2016 Air Quality Annual Status Report (ASR)

In fulfilment of Part IV of the Environment Act 1995 Local Air Quality Management

November 2016

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Executive Summary: Air Quality in Our Area

Norwich covers approximately 39 square kilometres in the heart of Norfolk with a population of circa 132,000 people. The population of the Norwich 'Travel to Work Area' ie the area of Norwich in which most people both live and work is circa 376,500. Norwich is the fourth most densely populated local authority district in the eastern region with approximately 34 people per hectare.

The City permits 33 'Part B' authorised processes, including petrol stations, road stone coating plant, vehicle re-sprayers and a crematorium. These processes are not considered to contribute significantly to air quality in the city. The major pollutant source in the city is road traffic. Source apportionment exercises identify oxides of nitrogen from road traffic to be the most significant source of nitrogen dioxide (NO_2) and, more specifically, buses and taxis to be the main contributor. Oxides of nitrogen are a by-product of incomplete combustion. An Air Quality Management Area (AQMA) covering an area around central Norwich was declared in 2012 for exceedances of the annual mean NO_2 objective.

In 2015 the council produced an updated Air Quality Action Plan (AQAP) that sets out measures to be taken to work towards achievement of the air quality objectives. The action plan can be accessed on the council website by following this link: https://www.norwich.gov.uk/downloads/file/3020/2015_air_quailty_action_plan .

Following on from this report, the council proposes to continue with automatic and passive NO_2 monitoring within the city area and; upon completion of further road changes currently being implemented in the city centre, consider amending the locations of monitoring positions to assess any resultant impacts.

A detailed assessment is not required for any pollutants and the council will progress to the next Annual Status Report in 2017.

This report has been undertaken in accordance with the Local Air Quality Management Technical Guidance (TG16) and associated tools (as updated in 2016).

Air Quality in Norwich

Air pollution is associated with a number of adverse health impacts. It is recognised as a contributing factor in the onset of heart disease and cancer. Additionally, air

pollution particularly affects the most vulnerable in society: children and older people, and those with heart and lung conditions. There is also often a strong correlation with equalities issues, because areas with poor air quality are also often the less affluent areas[1,2].

The annual health cost to society of the impacts of particulate matter alone in the UK is estimated to be around £16 billion[3].

Norwich City Council has monitored air quality in the city for many years. This report considers all new monitoring data and assesses the data against the Air Quality Strategy objectives. It also considers any changes that may have an impact on air quality.

The council have carried out all past rounds of review and assessment, and in doing so have consolidated the previous four smaller AQMAs into a single central AQMA. The extent of the central AQMA is shown in Figure 2.1. The AQMA was declared in 2012 for exceedances of the annual mean NO_2 objective. All other pollutants of concern have been screened out over time, though particulates are still measured using the automatic analyser. This is important, especially given the recent requirement for local authorities to contribute to reducing emissions and/or concentrations of $PM_{2.5}$ (particulate matter with an aerodynamic diameter of 2.5µm or less).

A considerable amount of monitoring is carried out within the AQMA, using passive diffusion tubes and an automatic analyser. The city also benefits from having a Government-owned AURN urban background station in its area (though not in the AQMA). Data from this station is used within the report.

Overall, NO_2 concentrations within the central AQMA are falling. In 2012, ten of the monitoring locations exceeded the annual mean objective. This has steadily reduced to five of those locations in 2015, plus an additional site that was added in 2013 on Chapelfield North. Whilst this improvement is very much welcomed, challenges still exist at these six locations to achieve the objective in the future.

[1] Environmental equity, air quality, socioeconomic status and respiratory health, 2010
[2] Air quality and social deprivation in the UK: an environmental inequalities analysis, 2006
[3] Defra. Abatement cost guidance for valuing changes in air quality, May 2013

The council works with partners within the Norfolk Environmental Protection Group's (NEPG) Air Quality sub-group, to ensure regular two-way engagement with representatives of Public Health England, and the Director of Public Health at Norfolk County Council. The council also has direct dialogue with officers of Norfolk County Council Highways Department on any significant changes to road layout or traffic flow that may be proposed within the city.

Actions to Improve Air Quality

Air pollution has risen up the corporate agenda at Norwich City Council since the first round of Review & Assessment, and the Transport Planning Officer now has to consider air quality issues for all new developments. Norfolk County Council has incorporated a local air quality strategy into its Local Transport Plan to deal with air quality issues and to try and reduce pollution associated with traffic in all future plans.

The 2015 AQAP identified the strengths of the previous action plan, the strategies that had the greatest impact on improving air quality, and built on this progress by concentrating on these strategies. As a result, the AQAP focussed principally on road infrastructure changes designed to further pedestrianize and divert traffic away from the congested city centre. The purpose of the road changes are also to improve traffic flow by introducing more one way systems, optimising traffic flow at junctions and reduce vehicle queuing.

At the time of writing, works are being carried out in the Westlegate area of Norwich and also the adjoining Ber Street, Golden Ball Street and All Saints Green areas. These proposals, drawn up by Norwich City Council and Norfolk County Council include; the creation of more pedestrian areas and the removal of traffic lights and kerbside barriers at a number of junctions. They are designed to be another step forward in supporting the vitality of the city centre by reducing conflict between vehicles, pedestrians and cyclists, while maintaining access for all modes of travel and contributing to improvement in air quality in the surrounding areas.

A good example of improvement in air quality resulting from the traffic changes in the city is the work done to implement new road layout and junction arrangements in the Chapelfield area of Norwich. This area is within the Central AQMA. Revised traffic flow and direction in the surrounding roads aimed to improve bus access and reduce through-traffic in the city centre. Triplicate diffusion tube monitoring was carried out

for a full year prior to the scheme commencing, and has continued since. As a result of the changes, the annual mean NO_2 concentration has reduced from 60.9µg/m^3 in 2013 to 43µg/m^3 in 2015

More information on major transport projects within Norwich can be found on the county council website here: https://www.norfolk.gov.uk/roads-and-transport/major-projects-and-improvement-plans/norwich/city-centre-improvements

Another key action being taken by Norfolk county council is the construction of the Northern Distributor Road (NDR). Construction work is in progress at the time of writing with a predicted opening in 2018. The NDR will provide a dual carriageway link from the national road network to Norwich International Airport and beyond, serving a large area of Broadland and North Norfolk, including existing and planned business and housing areas.

It is predicted that the NDR will:

- Reduce traffic flows on the northern sections of the Outer Ring Road, on key northern radial routes and on unsuitable residential and rural roads
- Reduce city centre through-traffic
- Reduce congestion by taking around 40,000 vehicles a day from congested and unsuitable roads, bringing relief to local communities and the city centre
- Significantly improve access for north Norwich and north and north east Norfolk, the wider road network and to Norwich International Airport
- Provide the transport infrastructure needed to allow planned and proposed growth to come forward
- Increase the opportunities for improving public transport and the provision for pedestrians and cyclists

More information on the NDR is available on the county council website here: https://www.norfolk.gov.uk/roads-and-transport/major-projects-and-improvement-plans/norwich/northern-distributor-road

A key proposal in the AQAP was to work with local bus companies to encourage updating of the fleet. First Eastern Counties made a £1.8m investment in nine brand new double deck vehicles for services into the city earlier in 2016. The new buses

are all Department for Transport 'low carbon certified' - a mark of fuel efficiency. Additionally, First Eastern Counties introduced 11 brand new single deck buses in October 2015 for the Norwich green line network at a value of £1.9m (photo below). All new vehicles are fitted with Euro 6 engines.

Local Priorities and Challenges

The council proposes to continue with automatic and passive NO_2 monitoring within the city area and; upon completion of further road changes currently being implemented, consider amending the locations of monitoring positions to assess any resultant impacts.

Norwich is a compact city with a medieval street layout, and trying to maintain the historic plan of the city whilst catering for modern society and transport is not always easy. However, this is a key factor to be considered as part of such schemes, and has proven its worth in the Chapelfield area for example.

Whilst the automatic monitoring station owned and run by the council is currently working satisfactorily, it is an ageing unit. There will come a time when it must be replaced, and this needs to be factored into the council budget.

The council will continue to support initiatives that contribute positively to improving air quality, such as the Car Club and Liftshare for example.

How to Get Involved

If people would like to find out more about air quality, and how they can contribute to improving it in their area, these links can provide further information:

- UK Air – The Govt's Air Information Resource: https://uk-air.defra.gov.uk/
- Norwich City Council's air quality reporting website: https://www.norwich.gov.uk/downloads/download/1917/air_quality_monitoring_reports_and_assessments
- Norfolk Car Club – 'Connecting Norfolk': http://www.norfolkcarclub.com/
- Norfolk Liftshare - https://liftshare.com/uk/community/norfolk
- 'Air Pollution' website – college/university level: http://www.air-quality.org.uk/index.php
- 'Clean Air Kids' air quality website for children aged 5-11: http://www.clean-air-kids.org.uk/index.html

Please note that Norwich City Council does not have control over third party websites, and is not responsible for their content, which it does not necessarily endorse.

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1 Local Air Quality Management

This report provides an overview of air quality in Norwich during 2015. It fulfils the requirements of Local Air Quality Management (LAQM) as set out in Part IV of the Environment Act (1995) and the relevant Policy and Technical Guidance documents.

The LAQM process places an obligation on all local authorities to regularly review and assess air quality in their areas, and to determine whether or not the air quality objectives are likely to be achieved. Where an exceedance is considered likely the local authority must declare an Air Quality Management Area (AQMA) and prepare an Air Quality Action Plan (AQAP) setting out the measures it intends to put in place in pursuit of the objectives. This Annual Status Report (ASR) is an annual requirement showing the strategies employed by Norwich City Council to improve air quality and any progress that has been made.

The statutory air quality objectives applicable to LAQM in England can be found in Table E.1 in Appendix E.

2 Actions to Improve Air Quality

2.1 Air Quality Management Areas

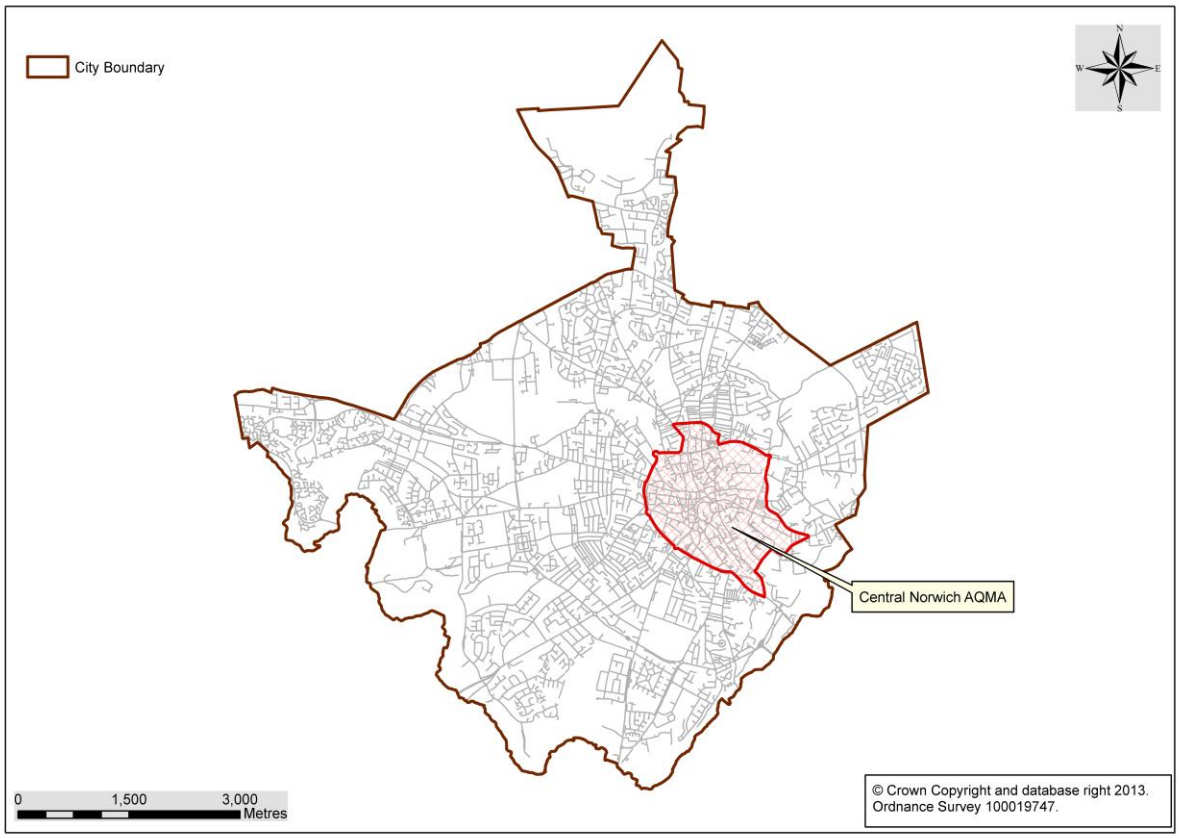
Air Quality Management Areas are declared when there is an exceedance or likely exceedance of an air quality objective. After declaration, the authority must prepare an Air Quality Action Plan (AQAP) within 12-18 months setting out measures it intends to put in place in pursuit of the objectives.

Details of the current AQMA declared by Norwich City Council can be found in Table 2.1. Further information related to declared or revoked AQMAs, including maps of AQMA boundaries are available online at https://uk-air.defra.gov.uk/aqma/local-authorities?la_id=187

Table 2.1 – Declared Air Quality Management Areas

AQMA Name	Pollutants and Air Quality Objectives	City / Town	One Line Description	Action Plan
Central AQMA	NO_2 annual mean	Norwich	An area encompassing the Centre of Norwich, broadly following the inner link road.	2015 AQAP https://www.norwich.gov.uk/downloads/file/3020/2015_air_quailty_action_plan

Figure 2.1 Map of the Central Norwich AQMA



2.2 Progress and Impact of Measures to address Air Quality in Norwich

Norwich City Council in combination with Norfolk County Council has taken forward a number of measures during the current reporting year of 2016 in pursuit of improving local air quality. Details of all measures completed, in progress or planned are set out in Table 2.2. More detail on these measures can be found in their respective Action Plans by clicking on the following link: https://www.norwich.gov.uk/downloads/file/3020/2015_air_quailty_action_plan.

Key measures are:

- Construction work on Northern Distributor Road (NDR) commenced
- Golden Ball Street and Farmers Avenue two-way traffic implemented
- Removal of general traffic except buses, taxis and cyclists from Red Lion Street
- Full closure of Westlegate – work commenced

- Cycle routes extended and more joined up within city to encourage cycling as well as, improved road safety
- Work with taxi operators to achieve improved Euro standards. It was previously intended to revise Hackney carriage vehicle licence conditions to include the requirement to achieve improved Euro standards by mandatory interim dates up until 1st April 2019, when they were to meet Euro V exhaust emission standards either by virtue of the vehicle's date of manufacture, or by way of an approved conversion. However, this policy has been revised such that no vehicle will be re-licenced as a Hackney carriage after 15 years beyond its first registration. This policy was approved by the licensing committee in June 2016, and will commence on 1st April 2017. This revised policy is broadly in line with the current London model, and will ensure continued improvement in Hackney carriage Euro standards beyond Euro V.

Progress has been slower than expected on installing signage to inform drivers of the AQMA in known congested areas. It is also planned to erect signage to encourage engine switch-off, and to display waiting time at traffic lights. These measures are anticipated to be in place in the next reporting year, after completion of the road layout changes.

Norwich City Council also expects the following measures to be completed over the course of the next reporting year, which will reduce congestion and facilitate other city centre road layout changes:

- Bus only on All Saints Green - Linked with work to deliver the implementation plan for the Norwich Area Transportation Strategy (NATSIP)
- Ring road junction improvements - Linked with work to deliver NATSIP
- Full closure of Westlegate

Table 2.2 – Progress on Measures to Improve Air Quality

Measure No.	Measure	EU Category	EU Classification	Lead Authority	Planning Phase	Implementation Phase	Key Performance Indicator	Target Pollution Reduction in the AQMA	Progress to Date	Estimated Completion Date	Comments
1	Title	Select from the categories in blue box	Select from the subcategories in blue box		Date	Date				Date	
2	Castle Meadow Low Emission Zone	Promoting Low Emission Transport	Low Emission Zone (LEZ)	Norwich City Council (NCC)	2004/05	2006/09	Reduction in NO_2 levels in Castle Meadow	Circa 10-15 µg/m^3 NO_2	Outcome unclear as in recent years NO_2 has been increasing but probably would have been worse without LEZ.	2018	Ongoing review of LEZ and the requirement to further reduce bus emissions. We will work with the bus companies and aim to achieve Euro V compliance within a time period of 3 years and use best practical means to achieve as close as possible Euro VI compliance. NoCC has successfully bid for funds to bring forward retro-fit of <Euro V buses
3	Westlegate removal of straight- ahead traffic movement	Traffic Management	Strategic highway improvements, Re-prioritising road space away from cars, including Access management, Selective vehicle priority, bus priority, high vehicle occupancy lane	NCC + Norfolk County Council (NoCC)	2013-	2014/15	Reduced city centre congestion	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre	Works completed as per plan	2015/16	Part of city centre measures to reduce through traffic

Measure No.	Measure	EU Category	EU Classification	Lead Authority	Planning Phase	Implementation Phase	Key Performance Indicator	Target Pollution Reduction in the AQMA	Progress to Date	Estimated Completion Date	Comments
4	Extension of Postwick Park and Ride site	Alternatives to private vehicle use	Bus based Park & Ride	NoCC	2013-	2017-2018	Reduced city centre congestion as well as wider network	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre	Works currently on target to be completed as per plan	2018	Capacity Improvements
5	Review of traffic light times & synchronisation to optimise traffic flow for all new road layout schemes	Traffic Management	UTC, Congestion management, traffic reduction	NCC	2014/15	2016-	Reduced city centre congestion as well as wider network	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Ongoing	N/A	Congestion should be minimised
6	Construction of Northern Distributor Road (NDR)	Transport Planning and Infrastructure	Other	NoCC	2005-	2015/18	Reduced city centre congestion as well as wider network	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Works currently on target to be completed as per plan	2018	Monitoring will show any generic decline in NO_2 levels once NDR is complete
7	Bus only on All Saints Green	Traffic Management	Strategic highway improvements, Reprioritising road space away from cars, including Access management, Selective vehicle priority, bus priority, high vehicle occupancy lane	NCC + Norfolk County Council (NoCC)	2015	2017	Improved bus transit and Restore All Saints Green as an attractive traffic-free open space	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Works currently on target to be completed as per plan	Early 2017	Pedestrianisation of All Saints Green (no longer required as a bus route)
8	Golden Ball Street & Farmers Avenue two-way	Traffic Management	UTC, congestion management, traffic reduction	NCC + Norfolk County Council (NoCC)	2015	2016	Reduced city centre congestion	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Completed	March 2016	Congestion should be minimised

Measure No.	Measure	EU Category	EU Classification	Lead Authority	Planning Phase	Implementation Phase	Key Performance Indicator	Target Pollution Reduction in the AQMA	Progress to Date	Estimated Completion Date	Comments
9	Removal of general traffic except buses, taxies and cyclists from Red Lion Street	Traffic Management	Strategic highway improvements, Re-prioritising road space away from cars, including Access management, Selective vehicle priority, bus priority, high vehicle occupancy lane	NCC + Norfolk County Council (NoCC)	2015	2016	Reduced city centre congestion	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Completed	March 2016	Congestion should be minimised
10	Full closure of Westlegate	Traffic Management	Strategic highway improvements, Re-prioritising road space away from cars, including Access management, Selective vehicle priority, bus priority, high vehicle occupancy lane	NCC + Norfolk County Council (NoCC)	2015	2016-	Reduced city centre congestion	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Completed	March 2016	Congestion should be minimised
11	Ring road junction improvements	Traffic Management	UTC, congestion management, traffic reduction	NCC + Norfolk County Council (NoCC)	2016-	2018-	Reduced city centre congestion as well as wider network	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Surveys and feasibility programmed for 2017/18	2018	To reduce congestion

Measure No.	Measure	EU Category	EU Classification	Lead Authority	Planning Phase	Implementation Phase	Key Performance Indicator	Target Pollution Reduction in the AQMA	Progress to Date	Estimated Completion Date	Comments
12	Removal of general traffic except buses, cyclists and taxies from Prince of Wales Road (except Eastern section)	Traffic Management	Strategic highway improvements, Re-prioritising road space away from cars, including Access management, Selective vehicle priority, bus priority, high vehicle occupancy lane	NCC + Norfolk County Council (NoCC)	2016/17	Long term - post NDR	Reduced city centre congestion	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Not started	TBC	Long term goal once NDR has been completed. Awaiting detailed design.
13	Bus only on Prince of Wales Road and Agricultural Hall Plain	Traffic Management	Strategic highway improvements, Re-prioritising road space away from cars, including Access management, Selective vehicle priority, bus priority, high vehicle occupancy lane	NCC + Norfolk County Council (NoCC)	2016/17	Long term - post NDR	Reduced city centre congestion	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Not started	TBC	Long term goal once NDR has been completed. Awaiting detailed design.
14	Removal of some non-bus, taxi and cycle through-traffic from Tombland	Traffic Management	Strategic highway improvements, Re-prioritising road space away from cars, including Access management, Selective vehicle priority, bus priority, high vehicle occupancy lane	NCC + Norfolk County Council (NoCC)	TBC	Long term - post NDR	Reduced city centre congestion	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Not started	TBC	Long term goal once NDR has been completed. Awaiting detailed design.

Measure No.	Measure	EU Category	EU Classification	Lead Authority	Planning Phase	Implementation Phase	Key Performance Indicator	Target Pollution Reduction in the AQMA	Progress to Date	Estimated Completion Date	Comments
15	CCAG programmes	Promoting Travel Alternatives	Promotion of cycling	NCC	2013	2014-2017	Reduction in vehicle use in city centre	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Ongoing	2017/18	Cycle routes extended and more joined up. Will encourage cycling as well as improved road safety.
16	Bus rapid transit	Transport Planning and Infrastructure	Bus route improvements	NCC + Norfolk County Council (NoCC)		Ongoing	Reduced city centre congestion as well as wider network	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Ongoing	Ongoing process	Bus rapid transit extended. Will encourage greater use of public transport/reduced use of private motorised transport
17	Signage to inform of AQMA in known congested areas. Signage to also encourage engine switch-off and display waiting time at traffic lights.	Public Information	Via other mechanisms	NCC + Norfolk County Council (NoCC)	2014/15	Ongoing	Reduction in NO_2 levels in AQMA	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Ongoing	TBC	Signage educates road users and reinforces AQMA. Need to secure funding from County to implement signage.
18	Education & information campaigns to encourage more responsible driving and the use of alternative modes	Promoting Travel Alternatives	Other	NCC + Norfolk County Council (NoCC)		Ongoing	Reduction in NO_2 levels in city centre and surrounds	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Ongoing	Ongoing process	Continuation of work to promote Transport for Norwich objectives
19	School Travel Plans	Promoting Travel Alternatives	School Travel Plans	NoCC		Implemented but requires updating	Reduction in NO_2 levels in city centre and surrounds	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Ongoing	Ongoing process	To date 88 school travel plans in place. County to request updated travel plans for schools inside new AQMA. Travel Plan to focus on using buses, cycling and walking to school to ensure travel by private car is minimised.

Measure No.	Measure	EU Category	EU Classification	Lead Authority	Planning Phase	Implementation Phase	Key Performance Indicator	Target Pollution Reduction in the AQMA	Progress to Date	Estimated Completion Date	Comments
20	Biogas	Vehicle Fleet Efficiency	Promoting Low Emission Public Transport	NCC + Norfolk County Council (NoCC)	2015-	2015-	Reduction in NO_2 levels in city centre and surrounds	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds		TBC	Anglian buses currently have 7 biogas buses powered by gas sourced from food waste. Biogas has both NOx, CO_2 and particulates benefits. Aim is to increase the number of biogas buses in operation and encourage more bus companies to follow suit.
21	Engine switch-off enforcement	Public information	Other	NCC	2016	2017	Reduction in NO_2 levels in city centre and surrounds	Complimentary to other measures; in particular Castle Meadow LEZ	In planning	2017	Proposal to use powers to enforce engine switch-off via use of fixed penalty notices

2.3 $PM_{2.5}$ – Local Authority Approach to Reducing Emissions and or Concentrations

As detailed in Policy Guidance LAQM.PG16 (Chapter 7), local authorities are expected to work towards reducing emissions and/or concentrations of $PM_{2.5}$ (particulate matter with an aerodynamic diameter of 2.5µm or less). There is clear evidence that $PM_{2.5}$ has a significant impact on human health, including premature mortality, allergic reactions, and cardiovascular diseases.

Norwich City Council is taking the following measures to address $PM_{2.5}$:

- Real-time monitoring of $PM_{2.5}$ is carried out at the AURN station at Lakenfields in the Norwich suburbs. This is an urban background site fitted with an FDMS $PM_{2.5}$ TEOM analyser. Norwich City Council has also operated a $PM_{2.5}$ TEOM analyser at its mobile monitoring station for many years (currently roadside). We hold a large amount of historic data for $PM_{2.5}$ therefore, and will use this to inform any trends in the ambient concentration of $PM_{2.5}$ across the city as a whole;
- The council is working with partners within the Norfolk Environmental Protection Group's (NEPG) Air Quality sub-group, to ensure regular two-way engagement with representatives of Public Health England, and the Director of Public Health at Norfolk County Council;
- The council has direct dialogue with officers of Norfolk County Council Highways Department, as well as through the NEPG sub group, on any significant changes to road layout or traffic flow that may be proposed within the city. $PM_{2.5}$ exposure will be considered alongside other pollutants as part of this dialogue.
- Measures described within Table 2.2 – 'Progress on Measures to Improve Air Quality' above, also have a contribution towards reducing $PM_{2.5}$ emissions and/or exposure.

3 Air Quality Monitoring Data and Comparison with Air Quality Objectives and National Compliance

3.1 Summary of Monitoring Undertaken

This section sets out what monitoring has taken place and how it compares with objectives.

3.1.1 Automatic Monitoring Sites

Norwich City Council undertook automatic (continuous) monitoring at two sites during 2016. Table A.1 in Appendix A shows the details of the sites. National monitoring results are available at Defra's website: https://uk-air.defra.gov.uk/data/ .

A map showing the location of the monitoring sites is provided in Appendix D. Further details on how the monitors are calibrated and how the data has been adjusted are included in Appendix C.

3.1.2 Non-Automatic Monitoring Sites

Norwich City Council undertook non- automatic (passive) monitoring of NO_2 at 26 sites during 2015. Table A.2 in Appendix A shows the details of the sites.

A map showing the location of the monitoring sites is provided in Appendix D. Further details on Quality Assurance/Quality Control (QA/QC) and bias adjustment for the diffusion tubes are included in Appendix C.

3.2 Individual Pollutants

The air quality monitoring results presented in this section are, where relevant, adjusted for "annualisation" and bias. Further details on adjustments are provided in Appendix C.

3.2.1 Nitrogen Dioxide (NO_2)

Table A.3 in Appendix A compares the ratified and adjusted monitored NO_2 annual mean concentrations for the past 5 years with the air quality objective of 40µg/m^3.

For diffusion tubes, the full 2015 dataset of monthly mean values is provided in Appendix B.

Table A.4 in Appendix A compares the ratified continuous monitored NO_2 hourly mean concentrations for the past 5 years with the air quality objective of 200µg/m^3, not to be exceeded more than 18 times per year.

The annual mean concentration at the Castle Meadow automatic monitoring site was recorded as 55µg/m^3 for 2015, which exceeds the annual mean objective by 15µg/m^3. This monitoring site is within the central AQMA, although it does not represent any nearby relevant exposure. There were 6 exceedences of the 1-hour mean over 4 days during 2015 (18 allowed), so this objective was not exceeded.

The Norwich Lakenfields urban background automatic monitoring site measured an annual mean concentration of 12µg/m^3. There were no exceedences of the 1-hour mean.

Table A.3 in Appendix A shows the diffusion tube results for 2015, corrected for bias using a national bias adjustment factor of 0.96 using Gradko Labs for analysis and the 50% TEA in Acetone method.

The national bias spreadsheet is shown in Appendix C and is available online here: http://laqm.defra.gov.uk/documents/Database_Diffusion_Tube_Bias_Factors_v06_16-Final.xls

The precision and accuracy spreadsheet used to calculate the local bias correction is also shown in Appendix C.

Using the National bias correction, a total of six sites exceeded the NO_2 annual mean objective of 40µg/m^3 during 2015. This is two less than 2014. These sites were:

- DT3 (St Stephens Street)
- DT11 (52 St Augustines Street)
- DT13 (Castle Meadow)
- DT14 (Castle Meadow 2)
- DT26 (3 Riverside Road)
- DT29 (Chapelfield North)

All of these sites are within the existing Norwich Central AQMA, though the tubes at St Stephens Street, Castle Meadow and Castle Meadow 2 are not situated at locations representative of relevant exposure for the annual mean.

The Castle Meadow tube indicated an annual mean of 56.4µg/m^3, which is more or less the same as 2014 (56.3µg/m^3). This location has been monitored for many years using a single diffusion tube, and is located approximately 60m along the road from our mobile automatic analyser. There was a very close agreement between the results from the diffusion tube and automatic analyser which adds confidence to the results.

The Chapelfield North site was a new triplicate site for 2013. It recorded an indicated annual mean of 60.9µg/m^3 in that year. The road was closed to general traffic between July and November 2014 for carriageway improvements, as part of a major change of road layout/traffic flow in central Norwich. In 2015 the site indicated an annual mean of 43.0µg/m^3, which, although still an exceedance of the objective, is a considerable improvement over the foregoing situation. Monitoring will continue to establish whether compliance with the nitrogen dioxide annual mean is achieved in the coming years.

The St Augustines Street site has been monitored for many years. Concentration levels have remained relatively static over the last few years, with an annual mean of 53.5µg/m^3 in 2015. This location represents a worst case scenario, being located on the building façade approximately 1m from the kerbside within a canyon street.

The Riverside Road site has seen reductions in concentration levels over the past three years. It recorded an annual mean of 47.2µg/m^3 in 2015.

3.2.2 Particulate Matter (PM_{10})

Table A.5 in Appendix A compares the ratified and adjusted monitored PM_{10} annual mean concentrations for the past 5 years with the air quality objective of 40µg/m^3.

Table A.6 in Appendix A compares the ratified continuous monitored PM_{10} daily mean concentrations for the past 5 years with the air quality objective of 50µg/m^3, not to be exceeded more than 35 times per year.

The annual mean concentration of PM_{10} at the Castle Meadow automatic monitoring site was recorded as 21µg/m^3, which is below the annual mean objective of 40µg/m^3. There were 6 exceedances of the 24-hour mean of 50µg/m^3 (35 allowed), and the maximum daily mean recorded was 68µg/m^3 (96% data capture). Since the station does not incorporate an FDMS device, the data was corrected using the Volatile Correction Method (VCM). This is discussed further in Appendix C.

For the Norwich Lakenfields monitoring site, there were 5 exceedances of the 24-hour mean, and the maximum daily mean recorded was 89µg/m^3. The annual mean concentration was 15µg/m^3 (88% data capture).

3.2.3 Particulate Matter ($PM_{2.5}$)

Table A.7 in Appendix A presents the ratified and adjusted monitored $PM_{2.5}$ annual mean concentrations for the Lakenfields site for the past 6 years. Additionally, data from the Castle Meadow site is shown for comparison. It should be noted however, that the $PM_{2.5}$ TEOM analyser at Castle Meadow is not fitted with an FDMS device. The analyser is therefore not considered to be equivalent to the reference measurement method. As such it is not detecting some of the peaks which are used for real-time public dissemination. However, there is a long history of $PM_{2.5}$ measurements in Norwich, and the TEOM measurements can be used to track any reduction of the $PM_{2.5}$ annual mean.

Figure 3.1 below shows the annual mean concentrations at both sites with reference to the annual average EU limit value of 25µg/m^3 to be met by 2020, though it must be noted that this is not in regulatory standards for local authorities. As can be seen, the EU limit value is already comfortably met. There has also been an overall steady reduction in the annual average at Lakenfields since 2012, which is in line with the EU target value of 15% reduction at background urban locations between 2010 and 2020.

In order to further bolster the data provided by the Castle Meadow TEOM, additional comparison has been made with the AURN station at Sandy in Bedford, which is a roadside site and operates an FDMS analyser. Figure 3.2 below compares the monthly means from 2011 to 2015 while all three stations were operational. Again, the Castle Meadow TEOM is missing some of the monthly peaks but the average looks similar.

It is considered that in seeking to reduce the concentration levels of other pollutants, that a beneficial impact on $PM_{2.5}$ concentartions will also be evident. Our historic monitoring data will be of considerable assistance in assessing such impacts.

Figure 3.1 – Annual Mean $PM_{2.5}$ concentrations in Norwich

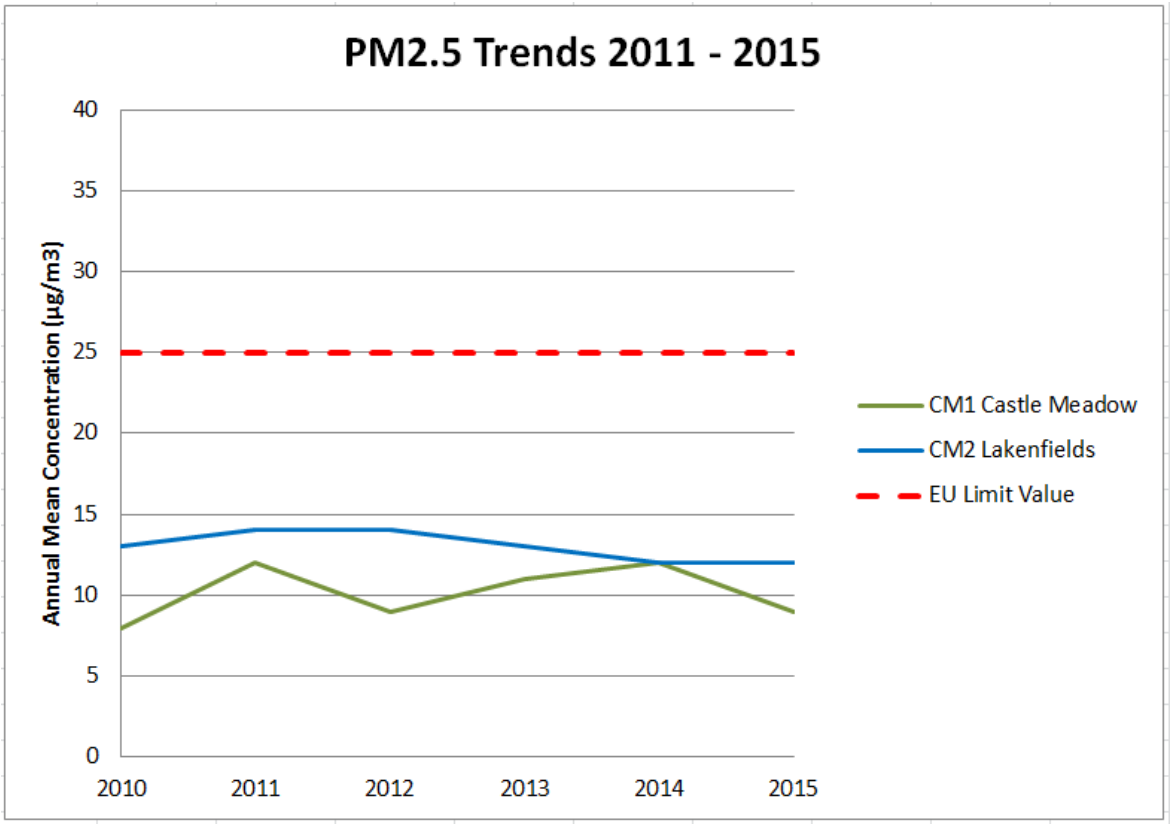
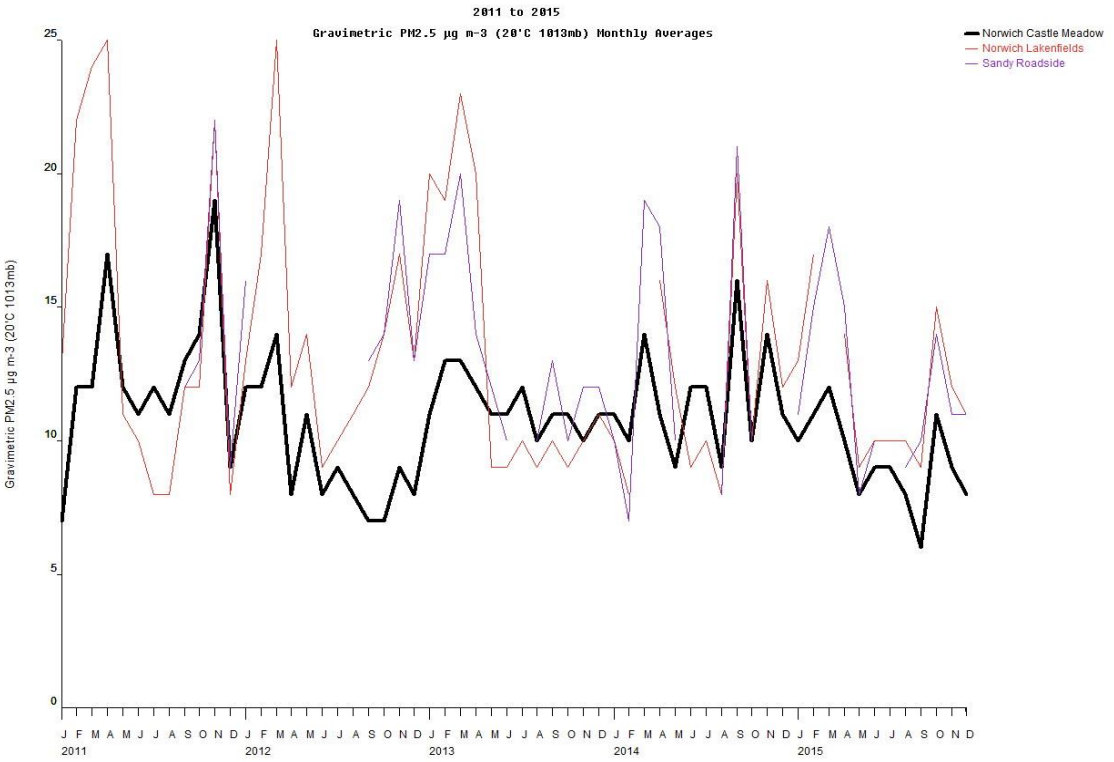


Figure 3.2 – Monthly Mean $PM_{2.5}$ concentrations 2011 to 2015



Appendix A: Monitoring Results

Table A.1 – Details of Automatic Monitoring Sites

Site ID and Name	Site Type	OS Grid Ref	Pollutants Monitored	In AQMA?	Monitoring Technique	Distance to Relevant Exposure (m) (1)	Distance to kerb of nearest road (m) (2)	Inlet Height (m)
CM1 Castle Meadow	Urban Roadside	X623202 Y308615	PM_{10}, NO_x, NO_2, $PM_{2.5}$	Y	Chemiluminescent (Ambirak); TEOM	N	1m	2.5
CM2 Lakenfields	Urban Background	X623637 Y306940	O_3, PM_{10}, NO_x, NO_2, $PM_{2.5}$	N	Chemiluminescent(Thermo), FDMS	Y (20m)	N/A	2.5

(1) 0m if the monitoring site is at a location of exposure (e.g. installed on the façade of a residential property).

(2) N/A if not applicable.

Table A.2 – Details of Non-Automatic NO_2 Monitoring Sites

Site ID	Site Name	Site Type	OS Grid Ref	In AQMA ?	Distance to Relevant Exposure (m) (1)	Distance to kerb of nearest road (m) (2)	Tube collocated with a Continuous Analyser?	Height (m)
DT1	256 King Street	Roadside	X 623863.04 Y 307678.60	Y	0	3.5	N	1.5
DT2	Queens Rd Travelodge	Roadside	X 622917.08 Y 307974.49	Y	N/A	N/A	N	2.5
DT3	St Stephens (mid)	Kerbside	X 622879.16 Y 308089.96	Y	N/A	N/A	N	2.5
DT4	Lakenfields	Urban Background	X 623681.24 Y 307015.82	N	20	N/A	Y	2.5
DT5	Chalk Hill Road	Roadside	X 623906.97 Y 308596.92	Y	0	7	N	2.5
DT6	130 Magdalen Street	Roadside	X 623160.89 Y 309550.43	Y	0	4	N	2.5
DT7	Reads Flour Mill	Kerbside	X 623796.25 Y 307772.13	Y	0	1	N	2.5
DT9	13 St Augustines St	Kerbside	X 622905.81 Y 309496.11	Y	N/A	1	N	2.5
DT10	32 St Augustines St	Kerbside	X 622865.96 Y 309529.93	Y	0	2	N	2.5
DT11	52 St Augustines St	Kerbside	X 622825.87 Y 309573.17	Y	0	1	N	2.5

Site ID	Site Name	Site Type	OS Grid Ref	In AQMA ?	Distance to Relevant Exposure (m) (1)	Distance to kerb of nearest road (m) (2)	Tube collocated with a Continuous Analyser?	Height (m)
DT12	65 St Augustines St	Kerbside	X 622813.72 Y 309609.96	Y	0	1	N	2.5
DT13	Castle Meadow	Roadside	X 623141.06 Y 308606.69	Y	N/A	N/A	N	2.5
DT14	Castle Meadow 2	Roadside	X 623250.50 Y 308590.12	Y	N/A	N/A	N	2.5
DT16	Zipfel House	Roadside	X 623185.69 Y 309649.68	Y	0	3	N	2.5
DT17	68 Bull Close Road	Roadside	X 623305.49 Y 309543.95	Y	0	4	N	1.5
DT18	Upper King Street	Kerbside	X 623337.40 Y 308632.52	Y	N/A	N/A	N	2.5
DT19	Cattlemarket Street	Roadside	X 623320.58 Y 308430.88	Y	0	2	N	2.5
DT20	Exchange St	Kerbside	X 623007.27 Y 308716.34	Y	N/A	1	N	2.5
DT21	Rotary House King Street	Roadside	X 623879.53 Y 307658.91	Y	3	2	N	1.5
DT22	Carrow Bridge House	Roadside	X 623900.96 Y 307709.56	Y	0	5	N	1.5
DT23	62 Magpie Road	Roadside	X 622970.72 Y 309652.02	Y	0	2	N	1.5

Site ID	Site Name	Site Type	OS Grid Ref	In AQMA ?	Distance to Relevant Exposure (m) (1)	Distance to kerb of nearest road (m) (2)	Tube collocated with a Continuous Analyser?	Height (m)
DT24	26 Bull Close Road	Roadside	X 623228.63 Y 309625.14	Y	0	5.5	N	1.5
DT25	24 Bargate Court	Roadside	X 623422.42 Y 309388.23	Y	0	4	N	2.5
DT26	3 Riverside Road	Roadside	X 623870.26 Y 308515.77	Y	0	3	N	2.5
DT28	71 Dukes Court	Roadside	X 622431.35 Y 308663.05	Y	0	4	N	2.5
DT29	4 Chapelfield North	Kerbside	X 622532.23 Y 308490.36	Y	0	1	N	2.5

(1) 0m if the monitoring site is at a location of exposure (e.g. installed on/adjacent to the façade of a residential property).

(2) N/A if not applicable.

Table A.3 – Annual Mean NO_2 Monitoring Results

Site ID	Site Type	Monitoring Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2015 (%) (2)	NO_2 Annual Mean Concentration (µg/m^3) (3)				
					2011	2012	2013	2014	2015
CM1	Urban Roadside	Automatic	95	95	**52**	**53**	**64**	**66**	**55**
CM2	Urban Background	Automatic	86	86	13	14	15	14	12.0
DT1	Roadside	Diffusion Tube	100	100	**41.9**	**43.8**	39.7	**41.5**	36.2
DT2	Roadside	Diffusion Tube	100	100	31.8	33.9	38.8	33.6	30.9
DT3	Kerbside	Diffusion Tube	100	100	**53**	**61.6**	**55.4**	**59.6**	**42.9**
DT4	Urban Background	Diffusion Tube	100	100	13.1	14.1	13.2	12.5	11.8
DT5	Roadside	Diffusion Tube	100	100	31.1	32.6	32.9	32.9	29.2
DT6	Roadside	Diffusion Tube	100	100	29	32.7	32.7	30.9	28.4
DT7	Kerbside	Diffusion Tube	92	92	23.1	24.1	23.5	23.2	21.2
DT9	Kerbside	Diffusion Tube	100	100	37.6	**41.7**	**45.1**	**41.9**	37.6
DT10	Kerbside	Diffusion Tube	100	100	36.2	**40.1**	**42.8**	39.4	37.5
DT11	Kerbside	Diffusion Tube	92	92	**47.5**	**52.1**	**51.2**	**48.6**	**53.5**

Site ID	Site Type	Monitoring Type	Valid Data Capture for Monitoring Period (%) [1]	Valid Data Capture 2015 (%) [2]	NO_2 Annual Mean Concentration ($\mu g/m^3$) [3]				
					2011	2012	2013	2014	2015
DT12	Kerbside	Diffusion Tube	100	100	29.6	35.1	33.2	31.9	31.4
DT13	Roadside	Diffusion Tube	100	100	**51.1**	**57.2**	**63.5**	**56.3**	**56.4**
DT14	Roadside	Diffusion Tube	100	100	**52.5**	**53.8**	**52.4**	**50.5**	**48.1**
DT16	Roadside	Diffusion Tube	100	100	**42.8**	**44.2**	**40.9**	39	34.8
DT17	Roadside	Diffusion Tube	100	100	29.1	31.2	29.8	29	26.9
DT18	Kerbside	Diffusion Tube	100	100	35.2	37.2	35.6	33.1	32.2
DT19	Roadside	Diffusion Tube	100	100	**45**	**47.2**	**46.7**	**46**	37.9
DT20	Kerbside	Diffusion Tube	100	100	32.7	30.7	30.3	31	27.5
DT21	Roadside	Diffusion Tube	100	100	**40.2**	38.1	36.7	36.6	34.3
DT22	Roadside	Diffusion Tube	100	100	24.7	26.1	27.2	24.7	21.6
DT23	Roadside	Diffusion Tube	100	100	31.6	34.4	33.1	32.1	29.6
DT24	Roadside	Diffusion Tube	100	100	35	34.6	32.2	31.5	30.0
DT25	Roadside	Diffusion Tube	100	100	35.1	36.9	37.2	35.1	34.2

Site ID	Site Type	Monitoring Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2015 (%) (2)	NO_2 Annual Mean Concentration ($\mu g/m^3$) (3)				
					2011	2012	2013	2014	2015
DT26	Roadside	Diffusion Tube	100	100	**49.4**	**51**	**52.4**	**51.2**	**47.2**
DT28	Roadside	Diffusion Tube	100	100	27.9	27.8	28.1	25.8	23.8
DT29	Kerbside	Diffusion Tube	100	100	-	-	**60.9**	38.1	**43.0**

Notes: Exceedances of the NO_2 annual mean objective of 40µg/m^3 are shown in **bold**.

NO_2 annual means exceeding 60µg/m^3, indicating a potential exceedance of the NO_2 1-hour mean objective are shown in **bold and underlined.**

(1) data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

(3) Means for diffusion tubes have been corrected for bias. All means have been "annualised" as per Technical Guidance LAQM.TG16 if valid data capture for the full calendar year is less than 75%. See Appendix C for details.

Figure A.1 – NO_2 trends 2011 to 2015

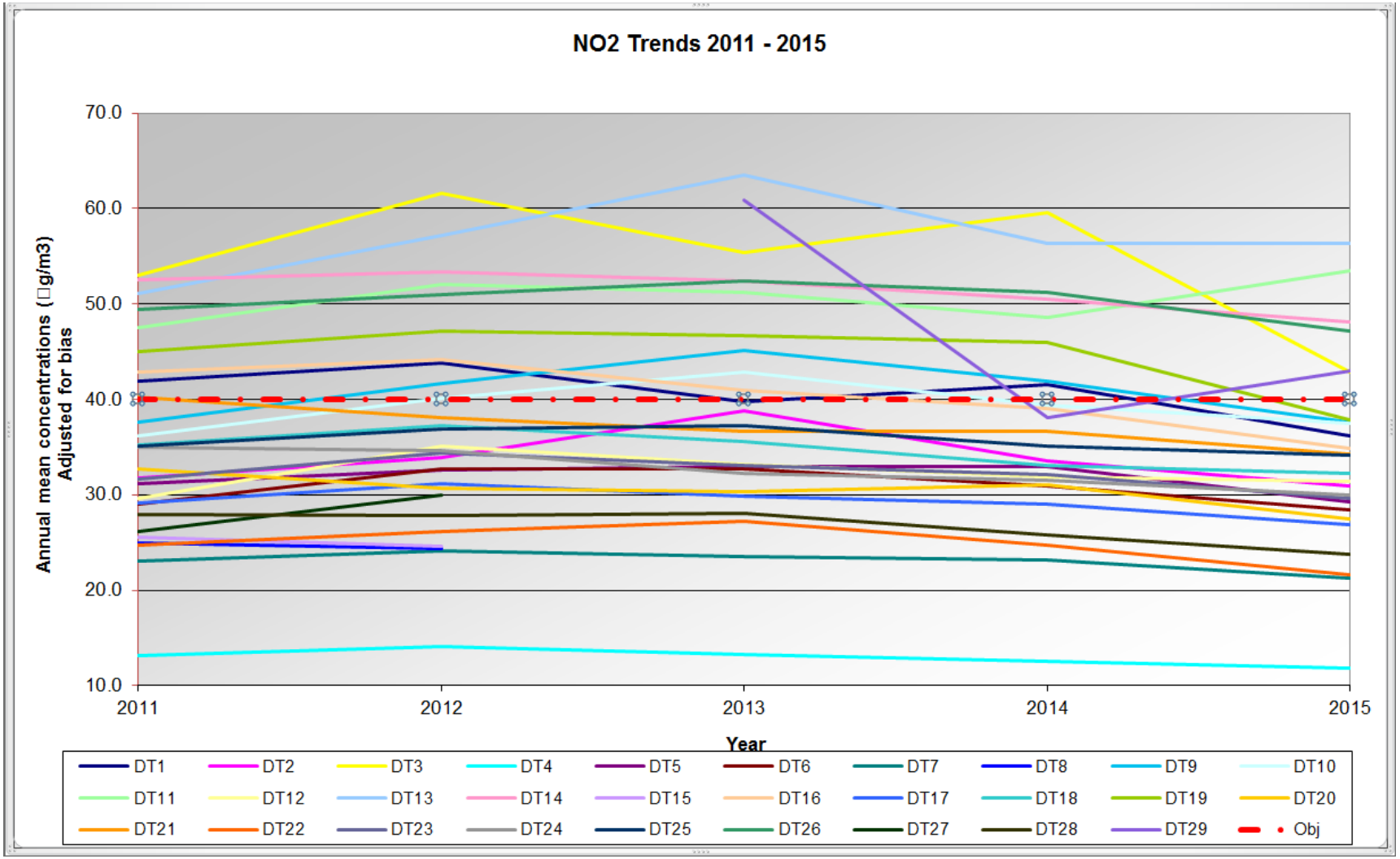


Table A.4 – 1-Hour Mean NO_2 Monitoring Results

Site ID	Site Type	Monitoring Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2015 (%) (2)	NO_2 1-Hour Means > 200µg/m^3 (3)				
					2011	2012	2013	2014	2015
CM1	Urban Roadside	Automatic	95	95	**54**	4	**72**	**57**	6
CM2	Urban Background	Automatic	86	86	0	0	0	0	0 (55)

Notes: Exceedances of the NO_2 1-hour mean objective (200µg/m^3 not to be exceeded more than 18 times/year) are shown in **bold.**

(1) data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

(3) If the period of valid data is less than 90%, the 99.8th percentile of 1-hour means is provided in brackets.

Table A.5 – Annual Mean PM_{10} Monitoring Results

Site ID	Site Type	Valid Data Capture for Monitoring Period (%) [1]	Valid Data Capture 2015 (%) [2]	PM_{10} Annual Mean Concentration ($\mu g/m^3$) [3]				
				2011	2012	2013	2014	2015
CM1	Urban Roadside	96	96	25	17	25	21	21
CM2	Urban Background	88	88	19	14	15	16	15

Notes: Exceedances of the PM_{10} annual mean objective of 40$\mu g/m^3$ are shown in **bold.**

(1) data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

(3) All means have been "annualised" as per Technical Guidance LAQM.TG16, valid data capture for the full calendar year is less than 75%. See Appendix C for details.

Table A.6 – 24-Hour Mean PM_{10} Monitoring Results

Site ID	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2015 (%) (2)	PM_{10} 24-Hour Means > 50µg/m^3 (3)				
				2011	2012	2013	2014	2015
CM1	Urban Roadside	96	96	17	7	15	9	6
CM2	Urban Background	88	88	13 (37)	1	3	0	5

Notes: Exceedances of the PM_{10} 24-hour mean objective (50µg/m^3 not to be exceeded more than 35 times/year) are shown in **bold.**

(1) data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

(3) If the period of valid data is less than 90%, the 90.4th percentile of 24-hour means is provided in brackets.

Table A.7 – $PM_{2.5}$ Monitoring Results

Site ID	Site Type	Valid Data Capture for Monitoring Period (%) [1]	Valid Data Capture 2015 (%) [2]	$PM_{2.5}$ Annual Mean Concentration ($\mu g/m^3$) [3]					
				2010	2011	2012	2013	2014	2015
CM1	Urban Roadside	97	97	8	12	9	11	12	9
CM2	Urban Background	91	91	13	14	14	13	12	12

(1) Data capture for the monitoring period, in cases where monitoring was only carried out for part of the year.

(2) Data capture for the full calendar year (e.g. if monitoring was carried out for 6 months, the maximum data capture for the full calendar year is 50%).

(3) All means have been "annualised" as per Technical Guidance LAQM.TG16, valid data capture for the full calendar year is less than 75%. See Appendix C for details.

Appendix B: Full Monthly Diffusion Tube Results for 2015

Table B.1 – NO_2 Monthly Diffusion Tube Results - 2015

Site ID	NO_2 Mean Concentrations ($\mu g/m^3$)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean	
													Raw Data	Bias Adjusted (1)
DT1	38.9	32.3	36.0	36.3	34.9	32.7	37.4	40.4	36.5	41.4	43.0	43.2	37.7	36.2
DT2	37.5	34.1	29.0	32.3	30.1	44.4	36.7	3.6	40.6	48.1	28.7	20.6	32.1	30.9
DT3	46.6	44.0	39.9	41.8	41.2	42.5	43.3	51.3	45.1	49.5	47.4	43.9	44.7	**42.9**
DT4	16.2	13.7	13.5	9.9	8.4	9.5	10.3	10.8	11.2	14.7	16.2	13.4	12.3	11.8
DT5	28.8	29.3	29.4	29.3	27.7	30.4	33.7	24.6	30.5	38.0	32.9	30.9	30.4	29.2
DT6	34.0	25.5	30.3	22.0	27.0	28.0	32.0	28.4	29.3	36.0	33.7	28.7	29.6	28.4
DT7	27.0		23.5	21.9	16.4	18.7	18.0	20.5	23.2	29.0	24.4	19.8	22.0	21.2
DT9	39.3	39.5	41.5	48.0	34.7	42.0	43.8	41.9	41.4	43.3	24.1	30.8	39.2	37.6
DT10	37.2	40.2	39.7	33.8	39.7	37.0	42.5	41.4	43.1	39.5	38.7	36.4	39.1	37.5
DT11	50.5	57.6		49.9	59.5	55.9	65.2	53.8	56.9	52.0	61.1	51.2	55.8	**53.5**
DT12	34.0	40.7	38.2	31.3	31.0	27.6	28.7	30.9	30.8	30.7	35.5	32.8	32.7	31.4
DT13	53.7	50.3	66.3	60.2	56.9	70.7	68.0	58.1	63.8	61.7	53.6	42.0	58.8	**56.4**
DT14	51.7	50.1	55.1	44.3	49.9	47.8	59.9	57.5	46.6	47.5	43.5	47.4	50.1	**48.1**

Site ID	NO_2 Mean Concentrations ($\mu g/m^3$)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean	
													Raw Data	Bias Adjusted (1)
DT16	40.1	40.3	26.3	27.3	34.7	32.9	32.2	39.7	38.4	35.8	45.6	41.9	36.3	34.8
DT17	35.2	32.4	25.2	30.2	22.7	22.0	26.0	27.3	25.9	27.8	32.8	28.7	28.0	26.9
DT18	40.4	32.5	31.6	33.2	32.5	36.3	38.4	31.0	32.8	32.3	34.4	27.2	33.5	32.2
DT19	34.8	38.6	29.3	41.9	32.8	37.2	40.5	45.7	40.6	44.7	41.8	46.2	39.5	37.9
DT20	27.7	28.4	26.0	21.7	21.5	22.7	25.0	26.7	46.8	33.4	34.5	29.2	28.6	27.5
DT21	39.0	35.3	34.8	34.6	32.6	31.4	40.3	35.6	32.9	33.6	40.5	38.7	35.8	34.3
DT22	29.6	27.1	21.6	17.9	16.7	20.5	20.1	21.1	22.3	26.7	25.5	21.5	22.5	21.6
DT23	32.7	34.2	20.5	27.3	26.8	27.9	32.7	35.2	30.1	30.9	36.4	34.8	30.8	29.6
DT24	40.8	37.3	25.2	30.7	30.8	27.5	29.8	27.2	29.8	29.1	34.9	32.3	31.3	30.0
DT25	34.5	35.4	37.5	32.7	30.1	35.7	35.4	37.1	38.0	45.7	36.5	28.5	35.6	34.2
DT26	44.8	47.4	39.1	45.3	44.4	46.7	55.6	57.1	49.9	54.0	55.6	50.6	49.2	**47.2**
DT28	28.4	28.4	24.8	20.8	18.7	21.1	23.8	23.9	26.5	30.4	28.4	22.4	24.8	23.8
DT29	42.6	37.4	41.5	47.0	42.2	49.2	49.8	49.0	55.6	57.4	38.7	27.4	44.8	**43.0**

(1) See Appendix C for details on bias adjustment

Appendix C: Supporting Technical Information / Air Quality Monitoring Data QA/QC

National Diffusion Tube Bias Adjustment Factors
Supplier/ Analyst: Gradko
Preparation Method: 50% TEA in Acetone
National Bias Adjustment Factor (from spreadsheet v06/16): **0.96**

Factor from Local Co-location Studies (Local Bias Adjustment Factor)
Norwich Lakenfields urban background AURN site **(based on 12 periods of data)**
Bias Factor A: **1.09** (0.94 – 1.29)
Bias B: -8% (-22% - 6%)
Diffusion Tubes Mean: 11µg/m³
Automatic Mean: 12µg/m³
Data Capture for periods used: 99%
Adjusted Tubes Mean: 12 (10-14) µg/m³

A copy of the precision and accuracy spreadsheet used to calculate the local bias correction is shown below:

Checking Precision and Accuracy of Triplicate Tubes

AEA Energy & Environment
From the AEA group

Diffusion Tubes Measurements										Automatic Method		Data Quality Check	
Period	Start Date dd/mm/yyyy	End Date dd/mm/yyyy	Tube 1 µgm^{-3}	Tube 2 µgm^{-3}	Tube 3 µgm^{-3}	Triplicate Mean	Standard Deviation	Coefficient of Variation (CV)	95% CI of mean	Period Mean	Data Capture (% DC)	Tubes Precision Check	Automatic Monitor Data
1	08/01/2015	04/02/2015	15.8	16.1	16.8	16	0.5	3	1.2	19.3	64	Good	or Data Capture
2	04/02/2015	04/03/2015	13.7	14.0	13.4	14	0.3	2	0.7		0	Good	or Data Capture
3	04/03/2015	01/04/2015	13.9	14.2	12.3	13	1.0	8	2.5	11.6	66	Good	or Data Capture
4	01/04/2015	29/04/2015	9.5	10.2		10	0.5	5	4.6	11.5	100	Good	Good
5	29/04/2015	01/06/2015	8.2	9.2	7.9	8	0.7	8	1.7	9	100	Good	Good
6	01/06/2015	01/07/2015	9.2	9.8	9.5	10	0.3	3	0.8	10	100	Good	Good
7	01/07/2015	31/07/2015	9.9	11.0	10.1	10	0.6	6	1.4	9	94	Good	Good
8	31/07/2015	25/08/2015	10.9	9.7	11.7	11	1.0	10	2.6	10	100	Good	Good
9	25/08/2015	29/09/2015	10.9	11.2	11.4	11	0.3	2	0.7	12	100	Good	Good
10	29/09/2015	26/10/2015	14.0	14.5	15.6	15	0.8	6	2.0	16	100	Good	Good
11	26/10/2015	30/11/2015	8.5	8.7	8.2	8	0.2	3	0.6	15.4	100	Good	Good
12	30/11/2015	05/01/2016	13.7	13.4	13.1	13	0.3	2	0.7	12	100	Good	Good
13													
											Overall survey -->	Good precision	Good Overall DC

It is necessary to have results for at least two tubes in order to calculate the precision of the measurements

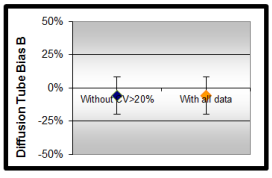
Site Name/ ID:	Norwich Lakenfields

Precision	12 out of 12 periods have a CV smaller than 20%

(Check average CV & DC from Accuracy calculations)

Accuracy	(with 95% confidence interval)
without periods with CV larger than 20%	
Bias calculated using 9 periods of data	
Bias factor A	1.09 (0.94 - 1.29)
Bias B	-8% (-22% - 6%)
Diffusion Tubes Mean:	11 µgm^{-3}
Mean CV (Precision):	5
Automatic Mean:	12 µgm^{-3}
Data Capture for periods used:	99%
Adjusted Tubes Mean:	12 (10 - 14) µgm^{-3}

Accuracy	(with 95% confidence interval)
WITH ALL DATA	
Bias calculated using 9 periods of data	
Bias factor A	1.09 (0.94 - 1.29)
Bias B	-8% (-22% - 6%)
Diffusion Tubes Mean:	11 µgm^{-3}
Mean CV (Precision):	5
Automatic Mean:	12 µgm^{-3}
Data Capture for periods used:	99%
Adjusted Tubes Mean:	12 (10 - 14) µgm^{-3}



Jaume Targa, for AEA
Version 04 - February 2011

If you have any enquiries about this spreadsheet please contact the LAQM Helpdesk at: LAQMHelpdesk@uk.bureauveritas.com

Discussion of Choice of Factor to Use

With regard to the selection of a bias adjustment factor for diffusion tubes, Technical Guidance (TG16) and the LAQM Support website advocate the use of a locally derived bias adjustment factor where available and relevant to the diffusion tube sites in question. Data from the co-location site at Lakenfields was therefore used to contribute to the national study and also to derive a local bias correction factor to be considered and applied if appropriate.

However, the technical guidance also states that where the survey consists of tubes exposed over a range of settings, which differ from the co-location site (eg the colocation site is in a very exposed setting and the tubes being assessed are on a building façade in a canyon-like street), then this indicates that the national adjustment factor may be more representative. Additionally, the automatic analyser experienced technical problems early in 2015 that resulted in poor data capture.

Therefore, to be as accurate as is reasonably possible using diffusion tubes, it was decided to use a correction derived from many surveys (15 including that from Norwich), and apply the nationally derived bias adjustment factor of 0.96. The Spreadsheet of National Bias Adjustment Factors (v.06/16) is shown below.

National Diffusion Tube Bias Adjustment Factor Spreadsheet — Spreadsheet Version Number: 06/16

Follow the steps below **in the correct order** to show the results of **relevant** co-location studies
Data only apply to tubes exposed monthly and are not suitable for correcting individual short-term monitoring periods
Whenever presenting adjusted data, you should state the adjustment factor used and the version of the spreadsheet
This spreadhseet will be updated every few months: the factors may therefore be subject to change. This should not discourage their immediate use.

This spreadsheet will be updated at the end of September 2016
LAQM Helpdesk Website

The LAQM Helpdesk is operated on behalf of Defra and the Devolved Administrations by Bureau Veritas, in conjunction with contract partners AECOM and the National Physical Laboratory.

Spreadsheet maintained by the National Physical Laboratory. Original compiled by Air Quality Consultants Ltd.

Step 1:	Step 2:	Step 3:	Step 4:								
Select the Laboratory that Analyses Your Tubes from the Drop-Down List	Select a Preparation Method from the Drop-Down List	Select a Year from the Drop-Down List	Where there is only one study for a chosen combination, you should use the adjustment factor shown with caution. Where there is more than one study, use the overall factor[3] shown in blue at the foot of the final column.								
If a laboratory is not shown, we have no data for this laboratory.	If a preparation method is not shown, we have no data for this method at this laboratory.	If a year is not shown, we have no data[2]	If you have your own co-location study then see footnote[4]. If uncertain what to do then contact the Local Air Quality Management Helpdesk at LAQMHelpdesk@uk.bureauveritas.com or 0800 0327953								
Analysed By[1]	**Method** To undo your selection, choose (All) from the pop-up list	**Year[2]** To undo your selection, choose (All)	**Site Type**	**Local Authority**	**Length of Study (months)**	**Diffusion Tube Mean Conc. (Dm) (µg/m³)**	**Automatic Monitor Mean Conc. (Cm) (µg/m³)**	**Bias (B)**	**Tube Precision[5]**	**Bias Adjustment Factor (A) (Cm/Dm)**	
Gradko	50% TEA in acetone	2015	R	Bedford Borough Council	12	35	33	6.4%	G	0.94	
Gradko	50% TEA in acetone	2015	UB	Norwich City Council	9	12	12	-3.3%	G	1.03	
Gradko	50% TEA in acetone	2015	R	West Berkshire Council	11	38	35	10.7%	G	0.90	
Gradko	50% TEA in acetone	2015	R	East Hampshire District Council	11	22	20	9.5%	G	0.91	
Gradko	50% TEA in acetone	2015	KS	London Borough of Croydon	12	54	52	4.7%	G	0.96	
Gradko	50% TEA in acetone	2015	B	London Borough of Richmond upon Thames	12	21	21	-0.2%	G	1.00	
Gradko	50% TEA in acetone	2015	R	London Borough of Richmond upon Thames	12	36	33	8.9%	G	0.92	
Gradko	50% TEA in acetone	2015	KS	Marylebone Road Intercomparison	12	86	81	6.4%	G	0.94	
Gradko	50% TEA in acetone	2015	UI	Middlesbrough	11	16	15	5.9%	G	0.94	
Gradko	50% TEA in acetone	2015	SI	Redcar & Cleveland	12	12	12	0.1%	G	1.00	
Gradko	50% TEA in acetone	2015	R	West Dorset District Council	12	12	11	15.5%	G	0.87	
Gradko	50% TEA in acetone	2015	R	Worthing Borough Council	11	42	37	14.5%	G	0.87	
Gradko	50% TEA in acetone	2015	R	Royal Borough of Windsor and Maidenhead	12	34	37	-8.4%	G	1.09	
Gradko	50% TEA in acetone	2015	R	Royal Borough of Windsor and Maidenhead	12	40	38	4.2%	G	0.96	
Gradko	50% TEA in acetone	2015	R	LB Newham	11	35	38	-9.9%	G	1.11	
Gradko	50% TEA in acetone	2015		Overall Factor[3] (15 studies)				Use		0.96	

PM Monitoring Adjustment

The Volatile Correction Method (VCM) allows corrections to be made to TEOM measurements for the loss of volatile components of particulate matter that occur due to the high sampling temperatures employed by these instruments. The resulting corrected measurements have been demonstrated as equivalent to the gravimetric reference equivalent.

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 VCM model was applied to the Castle Meadow TEOM data to calculate the Indicative Gravimetric Equivalent PM_{10} for the annual mean and 24-hour mean readings.

The Norwich Lakenfields site incorporates an FDMS device on the PM_{10} and $PM_{2.5}$ TEOMs.

QA/QC of Automatic Monitoring
In order to satisfy the requirements outlined in LAQM (TG16), the following QA/QC procedures were implemented:

- 2-weekly calibrations of the analysers;
- Annual audits;
- 6-monthly servicing of the monitoring site; and
- Data ratification.

Calibration of the analysers was carried out using certified compressed gas standards (ISO17025). This ensured that the calibration gas was traceable to national and international standards. In addition to the calibration, sample filters were changed for both gaseous and TEOM analysers and any faults were identified, thus minimising data loss.

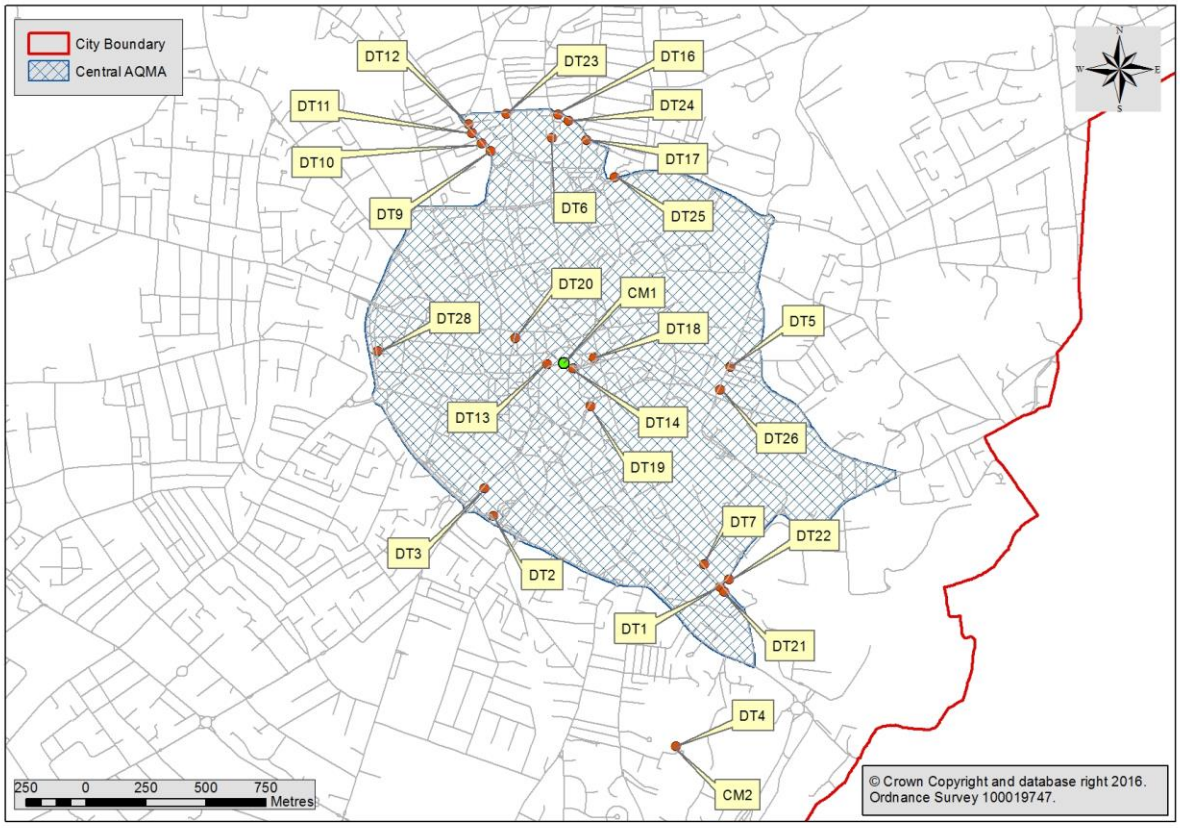
Audits of the monitoring site were carried out by Ricardo, and consisted of a number of performance checks to identify any faults with the equipment. The calibration cylinders were also checked against another gas standard in order to confirm the gas concentration. Any identified faults were forwarded on to the service unit for repair.

The final stage of the QA/QC process was to ratify the data. During ratification, all calibration, audit and service data are collated and the data is appropriately scaled. Any suspect data identified are deleted, thereby ensuring that the data sets are of a high quality. The data was ratified by Air Quality Data Management (AQDM).

QA/QC of Diffusion Tube Monitoring
The diffusion tubes are supplied and analysed by Gradko International utilising a 50% Triethanolamine (TEA) in Acetone preparation method. Gradko participate in the Workplace Analysis Scheme for Proficiency (WASP) and AIR PT scheme for NO_2 diffusion tube analysis (scoring 100% in each round of testing since 2012), and also the Annual Field Inter-Comparison Exercise. The lab follows the procedures set out by the Harmonisation Practical Guidance.

More information and results of the WASP testing is available on the following link: http://laqm.defra.gov.uk/diffusion-tubes/qa-qc-framework.html

Appendix D: Map of Monitoring Locations



Appendix E: Summary of Air Quality Objectives in England

Table E.1 – Air Quality Objectives in England

Pollutant	Air Quality Objective[4]	
	Concentration	Measured as
Nitrogen Dioxide (NO_2)	200 µg/m^3 not to be exceeded more than 18 times a year	1-hour mean
	40 µg/m^3	Annual mean
Particulate Matter (PM_{10})	50 µg/m^3, not to be exceeded more than 35 times a year	24-hour mean
	40 µg/m^3	Annual mean
Sulphur Dioxide (SO_2)	350 µg/m^3, not to be exceeded more than 24 times a year	1-hour mean
	125 µg/m^3, not to be exceeded more than 3 times a year	24-hour mean
	266 µg/m^3, not to be exceeded more than 35 times a year	15-minute mean

[4] The units are in micrograms of pollutant per cubic metre of air (µg/m^3).

Glossary of Terms

Abbreviation	Description
AQAP	Air Quality Action Plan - A detailed description of measures, outcomes, achievement dates and implementation methods, showing how the local authority intends to achieve air quality limit values'
AQMA	Air Quality Management Area – An area where air pollutant concentrations exceed / are likely to exceed the relevant air quality objectives. AQMAs are declared for specific pollutants and objectives
ASR	Air quality Annual Status Report
AURN	Automatic Urban & Rural Network
Defra	Department for Environment, Food and Rural Affairs
DMRB	Design Manual for Roads and Bridges – Air quality screening tool produced by Highways England
EU	European Union
FDMS	Filter Dynamics Measurement System
LAQM	Local Air Quality Management
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
PM_{10}	Airborne particulate matter with an aerodynamic diameter of 10µm (micrometres or microns) or less
$PM_{2.5}$	Airborne particulate matter with an aerodynamic diameter of 2.5µm or less
QA/QC	Quality Assurance and Quality Control
SO_2	Sulphur Dioxide
TEA	Triethanolamine: the reagent used in diffusion tubes as an absorbent for ambient NO_2
TEOM	Tapered Element Oscillating Microbalance

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