2017 Air Quality Annual Status Report (ASR)

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

July 2017

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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' processes, including petrol stations, road stone coating plant, vehicle re-sprayers and a crematorium. The Environment Agency permits the larger 'Part A' processes such as Briar agrochemical company. Neither Part A or Part B processes are 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 (See Appendix E).

In 2015 the council produced an updated Air Quality Action Plan (AQAP) that sets out measures to be taken in order 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 of the changes.

A detailed assessment is not required for any pollutants and the council will progress to the next Annual Status Report in 2018. In 2020 a review of the 2015 Action Plan will be required. This will be interesting as most if not all of the major road changes will have been implemented. The results may not however be realised until a further year on in order to allow for the results of NO_2 levels post road changes to be fully processed.

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 acquired during 2016 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 and on the Defra website

https://uk-air.defra.gov.uk/aqma/details?aqma_id=951.

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). Measures to reduce NO_2 resulting from road traffic will also have a positive benefit on reducing $PM_{2.5}$ levels.

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

[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

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 diffusion tube monitoring locations exceeded the annual mean objective of 40mg/m^3. This steadily reduced to six in 2015 despite an additional site being added in 2013 on Chapelfield North. In 2016 the number of locations increased to seven sites exceeding the annual mean objective but 3 of these only by 1mg/m^3. The site that exceeded this year but not last is also a site that has historically fluctuated around the 40mg/m^3 level. There are not considered to be any new major sources of pollution. Hence there are still challenges to reduce pollution levels in Norwich but, taken as a whole, the levels are promising as they are still on a slow downward trend.

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 as well as ensuring consistency of approach throughout the county. 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 and 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 pedestrianise 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 queueing.

For example, works are now complete in the Westlegate area of Norwich and also the adjoining Ber Street, Golden Ball Street and All Saints Green areas. These changes, 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 further 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 is 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 46µg/m^3 in 2016.

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

A key proposal in the AQAP was to work with local bus companies to encourage updating of the fleet. In 2016 First Eastern Counties made a £1.8m investment in nine brand new double deck vehicles which service the city. 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.

In addition, in 2016 through a DfT grant - Clean Technology Fund - 24 buses that were previously Euro 3 or 4 standard were upgraded to Euro 6 through a program of retrofitting using SCRT technology.

Unfortunately in the same year as this improvement in Norwich's bus fleet, 7 biogas buses were removed from Norwich when Anglian buses sold out to Go Ahead.

Norfolk County Council continue to work with bus operators to encourage fleet upgrades.

Another key action being taken by Norfolk County Council is the construction of the Northern Distributor Road (NDR). Construction work is still in progress 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 travelling through the city centre
- 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
- Increase the opportunities for improving public transport and the provision for pedestrians and cyclists and hence promote these modes of travel.

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

Conclusions & Priorities

The council proposes to continue with automatic and passive NO_2 monitoring within the city area. Upon completion of further road changes currently being implemented the council will review the locations of monitoring positions so as to assess any resultant impacts from these changes. No excursions of the NO2 objective was measured outside of the central AQMA and monitoring shows the trend is still of declining pollution levels.

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 all future schemes.

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 as well as its benefit in its current location.

The council will continue to support initiatives that contribute positively to improving air quality, such as the Car Club, Liftshare and encouraging engine switch off.

Local Engagement & How to Get Involved

Air quality is a subject that has reached the interest and concern of more and more people year on year. 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

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 2016. 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 area 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.

A summary of AQMA's declared by Norwich City Council can be found in Table 2.1 and a map of the AQMA in Figure 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

Figure 2.1 Map of the Central Norwich AQMA

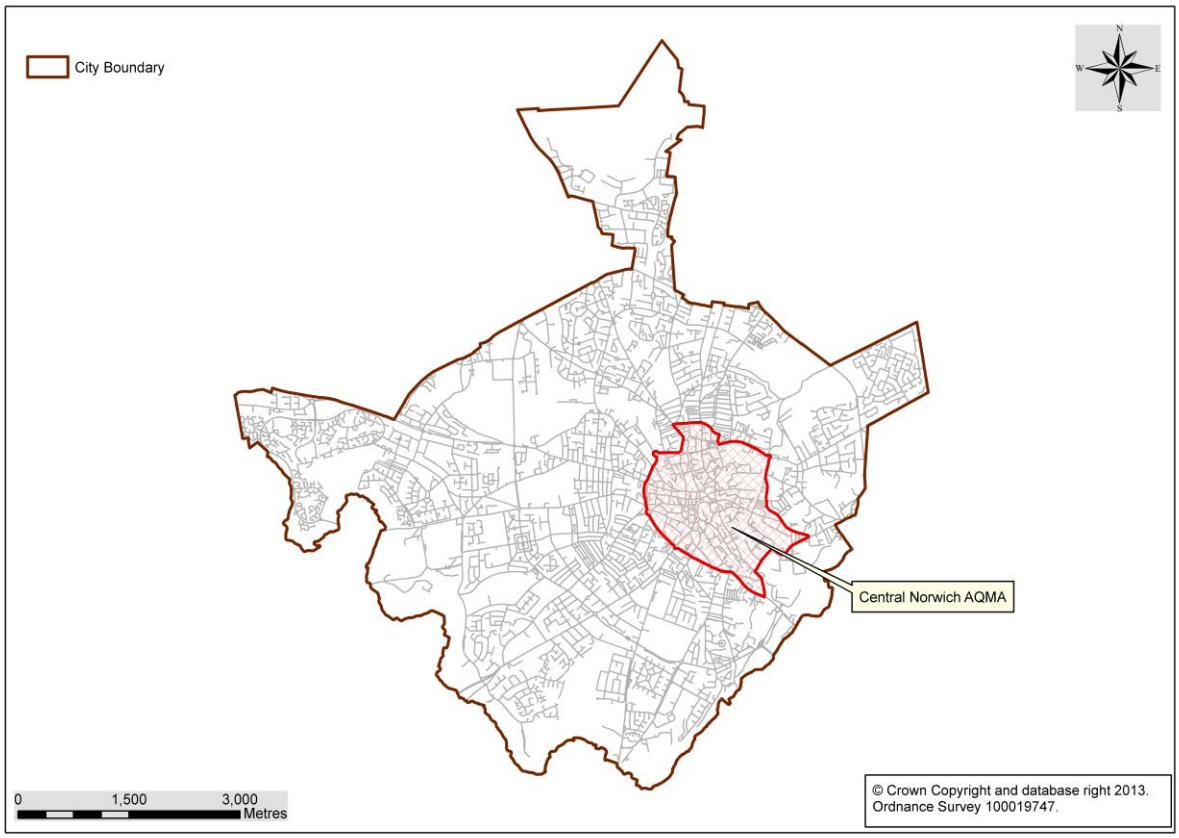


Table 2.1 – Declared Air Quality Management Area

AQMA Name	Date of Declaration	Pollutants and Air Quality Objectives	City / Town	One Line Description	Is Air Quality in AQMA Influenced by Roads Controlled by Highways England	Level of Exceedence (maximum monitored/ modelled concentration at a location of relevant exposure)		Action Plan
						At Declaration	Now	
Central AQMA	Nov 2012	NO_2 annual mean	Norwich	An area encompassing the Centre of Norwich, broadly following the inner link road.	No	52µg/m^3 (at 52 St Augustines Street)	51µg/m^3 (at 52 St Augustines Street)	2015 AQAP https://www.norwich.gov.uk/downloads/file/3020/2015_air_quality_action_plan

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

Defra's appraisal of last year's ASR concluded;

The report is well structured, detailed, and provides the information specified in the Guidance. The following comments are made:

1. *The local authority has recorded concentrations above the annual mean NO_2 objective in 2015 at a number of sites within the AQMA. Not all of these represent relevant exposure, and they should ensure that they distance correct the concentrations to the nearest façade of a property in future reports.*

2. *Measures within the plan should focus on the hotspot areas (i.e. those exceeding the objective) within the central AQMA. Future updates should clearly indicate that this is the case, for example in St Stephen's Street and St. Augustine's Street.*

In order to address point no.1 above, once proposed road re-structuring is complete, diffusion tube locations will be reviewed and revised where considered applicable. Distance corrections would be applied to Table A.3 where considered appropriate, for example, where a monitoring location is roadside but relevant exposure is set back from the road. Where relevant exposure is not considered to be applicable at a particular site, such as where the monitoring location is far enough away from the nearest relevant exposure such that other factors come in to play, N/A not applicable, has been entered in Table A.3. When considering only those locations that have NO_2 levels above the objective and applying the above principles to these locations, there are no sites that have been distance corrected.

The next Action Plan will address point no2.

Norwich City Council in combination with Norfolk County Council has taken forward a number of measures during the current reporting year of 2016/17 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 the latest Action Plan by clicking on the following link: https://www.norwich.gov.uk/downloads/file/3020/2015_air_quailty_action_plan.

Key completed measures are:

- Golden Ball Street and Farmers Avenue two-way traffic - implemented
- Removal of general traffic except buses, taxis and cyclists from Red Lion Street – implemented.
- Full closure of Westlegate – implemented.
- Restricted access on All Saints Green - Linked with work to deliver the implementation plan for the Norwich Area Transportation Strategy (NATSIP)- implemented.
- Cycle routes extended and more joined up within city to encourage cycling as well as improved road safety – pink pedalway implemented.
- Bus retrofit using SCRT technology. 24 buses that were previously Euro 3 or 4 standard upgraded to Euro 6 – implemented.
- Work with taxi operators to achieve improved Euro standards. A policy has been implemented such that no vehicle will be re-licenced as a Hackney carriage after 15 years beyond its first registration – implemented. This policy is broadly in line with the current London model, and will ensure continued improvement in Hackney carriage Euro standards beyond Euro V.

Norwich City Council expects the following measures to be either completed or being implemented over the course of the next reporting year which will reduce congestion and potentially facilitate other city centre road layout changes.

- Ring road junction improvements - Linked with work to deliver NATSIP. Survey work is now complete and data is being analysed which will determine required intervention measures.
- Review of traffic light optimisation – this is an ongoing project.
- Construction work on Northern Distributor Road (NDR) – phased opening commencing October 2017 to May 2018.
- Signage installed to encourage engine switch-off. At a later date, it is also intended to display waiting time at traffic lights and install signage to inform drivers of the AQMA in known congested areas.

- Cycle routes extended and more joined up within city to encourage cycling as well as improved road safety – blue & yellow pedalways scheduled to open autumn 2018.
- Norfolk County Council are researching the ability to be able to monitor for air pollutants at bus stops where there are already electronic displays.

In addition, in November this year the University of East Anglia (UEA) will commence a trial which will assess the behavioural approach of drivers to signage encouraging engine switch off. The signage will be sited at traffic lights on Riverside Road. Riverside Road truncates at a busy and congested 4-way junction. Space is limited on Riverside Rd due to it being sandwiched between the River Wensum and terrace housing. At the junction is Norwich train station and a bridge over the River Wensum. It is hoped the trial will identify the sign which elicits the best response from drivers to switch off engines whilst waiting at the traffic lights.

In tandem with the engine switch off signage pilot study, the University of East Anglia will conduct independent continuous monitoring of air pollutants at the Riverside Road junction. This will hopefully, at minimum, provide details on NO_2 levels during and after the engine switch off signage trial. If monitoring identifies a decrease in NO_2 levels, this will give impetus to engine switch off signage being deployed in other areas in the central AQMA and engine switch off enforcement through the issuing of fixed penalty notices.

Principle challenges and barriers to implementation that Norwich City Council anticipates facing are resourcing and funding issues and for this reason the implementation of some measures have been slower than expected.

Whilst the measures stated above and in Table 2.2 will help to contribute towards compliance, Norwich City Council anticipates that further additional measures not yet prescribed will be required in subsequent years to achieve compliance and enable the revocation on the central AQMA in Norwich.

Table 2.2 – Progress on Measures to Improve Air Quality

Measure No.	Measure	EU Category	EU Classification	Organisations Involved & funding Source	Planning Phase	Implementation Phase	Key Performance Indicator	Reduction in Pollutant /Emission from Measure	Progress to Date	Estimated/ Actual Completion Date	Comments/ Barriers to Implementation
1	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 – some reduction seen	Circa 10-15 µg/m^3 NO_2	Erratic decline in NO_2 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 2 years and use best practical means to achieve as close as possible Euro VI compliance.
2	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.	NCC + Norfolk County Council (NorCC)	2013	2014/15	Reduced city centre congestion – KPI met	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre	Works completed as per plan	Completed 2017	Part of city centre measures to reduce through traffic. Need to ensure traffic loading of nearby streets not adding to AQ issues which will be assessed and minimised by work on ring road junction improvements.
3	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	Ongoing	Congestion should be minimised but this needs to be monitored and where applicable diffusion tube sites reviewed. In addition, the work on ring road junction improvements will aid this.

Measure No.	Measure	EU Category	EU Classification	Organisations Involved & funding Source	Planning Phase	Implementation Phase	Key Performance Indicator	Reduction in Pollutant /Emission from Measure	Progress to Date	Estimated/ Actual Completion Date	Comments/ Barriers to Implementation
4	Construction of Northern Distributor Road (NDR)	Transport Planning and Infrastructure	Other	NorCC	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. Plans are for staged opening of NDR.
5	Restricted access on All Saints Green	Traffic Management	Strategic highway improvements, Reprioritising road space away from cars, including access management, selective vehicle priority, bus priority.	NCC NorCC	2015	2017	Improved bus transit to bus station and restore All Saints Green as an attractive traffic-free open space - KPI met	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Completed	Completed 2017	Pedestrianisation of All Saints Green - no longer required as a bus route
6	Golden Ball Street & Farmers Avenue two-way	Traffic Management	UTC, congestion management, traffic reduction	NCC + NorCC	2015	2016	Reduced city centre congestion – KPI met	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Completed	Completed March 2016	Congestion should be minimised . NorCC to consider pollution monitoring at bus stops.
7	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.	NCC + NorCC	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	Completed March 2017	Congestion minimised but need to ensure traffic loading on nearby streets not adding to AQ issues. Hence where applicable diffusion tube sites will be reviewed and work on ring road junction improvements will aid this.

Measure No.	Measure	EU Category	EU Classification	Organisations Involved & funding Source	Planning Phase	Implementation Phase	Key Performance Indicator	Reduction in Pollutant /Emission from Measure	Progress to Date	Estimated/ Actual Completion Date	Comments/ Barriers to Implementation
8	Full closure of Westlegate	Traffic Management	Strategic highway improvements, Re-prioritising road space away from cars, including access management, selective vehicle priority, bus priority.	NCC + NorCC	2015	2016	Reduced city centre congestion – KPI met	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Completed	Completed March 2017	Congestion should be minimised. Need to ensure traffic loading of nearby streets not adding to AQ issues which will be assessed and minimised by work on ring road junction improvements.
9	Ring road junction improvements	Traffic Management	UTC, congestion management, traffic reduction	NCC + Norfolk County Council (NorCC)	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 completed. In analysis and development of intervention phase.	2018	To reduce congestion
10	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 + NorCC	2014/15	Ongoing – trial on Riverside Rd to be implemented late 2017	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.
11	Education & information campaigns to encourage more responsible driving and the use of alternative modes	Promoting Travel Alternatives	Other	NCC + NorCC	Ongoing	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 utilising funding from DfT through Access fund.

Measure No.	Measure	EU Category	EU Classification	Organisations Involved & funding Source	Planning Phase	Implementation Phase	Key Performance Indicator	Reduction in Pollutant /Emission from Measure	Progress to Date	Estimated/ Actual Completion Date	Comments/ Barriers to Implementation
12	School Travel Plans	Promoting Travel Alternatives	School Travel Plans	NorCC		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	County to request updated travel plans - prioritising schools inside AQMA. Travel Plan to focus on using buses, cycling and walking to school to ensure travel by private car is minimised. County providing tools so schools can do own travel plan.
13	Low NOx Buses	Promoting Low Emission Transport	Public Vehicle Procurement prioritising uptake of low emission vehicles	NCC + NorCC	N/A-	N/A	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	N/A	N/A	24 buses upgraded from Euro 3-4 to Euro 6 through program of retrofitting utilising DfT grant. Anglian had 7 biogas buses but sold out to Go Ahead who removed all 7 biogas buses from its fleet. Aim is still to encourage bus companies to invest in biogas/low NOx buses.
14	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	2018	Proposal to use powers to enforce engine switch-off via use of fixed penalty notices
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	2018-19	Cycle routes extended and more joined up. Will encourage cycling as well as improved road safety.

Measure No.	Measure	EU Category	EU Classification	Organisations Involved & funding Source	Planning Phase	Implementation Phase	Key Performance Indicator	Reduction in Pollutant /Emission from Measure	Progress to Date	Estimated/ Actual Completion Date	Comments/ Barriers to Implementation
16	Removal of private vehicle traffic from Tombland	Traffic Management	Strategic highway improvements, Re-prioritising road space away from cars, including access management, selective vehicle priority, bus priority.	NCC + NorCC	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.
17	Bus rapid transit	Transport Planning and Infrastructure	Bus route improvements	NCC + NorCC	Ongoing	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
18	Rationalising and simplifying of traffic on Prince of Wales Road	Traffic Management	Strategic highway improvements, Re-prioritising road space away from cars, including access management, selective vehicle priority.	NCC + NorCC	2016/17	Long term	Reduced city centre congestion	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	In feasibility phase.	TBC	Awaiting detailed design.
19	Extension of Postwick Park and Ride site	Alternatives to private vehicle use	Bus based Park & Ride	NorCC	-	TBC	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	Project suspended	TBC	Still capacity on existing site. Plan to be reactivated when additional capacity required.

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 therefore hold a large amount of historic data for $PM_{2.5}$ 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' will 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 2016. 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 bias "annualisation" and distance correction. 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 2016 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 56µg/m^3 for 2016 which exceeds the annual mean objective by 16µg/m^3. This monitoring site is within the central AQMA.

It must be noted however that the Castle Meadow automatic analyser site is not representative of relevent exposure for the annual mean for NO_2. The closest residence is sufficiently far enough away that the NO_2 levels would not only be well below the objective level but other factors would come into play to make any corrections for distance not applicable. Using the Defra NO_2 Fall Off with Distance Correction (https://laqm.defra.gov.uk/tools-monitoring-data/no2-falloff.html), the nearest residence would need to lie within 7 metres of the automatic monitoring station for a breach of the annual mean NO_2 level to be applicable. At this location, this is not the case.

The Castle Meadow automatic analyser site can however be considered relevant exposure for the 1 hour mean as people may be expected to spend one hour or more at this location. The NO_2 levels at the site of the Castle Meadow automatic analyser did not breach the 1 hour objective as the measured levels only exceeded the 1 hour allowance of 200µg/m^3 4 times throughout 2016 whilst the objective allows for 18 exceedences in the year.

The Norwich Lakenfields urban background automatic monitoring site measured an annual mean concentration of 14.2 µg/m^3. Hence there is no exceedence of either the annual mean or the 1-hour mean.

Table A.3 in Appendix A shows the diffusion tube results for 2016, corrected for bias using a national bias adjustment factor of 1.01 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:

https://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html

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 seven sites exceeded the NO_2 annual mean objective of 40µg/m^3 during 2016. This is one site more than 2015 but this year three sites were only 1µg/m^3 over the annual mean objective whereas last year all 6 sites were 3µg/m^3 or more over the limit. These diffusion tube sites were:

- DT3 (St Stephens Street) – 41.1µg/m^3
- DT9 (13 St Augustines Street) - 40.2µg/m^3
- DT11 (52 St Augustines Street) – 50.7µg/m^3
- DT13 (Castle Meadow) – 45.9µg/m^3
- DT14 (Castle Meadow 2) – 41.1µg/m^3
- DT26 (3 Riverside Road) – 46.7µg/m^3
- DT29 (4 Chapelfield North) – 45.8µg/m^3

All of the above diffusion tube sites are within the existing Norwich Central AQMA, though the tubes at St Stephens Street, 13 St Augustines Street, Castle Meadow and Castle Meadow 2 are currently not situated at locations representative of relevant exposure for the NO_2 annual mean. Box 1.1 of the LAQM Technical Guidance (16) presents “Examples of Where the Air Quality Objectives Should Apply”.

The Castle Meadow diffusion tube (DT13) indicated an annual mean of 46µg/m^3 which is significantly less than last years annual mean of 56µg/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. This year there was not a close agreement between the results from the diffusion tube and the automatic analyser which suggests the pollution can vary quite considerably along this road. The automatic analyser is sited immediately adjacent to a bus stop which itself is close to a set of traffic lights which can promote static traffic, especially at peak times. This scenario would support the view that particularly high levels of pollution can be quite localised.

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 2016 the site indicated an annual mean of 46µg/m^3 which, although still an exceedance of the objective, is a considerable improvement over the previous situation. Monitoring will continue to establish whether compliance with the nitrogen dioxide annual mean is achieved in the coming years and the area will be reviewed to identify if the road changes have caused congestion elsewhere. Although it must be noted the new road layout moves traffic further away from sites of relevant exposure.

The St Augustines Street site at no 52 has been monitored for many years. Concentration levels have remained relatively static over the last few years with an annual mean of 51µg/m^3 in 2016. In 2015 the annual mean was 53 µg/m^3. This diffusion tube 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 few years but now appears to be levelling out at around 47 µg/m^3.

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 20µg/m^3 which is below the annual mean objective of 40µg/m^3. There were 4 exceedances of the 24-hour mean of 50µg/m^3 (35 allowed), and the maximum daily mean recorded was 60µg/m^3 (90.1% 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 was just 1 exceedance of the 24-hour mean at 56µg/m^3. The annual mean concentration was 16µg/m^3 (76% 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 5 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.

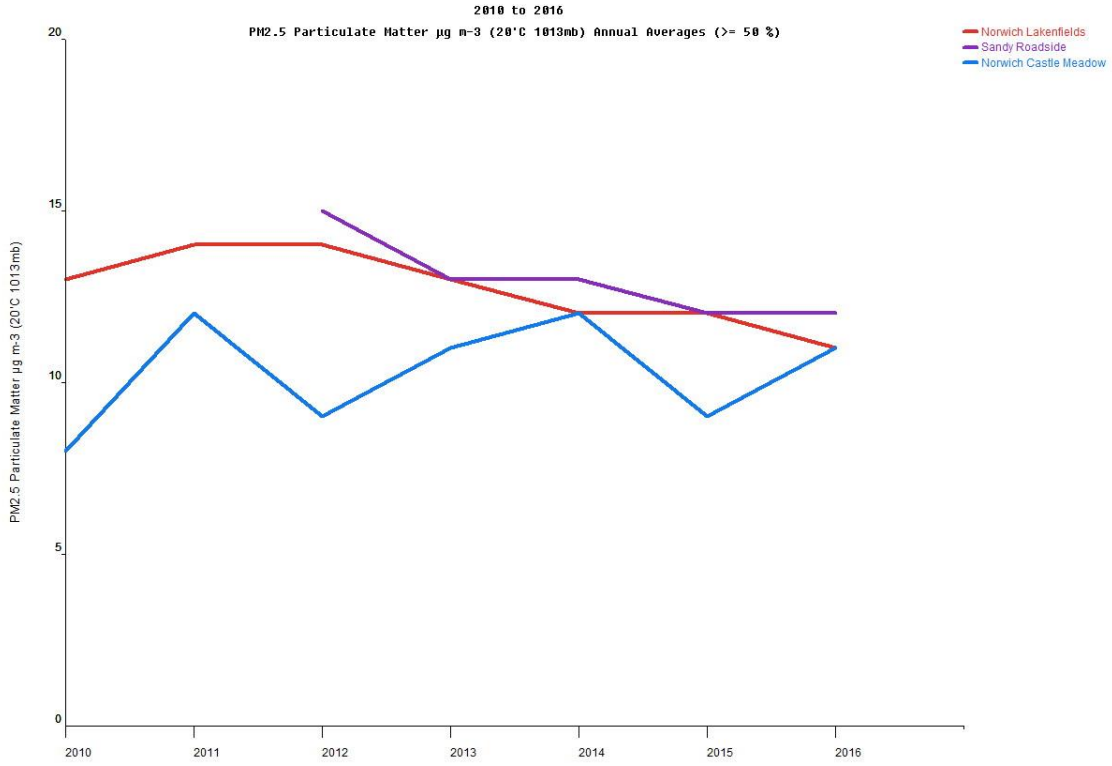
Figure 3.1 below shows the annual mean concentrations at both sites plus additional comparison has been made with the AURN station at Sandy in Bedford which is a roadside site and operates an FDMS analyser. The Castle Meadow TEOM is missing some of the monthly peaks but the average looks similar when comparing all 3 sites. The figure also demonstrates that both Norwich sites already comfortably meet the annual average EU limit value of 25µg/m^3 which is to be met by 2020.

It must however be noted that this is not in regulatory standards for local authorities.

There has 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.

It is considered that in seeking to reduce the concentration levels of other pollutants, namely NO2 from road traffic, a beneficial impact on $PM_{2.5}$ concentrations 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



Appendix A: Monitoring Results

Table A.1 – Details of Automatic Monitoring Sites

Site ID	Site Name	Site Type	X OS Grid Ref	Y 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	623202	308615	PM_{10}, NO_x, NO_2, $PM_{2.5}$	Y	Chemiluminescent (Ambirak); TEOM	N/A	1	2.5
CM2	Lakenfields	Urban Background	623637	306940	O_3, PM_{10}, NO_x, NO_2, $PM_{2.5}$	N	Chemiluminescent (Thermo); FDMS	20	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	X OS Grid Ref	Y OS Grid Ref	Pollutants Monitored	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	623863.04	307678.60	NO_2	Y	0	3.5	N	1.5
DT2	Queens Rd Travelodge	Roadside	622917.08	307974.49	NO_2	Y	N/A	5	N	2.5
DT3	St Stephens (mid)	Kerbside	622879.16	308089.96	NO_2	Y	N/A	2	N	2.5
DT4	Lakenfields	Urban Background	623681.24	307015.82	NO_2	N	20	1.5	Y	2.5
DT5	Chalk Hill Road	Roadside	623906.97	308596.92	NO_2	Y	0	7	N	2.5
DT6	130 Magdalen Street	Roadside	623160.89	309550.43	NO_2	Y	0	4	N	2.5
DT7	Reads Flour Mill	Kerbside	623796.25	307772.13	NO_2	Y	0	1	N	2.5
DT9	13 St Augustines St	Kerbside	622905.81	309496.11	NO_2	Y	N/A	1	N	2.5
DT10	32 St Augustines St	Kerbside	622865.96	309529.93	NO_2	Y	0	2	N	2.5
DT11	52 St Augustines St	Kerbside	622825.87	309573.17	NO_2	Y	0	1	N	2.5

Site ID	Site Name	Site Type	X OS Grid Ref	Y OS Grid Ref	Pollutants Monitored	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	622813.72	309609.96	NO_2	Y	0	1	N	2.5
DT13	Castle Meadow	Roadside	623141.06	308606.69	NO_2	Y	N/A	2.5	N	2.5
DT14	Castle Meadow 2	Roadside	623250.50	308590.12	NO_2	Y	N/A	1.5	N	2.5
DT16	Zipfel House	Roadside	623185.69	309649.68	NO_2	Y	0	3	N	2.5
DT17	68 Bull Close Road	Roadside	623305.49	309543.95	NO_2	Y	0	4	N	1.5
DT18	Upper King Street	Kerbside	623337.40	308632.52	NO_2	Y	N/A	1.5	N	2.5
DT19	Cattlemarket Street	Roadside	623320.58	308430.88	NO_2	Y	0	2	N	2.5
DT20	Exchange St	Kerbside	623007.27	308716.34	NO_2	Y	N/A	1	N	2.5
DT21	Rotary House King Street	Roadside	623879.53	307658.91	NO_2	Y	3	2	N	1.5
DT22	Carrow Bridge House	Roadside	623900.96	307709.56	NO_2	Y	0	5	N	1.5
DT23	62 Magpie Road	Roadside	622970.72	309652.02	NO_2	Y	0	2	N	1.5

Site ID	Site Name	Site Type	X OS Grid Ref	Y OS Grid Ref	Pollutants Monitored	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	623228.63	309625.14	NO_2	Y	0	5.5	N	1.5
DT25	24 Bargate Court	Roadside	623422.42	309388.23	NO_2	Y	0	4	N	2.5
DT26	3 Riverside Road	Roadside	623870.26	308515.77	NO_2	Y	0	3	N	2.5
DT28	71 Dukes Court	Roadside	622431.35	308663.05	NO_2	Y	0	4	N	2.5
DT29	4 Chapelfield North	Kerbside	622532.23	308490.36	NO_2	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).

N/A not applicable because Relevant Exposure too distant to be relevant.

(2) N/A if not applicable.

Table A.3 – Annual Mean NO_2 Monitoring Results 2011 to 2016

Site ID	Site Type	Monitoring Type	Location	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2016 (%) (2)	NO_2 Annual Mean Concentration ($\mu g/m^3$) (3)				
						2012	2013	2014	2015	2016
CM1	Urban Roadside	Automatic	Castle Meadow	95	95	**53**	**64**	**66**	**55**	**56**
CM2	Urban Background	Automatic	Lakenfields	86	86	14	15	14	12.0	14.2
DT1	Roadside	Diffusion tube	256 King Street	100	100	**43.8**	39.7	**41.5**	36.2	37.7
DT2	Roadside	Diffusion tube	Queens Rd Travelodge	100	100	33.9	38.8	33.6	30.9	33.2
DT3	Kerbside	Diffusion tube	St Stephens (mid)	100	100	**61.6**	**55.4**	**59.6**	**42.9**	**41.1**
DT4	Urban Background	Diffusion tube	Lakenfields	100	100	14.1	13.2	12.5	11.8	12.9
DT5	Roadside	Diffusion tube	Chalk Hill Road	100	100	32.6	32.9	32.9	29.2	29.9
DT6	Roadside	Diffusion tube	130 Magdalen Street	100	100	32.7	32.7	30.9	28.4	29.6
DT7	Kerbside	Diffusion tube	Reads Flour Mill	92	92	24.1	23.5	23.2	21.2	21.6
DT9	Kerbside	Diffusion tube	13 St Augustines St	100	100	**41.7**	**45.1**	**41.9**	37.6	**40.2**
DT10	Kerbside	Diffusion tube	32 St Augustines St	100	100	**40.1**	**42.8**	39.4	37.5	35.7
DT11	Kerbside	Diffusion tube	52 St Augustines St	92	92	**52.1**	**51.2**	**48.6**	**53.5**	**50.7**
DT12	Kerbside	Diffusion tube	65 St Augustines St	92	92	35.1	33.2	31.9	31.4	30.8

Site ID	Site Type	Monitoring Type	Location	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2016 (%) (2)	NO_2 Annual Mean Concentration ($\mu g/m^3$) (3)				
						2012	2013	2014	2015	2016
DT13	Roadside	Diffusion tube	Castle Meadow	100	100	**57.2**	**63.5**	**56.3**	**56.4**	**45.9**
DT14	Roadside	Diffusion tube	Castle Meadow 2	100	100	**53.8**	**52.4**	**50.5**	**48.1**	**41.1**
DT16	Roadside	Diffusion tube	Zipfel House	100	100	**44.2**	**40.9**	39	34.8	38.6
DT17	Roadside	Diffusion tube	68 Bull Close Road	92	92	31.2	29.8	29	26.9	26.9
DT18	Kerbside	Diffusion tube	Upper King Street	100	100	37.2	35.6	33.1	32.2	28.8
DT19	Roadside	Diffusion tube	Cattlemarket Street	100	100	**47.2**	**46.7**	**46**	37.9	39.1
DT20	Kerbside	Diffusion tube	Exchange St	100	100	30.7	30.3	31	27.5	31.6
DT21	Roadside	Diffusion tube	Rotary House King Street	100	100	38.1	36.7	36.6	34.3	32.9
DT22	Roadside	Diffusion tube	Carrow Bridge House	100	100	26.1	27.2	24.7	21.6	23.3
DT23	Roadside	Diffusion tube	62 Magpie Road	100	100	34.4	33.1	32.1	29.6	29.4
DT24	Roadside	Diffusion tube	26 Bull Close Road	100	100	34.6	32.2	31.5	30.0	30.2
DT25	Roadside	Diffusion tube	24 Bargate Court	100	100	36.9	37.2	35.1	34.2	35.0
DT26	Roadside	Diffusion tube	3 Riverside Road	100	100	**51**	**52.4**	**51.2**	**47.2**	**46.7**

Site ID	Site Type	Monitoring Type	Location	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2016 (%) (2)	NO_2 Annual Mean Concentration ($\mu g/m^3$) (3)				
						2012	2013	2014	2015	2016
DT28	Roadside	Diffusion tube	71 Dukes Court	100	100	27.8	28.1	25.8	23.8	25.3
DT29	Kerbside	Diffusion tube	4 Chapelfield North	100	100	-	**60.9**	38.1	**43.0**	**45.8**

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

NO_2 annual means exceeding $60\mu g/m^3$, 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 Boxes 7.9 and 7.10 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 2016

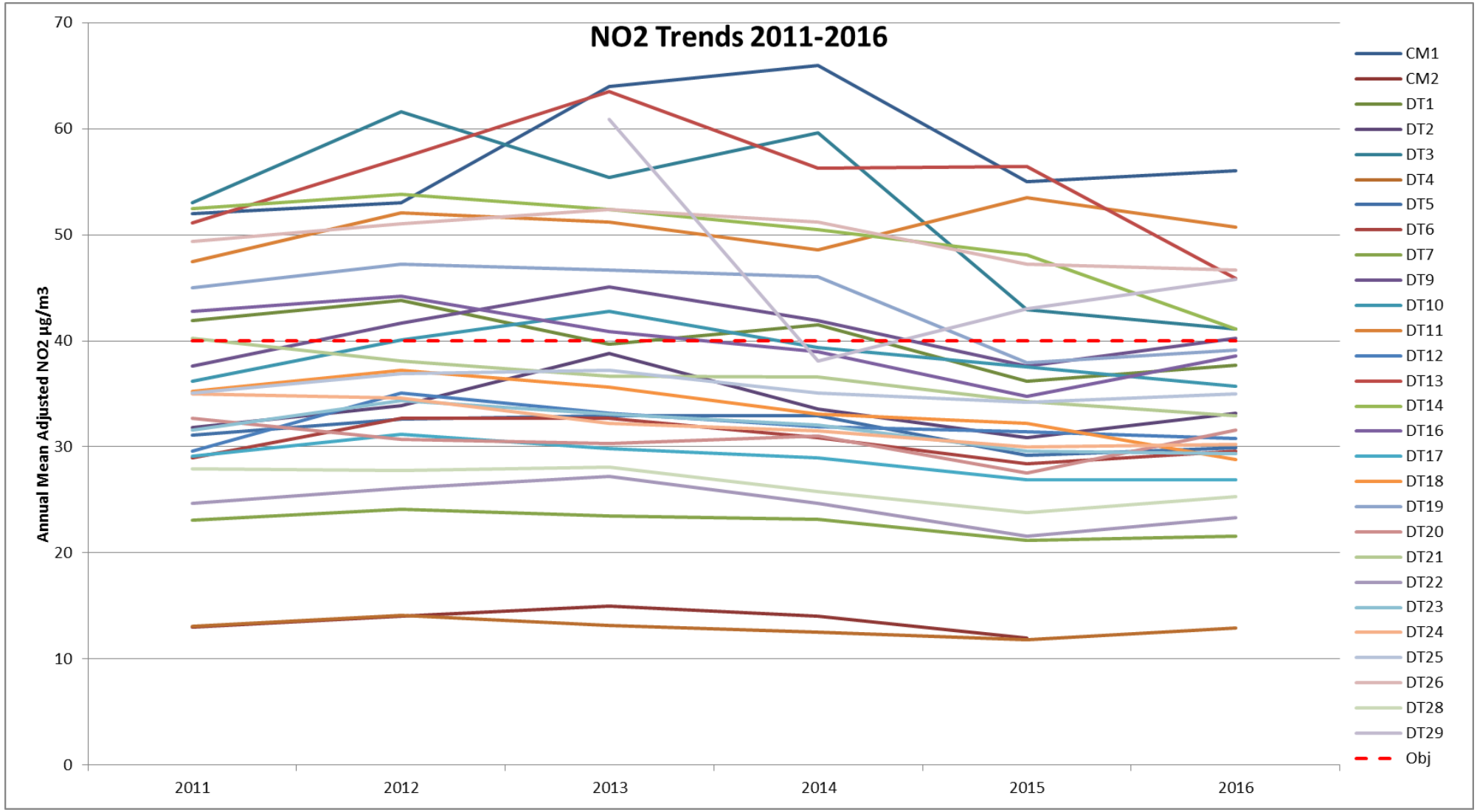


Table A.4 – 1-Hour Mean NO_2 Monitoring Results

Site ID	Site Type	Monitoring Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2016 (%) (2)	NO_2 1-Hour Means > 200µg/m^3 (3)				
					2012	2013	2014	2015	2016
CM1	Urban Roadside	Automatic	94	94	4	**72**	**57**	6	4
CM2	Urban Background	Automatic	91	91	0	0	0	0 (55)	0

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 85%, 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 2016 (%) (2)	PM_{10} Annual Mean Concentration ($\mu g/m^3$) (3)				
				2012	2013	2014	2015	2016
CM1	Urban Roadside	90.1	90.1	17	25	21	21	20
CM2	Urban Background	76	76	14	15	16	15	16

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 Boxes 7.9 and 7.10 in 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 2016 (%) (2)	PM_{10} 24-Hour Means > 50µg/m^3 (3)				
				2012	2013	2014	2015	2016
CM1	Urban Roadside	90	90	7	15	9	6	4
CM2	Urban Background	76	76	1	3	0	5	1(27)

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 85%, 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 2016 (%) (2)	$PM_{2.5}$ Annual Mean Concentration ($\mu g/m^3$) (3)				
				2012	2013	2014	2015	2016
CM1	Urban Roadside	93.2	93.2	9	11	12	9	11
CM2	Urban Background	78	78	14	13	12	12	11

(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 Boxes 7.9 and 7.10 in 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 2016

Table B.1 – NO_2 Monthly Diffusion Tube Results - 2016

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 (1.01) and annualised (1)	Distance Corrected to Nearest Exposure (2)
DT1	44.1	38.7	36.3	28.9	35.0	30.5	32.0	31.3	48.3	35.4	42.0	49.8	37.3	37.7	N/A
DT2	27.1	28.4	35.7	28.7	34.3	29.8	26.7	32.0	37.8	42.6	38.6	36.6	32.9	33.2	N/A
DT3	45.4	40.7	37.5	36.1	40.3	32.2	35.4	35.9	51.7	39.5	45.6	52.4	40.7	**41.1**	N/A
DT4	15.9	13.7	12.4	9.0	10.2	7.9	8.3	10.0	14.3	12.1	18.5	22.6	12.8	12.9	N/A
DT5	33.6	32.8	26.6	24.5	26.3	30.4	25.8	26.5	33.1	30.0	37.5	32.1	29.6	29.9	N/A
DT6	32.0	31.2	28.8	26.9	28.1	27.1	21.9	25.2	33.5	28.7	34.0	38.0	29.3	29.6	N/A
DT7	26.5	21.1	0.0	16.0	17.4	16.7	17.0	17.8	24.5	25.0	29.5	25.8	21.4	21.6	N/A
DT9	35.4	36.6	39.4	33.9	41.2	41.6	30.8	38.2	48.4	43.1	47.0	46.9	39.8	**40.2**	N/A
DT10	34.6	36.9	28.8	34.4	34.1	33.6	34.5	0.0	0.0	36.8	39.5	43.5	35.3	35.7	N/A

Site ID	NO_2 Mean Concentrations (µg/m^3)														
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean		
													Raw Data	Bias Adjusted (1.01) and annualised (1)	Distance Corrected to Nearest Exposure (2)
DT11	52.8	49.1	47.8	43.3	50.1	46.8	0.0	46.3	64.3	49.0	57.1	0.0	50.2	**50.7**	N/A
DT12	40.5	0.0	27.2	24.7	29.5	22.9	27.7	29.1	35.6	28.4	35.2	38.3	30.5	30.8	N/A
DT13	45.2	48.1	47.4	43.9	0.0	46.9	38.6	45.5	51.8	47.2	45.9	44.8	45.5	**45.9**	N/A
DT14	46.0	41.2	34.6	27.2	40.1	34.9	39.8	45.4	52.2	43.2	43.2	44.9	40.6	**41.1**	N/A
DT16	44.7	39.7	36.4	23.0	35.1	31.5	37.7	37.1	47.9	34.5	42.0	53.7	38.2	38.6	N/A
DT17	31.1	29.5	26.2	22.8	23.9	19.6	23.6	25.3	0.0	24.8	34.7	34.8	26.7	26.9	N/A
DT18	34.3	30.6	26.4	23.8	25.2	21.7	28.0	27.4	28.4	28.8	33.5	37.6	28.5	28.8	N/A
DT19	38.2	32.2	36.7	34.4	44.2	36.2	32.9	34.6	54.1	39.2	43.2	43.1	38.7	39.1	N/A
DT20	40.0	30.2	27.4	24.7	26.7	32.8	18.6	22.2	41.7	32.8	40.9	41.5	31.3	31.6	N/A
DT21	37.9	34.8	31.0	32.7	34.5	29.8	33.1	33.0	36.3	32.2	31.0	28.1	32.5	32.9	N/A
DT22	26.3	27.3	24.3	29.1	20.6	17.2	17.1	18.7	26.1	25.2	19.3	28.7	23.1	23.3	N/A

Site ID	NO_2 Mean Concentrations (µg/m^3)														
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Mean		
													Raw Data	Bias Adjusted (1.01) and annualised (1)	Distance Corrected to Nearest Exposure (2)
DT23	37.1	32.0	23.9	28.6	28.9	21.6	29.0	27.3	18.7	29.9	34.6	41.6	29.1	29.4	N/A
DT24	35.3	33.4	27.2	25.5	26.7	22.8	29.5	28.9	34.8	28.1	33.8	36.6	29.9	30.2	N/A
DT25	34.5	36.6	34.7	27.9	35.2	31.9	32.3	0.0	35.9	36.1	38.9	41.3	34.7	35.0	N/A
DT26	50.3	45.9	40.9	39.2	45.1	38.3	46.6	45.4	61.4	43.6	49.6	54.2	46.2	**46.7**	N/A
DT28	28.4	27.2	27.1	21.7	24.5	19.6	19.8	20.6	28.6	25.0	31.9	29.3	25.1	25.3	N/A
DT29	35.7	40.2	44.4	39.6	43.9	55.0	45.3	46.6	57.0	50.3	50.0	42.0	45.4	**45.8**	N/A

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) See Appendix C for details on bias adjustment and annualisation.

(2) Distance corrected to nearest relevant public exposure (**If N/A because either no relevant exposure or measurement <40µg/m^3**).

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): **1.01**

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: **1.14** (1.06-1.23)
Bias B: -12% (-18% - -5%)
Diffusion Tubes Mean: 13µg/m³
Automatic Mean: 15µg/m³
Data Capture for periods used: 99%
Adjusted Tubes Mean: 15 (14-16) 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	05/01/2016	01/02/2016	16.0	15.3	16.0	16	0.4	2	1.0	16.7	98.9	Good	Good
2	01/02/2016	01/03/2016	13.5	14.3	12.9	14	0.7	5	1.8	16.5	98.7	Good	Good
3	01/03/2016	30/03/2016	13.2	12.0	11.7	12	0.8	7	2.0	13.8	99.7	Good	Good
4	30/03/2016	26/04/2016	8.5	8.9	9.3	9	0.4	5	1.0	12.2	96.1	Good	Good
5	26/04/2016	24/05/2016	10.7	10.1	9.3	10	0.7	7	1.7	12	99	Good	Good
6	24/05/2016	27/06/2016	7.8	7.4	8.2	8	0.4	5	1.0	9	99.8	Good	Good
7	27/06/2016	26/07/2016	7.8	8.5	8.3	8	0.4	5	0.9	8	94.7	Good	Good
8	26/07/2016	06/09/2016	9.8	9.5	10.5	10	0.5	6	1.4	8	52.4	Good	r Data Capture
9	06/09/2016	27/09/2016	13.6	14.8	14.2	14	0.6	4	1.5	12	57.5	Good	r Data Capture
10	27/09/2016	29/10/2016	12.0	12.1	11.0	12	0.6	5	1.5	15	99.7	Good	Good
11	29/10/2016	05/12/2016	18.2	17.4	19.5	18	1.1	6	2.6	21.1	99.7	Good	Good
12	05/12/2016	09/01/2017	22.3	22.6	22.2	22	0.2	1	0.5	22.7	99.8	Good	Good
13													

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

Overall survey --> Good Good

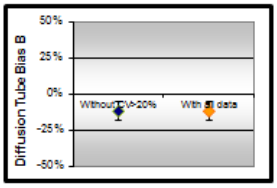
Site Name/ ID: Norwich Lakenfields

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 10 periods of data	
Bias factor A	1.14 (1.06 - 1.23)
Bias B	-12% (-18% - -5%)
Diffusion Tubes Mean:	13 µgm⁻³
Mean CV (Precision):	5
Automatic Mean:	15 µgm⁻³
Data Capture for periods used:	99%
Adjusted Tubes Mean:	15 (14 - 16) µgm⁻³

Accuracy (with 95% confidence interval) WITH ALL DATA	
Bias calculated using 10 periods of data	
Bias factor A	1.14 (1.06 - 1.23)
Bias B	-12% (-18% - -5%)
Diffusion Tubes Mean:	13 µgm⁻³
Mean CV (Precision):	5
Automatic Mean:	15 µgm⁻³
Data Capture for periods used:	99%
Adjusted Tubes Mean:	15 (14 - 16) 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 co-location 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. In addition there were 2 months of poor data capture from the local automatic analyser as indicated in the Checking Precision & Accuracy of Triplicate Tubes table.

Therefore, to be as accurate as is reasonably possible using diffusion tubes, it was decided to use a correction derived from the national database of 18 surveys (this does not include Norwich as Norwich will not now be included until the September 2017 update). The nationally derived bias adjustment factor of 1.01 has therefore been applied.

The Spreadsheet of National Bias Adjustment Factors (v.06/17) is shown below.

National Diffusion Tube Bias Adjustment Factor Spreadsheet — Spreadsheet Version Number: 06/17

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 spreadsheet 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 2017
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: Select the Laboratory that Analyses Your Tubes from the Drop-Down List

If a laboratory is not shown, we have no data for this laboratory.

Step 2: Select a Preparation Method from the Drop-Down List

If a preparation method is not shown, we have no data for this method at this laboratory.

Step 3: Select a Year from the Drop-Down List

If a year is not shown, we have no data[2]

Step 4: **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 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[4]	Bias Adjustment Factor (A) (Cm/Dm)
Aberdeen Scientific Services	20% TEA in water	2016		Overall Factor[3] (7 studies)				Use		0.85
Edinburgh Scientific Services	50% TEA in acetone	2016		Overall Factor[3] (6 studies)				Use		0.77
ESG Didcot	20% TEA in water	2016		Overall Factor[3] (3 studies)				Use		0.83
ESG Didcot	50% TEA in acetone	2016		Overall Factor[3] (38 studies)				Use		0.78
ESG Glasgow	20% TEA in water	2016		Overall Factor[3] (1 study)				Use		0.79
ESG Glasgow	50% TEA in acetone	2016		Overall Factor[3] (1 study)				Use		0.78
Glasgow Scientific Services	20% TEA in water	2016		Overall Factor[3] (9 studies)				Use		0.97
Gradko	20% TEA in water	2016		Overall Factor[3] (27 studies)				Use		0.92
Gradko	50% TEA in acetone	2016		Overall Factor[3] (18 studies)				Use		1.01
Lambeth Scientific Services	50% TEA in acetone	2016		Overall Factor[3] (5 study)				Use		1.04
Milton Keynes Council	20% TEA in water	2016		Overall Factor[3] (1 study)				Use		0.74
Northampton BC	20% TEA in water	2016		Overall Factor[3] (3 studies)				Use		0.85
Somerset County Council	20% TEA in water	2016		Overall Factor[3] (3 studies)				Use		0.88
South Yorkshire Air Quality Samplers	50% TEA in acetone	2016		Overall Factor[3] (2 studies)				Use		0.83
Staffordshire Scientific Services	20% TEA in water	2016		Overall Factor[3] (12 studies)				Use		0.91
Tayside Scientific Services	20% TEA in water	2016		Overall Factor[3] (5 studies)				Use		0.82
West Yorkshire Analytical Services	50% TEA in acetone	2016		Overall Factor[3] (7 studies)				Use		0.75

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 at Castle Meadow roadside station and 4-weekly calibrations at Lakenfields urban background station;
- Annual audits;
- 6-monthly servicing of the monitoring sites; 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 sites 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.

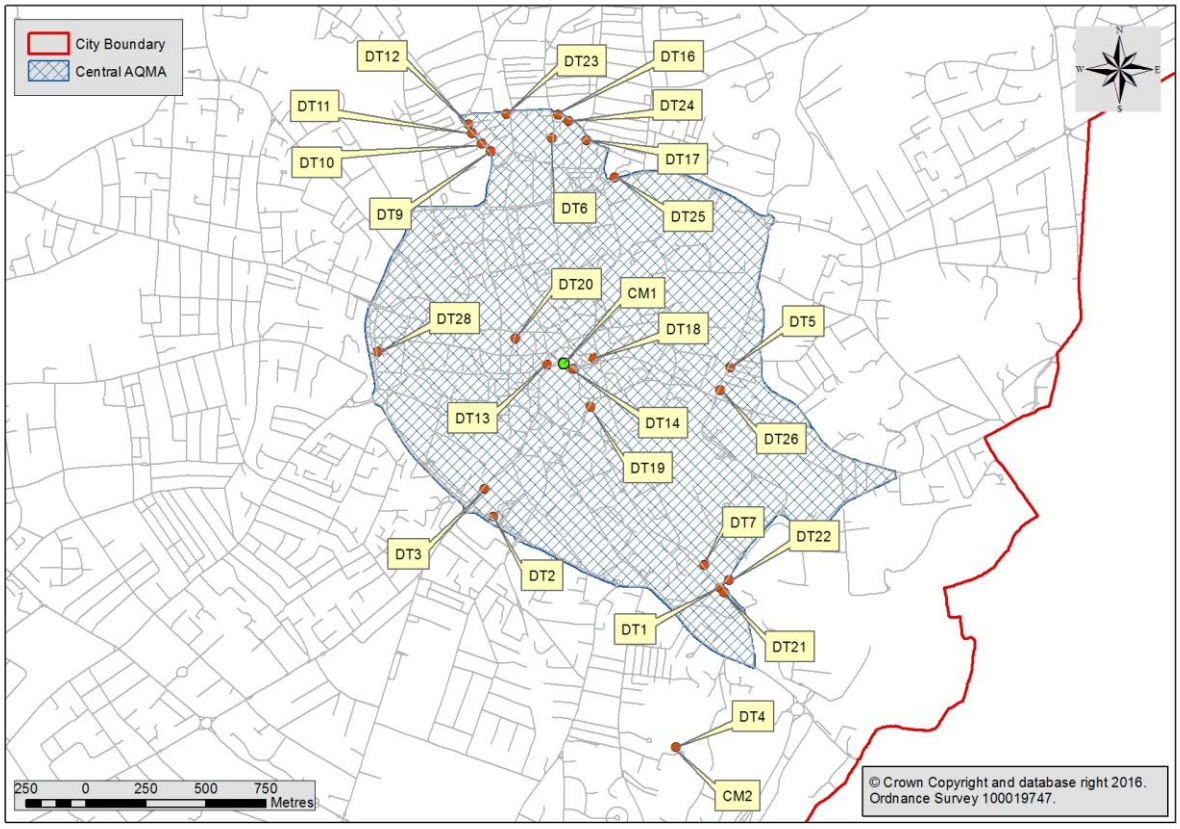
The final stage of the QA/QC process was to ratify the data. During ratification, all calibration, audit and service data are collated and the data is appropriately scaled. Any suspect data identified are deleted, thereby ensuring that the data sets are of a high quality. The Castle Meadow data was ratified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

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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