Ricardo Energy & Environment

Air Quality Monitoring at East Midlands Airport Annual Report for 2016

Report for Manchester Airport Group plc
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Contact:

Nick Rand
Ricardo Energy & Environment
Gemini Building, Harwell, Didcot, OX11 0QR, United Kingdom

t: +44 (0) 1235 75 8434
e: nick.rand@ricardo.com

Ricardo-AEA Ltd is certificated to ISO9001 and ISO14001

Author:

Sion Carpenter

Approved By:

Nick Rand

Date:

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Executive Summary

This report provides details of air quality monitoring conducted at East Midlands Airport during 2016. The work was carried out by Ricardo Energy & Environment on behalf of Manchester Airport Group plc. The aims of the programme are to monitor air pollution around the airport, to assess compliance with relevant national air quality objectives, and to investigate changes in air pollutant concentrations over time.

Automatic continuous monitoring was carried out at a single location within the Aeropark on the outskirts of the airport. The station monitored oxides of nitrogen (nitric oxide and nitrogen dioxide) and Particulate Matter (PM_{10}).

The minimum applicable data capture target of 90%, for the European Commission Air Quality Directive[1],was not achieved for the station PM and NO_x instruments. However the objective of 85% data capture set in TG16[5] was met.

The UK AQS hourly mean objective for NO_2 is 200 µg m^{-3}, with no more than 18 exceedances allowed each year. East Midlands Airport has registered no exceedances to this value during the year. Therefore, the site met this objective for 2016.

The annual mean AQS objective for NO_2 is 40 µg m^{-3}. This was met at East Midlands Airport.

PM_{10} may exceed the 24-hour mean limit of 50 µg m^{-3} no more than 35 times per year to meet the AQS objective. During 2016, using VCM corrected TEOM and FIDAS data only 1 exceedance to the limit value was registered at the site. This AQS objective was therefore met. The annual mean AQS target for PM_{10} is 40 µg m^{-3}. This objective was met at East Midlands Airport using VCM corrected TEOM and FIDAS data.

Average concentrations of NO, NO_2 and PM_{10} at the site were generally comparable to those measured at urban background air pollution monitoring sites in the East Midlands zone and a comparison to 2015 data showed a slight increase in annual mean NO_2 readings and a slight decrease in annual mean PM_{10} readings.

The pattern of monthly averaged concentrations throughout the year showed that concentrations of the primary pollutant NO and (secondary) NO_2, which is predominantly a secondary pollutant but does have primary components, showed the highest levels were from the winter months. PM_{10} showed no clear seasonal variation.

Wind speed and direction data gathered from the NOAA Integrated Surface Database using the R package Worldmet[9] were used to investigate effects on pollutant concentrations and potential sources. Bivariate plots of pollutant concentration indicated that nearby sources, such as the perimeter road, were probably the main source of NO.

With regards to NO_2, there also appeared to be a contribution from the south east at moderate wind speeds, possibly indicating a source further away. To the immediate south east is the main passenger terminal, to the immediate south west is the freight terminal. The M1 runs roughly north to south to the east with junction 23A to the south East.

For PM_{10} concentrations were high under calm conditions with light winds from; the south east, the location of the main passenger terminal and junction 23A of the M1 and from the north east, the direction of junction 24 of the M1.

A single high pollution episode occurred during 2016. Particularly high concentrations of PM_{10} were recorded on the 1st of November 2016, no obvious source or on site activity for this was identified but given the wind direction and the timing we suggest that it was due to Diwali and bonfire celebrations from the bordering residential areas.

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1 Introduction

1.1 Background

Airports are potentially significant sources of many air pollutants. Aircraft jet engines emit pollutants including oxides of nitrogen (NO_x), carbon monoxide (CO), oxides of sulphur (SO_x), particulate matter, hydrocarbons from partially combusted fuel, and other trace compounds. There are also pollutant emissions from the airside vehicles, and from the large number of road vehicles travelling to and from the airport each day. Also, East Midlands Airport is situated next to the M1 motorway and near the urban areas of Nottingham and Derby, containing many domestic, commercial and industrial sources of pollution.

Manchester Airport Group plc therefore carries out monitoring of ambient air quality at a single site located to the north of the runway in the bordering Aeropark. The site is also located close to some of the airport's nearest neighbouring residents.

The pollutants monitored at this site include:

- Oxides of nitrogen (nitric oxide (NO) and nitrogen dioxide (NO_2)).
- Particulate matter (PM_{10}).
- Particulate matter ($PM_{2.5}$, PM_1)*

*$PM_{2.5}$, PM_1 measured from the 22/12/17 after the installation of a FIDAS instrument.

The air quality monitoring equipment at East Midlands Airport was enhanced in December 2016 to a new Thermo 49i series NO_x and latest technology new multi-channel FIDAS Palas Particulate matter instrument.

Ricardo Energy & Environment was contracted by Manchester Airport Group plc (MAG) to carry out the required programme of air pollution measurements during 2016 and this report presents and summarises the fully validated and quality controlled dataset for the period 1st January to 31st December 2016.

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.

1.2 Aims and objectives

The aim of this monitoring programme is to monitor concentrations of several important air pollutants around the airport. 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. Additionally, NOAA meteorological data[9] were used to investigate the importance of various sources of pollution.

It is important to note that the pollutants measured in this study will have originated from a wide variety of sources, both local and long range. Not all of these sources will be directly connected with the airport.

Monitoring data collected at East Midlands are compared in this report with:

- Relevant UK air quality limit values and objectives.
- Corresponding results from a selection of national air pollution monitoring sites.
- Statistics related to airport activity.

In addition, periods of relatively high pollutant concentrations are examined in more detail.

1.3 UK air quality strategy

Within the European Union, controls on ambient air quality are covered by Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe[1], known as the Air Quality Directive. This consolidated three 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 through The Environment Act 1995 which 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 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, and the timescales, to achieve the air quality objectives. The legal framework given in the Environment Act has been adopted in the UK through the UK AQS. The most recent version of the AQS was published by Defra in 2007[2], and the currently applicable air quality objectives are summarised in Appendix 1 of this report. The detailed assessment of East Midlands Airport commissioned by North West Leicestershire district council in 2009 concluded that the Air quality objective for NO_2 would not be exceeded within 1000m of the airport as a result of air traffic emissions and so no AQMA was set up[7].

2 Air Quality Monitoring

2.1 Pollutants monitored

2.1.1 Nitrogen Oxides (NO_x)

Combustion processes emit a mixture of oxides of nitrogen – NO and NO_2 - collectively termed NO_x.

i) NO is described as a primary pollutant (meaning it is directly emitted from source). NO is not known to have any harmful effects on human health at ambient concentrations. However, it undergoes oxidation in the atmosphere to form the secondary pollutant NO_2.

ii) NO_2 has a primary (directly emitted) component and a secondary component, formed by oxidation of NO. NO_2 is a respiratory irritant and is toxic at high concentrations. It is also involved in the formation of photochemical smog and acid rain and may cause damage to crops and vegetation.

Of the NO_x emissions (including NO_2) considered to be airport-related, over 50 % arise from aircraft during take-off and landing, with around two-thirds of all emissions occurring at some distance from airport ground-level. The Air Quality Expert Group (AQEG) [3] has stated that: "*Around a third of all NO_x emissions from the aircraft (including ground-level emissions from auxiliary power units, engine testing etc., as well as take-off and landing) occur below 100 m in height. The remaining two-thirds occur between 100 m and 1000 m and contribute little to ground-level concentrations. Receptor modelling studies show the impact of airport activities on ground-level NO_2 concentrations. Studies have shown that although emissions associated with road traffic are smaller than those associated with aircraft, their impact on population exposure at locations around the airport are larger*". Previous rounds of review and assessment within the LAQM process have not highlighted any cases where airports appear to have caused exceedances of air quality objectives for particulate matter measured as PM_{10}. Therefore, in the context of LAQM, the key pollutant of concern from airports is 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[3].

2.1.2 Particulate Matter ($PM_{10, 2.5, 1}$ and TSP)

Airborne particulate matter varies widely in its physical and chemical composition, source and particle size. The subscript number is used to describe the size of the particle with PM_{10} having an effective size less than 10 µm, $PM_{2.5}$ an effective size less than 2.5 µm and PM_1 less than 1 µm. These are of greatest concern with regard to human health, as they are small enough to penetrate deep into the lungs. They can cause inflammation and a worsening of the condition of people with heart and lung diseases. In addition, they may carry surface absorbed carcinogenic compounds into the lungs. Larger particles, meanwhile, are not readily inhaled, and are removed relatively efficiently from the air by sedimentation.

The main sources of airborne particulate matter in the UK are combustion (industrial, commercial and residential fuel use). The next most significant source is road vehicle emissions. Based on 2015 National Atmospheric Emissions Inventory (NAEI) data, less than 0.1% of UK total PM_{10} emissions were believed to originate from civil aircraft taking off and landing[4].

Previous rounds of review and assessment within the LAQM process have not highlighted any cases where airports appear to have caused exceedances of air quality objectives for particulate matter measured as PM_{10}.

2.2 Monitoring sites and methods

Automatic monitoring was carried out at a single site during 2016 and is referred to as East Midlands Airport. The location descriptions of the sites fall into the category "other" as defined by the Defra Technical Guidance on air quality monitoring LAQM.TG(016)[5], (i.e. "*any special source-oriented or location category covering monitoring undertaken in relation to specific emission sources such as power stations, car-parks, airports or tunnels*").

Figure 2.1 shows a map with the location of the monitoring station. Figure 2.2 shows the East Midlands Airport monitoring station. The monitoring site is located within the Areopark to the north of the runway and perimeter road, 288m from the runway centre and 101m from the perimeter road. The curb side of the closest public road – Diseworth road is 28m to the north east of the site. The prevailing wind direction is from the south.

Figure 2.1 - Location of East Midlands Airport air quality monitoring site

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Figure 2.2 –East Midlands Airport air quality monitoring site

2.2.1 Automatic monitoring

The following techniques were used for the automatic monitoring of NO_x (i.e. NO and NO_2) and PM:

- PM_{10} – TEOM – Tapered element oscillating microbalance.
- PM10, 2.5, 1, TSP - FIDAS
- NO, NO_2 – Chemiluminescence.

Further information on these techniques is provided in Appendix 2 of this report. These analysers provide a continuous output, proportional to the pollutant concentration. This output is recorded and stored every 10 seconds, and averaged to 15-minute mean values by internal data loggers. The analysers are connected to a modem and interrogated through a GPRS internet device to download the data to Ricardo Energy & Environment. Data are downloaded hourly. The data are converted to concentration units at Ricardo Energy & Environment then averaged to hourly mean concentrations.

2.2.2 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[8], 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. Please note that the FDMS data for the final three months of 2016 (October – the 2nd of December) remain provisional at the time of writing and could change slightly when data ratification is completed at the end of March. Data after the 2nd of December was collected by the FIDAS instrument which doesn't require VCM correction.

3 Quality Assurance and Data Capture

3.1 Quality assurance and quality control

In line with current operational procedures within the Defra Automatic Urban and Rural Network (AURN)[8], full inter calibration audits of the MAG air quality monitoring site took place at six-monthly intervals. Full details of these UKAS-accredited calibrations, together with data validation and ratification procedures, are given in Appendix 3 of this report. In addition to instrument and calibration standard checking, the air intake sampling systems were cleaned and all other aspects of site infrastructure were checked.

Following the instrument and calibration gas checking, and the subsequent scaling and ratification of the data, the overall accuracy and precision figures for the pollutants monitored at East Midlands Airport are summarised in Table 3.1.

Table 3.1 – Estimated precision and accuracy of the data presented

Pollutant	Precision	Accuracy
NO	± 2.5	± 15 %
NO_2	± 6.9	± 15 %
$PM_{10, 25, 1}$	± 4	Estimated accuracy of a TEOM* ±30% or better: with VCM correction, estimated as ±25%. FIDAS: ±25% (estimated)

* accuracy of particle measurements cannot currently be assessed.

3.2 Data capture

Data capture statistics for the monitoring site are given in Table 3.2. A data capture target of 90% is recommended in the European Commission Air Quality Directive[1] and Defra Technical Guidance LAQM.TG (016)[5].

In 2016, the 90 % data capture target was not achieved for any of the analysed pollutants. Data capture for NO_2, the main pollutant of concern, was 86.07%. Table 3.3 details the major data gaps, greater than 24 hours, over the year.

Table 3.2 – Data capture statistics (%) for East Midlands Airport, 2016

Site	Grid reference	NO_x	NO_2	PM_{10}	$PM_{2.5}$	PM_1
East Midlands Airport	444215 326413	86.07	86.07	86.13	2.53	2.53

Table 3.3 – Significant data gaps (Periods > 24h) occurring at East Midlands Airport during 2016

Pollutant	Start date	End date	No. of days	Reason	Comments
PM_{10} and NOx	29/01/16	10/02/16	12.5	Power issues	
PM_{10}	21/02/16	25/02/16	4.3	Power issues	
NOx	12/05/16	15/05/16	2.8	Instrument Issue	
PM_{10} and NOx	15/07/16	25/07/16	9.7	Air Conditioner Fault	
PM_{10} and NOx	2/12/16	22/12/16	20.3	Site turned off while awaiting new equipment	

4 Results and Discussion

4.1 Automatic monitoring data

The summary statistics for 2016 are presented in Table 4.1. The time series of data for the full year, as measured by the automatic monitoring sites, are shown in Figure 4.1.

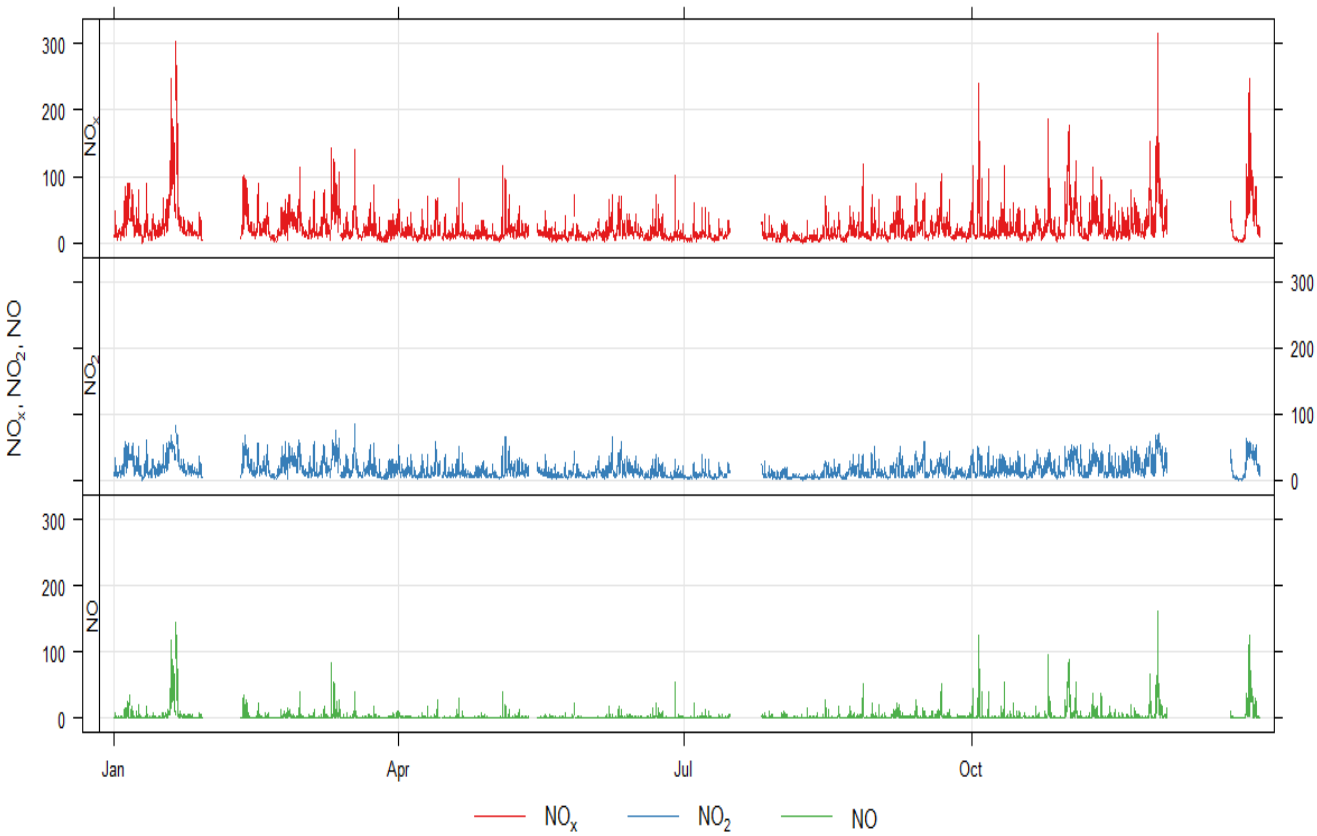
Table 4.1 – Air pollution statistics for East Midlands Airport, from 1st January to 31st December 2016

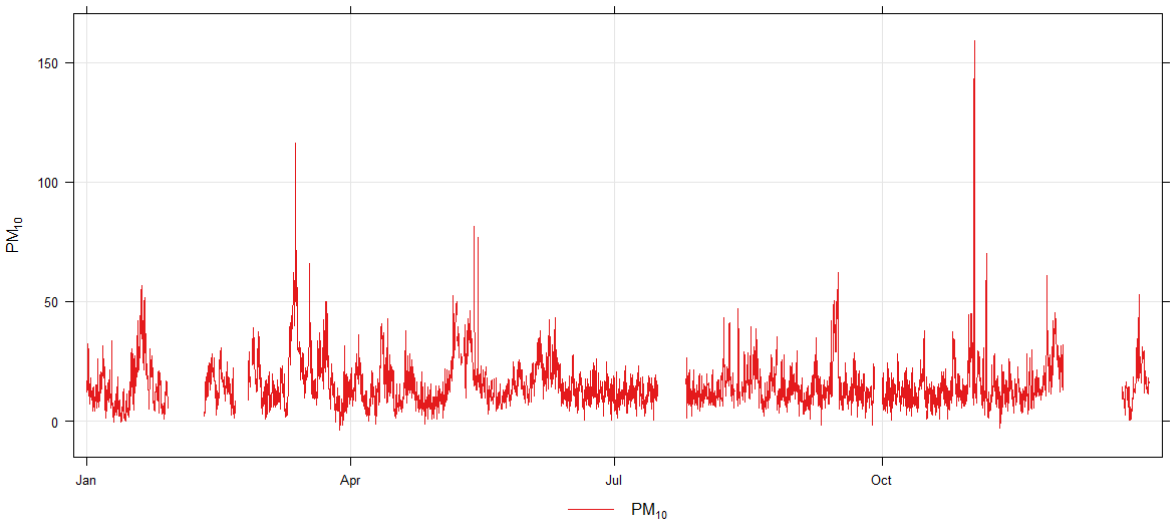
	NO (µg m^{-3})	NO_2 (µg m^{-3})	NO_x (µg m^{-3})	PM_{10} (µg m^{-3})*	PM_{10} (µg m^{-3}) VCM corrected+
Maximum hourly mean	163	86	315	189	159
Maximum running 8 hour mean	113	73	245	58	-
Maximum running 24 hour mean	65	59	157	39	-
Maximum daily mean	59	56	143	36	53
Average	3	17	22	15	14
Data capture	86.07	86.07	86.07	86.13	86.13

*combined TEOM and FIDAS data.

+combined VCM and FIDAS data.

Figure 4.1 – Time series of hourly averaged concentrations of NO_x (Top) and PM_{10} (Bottom) for the East Midlands Airport site, 2016





4.2 Comparison with air quality objectives

None of the annual, hourly (NO_2) or daily (PM_{10}) mean limits specified by Defra for all the analysed pollutants were exceeded at East Midlands Airport in 2016. The Details of UK air quality standards (AQS) and objectives specified by Defra are provided in Appendix[1].

The AQS objective for hourly mean NO_2 concentration is 200 µg m^{-3} which may be exceeded up to 18 times per calendar year. During 2016 there were no hourly mean NO_2 measurements exceeding 200 µg m^{-3} meaning that NO_2 levels stayed within the Defra "Low" band for the whole year, the AQS objective was accomplished for 2016.

The annual mean AQS objective for NO_2 is 40 µg m^{-3}. The annual mean at East Midlands was recorded at 17 µg m^{-3} this objective was therefore met.

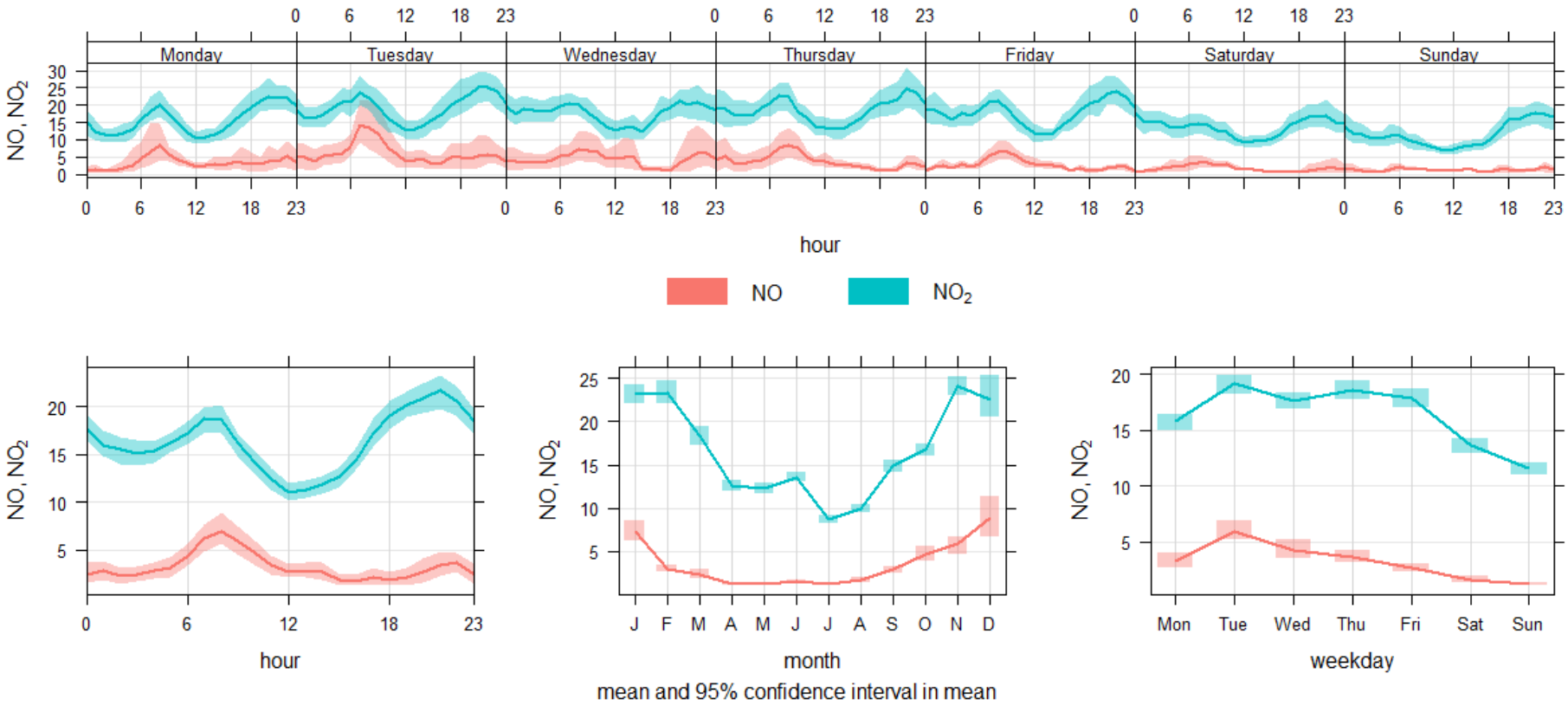
The AQS objective for PM_{10} is a maximum of 50 µg m^{-3} for 24h mean periods, not to be exceeded more than 35 times a year. VCM-corrected results show that there was a single exceedance, the maximum value being 53 µg m^{-3}. However, the site was well within the yearly maximum permitted number of exceedances of 35 times, therefore meeting the AQS objective for 24-hour mean PM_{10}.

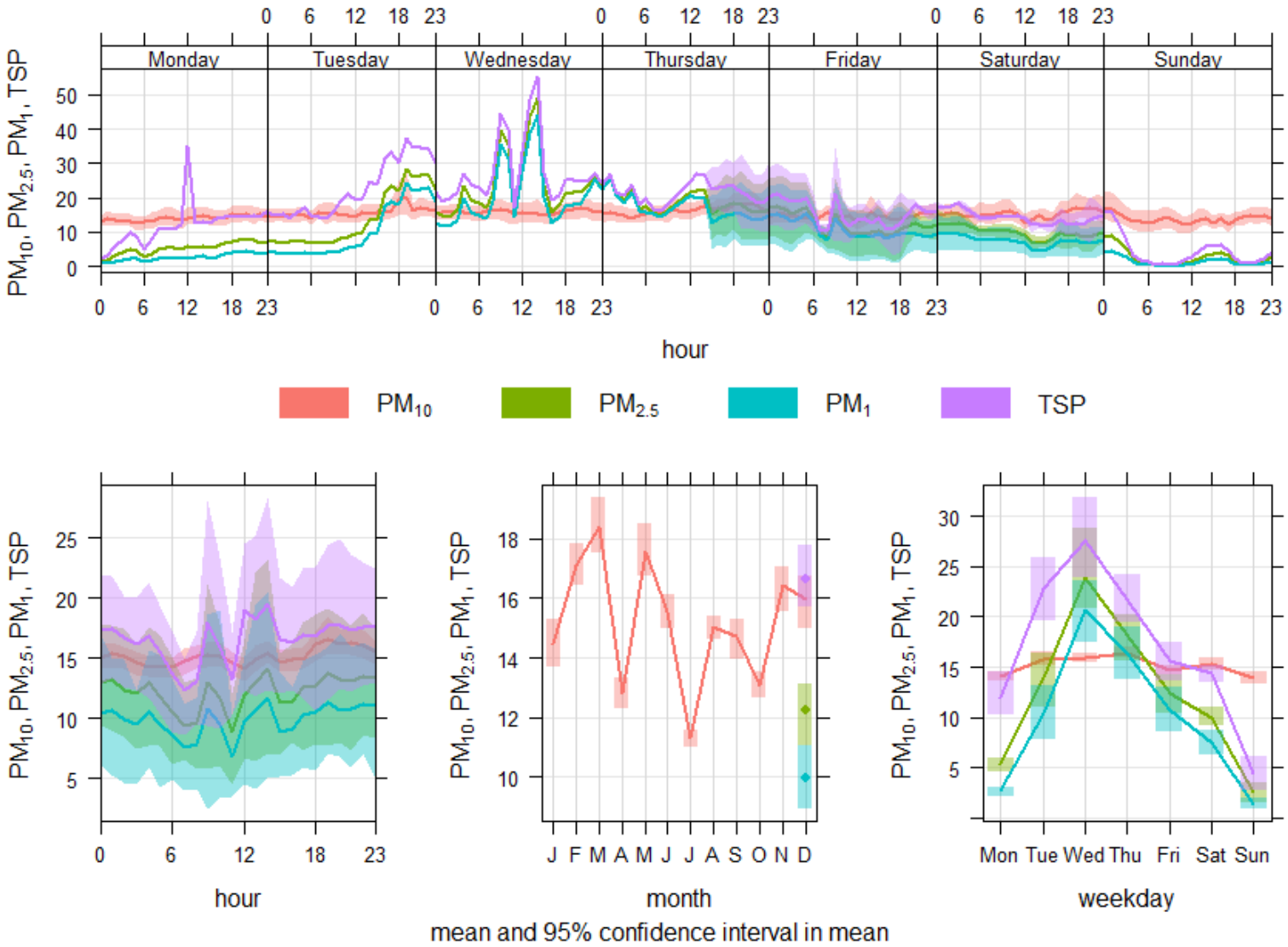
The annual mean AQS objective for PM_{10} is 40 µg m^{-3}. The site registered a VCM-corrected annual average of 14 µg m^{-3}, this objective was therefore met.

4.3 Temporal variation in pollutant concentrations

Figure 4.3 shows the variation of monthly, weekly, daily and hourly NO, NO_2 and PM concentrations averaged over the duration of 2016.

Figures 4.3 - Time series of seasonal and diurnal variations of NO_x (Top) and PM (Bottom) for the East Midlands Airport site, 2016




Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
PM10, PM2.5, PM1, TSP
hour
PM10
PM2.5
PM1
TSP
J F M A M J J A S O N D
month
Mon Tue Wed Thu Fri Sat Sun
weekday
mean and 95% confidence interval in mean

4.3.1 Seasonal variation

Seasonal variations are common for the pollutants measured at this site and can be observed in the 'month' plots of figures 4.3. Clear seasonal variation can be seen in the NO and NO_2 concentrations. The autumn and winter months recorded higher levels when emissions may be higher, and periods of cold, still weather reduce pollutant dispersion.

PM_{10} concentrations showed much less seasonal variation than oxides of nitrogen.

4.3.2 Diurnal variation

The diurnal variation analyses viewed in the 'hour' plots in figure 4.3 showed typical urban area daily patterns for NO and NO_2. Pronounced peaks can be seen for these pollutants during the morning, corresponding to rush hour traffic at around 07:00. Concentrations tend to decrease during the middle of the day, with a much broader evening road traffic rush-hour peak, building up from early afternoon. NO also showed a much smaller peak than NO_2 in the afternoons. This is likely to be because concentrations of oxidising agents in the atmosphere (particularly ozone) tend to increase in the afternoon, leading to enhanced oxidation of NO to NO_2.

The diurnal patterns for PM are determined by two main factors. The first is emissions of primary particulate matter, from sources such as vehicles. The second factor is the reaction that occurs between sulphur dioxide, NO_x and other chemical species, forming secondary sulphate and nitrate particles. Morning and afternoon road traffic rush-hour peaks for PM_{10} can be seen but these were less pronounced than those for oxides of nitrogen. Pronounced late morning and early afternoon peaks can also be seen for the other PM species, however, due to the limited time period that this data covers it is more likely to have been impacted by isolated events that distort the overall pattern.

4.3.3 Weekly variation

The analyses of each pollutants weekly variation showed that the same type of diurnal patterns occur for all the days of the week. NO early morning and late afternoon rush hour peaks are in general much more pronounced on Monday and Friday and overall levels are lower over the weekend. PM shows a similar but less pronounced trend with the exception of a significant peak on Tuesdays afternoons. This probably indicates that the origin comes from a regular work activity in the vicinity of the site, mixed with some vehicle emissions from roads.

4.4 Source investigation

In order to investigate the possible sources of air pollution being monitored around East Midlands Airport, meteorological data measured close to the site was used to add a directional component to the air pollutant concentrations. Wind speed and direction data was gathered using data gathered from the National Oceanic and Atmospheric Administration (NOAA) meteorological database[9].

Figure 4.41 shows the measured wind speed and direction data. 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 south west. Each "spoke" is divided into coloured sections representing wind speed intervals of 2 ms^{-1} as shown by the scale bar in the plot. The mean wind speed was 4.81 ms^{-1}. The maximum measured wind speed was 17 ms^{-1}. The top 10 highest wind speeds were recorded during January and February 2016.

Figure 4.41 - Wind rose showing the wind speeds and directions at East Midlands Airport in 2016

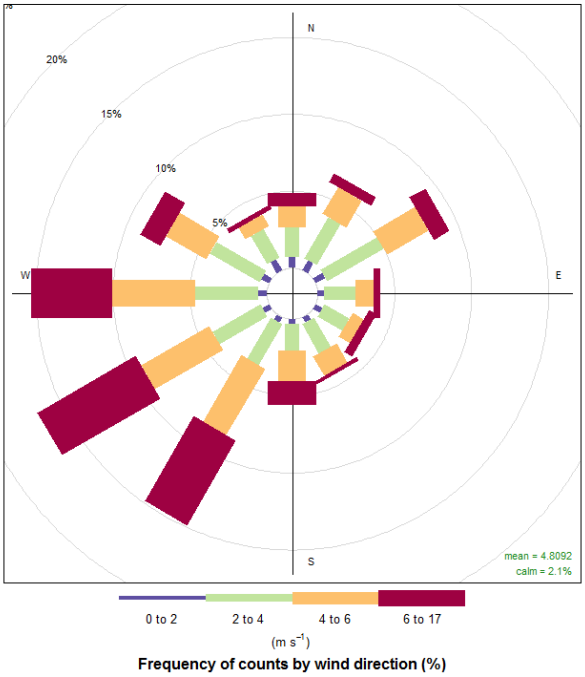


Figure 4.42 to Figure 4.44 show bivariate plots of hourly mean concentrations of NO, NO_2 and PM_{10} at East Midlands Airport against wind speed and wind direction. $PM_{2.5}$ and PM_1 are not shown due to the low data capture level.

These plots should be interpreted as follows:

- The wind speed is indicated by the distance from the centre of the plot; the grey circles indicate wind speeds in 2 ms^{-1} intervals.
- The pollutant concentration is indicated by the colour (as indicated by the scale).

These plots therefore show how pollutant concentrations varied 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 4.42 – Pollution rose for NO at East Midlands Airport

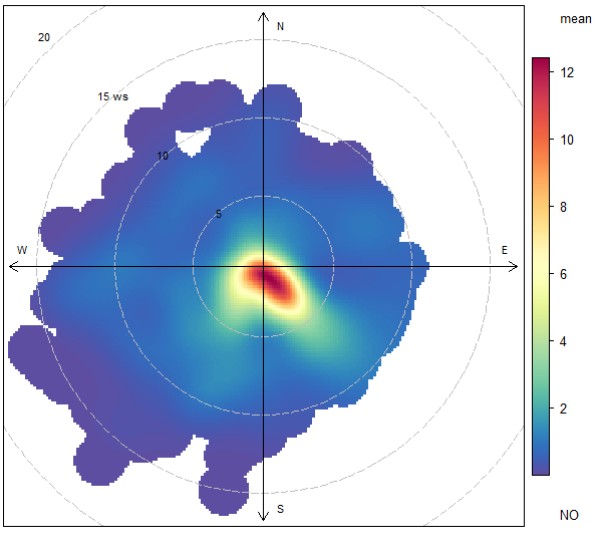


Figure 4.42 shows that the highest concentrations of NO occurred under calm conditions. Such conditions will have allowed NO emitted from nearby sources (vehicles on the northern perimeter road, Diseworth Road, and within the Areopark itself) to build up, reaching high concentrations. There were also moderate NO concentrations at greater wind speeds from the south east and to a lesser extent the south west. To the immediate south east is the main passenger terminal, to the immediate south west is the Freight terminal.

Figure 4.43 – Pollution rose for NO_2 at East Midlands Airport

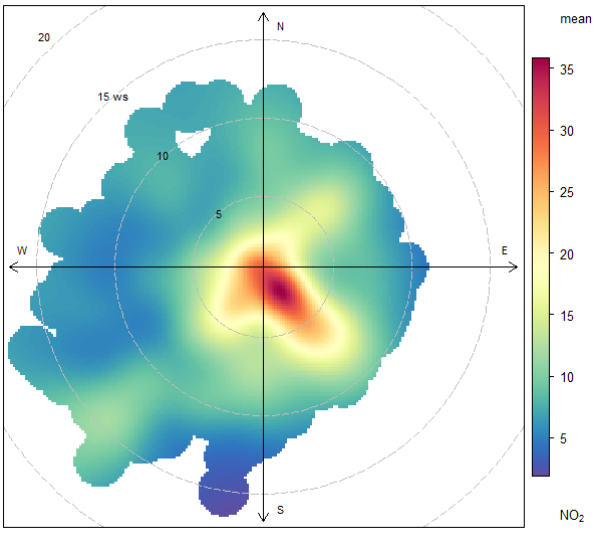


Figure 4.43 shows that the highest concentrations of NO_2 were associated with light winds (<5 ms^{-1}) from the south east, with calm conditions also contributing. Elevated levels were also associated with light winds from the south west and north east. The M1 runs roughly north south to the east with junction 24 to the north east.

Figure 4.44 – Pollution rose for PM_{10} at East Midlands Airport

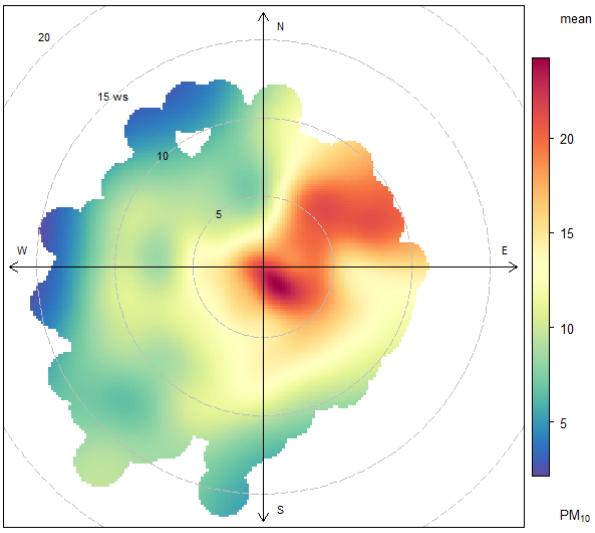


Figure 4.44 shows high concentrations occurred under calm to light wind conditions from the south east, where the passenger terminal is located. Elevated levels are also seen under windy conditions from the north east, the direction of junction 24. This is in contrast to the pattern observed last year where high levels were seen from the south east and south west with low levels occurring under calm conditions.

4.5 Periods of elevated pollutant concentration

The AQS objective establishes a daily mean limit value of 50 µg m^{-3} for PM_{10}, not to be exceeded more than 35 times a year, this limit was achieved for 2016.

In this section the single breach in the AQS objective for 24h mean period of PM_{10} VCM-corrected data is reviewed.

Upon identifying the raised data at 18:00 and 19:00 on the 1st of November the wind direction and speed were looked at. There were light winds (2.35 and 2.1ms^{-1}) at this time prevailing from 320 – 335 °, towards the main road into Castle Donnington and the outskirts of the town. This period is around Diwali and bon fire night, local celebrations are a likely cause for this pollution episode and elevated levels of PM can be seen at numerous stations across the UK at this time.

4.6 Comparison with other UK sites

Annual mean pollutant concentrations from the East Midlands station sites are compared in Table 4.6 with those measured at other air quality monitoring sites in the East Midlands zone. The sites selected are all part of the Defra UK national Automatic Urban and Rural Network (AURN) and are as follows:

- Leicester University: an urban background site located within the grounds of Leicester University.
- Leicester A594 Roadside: an urban traffic site located on the inner ring road.
- Nottingham Centre: an urban background site in a pedestrianised area in Nottingham city centre.
- Market Harborough: a rural site surrounded by farmland.
- Chilbolton: a rural site in Oxfordshire, included for comparative purposes.

Table 4.6- Annual mean of NO_2 and PM_{10} pollutant concentrations at East Midlands Airport compared with other sites, 2016

Site	Type	NO_2 (µg m^{-3})	PM_{10} (µg m^{-3})
East Midlands Airport	Other	17	14
Leicester University	Urban Background	28	-
Leicester A594 Roadside	Urban traffic	41	22
Nottingham Centre	Urban Background	31	17
Market Harborough	Rural Background	11	-
Chilbolton	Rural	14	15

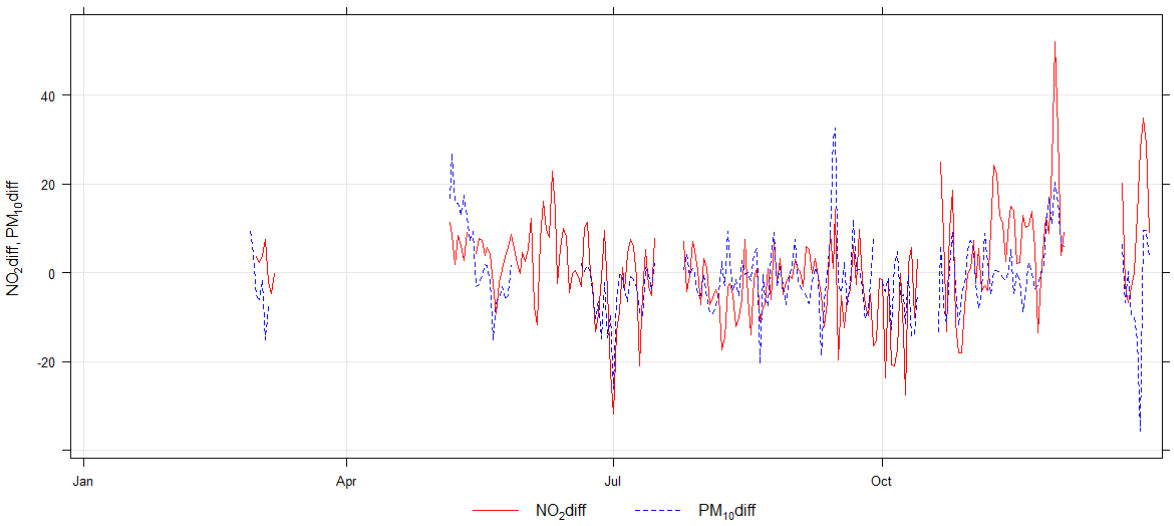
– means the pollutant was not measured at that location.

The annual mean NO_2 concentrations at East Midlands Airport are lower than those recorded at any of the urban sites and is more alike to those recorded at the two rural sites, which is to be expected given its semi-rural location.

The annual mean PM_{10} is broadly comparable with the urban background and rural sites listed and does not reach the levels of the urban traffic site.

4.7 Comparison with previous years

Figure 4.71 – difference in daily average concentration levels between 2015 and 2016 for both NO_2 and PM_{10}.



While Figure 4.71 shows no clear overall increase or decrease in levels, a seasonal difference can be interpreted with the summer and early autumn months appearing to be lower than the previous year. It must however be remembered that differences in the daily means between 2015 and 2016 will be impacted upon by external factors such as metrological conditions and that there are substantial periods where no comparison can be made. When hourly data is used to calculate annual means the mean difference between 2015 and 2016 NO_2 levels was 0.78 and PM_{10} – 1.22. With the addition of future years data, a clearer pattern may be seen.

5 Conclusions

The following conclusions have been drawn from the results of the air quality monitoring programme at East Midlands Airport during 2016.

Oxides of nitrogen and particulate matter (as PM_{10} and $PM_{2.5}$) were monitored throughout 2016 at a single site located in the Areopark bordering the northern edge of the airport. The conclusions of the 2016 monitoring programme are summarised below:

1. Data capture of at least 90% was not achieved at the site for either pollutant.

2. There was no exceedance to the AQS objective of 200 µg m^{-3} for hourly mean NO_2 more than the 18 permitted times per year during 2016.

3. There was no exceedance of the annual mean AQS objective of 40 µg m^{-3} for NO_2 in 2016.

4. Reviewing VCM-corrected data there was only a single exceedance of the AQS objective for 24-hour mean of 50 µg m^{-3} (not to be exceeded more than 35 times a year) and no exceedance of the annual mean of 40 µg m^{-3} for PM_{10}.

5. The diurnal patterns of concentrations of all pollutants were similar to those observed at other urban monitoring sites. Peak concentrations of NO, NO_2 and particulate matter coincided with the morning and evening rush hour periods.

6. Meteorological data was used allowing the effect of wind direction and speed to be investigated. A bivariate plot of NO concentration and wind data showed that concentrations of NO were typically highest in calm conditions, with additional signals from the south east at light wind speeds, indicating that the main sources of this pollutants were nearby. The pattern was broadly similar for NO2, with additional signals also appearing from the south west and north east at higher wind speeds. The patterns for PM_{10} were similar to that of NO2 but with a weaker south west and stronger north eastern signal.

7. Mean concentrations of pollutants in 2016 were comparable with those measured at rural monitoring sites the East Midlands.

8. The annual means of NO2 and PM10 in 2016 are similar to those of 2015 with a minor increase and decrease in levels respectively.

9. PM10 sources have potentially changed as the polar plot indicates a shift from sources at distance to the south east and south west to a more local source with additional increase levels from the north west.

6 Acknowledgements

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Appendices

Appendix 1: Air Quality objectives and Index bands

Appendix 2: Monitoring apparatus and techniques

Appendix 3: Quality assurance and quality control

Appendix 1 – Air Quality objectives and Index bands

Table A1.1: UK air quality objectives for protection of human health, July 2007

Pollutant	Air Quality objective		Date to be achieved by
	Concentration	Measured as	
Benzene All authorities	16.25 µg m^{-3}	Running annual mean	31/12/2003
England and Wales only	5.00 µg m^{-3}	Annual mean	31/12/2010
Scotland and Northern Ireland	3.25 µg m^{-3}	Running annual mean	31/12/2010
1,3-Butadiene	2.25 µg m^{-3}	Running annual mean	31/12/2003
Carbon monoxide England, Wales and Northern Ireland	10.0 mg m^{-3}	Maximum daily running 8-hour mean	31/12/2003
Scotland	10.0 mg m^{-3}	Running 8-hour mean	31/12/2003
Lead	0.5 µg m^{-3}	Annual mean	31/12/2004
	0.25 µg m^{-3}	Annual mean	31/12/2008
Nitrogen dioxide	200 µg m^{-3} not to be exceeded more than 18 times a year	1-hour mean	31/12/2005
	40 µg m^{-3}	Annual mean	31/12/2005
Particles (PM_{10}) (gravimetric) All authorities	50 µg m^{-3}, not to be exceeded more than 35 times a year	24-hour mean	31/12/2004
	40 µg m^{-3}	Annual mean	31/12/2004
Scotland	50 µg m^{-3}, not to be exceeded more than 7 times a year	24-hour mean	31/12/2010
	18 µg m^{-3}	Annual mean	31/12/2010
Particles ($PM_{2.5}$) (gravimetric)* All authorities	25 µg m^{-3} (target)	Annual mean	2020
	15% cut in urban background exposure	Annual mean	2010-2020
Scotland only	12 µg m^{-3} (limit)	Annual mean	2020
Sulphur dioxide	350 µg m^{-3}, not to be exceeded more than 24 times a year	1-hour mean	31/12/2004

	125 µg m^{-3}, not to be exceeded more than 3 times a year	24-hour mean	31/12/2004
	266 µg m^{-3}, not to be exceeded more than 35 times a year	15-minute mean	31/12/2005
PAH*	0.25 ng m^{-3}	Annual mean	31/12/2010
Ozone*	100 µg m^{-3} not to be exceeded over 10 days a year	8-hour mean	31/12/2005

** Not included in regulations.*

Table A1.2: UK air quality objectives for protection of vegetation and ecosystems, July 2007

Pollutant	Air Quality objective		Date to be achieved by
	Concentration	Measured as	
Nitrogen oxides measured as NO_2	30 µg m^{-3}	Annual mean	31st December 2000
Sulphur dioxide	20 µg m^{-3}	Annual mean	31st December 2000
	20 µg m^{-3}	Winter average (October to March)	31st December 2000
Ozone	18 µg m^{-3}	AOT40+, calculated from 1-hour values May to July. Mean of 5 years, starting 2010	1st January 2010

+ AOT40 is the sum of the differences between hourly concentrations greater than 80 µg m^{-3} (= 40 ppb) and 80 µg m^{-3} over a given period using only 1-hour averages measured between 08:00 and 20:00.

DEFRA Air Pollution bands and index values

Table A1.3: Air pollution bandings and descriptions

Band	Index	Health descriptor
Low	1 to 3	Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants.
Moderate	4 to 6	Mild effects, unlikely to require action, may be noticed amongst sensitive individuals.
High	7 to 9	Significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed (e.g. reducing exposure by spending less time in polluted areas outdoors). Asthmatics will find that their 'reliever' inhaler is likely to reverse the effects on the lung.
Very High	10	The effects on sensitive individuals described for 'High' levels of pollution may worsen.

Table A1.4: Air pollution bandings and descriptions

Band	Index	O_3	NO_2	SO_2	$PM_{2.5}$	PM_{10}
		Daily max 8-hour mean (µg m^{-3})*	Hourly mean (µg m^{-3})	15 minute mean (µg m^{-3})	24 hour mean (µg m^{-3})	24 hour mean (µg m^{-3})
Low	1	0-33	0-67	0-88	0-11	0-16
	2	34-66	68-134	89-177	12-23	17-33
	3	67-100	135-200	178-266	24-35	34-50
Moderate	4	101-120	201-267	267-354	36-41	51-58
	5	121-140	268-334	355-443	42-47	59-66
	6	141-160	335-400	444-532	48-53	67-75
High	7	161-187	401-467	533-710	54-58	76-83
	8	188-213	468-534	711-887	59-64	84-91
	9	214-240	535-600	888-1,064	65-70	92-100
Very High	10	241 or more	601 or more	1,065 or more	71 or more	101 or more

Appendix 2 – Monitoring apparatus and techniques

Monitoring equipment

The following continuous monitoring methods were used at the East Midlands air quality monitoring station:

- NO, NO_2: chemiluminescence with ozone.
- A TEOM: tapered element oscillating microbalance.
- FIDAS: Fine Dust Analysis Systems.

These methods were selected in order to provide real-time data. The chemiluminescence and the UV absorption analysers are the European reference method for ambient NO_2 monitoring.

Each analyser provides a continuous output, proportional to the pollutant concentration. This output is recorded and stored every 10 seconds, and averaged to 15 minute average values by the on-site data logger. This logger is connected to a modem and interrogated twice daily, by telephone, to download the data to Ricardo Energy & Environment. The data are then converted to concentration units and averaged to hourly mean concentrations.

The NO_x analyser is equipped with an automatic calibration system, which can be triggered daily under the control of the on board data logger. Fully certificated calibration gas cylinders are also used at each site for manual calibration.

The TEOM unit provides particulate matter (PM) measurement. The device provides high-resolution PM mass concentration readings for both short-term averages (one hour) as well as 24-hour averages. The system's basic output consists of a 1-hour average mass concentration (in $\mu g/m^3$) of PM updated every six minutes.

The FIDAS unit employs a white light LED light scatter method that offers additional information on both particle size distribution from 0.18 to 30 microns (PM1, PM2.5, PM4, PM10 and Total Suspended Particles (TSP).

Appendix 3 – Quality assurance and Quality control

Ricardo Energy & Environment operates air quality monitoring stations within a tightly controlled and documented quality assurance and quality control (QA/QC) system. These procedures are documented in the AURN QA/QC manual[6].

Elements covered within this system include: definition of monitoring objectives, equipment selection, and site selection, protocols for instrument operation calibration, service and maintenance, integrity of calibration gas standards, data review, scrutiny and validation.

All gas calibration standards used for routine analyser calibration are certified against traceable primary gas calibration standards at 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 regular six-monthly inter calibration and audit check undertaken at every monitoring site. This audit has two principal functions: firstly, to check the instruments 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.

In line with current operational procedures within the Defra AURN, full inter calibration audits take place at the end of winter and summer. 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.

All air pollution measurements are reviewed daily by experienced staff at Ricardo Energy & Environment. Data are compared with corresponding results from AURN monitoring stations and with expected air pollutant concentrations under the prevailing meteorological conditions. This review process rapidly highlights any unusual or unexpected measurements, which may require further investigation. When such data are identified, attempts are made to reconcile the data against known or possible local air pollution sources or local meteorology, and to confirm the correct operation of all monitors. In addition, the results of the daily automatic instrument calibrations (see Appendix 2) are examined to identify any possible instrument faults. Should any faults be identified or suspected, arrangements are made for Ricardo Energy & Environment personnel or equipment service contractors to visit the site as soon as possible.

At the end of every quarter, the data for that period are reviewed to check for any spurious values and to apply the best daily zero and sensitivity factors, and to account for information which only became available after the initial daily processing. At this time, any data gaps are filled with data from the data logger back-up memory to produce as complete a data record as possible.

Finally, the data are re-examined on an annual basis, when information from the six-monthly inter calibration audits can be incorporated. After completion of this process, the data are fully validated and finalised, for compilation in the annual report.

Following these three-stage data checking and review procedures allows the overall accuracy and precision of the data to be calculated. The accuracy and precision figures for the pollutants monitored at East Midlands Airport are summarised in Table 3.1 on page 6.

Method

All of the air quality monitoring equipment at both sites is housed in purpose-built enclosures. The native units of the analysers are volumetric (e.g. ppb). Conversion factors from volumetric to mass concentration measurement for gaseous pollutants are provided below:

- NO 1 ppb = 1.25 µg m^{-3}
- NO_2 1 ppb = 1.91 µg m^{-3}

In this report, the mass concentration of NO_x has been calculated as follows:

NO_x µg m^{-3} = (NO ppb + NO_2 ppb) *x* 1.91.

This complies with the requirements of the Air Quality Directive[1] and is also the convention generally adopted in air quality modelling.

The Gemini Building
Fermi Avenue
Harwell
Didcot
Oxfordshire
OX11 0QR
United Kingdom

t: +44 (0)1235 753000
e: enquiry@ricardo.com

ee.ricardo.com