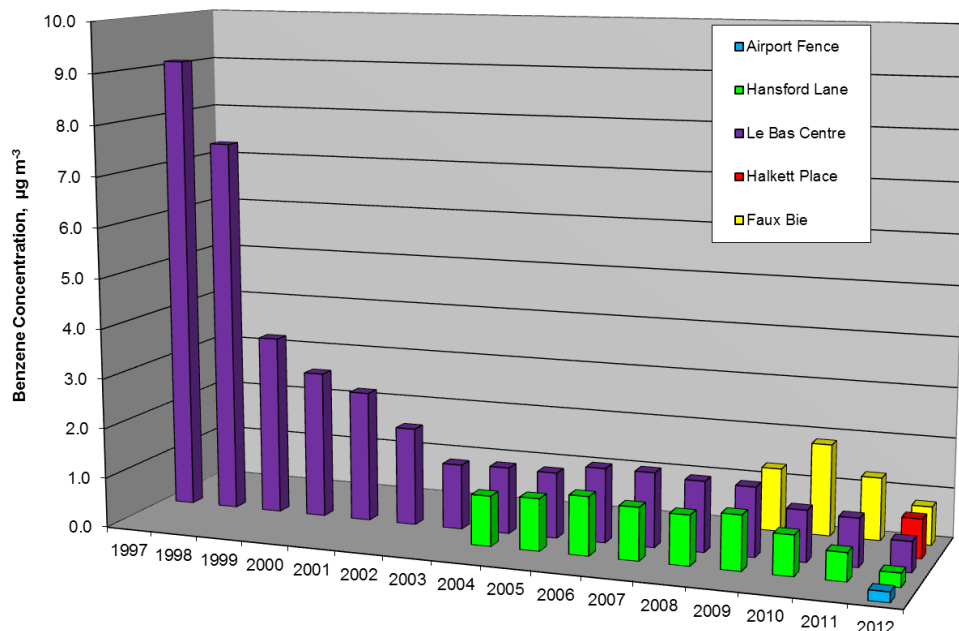


Figure 4-13: Trends in toluene concentrations

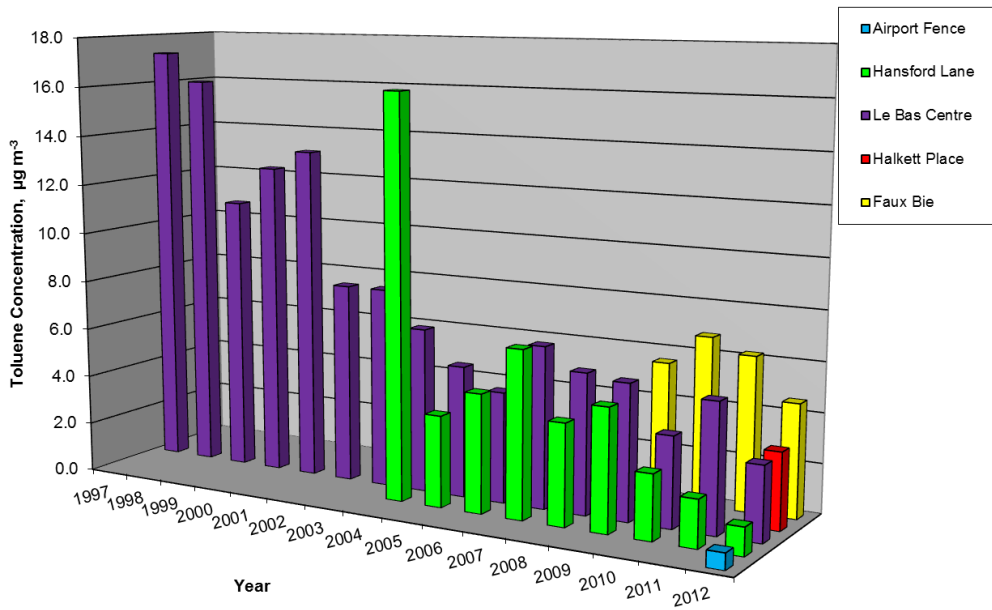


Figure 4-14: Trends in ethylbenzene concentrations

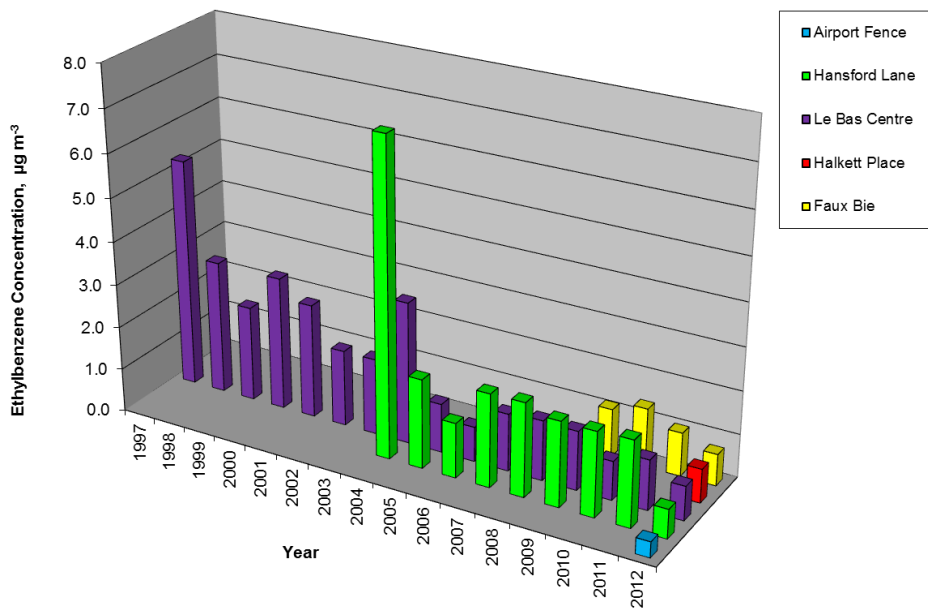


Figure 4-15: Trends in m- + p- xylene concentrations

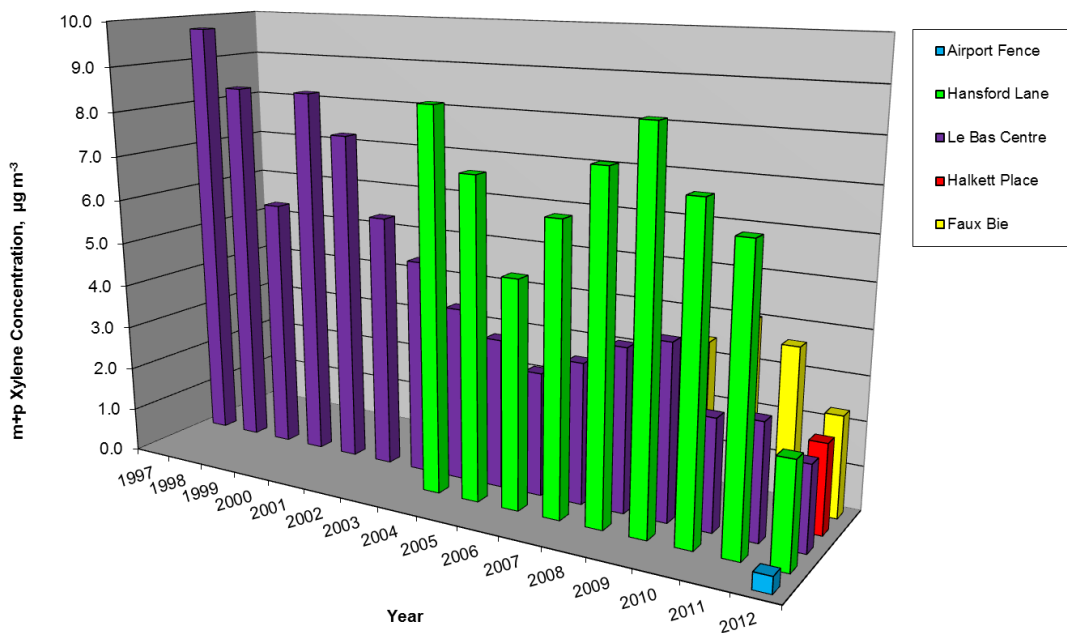
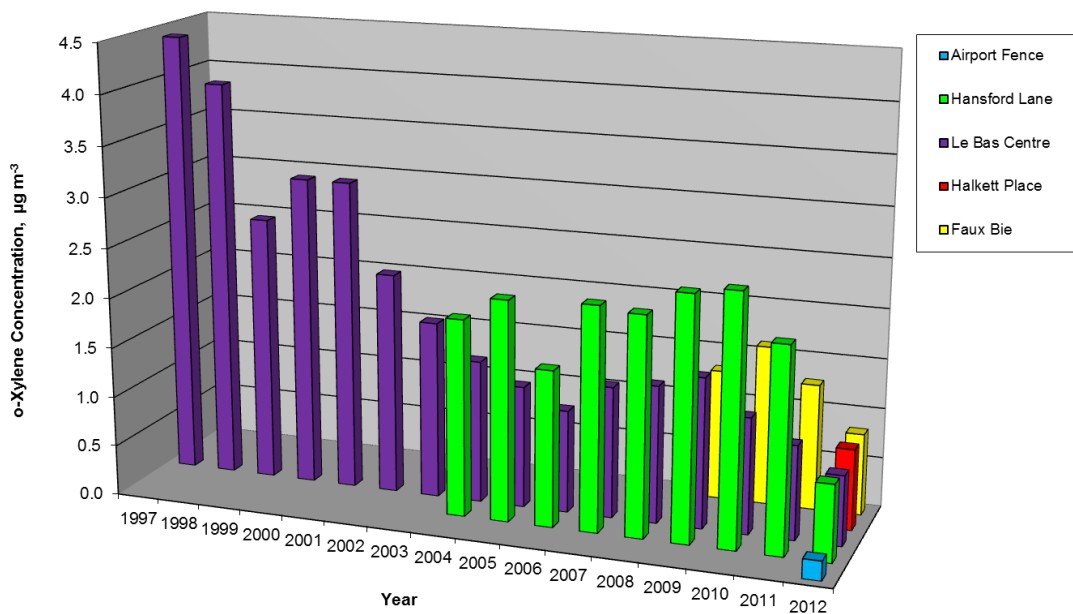


Figure 4-16: Trends in o-xylene concentrations



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 to 2004), but no clear pattern in recent years.
- Ethylbenzene concentrations have generally decreased. The high annual mean measured at Hansford Lane in 2004 (its first year of monitoring) does not appear to be typical of the site in subsequent years.
- Concentrations of xylenes are now generally lower than in the early years of the survey. At Hansford Lane (near the paint spraying process), concentrations of m- +p-xylene and of o-xylene have fluctuated since 2006, after having decreased in the early years of monitoring at this site. However, concentrations of both appear to have decreased in 2011, relative to the previous three years.

5 Conclusions and recommendations

Ricardo-AEA has continued the ongoing air quality monitoring programme in Jersey during 2012, on behalf of the States of Jersey Public Health Services. This was the sixteenth 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. Diffusion tubes were also co-located (in triplicate) with the automatic site at Halkett Place. This was supplemented by diffusion tubes for indicative monitoring of NO₂ at an additional 11 sites around the island.

Hydrocarbons (benzene, toluene, ethylbenzene 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, one of which has been in operation since 1997. Halkett Place was introduced in 2011 to replace a monitoring site at Beresford Street. Monitoring at la Route de l'Hermite was moved to the Airport Fence in March 2012.

The main conclusions of the monitoring programme are summarised below.

5.1 NO₂ results

1. The maximum hourly mean NO₂ concentration at the Halkett Place automatic monitoring station was 199 µg m⁻³. The EC Directive limit value (and AQS objective) for 1-hour mean NO₂ concentration is 200 µg m⁻³, with 18 exceedances permitted per calendar year. The maximum hourly mean reported by this site was within this value, and there were no exceedances. Therefore Halkett Place met the limit value and objective.
2. The annual mean NO₂ concentration measured by the automatic analyser at Halkett Place was 30 µg m⁻³. This is well within the EC Directive limit value and AQS objective of 40 µg m⁻³ for annual mean NO₂. Having achieved compliance by 2010 as required, the States of Jersey must continue to demonstrate ongoing compliance.
3. Diffusion tubes exposed in triplicate alongside the automatic analyser underestimated slightly compared with the reference method, giving an annual mean of 27 µg m⁻³ compared with the automatic annual mean of 30 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 years' results.
5. The diurnal variation in concentrations of oxides of nitrogen at Halkett Place was generally typical of an urban site, but with a particularly early (and sharp) morning rush hour peak, and barely any afternoon rush hour peak. This is thought to be due to traffic patterns around the site: there is early morning traffic associated with the market and with waste collection from the previous day.
6. Monthly mean NO₂ concentrations at the diffusion tube sites showed no clear seasonal pattern, as observed in previous years.
7. Annual mean NO₂ concentrations at most of the 12 diffusion tube sites were slightly lower than those measured in 2011, following an increase on 2010 levels.
8. Annual mean NO₂ concentrations at kerbside and roadside sites were lower than those recorded in previous years. Concentrations of NO₂ at the residential and rural sites remain stable and well below the limit value and AQS objective. There is a decrease in concentrations at the urban background site (Le Bas Centre).

5.2 Hydrocarbon diffusion tube results

1. Annual mean benzene concentrations at all five sites were well within the EC Directive limit value of $5 \mu\text{g m}^{-3}$. Having achieved compliance by 2010 as required, the States of Jersey must continue to demonstrate ongoing compliance.
2. The Airport Fence site recorded the lowest concentrations of all the BTEX hydrocarbons. This replaced a new site at La Route de l'Hermitte on the northern perimeter of the airfield, which also recorded very low concentrations in 2011.
3. Annual mean concentrations of BTEX hydrocarbons were comparable with those measured in recent years.

5.3 Recommendations

It is recommended that the monitoring programme be continued, to demonstrate continuing compliance with air quality limit values and objectives. Also, consideration should be given to aligning the monitoring programme with the requirements of Jersey's Air Quality Strategy.

Low measured values of BTEX hydrocarbons mean that the results shown here may only be taken as indicative measurements. These indicative measurements serve the purpose of confirming that benzene concentrations at the sites are within relevant limit values. However, if accurate measurement of hydrocarbons is required, it may be appropriate to consider installation of pumped-tube sampling at key sites, as used at UK mainland Non-Automatic Hydrocarbon Network sites.

6 Acknowledgements

Ricardo-AEA gratefully acknowledges the help and support of the staff of the States of Jersey Environmental Health Services in this monitoring study.

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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 - 2012

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

Table A1-1: 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)
ED Directive on Ambient Air Quality and Cleaner Air for Europe ⁽⁴⁾	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⁽⁵⁾	Health Guideline	1-hour mean	200
(Non-Mandatory Guidelines)	Health Guideline	Annual mean	40

(1) Conversions between $\mu\text{g m}^{-3}$ and ppb are as used by the EC, ie $1 \text{ ppb NO}_2 = 1.91 \mu\text{g m}^{-3}$ 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 2008/50/EC.

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

Table A1-2: 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 ⁽⁷⁾	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, ie 1 ppb 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.

Table A1-3: 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

The analyser at Halkett Place is calibrated monthly by the Environmental Health team. Standard gas calibration mixtures are used to check the instrument's span, and chemically scrubbed air is used to check the instrument's zero. All gas calibration standards used for routine analyser calibration are certified against traceable primary gas calibration standards from the Gas Standards Calibration Laboratory at Ricardo-AEA. The calibration laboratory operates within a specific and documented quality system and has UKAS accreditation for calibration of the gas standards used in this survey.

An important aspect of QA / QC procedures is the 12-monthly intercalibration and audit check undertaken every 12 months. This audit has two principal functions, firstly to check the instrument and the site infrastructure, and secondly to recalibrate the transfer gas standards routinely used on-site, using standards recently checked in the calibration laboratory. Ricardo-AEA's audit calibration procedures are UKAS accredited to ISO 17025.

Full intercalibration audits take place annually. At these visits, the essential functional parameters of the monitors, such as noise, linearity and, for the NO_x monitor, the efficiency of the NO₂ to NO converter are fully tested. In addition, the on-site transfer calibration standards are checked and re-calibrated if necessary, the air intake sampling system is cleaned and checked and all other aspects of site infrastructure are checked. In 2012 this exercise was combined with a full service of the analyser and sampler pump. The same is planned for the 2013 scheduled visit.

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 NOx 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.

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

where D = the average NO₂ concentration as measured using diffusion tubes; and

C = the average NO₂ concentration as measured using the automatic analyser.

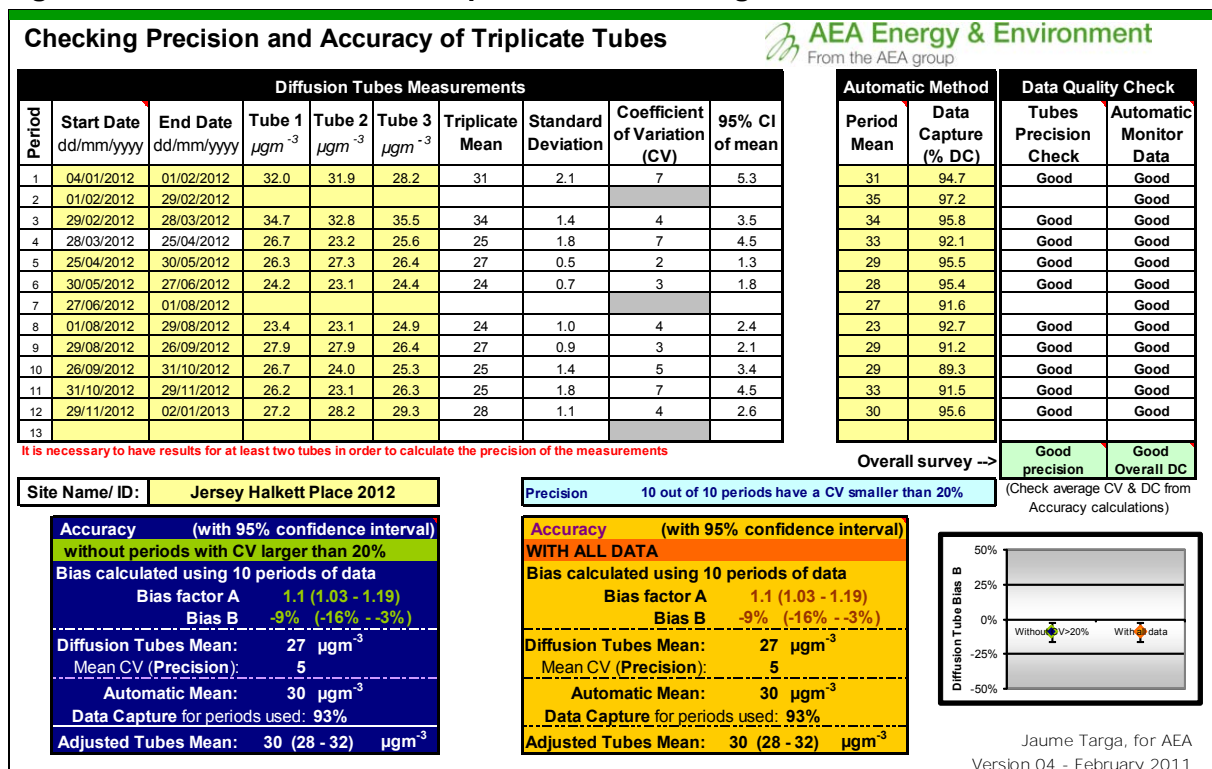
The diffusion tube annual mean concentrations measured at the other (non-co-located) sites can be adjusted for the diffusion tube over- / under-read by application of a bias adjustment factor, calculated as follows.

$$\text{Bias adjustment factor} = C / D$$

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 Ricardo-AEA: see Figure A3-1 below. This spreadsheet shows the diffusion tube concentrations to one 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.

Figure A3-1: Precision and bias spreadsheet showing Halkett Place dataset



Appendix 4 - BTEX diffusion tubes: Monthly dataset and annual means 1997 - 2012

Table A4-1: Monthly mean hydrocarbon concentrations, $\mu\text{g m}^{-3}$ – Le Bas Centre

Start date	Benzene	Toluene	Ethyl benzene	m,p xylene	o xylene
4-Jan-12	1.6	4.7	1.2	3.6	1.4
1-Feb-12	0.14	0.7	(<0.1)	0.4	0.1
29-Feb-12	0.4	1.9	0.3	1.5	0.5
28-Mar-12	0.5	3.0	0.4	1.2	0.5
25-Apr-12	0.4	2.1	0.4	1.3	0.5
30-May-12	no data	no data	no data	no data	no data
27-Jun-12	0.6	2.8	0.7	2.1	0.8
1-Aug-12	1.0	7.7	3.7	5.1	2.0
29-Aug-12	(<0.3)	1.3	(<0.3)	0.6	(<0.3)
26-Sep-12	0.6	3.6	0.7	2.5	0.8
31-Oct-12	1.0	3.3	0.5	1.9	0.5
29-Nov-12	0.3	1.6	0.5	0.8	0.3
Average	0.6	3.0	0.9	1.9	0.8

Table A4-2: Monthly mean hydrocarbon concentrations, $\mu\text{g m}^{-3}$ – Faux Bie

Start date	Benzene	Toluene	Ethyl benzene	m,p xylene	o xylene
4-Jan-12	1.0	4.2	0.6	2.1	0.7
1-Feb-12	0.5	2.8	0.3	1.5	0.7
29-Feb-12	0.5	1.9	0.7	1.2	0.5
28-Mar-12	1.0	3.5	0.4	1.9	0.6
25-Apr-12	1.4	7.3	1.1	4.3	1.4
30-May-12	0.2	2.8	0.3	1.1	0.4
27-Jun-12	1.8	11.2	1.9	6.5	2.3
1-Aug-12	0.3	3.9	0.5	1.6	0.5
29-Aug-12	1.0	6.2	0.8	2.6	0.9
26-Sep-12	0.4	3.3	0.5	1.5	0.5
31-Oct-12	0.7	5.1	0.7	2.0	1.0
29-Nov-12	0.4	2.1	1.0	1.2	0.7
Average	0.8	4.5	0.7	2.3	0.9

Table A4-3: Monthly mean hydrocarbon concentrations, $\mu\text{g m}^{-3}$ – Hansford Lane

Start date	Benzene	Toluene	Ethyl benzene	m,p xylene	o xylene
4-Jan-12	0.7	1.8	0.6	2.2	0.8
1-Feb-12	0.7	0.5	0.3	1.3	0.4
29-Feb-12	0.4	3.6	1.8	6.1	1.9
28-Mar-12	(<0.1)	0.8	0.4	1.5	0.5
25-Apr-12	0.2	1.0	0.7	2.7	0.8
30-May-12	0.1	0.4	0.2	0.7	0.3
27-Jun-12	(<0.2)	1.0	1.0	3.4	1.1
1-Aug-12	(<0.2)	0.6	0.7	2.1	0.6
29-Aug-12	(<0.3)	0.6	0.5	2.0	0.7
26-Sep-12	0.4	2.2	1.5	4.1	1.4
31-Oct-12	(<0.3)	0.3	(<0.3)	0.8	(<0.3)
29-Nov-12	(<0.3)	0.5	0.3	1.3	0.5
Average	0.4	1.1	0.7	2.3	0.8

Table A4-4: Monthly mean hydrocarbon concentrations, $\mu\text{g m}^{-3}$ – La Route de l’Hermitte

Start date	Benzene	Toluene	Ethyl benzene	m,p xylene	o xylene
4-Jan-12	0.6	0.8	0.1	0.3	0.1
1-Feb-12	(<0.1)	0.1	(<0.1)	0.1	(<0.1)
29-Feb-12	-	-	-	-	-
28-Mar-12	-	-	-	-	-
25-Apr-12	-	-	-	-	-
30-May-12	-	-	-	-	-
27-Jun-12	-	-	-	-	-
1-Aug-12	-	-	-	-	-
29-Aug-12	-	-	-	-	-
26-Sep-12	-	-	-	-	-
31-Oct-12	-	-	-	-	-
29-Nov-12	-	-	-	-	-
Average	0.6	0.5	0.1	0.2	0.1

Table A4-5: Monthly mean hydrocarbon concentrations, $\mu\text{g m}^{-3}$ – Airport Fence

Start date	Benzene	Toluene	Ethyl benzene	m,p xylene	o xylene
4-Jan-12	-	-	-	-	-
1-Feb-12	-	-	-	-	-
29-Feb-12	0.8	2.6	2.1	2.3	0.9
28-Mar-12	(<0.1)	0.3	(<0.1)	0.1	(<0.1)
25-Apr-12	0.1	0.5	(<0.1)	0.2	(<0.1)
30-May-12	no data	no data	no data	no data	no data
27-Jun-12	0.2	0.4	(<0.2)	(<0.2)	(<0.2)
1-Aug-12	(<0.2)	0.2	(<0.2)	(<0.2)	(<0.2)
29-Aug-12	(<0.3)	0.5	(<0.3)	(<0.3)	(<0.3)
26-Sep-12	(<0.3)	<0.2	(<0.2)	(<0.2)	(<0.2)
31-Oct-12	(<0.3))	1.1	(<0.3)	(<0.3)	(<0.3)
29-Nov-12	(<0.3	<0.2	0.4	(<0.2)	(<0.2)
Average	0.4	0.8	1.3	0.9	0.9

Table A4-6: Monthly mean hydrocarbon concentrations, $\mu\text{g m}^{-3}$ – Halkett Place

Start date	Benzene	Toluene	Ethyl benzene	m,p xylene	o xylene
4-Jan-12	no data	no data	no data	no data	no data
1-Feb-12	0.7	1.5	0.2	1.0	0.4
29-Feb-12	1.4	4.7	0.9	2.6	1.0
28-Mar-12	1.8	5.0	1.0	2.8	1.2
25-Apr-12	0.2	1.1	0.2	0.7	0.3
30-May-12	no data	no data	no data	no data	no data
27-Jun-12	0.9	4.9	3.0	5.3	2.5
1-Aug-12	0.5	3.2	0.7	2.4	0.9
29-Aug-12	0.4	2.1	0.4	1.1	0.4
26-Sep-12	0.8	3.9	0.8	2.6	1.0
31-Oct-12	0.4	1.8	0.4	0.7	(<0.3)
29-Nov-12	0.6	2.3	0.3	0.8	0.3
Average	0.8	3.1	0.8	2.0	0.9

Table A4-7: Monthly mean hydrocarbon concentrations, $\mu\text{g m}^{-3}$ – Travel blank

Start date	Benzene	Toluene	Ethyl benzene	m,p xylene	o xylene
4-Jan-12	0.08	0.08	0.07	0.04	0.01
1-Feb-12	0.33	0.73	0.34	0.44	0.23
29-Feb-12	0.16	0.19	0.13	0.11	0.02
28-Mar-12	0.22	0.11	0.16	0.10	0.02
25-Apr-12	0.11	0.06	0.10	0.05	0.09
30-May-12	0.11	0.11	0.17	0.21	0.08
27-Jun-12	0.26	0.15	0.23	0.17	(<0.2)
1-Aug-12	(<0.2)	0.46	(<0.2)	(<0.2)	(<0.2)
29-Aug-12	0.14	0.08	0.08	0.05	0.01
26-Sep-12	0.12	0.12	0.12	0.09	0.02
31-Oct-12	0.18	0.13	0.15	0.15	0.23
29-Nov-12	0.26	0.23	(<0.2)	(<0.2)	(<0.2)
Average	0.2	0.2	0.2	0.1	0.1

Table A4-8: Comparison of hydrocarbon concentrations, Jersey, 1997 - 2012

	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
2011	1.0	4.4	1.0	3.2	1.1
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
2011	1.0	5.1	1.2	2.6	0.9
2012	0.6	3.0	0.8	1.9	0.7
Airport					
1997					
1998					
1999					
2000					
2001					
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
2011	0.4	1.1	0.3	0.7	0.2

Hansford Lane					
1997					
1998					
1999					
2000					
2001					
2002					
2003					
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
2011	0.6	1.9	2.0	6.5	2.0
2012	0.3	1.1	0.7	2.3	0.8
Faux Bie					
1997					
1998					
1999					
2000					
2001					
2002					
2003					
2004					
2005					
2006					
2007					
2008					
2009	1.3	5.5	1.1	3.4	1.3
2010	1.8	6.7	1.4	4.0	1.6
2011	1.3	6.2	1.0	3.6	1.3
2012	0.8	4.5	0.7	2.3	0.8
Airport Fence					
1997					
1998					
1999					
2000					
2001					
2002					
2003					
2004					
2005					
2006					
2007					
2008					
2009					
2010					
2011					
2012	0.2	0.6	0.4	0.4	0.2

Halkett Place					
1997					
1998					
1999					
2000					
2001					
2002					
2003					
2004					
2005					
2006					
2007					
2008					
2009					
2010					
2011					
2012	0.8	3.1	0.8	2.0	0.8

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