Air Quality Monitoring Annual Report 2014

Birmingham Airport

Report for Birmingham Airport Ltd

Ricardo-AEA/R/3450
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Executive summary

Birmingham Airport commissioned Ricardo-AEA to produce an annual report to provide analysis and commentary on the 2014 data sets from the Birmingham Airport air quality monitoring station, as managed and collated by Ricardo-AEA. This ambient air quality monitoring survey forms part of the Airport's commitment to monitor air quality within the requirements of the Section 106 Obligations with Solihull MBC. The objective of the monitoring is to provide information on current air quality in the area and the levels of pollution to which the community is currently exposed.

In the context of Local Air Quality Management, nitrogen dioxide (NO_2) is the main pollutant of specific relevance to airport emission sources. A demonstration of Birmingham Airport's compliance with the UK Air Quality Strategy (AQS) Objectives for NO_2 is provided in the table below.

Pollutant	AQS Objective	Threshold	Result for Birmingham Airport	Objective met?
NO_2	1-hr mean not to be exceeded more than 18 times a year	200 µg m^{-3}	0 exceedances	Yes
	Annual mean	40 µg m^{-3}	25 µg m^{-3}	Yes

The AQS objectives for carbon monoxide (CO), sulphur dioxide (SO_2), PM_{10} particulate matter and ozone were also met during 2014.

In 2014, ozone met the applicable Air Quality Strategy (AQS) objective. Ozone is a transboundary pollutant which is difficult to control by local measures: it is therefore not currently included in the Local Air Quality Management regime.

The investigation of potential pollutant sources identified the airport as a key source of the NO, NO_2, and CO measured at the monitoring site. Highest concentrations of particulate matter (PM_{10}) tended to occur at higher wind speeds and with an easterly wind direction.

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1 Introduction

Birmingham Airport Ltd (referred to here as "Birmingham Airport") has undertaken continuous ambient air quality monitoring at a monitoring station on the airport premises since April 1995. This forms part of the Airport's commitment to monitor air quality through the requirements of the Section 106 Planning Agreement between Solihull Metropolitan Borough Council (SMBC) and Birmingham Airport. The monitoring is intended to provide information on current air quality in the area and the levels of pollution to which the neighbouring community is exposed. The data from the air monitoring station are managed and collated by Ricardo-AEA Ltd. This report has been prepared by Ricardo-AEA on behalf of Birmingham Airport, to provide analysis and commentary on the 2014 dataset.

1.1 UK Air Quality Strategy

Within the European Union, ambient air quality is covered by Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe[1], known as the Air Quality Directive (AQD). This consolidated four previously existing Directives, which set limit values for a range of air pollutants with known health impacts. The original Directives were transposed into UK law via the Environment Act 1995 and subsequent Statutory Instruments. This Act also placed a requirement on the Secretary of State for the Environment to produce a national air quality strategy containing standards, objectives and measures for improving ambient air quality.

The Environment Act 1995 also introduced the system of local air quality management (LAQM). This requires local authorities to review and assess air quality in their areas against the national air quality objectives. Where any objective is unlikely to be met by the relevant deadline, the local authority must designate an air quality management area (AQMA). Local authorities then have a duty to carry out further assessments within any AQMAs and draw up an action plan specifying the measures to be carried out to achieve the air quality objectives, and the timescale for this. The legal framework given in the Environment Act has been adopted in the UK via the UK Air Quality Strategy.

The air quality objectives are based on 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. All Air Quality Strategy objectives must be at least as stringent as the EC limit values.

Since its original publication in 1997, the UK Air Quality Strategy has undergone a number of updates. These have reflected improvements in the understanding of air pollutants and their health effects. They have 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 $PM_{2.5}$ particulate matter. The latest version of the strategy was published by Defra in 2007[2]. The current UK air quality objectives for the pollutants monitored at Birmingham Airport are presented in Table 1-1.

Table 1-1: Applicable objectives included in the Air Quality Standards Regulations (2010) for the purpose of Local Air Quality Management.

Pollutant	Air Quality Objective		To be achieved by
	Concentration	Measured as	
Benzene (England and Wales)	5.00 µg m^{-3}	Annual mean	31 December 2010
Carbon monoxide (CO) (England, Wales and N. Ireland)	10.0 mg m^{-3}	Maximum daily running 8-hour mean	31 December 2003
Nitrogen dioxide (NO_2)	200 µg m^{-3} not to be exceeded more than 18 times a year	1-hour mean	31 December 2005
	40 µg m^{-3}	Annual mean	31 December 2005
Particles (PM_{10}) (gravimetric) (All authorities)	50 µg m^{-3}, not to be exceeded more than 35 times a year	24 hour running mean	31 December 2004
	40 µg m^{-3}	Annual mean	31 December 2004
Sulphur dioxide (SO_2)	266 µg m^{-3}, not to be exceeded more than 35 times a year	15-minute mean	31 December 2005
	350 µg m^{-3}, not to be exceeded more than 24 times a year	1-hour mean	31 December 2004
	125 µg m^{-3}, not to be exceeded more than 3 times a year	24-hour mean	31 December 2004
Ozone (O_3)*	100 µg m^{-3} not to be exceeded more than 10 times a year	8 hourly running or hourly mean*	31 December 2005

*** not included as part of the LAQM regime.**

1.2 Emissions from Airports

Aircraft produce the same types of emissions as many other combustion processes. Aircraft jet engines, like many other vehicle engines, produce carbon dioxide (CO_2), water vapour (H_2O), nitrogen oxides (NOx), carbon monoxide (CO), oxides of sulphur (SOx), particulate matter of various sizes, hydrocarbons from partially combusted fuel, and other trace compounds. In addition to the aircraft, there will also be emissions from the airside vehicles, and from road vehicles travelling to and from the airport.

The Defra Technical Guidance document for LAQM (LAQM.TG(09))[3] states that concentrations of particulate matter, measured as PM_{10}, have *not* been found to be significantly elevated around airports (section 5.25 and Box 5.4 of LAQM.TG(09)). In the context of LAQM, the pollutant of most concern around airports is nitrogen dioxide (NO_2). Local Authorities whose areas contain airports with over 10 million passengers per annum must take these into account in their annual Review and Assessment of air quality.

1.2.1 The Air Quality Strategy and Birmingham Airport

The UK Air Quality Strategy Objectives apply anywhere that public exposure may occur, for example at residential properties, at a bus stop etc. As the airport monitoring site is located by the runway, where members of the public do not have access, strictly these limits do not apply. However, this report compares the data from the site with the Air Quality Strategy (AQS) Objectives. If the site is showing compliance with the objectives for the primary pollutants that are likely to be emitted directly from the airport - namely NO_2, PM_{10}, CO and SO_2 - then it is reasonable to assume that, in the absence of any other significant sources, the objectives are likely to be met at the nearby residential properties.

For the purposes of LAQM, the airport falls under the jurisdiction of Solihull MBC. The Council has reviewed air quality across their area and found that pollutant levels do not exceed the AQS Objectives. Therefore, at the time of writing (Feb 2015), no air quality management areas have been declared in Solihull.

2 Monitoring Methodology

2.1 Pollutants and Measurement Techniques

The following pollutants were monitored at Birmingham Airport in 2014:

- Particulate matter as PM_{10}
- Oxides of nitrogen - NOx, which comprises nitrogen dioxide (NO_2) and nitric oxide (NO)
- Carbon monoxide (CO)
- Ozone (O_3)
- Sulphur dioxide (SO_2)

Ozone is a secondary pollutant; it is formed by chemical reactions in the air, involving precursor pollutants, rather than emitted directly from source. It is therefore trans-boundary in nature. As a result, Local Authorities have little control over ozone concentrations in their areas. The Government has recognised the problems associated with achieving the air quality objective for ozone, and this is not included in the LAQM regime.

Table 2-1 shows the measurement technique employed for each pollutant.

Table 2-1: Measurement techniques employed at Birmingham Airport in 2014

Pollutant	Measurement Technique
PM_{10}	Tapered Element Oscillating Microbalance (TEOM)
NO_2	Chemiluminescence
NOx	Chemiluminescence
CO	Non-dispersive infrared absorption (NDIR)
O_3	Non-dispersive ultraviolet absorption technology (NDUV)
SO_2	Ultraviolet Fluorescence (UVF)

Fortnightly calibrations are performed by Local Site Operators (LSOs) based at Birmingham Airport, to monitor the performance of the analysers. Data from these fortnightly checks, and from two six-monthly independent QA/QC audits carried out by Ricardo-AEA, are used to scale and ratify the data. This data scaling and ratification is carried out by Ricardo-AEA. The analysers are also serviced on a six-monthly basis to ensure their continued operation.

All ambient concentration measurements in the report are quoted in microgrammes per cubic metre ($\mu g\ m^{-3}$) or in the case of carbon monoxide milligrammes per cubic metre ($mg\ m^{-3}$) at reference conditions of 20 °C, 1013 mbar.

Previous reports in this series included indicative measurements of benzene, toluene, ethylbenzene and xylene, made using diffusion tubes. Benzene is the only one of these hydrocarbons for which there is an AQS Objective. These measurements indicated that annual mean benzene concentrations had been well within the AQS Objective since monitoring began in 2006. Therefore, monitoring of hydrocarbons was discontinued at the end of 2013.

2.2 VCM Correction of PM_{10} Data

The TEOM particulate monitor uses a 50 °C heated sample inlet to prevent condensation on the filter. Although necessary, this elevated temperature can result in the loss of volatile and semi-volatile components of PM_{10}, such as ammonium nitrate.

It is not possible to address this problem by applying a simple correction factor. However, King's College London (KCL) have developed a Volatile Correction Model[3], which allows

TEOM PM_{10} data to be corrected for the volatile components lost as a result of the TEOM's heated inlet. The model is available at http://www.volatile-correction-model.info/Default.aspx. It uses data from nearby TEOM-FDMS particulate analysers, which measure the volatile and non-volatile components of the PM_{10}. The volatile component (which typically does not vary much over a large region), can be added to the TEOM measurement. KCL state that the resulting corrected measurements have been demonstrated as equivalent to the gravimetric reference equivalent. In this report, the VCM has been used to correct PM_{10} data where applicable. Where this has been done, it is clearly indicated. The methodology for the VCM correction of PM_{10} data is presented in Appendix 1.

2.3 Monitoring Location

The monitoring site is located on the airfield near airport buildings to the east of the runway and north-west of the Main Terminal (OS grid ref. 417395, 284240), having previously been located to the west of the apron area, approximately 300 m due west of the Main Terminal. The site relocation occurred in January 2006. The current location of the monitoring site is shown in Figure 2-1. A map showing the old and new locations is included in Appendix 2.

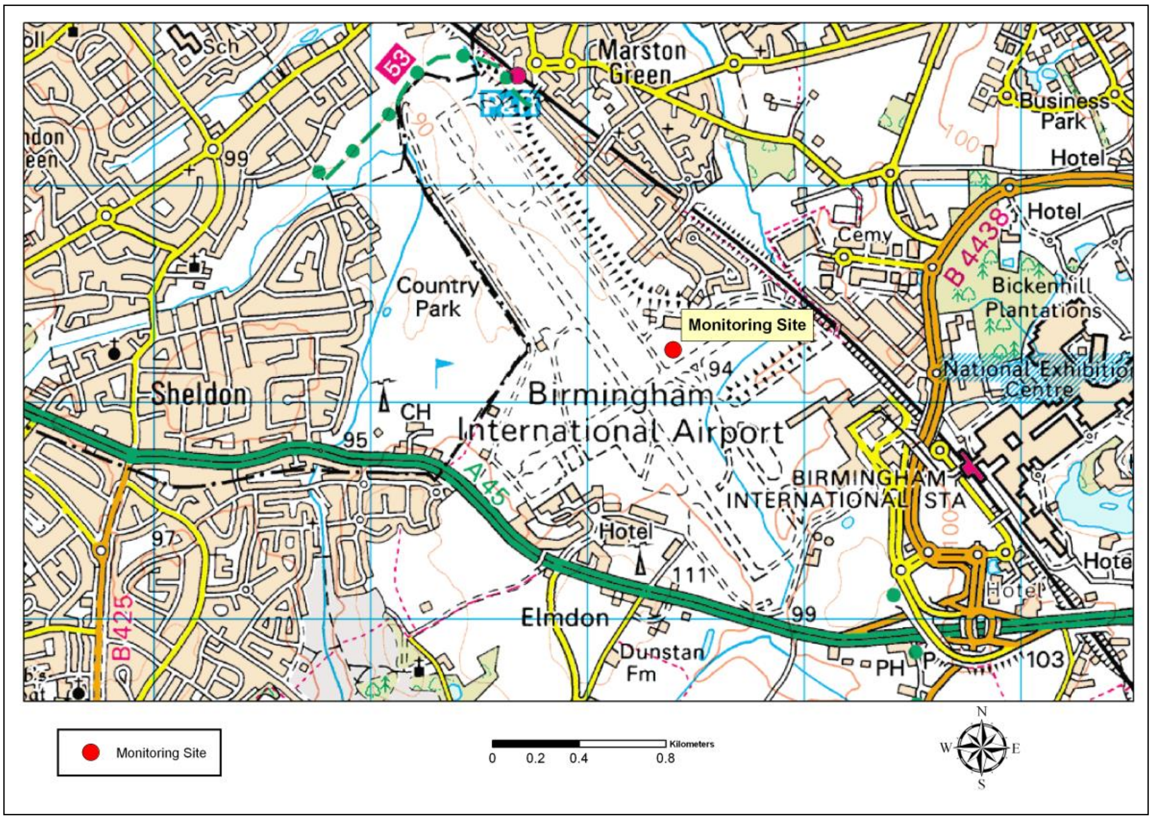


Figure 2-1: Location of monitoring site. *© Crown Copyright Ordnance Survey Reproduced from Landranger 1:50000 map series, Licence number 100040905*

2.4 Meteorological Data

The following meteorological data were collected at the monitoring station:

- Ambient Temperature (°C)
- Pressure (mbar)
- Relative Humidity (%)
- Wind Direction (°)
- Wind Speed (m s^{-1})

The meteorological data are not covered by the data management contract with Ricardo-AEA. All checking and QA/QC on the meteorological data are carried out by Birmingham Airport, who have sole responsibility for the accuracy of all meteorological data used in this report.

The wind speed and direction frequencies for the whole of 2014 are shown in Figure 2-2. The meteorological data are summarised by direction and by different wind speed categories. Wind speeds are split into the 2 m s^{-1} intervals shown by the scale bar in each plot. The grey circles indicate the percentage of time over the period that the wind was measured from each direction, e.g. Figure 2-2 shows that the wind direction was from the easterly sector (bearing 180º ± 15º, i.e. 165º-195º) for approximately 10% of the year.

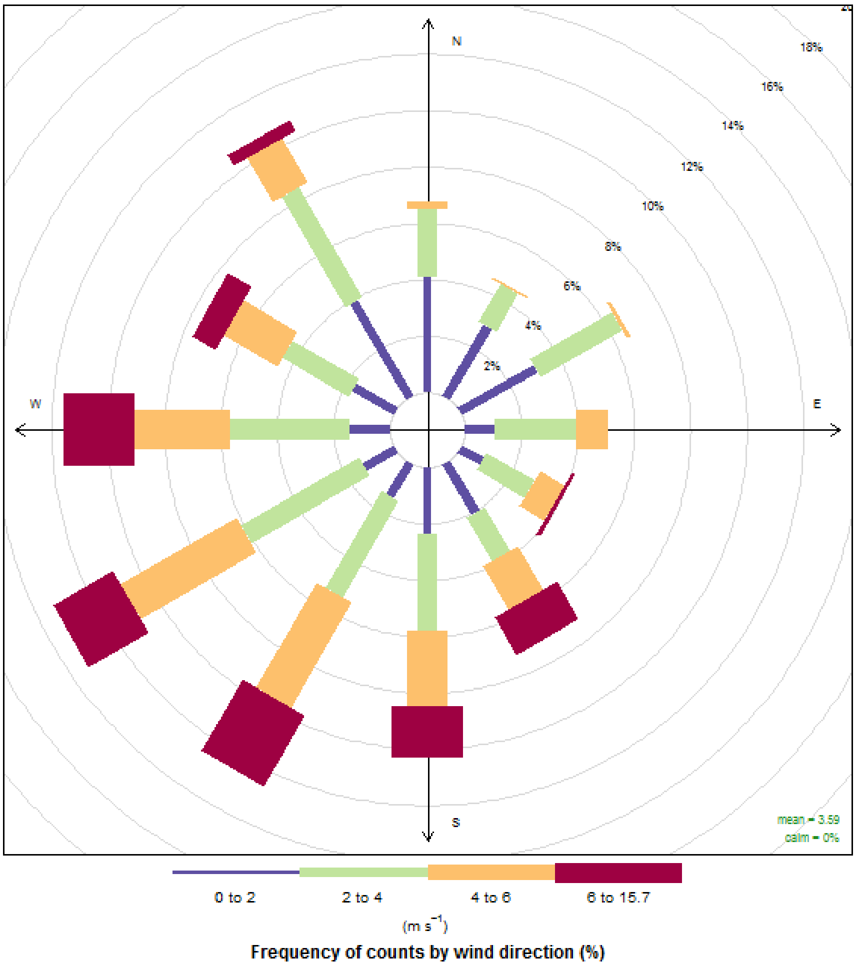


Figure 2-2: Wind rose showing the wind speed and direction in 2014.
(The concentric circles indicate the percentage of time that the wind was blowing from each direction.)

During 2014 the wind direction was most frequently in the range 195º - 345º, i.e. between approximately the south west and north west. Highest wind speeds occurred most often when the wind direction was in the range 195º - 290º; this is consistent with the UK's south westerly prevailing wind direction.

The wind speed and direction data, split by month, are shown in Figure 2-3. Periods of high winds occurred in February, December and January 2014. By contrast the summer months show fewer instances of high winds.

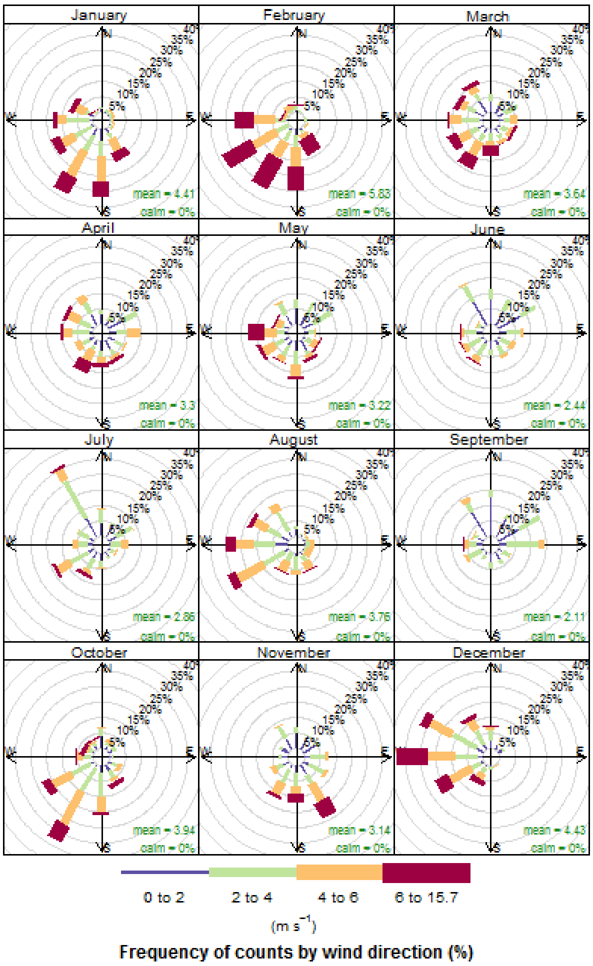


Figure 2-3: Wind rose showing wind speed and direction by month.

2.5 Regional Analysis

As part of the analyses presented in Section 3, pollutant concentrations from Birmingham Airport are compared to concentrations from other local monitoring sites. This enables the pollutant concentrations recorded at Birmingham Airport to be examined in a regional context. The three monitoring sites used for this comparison are Birmingham Tyburn, Birmingham Tyburn Roadside and Birmingham Acocks Green. Details of these are as follows:

- Birmingham Tyburn: this monitoring station is classified as ‘Urban Background’, and located to the rear of the council offices. The nearest main road is approximately 60 metres from the station, with the M6 motorway approximately 600 metres to the south. It measures NOx, O_3, PM_{10} $PM_{2.5}$ and SO_2. Monitoring of particulate matter has been carried out using the FDMS-TEOM since 2009.

- The Birmingham Tyburn Roadside monitoring station site is classified as an ‘Urban Traffic’ site, located on the south side of the A38 approximately 7m from the kerbside, and 60 metres north of the Birmingham Tyburn site. Both are part of the National Automatic Urban and Rural Network (AURN). It measures NOx, O_3, PM_{10} and $PM_{2.5}$. Monitoring of particulate matter has been carried out using the FDMS-TEOM since 2009.

- Birmingham Acocks Green is an ‘Urban Background’ monitoring station, located in the grounds of an annex to a large school. The monitoring station is approximately 70 metres from the nearest major road. This monitoring station was started up in 2011 and measures NOx, O_3 and $PM_{2.5}$, the latter using an FDMS-TEOM.

3 Results and Discussion

This section provides a summary of the data for 2014 and a comparison with the AQS Objectives. It also compares results from the Birmingham Airport site with those from other monitoring sites in the area, and identifies potential emission sources based upon pollution measurements and meteorological data from the site.

3.1 Annual Data Summary

3.1.1 Automatic monitoring data

Table 3-1 presents the key statistics for each pollutant. The Defra Technical Guidance document for LAQM (LAQM.TG(09))[3], requires the use of the Volatile Correction Model (VCM)[4] to correct TEOM data to gravimetric equivalent, as explained in section 2.2. The hourly average concentrations of PM_{10} in this section are therefore corrected using the VCM to enable direct comparison with the Air Quality Strategy (AQS) objectives. The FDMS data used for this purpose are from AURN sites: AURN data for October-December 2014 have not been fully ratified at the time of writing. Therefore it is possible there may be some minor changes to the VCM correction when the fully ratified dataset is released at the end of March 2015.

Data capture for all monitored pollutants except SO_2 was above the Defra target of 90%[4] for ratified datasets. This data capture target does not include losses due to regular calibration or maintenance of the instrument. Any data capture rate above 75% is deemed representative of the full annual period.

Table 3-1: Summary air quality statistics for Birmingham Airport - 2014.

Statistic	PM_{10} µgm^{-3}*	NO_x as NO_2, µg m^{-3}	NO µg m^{-3}	NO_2 µg m^{-3}	O_3 µg m^{-3}	SO_2 µg m^{-3}	CO mg m^{-3}
Maximum 15-minute mean (SO_2 only)	-	-	-	-	-	37	-
Maximum hourly mean	349	1031	576	147	132	32	1.6
Maximum running 8-hour mean	-	-	-	-	116	-	1
Maximum running 24-hour mean	80.1	-	-	-	-	-	-
Maximum daily mean	71.1	439	237	76	84	12	1
Average	18	38	9	24	45	2	0.2
Data capture	91.3	96.9	96.9	96.9	93.3	88.3	96.7

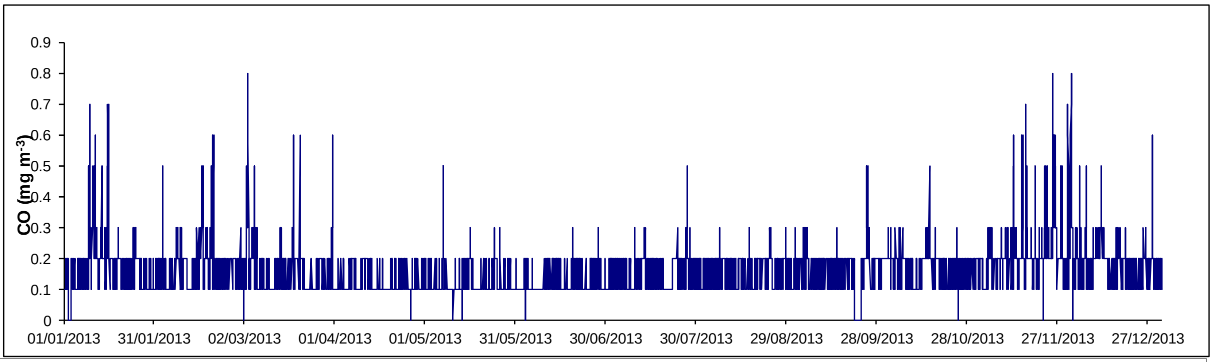
* VCM corrected using provisional FDMS data from AURN sites

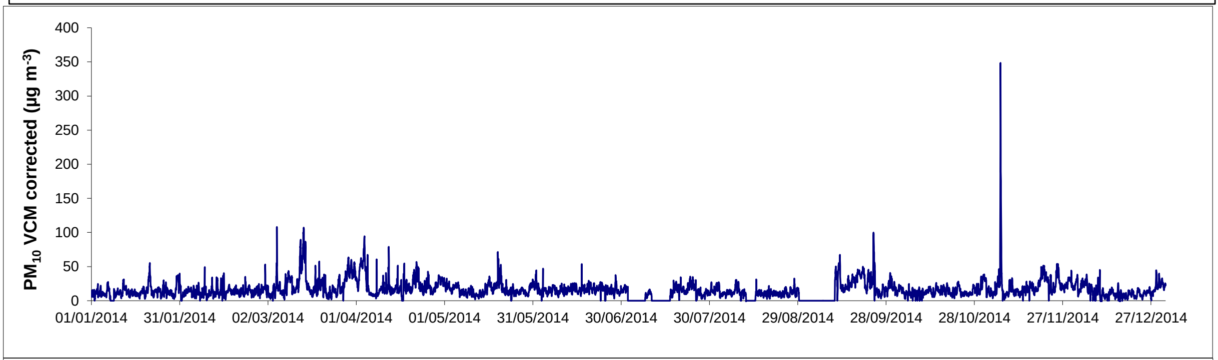
Table 3-2 shows all gaps in the data set, and the reasons for them. A server change in April caused several days' data loss for most of the analysers. The TEOM was affected by a number of short power interruptions which affected its software.

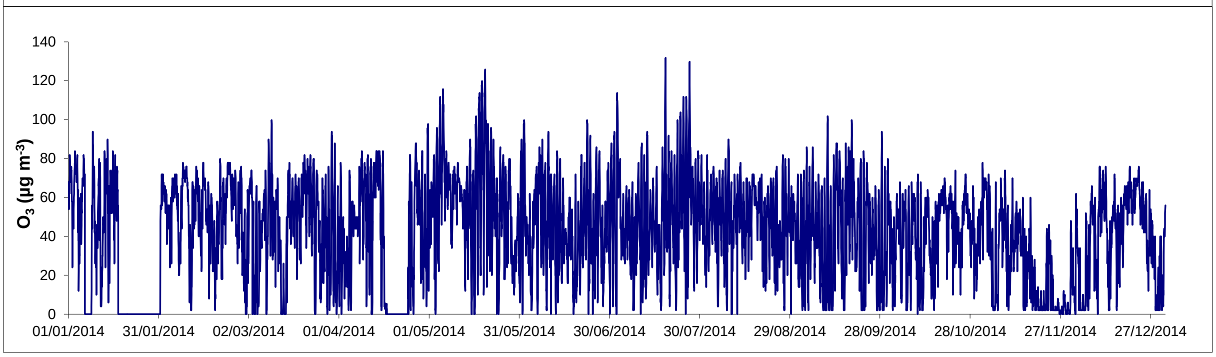
Table 3-2: Gaps in 2014 Data Set

Parameter affected	Date started	Date ended	Duration (days)	Reason
CO, NOx, O_3	06/01/2014	08/01/2014	2.2	Service
SO_2	06/01/2014	13/01/2014	7.1	Instrument removed for repair after service
PM_{10}	07/01/2014	08/01/2014	1.2	Unstable, following LSO calibration.
O3	17/01/2014	31/01/2014	14	Problem between LSO calibrations 17th & 31st Jan 2014.
PM_{10}	31/01/2014	31/01/2014	0.4	Unstable, following LSO calibration.
CO	16/04/2014	25/04/2014	9.0	Data transfer issue, due to server change
NOx	16/04/2014	24/04/2014	7.7	Data transfer issue, due to server change
O_3	17/04/2014	23/04/2014	7.0	Data transfer issue, due to server change
SO_2	17/04/2014	23/04/2014	7.0	Data transfer issue, due to server change
PM_{10}	24/06/2014	24/06/2014	0.3	QAQC Audit
PM_{10}	02/07/2014	08/07/2014	5.9	Brief power cut causing TEOM software loss.
PM_{10}	10/07/2014	16/07/2014	6.3	Brief power cut causing TEOM software loss.
CO NOx, PM_{10}, SO_2	09/08/2014	09/08/2014	0.3	Communications fault
PM10	11/08/2014	14/08/2014	3.1	Brief power cut causing TEOM software loss.
PM10	29/08/2014	10/09/2014	12.2	Brief power cut causing TEOM software loss.
SO_2	11/11/2014	08/12/2014	27.3	Fault resolved by engineer callout.

Figure 3-1 presents the hourly average concentrations for PM_{10}, O_3, SO_2 and CO, with hourly average concentrations of NO, NO_2 and NOx in Figure 3-2. A statistical summary of results from 2006-2014 is provided in Appendix 3.


CO (mg m-3)
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
01/01/2013 31/01/2013 02/03/2013 01/04/2013 01/05/2013 31/05/2013 30/06/2013 30/07/2013 29/08/2013 28/09/2013 28/10/2013 27/11/2013 27/12/2013


PM10 VCM corrected (µg m-3)
0 50 100 150 200 250 300 350 400
01/01/2014 31/01/2014 02/03/2014 01/04/2014 01/05/2014 31/05/2014 30/06/2014 30/07/2014 29/08/2014 28/09/2014 28/10/2014 27/11/2014 27/12/2014


O3 (µg m-3)
0 20 40 60 80 100 120 140
01/01/2014 31/01/2014 02/03/2014 01/04/2014 01/05/2014 31/05/2014 30/06/2014 30/07/2014 29/08/2014 28/09/2014 28/10/2014 27/11/2014 27/12/2014

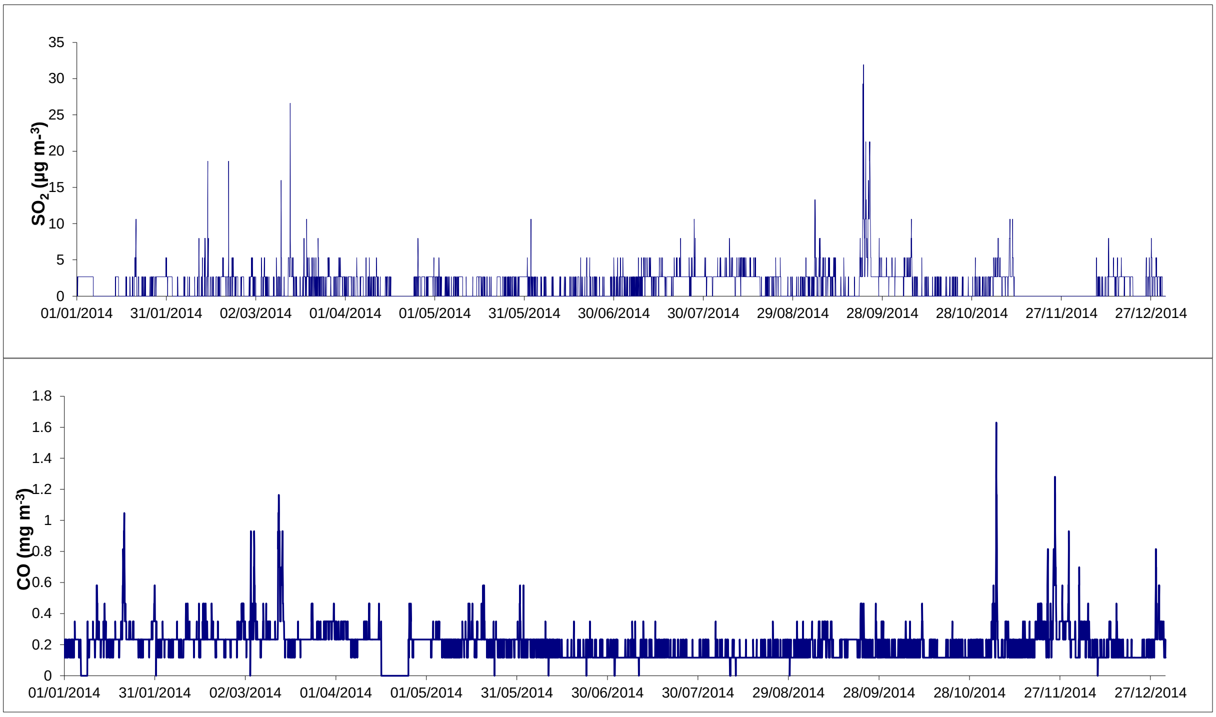
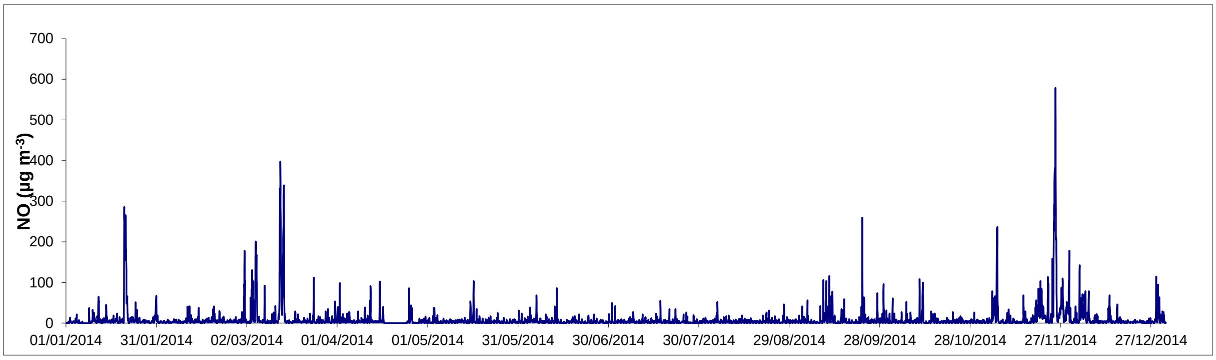


Figure 3-1 Hourly mean PM_{10}, O_3, SO_2 and CO concentrations at Birmingham Airport 2014.



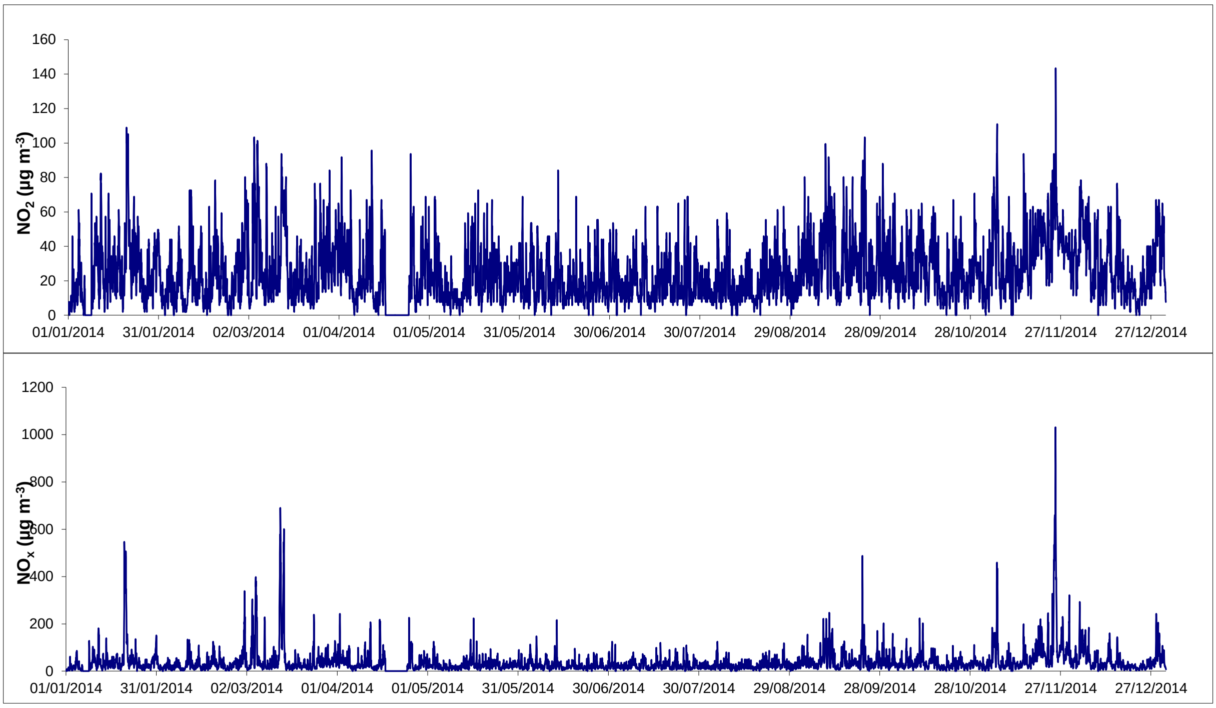


Figure 3-2 Hourly mean NO, NO_2 and NOx concentrations at Birmingham Airport 2014.

3.2 Comparison with Other Local Monitoring Sites

Table 3-3 compares the annual mean and maximum concentrations at Birmingham Airport with those measured at the other three Birmingham AURN sites.

Table 3-3: A comparison of summary statistics for Birmingham Airport and three local AURN monitoring sites.

Parameter	Birmingham Airport	Birmingham Tyburn Roadside	Birmingham Tyburn	Birmingham Acocks Green
Annual mean				
PM_{10} (µg m^{-3})	18	20	19 (86% data capture)	-
NO_2 (µg m^{-3})	24	46	30	41
O_3 (µg m^{-3})	45	34	40	45
SO_2 (µg m^{-3})	2	-	1	-
CO (mg m^{-3})	0	-	-	-

* VCM corrected using provisional FDMS data from AURN sites

The annual mean concentration of PM_{10} measured at the Birmingham Airport site in 2014 was comparable with those measured at the other Birmingham sites. The annual mean concentration of SO_2 at Birmingham Airport was low, though slightly higher than that measured at Birmingham Tyburn. The annual mean concentration of NO_2 at Birmingham Airport was lower than at the other three sites, all of which are closer to the centre of the city. The annual mean concentration of ozone at the airport site was similar to that measured at the two urban background sites (Acocks Green and Tyburn) but higher than at Birmingham Tyburn Roadside. The NO_2 and O_3 statistics together indicate that the quantity of emissions in the immediate vicinity of the other Birmingham monitoring stations is greater than at Birmingham Airport. The higher ozone concentration at the airport site indicates there is less NO to react with the available ozone, and thus ozone concentrations are not depleted as they typically are at roadside sites.

3.3 Comparison with AQS Objectives

Table 3.4 presents a comparison of the monitoring data with Air Quality Strategy Objectives for the protection of human health. The AQS Objectives for the pollutants included in the regulations were met in 2015 at Birmingham Airport.

Table 3-4: Comparison with AQS Objectives for the protection of human health.

Pollutant	AQS Objective	Threshold	Result for Birmingham Airport	Objective met?
PM_{10}	24-hr mean not to be exceeded more than 35 times a year	50 µg m^{-3}	5 days	Yes
	Annual mean	40 µg m^{-3}	18 µg m^{-3}	Yes
NO_2	1-hr mean not to be exceeded more than 18 times a year	200 µg m^{-3}	0 exceedances	Yes
	Annual mean	40 µg m^{-3}	25 µg m^{-3}	Yes
O_3	Daily maximum of running 8-hour means not to be exceeded more than 10 times a year ***(not included in LAQM)***	100 µg m^{-3}	9 days	Yes
SO_2	15-min mean not to be exceeded more than 35 times a year	266 µg m^{-3}	0 exceedances	Yes
	1-hr mean not to be exceeded more than 24 times a year	350 µg m^{-3}	0 exceedances	Yes
	24-hr mean not to be exceeded more than 3 times a year	125 µg m^{-3}	0 exceedances	Yes
CO	Maximum daily running 8 hour mean	10 mg m^{-3}	0 exceedances	Yes

There were five days on which the VCM-corrected daily mean PM_{10} concentration exceeded the AQS objective of 50 µg m^{-3}. This is well within the maximum number of exceedances permitted (35 per calendar year). The annual mean of 18 µg m^{-3} was below the AQS objective of 40 µg m^{-3}.

NO_2 is the key pollutant of concern within Local Air Quality Management, especially around airports. There were no measured exceedances of the NO_2 hourly mean objective. The annual mean of 25 µg m^{-3} was also well below the annual mean objective of 40 µg m^{-3}.

AQS objectives for CO, SO_2 and ozone were also met in 2014.

3.4 Emissions Sources

In order to investigate the possible sources of air pollution at the Birmingham Airport site, meteorological data from the site were used to produce bivariate polar plots of hourly pollutant concentrations against the corresponding wind speed and wind direction (Figure 3-3). The further the data point is plotted from the central position on the plot the higher the wind speed when the value was recorded; the pollutant concentration is shown by colour – see the key to the right of each plot. **The meteorological data are not covered by the data management**

contract with Ricardo-AEA. All checking and QA/QC on the meteorological data are carried out by Birmingham Airport, who have sole responsibility for the accuracy of all meteorological data used in this report.

These plots are intended to provide a visual indication as to the direction of possible sources of pollution that are being measured at the site. They do not usually allow conclusive identification of specific sources.

As with previous years the plot of CO shows that the highest concentration is in the centre of the plot (i.e. when wind speeds are low) with lower concentrations as wind speeds increase. This pattern indicates the main source of CO is in close proximity of the monitoring site, and dispersion of this pollutant increases with increasing wind speed.

The pollution rose for SO_2 shows a very different pattern. There is little SO_2 evident at low wind speeds. Higher wind speeds bring slightly higher concentrations of this pollutant, particularly from the north west. However, there is no clear directional pattern and SO_2 concentrations remain low.

NO (which, like CO and SO_2, is a “primary” pollutant i.e. one emitted directly from source rather than formed from chemical reactions in the air) shows a clear pattern of highest concentrations in the centre of the plot, i.e. associated with low wind speeds. This is a clear indication that the main sources of this pollutant are nearby – probably aircraft and airside vehicles.

For NO_2, which has both a primary and secondary component, there is some evidence of sources to the north east and south east, the direction of the runways and car park. However, the 2014 plot shows less evidence of contributions at higher wind speeds.

The pollution rose for VCM-corrected PM_{10} shows a contribution from the east of the site. In 2014, highest concentrations appeared to occur at highest wind speeds – this could perhaps have included some wind-blown dust.

The final bivariate plot shows concentrations of ozone. This shows a contrasting pattern to that of CO and NO, in that lowest ozone concentrations are associated with calm conditions. Being a secondary pollutant ozone is formed from chemical reactions in the ambient air. The plot demonstrates that higher concentrations of ozone are measured at the site when wind speeds are sufficient to bring in ozone-rich air from other areas of the region. At very low wind speeds, when NO concentrations are highest, any ozone present reacts with the NO emitted by the sources in the immediate vicinity.

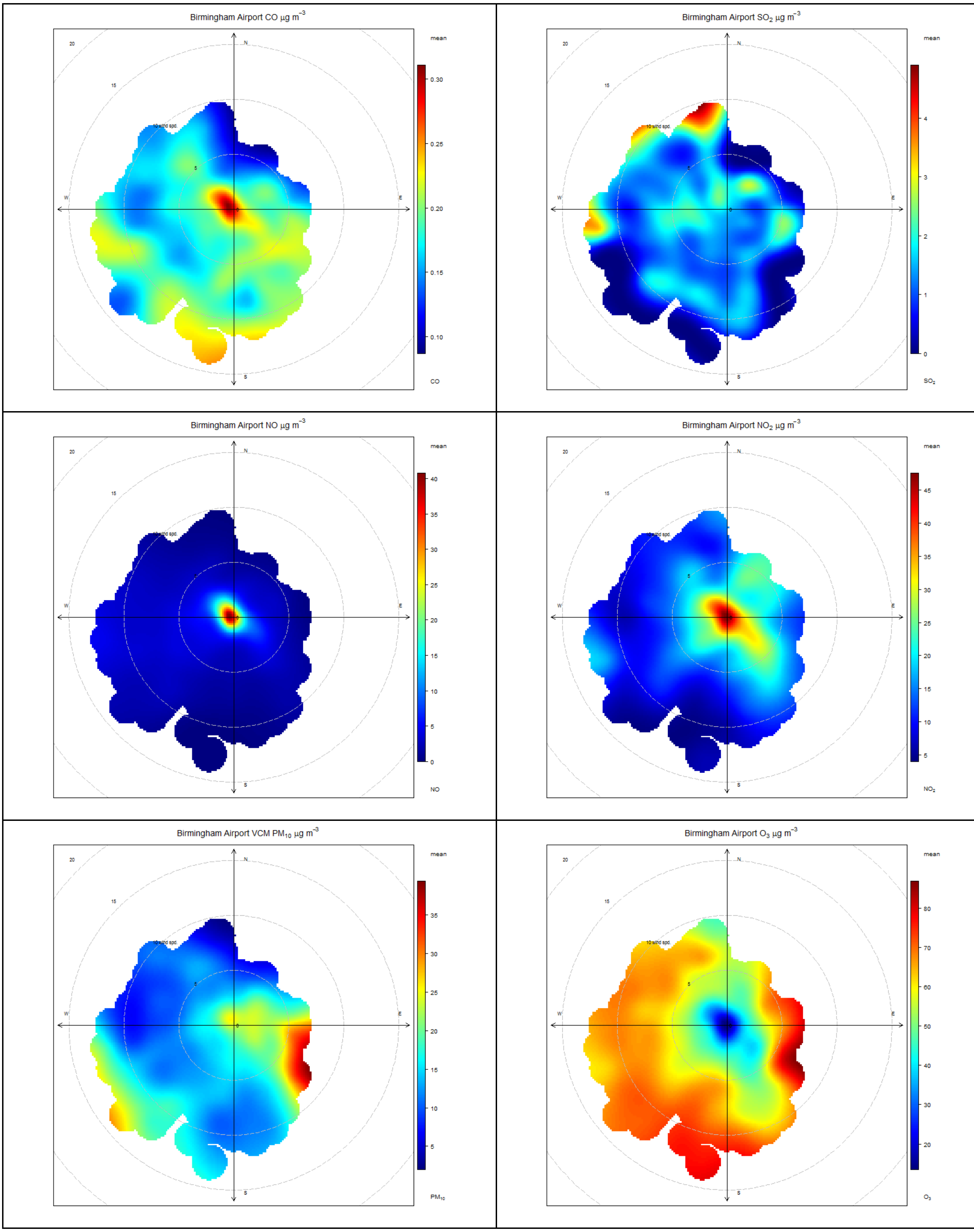


Figure 3-3: Bivariate plots showing pollutant concentrations as a function of both wind direction and wind speed.

4 Conclusions

The conclusions of Ricardo-AEA's examination of the 2014 dataset from Birmingham Airport's ongoing air quality monitoring are as follows:

1. Data capture of at least 90% was achieved for all the pollutants monitored at Birmingham Airport. This met the Defra target of 90%[3], set in LAQM.TG(09) and allowed for calculation of robust annual statistics.

2. All of the Air Quality Strategy Objectives for the protection of human health were met at the site during 2014.

3. NO_2 is the pollutant of most concern with specific relevance to airport emission sources as detailed within TG(09)[3]. No exceedances of the Air Quality Strategy objective for hourly mean NO_2 (200 µg m^{-3}, not to be exceeded more than 18 times a year) were recorded at Birmingham Airport.

4. The annual mean NO_2 concentration of 25 µg m^{-3} was within the Air Quality Strategy objective of 40 µg m^{-3}.

5. The annual mean concentration of PM_{10}, after VCM correction, was 18 µg m^{-3}, which is within the Air Quality Strategy objective for this parameter of 40 µg m^{-3}. There were 5 days on which the daily mean exceeded the relevant Air Quality Strategy objective of 50 µg m^{-3}. A maximum of 35 exceedances is permitted during a calendar year.

6. The Air Quality Strategy objective of 100 µg m^{-3} for 8-hour mean ozone concentration was exceeded on 9 days – which is within the permitted maximum of 10. Ozone is a long-range, transboundary pollutant which is difficult to control by local measures.

7. Investigation of emission sources, using meteorological data provided by Birmingham Airport, indicated that there were sources of NO, NO_2 and CO at the airport or in its immediate vicinity. At higher wind speeds a contribution to PM_{10} concentrations was identified from sources to the east and south-east.

8. Ozone concentrations showed a contrasting pattern, with lowest concentrations being associated with low wind speeds. At low wind speeds, concentrations of NO are highest, and concentrations of O_3 are reduced by its reactions with NO.

5 References

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2. Defra (2007). The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (Volume 1). Department for Environment, Food and Rural Affairs in partnership with the Scottish Executive, Welsh Assembly Government and Department of the Environment Northern Ireland. July 2007. https://www.gov.uk/government/publications/the-air-quality-strategy-for-england-scotland-wales-and-northern-ireland-vol-1 (Accessed 13th Feb 2015).

3. Defra (2009). Part IV of the Environment Act 1995. Local Air Quality Management – Technical Guidance TG(09). Department for Environment, Food and Rural Affairs in partnership with the Scottish Executive, Welsh Assembly Government and Department of the Environment Northern Ireland. January 2009. http://laqm.defra.gov.uk/technical-guidance/ (Accessed 5th Feb 2015).

4. King's College London Volatile Correction Model available at http://www.volatile-correction-model.info/Default.aspx . July 2008. (Accessed 13th Feb 2015).

Appendices

Appendix 1: VCM Correction of PM_{10} Data

Appendix 2: Monitoring Station Location

Appendix 3: Statistical Summary 2006 to 2014

Appendix 1 – VCM Correction of PM_{10} Data

TEOM

The PM_{10} monitoring data recorded by TEOM monitors were corrected with the king's College Volatile Correction Model (VCM). This online tool allows TEOM measurements to be corrected for the loss of volatile components of particulate matter that occur due to the high sampling temperatures employed by this instrument. The resulting corrected measurements have been demonstrated as equivalent to the gravimetric reference equivalent.

Method:

The following data are required as inputs to the VCM:

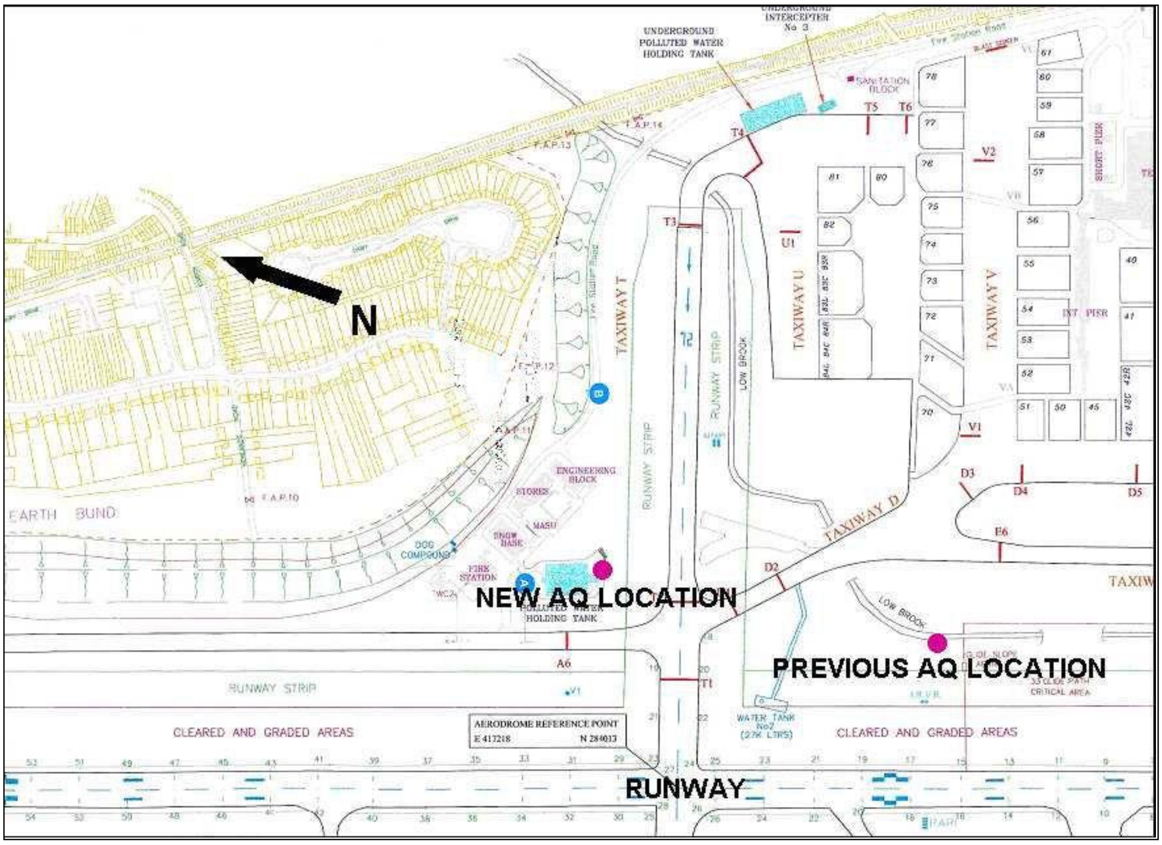
- Daily or hourly average temperatures
- Daily or hourly pressures
- Daily or hourly TEOM concentrations (μg m^{-3})
- Daily or hourly FDMS (Filter Dynamic Measurement System) purge measurements (μg m^{-3})

The VCM works by using the volatile particulate matter measurements provided by nearby FDMS instruments (within 130 km) to assess the loss of PM_{10} from the TEOM; this value is then added back onto the TEOM measurements.

The correction generated by the VCM is geographically specific, so an exact location of the TEOM instrument is therefore required.

The VCM can be accessed through http://www.volatile-correction-model.info.

Appendix 2 – Monitoring Station Location



Site 1 is the old AQ location. Site 2 is the current AQ location, operational from 10/01/06 onwards.

Appendix 3 - Statistical Summary 2006 to 2014

Statistic	PM_{10} (µgm^{-3})†	NO_x (as NO_2) (µgm^{-3})	NO (µgm^{-3})	NO_2 (µgm^{-3})	O_3 (µgm^{-3})	SO_2 (µgm^{-3})	CO (mgm^{-3})	Benzene (µgm^{-3})
2014								
Max. hourly mean	349	1031	579	143	132	32	1.6	nm
Annual mean	18	39	9	25	45	2	0.2	nm
Max. daily mean	71.1	439	237	76	84	12	1	nm
Max. running 8-hr mean	-	-	-	-	116	-	1	nm
Max. 15-min mean	-	-	-	-	-	37	-	nm
Data capture (%)	91.3	96.9	96.9	96.9	93.3	88.3	96.7	nm
2013								
Max. hourly mean	106	551	286	115	158	29	0.8	-
Annual mean	19	35	8	24	47	1	0.2	0.49**
Max. daily mean	62	224	101	69	96	8	0.4	-
Max. running 8-hr mean	-	339	175	91	138	16	0.7	-
Max. 15-min mean	-	657	351	128	160	37	1.4	-
Data capture (%)	95.8%	98.8%	98.8%	98.8%	99.1%	98.9%	98.9%	**100%**
2012								
Max. hourly mean	157	605	321	115	158	56	1.6	-
Annual mean	18	40	10	24	41	2	0.2	0.41**
Max. daily mean	51	-	-	-	-	11	-	-
Max. running 8-hr mean	-	-	-	-	144	-	1.2	-
Max. 15-min mean	-	-	-	-	-	61	-	-
Data capture (%)	97	98	98	98	99	98	99	100
2011								
Max. hourly mean	135	460	241	117	158	35	0.9	-
Annual mean	21	36	8	24	49	2	0.2	0.51**
Max. daily mean	71	-	-	-	-	8	-	-
Max. running 8-hr mean	-	-	-	-	136	-	0.8	-
Max. 15-min mean	-	-	-	-	-	40	-	-
Data capture (%)	91	96	96	96	96	96	96	92
2010								
Max. hourly mean	200	682	371	159	168	32	1.5	-
Annual mean	19	46	12	28	41	2	0.2	0.8**
Max. daily mean	48	-	-	-	-	7	-	-
Max. running 8-hr mean	-	-	-	-	144	-	0.8	-
Max. 15-min mean	-	-	-	-	-	32	-	-
Data capture (%)	93	99	99	99	99	97	97	100
2009								
Max. hourly mean	85	640	356	180	126	35	2.0	-
Annual mean	18	34	9	21	42	2	0.2	*1.0**
Max. daily mean	55	-	-	-	-	10	-	-
Max. running 8-hr mean	-	-	-	-	108	-	1.6	-
Max. 15-min mean	-	-	-	-	-	37	-	-

Statistic	PM_{10} (μgm^{-3})†	NO_x (as NO_2) (μgm^{-3})	NO (μgm^{-3})	NO_2 (μgm^{-3})	O_3 (μgm^{-3})	SO_2 (μgm^{-3})	CO (mgm^{-3})	Benzene (μgm^{-3})
Data capture (%)	92	94	94	94	94	94	94	100
2008								
Max. hourly mean	305	1289	720	220	158	29	3.1	
Annual mean	16	41	11	25	47	2	0.2	0.9**
Max. daily mean	61	-	-	-	-	9	-	-
Max. running 8-hr mean	-	-	-	-	152	-	2.4	-
Max. 15-min mean	-	-	-	-	-	29	-	-
Data capture (%)	91.3	95.6	95.6	95.6	91.5	95.6	95.6	100.0
2007								
Max. hourly mean	244	932	521	145	148	*43**	2.6	
Annual mean	21	49	14	28	40	*5**	0.2	1.0**
Max. daily mean	116	-	-	-	-	*13**	-	
Max. running 8-hr mean	-	-	-	-	135	-	1.6	
Max. 15-min mean	-	-	-	-	-	*90**	-	
Data capture (%)	89.7	86.5	86.5	86.5	99.2	40.2	97.5	100.0
2006								
Max. hourly mean	466	686	349	189	202	32	2.1	
Annual mean	22	47	13	27	47	5	0.2	1.1**
Max. daily mean	92	-	-	-	-	16	-	
Max. running 8-hr mean	-	-	-	-	195	-	1.7	
Max. 15-min mean	-	-	-	-	-	43	-	
Data capture (%)	90.4	79.8	79.8	79.8	93.8	91.6	93.3	100.0

† - VCM corrected 2009 onwards; * Results indicative only due to the low data capture.; ** Results based on monthly exposure periods. Benzene monitoring discontinued at end of 2013.

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