



Ricardo
Energy & Environment

Air Quality Monitoring in Jersey 2015

Report for the States of Jersey
ED60773 2015 report

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Executive summary

This report presents the results for 2015 of an ongoing programme of air quality monitoring in Jersey, carried out by Ricardo Energy & Environment 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 20 sites, and a suite of four hydrocarbons (benzene, toluene, ethylbenzene and xylenes) at a further five sites. Hydrocarbon 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 2015 non-automatic monitoring programme continued a long-term survey that has operated in Jersey since 1997.

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 Department.

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.

After application of a bias adjustment factor, the annual mean concentrations of NO₂ did not exceed the EC Directive limit value at any of the 20 sites.

The diurnal pattern in concentrations of oxides of nitrogen at Halkett Place was similar to that observed in previous years. There was a clear peak in the early morning between 07:00 and 08:00, with another slight peak in the afternoon rush-hour. The morning peak is thought to reflect early activity of market retailers arriving to set-up for the day and of daily refuse collections.

All five 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 site at Faux Bie Terrace measured the highest annual mean benzene concentration, of 1.6 µg m⁻³. Faux Bie Terrace represents the nearest relevant public exposure to a petrol station.

Hydrocarbon concentrations at Le Bas Centre, the Airport Fence, Hansford Lane and Faux Bie sites showed a slight increase compared with 2014, while most hydrocarbon concentrations at Halkett Place have slightly decreased (the exception being ethylbenzene). Over the long term, hydrocarbon concentrations have generally decreased at La Bas Centre, Halkett Place and Hansford Lane. However, at the Airport Fence and Faux Bie sites they have started to increase in recent years.

Table of contents

1	Introduction	1
1.1	Background	1
1.2	Objectives.....	1
2	Details of Monitoring Programme	2
2.1	Pollutants Monitored.....	2
2.2	Air Quality Limit Values and Objectives	3
2.3	Monitoring Methodologies	4
2.4	Monitoring sites	5
3	Quality Assurance and Data Capture	14
3.1	Quality Assurance and Quality Control	14
3.2	Data Capture	14
3.3	Diffusion Tube Uncertainty and Detection Limits	14
4	Results and Discussion	15
4.1	Presentation of Results	15
4.2	Comparison with NO ₂ Guidelines, Limit Values and Objectives	19
4.3	Diurnal and Seasonal Variation in NO ₂ Concentration.....	20
4.4	Hydrocarbons	25
5	Conclusions and Recommendations	34
5.1	NO ₂ Results	34
5.2	Hydrocarbon Diffusion Tube Results.....	34
5.3	Recommendations	34
6	Acknowledgements	36
7	References	37

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 Datasets and Annual Means 1997 - 2015

1 Introduction

1.1 Background

This report describes a programme of air quality monitoring carried out on the island of Jersey in 2015, undertaken by Ricardo Energy & Environment, on behalf of the States of Jersey Public Health Services. This is the 19th 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 a total of 20 locations on the island (including Halkett Place), using low cost passive samplers (Palmer type diffusion tubes). The suite of hydrocarbon species were monitored using 'BTEX' diffusion tubes at five sites.

This report presents the results obtained in the 2015 survey, and compares the data from Jersey with relevant air quality limit values, objectives and guidelines as well as data from selected UK monitoring stations and previous years' monitoring programmes.

1.2 Objectives

This year's monitoring is the continuation of a survey that has been carried out since 1997. This report is the latest in a series of annual reports¹. The objective, as in previous years, was to monitor at sites where pollutant concentrations were expected to be high, and compare these with background locations. The monitoring sites consisted of urban and rural background sites, in addition to locations where higher pollutant concentrations might be expected, such as roadside and kerbside sites, as well as locations close to specific emission sources (for example 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. The 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 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 are found in vehicle fuel, and occur in vehicle emissions. In most urban areas, vehicle emissions constitute the major source of hydrocarbons, in particular benzene. There is the potential they may be released to the air from facilities where fuels are stored or handled (such as petrol stations).

There are wide range of hydrocarbons are emitted from both fuel storage and handling, and in fuel combustion from 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 small concentrations in petrol and other liquid fuels; for urban areas, the major source for benzene is vehicle emissions. In the UK, the annual mean concentrations for benzene 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 found in petrol, it can be 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 concentration, although there are occupational limits for workplace exposure², and a World Health Organisation (WHO) guideline of 260 µg m⁻³ for the weekly mean³.

The major concern associated with human exposure to toluene is its effect on the central nervous system: it is not believed to be carcinogenic³. Typical ambient concentrations are usually less than 5 µg m⁻³ in rural areas and in the range 5-150 µg m⁻³ in urban areas³.

In this report, concentrations 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 = 0.261 ppb for toluene at 293 K (20 °C) and 1013 mb (only applicable to toluene).

2.1.2.3 Ethylbenzene

There are no limits for ambient concentration of ethylbenzene, and although there are occupational limits relating to workplace exposure², as discussed in previous reports, these 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 where it is used (such as vehicle paint spraying).

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

$1 \mu\text{g m}^{-3} = 0.226 \text{ ppb}$ 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 guidelines³ 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 guideline³ 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)⁴. 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 Directive⁴ contains limit values for NO₂ as follows:

- 200 $\mu\text{g m}^{-3}$ as an hourly mean, not to be exceeded more than 18 times per calendar year. To have been achieved by 1st January 2010.
- 40 $\mu\text{g m}^{-3}$ 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 $\mu\text{g m}^{-3}$, for protection of vegetation (relevant in rural areas only).

The same Directive⁴ also sets a limit of 5 $\mu\text{g m}^{-3}$ for the annual mean of 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)⁵ 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 Strategy⁵ 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.
- 3.25 $\mu\text{g m}^{-3}$ (for the calendar year mean in Scotland and Northern Ireland), to have been achieved by 31st December 2010.
- 5 $\mu\text{g m}^{-3}$ (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 $\mu\text{g m}^{-3}$ 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. The 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 Energy & Environment. Data are downloaded daily and uploaded onto the publicly available website www.jerseymet.gov.je.

2.3.2 Diffusive Sampling of NO_2 and Hydrocarbons

The automatic monitoring site at Halkett Place was supplemented by indicative monitoring, using diffusion tubes, for NO_2 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 NO_2 diffusion tubes

Palmes-type diffusion tubes were used for NO_2 . 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 NO_2) to be monitored. The tube is mounted vertically with the open end at the bottom. Ambient NO_2 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 NO_2 tubes. They are longer, thinner, and made of metal rather than plastic. These tubes are fitted at both ends with brass Swagelok fittings. A separate 'diffusion cap' is supplied. Immediately before exposure, the Swagelok end fitting is replaced with the diffusion cap. The cap is removed after exposure, and is replaced with the Swagelok fitting. BTEX diffusion tubes are very sensitive to interference by solvents.

2.3.2.3 Preparation and analysis

Diffusion tubes were prepared and analysed by Gradko International Ltd. They were supplied to the local Technical Officers of Jersey's Public Health Services, who carried out the tube changing. The tubes were supplied in a 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)⁶ states that when using diffusion tubes for indicative NO_2 monitoring, correction should be made where applicable for any systematic bias (i.e. over-read or under-read compared to the automatic chemiluminescent technique; the reference method for NO_2). By co-locating diffusion tubes with the automatic monitoring site at Halkett Place, it was possible to calculate a bias adjustment factor, which could be applied to the annual mean diffusion tube measurements in this survey. The NO_2 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 NO_2 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 because they 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 be an approximation 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

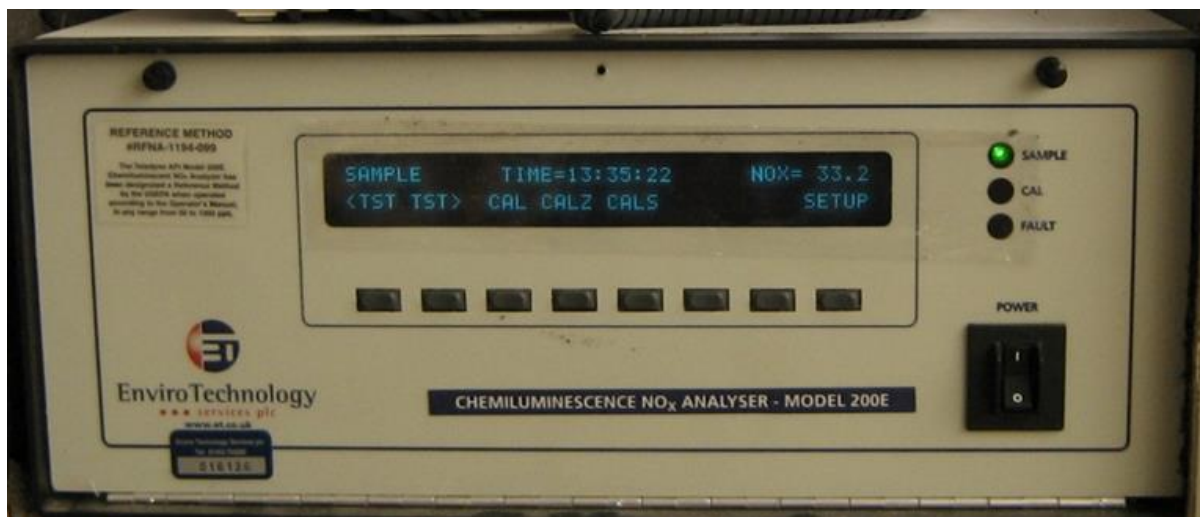
Month	Start date	End date
January	07/01/2015	04/02/2015
February	04/02/2015	04/03/2015
March	04/03/2015	01/04/2015
April	01/04/2015	29/04/2015
May	29/04/2015	27/05/2015
June	27/05/2015	01/07/2015
July	01/07/2015	29/07/2015
August	29/07/2015	26/08/2015
September	26/08/2015	30/09/2015
October	30/09/2015	28/10/2015
November	28/10/2015	02/12/2015
December	02/12/2015	06/01/2016

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 location where levels of NO₂ are 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 four metres.

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

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

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

As explained in section 2.3, diffusion tubes were used to monitor NO₂ at sites in a range of different environments around Jersey. Table 2–2 lists the NO₂ diffusion tube sites, Figure 2-3 and Figure 2-7 show their locations.

At the start of 2015 there were 18 NO₂ diffusion tube monitoring sites in operation. During the year, two further sites were added in August. These were:

- Castle Street and Esplanade Junction
- Carey Olson Esplanade

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
Bellozanne STW, Route es Nouaux	639 497	Diffusion tube	Sewage Treatment Works
Bellozanne STW, Gate 4	639 500	Diffusion tube	Sewage Treatment Works
Bellozanne STW, Green Waste Sign	639 502	Diffusion tube	Sewage Treatment Works
La Collette Gardens	651 474	Diffusion tube	Power Station
South Hill Fort Regent	650 478	Diffusion tube	Power Station
South Hill Park	650 474	Diffusion tube	Power Station
Castle St & Esplanade Junction	648 483	Diffusion tube	Roadside
Carey Olson Esplanade	647 484	Diffusion tube	Roadside

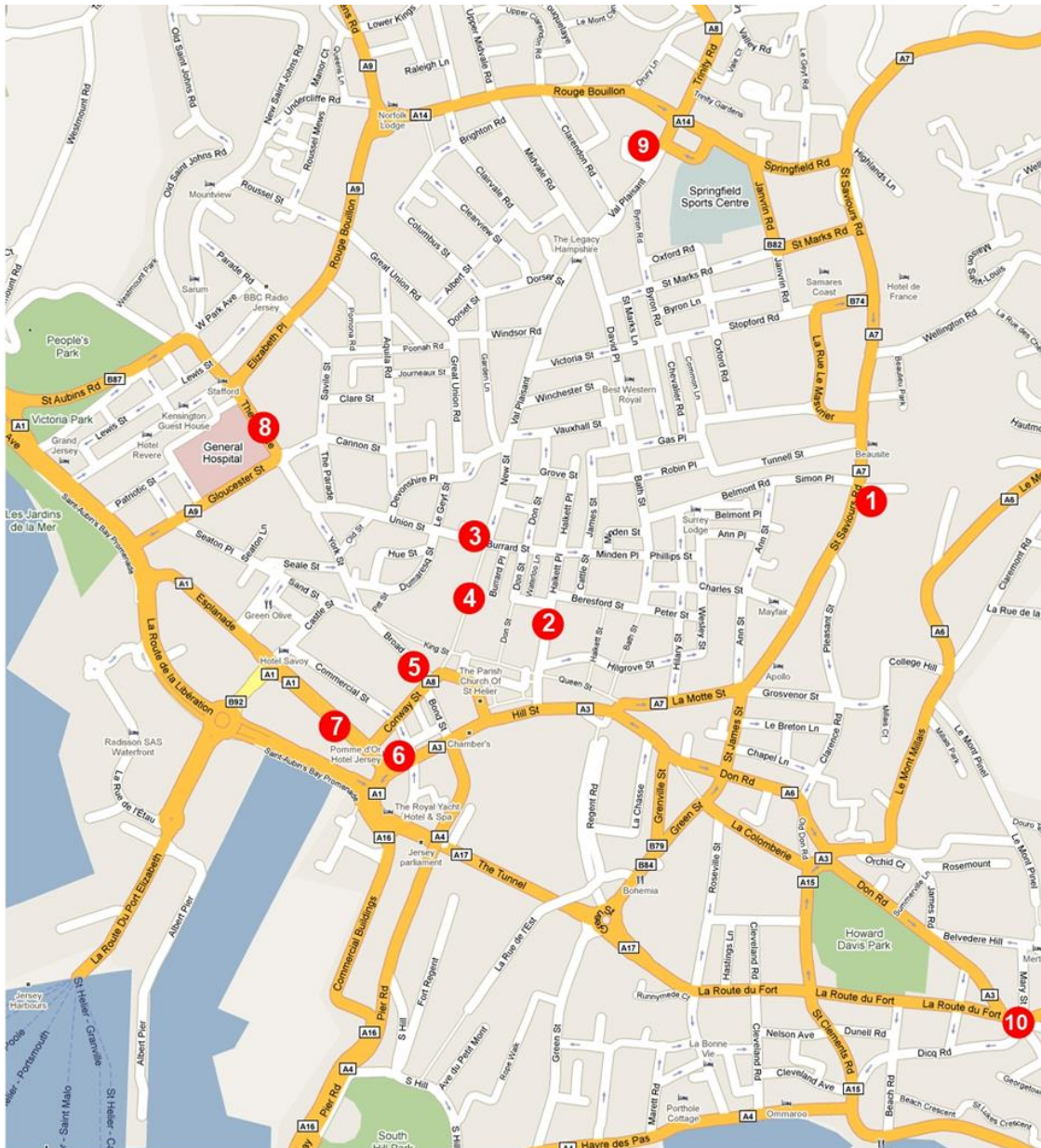
Kerbside: less than 1 m from kerb of a busy road.

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.

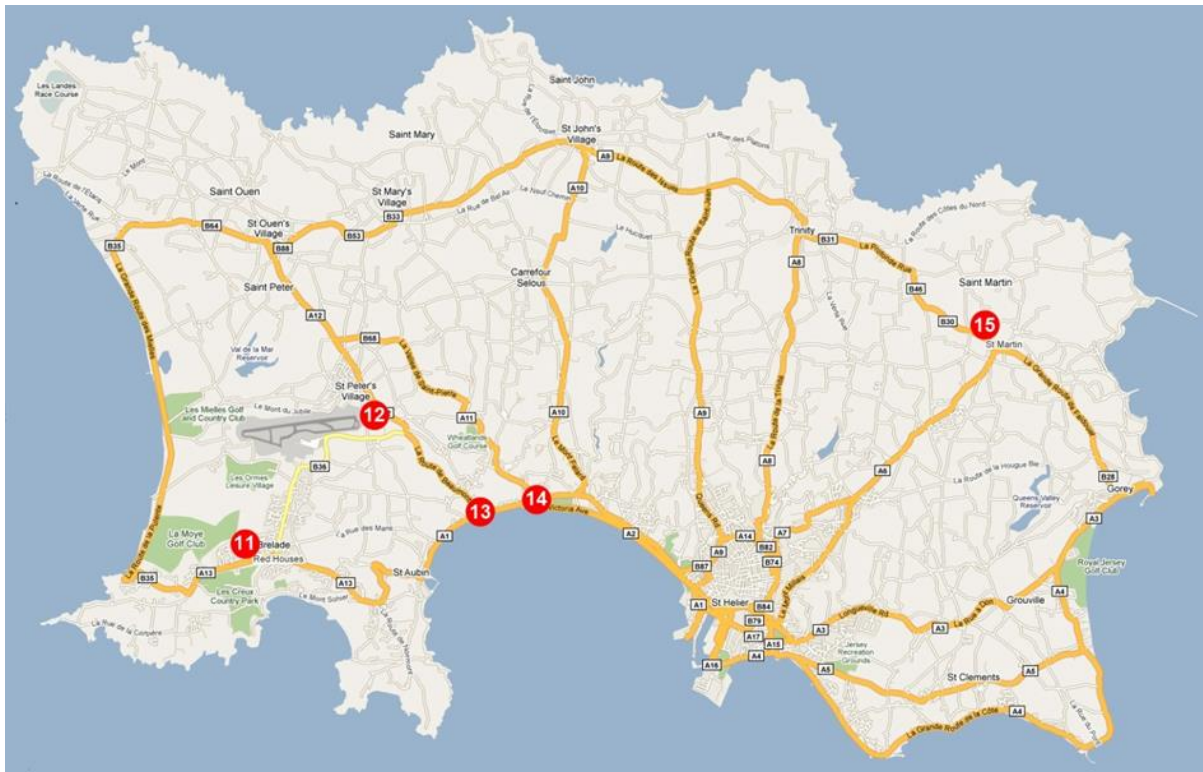
Figure 2-3: Site locations in St Helier town



Key:

Number	Site name	Pollutants	Number	Site Name	Pollutants
1	Les 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

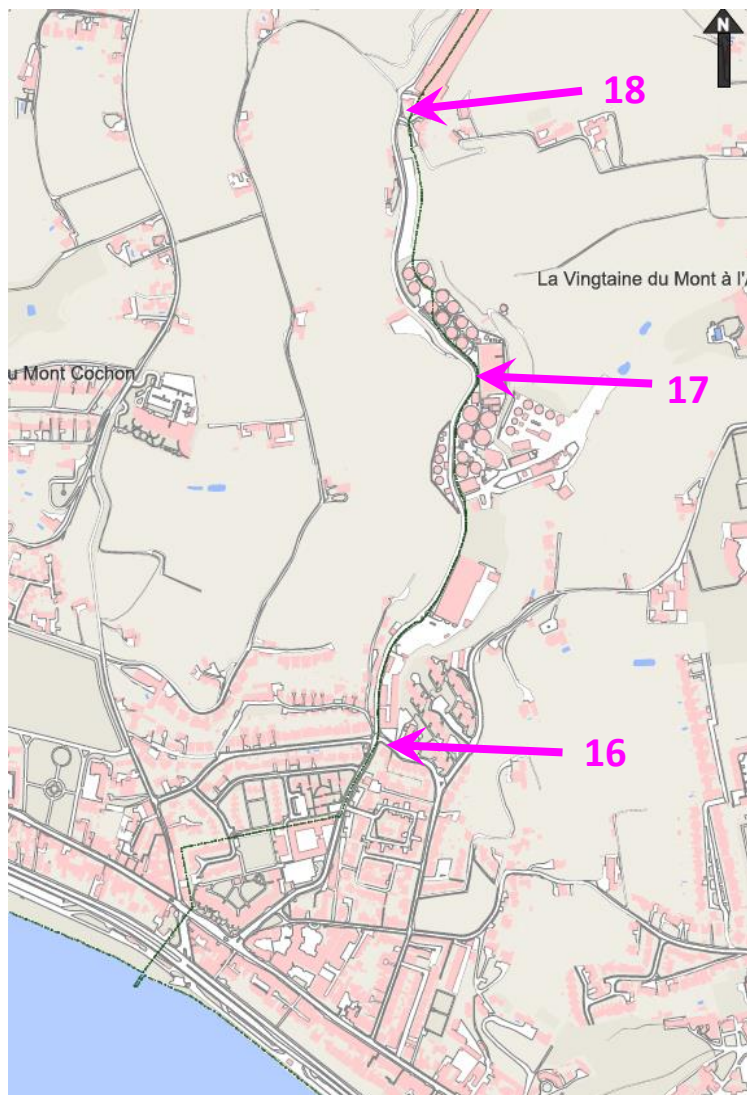
Figure 2-4: Site locations outside St Helier



Key:

Number	Site name	Pollutants	Number	Site name	Pollutants
11	Les Quennevais	NO ₂	14	Hansford Lane	BTEX
12	Airport Fence	BTEX	15	Rue Des Raisies	NO ₂
13	Beaumont	NO ₂			

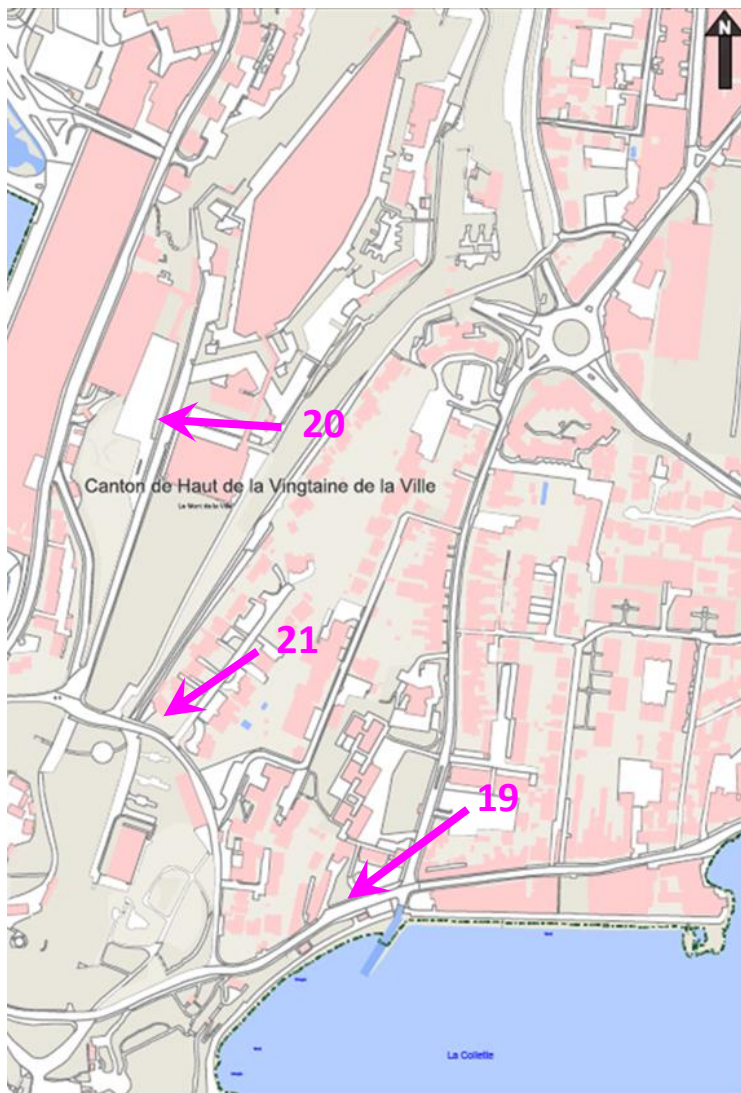
Figure 2-5: Site locations on Bellozanne Road near to sewage treatment works



Key:

Number	Site name	Pollutants
16	Bellozanne STW, Route es Nouveaux	NO ₂
17	Bellozanne STW, Gate 4	NO ₂
18	Bellozanne STW, Green Waste Sign	NO ₂

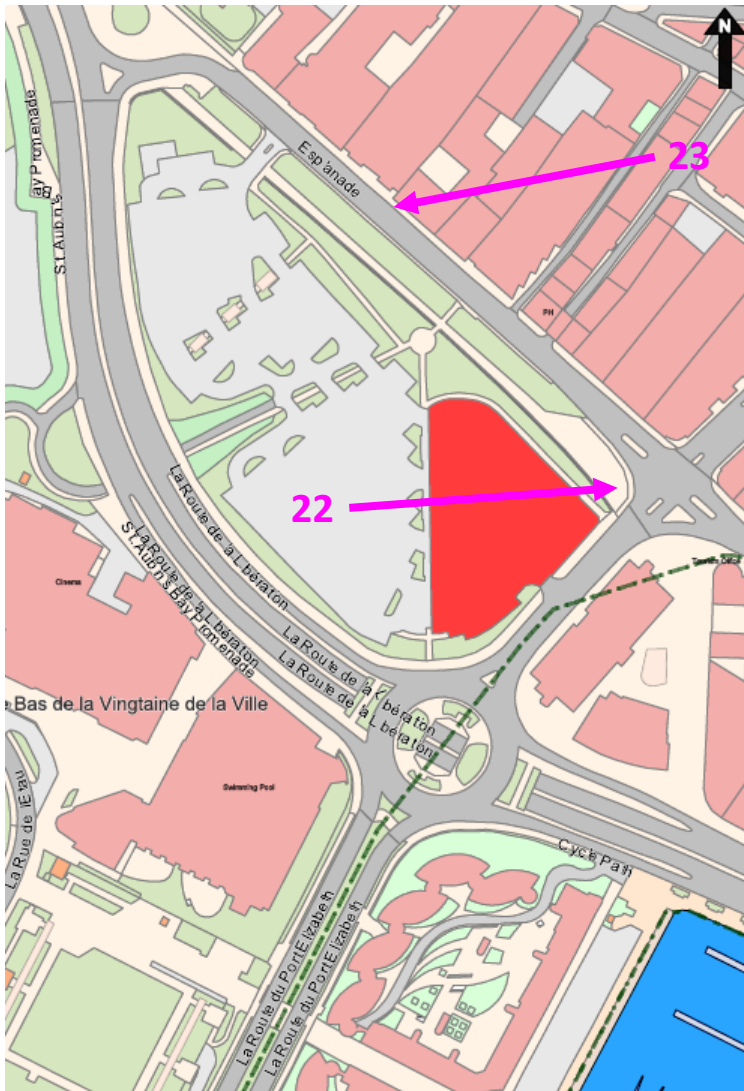
Figure 2-6: Site locations at East & North-East of La Collette



Key:

Number	Site name	Pollutants
19	La Collette Gardens	NO ₂
20	South Hill Fort Regent	NO ₂
21	South Hill Park	NO ₂

Figure 2-7: Site location Town Centre



Key:

Number	Site name	Pollutants
22	Junction of Castle St & Esplanade	NO ₂
23	Carey Olson Esplanade	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 were exposed in triplicate, to allow assessment of precision. All other diffusion tube sites use single tubes.

BTEX hydrocarbons were monitored at five sites during 2015, 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
Les Bas Centre	658 489	Urban background site which has operated since 1997.
Halkett Place	653 486	Urban roadside site which has operated since Sept 2011
Airport Fence	512 598	Rural background site on the airport perimeter fence, in operation since March 2012.
Hansford Lane	633 499	Urban background site near a paint spraying process.
Faux Bie	658 495	Urban background site, near fuel filling station. Represents the nearest public exposure to a petrol station.

Le Bas Centre is intended to monitor hydrocarbon concentrations at an urban background location. Hansford Lane is close to a paint spraying process, 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, which had to be relocated in 2012.

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)⁶. The Halkett Place site achieved the data capture target of 90%. The only significant data gap was between the 21st and 22nd of August (26 hours); this was due to the annual audit and service.

Table 3–2: Jersey Halkett Place – Data capture statistics 2015

Site	NO	NO ₂	NO _x
Jersey Halkett Place	95.6%	95.6%	95.6%

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 ranged from ± 5.2% to ± 7.8% for the NO₂ diffusion tubes and from ± 9.6% to ± 10.9% for the 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 are 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 2015 was equivalent to an ambient concentration of 0.2 µg m⁻³ assuming an exposure period of 28 days. For hydrocarbons, the limit of detection equated to ambient concentrations in the region of 0.21 to 0.27 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 most measurements with the exception of toluene, and of m+p xylenes at some sites. 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

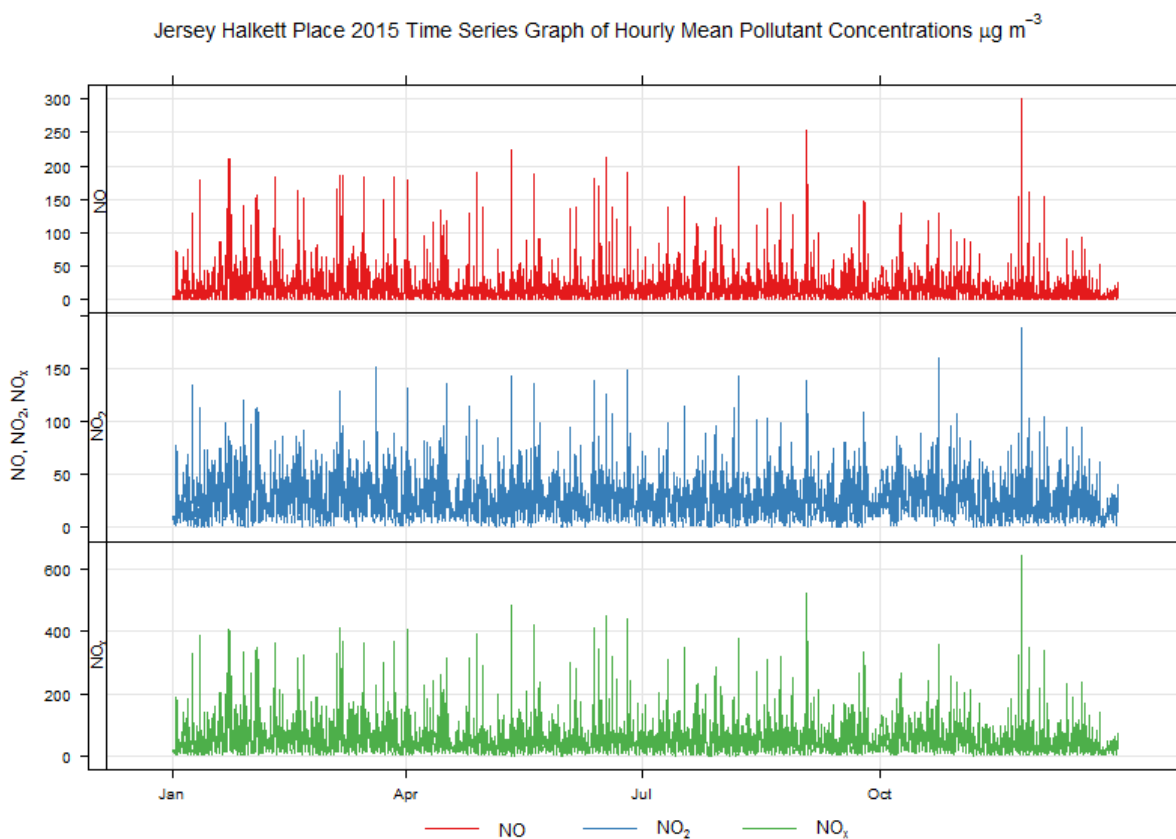
4.1.1 Automatic NO₂ Monitoring Results

Table 4–1 shows the key statistics for oxides of nitrogen measured by the automatic analyser at Halkett Place. Table 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 time scale and throughout the year, Figure 4-1.

Table 4–1: Oxides of nitrogen at Jersey Halkett Place – air quality statistics for 2015

Pollutant	NO µg m ⁻³	NO ₂ µg m ⁻³	NO _x µg m ⁻³
Maximum 15-minute mean	649	443	1266
Maximum hourly mean	300	189	647
Maximum running 8-hour mean	105	80	217
Maximum running 24-hour mean	61	54	141
Maximum daily mean	61	54	139
Average	16	27	51
Data capture	95.6%	95.6%	95.6%

Figure 4-1: Time series plots of hourly mean pollutant concentrations at Halkett Place, 2015



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.

One result was missing: The March 2015 tube for South Hill Fort Regent was returned unexposed.

The calculated bias adjustment factor (BAF) for the 2015 diffusion tube data set is 0.99 as shown in Appendix 3 Figure A3- 1.

Table 4–2: NO₂ diffusion tube results 2015, Jersey. Concentrations (rounded), µg m⁻³.

Site	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Annual mean µg m ⁻³	Annual mean X BAF µg m ⁻³
Beaumont (K)	33	37	40	46	31	35	31	39	36	41	27	17	34	34
Broad Street (K)	26	31	34	30	29	27	27	31	28	30	28	26	29	29
Georgetown (K)	31	36	41	35	31	32	26	32	36	35	31	23	32	32
The Parade (K)	21	25	26	23	22	21	22	25	23	25	25	20	23	23
Weighbridge (K)	34	38	40	33	40	38	34	40	35	33	32	21	35	35
Halkett Place 1 (R)	27	25	33	29	28	28	27	28	26	30	28	21	27	27
Halkett Place 2 (R)	27	27	32	29	25	28	27	28	28	30	27	20	27	27
Halkett Place 3 (R)	28	29	33	30	26	29	26	26	23	28	26	19	27	27
Halkett Place Mean	27	27	33	29	27	28	27	27	25	29	27	20	27	27
Liberation Station (R)	31	31	34	36	31	33	30	37	37	42	29	12	32	32
New Street (R)	19	21	22	18	15	16	14	17	14	21	22	27	19	19
Union Street (R)	27	28	30	28	30	26	27	28	24	26	34	31	28	28
Castle St/Esplanade (R)	-	-	-	-	-	-	-	28	37	34	28	18	N/A*	N/A*
Carey Olson Esplanade (R)	-	-	-	-	-	-	-	25	23	25	21	20	N/A*	N/A*

Site	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Annual mean µg m ⁻³	Annual mean X BAF µg m ⁻³
Bellozanne 1	16	18	19	19	14	15	10	15	8	16	16	9	15	14
Bellozanne 2	13	14	16	17	10	12	9	10	11	14	11	11	12	12
Bellozanne 3	12	12	13	12	8	9	14	10	14	9	7	13	11	11
La Collette Gdns	17	18	18	13	14	12	11	12	14	17	14	8	14	14
South Hill Fort Regent	19	21	no data	15	16	15	14	15	13	14	16	14	16	15
South Hill Park	16	17	37	15	18	14	16	15	14	16	11	8	16	16
Le Bas Centre (UB)	19	18	24	20	17	18	18	18	16	20	20	18	19	19
Les Quennevais (S)	7.0	9.4	11.7	11.5	5.1	6.3	4.1	6.4	6.4	11.2	6.3	5.7	7.6	7.5
Rue des Raisies (Ru)	5.0	6.1	8.1	6.2	3.6	5.2	4.1	4.6	4.4	6.0	5.1	4.7	5.3	5.2

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

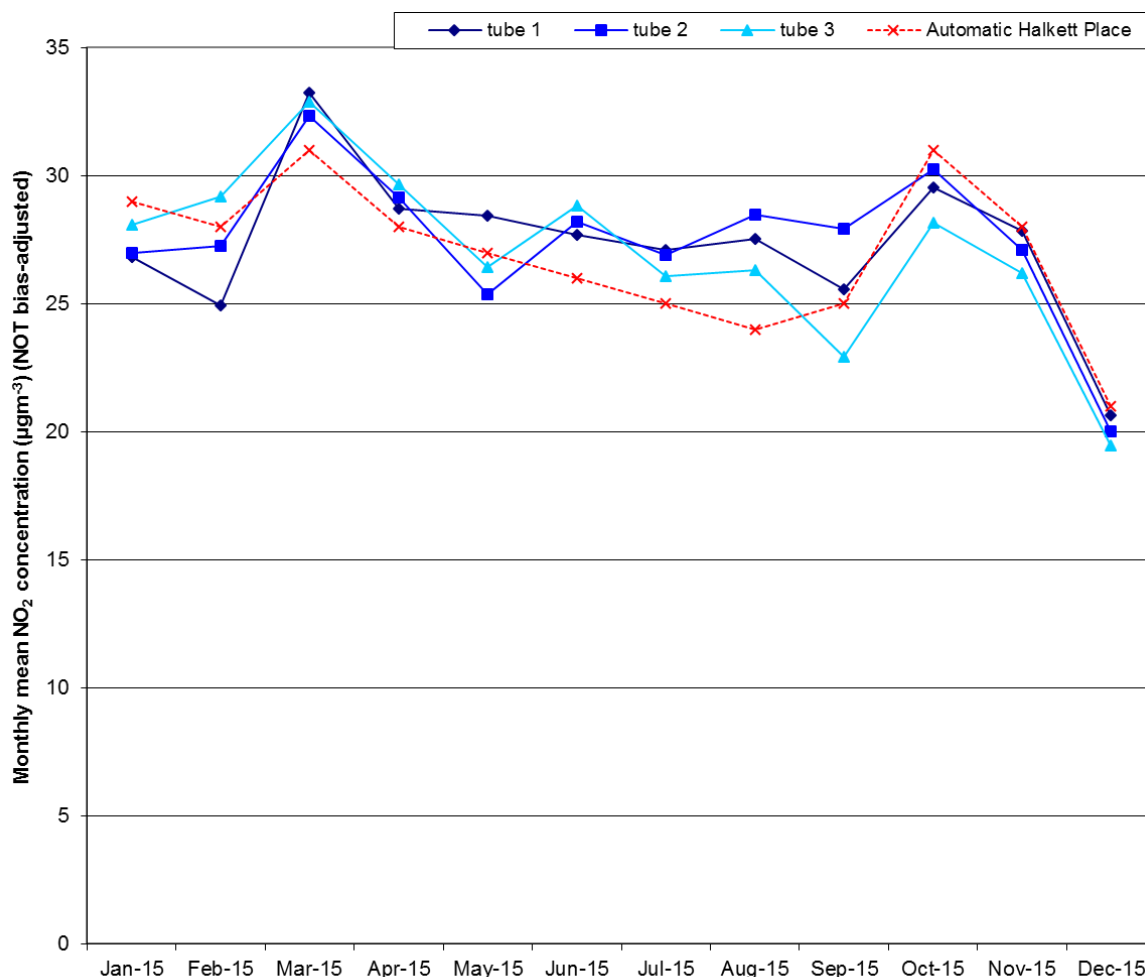
* The annual mean is not included for these two sites, as there are less than nine months of NO₂ diffusion tube monitoring results.

Individual monthly mean NO₂ results ranged from 3.6 µg m⁻³ (in May at the rural Rue des Raisies site), to 46 µg m⁻³ (in April at the kerbside Beaumont site).

Table 4–2 includes the two new sites. However, as they started up later in the year, neither have the minimum nine months' data required for a valid annual mean.

Figure 4-2 shows the monthly mean NO₂ concentrations, as measured by diffusion tubes and by the automatic analyser, at Halkett Place. Agreement between the two methods were good.

Figure 4-2: 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 Air Quality Directive⁴ 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 Strategy⁵ contains objectives for NO₂, which are very similar to the Directive limits above, the only difference being they had to be achieved by 31st December 2005.

The 1-hour mean at the Halkett Place automatic monitoring site did not exceed $200 \mu\text{g m}^{-3}$ on any occasion in 2015. Therefore this site met the EC Directive limit value and AQS objective for this parameter. The annual mean concentration of $27 \mu\text{g m}^{-3}$ as measured by the automatic analyser at Halkett Place was well within the EC limit value of $40 \mu\text{g m}^{-3}$.

Due to 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. After applying the bias adjustment factor, no sites exceeded the annual mean limit value of $40 \mu\text{g m}^{-3}$.

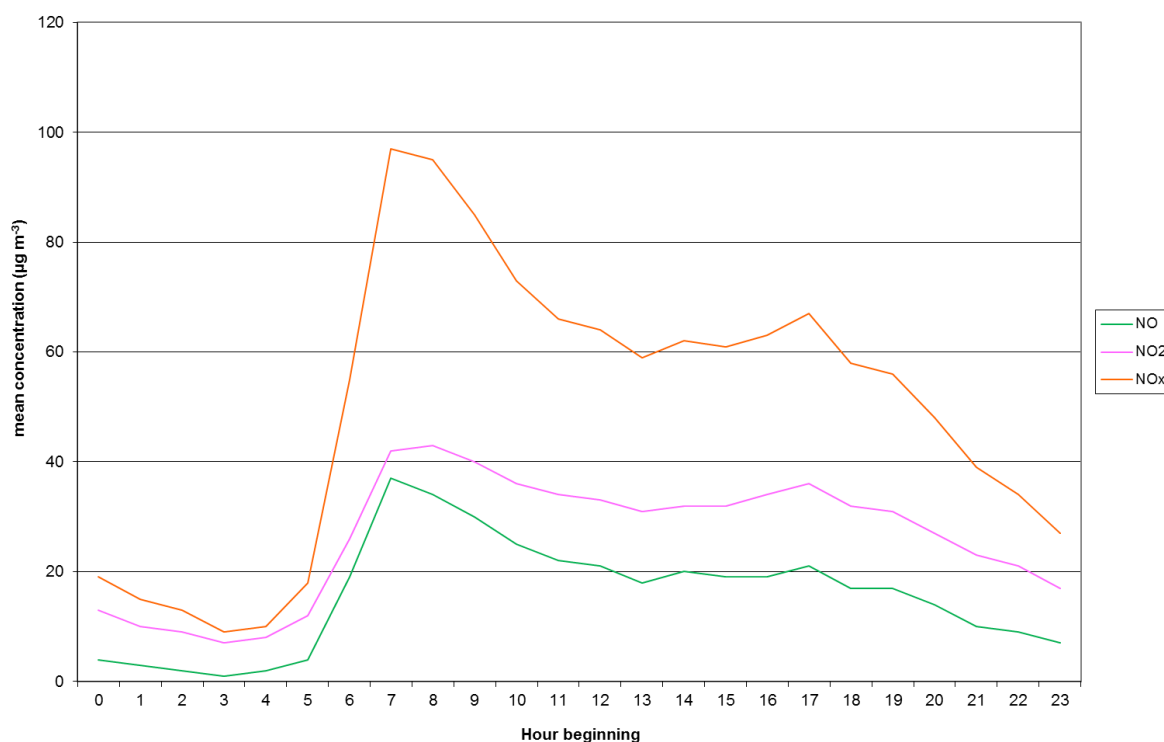
The $30 \mu\text{g m}^{-3}$ limit for protection of vegetation is only applicable at rural sites, and is therefore only relevant to Rue des Raisies. The annual mean NO_2 concentration of $5.2 \mu\text{g m}^{-3}$ at this rural site was well within the limit value.

4.3 Diurnal and Seasonal Variation in NO_2 Concentration

4.3.1 Diurnal Variation in NO , NO_2 and total NO_x at Halkett Place, 2015

Figure 4-3 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 2015, as measured by the automatic monitor at Halkett Place.

Figure 4-3 Diurnal variation in concentrations of NO , NO_2 and NO_x at Halkett Place, 2015



The curve for NO , a primary pollutant (i.e. directly emitted from source) emitted from road vehicles and other combustion sources, shows a sharp morning peak at 07:00. Concentrations then decrease through the morning, plateauing between 12:00 and 17:00; finally decreasing further around 18:00 with barely any afternoon or evening rush hour peak.

For NO_2 , having both primary (i.e. directly emitted) and secondary (i.e. oxidation of NO) components, there is an early morning peak at 07:00 to 08:00, decreasing to a plateau through the rest of the morning. There is a small late afternoon peak around 17:00, then the concentration decreases through the remainder of the evening. The small late afternoon peak it is less pronounced compared with the morning's highest concentration.

Based on Ricardo Energy & Environment's experience with data from the Automatic Urban and Rural Network (AURN), 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 sharp. This may be explained by the 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 vehicle emissions from these activities are responsible for the distinctive morning pattern at Halkett Place.

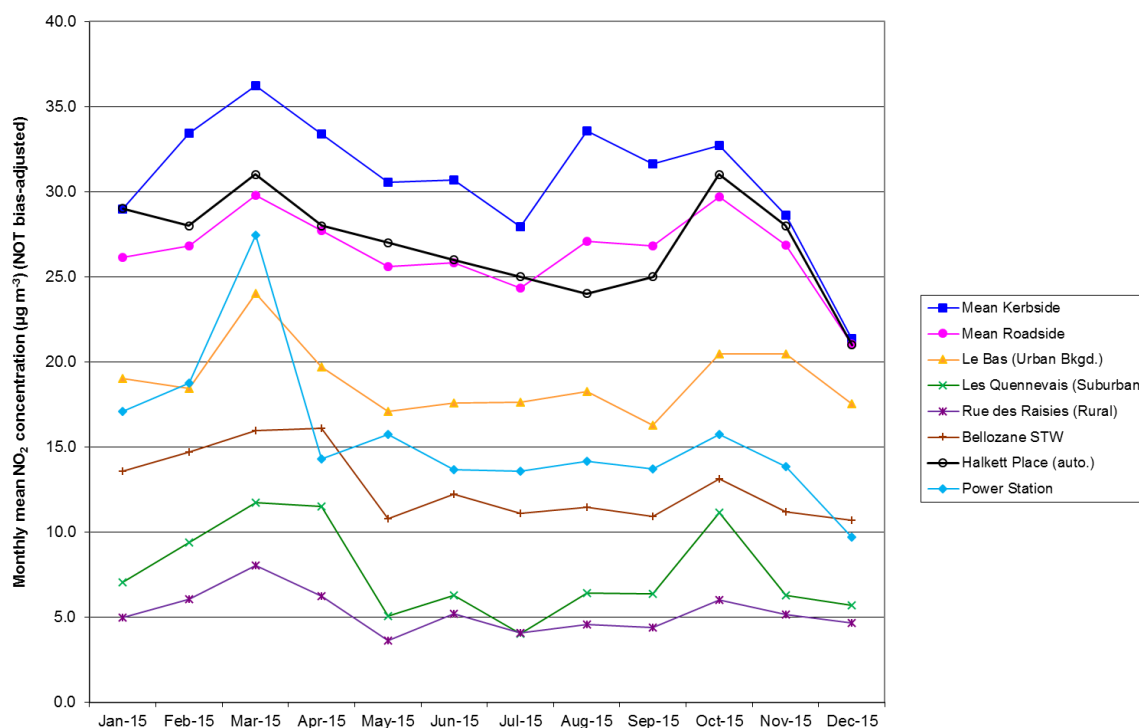
Halkett Place does not exhibit a substantial afternoon or evening rush hour peak (as observed at many roadside AURN sites). This is unusual for an urban site. In the afternoon, concentrations of oxidising agents in the atmosphere (particularly ozone) tend to increase, leading to enhanced oxidation of 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 little afternoon rush hour traffic in this area. Most traffic is associated with the market and shoppers, occurring during the morning, afternoons are relatively quiet.

4.3.2 Seasonal Variation in NO₂ Concentration

Figure 4-4 shows the monthly mean NO₂ concentrations measured at the diffusion tube sites and Halkett Place. Including:

- The mean of the five kerbside sites.
- The mean of the four roadside sites.
- The monthly means measured at:
 - The single urban background site (Le Bas Centre).
 - The suburban residential site (Les Quennevais).
 - The rural site (Rue des Raisies).
 - The Sewage Treatment Works (Bellozanne 1-3).
 - The Power Station sites (La Collette Gardens, South Hill Fort Regent and South Hill Park).
- The monthly means (based on the same periods as the diffusion tube exposures) for the Halkett Place automatic site.

Figure 4-4 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. Historically, the sites in Jersey have not shown this, or indeed any, consistent seasonal pattern. However, in 2015, urban concentrations were slightly higher towards the end of the

winter and beginning of spring. The highest monthly means for all sets of sites were recorded in March. This was also the case for the automatic analyser.

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 from the final three months of 2015 have not been fully ratified at the time of writing, so the annual means below are based on data that are partly still provisional. 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
- 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	2015 Annual mean NO ₂ concentration $\mu\text{g m}^{-3}$
Brighton Preston Park	15
Exeter Roadside	29
Plymouth Centre	19
Yarner Wood	4
Jersey Halkett Place (automatic)	27

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 35 $\mu\text{g m}^{-3}$. The annual means at Exeter Roadside and Plymouth Centre (29 $\mu\text{g m}^{-3}$ and 19 $\mu\text{g m}^{-3}$ respectively) were within this range. The mean concentration measured at Exeter Roadside is comparable with the annual mean of 27 $\mu\text{g m}^{-3}$ as 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 $\mu\text{g m}^{-3}$, the same as the annual mean from the urban background site at Plymouth Centre. The residential background site at Les Quennevais had a bias-adjusted annual mean NO₂ concentration of 7.5 $\mu\text{g m}^{-3}$: this is a higher than the rural Yarner Wood site in Devon. The bias-adjusted annual mean of 5.2 $\mu\text{g m}^{-3}$ at the Jersey rural background site, Rue des Raisies was also higher than that measured remote Yarner Wood site.

4.3.4 Trends in NO₂ at Long-running Sites

There are 10 sites in the survey which have been in operation since 2005 or earlier and therefore now have 11 years of data. The annual mean NO₂ concentrations are shown in Table 4–4 and illustrated in Figure 4-5. The data is 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 is 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). Several exceeded the EC Directive limit value of 40 $\mu\text{g m}^{-3}$, and there were no sign of concentrations decreasing. From 2004 onwards, concentrations began to decrease. In 2015, (after application of the bias adjustment factor), all sites remained below 40 $\mu\text{g m}^{-3}$.

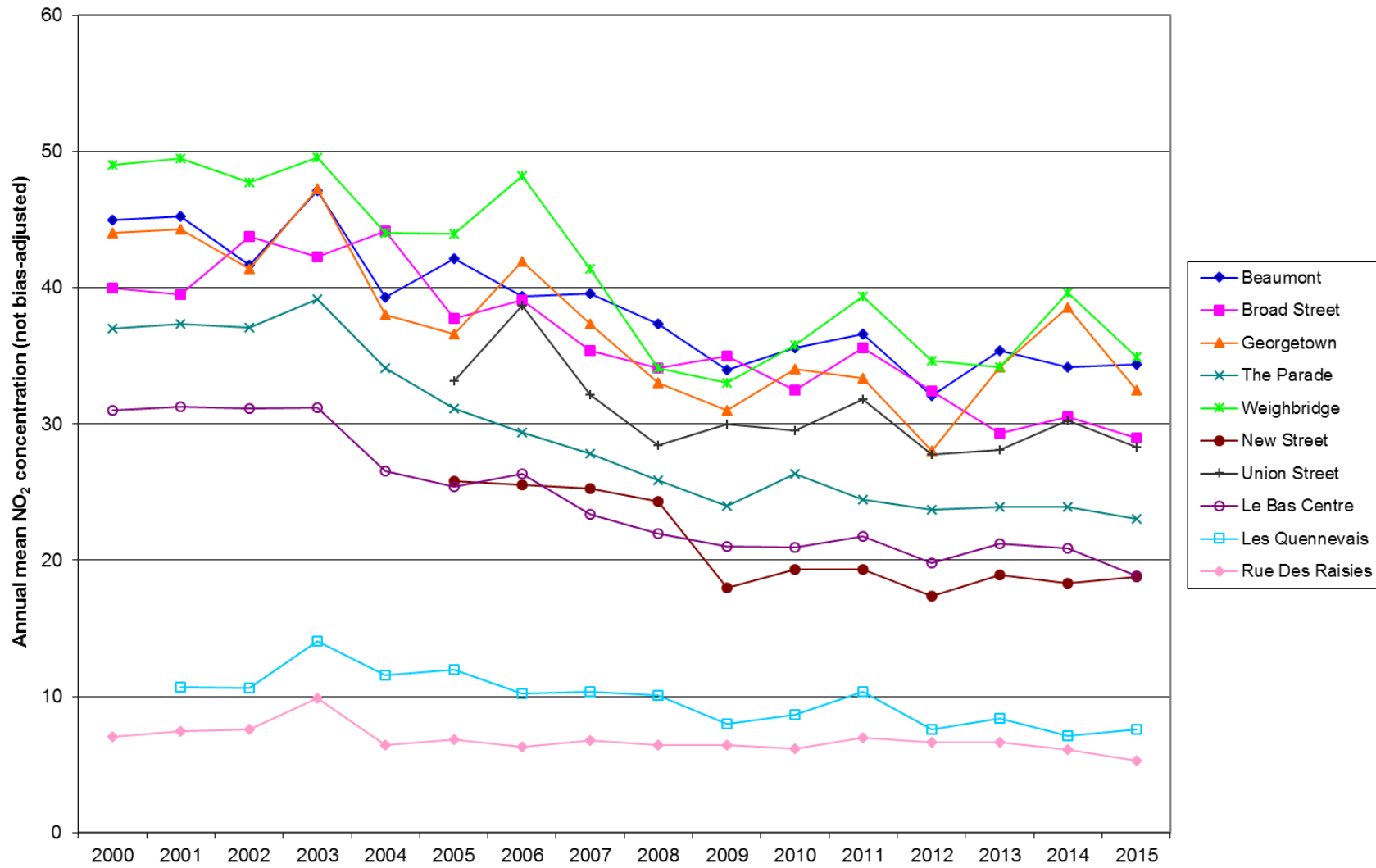
Figure 4-5 illustrates how the annual mean concentrations remained stable from 2000 to 2003. This was followed by a period when NO₂ concentrations at the urban sites appeared to show a general decrease, until around 2012. However, since then, annual mean NO₂ concentrations at several of the sites have remained stable, or in some cases (such as Georgetown and Weighbridge) begun to increase again. NO₂ concentrations typically fluctuate from year to year due to meteorological and other factors.

Table 4–4: Annual mean NO₂ concentrations at the diffusion tube sites, µg m⁻³ (NOT bias adjusted)

Site	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Beaumont (K)	45	45	42	47	39	42	39	40	37	34	36	37	32	35	34	34
Broad Street (K)	40	39	44	42	44	38	39	35	34	35	32	36	32	29	30	29
Georgetown (K)	44	44	41	47	38	37	42	37	33	31	34	33	28	34	39	32
The Parade (K)	37	37	37	39	34	31	29	28	26	24	26	24	24	24	24	23
Weighbridge (K)	49	49	48	50	44	44	48	41	34	33	36	39	35	34	40	35
New Street (R)	-	-	-	-	-	26	26	25	24	18	19	19	17	19	18	19
Union Street (R)	-	-	-	-	-	33	39	32	28	30	30	32	28	28	30	28
Le Bas Centre (UB)	31	31	31	31	27	25	26	23	22	21	21	22	20	21	21	19
Les Quennevais (S)		11	11	14	12	12	10	10.3	10.1	8.0	8.7	10.4	7.6	8.4	7.1	8
Rue Des Raisies (Ru)	7	7	8	10	6	7	6	6.8	6.5	6.4	6.2	7.0	6.6	6.6	6.1	5

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

Figure 4-5: Annual mean NO₂ concentrations (NOT adjusted for diffusion tube bias)



4.4 Hydrocarbons

Full monthly results of the hydrocarbon survey for the five BTEX sites are shown in Appendix 4, Table A4- 1 to A4- 5.

A summary of the annual average hydrocarbon concentrations is shown in Table 4–5 and Table A4- 2. There were numerous instances throughout the year when the reported results were less than the limit of detection, especially for ethylbenzene, and o-xylene. 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- 3. These gave consistently lower results than the exposed tubes.

Table 4–6 Summary of average hydrocarbon concentrations ($\mu\text{g m}^{-3}$), Jersey, 2015

Site	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
Le Bas Centre	0.9	2.6	0.6	2.1	0.9
Halkett Place (Central Market)	0.7	2.3	1.0	2.0	0.8
Airport Fence	0.5	1.4	0.6	1.1	0.5
Hansford Lane	0.5	2.9	1.4	5.3	1.8
Faux Bie	1.6	10.3	1.8	6.4	2.5
Travel blank	0.1	0.1	0.1	0.1	0.1

Highest annual mean concentrations of all the hydrocarbons in 2015 were measured at Faux Bie, which is at the nearest housing to a petrol station. It is likely that the evaporation of benzene and toluene in particular, from fuel as it is stored or dispensed, is contributing to ambient levels.

The Hansford Lane site (near a paint spraying process) has in the past measured relatively high concentrations of m+p-xylene and o-xylene. However, in 2015 it measured lower concentrations of both of these species than did the Faux Bie site. The paint spraying process is not expected to be a significant source of benzene or toluene and the concentrations of these two hydrocarbons at Hansford Lane were similar to or lower than those at Le Bas and Halkett Place. Graphical representations of monthly mean hydrocarbon concentrations are shown in Figure 4-6 to

Figure 4-10. All five figures use identical y-axes, for ease of comparison.

The February 2015 results are missing for all sites except le Bas Centre: this is because of an instrument failure at the analytical laboratory. In addition, the August BTEX diffusion tube from the Faux Bie site was returned with its cap missing. This therefore invalidated the results.

Figure 4-6: Monthly mean hydrocarbon concentrations at Le Bas Centre, 2015

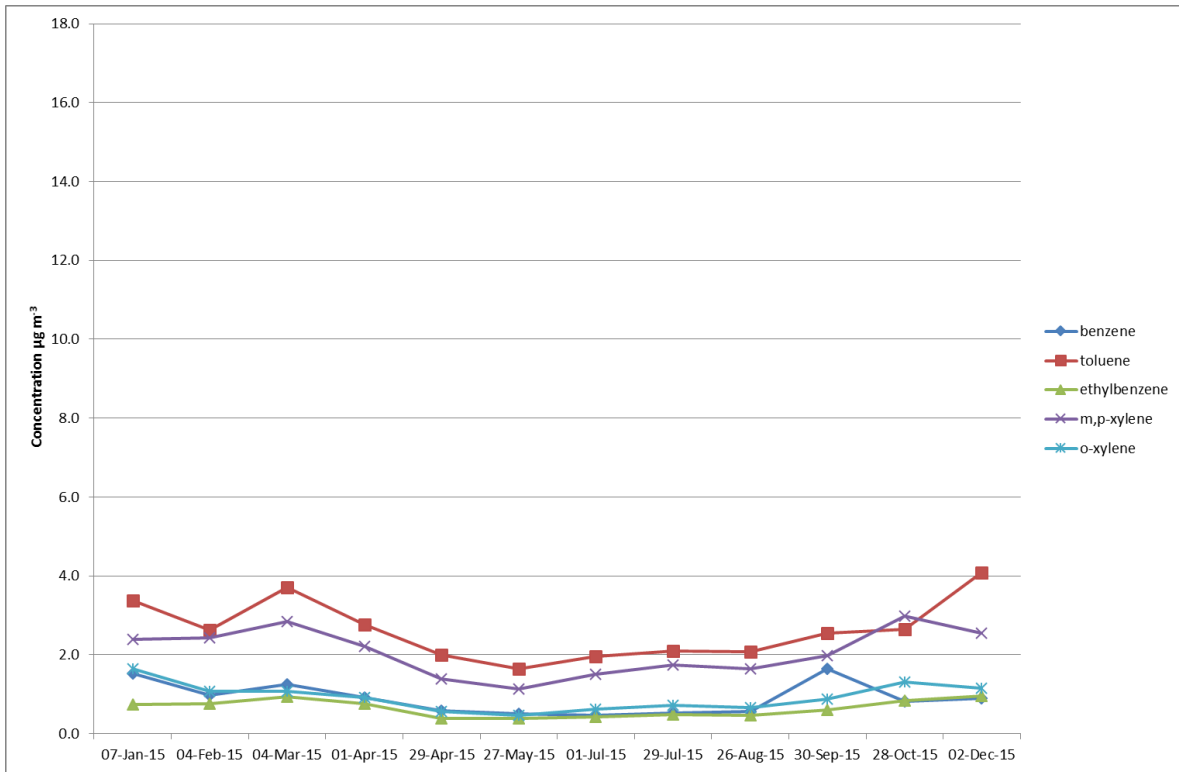


Figure 4-7 Monthly mean hydrocarbon concentrations at Halkett Place, 2015

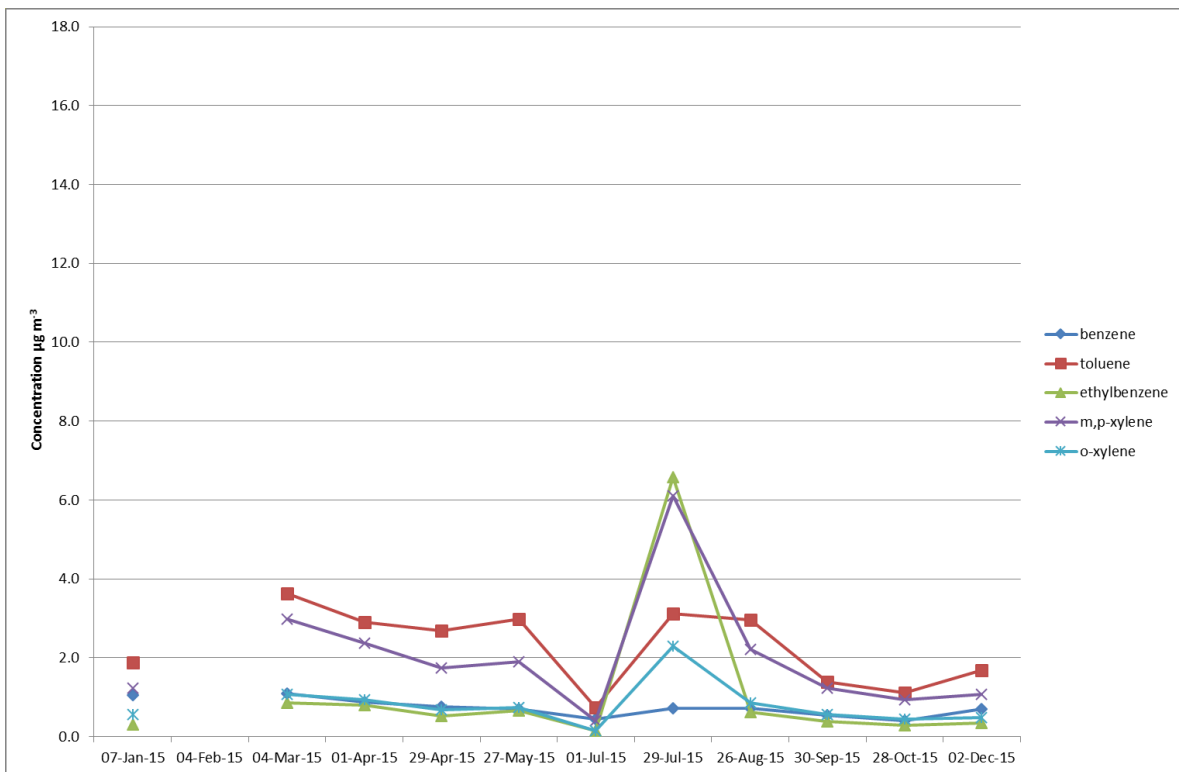


Figure 4-8: Monthly mean hydrocarbon concentrations at Airport Fence, 2015

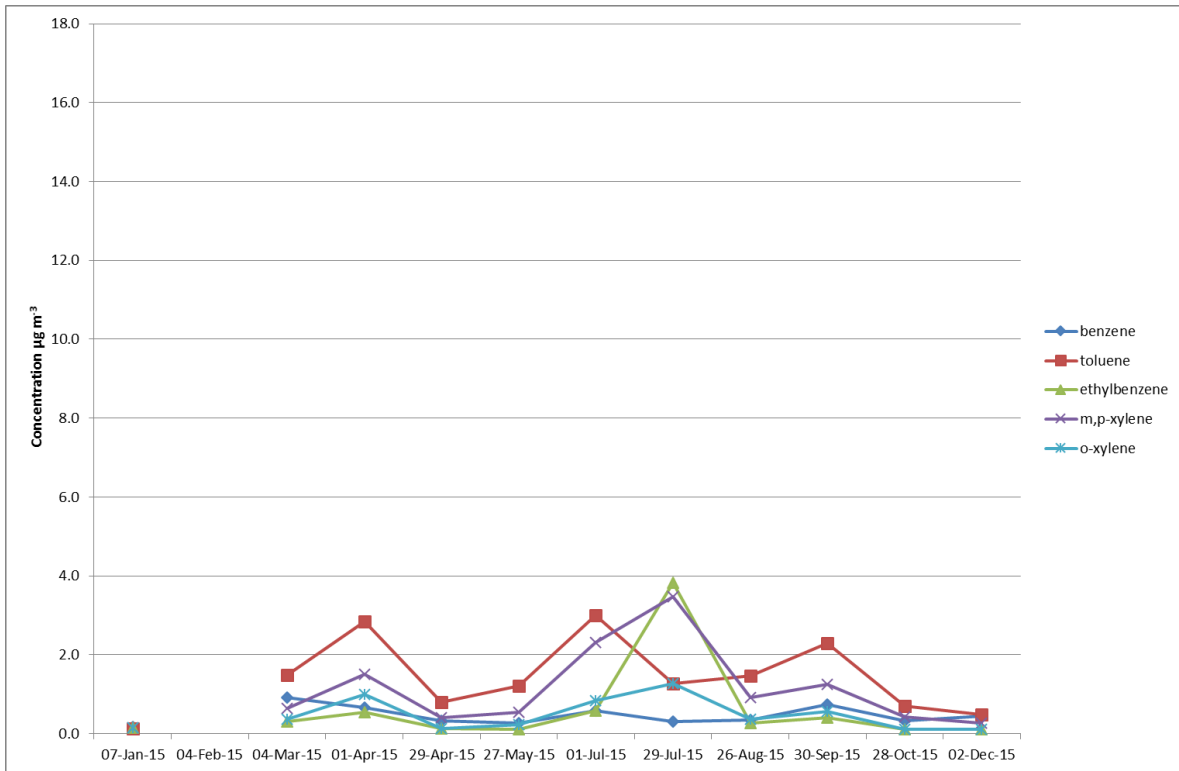


Figure 4-9: Monthly mean hydrocarbon concentrations at Hansford Lane, 2015

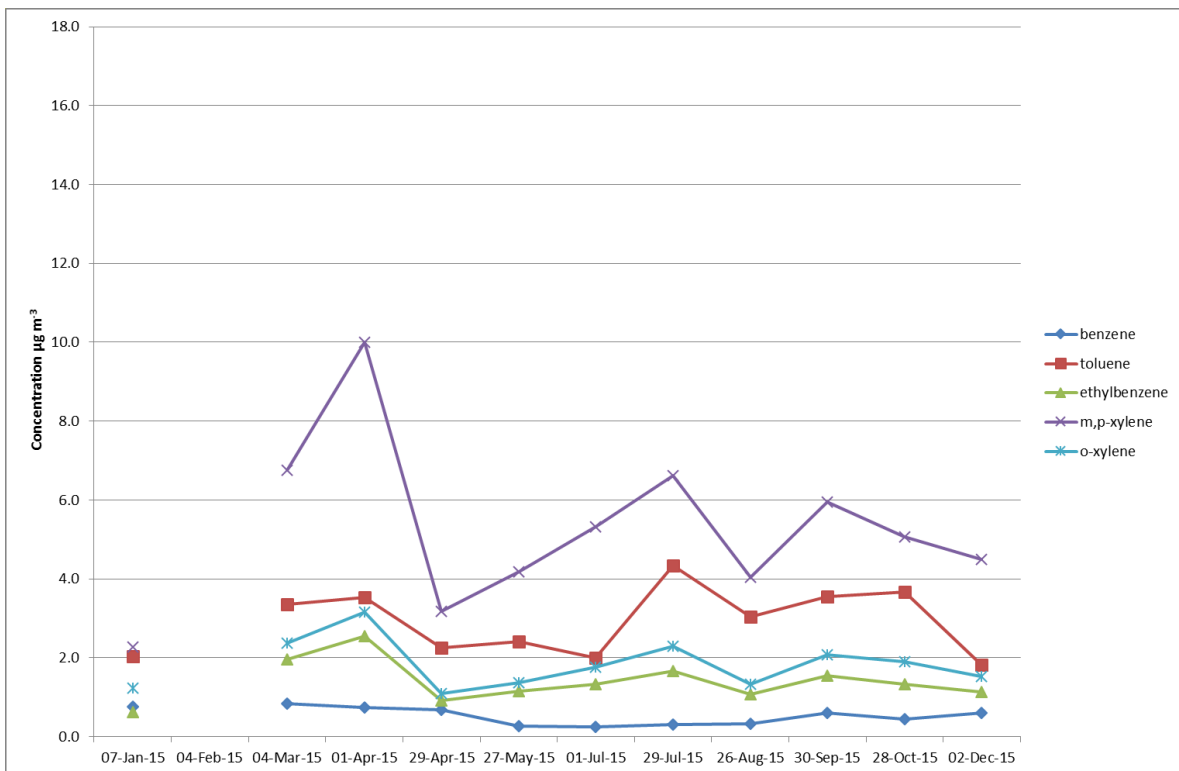
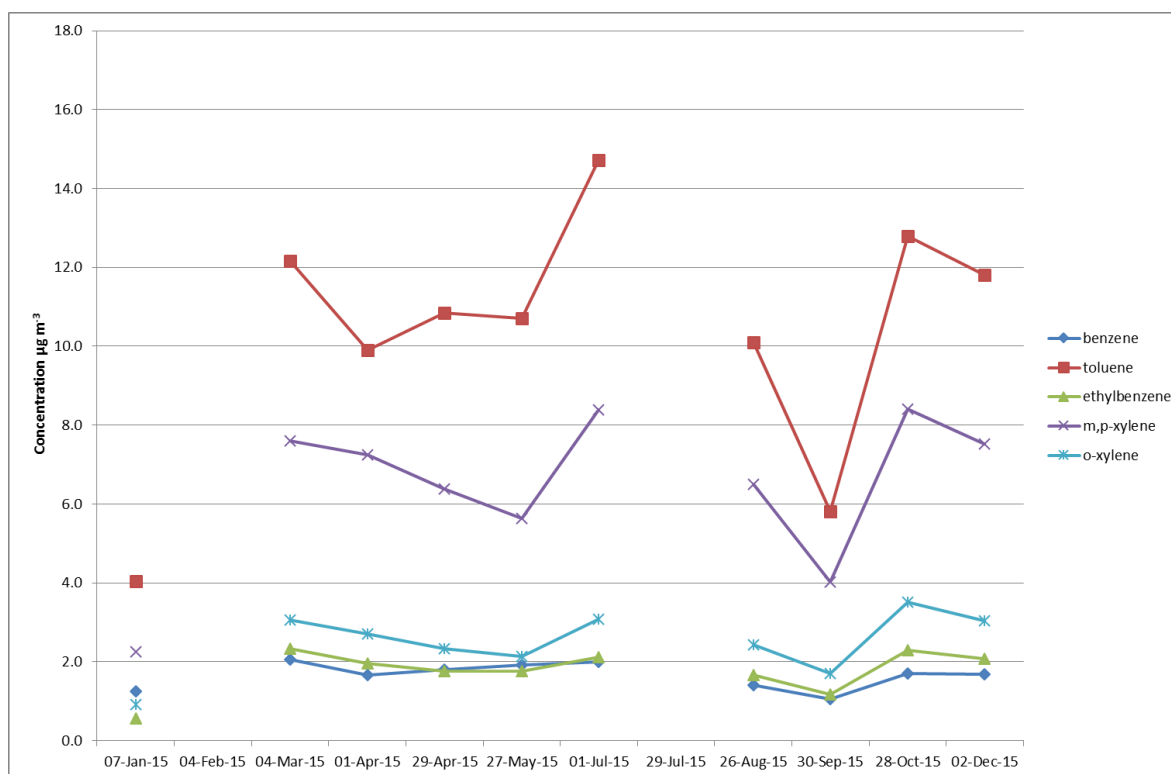


Figure 4-10: Monthly mean hydrocarbon concentrations at Faux Bie, 2015

The charts clearly show the differences in hydrocarbon concentrations between each location. The Airport Fence site recorded the lowest concentrations of all the BTEX hydrocarbons, frequently below the detection limit except for toluene.

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 Air Quality Directive⁴ sets a limit of $5 \mu\text{g m}^{-3}$ for the annual mean of benzene, to be achieved by 2010. All sites met this limit in 2015, and have done so since 1999 (or since they started operation).

The UK Air Quality Strategy⁵ 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 Previous Years' Hydrocarbon Results

Figure 4-11 to Figure 4-15 show how the annual mean hydrocarbon concentrations at the five Jersey sites have changed over the years of monitoring. The data is also provided in tabular form in Appendix 4.

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 4-11: Time series of benzene concentrations

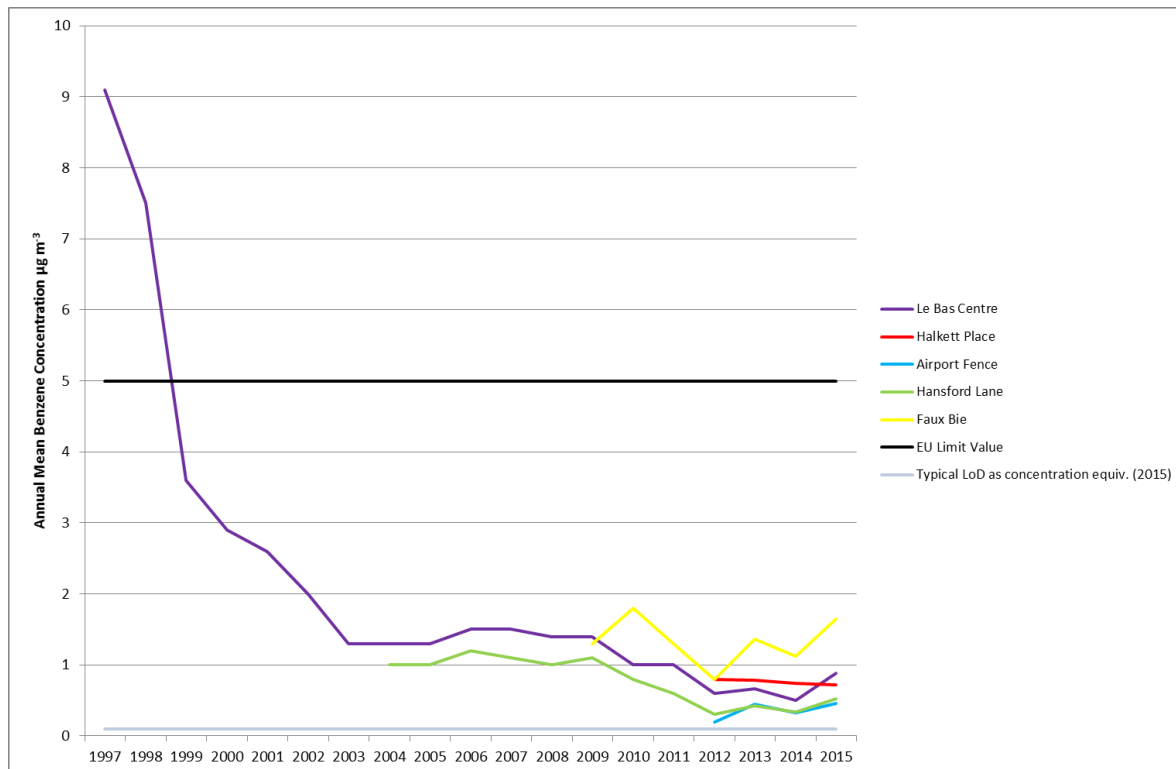


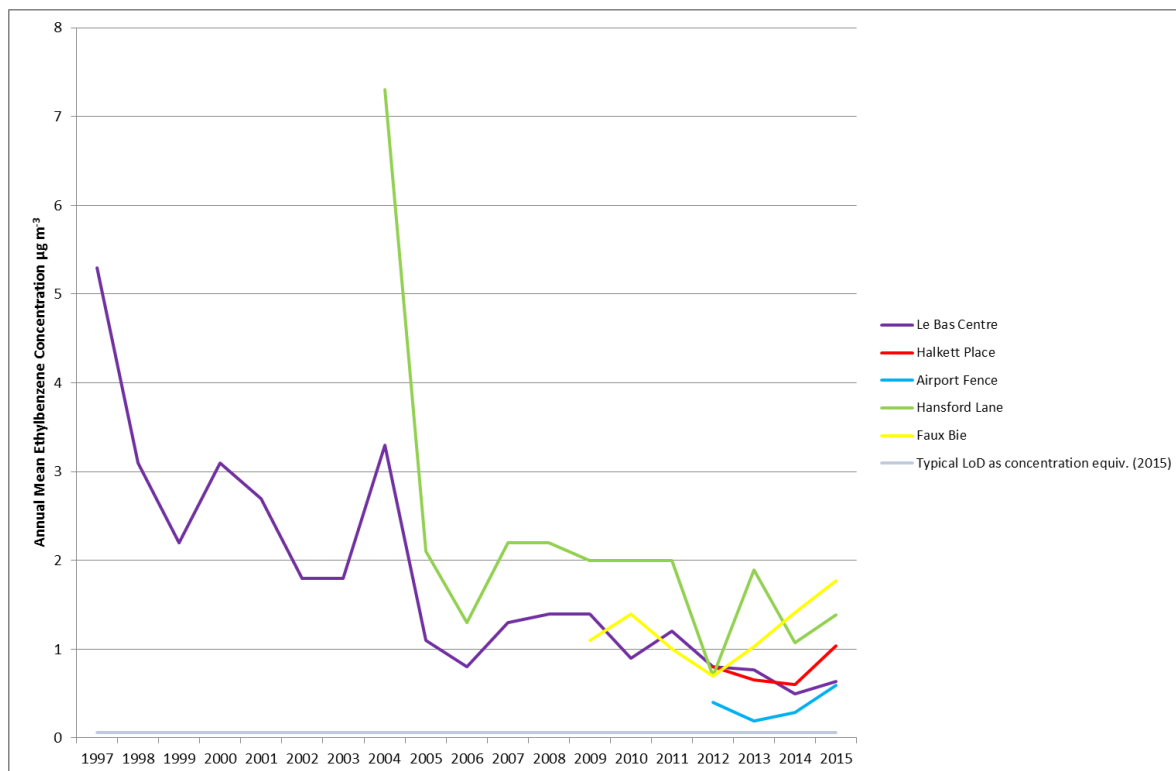
Figure 4-11 shows the annual mean benzene concentrations. It includes the EU limit value of $5 \mu\text{g m}^{-3}$, shown as a black line, and the typical LoD equivalent concentration, shown as a grey line. Le Bas Centre has been in operation since 1997. Annual mean concentrations of benzene at this very long-running site 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. This site has shown a further modest decrease between 2009 and 2012, as has Hansford Lane. Annual mean concentrations at all sites except Faux Bie are now less than $1 \mu\text{g m}^{-3}$.

Figure 4-12: Time series of toluene concentrations



Figure 4-12 shows toluene concentrations. The ambient concentration equivalent to the typical LoD for toluene is shown as a grey line for comparison. The two longest-running sites, Le Bas Centre and Hansford Lane, show general decreases over the past ten years, though these are not consistent. Toluene concentrations at the Faux Bie site have increased since 2012, and the annual mean for 2015 was the highest since monitoring began at this site.

Figure 4-13: Time series of ethylbenzene concentrations



The pattern for ethylbenzene, Figure 4-13, is similar to the toluene time series, Figure 4-12.

Figure 4-14 Time series of m+p-xylene concentrations

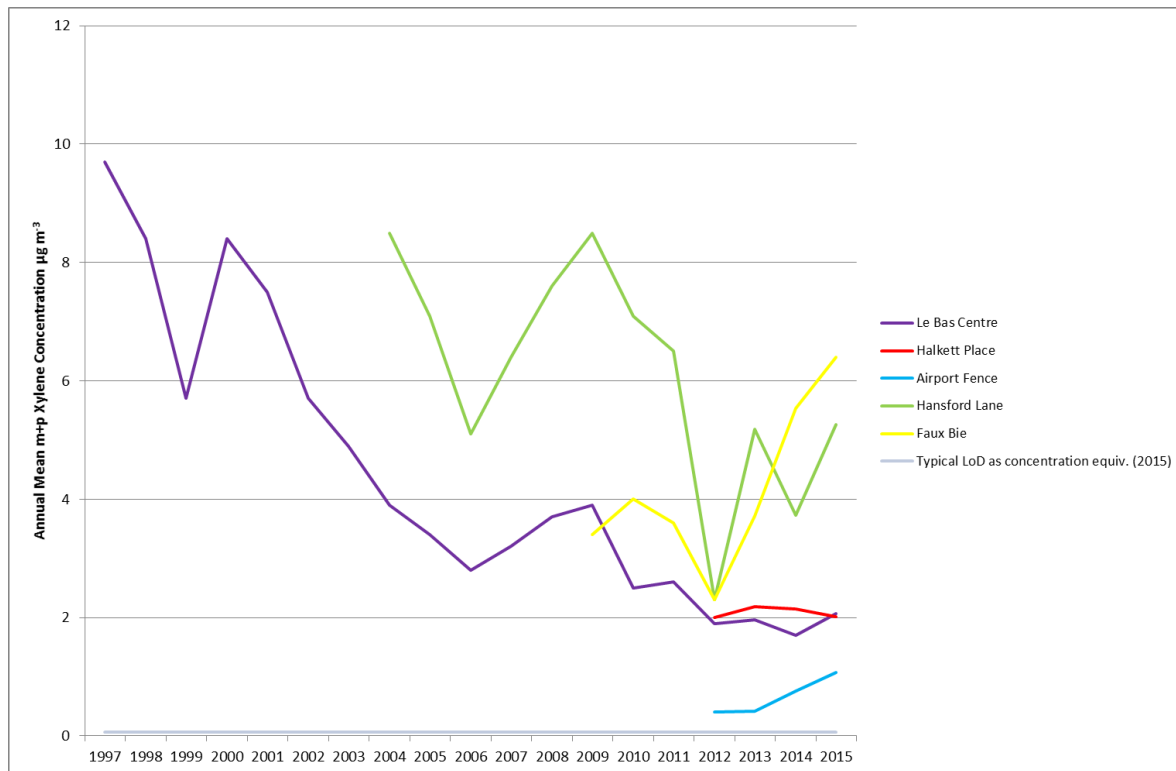


Figure 4-15 Time series of o-xylene concentrations



Concentrations of xylenes (Figure 4-14 and Figure 4-15) are 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 considerably from year to year; however, overall concentrations are low. Xylene concentrations at the Faux Bie site have increased over the last three years.

It is also important to note how low current hydrocarbon concentrations are, compared to the LoD equivalent concentration (in 2015, typically around $0.16 \mu\text{g m}^{-3}$ for benzene, $0.15 \mu\text{g m}^{-3}$ for toluene and $0.18 \mu\text{g m}^{-3}$ for the other hydrocarbons). In the case of the Airport Fence site, monthly mean concentrations of ethylbenzene and o-xylene were frequently below the LoD.

5 Conclusions and Recommendations

Ricardo Energy & Environment has continued the ongoing air quality monitoring programme in Jersey during 2015, on behalf of the States of Jersey Public Health Services. This was the 19th 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 20 sites around the island.

Hydrocarbons (benzene, toluene, ethylbenzene and xylenes, collectively termed BTEX) were measured at five sites, 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.

5.1 NO₂ Results

1. The annual mean NO₂ concentration measured by the automatic analyser at Halkett Place was 27 µg m⁻³. This is 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.
2. 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. There were no hourly means greater than this value measured at Halkett Place. Therefore Halkett Place met the limit value and objective.
3. Diffusion tubes exposed in triplicate alongside the automatic analyser gave an annual mean of 27 µg m⁻³, which was within 1 µg m⁻³ of the annual mean as measured by the automatic analyser.
4. Annual mean NO₂ concentrations at all diffusion tube monitoring sites were within the EC limit value.
5. The diurnal variation in oxide concentrations of nitrogen at Halkett Place were generally typical of an urban site, but had a particularly early (and sharp) morning rush hour peak, with a slight afternoon rush hour peak. This is thought to be due to traffic patterns around the site; this being 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 did not show a typical seasonal pattern; on average the highest concentrations in 2015 were measured in March.
7. Annual mean NO₂ concentrations at Jersey's urban sites appear to have generally decreased between 2003 and 2012: since then, concentrations have remained generally stable at most sites.
8. Annual mean NO₂ concentrations at most of Jersey's diffusion tube monitoring sites were slightly lower in 2015 compared with 2014. Pollutant concentrations are expected to fluctuate from year to year, due to meteorological and other factors.

5.2 Hydrocarbon Diffusion Tube Results

1. Annual mean benzene concentrations at all five sites were within the EC Directive limit value of 5 µg 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, and several results were below the limit of detection of the method.
3. Annual mean concentrations of BTEX hydrocarbons were comparable with those measured in recent years, though in most cases slightly higher than in 2014.

5.3 Recommendations

It is recommended that the monitoring programme be continued; consideration should be given to aligning the monitoring programme with the requirements of Jersey's Air Quality Strategy.

Measured concentrations of BTEX hydrocarbons at most of the sites were very low, and in some cases typically below the limit of detection. The results should therefore only be taken as indicative measurements, for 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 Energy & Environment 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 - 2015

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⁾ /μg 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⁾ (Non-Mandatory Guidelines)	Health Guideline	1-hour mean	200
	Health Guideline	Annual mean	40

¹ Conversions between μg m⁻³ and ppb are as used by the EC, ie 1 ppb NO₂ = 1.91 μg 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 ⁽⁶⁾ /μg m ⁻³ (ppb)
The Air Quality Strategy ^(7,8) All UK	Objective for Dec. 31 st 2003	Running annual mean	16.25 (5)
England ⁽⁹⁾ & Wales ⁽¹⁰⁾ only:	Objective for Dec. 31 st 2010	Annual mean	5 (1.54)
Scotland ⁽¹¹⁾ & Northern Ireland	Objective for Dec. 31 st 2010	Running annual mean	3.25 (1.0)
ED Directive on Ambient Air Quality and Cleaner Air for Europe ⁽¹²⁾	Limit Value. To be achieved by Jan 1 st 2010	Annual calendar year mean	5 (1.5)

Table A1- 3 Toluene

Guideline set by	Description	Criteria based on	Value ⁽¹⁾ /μg m ⁻³ (ppb)
World Health Organisation ⁽¹³⁾ (Non-Mandatory Guideline)	Health Guideline	1-week mean	260 μg m ⁻³ or 0.26 mg m ⁻³

⁶ Conversions between μg m⁻³ and ppb are as used by the EC, ie 1 ppb NO₂ = 1.91 μg m⁻³ at 20 °C and 1013 mB.

⁷ The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. July 2007, The Stationery Office, ID 5611194 07/07.

⁸ 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)).

⁹ Air Quality (Amendment) (England) Regulations 2002 (SI 2002/3043).

¹⁰ Air Quality (Amendment) (Wales) Regulations 2002 (SI 2002/3182 (W298)).

¹¹ Air Quality (Amendment) (Scotland) Regulations 2002 (SI 2002/297).

¹² Council Directive 2008/50/EC.

¹³ 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 Energy & Environment. 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 annual 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 Energy & Environment's audit calibration procedures are UKAS accredited to ISO 17025.

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 2015 this exercise was combined with a full service of the analyser and sampler pump. The same is planned for the 2016 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 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.

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

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

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

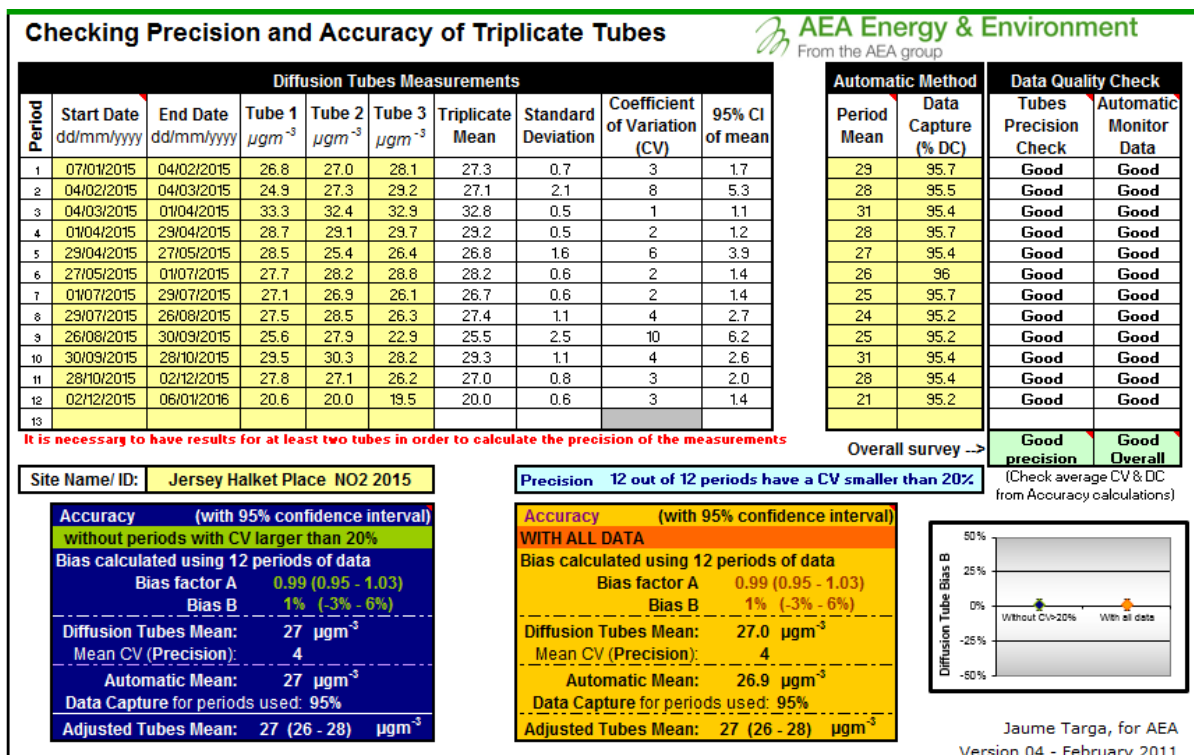
The diffusion tube annual mean concentrations measured at the other (non-co-located) sites can be adjusted for the diffusion tube over/under-read by application of a bias adjustment factor, calculated as follows.

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

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 Energy & Environment (at that time trading as AEA Energy & Environment): Figure A3- 2, see 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- 2 Precision and bias spreadsheet showing Halkett Place dataset



Appendix 4 - BTEX diffusion tubes: Monthly dataset and annual means 1997 - 2015

Figures in red are results less than the analytical limit of detection. They have been treated as ½ LoD for calculation purposes. Results are supplied in units of parts per billion (ppb) and converted.

Table A4- 4 Monthly mean hydrocarbon concentrations, $\mu\text{g m}^{-3}$ – Le Bas Centre

Le Bas Centre	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
07-Jan-15	1.5	3.4	0.7	2.4	1.6
04-Feb-15	1.0	2.6	0.7	2.4	1.1
04-Mar-15	1.2	3.7	0.9	2.8	1.1
01-Apr-15	0.9	2.8	0.8	2.2	0.9
29-Apr-15	0.6	2.0	0.4	1.4	0.6
27-May-15	0.5	1.6	0.4	1.1	0.5
01-Jul-15	0.5	2.0	0.4	1.5	0.6
29-Jul-15	0.5	2.1	0.5	1.7	0.7
26-Aug-15	0.6	2.1	0.5	1.6	0.7
30-Sep-15	1.6	2.5	0.6	2.0	0.9
28-Oct-15	0.8	2.6	0.8	3.0	1.3
02-Dec-15	0.9	4.1	1.0	2.5	1.2
Average	0.9	2.6	0.6	2.1	0.9

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

Halkett Place	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
07-Jan-15	1.0	1.9	0.3	1.2	0.6
04-Feb-15	no data	no data	no data	no data	no data
04-Mar-15	1.1	3.6	0.8	3.0	1.1
01-Apr-15	0.9	2.9	0.8	2.4	0.9
29-Apr-15	0.8	2.7	0.5	1.7	0.7
27-May-15	0.7	3.0	0.7	1.9	0.7
01-Jul-15	0.4	0.7	0.1	0.4	0.1
29-Jul-15	0.7	3.1	6.6	6.1	2.3
26-Aug-15	0.7	3.0	0.6	2.2	0.9
30-Sep-15	0.5	1.4	0.4	1.2	0.6
28-Oct-15	0.4	1.1	0.3	0.9	0.5
02-Dec-15	0.7	1.7	0.3	1.1	0.5
Average	0.7	2.3	1.0	2.0	0.8

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

Airport Fence	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
07-Jan-15	0.2	0.1	0.1	0.1	0.1
04-Feb-15	no data	no data	no data	no data	no data
04-Mar-15	0.9	1.5	0.3	0.6	0.4
01-Apr-15	0.7	2.8	0.5	1.5	1.0
29-Apr-15	0.3	0.8	0.1	0.4	0.1
27-May-15	0.3	1.2	0.1	0.5	0.2
01-Jul-15	0.6	3.0	0.6	2.3	0.8
29-Jul-15	0.3	1.3	3.8	3.5	1.3
26-Aug-15	0.3	1.5	0.3	0.9	0.4
30-Sep-15	0.7	2.3	0.4	1.2	0.6
28-Oct-15	0.3	0.7	0.1	0.4	0.1
02-Dec-15	0.4	0.5	0.1	0.3	0.1
Average	0.5	1.4	0.6	1.1	0.5

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

Hansford Lane	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
07-Jan-15	0.8	2.0	0.6	2.3	1.2
04-Feb-15	no data	no data	no data	no data	no data
04-Mar-15	0.8	3.4	2.0	6.8	2.4
01-Apr-15	0.7	3.5	2.5	10.0	3.1
29-Apr-15	0.7	2.2	0.9	3.2	1.1
27-May-15	0.3	2.4	1.2	4.2	1.4
01-Jul-15	0.2	2.0	1.3	5.3	1.8
29-Jul-15	0.3	4.3	1.7	6.6	2.3
26-Aug-15	0.3	3.0	1.1	4.0	1.3
30-Sep-15	0.6	3.5	1.5	6.0	2.1
28-Oct-15	0.5	3.7	1.3	5.1	1.9
02-Dec-15	0.6	1.8	1.1	4.5	1.5
Average	0.5	2.9	1.4	5.3	1.8

Table A4- 8 Monthly mean hydrocarbon concentrations, $\mu\text{g m}^{-3}$ – Faux Bie

Faux Bie	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
07-Jan-15	1.2	4.0	0.6	2.3	0.9
04-Feb-15	no data	no data	no data	no data	no data
04-Mar-15	2.0	12.2	2.3	7.6	3.1
01-Apr-15	1.7	9.9	2.0	7.2	2.7
29-Apr-15	1.8	10.8	1.8	6.4	2.3
27-May-15	1.9	10.7	1.8	5.6	2.1
01-Jul-15	2.0	14.7	2.1	8.4	3.1
29-Jul-15	rejected	rejected	rejected	rejected	rejected
26-Aug-15	1.4	10.1	1.7	6.5	2.4
30-Sep-15	1.1	5.8	1.2	4.0	1.7
28-Oct-15	1.7	12.8	2.3	8.4	3.5
02-Dec-15	1.7	11.8	2.1	7.5	3.0
Average	1.6	10.3	1.8	6.4	2.5

July tube was returned from Jersey with its cap missing: the result is therefore invalid.

Table A4- 9 Monthly mean hydrocarbon concentrations, $\mu\text{g m}^{-3}$ – Travel blank

Travel blank	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
07-Jan-15	0.2	0.1	0.1	0.1	0.1
04-Feb-15	0.3	0.2	0.2	0.1	0.1
04-Mar-15	0.2	0.1	0.1	0.1	0.0
01-Apr-15	0.1	0.1	0.1	0.0	0.1
29-Apr-15	0.1	0.1	0.1	0.1	0.1
27-May-15	0.1	0.1	0.6	0.5	0.1
01-Jul-15	0.0	0.1	0.0	0.0	0.0
29-Jul-15	0.0	0.1	0.0	0.1	0.1
26-Aug-15	0.0	0.1	0.0	0.1	0.0
30-Sep-15	0.0	0.0	0.0	0.0	0.1
28-Oct-15	0.1	0.1	0.0	0.1	0.1
02-Dec-15	0.0	0.1	0.0	0.0	0.0
Average	0.1	0.1	0.1	0.1	0.1

Table A4- 10 Comparison of hydrocarbon concentrations, Jersey, 1997 – 2015

	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
	$\mu\text{g m}^{-3}$	$\mu\text{g m}^{-3}$	$\mu\text{g m}^{-3}$	$\mu\text{g m}^{-3}$	$\mu\text{g m}^{-3}$
Le Bas Centre					
1997	9.1	17.2	5.3	9.7	4.4
1998	7.5	16.1	3.1	8.4	4
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	8	1.8	5.7	2.2
2003	1.3	8	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
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	3.6	0.9	2.5	1.2
2011	1	5.1	1.2	2.6	0.9
2012	0.6	3	0.8	1.9	0.7
2013	0.7	2.4	0.8	2.0	0.7
2014	0.5	2.1	0.5	1.7	0.6
2015	0.9	2.6	0.6	2.1	0.9
Halkett Place					
2012	0.8	3.1	0.8	2	0.8
2013	0.8	2.9	0.7	2.2	0.9
2014	0.7	2.9	0.6	2.1	0.9
2015	0.7	2.3	1.0	2.0	0.8
Airport Fence					
2012	0.2	0.6	0.4	0.4	0.2
2013	0.4	1.0	0.2	0.4	0.2
2014	0.3	1.3	0.3	0.8	0.3
2015	0.5	1.4	0.6	1.1	0.5
Hansford Lane					
2004	1	16.1	7.3	8.5	2
2005	1	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	4	2.2	7.6	2.2
2009	1.1	4.9	2	8.5	2.4

Table A4- 11 (Continued) Comparison of hydrocarbon concentrations, Jersey, 1997 – 2015

	Benzene	Toluene	Ethylbenzene	m+p-xylene	o-xylene
	$\mu\text{g m}^{-3}$	$\mu\text{g m}^{-3}$	$\mu\text{g m}^{-3}$	$\mu\text{g m}^{-3}$	$\mu\text{g m}^{-3}$
2010	0.8	2.6	2	7.1	2.5
2011	0.6	1.9	2	6.5	2
2012	0.3	1.1	0.7	2.3	0.8
2013	0.4	2.6	1.9	5.2	1.8
2014	0.3	2.1	1.1	3.7	1.2
2015	0.5	2.9	1.4	5.3	1.8
Faux Bie					
2009	1.3	5.5	1.1	3.4	1.3
2010	1.8	6.7	1.4	4	1.6
2011	1.3	6.2	1	3.6	1.3
2012	0.8	4.5	0.7	2.3	0.8
2013	1.4	6.7	1.0	3.7	1.4
2014	1.1	8.7	1.4	5.5	2.0
2015	1.6	10.3	1.8	6.4	2.5



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