Air Quality in Jersey 2022

Annual Report for 2022

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Executive Summary

This report presents the results for 2022 of an ongoing programme of air quality monitoring in Jersey, carried out by Ricardo Energy & Environment on behalf of the Natural Environment Department of the Government of Jersey.

The air quality monitoring programme in Jersey during 2022 consisted of the following:

- Automatic monitoring of nitrogen dioxide (NO_2).
- Passive diffusion tube measurements for NO_2 and hydrocarbons.

An automatic monitoring station for (NO_2) has been located in the Central Market, Halkett Place, St Helier since January 2008. In November of 2021 this was re-located to a new position to measure NO_2 levels from traffic using Beresford Street. In addition, non-automatic diffusion tube samplers were used for indicative monitoring of NO_2 at 23 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 tubes were supplied and analysed by Gradko International Ltd and changed by Technical Officers of Jersey's Natural Environment Department. The 2022 non-automatic monitoring programme continued a long-term survey that has operated in Jersey since 1997.

Over the past two years (2021 and 2020) the Covid-19 pandemic has affected the deployment and collection of the diffusion tubes, as well as a noteable change in measurements as a result of restrictions imposed. During 2022 the effects of the pandemic on this programme were felt less as there were no considerable changes to the diffusion tube calendar. All restrictions on the island were removed by the beginning of 2022, and as a result concentrations and patterns seen in this report illustrate the continual recovery from the pandemic.

The automatic monitoring site at Beresford Street Market met the EC Directive limit value (and AQS objective) for the 1-hour mean NO_2 concentration (with 0 of 18 allowed 1-hour exceedances). The instrument achieved the 90% data capture required to create an annual average.

The 2022 period mean from the automatic monitor at Beresford Street Market was 17 µg m^{-3}, lower than that recorded at the Halkett Place site in 2021(21 µg m^{-3}).

Annual mean concentrations of NO_2 did not exceed the EC Directive limit value of 40 µg m^{-3} at any of the diffusion tube sites. For comparison annual averages had a bias adjustment factor applied which gave lower annual averages for all sites. Diffusion tubes measure over a monthly period therefore, the results are an average and not applicable to measuring peaks or low levels of pollution at any specific time.

The diurnal variation in NO_2 concentrations at Beresford Street Market showed some similarities to an urban site but had a particularly early (and sharp) morning rush hour peak, with a gentle but broad evening peak 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 use of the short term parking next to the site where drivers regularly leave vehicles running. Diurnal plots for Thursday show a flatter peak of lower magnitude compared to other weekdays, reflective of the market closing at 2PM on this day.

The pattern of monthly averaged concentrations throughout the year showed that concentrations of NO_2 were typically highest in the winter months. Bivariate plots of NO_2 concentration indicated that nearby sources, such as vehicles using Beresford Street, were probably the main source of NO_2. There is also a source of NO_2 seen to the southeast and southwest under windier conditions, possible sources include multiple main roads and the port.

Each of the hydrocarbon sites provided annual means below that required of the EC Directive limit value for benzene (5 µg m^{-3} as an annual mean, to be achieved by 2010). Since the introduction of catalytic converters in 1991 and the limiting of benzene concentrations in petrol to 1% in the year 2000, ambient measured concentrations have declined in the UK [1]. The site at Harrington's Garage measured the highest annual mean benzene concentrations, of 0.6 µg m^{-3}, similar to the average at Faux Bie Terrace of 0.5 µg m^{-3}. Both of these sites represents relevant public exposure near to petrol stations. Concentrations at Faux Bie Terrace which has been in operation since 2009 have decreased since a stage 2 vapour recovery system was installed in 2016.

Hydrocarbon concentrations were similar to 2021, except for ethylbenzene and xylene concentrations at Harrington's Garage and Faux Bie Terrace where there was considerable increases (although still significantly below occupational exposure levels). Over the long term, hydrocarbon concentrations have generally decreased at all sites that have been operational for 5 years or more. Long term trends at Rue de Pres and Beresford Street Market will be seen after these sites remain in operation for future years.

[1] UKPIA Statistical Review, 2018. Available at: https://www.ukpia.com/media/1008/ukpia-statistical-review-2018.pdf (Accessed 29 March 2023)

Introduction

Background

Jersey is the largest of the Channel Islands at 45 square miles, with a population 107,800 [2]. Both air and sea transport links to the UK and France make it easy to travel to nearby destinations in less than an hour.

This report describes a programme of air quality monitoring carried out on the island of Jersey in 2022, undertaken by Ricardo Energy & Environment, on behalf of Jersey's Environment Department. The report presents and summarises the fully validated and quality controlled dataset for the period 1st January to 31st December 2022. This is the 26th 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 (NO_2), and a range of hydrocarbon species (benzene, toluene, ethylbenzene and three xylene compounds). NO_2 was measured by an automatic monitor, situated at Beresford Street Market located next to the Central Market in St Helier. This was supplemented by indicative monitoring of NO_2 using low-cost passive samplers (Palmes type diffusion tubes). At the beginning of the year there were 18 locations, however in May 2022 five new sites were installed, meaning there were 23 sites in operation between May to December 2022. The suite of hydrocarbon species were monitored using 'BTEX' diffusion tubes at five sites during the year.

This report presents the results obtained in the 2022 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.

Data in the annual report have been processed according to the rigorous quality assurance and quality control procedures used by Ricardo Energy & Environment. These ensure the data are reliable, accurate and traceable to UK national measurement standards.

In addition to this report, Jersey has daily access to provisional data from its monitoring sites via their own air quality monitoring page [3] and data from the UK's national air quality

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[2] Pricewaterhouse Coopers, 2022. "About the Channel Islands." https://www.pwc.com/jg/en/about-us/about-the-channel-islands.html (Accessed 29 March 2023)

[3] Government of Jersey, 2023. "Government of Jersey - Air Quality Monitoring." https://www.gov.je/Environment/ProtectingEnvironment/Air/pages/airquality.aspx (Accessed 29 March 2023)

monitoring network, through the Defra UK Air Information Resource (UK-AIR) [4]. Data is also available via Ricardo's Jersey Air web page [5].

Aims and Objectives

Monitoring during 2022 is the continuation of a survey that has been carried out since 1997. This report is the latest in a series of annual reports. 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, a petrol station).

The results of the monitoring are used to assess whether applicable national air quality objectives have been met, and how pollutant concentrations in the area have changed over time.

Impact of Covid-19 Restrictions on Monitoring

2020 and 2021 saw severe disruption to daily life for all of the world and Jersey was no different. Previous reports in this series have described the time line of events relating to restrictions as a result of coronavirus and the impacts this had on tourism in Jersey. They also explained the disruption to the monitoring programme, mainly relating to deployment and collection of diffusion tubes.

In 2022 there were 845,000 arrivals by air and sea combined [6]. This was an increase of roughly 109% on 2021, however still roughly only 72% of the 1.18 million air and sea arrivals in 2019 (pre-coronavrius). Therefore, it can be said that Jersey is continuing to recover from the effects of coronavirus but there is an upward trend in recovery since 2021 which is expected to continue in 2023.

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[4] Department for Environment, Food; Rural Affairs, 2023. "UK-AIR, Air Quality Information Resource." http://uk-air.defra.gov.uk/ (Accessed 29 March 2023)

[5] Ricardo-AEA, 2023. "Air Pollution in Jersey." http://jerseyair.ricardo-aea.com/ (Accessed 11 April 2023)

[6] Government of Jersey - Open Data, 2023. https://opendata.gov.je/dataset/passenger-statistics/resource/dcc8a6c2-152a-48c0-b24b-de1774354d3c. (Accessed 11 April 2023)

Details of the Monitoring Programme

Pollutants Monitored

NO_x

A mixture of nitrogen dioxide (NO_2) and nitric oxide (NO) is emitted by combustion processes. The mixture of oxides of nitrogen is termed NO_x. NO is subsequently oxidised to NO_2 in the atmosphere. NO_2 is an irritant to the respiratory system and can affect human health. Ambient concentrations of NO_2 are likely to be highest in the most built-up areas, especially where traffic is congested, or where buildings either side of the street create a 'canyon' effect, impeding the dispersion of vehicle emissions. The units used for NO_2 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.

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).

A wide range of hydrocarbons are emitted from fuel storage, handling and combustion. It is not easy to measure all 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).

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} and have declined since the introduction of catalytic converters in 1991 and the limiting of benzene concentrations in petrol to 1% in the year 2000 [7].

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).

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 exposure [8], and a World Health Organisation (WHO) guideline of 260 µg m^{-3} for the weekly mean [9].

The major concern associated with human exposure to toluene is its effect on the central nervous system: it is not believed to be carcinogenic [10]. 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 areas [11].

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).

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[7] UKPIA Statistical Review, 2018. Available at: https://www.ukpia.com/media/1008/ukpia-statistical-review-2018.pdf (Accessed 29 March 2023)

[8] Health and Safety Executive, 2020. *EH40/2005 Workplace Exposure Limits.* https://www.hse.gov.uk/pubns/priced/eh40.pdf (Accessed 12 April 2023)

[9] World Health Organisation, 2000. *Air Quality Guidelines for Europe (2nd Edition).* https://apps.who.int/iris/bitstream/handle/10665/107335/9789289013581-eng.pdf?sequence=1&isAllowed=y (Accessed 12 April 2023)

[10] World Health Organisation, 2000. *Air Quality Guidelines for Europe (2nd Edition).* https://apps.who.int/iris/bitstream/handle/10665/107335/9789289013581-eng.pdf?sequence=1&isAllowed=y (Accessed 12 April 2023)

[11] World Health Organisation, 2000. *Air Quality Guidelines for Europe (2nd Edition).* https://apps.who.int/iris/bitstream/handle/10665/107335/9789289013581-eng.pdf?sequence=1&isAllowed=y (Accessed 12 April 2023)

Ethylbenzene

There are no limits for ambient concentrations of ethylbenzene. Although, there are occupational limits relating to workplace exposure [12], as discussed in previous reports, these are several orders of magnitude higher than typical outdoor ambient concentrations.

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 (µg m^{-3}). Some earlier reports used parts per billion (ppb). To convert to ppb, if required, the following relationship should be used: 1 µg 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).

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.

World Health Organisation

The World Health Organisation (WHO) issued non-mandatory, advisory, guidelines for a variety of pollutants in 2005 using currently available scientific evidence on the effects of air pollution on human health. New, updated, guidelines were introduced in September 2021 which significantly reduced the Annual mean limit of NO_2 from 40 µg m^{-3} to 10 µg m^{-3} and the 24 hour mean being reduced to 25 µg m^{-3}. In light of the growing evidence of harm that PM_{10} and $PM_{2.5}$ can cause the Annual mean limits were reduced from 20 µg m^{-3} to 15 µg m^{-3} and 10 µg m^{-3} to 5 µg m^{-3} respectively.

European Community

Throughout Europe, ambient air quality is regulated by the most recent EC Directive on Ambient Air Quality and Cleaner Air for Europe 2008/50/EC [13]. 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 NO_2 and benzene

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[12] Health and Safety Executive, 2020. *EH40/2005 Workplace Exposure Limits.* https://www.hse.gov.uk/pubns/priced/eh40.pdf (Accessed 12 April 2023)

[13] Official Journal of the European Union, 2008. *Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe.* http://data.europa.eu/eli/dir/2008/50/oj/eng (Accessed 29 March 2023)

are covered by this Directive. The Government of Jersey have agreed to meet the EU health limits. The Air Quality Directive [14] contains limit values for NO_2 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 Directive [15] also sets a limit of 5 µg 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.

The UK Air Quality Strategy

The Environment Act 1995 required the UK to transpose the original EU Directive on Ambient Air Quality and Cleaner Air for Europe 2008/50/EC [16] and its update EU/1480 [17] into UK law. It also placed a requirement on the Secretary of State for the Environment to produce a national Air Quality Strategy (AQS) containing standards, objectives and measures for improving ambient air quality. The original AQS was published in 1997, and contained air quality objectives based on the recommendations of the Expert Panel on Air Quality Standards (EPAQS) regarding the levels of air pollutants at which there would be little risk to human health. The AQS has since undergone a number of revisions, and as of the Environment Act 2021 must be reviewed at least every 5 years. These revisions have reflected improvements in the understanding of air pollutants and their health effects. They also incorporated new European limit values, both for pollutants already covered by the Strategy and for newly introduced pollutants such as polycyclic aromatic hydrocarbons and

[14] Official Journal of the European Union, 2008. *Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe.* http://data.europa.eu/eli/dir/2008/50/oj/eng (Accessed 29 March 2023)

[15] Official Journal of the European Union, 2008. *Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe.* http://data.europa.eu/eli/dir/2008/50/oj/eng (Accessed 29 March 2023)

[16] Official Journal of the European Union, 2008. *Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe.* http://data.europa.eu/eli/dir/2008/50/oj/eng (Accessed 29 March 2023)

[17] Official Journal of the European Union, 2015. *COMMISSION DIRECTIVE (EU) 2015/ 1480 - of 28 August 2015 - Amending Several Annexes to Directives 2004/ 107/ EC and 2008/ 50/ EC of the European Parliament and of the Council Laying down the Rules Concerning Reference Methods, Data Validation and Location of Sampling Points for the Assessment of Ambient Air Quality (Text with EEA Relevance).* https://eur-lex.europa.eu/eli/dir/2015/1480/oj. (Accessed 29 March 2023)

$PM_{2.5}$ particulate matter. The latest version of the strategy was published by Defra in 2007. With the UK's exit from the EU the UK's AQS is no longer tied to that of the EU, however the current objectives are at least as stringent as the EC limit values.

The UK Air Quality Strategy's objectives for NO_2 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 Strategy [18] 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 Jersey has chosen to comply with.

Jersey Air Quality Strategy

The most recent Jersey Air Quality Strategy was published in 2013 [19] and is largely based on the WHO [20], EU [21] and UK [22] policies described above and its limit values are the same.

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[18] Department for Environment, Food and Rural Affairs in partnership with the Scottish Executive, Welsh Assembly Government and Department of the Environment Northern Ireland, 2007. *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69336/pb12654-air-quality-strategy-vol1-070712.pdf (Accessed 29 March 2023)

[19] States of Jersey, 2013. *Jersey Air Quality Strategy 2013.* https://statesassembly.gov.je/assemblyreports/2013/r.049-2013.pdf (Accessed 30 March 2023)

[20] World Health Organisation, 2005. *WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulphur Dioxide, Global Update 2005.* http://apps.who.int/iris/bitstream/handle/10665/69477/WHO_SDE_PHE_OEH_06.02_eng.pdf;jsessionid=679FCD5CBEACDDD39B97F43A61C2FB14?sequence=1 (Accessed 30 March 2023)

[21] Official Journal of the European Union, 2008. *Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe.* http://data.europa.eu/eli/dir/2008/50/oj/eng (Accessed 29 March 2023)

[22] Department for Environment, Food and Rural Affairs in partnership with the Scottish Executive, Welsh Assembly Government and Department of the Environment Northern

As Jersey is not an EU member state there is no legal requirement to implement the EU Directive however, the Government of Jersey recognise the importance and relevance of the limit values to Jersey. The Jersey Air Quality Strategy works within the EU and UK limit values and puts in place a project plan and policies to ensure compliance. In light of reductions in concentrations and improvements in technology since the AQS was last published, now would be a good opportunity to review and potentially update the document.

Monitoring Sites and Methods

Automatic Methods

Oxides of nitrogen were monitored using a chemiluminescent analyser, located at the Central Market, St Helier, sampling from Beresford Street. This automatic monitoring site started operation in November 2021. The location descriptions of the site falls into the category "Roadside" as defined by the Defra Technical Guidance on air quality monitoring LAQM.TG(22) [23].

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: http://jerseyair.ricardo-aea.com

Diffusive Sampling of NO_2 and Hydrocarbons

The automatic monitoring site of Beresford Street 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. They are located in places and heights of relevant exposure, usually attached to lampposts at approximately 2m-4m above ground.

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

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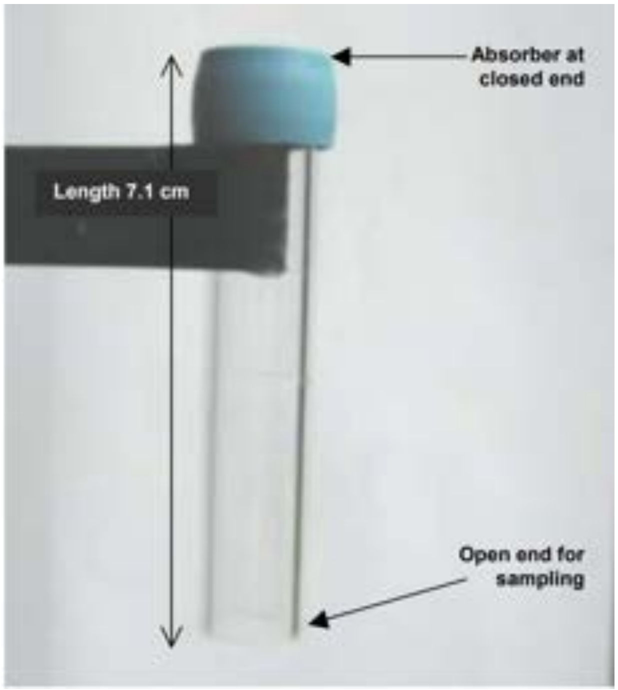
Ireland, 2007. *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69336/pb12654-air-quality-strategy-vol1-070712.pdf (Accessed 29 March 2023)

[23] Department for Environment, Food; Rural Affairs, 2022 *Local Air Quality Management - Technical Guidance LAQM.TG (22).* https://laqm.defra.gov.uk/wp-content/uploads/2022/08/LAQM-TG22-August-22-v1.0.pdf (Accessed 30 March 2023)

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.

Figure 1: NO_2 diffusion tube



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.

Figure 2: BTEX diffusion tube

Preparation and Analysis

Diffusion tubes were prepared and analysed by Gradko International Ltd. They were supplied to the Water and Air Technical Officers of Jersey's Government, who carried out the tube changing. The tubes were supplied in a sealed condition prior to exposure. After exposure, the tubes were again sealed and returned to Gradko for analysis. The UK Local Air Quality Management Technical Guidance LAQM.TG(22) [24] 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 Beresford Street Market, it is 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' NO_2 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.

[24] Department for Environment, Food; Rural Affairs, 2022 *Local Air Quality Management - Technical Guidance LAQM.TG (22).* https://laqm.defra.gov.uk/wp-content/uploads/2022/08/LAQM-TG22-August-22-v1.0.pdf (Accessed 30 March 2023)

Gradko also retained one tube from each batch, in a sealed bag in their premises, as a 'laboratory blank'. The travel blank results for NO_2 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.

Calendar of Diffusion Tube Exposure Periods

The calendar of exposure periods used for the NO_2 and BTEX diffusion tubes is shown in Table 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. It was not always possible to stick to the intended dates, actual change over dates are also shown in the below Table 1.

Table 1: Diffusion tube exposure periods

Month	Intended Start Date	Intended End Date	Actual Start Date	Actual End Date
January	2022-01-05	2022-02-02	2022-01-05	2022-02-02
February	2022-02-02	2022-03-02	2022-02-02	2022-03-02
March	2022-03-02	2022-03-30	2022-03-02	2022-03-30
April	2022-03-30	2022-05-04	2022-03-30	2022-05-05
May	2022-05-04	2022-06-08	2022-05-05	2022-06-01
June	2022-06-08	2022-07-06	2022-06-01	2022-07-06
July	2022-07-06	2022-08-03	2022-07-06	2022-08-03
August	2022-08-03	2022-08-31	2022-08-03	2022-08-31
September	2022-08-31	2022-09-28	2022-08-31	2022-09-28
October	2022-09-28	2022-11-02	2022-09-28	2022-11-02
November	2022-11-02	2022-11-30	2022-11-02	2022-11-30
December	2022-11-30	2023-01-04	2022-11-30	2023-01-04

Monitoring Sites

Automatic monitoring of oxides of nitrogen was carried out at the Central Market, Beresford Street, in St Helier shown in Figure 3 between 1st January and 31st December. The site represent a roadside location where levels of NO_2 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 located on a column at a hight of approximately four meters. The chemiluminescent NO_x analyser itself shown in Figure 4 is located within the building. The analyser is calibrated by the Government of Jersey's Water and Air's Technical officers. Details of the calibration procedure is provided in Appendix 2.

Figure 3: Beresford Street Market air quality monitoring site

Figure 4: Automatic NO_x analyser at Beresford Street, St Helier

As explained above, diffusion tubes were used to monitor NO_2 at sites in a range of different environments around Jersey. Diffusion tubes were also co-located with the automatic monitoring site at Beresford Street Market, and the results of this co-located monitoring have been 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 NO_2. The tubes at this site were exposed in triplicate, to allow assessment of precision. All other diffusion tube sites use single tubes.

From the May 2022 exposure five new diffusion tube NO_2 sites were installed at Lewis Street, Aquila Road, Brighton Road, Janvrin Road and Roseville Street (South). These tubes were installed at the request of the Parish of St Helier as there are plans to improve these areas and limit traffic. This should provide baseline data to determine if there is an improvement in air quality following the road improvements in the next few years. Following the November 2022 collection multiple site changes were made by the Government of Jersey including lowering of tubes and relocating some tubes to nearby lamp posts, all due to safety concerns. As these site changes were all less than 10m from the previous location the site names have remained the same. Details of site specific changes in November are listed in Table 2.

Table 2: Diffusion tube & BTEX tube relocations in November 2022

Site	Pollutant	Relocation Comment
The Parade	NO2	Lowered tube site
Weighbridge	NO2	Moved to pole next to existing site
Liberation Station	NO2	Lowered tube site
Les Quennevais School (New Site)	NO2	Moved to safer site 10m away
Beaumont	NO2	Moved to safer site 10m away
Overdale Nursery	NO2	Lowered tube site
Overdale Bend	NO2	Lowered tube site
Overdale Entrance	NO2	Moved across road 6m
Georgetown	NO2	Moved to pole 2m away and lowered tube
Le Bas Centre	NO2 & BTEX	Lowered tube site
Gloucester Street (Hospital)	NO2	Moved further up roadon the same side
Lewis Street	NO2	Lowered tube site
Aquila Road	NO2	Lowered tube site
Brighton Road	NO2	Lowered tube site
Roseville St (S)	NO2	Lowered tube site
Rue de Pres Trading Estate	BTEX	Moved across road 6m

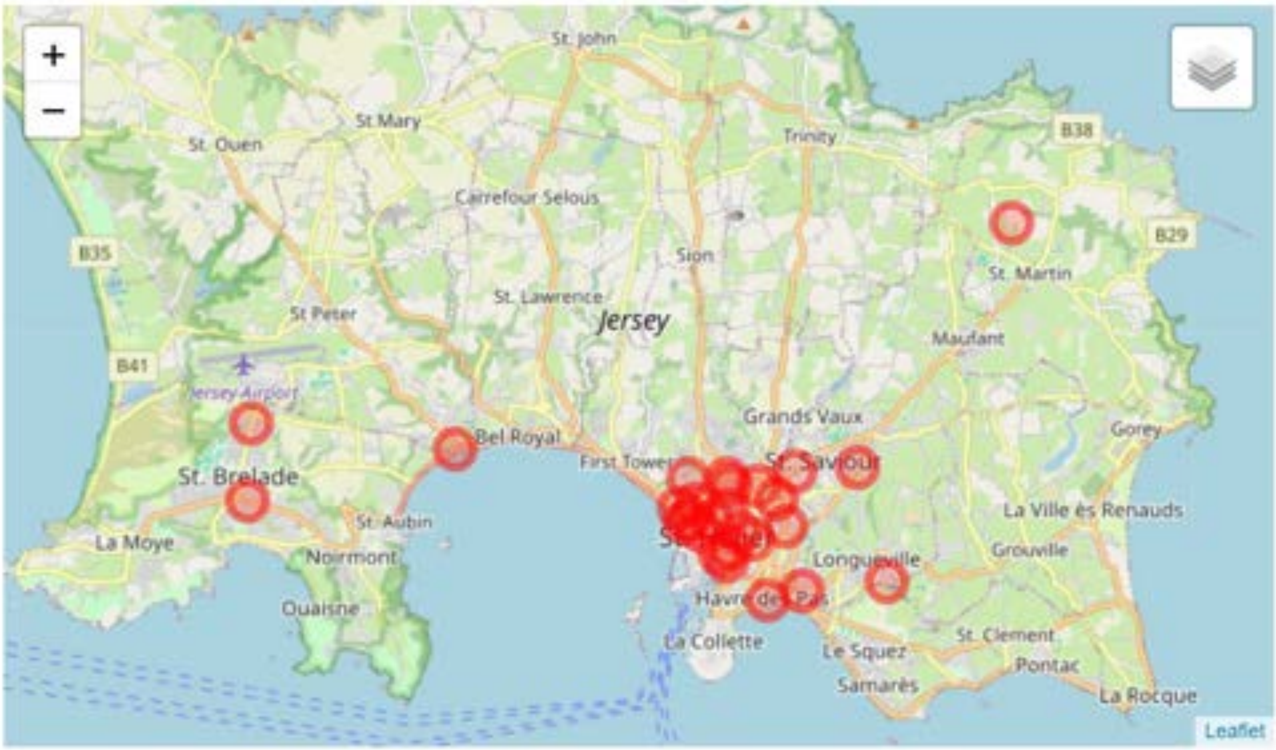
BTEX hydrocarbons were monitored at five sites during 2022 shown on Figure 5. The aim was to investigate sites likely to be affected by different emission sources and compare these with background sites. Following the November 2022 collection two sites were moved close to the previous sites, as these site changes were all less than 10m from the previous location the site names have remained the same. Details of site specific changes in November are listed in Table 2.

Le Bas Centre is intended to monitor hydrocarbon concentrations at an urban background location. Rue de Pres Trading Estate, in an industrial estate near to a paint spraying business. The Faux Bie site is located near a fuel filling station, a potential source of hydrocarbon emissions including benzene. The monitoring site is between a fuel filling station and a nearby block of flats 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. A Stage 2 Vapour Recovery System was later installed at the fuel filling station in 2016, and the replacement of the fuel storage tanks during August 2017. The Harrington’s Garage site was introduced as a replacement to the Airport Fence location and has been in operation since January 2019. The site is located on the A13 Rue de Genets, aiming to assess levels of BTEX from a typical garage with petrol and diesel storage and dispensing facilities where there is no Vapour Recovery system currently in place.

Figure 5 shows a map of the locations of all monitoring sites used in this study. The map can be zoomed in and out and more information on the monitoring sites can be obtained from clicking on the marker. Note the following regarding site classifications:

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

Figure 5: Locations of the Jersey air monitoring sites



Other Monitoring in Jersey

In addition to the monitoring sites detailed in this report, the Government of Jersey also run two Osiris particulate monitors on the island, as well as three AQ sensors units. As the data from these five additional automatic instruments are not subject to full QA/QC at present and are part of on-going trials, the data and results have not been included in this report.

Quality Assurance and Data Capture

Quality Assurance and Quality Control

A full intercalibration audit of the Jersey Beresford Street Market air quality monitoring site takes place annually, summarised in Table 3 and Table 4. In addition to instrument and calibration standard checking, the air intake sampling system is cleaned, and all other aspects of site infrastructure are checked. An additional audit, which counted as a commissioning audit for Beresford Street took place in January 2022, this also brought audits back in line following delayed audits from 2021 due to coronavirus restrictions.

Table 3: Results of the January 2022 intercalibration audit

Species	Analyser Serial no	Zero Response	Zero uncertainty ppb	Calibration Factor	Factor uncertainty %	Converter eff. (%)
NOx	1002	4.8	2.8	1.5659	3.8	98.7 (256ppb)
NO	1002	3.1	2.8	1.5458	3.8	N/A

Table 4: Results of the November 2022 intercalibration audit

Species	Analyser Serial no	Zero Response	Zero uncertainty ppb	Calibration Factor	Factor uncertainty %	Converter eff. (%)
NOx	1002	5.4	2.7	1.3276	3.5	98.8 (249ppb)
NO	1002	1.6	2.7	1.322	3.5	98.1 (128ppb)

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 5. These are given in ppb, the “native” unit of the automatic data.

Table 5: Estimated precision and accuracy of the data presented

Pollutant	Precision	Accuracy
NO	± 5 ppb	± 15%
NO2	± 5 ppb	± 15%

Results and Discussion

Summary Statistics

Overall data capture statistics along with summary statistics for the five monitoring sites are provided in Table 6 below. The data capture statistic represents the percentage of valid data measured for the whole reporting period. A data capture target of 90% is recommended in the European Commission Air Quality Directive [25] and Defra Technical

[25] Official Journal of the European Union, 2008. *Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe.* http://data.europa.eu/eli/dir/2008/50/oj/eng (Accessed 29 March 2023)

Guidance is 85% LAQM.TG (22) [26], in order to assess annual data sets against long term targets.

In 2022, data capture for NO_2 at Beresford Street Market attained data capture of 97.7%, greater than 90% required from the European Commission Air Quality Directive.

NO_2

Table 6 Summary statistics for NO_2

Site	Annual mean	Annual data capture	Hourly maximum	99.8 percentile of hourly mean	98 percentile of hourly mean	Daily maximum	90 percentile of daily mean
Jersey Beresford Street Market	17	97.7%	99.2	73.9	54.2	41.6	25.7

Data Gaps

Significant data gaps for periods more than 6 hours for the Jersey Beresford Street Market are shown in Table 7.

Table 7: Significant data gaps, 2022

Site	Pollutants	Start date	End date	No. of days	Reason
Jersey Beresford Street Market	NO2	2022-01-17	2022-01-18	1	Audit & service
Jersey Beresford Street Market	NO2	2022-07-18	2022-07-19	1.3	Analyser turned off by LSO during period of hot weather
Jersey Beresford Street Market	Site	2022-10-27	2022-10-28	0.8	Power cut
Jersey Beresford Street Market	Site	2022-10-29	2022-11-01	2.7	Power cut
Jersey Beresford Street Market	NO2	2022-11-08	2022-11-09	0.7	Audit & service

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 are shown in Table 8. 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 NO_2 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. The analytical limit of detection was in the range 0.028 µg NO_2 to 0.031 µg NO_2. The ambient concentration that this equates to depends on the exposure period, but for the 4-week and 5-week periods used in this study, the limit of detection ranged from 0.491 µg m^{-3} to 0.636 µg m^{-3}. For benzene, the limit of detection equated to an ambient concentration between 0.21 µg m^{-3} and 0.27 µg m^{-3}. The

[26] Department for Environment, Food; Rural Affairs, 2022 *Local Air Quality Management - Technical Guidance LAQM.TG (22).* https://laqm.defra.gov.uk/wp-content/uploads/2022/08/LAQM-TG22-August-22-v1.0.pdf (Accessed 30 March 2023)

laboratory advises that results lower than 10 times the limit of detection, LOD, will have a higher level of uncertainty. In the case of the NO_2 sites, ambient concentrations are well above this threshold, apart from at Les Quennevais and Rue des Raisies. Therefore, the NO_2 measurements at these two sites are likely to have overall uncertainty greater than ± 25% and should be treated as indicative only. However, for BTEX hydrocarbons in Jersey, this was not the case for most measurements except for benzene, toluene and m+p xylenes at some sites and other isolated measurements. The BTEX hydrocarbon measurements are therefore likely to have overall uncertainty greater that ± 25% and should be treated as indicative only.

Table 8: Percentage uncertainty on the analysis of diffusion tubes

Uncertainty	NO2	Benzene	Toluene	Ethylbenzene	m/pXylene	oXylene
% Uncertainty	± 9.7	± 11	± 12	± 11	± 13	± 11

Results and Discussion

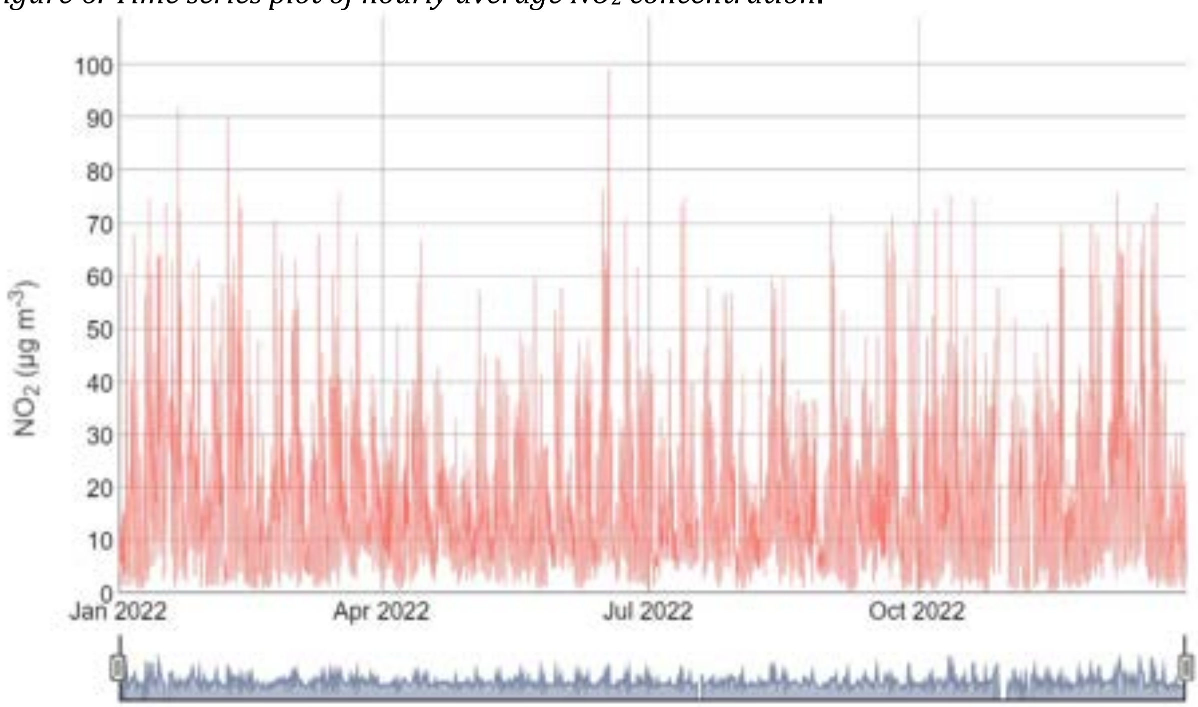
Time Series Plot

Below are hourly and daily time series plots of concentrations of NO_2 at Jersey Beresford Street Market. It is possible to zoom in on a section of the graph using the sliders below the chart.

The highest hourly peaks of NO_2 were recorded in mid June with significant high periods also seen in January, February and December.

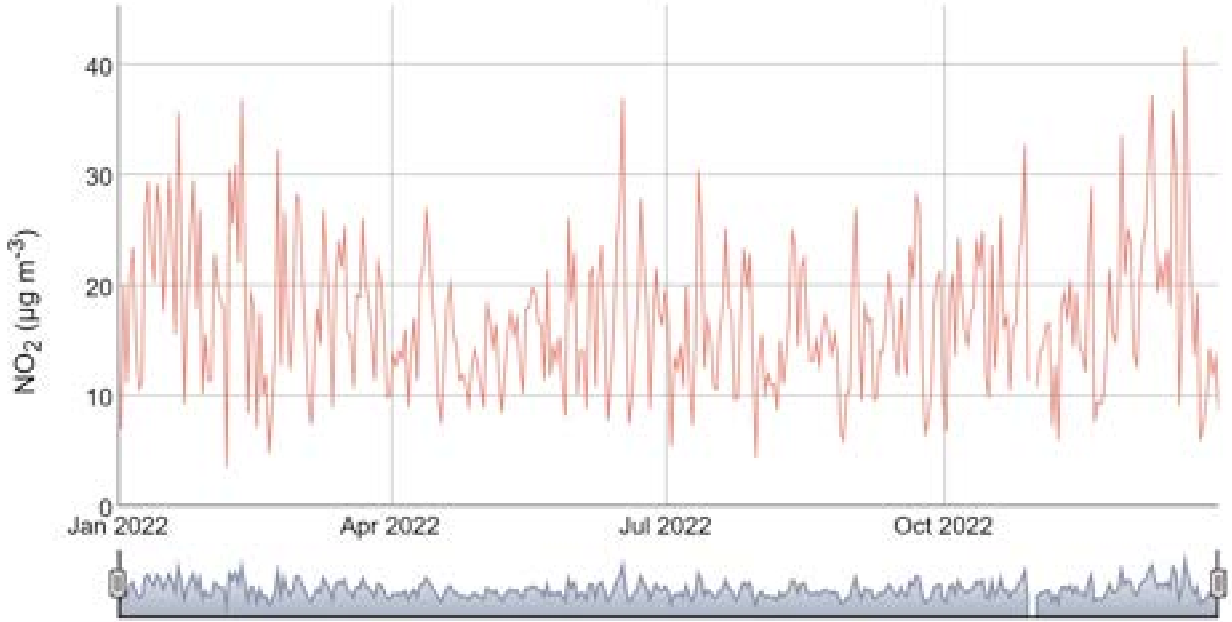
NO_2 Hourly

Figure 6: Time series plot of hourly average NO_2 concentration.



NO_2 Daily

Figure 7: Time series plot of daily average NO_2 concentration.



NO_2 Diffusion Tube Results

NO_2 diffusion tube results are presented in Table 9. Although reported by the analyser to two decimal places, the monthly mean results reported here have been rounded to one decimal place, in view of the estimated uncertainty of ± 25% on diffusion tube measurements. Details of site closures and openings during 2022 are given in section 2.4.

Diffusion tubes are affected by several artefacts, which can cause them to under-read or over-read with respect to the reference technique. It has therefore become common practice to calculate and apply a "bias adjustment factor" to annual mean NO_2 concentrations measured by diffusion tubes, using co-located diffusion tube and automatic analyser measurements. This bias adjustment factor is calculated as the ratio of the automatic analyser result to the diffusion tube result. This factor can then be used to correct the annual means measured at the other monitoring locations. The bias adjustment factor was calculated using unrounded values from all months. On this basis, the bias adjustment factor was calculated to be 0.78.

Please note:

- Only the annual mean concentration (not individual monthly values) should be adjusted in this way. This is because diffusion tube bias can vary considerably from month to month due to meteorological and other factors.
- Even after application of a bias adjustment factor, diffusion tube measurements remain indicative only.

Table 9 includes monthly values from each site and Table 10 shows the raw 2022 annual mean and the Bias adjusted 2022 annual mean. Sites that recorded a data capture less than 75% have been annualised as per guidance in LAQM.TG(22) [27] using data from Bournemouth, Southampton, Charlton Mackrell and Yarner Wood as the nearest sites in the UK national network to Jersey. The annual mean for 2021 is included for comparative purposes. Raw (not bias adjusted) monthly values are reported to allow for comparison against past data recorded before bias adjustment was introduced. Individual monthly mean NO_2 results ranged from 3.6 $\mu g\ m^{-3}$ (in November at the Rue des Raises site) to 47.4 $\mu g\ m^{-3}$ (in March at the St Saviours Hill site). The annual mean for the majority of sites remained relatively consistent between 2021 and 2022 with most sites being within +/- 3 $\mu g\ m^{-3}$. For this report the annual mean will be used unless otherwise stated.

[27] Department for Environment, Food; Rural Affairs, 2022 *Local Air Quality Management - Technical Guidance LAQM.TG (22).* https://laqm.defra.gov.uk/wp-content/uploads/2022/08/LAQM-TG22-August-22-v1.0.pdf (Accessed 30 March 2023)

Table 9 NO_2 diffusion tube results 2022, in µg m^{-3}

	January	February	March	April	May	June	July	August	September	October	November	December
start date	05-01-2022	02-02-2022	02-03-2022	30-03-2022	05-05-2022	01-06-2022	06-07-2022	03-08-2022	31-08-2022	28-09-2022	02-11-2022	30-11-202
end date	02-02-2022	02-03-2022	30-03-2022	05-05-2022	01-06-2022	06-07-2022	03-08-2022	31-08-2022	28-09-2022	02-11-2022	30-11-2022	04-01-202
Aquila Road					13.2	10.9	12.8	11.4	13.8	13.2	13.1	16.7
Beaumont	30.8	25.7	43.9	32.2	29.9	30.7	37.9	39.6	37.8	25.4	21.4	32.3
Brighton Road					9.9	8.9	10.3	10.1	11.8	11.2	12.0	17.9
Broad Street	18.0	17.1	18.3	11.8	15.3	16.0	15.8	14.0	15.2	16.1	15.6	18.2
Central Market 2	24.2	24.6	24.4	14.0	19.9	20.2	19.5	18.2	22.1	23.7	22.6	27.1
Georgetown	39.8	30.4	39.8	23.4	30.8	26.1	29.8	30.8	33.9	26.1	26.8	33.9
Gloucester Street (Hospital)	32.5	34.3	37.6	22.7	33.1	32.2	30.3	32.2	32.4	30.8	29.3	30.0
Janvrin Road					12.6		12.1		13.2	12.2	13.5	15.8
Le Bas Centre	22.7	20.3	22.2	12.2	16.8	17.1	17.6	15.7	19.4	18.8	20.1	20.0
Les Quennevais School (New Site)	10.4	8.5	13.5	8.6	6.9	6.8	8.1	8.1	8.8	6.8	5.1	12.0
Lewis Street					14.3	13.6	15.5	14.8	16.3	13.8	12.9	18.5
Liberation Station	30.7	24.5	30.8	25.0	27.1	25.4	28.7	26.4	28.5	23.1	21.5	26.6
Overdale Bend	15.0	11.4	17.5	10.4	11.4	9.8	11.3	11.8	11.2	9.9	10.3	15.5
Overdale Entrance	11.6		11.2	7.2	8.4	7.5	8.9	8.4	9.3	8.4	8.4	12.5
Overdale Nursery	16.1	13.5	17.8	10.6	12.7	10.5	14.8	14.6	14.6	13.6	12.9	16.6
Rosaville St (S)					10.1	14.9	19.4	15.2	18.1	14.7	14.4	19.3
Rouge Bouillon School	24.4	19.7	26.4	15.9	17.8			20.3	21.9	18.3	16.5	25.3
Rue des Raisies	5.6	4.2	6.7	4.3	4.5	4.8	5.7	4.9	4.7	3.7	3.8	6.2
St Saviours Hill	29.9	38.7	47.4	26.9	34.1		31.1	34.2	35.0	39.1	43.9	43.6
St Saviours School	17.4	15.7	19.4	11.7	13.8	13.3	12.5	14.8	15.5	14.6	14.5	19.2
The Parade	25.3	24.0	27.5	15.4	21.1	20.4	22.2	19.0	22.5	21.2	20.6	23.2
Union Street	26.4	26.3	26.6	15.4	21.0	16.9	18.7	17.8	21.6	23.8	24.7	26.0
Weighbridge	29.6	30.0	32.1	20.1	30.0	30.3	28.3	26.3	28.6	27.8	29.5	28.8

Table 10 Annual averages of the NO_2 diffusion in 2022, in µg m^{-3}

	2022 annual average	2021 annual average	2022 BIAS adjusted mean
Aquila Road *	15.7		12.2
Beaumont	32.6	33.3	25.6
Brighton Road *	13.8		10.7
Broad Street	15.9	16.6	12.6
Beresford Street	21.7		16.8
Georgetown	30.9	30.9	24.1
Gloucester Street (Hospital)	31.3	28.5	24.5
Janvrin Road *	15.1		11.8
La Bas Centre	18.5	18.3	14.6
Les Quennevais School (New Site)	8.5		6.6
Lewis Street *	17.8		14.0
Liberation Station	27.0	28.9	21.1
Overdale Bend	12.1	11.8	9.5
Overdale Entrance	14.3	8.5	11.2
Overdale Nursery	13.9	12.6	10.9
Roseville Street (S) *	19.7		15.6
Rouge Bouillon School	20.6	21.1	16.1
Rue des Raises	4.9	7.0	3.8
St Saviours Hill	36.7	36.4	28.6
St Saviours School	15.2	16.1	11.8
The Parade	21.9	22.4	17.1
Union Street	22.1	22.8	17.2
Weighbridge	28.5	27.0	22.2

Table 11 lists the missing diffusion tube results throughout 2022, including outliers and missing tube results.

Table 11 Details of the NO_2 diffusion tube results missing or rejected

Site	Month	NO2 µg m-3	Reason for rejection
Overdale Entrance	February	70.2	Outlier against other months considered erroneous
Central Market 2 tube 3	May		Missing on collection
Rouge Bouillon School	June		Missing on collection
St Saviours Hill	June		Missing on collection
Janvrin Road	June		Missing on collection
Rouge Bouillon School	July		Missing on collection
Janvrin Road	August		Missing on collection

The typical pattern in UK urban areas is for NO_2 concentrations to be generally higher in the winter and lower in the summer. The highest concentrations were generally recorded in the winter months of January, March and December. The spring and summer months between May and September had consistently average concentrations with very little variation. Sites with some of the highest concentrations include St Saviours Hill, Beaumont and Gloucester Street (Hospital), whilst Rue des Raises consistently sits below all other sites.

Figure 8: Non bias adjusted monthly mean NO2 diffusion tube results in 2022 in μg m-3

Comparison with NO_2 Guidelines, Limit Values and Objectives

Limit values, AQS objectives and WHO guidelines for NO_2 are described in earlier sections of this report. These are based on the hourly and annual means. The Air Quality Directive [28] contains limit values for NO_2 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 Strategy [29] contains objectives for NO_2, which are very similar to the Directive limits above, the only difference being they had to be achieved by 31st December 2005.

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[28] Official Journal of the European Union, 2008. *Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe.* http://data.europa.eu/eli/dir/2008/50/oj/eng (Accessed 29 March 2023)

[29] Department for Environment, Food and Rural Affairs in partnership with the Scottish Executive, Welsh Assembly Government and Department of the Environment Northern Ireland, 2007. *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.*

The 1-hour mean at the Beresford Street automatic monitoring sites did not exceed 200 µg m^{-3} in 2022. Therefore, this site met the EC Directive limit value and AQS objective for this parameter.

The period mean concentration of 17 µg m^{-3} as measured by the automatic analyser at Beresford Street was well within the EC limit value of 40 µg m^{-3}.

The updated WHO guidelines introduced in 2021 advise an annual mean limit for NO_2 of 10 µg m^{-3}. Jersey Beresford Street did not meet this guideline during 2022.

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. Neither the raw nor bias adjusted annual average calculated in this report showed a site exceeding the annual mean limit value of 40 µg m^{-3}.

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 NO_2 concentration of 4.9 µg m^{-3} at this rural site was well within the limit value.

Time Variation Plot

Figure 9 below show the variation of monthly, weekly, daily and hourly NO_2 concentrations during 2022 at Beresford Street Market.

Seasonal variation

Seasonal variations can be observed in the 'month' plots of Figure 9. NO_2 concentrations follow the expected seasonal cycle, with lower concentrations observed in summer and elevated concentrations in winter, with the highest concentrations seen in January and December. This seasonal cycle is typical for urban areas when the highest levels of primary pollutants tend to occur in the winter months, when emissions may be higher, and periods of cold, still weather reduce pollutant dispersion.

Weekly variation

The analyses of each pollutants' weekly variation showed that a similar type of diurnal patterns occur for all the days of the week except for Sunday. The NO_2 early morning rush hour peaks are, in general, much more pronounced Monday to Friday and overall levels are lower over the weekend. Particularly Sundays when most shops are closed. Concentrations then tend to decrease during the middle of the day, with a less pronounced and broader evening road traffic rush-hour signature from early afternoon.

Diurnal variation

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https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69336/pb12654-air-quality-strategy-vol1-070712.pdf (Accessed 29 March 2023)

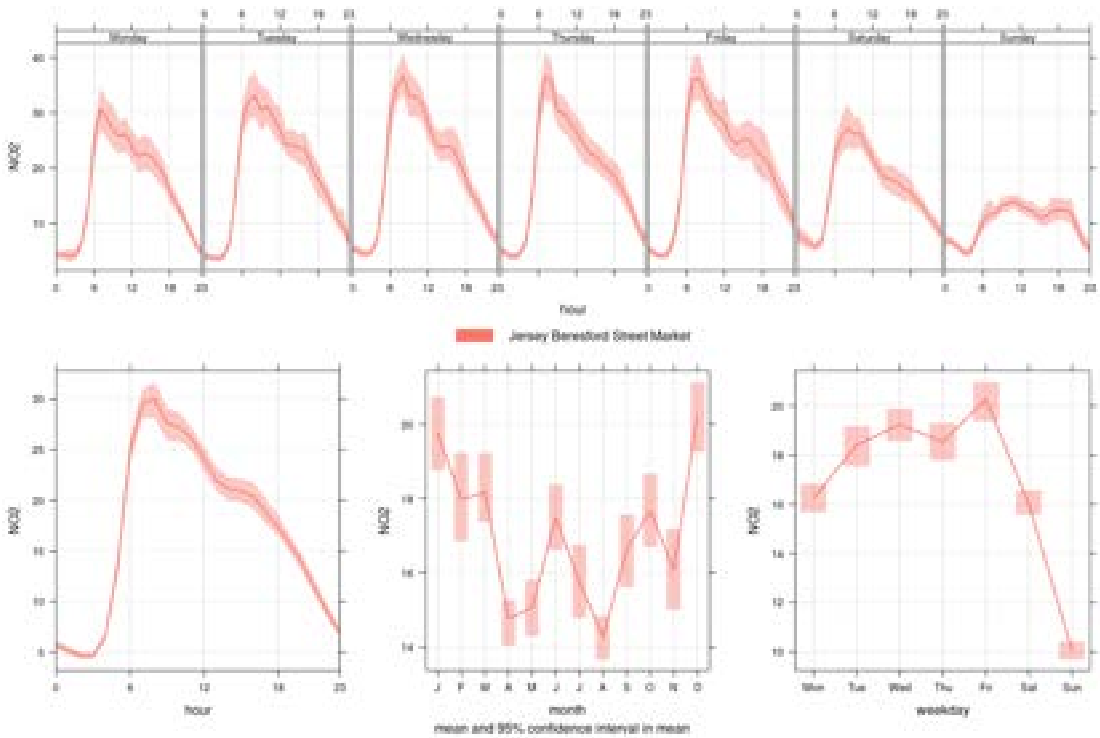
The diurnal variation analyses for the full year can be viewed in the ‘hour’ plot and for individual months in Figure 9. Both show typical urban area daily patterns for NO_2. Pronounced peaks can be seen during the morning, corresponding to rush hour traffic at around 07:00. The peak coincides with the time at which the market traders arrive and set up for the day, coinciding with the busier times of the day, just prior to the market opening at 07:30. It is believed vehicle emissions from these activities are responsible for the distinctively sharp morning pattern at Beresford Street. Concentrations tend to decrease during the middle of the day, with a much broader evening road traffic rush-hour peak, building up slightly from early afternoon. The market closes at 2PM on Thursdays which could explain the lack of an afternoon/evening peak when compared to other days. This trend was not seen at the decommissioned Halkett Place site in previous years.

Generally Beresford Street exhibits a very gentle afternoon NO_2 rush hour peak (as observed at many roadside UK AURN sites), much lower than the magnitude of the morning rush hour peak. In the afternoon, concentrations of oxidising agents in the atmosphere (particularly ozone) tend to increase, leading to enhanced oxidation of NO to NO_2. This typically causes the afternoon NO_2 peak at many urban sites to be higher than the morning NO_2 peak. However, this is not the case at Beresford Street. 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.

Jersey has a significant tourism industry and pollutant concentrations can remain relatively high during the summer months. Although Figure 9 shows the highest monthly concentrations in 2022 to be in the winter months, June does appear to be elevated and to some extent July when compared to the other spring and summer months can be seen with the significant drop in April and May of 2020 which is more pronounced than in prior years. The transition from winter to summer concentrations in 2022 is more harsh when compared to 2021. August recorded the lowest average during 2022, these reduced levels could be as a result of less traffic on the island during school holidays.

NO_2

Figure 9: Temporal variation NO_2.



Source Investigation

In order to investigate the possible sources of air pollution being monitored around Beresford Street, meteorological data measured at Jersey airport were used to add a directional component to the air pollutant concentrations. Wind speed and direction data was gathered using data from the National Oceanic and Atmospheric Administration (NOAA) meteorological database.

Figure 10 show the measured wind speed and direction data for Jersey Airport. The lengths of the "spokes" against the concentric circles indicate the percentage of time during the year that the wind was measured from each direction. The prevailing wind can be seen to be from the west. Each "spoke" is divided into coloured sections representing wind speed intervals of 2 ms^{-1}, followed by a final interval of 14.4 ms^{-1}. The mean wind speed was 5.73 ms^{-1}. The maximum hourly measured wind speed during 2022 was 20.4 ms^{-1}. The highest wind speeds were recorded in February 2022.

Figure 11 and Figure 12 show bivariate plots, ''pollution roses'' of hourly mean pollutant concentrations against the corresponding wind speed and wind direction. These plots should be interpreted as follows:

- The wind direction is indicated as in the wind rose above (north, south, east and west are indicated).

- The wind speed is indicated by the distance from the centre of the plot: the concentric circles indicate wind speeds in 5 ms^{-1} intervals.
- The pollutant concentration is indicated by the colour (as indicated by the scale).

These plots therefore show how pollutant concentration varies with wind direction and wind speed.

The plots do not show distance of pollutant emission sources from the monitoring site. However, in the case of primary pollutants such as NO, the concentrations at very low wind speeds are dominated by emission sources close by, while at higher wind speeds, effects are seen from sources further away.

Figure 10: Wind rose showing the wind speed and directions at Jersey airport from 1st January to 31st December 2022

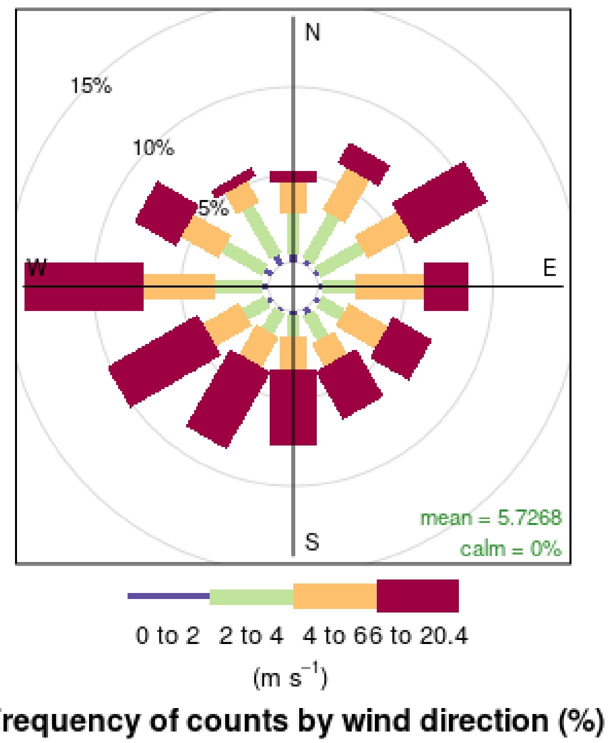
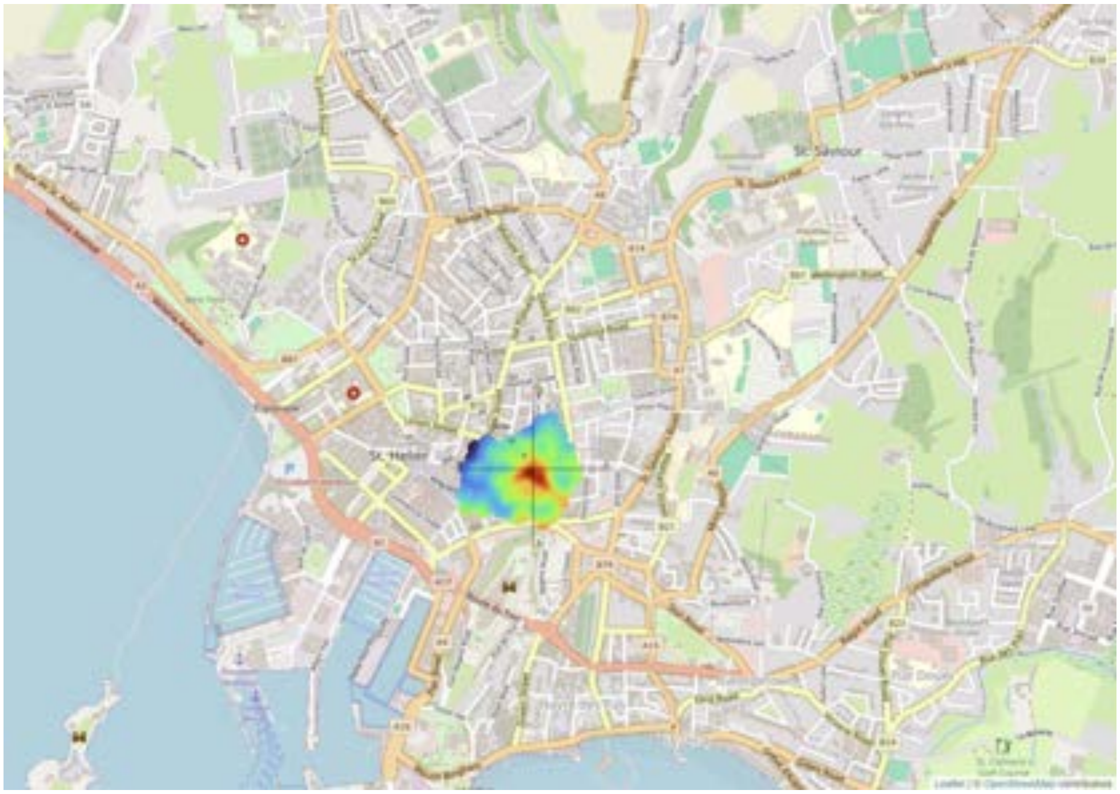


Figure 11 and Figure 12 show that elevated concentrations of NO and NO_2 occurred under calm and light wind conditions. Such conditions will have allowed NO and NO_2 emitted from nearby sources to build up, reaching higher concentrations. These sources are primarily vehicles on the surrounding streets and those using Beresford Street as a cut through or using the on-street parking location. There is also evidence of higher concentrations of both pollutants seen under windier conditions from the southeast and southwest. Towards the southwest lies multiple main roads including La Route du Fort and the A4, as well as smaller roads serving residents and local businesses. There is also the possibility of a street canyon effect which would allow concentrations of pollutants to build up when prevailing wind from the south east blows across the top of the buildings. Possible sources from the southwest could include the port and marina as well as the A1, specifically near to the western end of the tunnel.

NO_2

Figure 11: Pollution rose for NO2 at Beresford Street, 2022



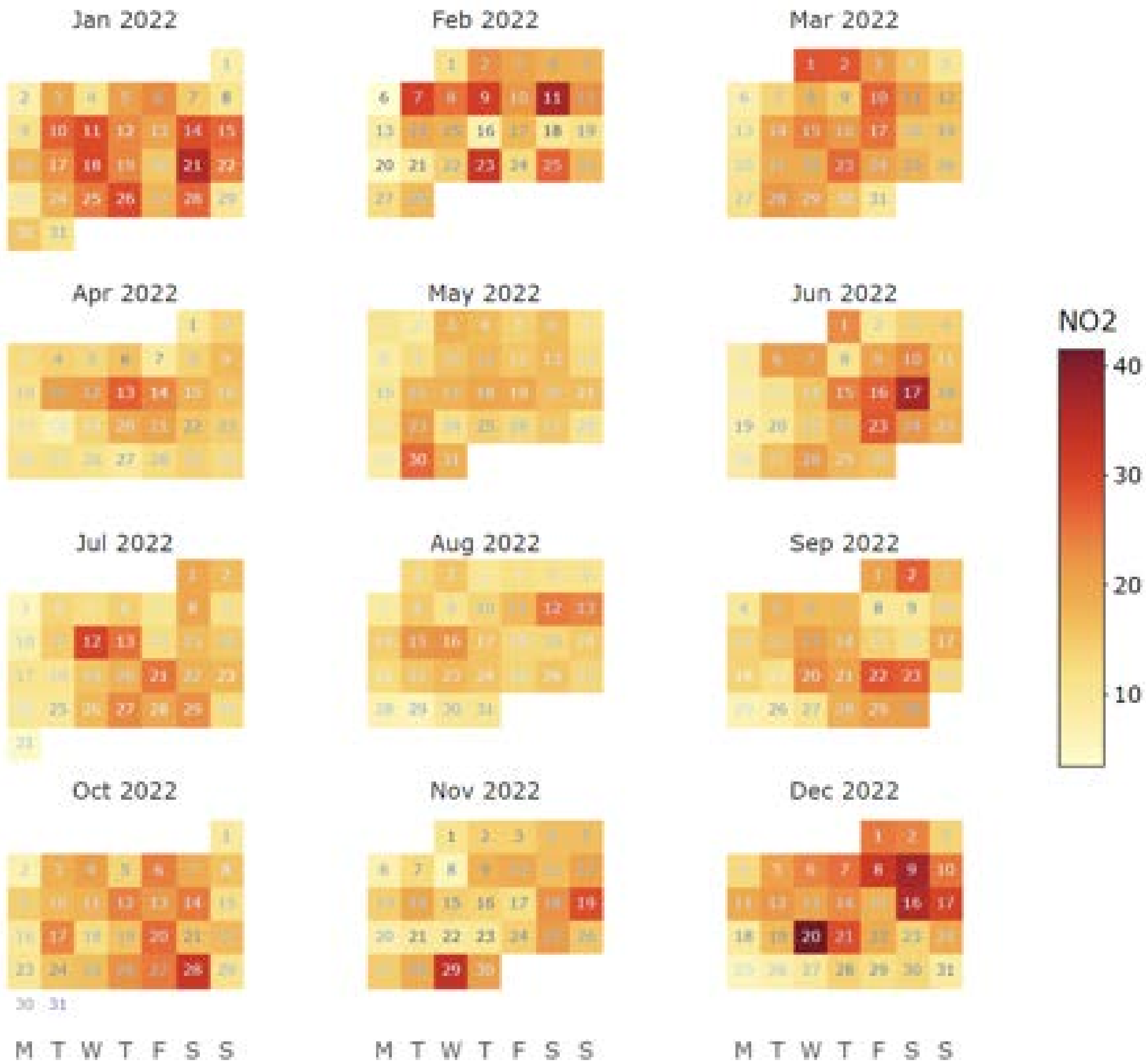
NO

Figure 12: Pollution rose for NO at Beresford Street, 2022

Calendar Plot

Figure 13 shows interactive versions of calendar plots. The date is coloured by the NO_2 concentration ($\mu g\ m^{-3}$) for that day. The actual value can also be seen by hovering the mouse on the cell, along with the wind speed.

Figure 13: Calendar Plot for NO2 at Beresford Street, 2022



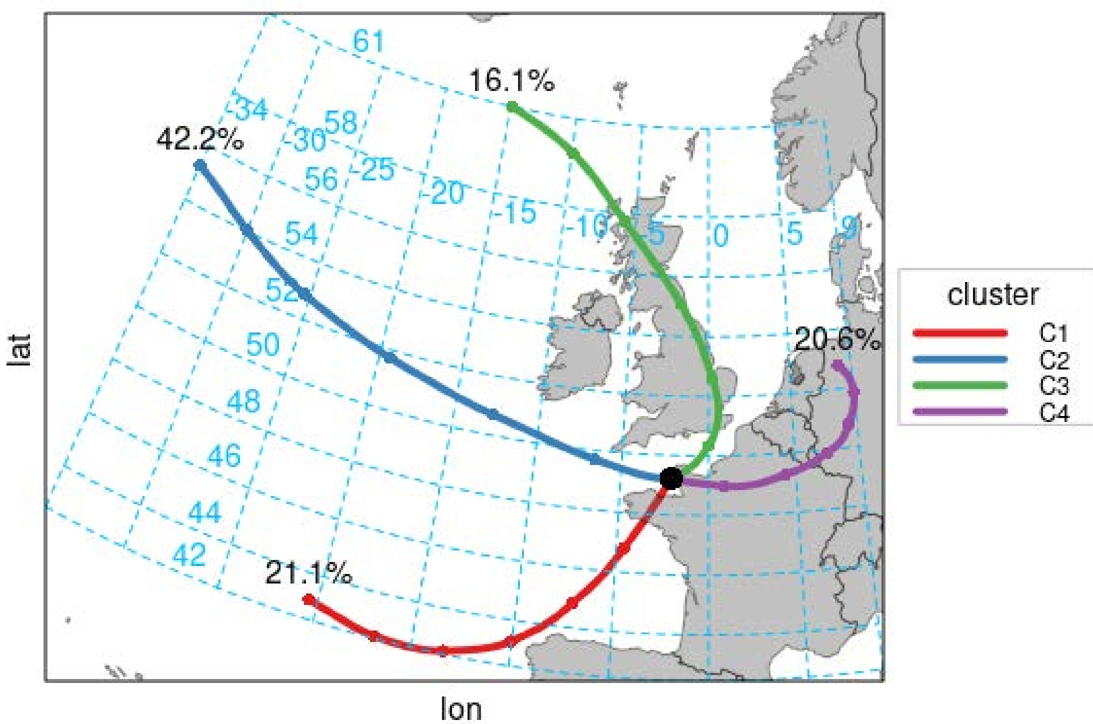
Back Trajectory Analysis

The back trajectory plot shows data from the HYSPLIT model [30] run in analysis mode. This shows the air mass back trajectories for the period covered by the report. Three different kinds of plot are shown. One statistically groups the trajectories into similar clusters and shows the proportion of time during the report period that each represents. This is useful to get an overview of air mass origins during the report period. On additional tabs, the trajectories associated with exceedances of the LV (1-hr for NO_2) are shown. A plot of the trajectories associated with the top 10 measured concentrations is also presented.

Trajectory Clusters

72-hour air mass back trajectories arriving at Jersey for the reporting period are grouped into 4 clusters, shown in Figure 14. This shows the approximate proportion of time air masses were arriving from each compass point during 2022.

Figure 14: 72-hour air mass back trajectories arriving at Jersey during 2022



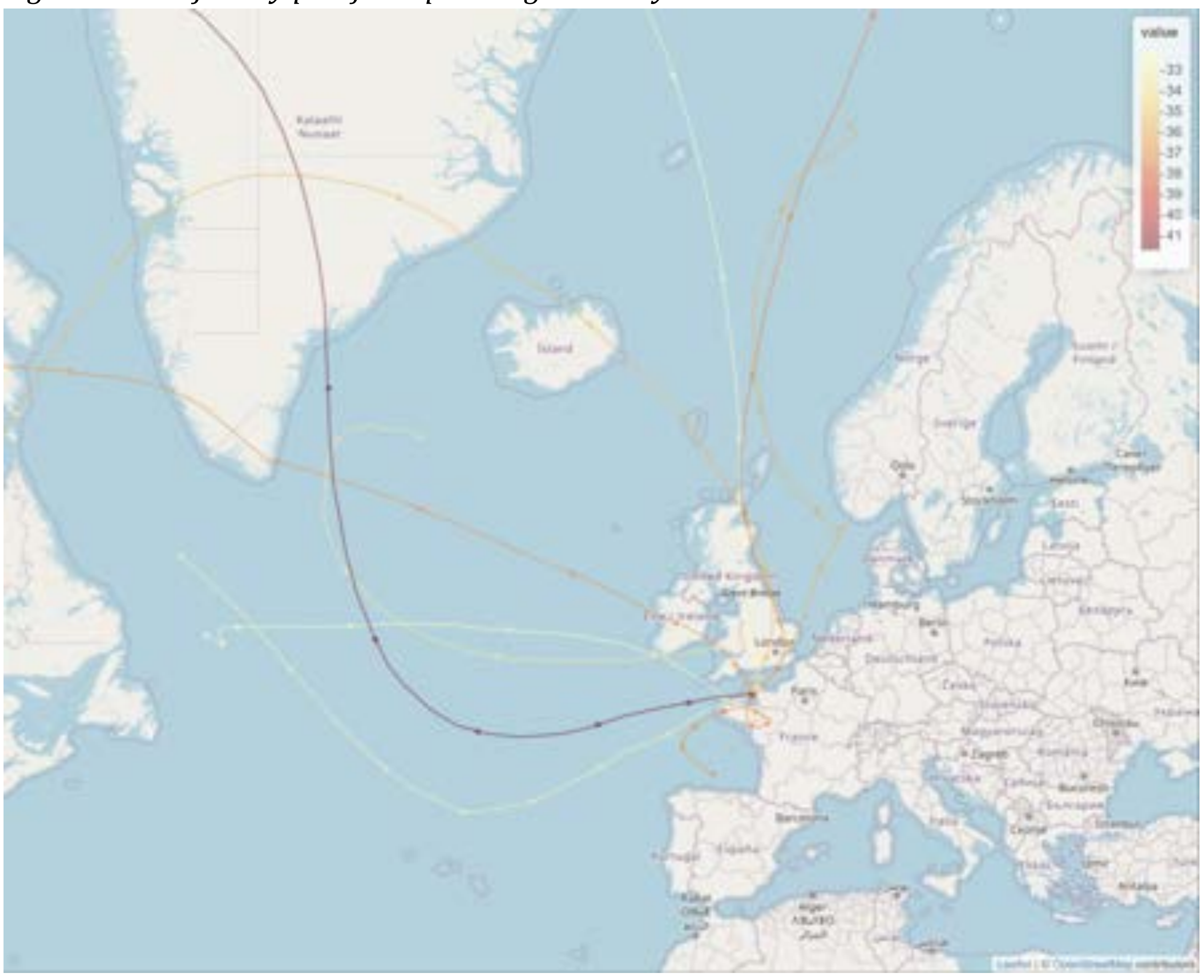
Air mass back trajectories over these spatial scales do not vary locally so the receptor location used in this report has been selected from a range of national receptor locations maintained by Ricardo Energy & Environment. The receptor point used here is Jersey.

[30] National Oceanic and Atmospheric Administration, 2023. "HYSPLIT." https://www.arl.noaa.gov/hysplit/ (Accessed 30 March 2023)

Trajectories Associated with Top Ten Most Polluted Days

The average daily concentration for NO_2 for Beresford Street is calculated, with the top 10 most polluted days identified and linked to its back trajectory data in the plot below (Figure 15). Figure 15 shows that the top ten most polluted days in relation to NO_2 are linked with air masses that originate from varying directions. This suggests that imported pollution is not a prominent contributor to high NO_2 in Jersey and it is more likely associated with more local factors such as those described in section 5.5 of this report.

Figure 15: Trajectory plot for top ten highest daily NO_2 concentrations.



Comparison with UK NO_2 Data

Table 12 compares the annual NO_2 concentration measured at Beresford Street Market with those measured at a selection of UK air quality monitoring stations in the national Automatic Urban and Rural Network and in Guernsey, both using automatic (chemiluminescent) NO_2 analysers. 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.
- Guernsey Bulwer Avenue - a roadside site in the north east of Guernsey.

The annual mean NO_2 concentrations, from diffusion tubes with exposure periods between 4 and 5 weeks, measured at the kerbside and roadside sites in Jersey (rounded to the nearest integer) ranged from 12 to 37 µg m^{-3}. However, bias adjusted annual averages ranged from 10 to 29 µg m^{-3}.
The mean concentrations measured at Exeter Roadside, 18 µg m^{-3}, and Plymouth Tavistock Road, 16 µg m^{-3}, are similar to the 17 µg m^{-3} as measured by the automatic analyser at Beresford Street Market. The Jersey urban background site at Le Bas Centre had an annual mean NO_2 concentration of 19 µg m^{-3}, higher than that of the automatic analyser at Beresford Street. The residential background/school site at Les Quennevais (new site) measured an annual mean NO_2 concentration of 9 µg m^{-3}, higher than the rural Yarner Wood site in Devon. The annual mean of 4.9 µg m^{-3} (3.8 µg m^{-3} when bias adjusted) at the Jersey rural background site, Rue des Raisies, was similar to that measured at the Yarner Wood site. A comparison between 2022 averages for Jersey Beresford Street Market and Guernsey Bulwer Avenue show that whilst the Jersey site is slighly higher than the Guernsey site, both are well within the 40 µg m^{-3} annual limit set by the European Union. All of the UK mainland sites with the exception of Plymouth Centre showed a decrease in levels compared to 2021. A comparison cannot be made for Beresford Street in 2022 as this was the first full calendar year of operation.

Table 12 Comparison of NO_2 in Jersey with UK automatic sites, 2021-2022

Site	2022 Annual mean NO2 concentration ug m-3	Annual mean NO2 concentration 2021 ug m-3
Exeter Roadside	18	19
Bournemouth	10	10
Plymouth Tavistock Road	16	17
Plymouth Centre	16	12
Yarner Wood	3	4
Jersey Beresford Street Market	17	
Guernsey Bulwer Avenue	13	

Trends in NO_2 at Long-running Sites

The annual mean NO_2 concentrations for diffusion tube sites which had over 75% data capture are illustrated in Figure 16, the five new sites are not included in as they did not run the entire year. 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.

Broad Street became pedestrianised on the 23rd of May 2020 in order to allow greater social distancing for pedestrians, this is reflected in a 27% reduction in the annual mean concentrations in 2020. This has been followed by further reductions in 2021 and 2022 to 17 and 16 µg m^{-3} respectively.

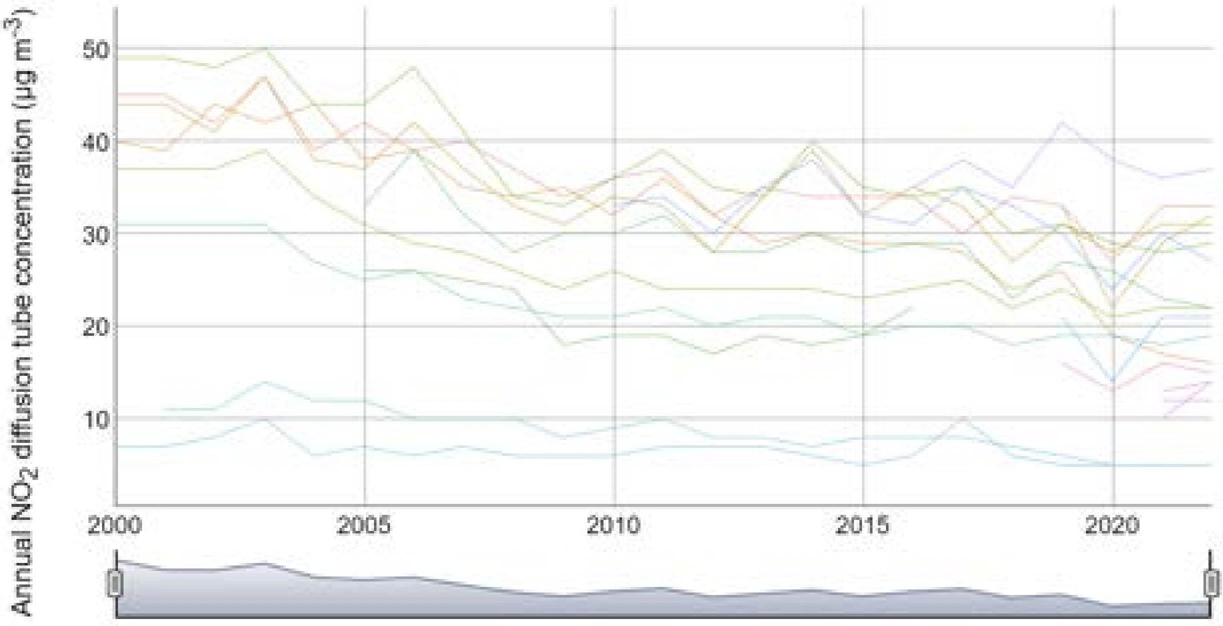
Annual mean NO_2 concentrations at historic kerbside, roadside and urban background sites (Weighbridge, Georgetown, Beaumont, The Parade, Broad Street, and Le Bas) from 2004 onwards show a decreasing trend. In 2022 all sites remained below 40 µg m^{-3}. Many sites saw concentrations increase compared to 2021, likely down to the relaxation of restrictions imposed due to coronavirus over the previous two years.

Figure 16 illustrates how since 2012 annual mean NO_2 concentrations at several of the sites have remained stable with typical fluctuations from year to year due to meteorological conditions and other factors. As traffic volumes have increased since monitoring began, fluctuations in concentrations are likely linked to increased vehicle efficiency and cleaner fuels. A recent study into vehicle emissions in Jersey [31] found that newer petrol vehicles produce fewer NO_x emissions. It also found that there is an increase in newer petrol cars compared to a decline in diesel on the island, with plans to introduce MOT style testing in the future. This will further increase visibility of emissions and potentially reduce the number of heavily polluting vehicles on the roads, in turn contributing to a continued reduction in ambient concentrations.

As a more focused example of the differences between site locations; it is interesting to note the lower trend of readings from the now discontinued New Street site compared to Union Street. The two locations were very close with the Union Street tube located on the corner of Union Street and New Street which run perpendicular to each other. New Street is access only and therefore, carries much lower traffic volumes. As the prevailing wind is from the West with the least wind coming from the North, very little of the pollution from Union Street is carried to the more southerly New Street location. This indicates how localised NO_2 distribution can be with certain mitigating factors.

[31] Ricardo Energy & Environment, 2017 *Vehicle Emissions Remote Sensing in Jersey.* https://www.gov.je/SiteCollectionDocuments/Government%20and%20administration/R%20Vehicle%20emissions%20remote%20sensing%20in%20Jersey%2020180816%20DM.pdf (Accessed 30 March 2023)

Figure 16: Annual mean NO_2 concentrations (NOT adjusted for diffusion tube bias)



Hydrocarbons

Full monthly results of the hydrocarbon survey for the five BTEX sites and a summary of the annual average hydrocarbon concentrations are shown below in Table 14 and Table 15 respectively. Travel blank values are included and gave consistently lower results than the exposed tubes which the exception of most pollutants in January 2022 which had elevated levels in the Travel Blank. The following exposures were noted to have loose end caps and it is therefore possible that the elevated concentrations reported were influenced by this:

- January 2022 - Rue de Pres Trading Estate
- May 2022 - All BTEX sites
- September 2022 - Harrington's Garage & Faux Bie Terrace
- December 2022 - Le Bas Centre, Harrington's Garage & Faux Bie Terrace.

For most of the deployments listed above these corresponded with elevated concentrations by the BTEX tubes, therefore these measurements should be treated with caution.

For BTEX tubes monthly data by pollutant is displayed in Figure 17 to Figure 19.

Hydrocarbons Results

The highest annual mean concentrations of benzene and toluene in 2022 were measured at Harrington's Garage, which is sited by a fuelling station with no Vapour Recovery system. Faux Bie Terrace recorded the highest average concentrations of ethylbenzene, mp-xylene and o-xylene, this site is between a petrol station and the nearest housing to it (12m from flats). It is important to note that, despite the higher concentrations at these two sites compared to other Jersey sites, the annual mean of 0.6 µg m^{-3} for benzene is still well below the annual limit value of 5 µg m^{-3}.

At Faux Bie Terrace after a Stage 2 Vapour Recovery System was installed at the fuel filling station in 2016, and the replacement of the fuel storage tanks during August 2017, all hydrocarbon pollutants having decreased at this location. Concentrations over the last three years have remained relatively flat before 2022.

Full Hydrocarbons Results

Table 14 Jersey BTEX tube results in 2022 in µg m^{-3}

Pid	start date	end date	Beresford Street Market	Faux Bie Terrace	Harrington's Garage	Le Bas Centre	Rue de Pres Trading Estate	TRAVEL BLANK
BENZENE	2022-01-05	2022-02-02	0.4	0.7	0.4	0.3	0.5	0.2
BENZENE	2022-02-02	2022-03-02	0.5	0.7	0.5	0.4	0.3	0.2
BENZENE	2022-03-02	2022-03-30	0.5	0.6	0.4	0.4	0.5	0
BENZENE	2022-03-30	2022-05-05	0.3	0.4	0.3	0.3	0.2	0.1
BENZENE	2022-05-05	2022-06-01	0.3	0.7	0.6	0.6	0.4	0.1
BENZENE	2022-06-01	2022-07-06	0.2	0.4	0.3	0.2	0.2	0.1
BENZENE	2022-07-06	2022-08-03	0.3	0.5	1	0.3	0.2	0.2
BENZENE	2022-08-03	2022-08-31	0.4	0.5	0.9	0.3	0.2	0.1
BENZENE	2022-08-31	2022-09-28	0.3	0.5	0.7	0.3	0.2	0.1
BENZENE	2022-09-28	2022-11-02	0.3	0.5	0.5	0.3	0.2	0.1
BENZENE	2022-11-02	2022-11-30	0.3	0.6	0.5	0.3	0.2	0.1
BENZENE	2022-11-30	2023-01-04	0.4	0.4	0.8	0.4	0.3	0
ETHBENZ	2022-01-05	2022-02-02	0.3	0.3	0.3	0.3	3.8	0.4
ETHBENZ	2022-02-02	2022-03-02	0.3	0.4	0.3	0.3	0.3	0
ETHBENZ	2022-03-02	2022-03-30	0.3	0.3	0.3	0.3	0.3	0.1
ETHBENZ	2022-03-30	2022-05-05	0.2	0.2	0.8	0.2	0.2	0
ETHBENZ	2022-05-05	2022-06-01	3.7	3	0.5	1.3	0.3	0
ETHBENZ	2022-06-01	2022-07-06	0.2	0.3	0.2	0.2	0.2	0.1
ETHBENZ	2022-07-06	2022-08-03	0.3	0.4	1	0.3	0.3	0.1
ETHBENZ	2022-08-03	2022-08-31	0.3	0.3	0.9	0.3	5	0
ETHBENZ	2022-08-31	2022-09-28	0.3	6.9	0.7	0.4	0.3	0
ETHBENZ	2022-09-28	2022-11-02	0.2	0.5	0.4	0.2	0.2	0
ETHBENZ	2022-11-02	2022-11-30	0.3	0.4	0.3	0.3	0.3	0.1
ETHBENZ	2022-11-30	2023-01-04	0.2	0.3	5.3	0.6	0.2	0

Pid	start date	end date	Beresford Street Market	Faux Bie Terrace	Harrington's Garage	Le Bas Centre	Rue de Pres Trading Estate	TRAVEL BLANK
mpXYLENE	2022-01-05	2022-02-02	0.5	1	0.3	0.6	3.2	0.5
mpXYLENE	2022-02-02	2022-03-02	0.6	1.5	0.4	0.6	0.3	0.1
mpXYLENE	2022-03-02	2022-03-30	0.7	1.3	0.6	0.9	0.9	0.3
mpXYLENE	2022-03-30	2022-05-05	0.4	0.8	1	0.7	0.8	0.3
mpXYLENE	2022-05-05	2022-06-01	3.4	4	1.4	2	1.2	0.2
mpXYLENE	2022-06-01	2022-07-06	0.7	1.3	0.7	0.4	0.9	0.3
mpXYLENE	2022-07-06	2022-08-03	1	1.9	3.4	1.4	1.3	0.8
mpXYLENE	2022-08-03	2022-08-31	1.3	1.8	2.7	1	5.9	0.1
mpXYLENE	2022-08-31	2022-09-28	0.9	7.4	2.2	1.1	0.6	0.9
mpXYLENE	2022-09-28	2022-11-02	0.7	2	1.5	0.5	0.4	0
mpXYLENE	2022-11-02	2022-11-30	0.8	1.4	0.8	0.4	0.3	0.1
mpXYLENE	2022-11-30	2023-01-04	0.4	0.7	6.2	1	0.3	0
oXYLENE	2022-01-05	2022-02-02	0.3	0.4	0.3	0.3	1.4	0.2
oXYLENE	2022-02-02	2022-03-02	0.3	0.6	0.3	0.3	0.3	0
oXYLENE	2022-03-02	2022-03-30	0.3	0.4	0.3	0.3	0.4	0.1
oXYLENE	2022-03-30	2022-05-05	0.2	0.2	0.4	0.2	0.3	0
oXYLENE	2022-05-05	2022-06-01	1.5	1.5	0.5	0.7	0.4	0
oXYLENE	2022-06-01	2022-07-06	0.3	0.5	0.3	0.2	0.3	0.2
oXYLENE	2022-07-06	2022-08-03	0.3	0.6	1.2	0.4	0.5	0.2
oXYLENE	2022-08-03	2022-08-31	0.6	0.9	1	0.3	2.6	0
oXYLENE	2022-08-31	2022-09-28	0.3	3	0.8	0.4	0.3	0.5
oXYLENE	2022-09-28	2022-11-02	0.3	0.8	0.6	0.2	0.2	0
oXYLENE	2022-11-02	2022-11-30	0.3	0.6	0.3	0.3	0.3	0
oXYLENE	2022-11-30	2023-01-04	0.2	0.3	2.8	0.4	0.2	0

Pid	start date	end date	Beresford Street Market	Faux Bie Terrace	Harrington's Garage	Le Bas Centre	Rue de Pres Trading Estate	TRAVEL BLANK
TOLUENE	2022-01-05	2022-02-02	0.9	2.5	1	1.3	3.5	1.5
TOLUENE	2022-02-02	2022-03-02	0.8	2.7	1.1	1	0.7	0
TOLUENE	2022-03-02	2022-03-30	0.8	1.9	1	1	2	0.1
TOLUENE	2022-03-30	2022-05-05	0.5	0.9	0.9	0.7	0.8	0
TOLUENE	2022-05-05	2022-06-01	0.8	5.7	4.6	2.9	4	0.1
TOLUENE	2022-06-01	2022-07-06	0.7	1.7	1.5	0.7	0.6	0.1
TOLUENE	2022-07-06	2022-08-03	0.7	2.2	5.4	0.7	0.7	0
TOLUENE	2022-08-03	2022-08-31	0.6	1.6	5.8	0.9	0.9	0
TOLUENE	2022-08-31	2022-09-28	0.7	2.7	4.4	0.8	0.7	0
TOLUENE	2022-09-28	2022-11-02	0.9	2.5	2.9	0.9	0.7	0
TOLUENE	2022-11-02	2022-11-30	0.7	2.8	2.4	0.8	0.4	0
TOLUENE	2022-11-30	2023-01-04	0.9	1.5	3.8	1.3	0.8	0

Hydrocarbons Annual Data Summary

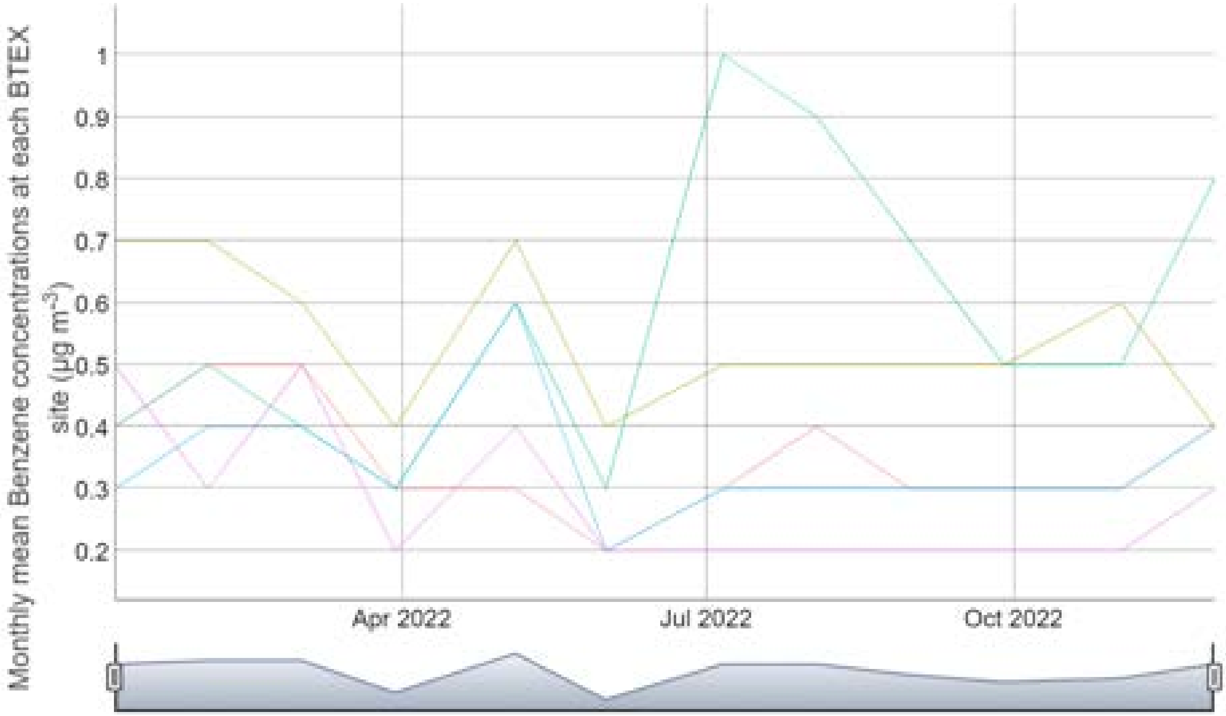
Table 15 Summary of average hydrocarbon concentrations in Jersey, 2022, in µg m^{-3}

Pid	Beresford Street Market	Faux Bie Terrace	Harrington's Garage	Le Bas Centre	Rue de Pres Trading Estate	TRAVEL BLANK
BENZENE	0.3	0.5	0.6	0.3	0.3	0.1
ETHBENZ	0.6	1.1	0.9	0.4	0.9	0.1
TOLUENE	0.8	2.4	2.9	1.1	1.3	0.1
mpXYLENE	0.9	2.1	1.8	0.9	1.3	0.3
oXYLENE	0.4	0.8	0.7	0.3	0.6	0.1

Hydrocarbons by Pollutant

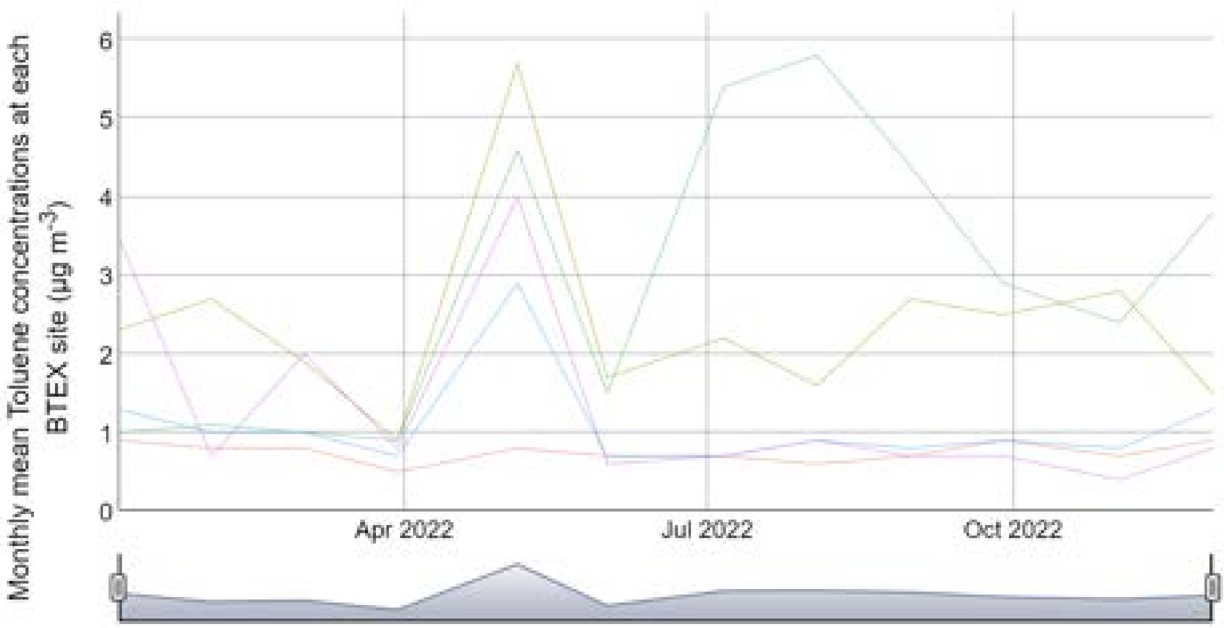
Benzene

Figure 17: Monthly mean Benzene concentrations at each BTEX site in µg m^{-3}



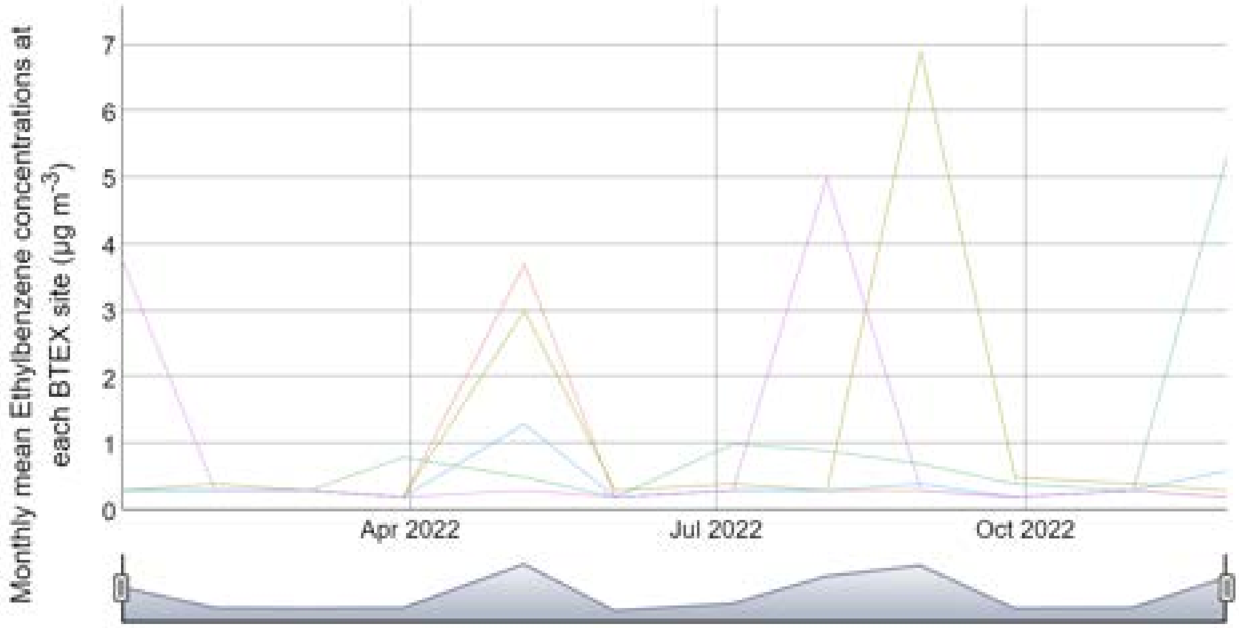
Toluene

Figure 18: Monthly mean Toluene concentrations at each BTEX site in µg m^{-3}



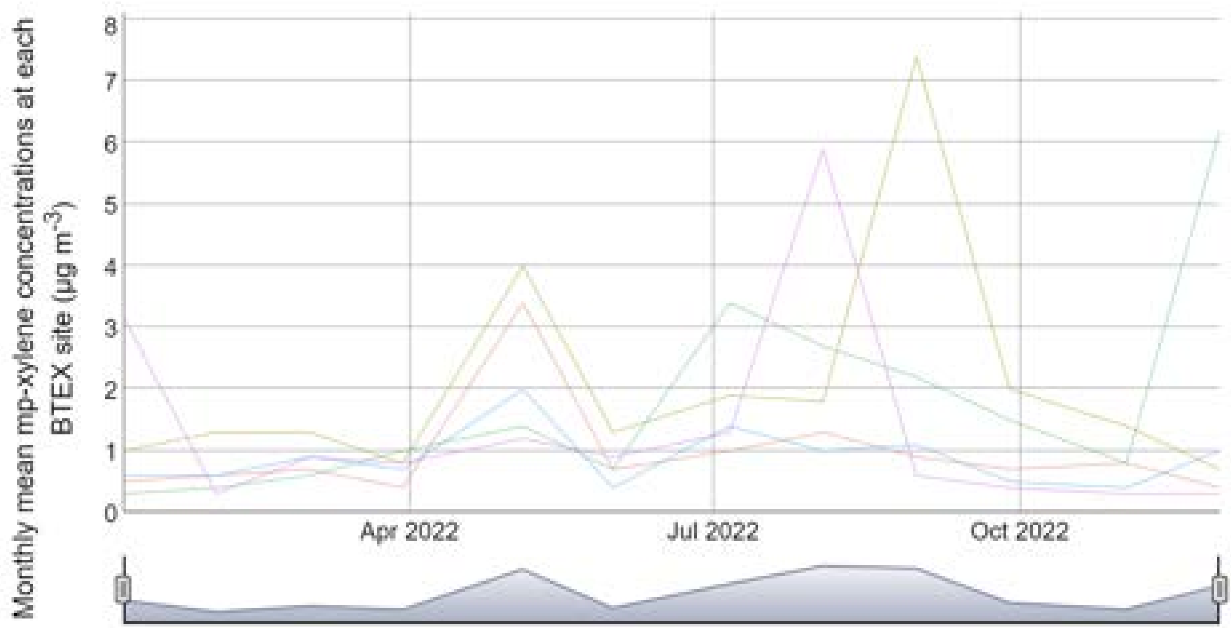
Ethylbenzene

Figure 19: Monthly mean Ethylbenzene concentrations at each BTEX site in µg m⁻³



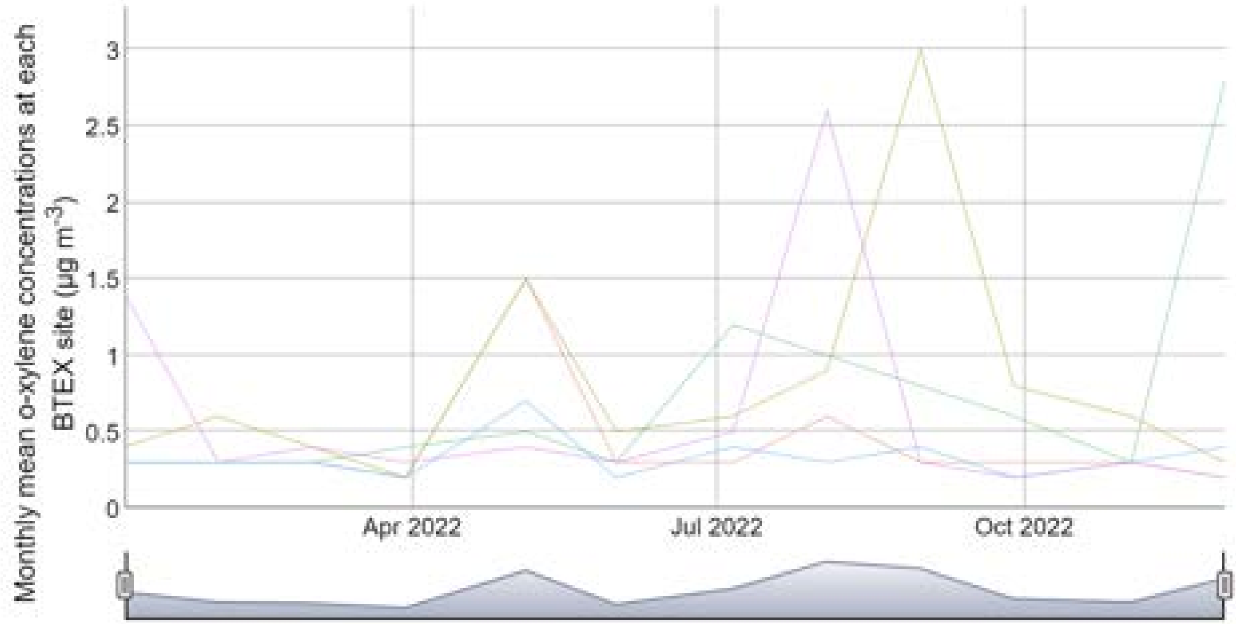
mp-xylene

Figure 20: Monthly mean mp-xylene concentrations at each BTEX site in µg m⁻³



o-xylene

Figure 21: Monthly mean o-xylene concentrations at each BTEX site in µg m^{-3}



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 Directive [32] sets a limit of 5 µg m^{-3} for the annual mean of benzene, to be achieved by 2010. All sites met this limit in 2022 and have done so since 1999 (or since they started operation).

The UK Air Quality Strategy [33] sets the following objectives for benzene:

- 16.25 µg m^{-3} (for the running annual mean), to have been achieved by 31st December 2003.
- 5 µg 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.

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[32] Official Journal of the European Union, 2008. *Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe.* http://data.europa.eu/eli/dir/2008/50/oj/eng (Accessed 29 March 2023)

[33] Department for Environment, Food and Rural Affairs in partnership with the Scottish Executive, Welsh Assembly Government and Department of the Environment Northern Ireland, 2007. *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69336/pb12654-air-quality-strategy-vol1-070712.pdf (Accessed 29 March 2023)

- 3.25 µg 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 µg m^{-3} at all the Jersey sites. The calendar year mean benzene concentration was below 3.25 µg m^{-3} at all Jersey sites. Therefore, these sites meet the tightest AQS objectives for benzene (those applying to Scotland and Northern Ireland).

Comparison with Previous Years' Hydrocarbons Results

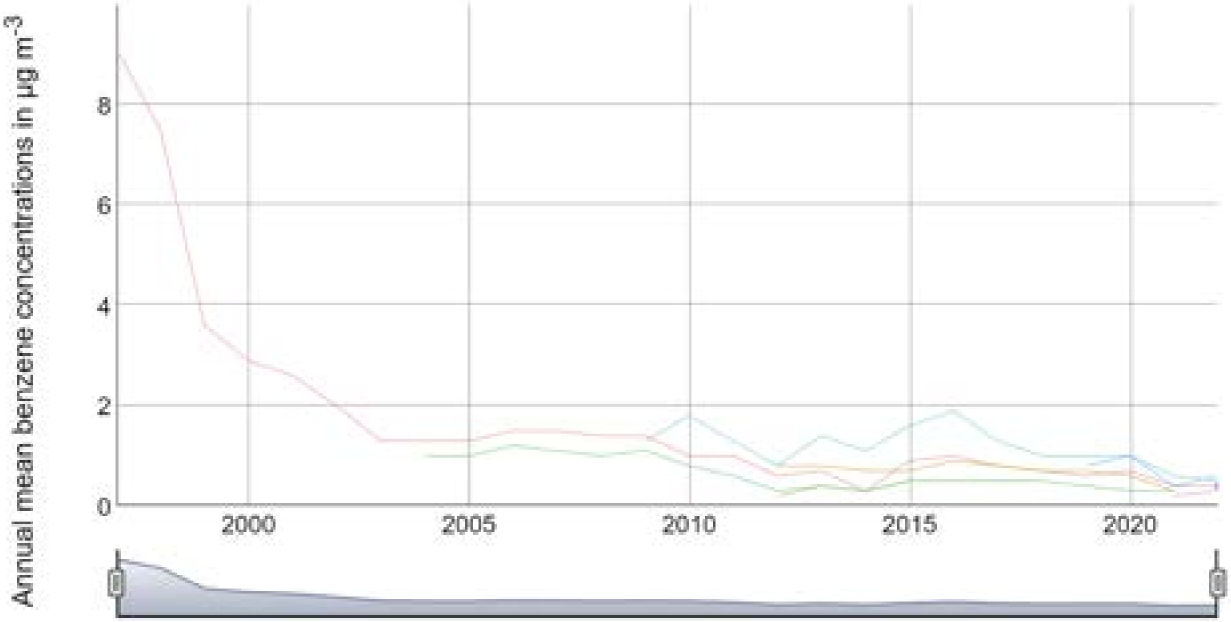
Figure 22 to Figure 25 show how the annual mean hydrocarbon concentrations at the five Jersey sites have changed over the years of monitoring. Historic sites are also included for comparison and include Airport Fence, Hansford Lane and Central Market. Beresford Street has not been included as this site has only run for one full calendar year, and can therefore not be compared to previous annual averages. It is important to remember that pollutant concentrations are expected to show considerable year-to-year variation mainly due to meteorological variations and other factors.

Generally, concentrations of all pollutants at all sites remained similar or saw slighy increases compared to 2021. This could possibly be contributed by easing of coronavirus restrictions allowing increased activity on the island in 2022, particularly more use of fuel filling stations. This is evident from the increases in annual concentrations between 2021 and 2022 of most pollutants at both the Harrington's Garage and Faux Bie Terrace sites (both sited near to fuel stations). It is however important to note that annual concentrations of all pollutants measured by the BTEX tubes remain low, below the limit value for benzene and occupational exposure limits for other pollutants.

Benzene

Figure 22 shows the annual mean benzene concentrations. The EU limit value is 5 µg m^{-3} and the typical LoD as concentration equivalent is 0.097 µg m^{-3}. Le Bas Centre has been in operation since 1997 and the annual mean concentrations of benzene show a marked drop over the years running to the year 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 (including Beresford Street) were equal to or lower than 0.6 µg m^{-3} in 2022 and represent similar concentrations to those measured in 2021.

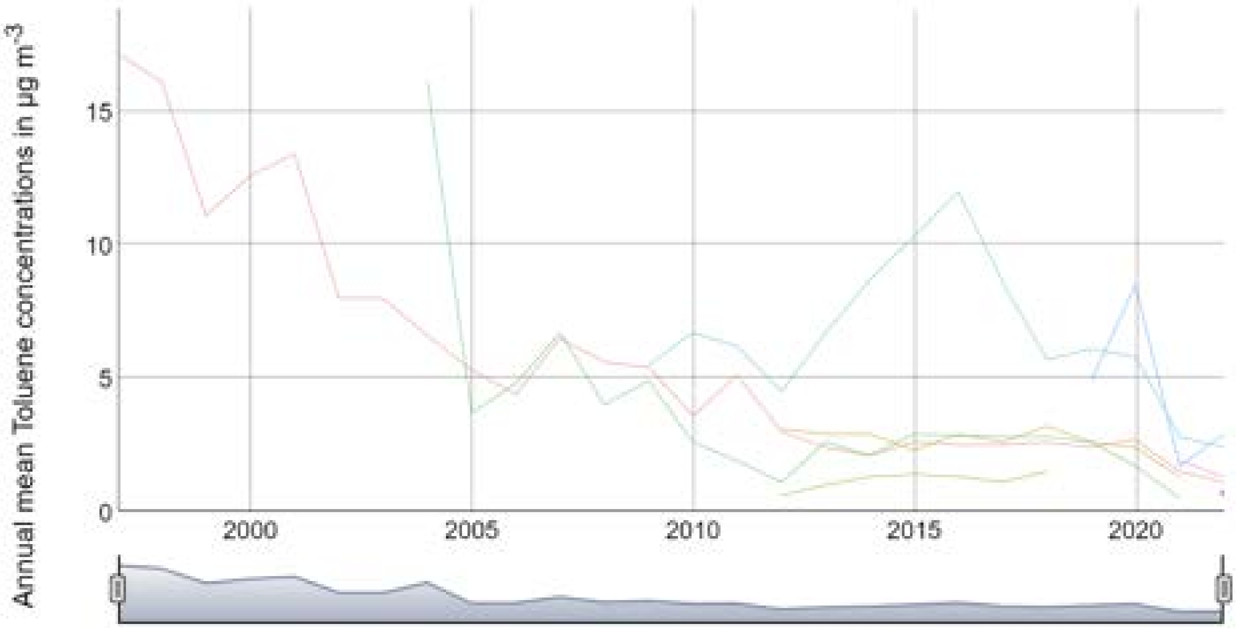
Figure 22: Time series of annual mean benzene concentrations in µg m⁻³



Toluene

Figure 23 shows toluene concentrations. The ambient concentration equivalent to the typical LoD for toluene is 0.11 µg m^{-3}. The two longest-running sites, Le Bas Centre and Hansford Lane (closed from 2021), show general decreases over the past twelve years, though these are not consistent. All sites have had relatively stable yearly averages since 2012 except for concentrations at the Faux Bie site which increased year on year between 2012 and 2016. However, concentrations decreased considerably after filling station upgrades in 2016 and 2017. Faux Bie now presents similar concentrations to the Harrington's Garage site, both of which are located near to fuel filling stations. 2022 average concentrations at Harrington's Garage increased by 1 µg m^{-3} compared to 2021, different to the other three sites that all showed steady decreases.

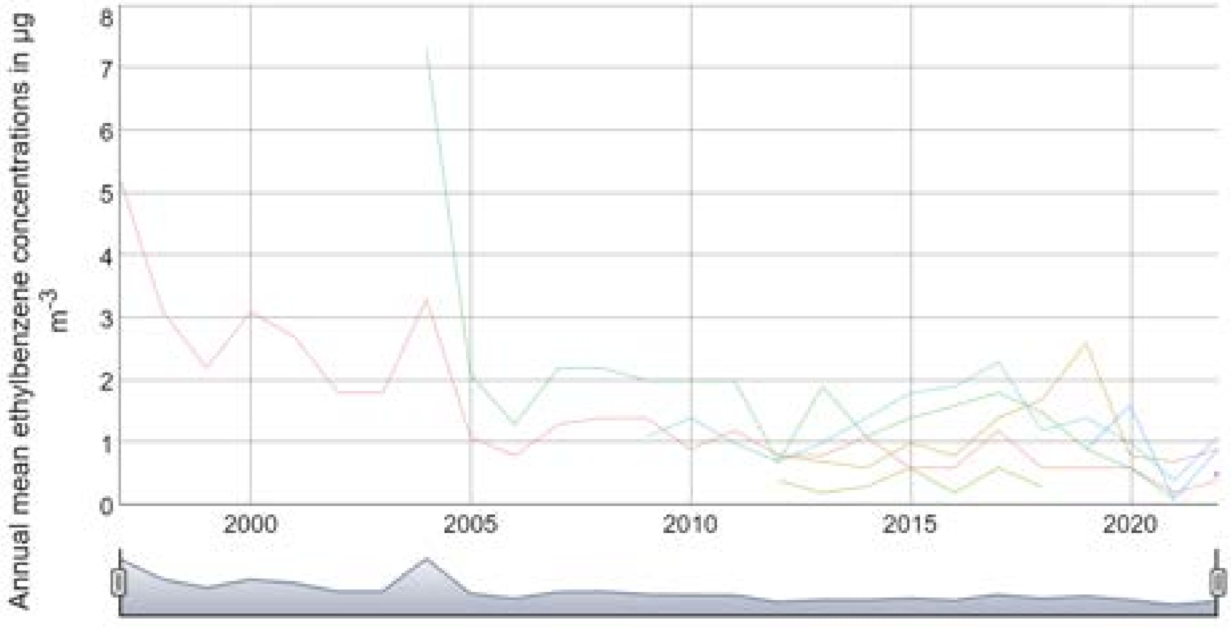
Figure 23: Time series of annual mean toluene concentrations in µg m-3



Ethylbenzene

The pattern for ethylbenzene in Figure 24 generally show that all sites have slighty increased in 2022, particularly Harrington's Garage and Faux Bie Terrace. However it is possible that individual months with high measurements contribute to this trend, therefore this illustrates that a longer time period is required to establish a trend that isn't influenced by short term events or meteorological conditions. This is particularly the case with Harrington's Garage, Rue de Pres and Beresford Street where a longer time period is required to illustrate long term trends.

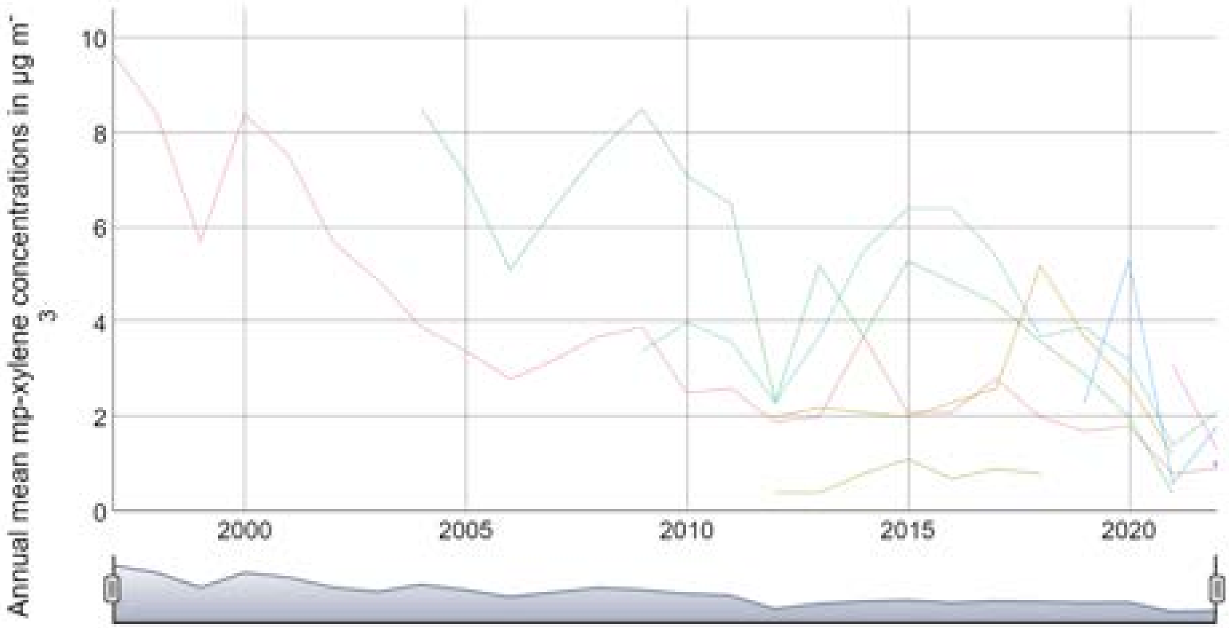
Figure 24: Time series of annual mean ethylbenzene concentrations in µg m^{-3}



mp-xylene

Concentrations of xylenes (Figure 25 and Figure 26) have generally decreased since monitoring began except for Faux Bie which saw a steady increase since 2012, though this has reversed since filling station upgrades in 2016 and 2017. 2022 was an exception to this as annual average concentrations increased by 0.3 µg m^{-3}, though still below years before 2020. At Hansford Lane, concentrations of m+p-xylene and of o-xylene have fluctuated considerably from year to year; however, overall concentrations and as with the other BTEX species have shown a large drop since the closure of the paint spraying business in 2019. M+pxylene and oxylene concentrations in 2022 at Harrington's Garage and Faux Bie Terrace presented an increase compared to 2021, although all remain below 1 µg m^{-3}. Further detailed analysis of annual concentrations at Rue de Pres and Beresford Street will be made as multiple years of data are obtained. It is also important to note how low current hydrocarbon concentrations are, compared to the LoD equivalent concentration (in 2022, typically around 0.21 µg m^{-3} for benzene, 0.21 µg m^{-3} for toluene and 0.27 µg m^{-3} for the other hydrocarbons).

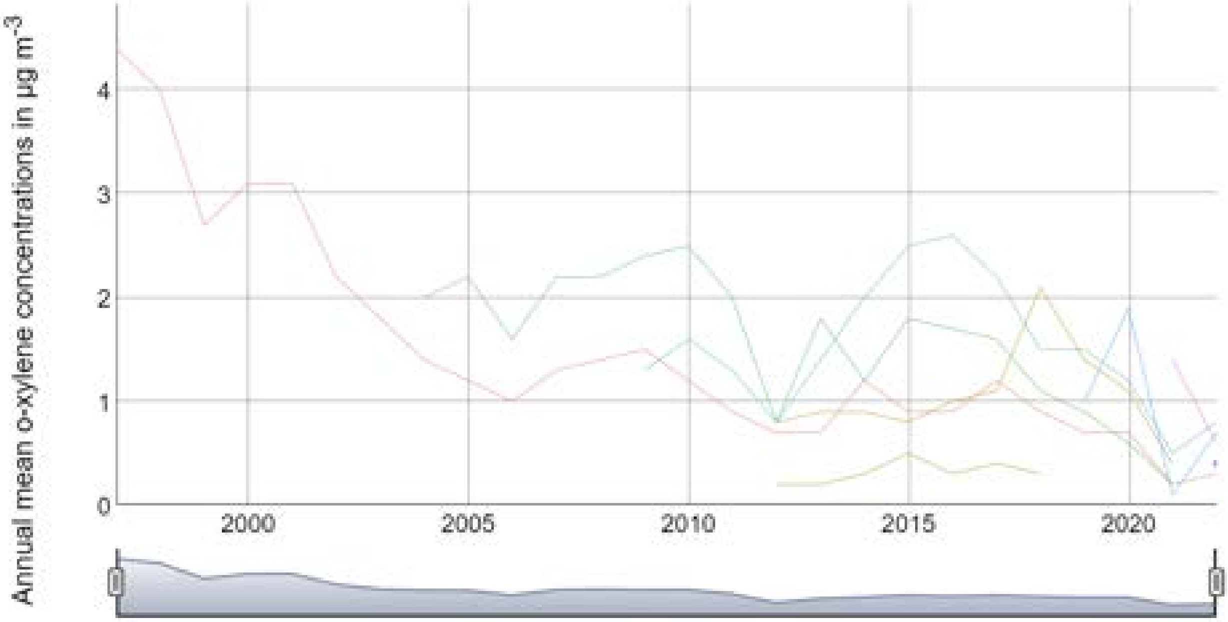
Figure 25: Time series of annual mean mp-xylene concentrations in µg m^{-3}



o-xylene

Concentrations of xylenes (Figure 25 and Figure 26) have generally decreased since monitoring began except for Faux Bie which saw a steady increase since 2012, though this has reversed since filling station upgrades in 2016 and 2017. 2022 was an exception to this as annual average concentrations increased by 0.3 µg m^{-3}, though still below years before 2020. At Hansford Lane, concentrations of m+p-xylene and of o-xylene have fluctuated considerably from year to year; however, overall concentrations and as with the other BTEX species have shown a large drop since the closure of the paint spraying business in 2019. M+pxylene and oxylene concentrations in 2022 at Harrington's Garage and Faux Bie Terrace presented an increase compared to 2021, although all remain below 1 µg m^{-3}. Further detailed analysis of annual concentrations at Rue de Pres and Beresford Street will be made as multiple years of data are obtained. It is also important to note how low current hydrocarbon concentrations are, compared to the LoD equivalent concentration (in 2022, typically around 0.21 µg m^{-3} for benzene, 0.21 µg m^{-3} for toluene and 0.27 µg m^{-3} for the other hydrocarbons).

Figure 26: Time series of annual mean o-xylene concentrations in µg m⁻³



Conclusions and Recommendations

Ricardo Energy & Environment has continued the ongoing air quality monitoring programme in Jersey during 2022, on behalf of the Government of Jersey. This was the 26th year of monitoring. Oxides of nitrogen were monitored at one automatic monitoring station which changed location in November 2021 from a roadside position at the Central Market, Halkett Place in St Helier to a roadside position at the Central Market, Beresford Street, St Helier. Diffusion tubes were also co-located (in triplicate) with the automatic site at this location. This was supplemented by diffusion tubes for indicative monitoring of NO_2 at an additional 22 sites around the island. All complications that were seen in the previous two years relating to data collection and the data itself were no longer issues in 2022. 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.

NO_2 Results

1. The period mean NO_2 concentration measured by the automatic analyser at Beresford Street Market was 17 µg m^{-3} (rounded to the nearest integer). This site recorded 98% data capture for the 2022 calendar year, above the limit required to report an annual mean. This is therefore within the EC Directive limit value and AQS objective of 40 µg m^{-3} for annual mean NO_2. Having achieved compliance by 2010 as required by all European Union member states the Government of Jersey are advised to continue to demonstrate ongoing compliance as has been done since 2010.
2. 2022 was the first full calendar year of monitoring at Beresford Street Market, therefore it is difficult to make direct comparisons between this site and others. Jersey

is also continuing it's recovery from coronavirus, therefore making comparisons between previous years difficult. It is recommended that monitoring is continued at Beresford Street Market for further years to enable these comparisons.

3. The EC Directive limit value (and AQS objective) for 1-hour mean NO_2 concentration is 200 µg m^{-3}, with 18 exceedances permitted per calendar year. There were no hourly means greater than this value measured at the Beresford Street Market automatic site, the highest hourly value measured was 99.2 µg m^{-3}. Therefore, this site met the limit value objective.
4. NO_2 diffusion tubes exposed in triplicate alongside the automatic analyser at Beresford Street Market (Central Market 2) measured a 22 µg m^{-3} annual mean.
5. Annual mean NO_2 concentrations at all diffusion tube monitoring sites were within the EC limit value of 40 µg m^{-3}.
6. The updated WHO guidelines introduced in 2021 advise an annual mean limit for NO_2 of 10 µg m^{-3}. Jersey Beresford Street did not meet this guideline during 2022.
7. The diurnal variation in NO_2 concentrations at Beresford Street Market showed some similarities to an urban site but had a particularly early (and sharp) morning rush hour peak, with a gentle but broad evening peak 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 use of the short term parking next to the site where drivers regularly leave vehicles running.
8. Seasonal variations in monthly mean NO_2 concentrations at the diffusion tube sites have historically been hard to see, however in 2022 seasonal variations can be seen with the highest concentrations in generally measured in January and March whilst lower concentrations were seen between May and September.
9. Annual mean NO_2 concentrations at Jersey's urban sites appear to have generally decreased between 2003 and 2012. Since then concentrations have remained largely stable at most sites.
10. Annual mean NO_2 concentrations at all of Jersey's diffusion tube monitoring sites were similar in 2022 compared with 2021. Pollutant concentrations are expected to fluctuate from year to year, due to meteorological and other factors, the COVID-19 pandemic being the obvious major one for 2020 and beyond.

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 Government of Jersey must continue to demonstrate ongoing compliance.
2. All sites measured relatively low, however Harrington's Garage and Faux Bie Terrace do show slightly higher average measurements than the other three sites for most pollutants, possibly as a result of their proximity to fuel filling stations.
3. Annual mean concentrations of benzene and toluene at all sites were similar to those in 2021, except for Harrington's Garage where an increase of roughly 70% was seen.

4. Annual mean concentrations of ethylbenzene, m+p-xylene and o-xylene at Harrington's Garage and Faux Bie Terrace showed a considerable increase on 2021 concentrations. Rue de Pres Trading Estate and Le Bas Centre were similar to those measured in recent years.

Recommendations

It is recommended that the monitoring programme be continued as part of Jersey's Air Quality Strategy. Measured concentrations of BTEX hydrocarbons at most of the sites were very low. 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 are 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. To further reduce VOC emissions from petrol stations and Jersey's fuel farm it is recommended that the States of Jersey consider developing vapour recovery legislation.

Continual review of the diffusion tube network is recommended to assess any sites that no longer represent relevant exposure and can be removed or relocated. The diffusion tube results indicate no sites breaching or close to the annual average NO_2 limit values. As such, an expansion of the automatic NO_x monitoring network is not required, it is recommended that monitoring continues at the Beresford Street Market urban roadside location. This helps for better comparison between the other roadside and kerbside diffusion tube sites and enables an appropriate co-location for diffusion tubes used for annual BIAS adjustment. It also ensures that Jersey's monitoring network aligns with the strategy stated in LAQM.TG(22) whereby monitoring sites are "sufficiently close to the dominant pollution source (i.e. in the vast majority of cases, at roadside sites)"[34]. If the Government of Jersey would like to expand the network, monitoring at a background site would be beneficial to "determine long-term trends, as such sites are less likely to be affected by variations in local sources, for example, changes in traffic on a particular road" [35].

Based on the 2019 UK Clean Air Strategy [36] and its emphasis on $PM_{2.5}$ reduction the Government of Jersey may wish to install reference equivalent analysers in an aim to

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[34] Department for Environment, Food; Rural Affairs, 2022 *Local Air Quality Management - Technical Guidance LAQM.TG (22).* https://laqm.defra.gov.uk/wp-content/uploads/2022/08/LAQM-TG22-August-22-v1.0.pdf (Accessed 30 March 2023)

[35] Department for Environment, Food; Rural Affairs, 2022 *Local Air Quality Management - Technical Guidance LAQM.TG (22).* https://laqm.defra.gov.uk/wp-content/uploads/2022/08/LAQM-TG22-August-22-v1.0.pdf (Accessed 30 March 2023)

[36] Department for Environment, Food; Rural Affairs, 2019. *Clean Air Strategy.* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf (Accessed 11 April 2023)

expanding their particulate monitoring network and demonstrating compliance with the annual WHO $PM_{2.5}$ guideline of 5 µg m^{-3}.

With ongoing reductions in concentrations and improvements in technology since the Jersey Air Quality Strategy was last published in 2013, now would be a good opportunity to review and potentially update the document. Ricardo understands that with a recent restructure during 2021, with Air Quality monitoring moving to a dedicated scientific team, and Government Plan funding allocation, the Government of Jersey have moved to prioritise the development of the existing Air Quality monitoring programme to meet new and existing environmental challenges.

Appendix I - Air Quality objectives

Table 26: UK air quality objectives for protection of human health, July 2007

	Pollutant	Metric	Type	Legal value
1	NO_2	1-hr	LV	200 µg m^{-3} (18 allowed)
2	NO_2	Annual mean	LV	40 µg m^{-3}
3	PM_{10}	24-hr	LV	50 µg m^{-3} (35 allowed)
4	PM_{10}	Annual mean	LV	40 µg m^{-3}
5	$PM_{2.5}$	Annual mean	LV (stage 1)	25 µg m^{-3}
6	$PM_{2.5}$	Annual mean	LV (stage 2)	20 µg m^{-3}
7	SO_2	1-hr	LV	350 µg m^{-3} (24 allowed)
8	SO_2	24-hr	LV	125 µg m^{-3} (3 allowed)
9	CO	8-hr mean	LV	10 mg m^{-3}
10	Ozone	Maximum daily running 8-hour mean	LV	100 µg m^{-3} (10 allowed)
11	Ozone	Maximum daily running 8-hour mean	LTO	120 µg m^{-3}
12	Benzene	Annual mean	LV	5.0 µg m^{-3}
13	Benzo[a]pyrene	Annual mean	TV	1.0 ng m^{-3}
14	Arsenic	Annual mean	TV	6.0 ng m^{-3}
15	Cadmium	Annual mean	TV	5.0 ng m^{-3}
16	Nickel	Annual mean	TV	20.0 ng m^{-3}
17	Lead	Annual mean	LV	0.5 µg m^{-3}

Table 27: Air pollution bandings and descriptions

Banding	Index	Accompanying health messages for at-risk individuals*	Accompanying health messages for the general population
Low	1,2,3	Enjoy your usual outdoor activities.	Enjoy your usual outdoor activities.
Moderate	4,5,6	Adults and children with lung problems, and adults with heart problems, who experience symptoms, should consider reducing strenuous physical activity, particularly outdoors.	Enjoy your usual outdoor activities.
High	7,8,9	Adults and children with lung problems, and adults with heart problems, should reduce strenuous physical exertion, particularly outdoors, and particularly if they experience symptoms. People with asthma may find they need to use their reliever inhaler more often. Older people should also reduce physical exertion.	Anyone experiencing discomfort such as sore eyes, cough or sore throat should consider reducing activity, particularly outdoors.
Very High	10	Adults and children with lung problems, adults with heart problems, and older people, should avoid strenuous physical activity. People with asthma may find they need to use their reliever inhaler more often.	Reduce physical exertion, particularly outdoors, especially if you experience symptoms such as cough or sore throat.

Table 28: Air pollution bandings and descriptions

Band	Index	Ozone	Nitrogen Dioxide	Sulphur Dioxide	PM2.5 Particles (EU Reference Equivalent)	PM10 Particles (EU Reference Equivalent)
		Running 8 hourly mean	hourly mean	15 minute mean	24 hour mean	24 hour mean
		μgm-3	μgm-3	μgm-3	μgm-3	μgm-3
Low	1	0-33	0-67	0-88	0-11	0-16
Low	2	34-66	68-134	89-177	45261	17-33
Low	3	67-100	135-200	178-266	24-35	34-50
Moderate	4	101-120	201-267	267-354	36-41	51-58
Moderate	5	121-140	268-334	355-443	42-47	59-66
Moderate	6	141-160	335-400	444-532	48-53	67-75
High	7	161-187	401-467	533-710	54-58	76-83
High	8	188-213	468-534	711-887	59-64	84-91
High	9	214-240	535-600	888-1064	65-70	92-100
Very High	10	241 or more	601 or more	1065 or more	71 or more	101 or more

Appendix II - Monitoring Apparatus and Techniques

The analyser at Beresford Street is calibrated monthly by officers from the Natural Environment Department. 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 usually 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 NO_2 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.