2019 Air Quality Annual Status Report (ASR)

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

June 2019

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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 Norwich City Council (also referred to as 'the council') permits 33 'Part B' processes, including petrol stations, road stone coating plant, timber and cement batching installations, aircraft & vehicle re-sprayers and a crematorium. The Environment Agency permits larger 'Part A' processes which, in Norwich, constitutes Briar, an agrochemical company. No 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 .

Norwich City Council proposes to continue with automatic and passive NO_2 monitoring within the city area. However, in response to road changes, which have aimed at restricting general traffic from travelling through the city centre, at the start of 2018, 13 NO_2 diffusion tube monitoring positions were removed and 9 new locations added. The purpose of these changes was to site tubes so as to best assess any impact the road changes have had on NO2 levels. This includes locations which are now taking higher loading of traffic as a result of the road changes. In addition, diffusion tubes have been removed that do not represent relevant exposure, and/or where levels have consistently fallen below the objective

level. It is therefore felt the data presented in this report gives a good indication of pollution levels at key locations. Re-assessment of the passive diffusion tube (DT) monitoring positions will continue as further road infrastructure changes are implemented.

A detailed assessment is not required for any pollutants and the council will progress to the next Annual Status Report in 2020. Also in 2020, a review of the 2015 Action Plan will be undertaken. This will be interesting as most if not all of the major road changes will have been implemented. Although the benefits may not be realised until a further year or so on.

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 City

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 since 1998. This report considers all new monitoring data acquired during 2018 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.

[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 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 on Castle Meadow. The city also benefits from having a Government-owned AURN urban background station (Norwich Lakenfields) in its area (though not in the AQMA). Data from these stations are used within the report.

The automatic analyser at Castle Meadow shows that there are still challenges on this bus & taxi only street. Annual mean levels have been fairly consistent over the last few years, exceeding the objective level by around 14µg/m^3. This year however the 1 hour mean was also exceeded, albeit only by 1 additional exceedance of the 200µg/m^3 allowance of 18 times/year.

Overall, NO_2 concentrations within the central AQMA are falling. In 2012, 10 of the diffusion tube monitoring locations exceeded the annual mean objective of 40µg/m^3. This steadily reduced to 6 in 2015 despite an additional site being added in 2013 on Chapel Field North. In 2016 the number of locations exceeding the annual mean objective increased to 7 sites but 3 of these only by 1µg/m^3. In 2017 the number of sites dropped back down to 6. In 2018, levels fell again and quite significantly and, after DT locations having been rationalised and distance corrections applied, only 2 locations exceeded the objective level, only 1 of which representing relevant exposure - 52 St Augustines Street.

There are not considered to be any new major sources of pollution. Hence although there are still challenges to reduce pollution levels in Norwich, the results this year look very promising and, provided these levels are maintained, suggest the measures identified in the Action Plan are working.

Measures to reduce NO_2 from road traffic will also, to some extent, have a positive benefit on reducing $PM_{2.5}$ levels although $PM_{2.5}$ in Norwich is known to be mostly a transboundary rather than city derived pollutant and hence strongly affected by meteorology. Both Castle Meadow & Norwich Lakenfields automatic stations show

that the annual mean objective level of 25µg/m^3 (not set in Regulations) was easily met and in 2018 both stations also met the World Health Organisation recommended guideline level of 10µg/m^3.

Actions to Improve Air Quality

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

The 2015 Air Quality Action Plan (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 by concentrating on these strategies in particular. As a result, the AQAP focussed principally on road infrastructure changes designed to further pedestrianise and divert general traffic away from the congested city centre. In addition the policy has been to encourage the use of public transport by prioritising bus routes, improving bus frequency on key routes and providing easy access to Park & Ride facilities. The policy has also been to encourage cycling by lengthening and linking up cycle routes. 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. Most of the road changes have now been implemented but the bus and taxi only roads remain some of the most polluted streets in Norwich and hence Norfolk County Council are also concentrating efforts to encourage bus companies to upgrade or replace the older more polluting vehicles. This strategy will be strengthened by the proposed revision of the Bus Charter to introduce target dates for Euro 5 and then Euro 6 compliance initially within the Low Emission Zone.

Work is now complete in the Westlegate area of Norwich and also the adjoining Ber Street, Golden Ball Street, All Saints Green, Red Lion Street and St Stephen's 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. On some of these streets this also includes the removal of private motorised vehicles giving access only to buses, coaches, taxis, delivery vehicles and bikes. These changes 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 implementation of new road layout and junction arrangements in the Chapel Field area of Norwich which revised the traffic flow 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 61µg/m^3 in 2013 to around 38µg/m^3 (when distance corrected) in both 2018 and 2017, thus improving air quality for residents fronting the road and those using the public gardens opposite. The traffic from Chapel Field North has now been fed onto Cleveland Road and Bethel Street where, in 2018, new diffusion tubes were installed. Even without distance correction, both these locations show NO_2 levels to be well below the objective level.

Reassuringly other streets which have been identified as likely to take a greater volume of traffic as a result of the road changes have all come in under the objective level. Greater detail is presented in Section 3.2.1.

All these above mentioned areas are within the central AQMA.

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 having been taken by Norfolk County Council is the construction of the Norwich Northern Distributor Road (NDR) which was completed in April 2017. The NDR provides 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 general traffic 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.

It is not expected that the full benefits will be seen for another year or so, until the road is fully utilised but traffic monitoring has been completed and is currently being analysed. Plans continue to be progressed to construct the Western Link, which will connect the western end of the NDR with the A47 to the west of Norwich. Construction is expected late 2022 but a key aim of this scheme is to remove traffic from congested suburban city streets as well as the outer ring road west of the city. It is probably not until there is completion of this final link that the greatest impact in the city will be seen.

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. 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. All new vehicles are fitted with Euro 6 engines.

In 2016 through a Department for Transport (DfT) grant - Clean Technology Fund - 24 buses that were previously Euro 3 or 4 standard were upgraded to close to Euro 6 through a program of retrofitting using Selective Catalytic Reduction Technology (SCRT).

The upgrading of bus fleets is a slow and costly process but County Council continues to work with the bus operators and continues to apply for grants on their

behalf in order to upgrade and replace the current fleet of older more polluting vehicles.

A more immediate beneficial impact on air quality is considered to be engine switch off when idling. In 2018, Norwich City Council applied to the Secretary of State for enforcement powers in order to enact the Road Traffic Regulations 2002 with the ultimate aim to issue Fixed Penalty Notices for engine switch off offences. These powers were acquired in early 2018 and enforcement commenced in the autumn on bus and taxi only roads ie Castle Meadow and St Stephens Street. It is anticipated that this policy will eventually be rolled out across the city but primary concern is within the AQMA. Any results from this enforcement action is not expected to be seen until the 2019 data is analysed.

The Bus Charter for Norwich, brought in in 2009, is due a comprehensive review. Targets are to be set which reflect the progress in engine technology and current pollution issues. The revision will set target dates for Euro 5 and then Euro 6 compliant only buses in certain parts of the city, starting with buses transiting through the Low Emission Zone. At a later date it is expected that this compliance will be required across the whole city. The Bus Charter revision is also welcomed by councils outside Norwich as buses that transit through Norwich also travel through the rural towns and villages.

The council works with other Local Authorities which comprise the Norfolk Environmental Protection Group (NEPG) Air Quality sub-group to ensure consistency of approach throughout the county but also to engage with representatives of Public Health England and Public Health Norfolk as well as Highways at Norfolk County Council. Both Highways and Public Health representatives now participate in the NEPG sub-group meetings and play an important role at helping the group achieve its aims and vice versa, such as participation in a collaborative Norfolk Clean Air Day event and identifying potential funding initiatives.

In addition, in early 2018, a working group of representatives from Norwich City Council, Broadland District Council, South Norfolk Council and Norfolk County Council (Highways) was set up specifically to develop a multi-authority approach to tackling poor air quality from transport with the Greater Norwich Area. The aims of the group are;

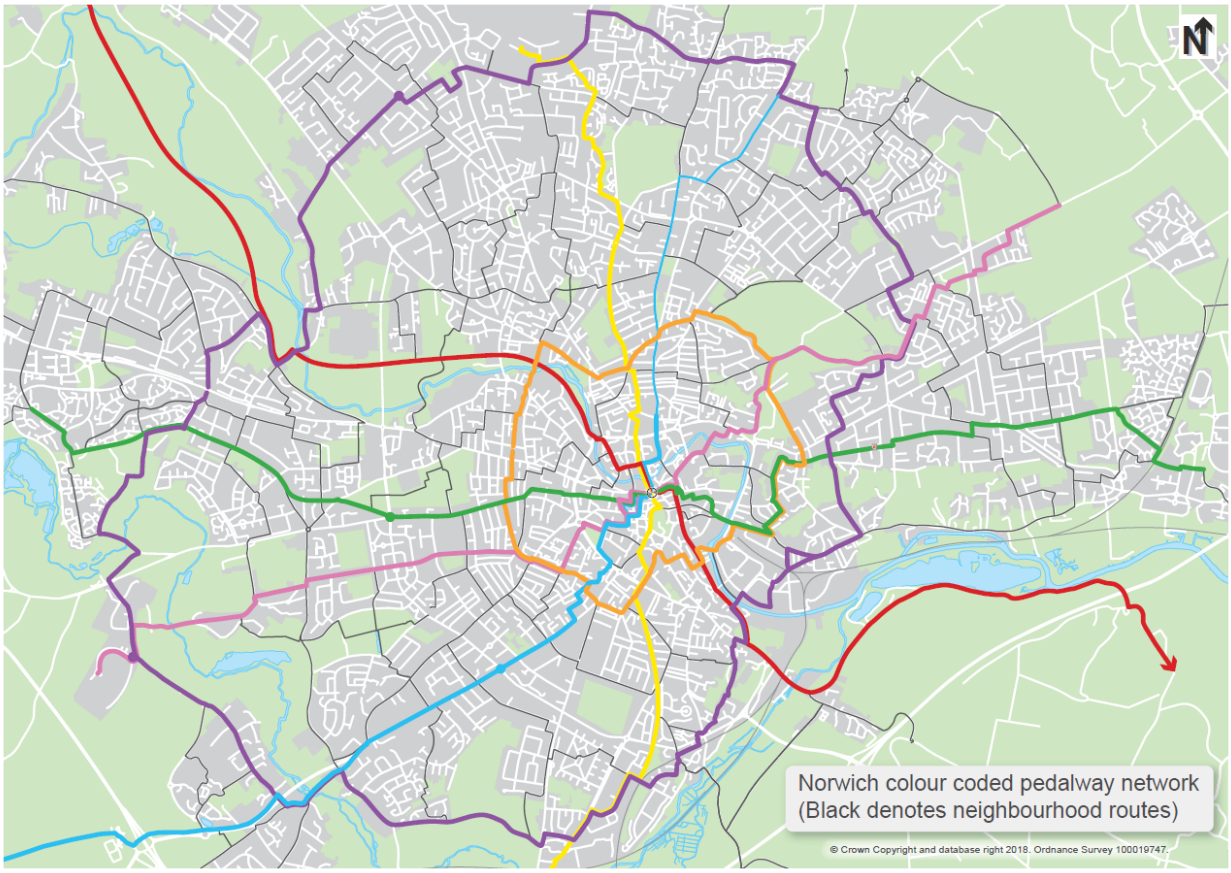
- To produce a positive change to air quality from transport.

- To develop better education of all road users to the effect of transport emissions on human health and the wider environment.
- Commit to working as a team to consider air quality as a cross boundary issue.
- Commit to working with stakeholders to develop and implement projects.
- Identify joint funding opportunities for delivering air quality projects.
- Collate data on air quality before, during and after projects.
- Evaluate the impact of air quality improvement projects and determine if they have been effective and appropriate to be adopted elsewhere.
- Share findings of projects with interested third parties.

Clearly benefits aimed at improving air quality in adjoining district councils have a positive impact for the city, especially when it comes to improvements in bus fleets which serve not just Norwich but the communities beyond.

It has been a long standing commitment in the Norwich Area Transportation Strategy (NATS) that the priority is to promote walking, cycling and the use of public transport in order to encourage a modal shift by reducing the reliance on the private car. In support of this commitment, in 2012 a cycle network for the greater Norwich area was adopted which included 5 radial and 2 orbital pedalway routes and a number of neighbourhood cycle routes connecting those pedalway routes. Each of the 7 pedalways was colour coded.

See City Schematic of Norwich Pedalways below.



Since being awarded Cycle City Ambition status in 2013, Norwich has seen a significant increase in cycling. In 2018 there were 37% more cyclists crossing the inner and outer ring roads than in 2013 (data from annual ring road count undertaken each autumn). Over the same 2013-2018 period, cycling on Newmarket Road, a section of the blue pedalway in the west of the city (and completed as part of the second phase of Cycle City Ambition funding), more than doubled.

With 13% of adults cycling 3 or more times per week for travel, Norwich is now 4th placed Local Authority in England for this measure* (for comparison against 5% in Norfolk and 3.3% in England). With increasing cycle connectivity, this figure is only expected to increase.

Electric vehicle charging points have now been increased to 51 x 7kW or above within the Norwich City Council district boundary. 7 of these are owned by the council and are located in Rose Lane Car Park (6 X 7kW) and one 50kW rapid charger in Earlham Park Car Park next to the University of East Anglia Enterprise Centre. The council will continue to encourage the installation of electric charging points and, for the larger scale planning developments, have made it an objective of the application.

*Based on the government's national travel survey

A good working relationship has been developed with the Environmental Science Department at University of East Anglia (UEA) and collaborative research projects have already been undertaken. It is hoped further collaborations with the UEA and other partner authorities will nurture research projects into air pollution and provide a more holistic approach when applying for government funding.

Conclusions and Priorities

The council proposes to continue with automatic and passive NO_2 monitoring within the city area. As completion of road changes are implemented, the council will review the locations of passive monitoring positions so as to assess any resulting impacts from these changes. No excursions of the NO_2 objective were measured outside of the central AQMA. Monitoring shows the trend of declining pollution levels continues. The boundaries of the current AQMA will not be reconsidered until all proposed road changes are complete and sufficient monitoring data has been acquired to give full confidence to any changes.

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 straight forward. 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 consideration needs to be factored into the council budget. In addition, its location is not one of relevant exposure (provided there is no exceedances of the 1 hour mean) and hence as the council have now acquired over 10 years of data, the added benefit of this data is fairly limited. However the introduction of engine switch off enforcement in late 2018, the strive to replace ageing polluting buses and the updating of the Bus Charter to introduce a target date for Euro 6 compliance in the Low Emission Zone means that the council is hoping to see improvements in air quality along Castle Meadow and hence the station still has a useful purpose in monitoring any changes. With this in mind, the council are actively engaging with suppliers of mobile monitoring units and co-location trial studies are currently being undertaken so the accuracy and reliability of these units, specifically for NO2 and particulates, can be assessed for potential future application.

The Action Plan is due to be updated in 2020 and hence a comprehensive review of air quality, problem areas and additional measures that will be required to combat this will need to be considered by both City & County Council and all relevant partners.

The council will also continue to support initiatives that contribute positively to improving air quality, such as;

- encouraging car sharing in partnership with Liftshare;
- encouraging schools to develop travel plans, including using the Modeshift Stars software;
- encourage and enforce engine switch off;
- support the Norfolk Car Club;
- Support cycle schemes.

Local Engagement and 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 anyone 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
- Modeshift Stars is a national schools awards scheme that has been established to recognise schools that have demonstrated excellence in supporting cycling, walking and other forms of sustainable travel https://modeshiftstars.org/

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.

For Clean Air Day the Norfolk Environmental Protection Group along with Public Health Norfolk and Highways have, in collaboration, organised an event which allows the public to discuss any air quality issues or concerns and learn more about how to help themselves improve the air they breathe. The Group will be promoting issues which apply to both city and rural living such as;

Encouraging children to walk or cycle to school and find routes away from busy roads. Poster competitions will be conducted to engage participants;

Encouraging anyone to abandon the car on Clean Air Day and use an alternative mode of transport such as car share, public transport, cycle or walk;

Self-help such as being aware of the correct use of a woodburner/open fire, walking side streets rather than main roads, engine switch off when idling, eco-driving etc.

Clean Air Day will be well publicised and it is hoped that any changes in behaviour will be perpetuated beyond 20th June.

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1 Local Air Quality Management

This report provides an overview of air quality in Norwich City Council during 2018. 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 (AQMAs) 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 compliance with the objectives.

A summary of AQMAs 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

Alternatively, see Appendix D: Map(s) of Monitoring Locations and AQMAs, which provides for a map of air quality monitoring locations in relation to the AQMA(s).

Figure 2. 1 Map of the Central Norwich AQMA

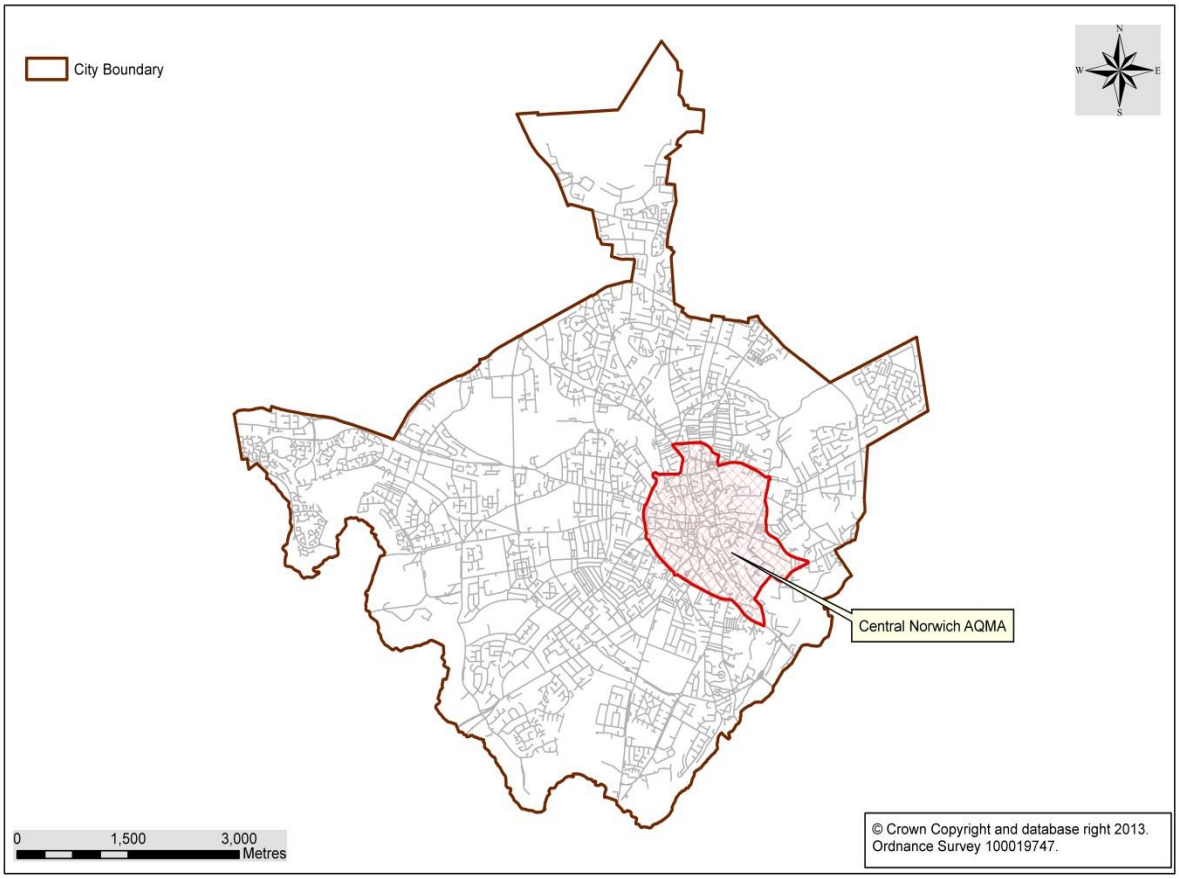


Table 2.1 – Declared Air Quality Management Areas

AQMA Name	Date of Declaration	Pollutants and Air Quality Objectives	City / Town	One Line Description	Is air quality in the AQMA influenced by roads controlled by Highways England?	Level of Exceedance (maximum monitored/modelled concentration at a location of relevant exposure)				Action Plan		
						At Declaration		Now		Name	Date of Publication	Link
Central AQMA	Nov-12	NO2 annual mean	Norwich	An area encompassing the centre of Norwich, broadly following the inner link road	NO	52 (at 52 St Augustines Street)	µg/m3	44 (at 52 St Augustines Street)	µg/m3	Action Plan for City of Norwich	2015	https://www.norwich.gov.uk/downloads/file/3020/2015_air_quailty_action_plan

☒ **Norwich City Council confirm the information on UK-Air regarding their AQMA(s) is up to date**

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

Defra's appraisal of last year's ASR concluded

Commentary

The report is well structured, detailed, and provides the information specified in the Guidance, following the latest reporting template. The following comments are provided.

1. *In 2017 there have been only two exceedances of the annual mean NO_2 objective at sites of relevant exposure (DT11 and DT26), and NO_2 concentrations appear to generally be improving across the City. There have been no exceedances of the hourly NO_2 objective, or of PM_{10} and $PM_{2.5}$ objectives in 2017.*

2. *There have been exceedances of the annual mean NO_2 objective at automatic site CM1, and four further diffusion tube sites, all of which are not representative of relevant exposure. It is unclear whether there are likely to be at the closest receptors to these sites as distance correction calculations have not been applied.*

3. *As specified in the Technical Guidance TG(16), distance corrections must be applied at all sites which are not representative of relevant exposure where there are exceedances of air quality objectives, and are additionally recommended where concentrations are within 10% of the objective level. These must be included in future reporting, and presented in Table B.1 with full details of calculations provided in Appendix C.*

4. *Annualisation appears to have been applied to site DT30, however no details of annualisation calculations have been provided. These must be included in Appendix C in future reports.*

5. *The Council does not provide or make reference to monitoring results for O_3 at automatic site CM2. This should be included in future reporting.*

6. *It is very encouraging to see that the Council have reviewed the locations of their monitoring sites in relation to recent changes to the roads and relevant*

exposure. The Council should continue to review their monitoring network on a regular basis to ensure that monitoring is always taking place at all locations of potential exceedance where there is relevant exposure.

7. *It is evident that the Council has made significant progress in developing and implementing AQAP measures which target improvement at pollution hotspots. Particular success appears to have been achieved via the new road layout and junction arrangements in Chapel Field, which have reduced the annual mean concentrations from 60.9 µg/m^3 in 2013 to 37.1 µg/m^3 in 2017.*

8. *The Council should continue to develop and implement measures which target improvement in the identified hotspot areas, giving priority (where there are funding/resource constraints,) to those measures estimated to have the greatest pollution reduction.*

9. *The Local Authority has a number of measures in place to address $PM_{2.5}$ as detailed in Section 2.3, which demonstrate their commitment to working with Public Health England to address this pollutant. It would be useful if the Council could make reference to the Public Health Outcomes Framework and their relevant local indicator for $PM_{2.5}$ in this section of the report.*

10. *It would be useful if additional smaller scale maps could be provided in addition to the large scale map in Appendix D, to demonstrate the locations of monitoring sites respective of their adjacent roads and buildings.*

In order to address points made, and now that a number of road changes have been completed, in January 2018 13 diffusion tube locations were removed and 9 new locations installed. The new locations represent;

1) locations of relevant exposure as close as possible to the previous tube where it was formally at a non-relevant exposure location, or
2) where new hotspots may be occurring as a result of the road changes, or
3) where new significant development is planned or approved.

The diffusion tubes that were removed are those where there have been a number of years of monitoring and NO_2 levels have been consistently below the objective level or where they are at sites of non-relevant exposure.

This program of reassessing monitoring locations will be ongoing and particularly whilst road changes continue to be implemented.

Distance corrections have been applied in Table B.1, where appropriate, and explanations are given in the Notes at the bottom of the table. Greater detail on distance corrections is given in Appendix C.

Norwich Lakenfields ozone, O3, monitoring results have been commented on in Section 3.2.4.

A link to the Public Health Outcomes Framework has been given in Section 2.3.

Norwich City Council in combination with Norfolk County Council has taken forward a number of direct measures during the current reporting year of 2018 in pursuit of improving local air quality. Details of all measures completed, in progress or planned are set out in Table 2.2. The Table has been ordered in terms of perceived importance in terms of its potential to reduce air pollution.

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 shown as shaded at the bottom of Table 2.2 and are listed below:

- Golden Ball Street and Farmers Avenue two-way traffic – completed.
- Removal of general traffic except buses, taxis and bikes from Red Lion Street – completed.
- Full closure of Westlegate – completed.
- Restricted access on All Saints Green - Linked with work to deliver the implementation plan for the Norwich Area Transportation Strategy (NATS) - completed.
- Northern Distributor Road – completed.
- Cycle routes extended and more joined up within city to encourage cycling as well as improve road safety – Pink pedalway totalling 12.2 km & Blue & Yellow totalling 31km – completed.

- Bus retrofit using SCRT technology. 24 buses that were previously Euro 3 or 4 standard upgraded to close to Euro 6 – completed but the process of applying for funding to convert further buses is ongoing.
- 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 – completed.

  This policy is broadly in line with the current London model, and will ensure continued improvement in Hackney carriage Euro standards beyond Euro 5.
- Enactment of The Road Traffic (Vehicles Emissions) (Fixed Penalty) (England) Regulations 2002 and the implementation of engine switch off enforcement - completed.

  Currently being undertaken on bus & taxi only roads. Failure to comply when asked to switch engine off when idling results in the issue of a Fixed Penalty Notices as an on the spot fine of £20. Expected to be extended to include other congested roads.

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

- Ring road junction improvements - Linked with work to deliver NATS. Survey work is now complete and data is being analysed which will determine required intervention measures.
- Rationalising and simplifying of traffic on Prince of Wales Road – Works underway to reduce congestion and encourage greater levels of sustainable modes on this important link between the rail station and city centre which will include improved cycleways and cycle junctions.
- Bus Rapid Transit – changes in road infrastructure to facilitate this - ongoing
- Review of traffic light optimisation – ongoing.

- Review of Castle Meadow Low Emission Zone and more focussed work with bus operators to agree target dates for only buses that meet Euro 5 compliance, and then Euro 6, to transit through LEZ.
- Signage to inform drivers of AQMA in known congested areas and encourage engine switch-off. It is also intended to look at the option of displaying waiting times at traffic lights.
- County Council to request schools, particularly within AQMA, to update school travel plans. (This is also being encouraged as part of the Norfolk Clean Air Day campaign).
- Successful bid for £1.7million of DfT Cycle Safety funding giving an overall total of £2.35 million (including local contribution) on two improvement schemes on Earlham Road and the green pedalway route - to start June 2019.
- Norfolk County Council are researching the ability to be able to monitor for air pollutants at bus stops where there are already electronic displays.
- Funding agreed for a docked cycle scheme.

In November 2017, the University of East Anglia (UEA) commenced a trial assessing the behavioural approach of drivers to different signage encouraging engine switch off. The signage was sited at traffic lights on Riverside Road where the NO_2 levels have always exceeded the objective level, but has been steadily decreasing. In 2018 the levels dropped below 40 µg/m^3. Riverside Road truncates at a busy and congested 4-way junction. At the junction is Norwich train station and a bridge over the River Wensum. It would be interesting to think the trial was still influencing drivers behaviour especially given the media coverage on engine switch off enforcement in other parts of the city.

It is thought the UEA results may feed into the type of message delivered on signage in areas outside dedicated engine switch off enforcement zones but inside the AQMA. It is proposed that in the future waiting times will be displayed at traffic light junctions which will again encourage engine switch off.

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

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 of the central AQMA in Norwich.

Table 2.2 – Progress on Measures to Improve Air Quality

Measure No.	Measure	EU Category	EU Classification	Organisations involved and 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	Circa 10-15 $\mu g/m^3$ NO_2	Erratic decline in NO_2 but probably would have been worse without LEZ.	Ongoing	Ongoing review of LEZ and the requirement to further reduce bus emissions. We are committed to agreeing with bus operators firm agreed dates for Euro 5, Euro 6 and zero emission compliance. Engine switch off enforcement commenced in autumn 2018 on Castle Meadow & St Stephens where there is bus & taxi only traffic.
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. Sophisticated proprietary software used for traffic modelling.
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.	Ongoing	Feasibility work on revised junction layouts and traffic flows is currently being undertaken as part of preparation of funding bids.
10	Signage informing engine switch-off enforcement. Electronic displays at traffic lights giving waiting times.	Public Information	Via other mechanisms	NCC + NorCC	2014/15	Ongoing – trial on Riverside Rd 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	Ongoing but October 2018 for switch off enforcement on Castle Meadow	New signage associated with enforcement of engine switch off educates road users and reinforces AQMA. The option to display waiting time at traffic lights is being considered.

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	Continuation of work to promote Transport for Norwich objectives utilising funding from DfT through Access fund.
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	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 to promote use of Modeshift Stars software with schools so they can generate and manage their own travel plans. School travel plans to be highlighted as part of Clean Air Day campaign – led by County & Public Health Norfolk.
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	24 buses retrofitted by June 2018	Ongoing	24 buses upgraded from Euro 3-4 to being close to Euro 6 through program of retrofitting utilising DfT grant. An unsuccessful application for funding was made to DEFRA in November 2018 for the retrofitment of a further 26 vehicles. Aim is to work in partnership with bus operators on funding opportunities relating to low NOx emission vehicles.
14	Engine switch-off enforcement	Public information	Other	NCC	2016	2018	Reduction in NO_2 levels in city centre and surrounds	Complimentary to other measures; in particular Castle Meadow LEZ.	Agreement obtained. Transport operators contacted.	Commenced August 2018	Use of powers to enforce engine switch-off via issue of fixed penalty notices. Enforcement commenced specifically on Castle Meadow & St Stephens where bus & taxi only traffic.
15	CCAG programmes	Promoting Travel Alternatives	Promotion of cycling	NCC, NorCC & DfT	2013	2014-2019	Reduction in vehicle use in city centre. Increased no. people cycling	Specific value not known but will contribute to overall reduction in NO_2 levels in city centre and surrounds	Ongoing	December 2019 for current available funding. £1.7million further DfT funding	Cycle routes extended and more joined up. Will encourage cycling as well as improved road safety. Successful funding application submitted to DfT Spring 2018 for 2 cycle schemes in west of city.

										successfully bid on during 2018 for 2 cycle improvement schemes due for completion 2019	
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	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. Will be considered in light of emerging Transport for Norwich Strategy Review
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	The provision of priority measures to speed up bus journey times and improve bus journey time reliability remain central to the delivery of the transport strategy for Norwich.
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	Approval to construct given at June 2018 Highways Committee	2019	Works underway to reduce congestion and encourage greater levels of sustainable modes on this important link between the rail station and city centre.
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	While spare capacity remains at the existing site, expansion of the site will remain on hold.

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..
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	Completed	Completed 2018	Post construction monitoring will be undertaken.
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	Works completed as part of pedestrianisation of All Saints Green.
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	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	Works completed.

			priority.								
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	Works completed.
20	UEA behavioural messages to encourage drivers to turn off idling engines	Public Information	Other	NCC + NorCC	-	2017	Proportion of drivers who switched off engine in presence of signage. 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 & surrounds	Results showed that proportion of drivers switching off engines rose from 9.6% pre-intervention to 17% with signage.	2018	This research supports further use of signage to encourage drivers to switch off idling engines which will compliment enforcement approach being adopted.

Shading indicates projects complete.

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 Norfolk who play an active role at the quarterly NEPG meetings. This allows for an exchange of information and data including that referenced in the Public Health Outcomes Framework;

  https://fingertips.phe.org.uk/profile/public-health-outcomes-framework/data#page/3/gid/1000043/pat/102/par/E10000020/ati/101/are/E07000148/iid/30101/age/230/sex/4
- The council has direct dialogue with officers of Norfolk County Council Highways Department, who also regularly attend the NEPG sub group and hence feedback 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 positive contribution towards reducing $PM_{2.5}$ emissions

and/or exposure. It is however understood that, at least in Norwich, $PM_{2.5}$ is primarily a transboundary pollutant. Figure A3 shows that the urban background monitoring station is just as likely to have elevated levels of $PM_{2.5}$ as the urban kerbside site thus indicating traffic pollution is not the primary source of $PM_{2.5}$. The Defra derived data shown in Figure A.4 illustrates that in 2015 the primary contributor of $PM_{2.5}$ in Norwich was residual particulates and salt. Norwich has a rural hinterland with a large agricultural industry and it is activities associated with this that are also expected to be a potentially significant contributor.

- The minimisation of airbourne particulates will continue to be an important factor in all planning application considerations. Developers are encouraged to be part of the Considerate Contractors Scheme and have a fully adhered to onsite Environmental Policy.
- Norwich has 4 Smoke Free Zones although these have a historical origin rather than present day significance. The Council actively tries to educate owners and potential owners of woodburners and open fires as to the importance of burning material which does not produce smoke or fume. This is primarily implemented through it's website, planning applications and educational days such as Clean Air Day.

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

3.1 Summary of Monitoring Undertaken

3.1.1 Automatic Monitoring Sites

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

Norwich City Council undertook automatic (continuous) monitoring at one site, Castle Meadow, during 2018. Also within its district is an automatic continuous monitoring site (Norwich Lakenfields) run by DEFRA which forms part of the AURN (Automatic Urban & Rural Network). 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 23 sites during 2018. Table A.2 in Appendix A shows the details of the sites.

Maps showing the location of the monitoring sites are provided in Appendix D. Further details on Quality Assurance/Quality Control (QA/QC) for the diffusion tubes, including bias adjustments and any other adjustments applied (e.g. "annualisation" and/or distance correction), 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 2018 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.

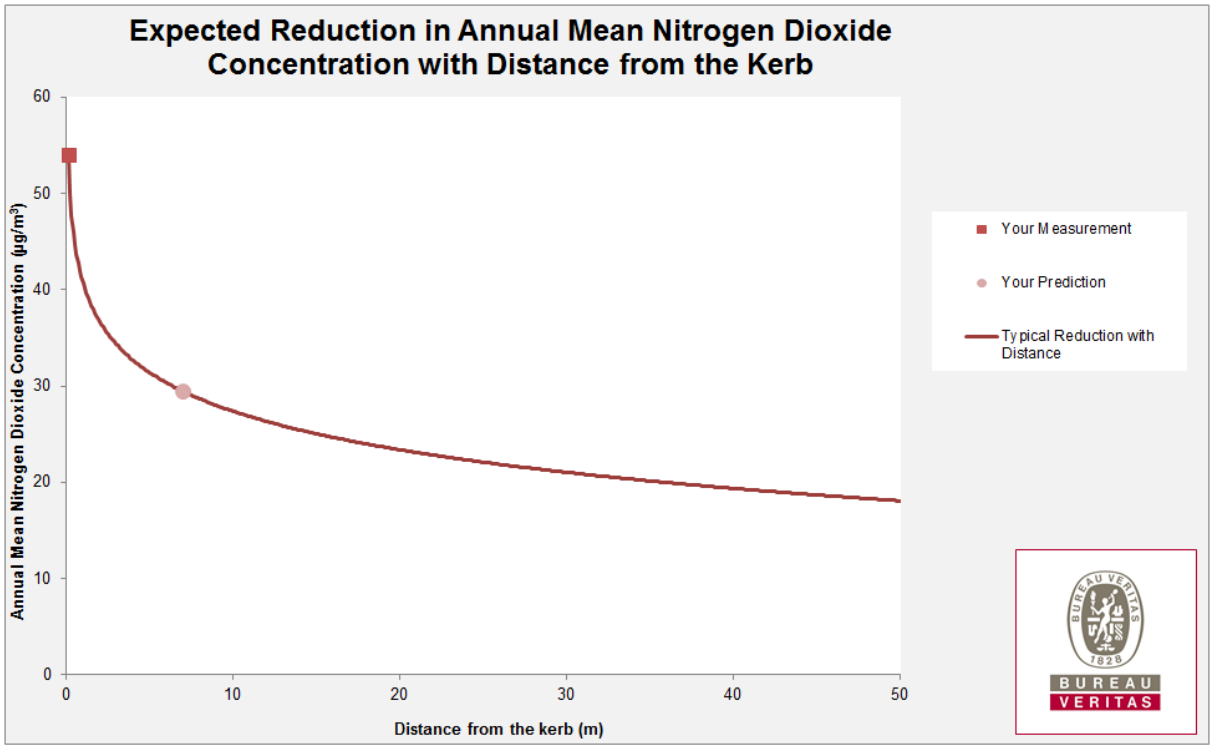
The annual mean concentration at the Castle Meadow automatic monitoring site was recorded as 54µg/m^3 for 2018 which exceeds the annual mean objective by 14µg/m^3 but is encouragingly lower than most previous years despite the fact that bus traffic using Castle Meadow has probably only increased. This monitoring site is within the central AQMA.

It must be noted 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 which would make any corrections for distance not applicable. Figure 3.1 illustrates the Defra NO_2 Fall Off with Distance Correction (https://laqm.defra.gov.uk/tools-monitoring-data/no2-falloff.html) for a roadside mean annual NO_2 level of 54 µg/m^3. The purpose of this graph is to illustrate how rapidly levels diminish with distance.

The Castle Meadow automatic analyser site can however be considered relevant exposure for the 1 hour mean as pedestrians 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 breach this 1 hour objective as the measured levels exceeded the 1 hour allowance of 200µg/m^3 on 19 occasions throughout 2018, the objective allowing for 18 exceedences in the year. The highest exceedence level was 266 µg/m^3.

It is anticipated that with the move towards cleaner buses and the enforcement of engine switch off, Castle Meadow NO_2 levels are expected to decrease as it is felt that individual high polluting buses are significantly contributing to this problem.

Figure 3. 1 Example of NO_2 Fall Off With Distance



The Norwich Lakenfields urban background automatic monitoring site measured an annual mean concentration of 12 µg/m^3. Hence there is no exceedence of either the annual mean or the 1-hour mean. Figure A.2 shows that the NO_2 levels of the urban background site Norwich Lakenfields closely matches those of rural background sites such as Wicken Fen and St Osyth. In addition the underlying background trend can still be seen in the Castle Meadow data.

Table A.3 in Appendix A shows the diffusion tube results for 2018, corrected for bias using a locally derived bias adjustment factor of 0.86 using the 50% TEA in Acetone method.

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

The national bias spreadsheet is also shown in Appendix C and is available online here:

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

Using the local bias correction, a total of 4 diffusion tube sites exceeded the NO_2 annual mean objective of 40µg/m^3 during 2018. However when distance corrected for relevant exposure only 2 sites exceeded, 52 St Augustines and Castle Meadow mid. Castle Meadow Mid can not however be classified as relevant exposure as the residential flats above the shops have non-opening windows and hence is only relevant for the 1 hour mean.

These results are a considerable improvement on previous years, especially as sites that have consistently exceeded, for example the triplicate tubes at 3 Riverside Road in 2018 fell below the objective level for the first time.

It is questioned whether the elevated levels seen last year may have been due to added congestion as a result of road works during the implementation of road changes. It is hoped that the improved results this year are a result of the benefits now being observed from the road changes.

In 2018, 9 new DT locations were added whilst 13 were removed; the latter due to NO_2 levels being either consistently below the objective level or representing locations of non relevant exposure.

Figure A.1 presents the results of the bias corrected annual mean for passive NO_2 monitoring from 2011 -2018. The trends illustrate this slow but steady reduction in levels.

Riverside Road has shown a consistent decline in NO_2 annual mean for the last 6 years, being 52 µg/m^3 in 2013 and 39 µg/m^3 in 2018. It would be interesting to think the escalation in decline in 2018 was enhanced by the UEA engine switch off trial and perhaps reinforced by media coverage concerning engine switch off enforcement.

The diffusion tube sites exceeding the objective level were:

- DT11 (52 St Augustines Street) – 44µg/m^3
- DT13 (Castle Meadow) – 45µg/m^3 (not relevant exposure unless 1 hour mean exceeded)
- DT29 (4 Chapelfield North) – 41µg/m^3 (38µg/m^3 when distance corrected)
- DT34 (41 St Stephens Street) – 41µg/m^3 (31µg/m^3 when distance corrected)

All of the above diffusion tube sites are within the existing Norwich Central AQMA. Reassuringly 52 St Augustines is significantly lower than previous years (54µg/m^3 in 2017) but this decrease is difficult to explain as there have been no road changes in this area. This diffusion tube location represents a worst case scenario being located on the building façade approximately 1m from the kerbside within a canyon street.

Castle Meadow Mid (formally Castle Meadow 2) is a bus & taxi only street and hence not unsurprisingly levels have fluctuated over the years and, in some cases, quite dramatically, but this year the annual mean is the lowest it has been. The only change that occurred on Castle Meadow was the introduction of engine switch off enforcement in September 2018. It would be encouraging to think the reduction in levels could be as a result of this coupled with the determined efforts to remove older polluting buses from the Low Emission Zone. This location is not considered to be relevant exposure as the first floor flat has non-opening windows. This is the only residential accommodation on Castle Meadow but monitoring continues as an exceedence of the 1 hour mean would represent relevant exposure. This DT is located approximately 60m along the road from NCC automatic analyser. This year there was no agreement between the results from the diffusion tube and the automatic analyser which is only to be expected on a busy urban street frequented almost solely by buses .

The automatic analyser is sited immediately adjacent to a bus stop which itself is close to a set of traffic lights and hence queueing traffic is quite typical, especially at peak times. This scenario would support the view that particularly high levels of pollution can be quite localised. It is however the keen intention of Norfolk County Council to continue to encourage bus operators to replace older, polluting vehicles for buses using cleaner technology and especially for buses using the Castle Meadow Low Emission Zone. It is the intention to update the Bus Charter this year and bring in target dates for Euro VI compliance, starting with the Low Emission Zone.

Since the road changes in 2013 affecting Chapel Field North there has been a consistent decrease in NO_2 levels and, in 2017, the NO_2 annual mean dropped below the objective level to 37µg/m^3. Due to foliage growth on the façade of the building on Chapel Field North, the triplicate diffusion tubes were moved to a lamp post closer to

the road. When distance corrected the NO_2 levels are very similar to last year and hence continue to fall below the objective level.

St Stephens Street is a bus and taxi only road and the DT site is located on a kerbside bus stop. At the start of 2018, this site was moved a few metres as units above the ground level shops are in the process of being converted to student accommodation. Once distance corrected for the proposed first floor residential units, the annual mean falls well below the objective level.

A revised junction at Finkelgate/Queens Road, which included the installation of traffic lights, resulted in an inevitable degree of traffic queueingat peak times which precipitated complaints from local residents. A triplicate of diffusion tubes was installed in 2018 on the façade of a house on the junction. The annual mean of 37µg/m^3 showed no exceedence of the objective level. A feeder road onto the busy Queens Road and Finkelgate junction is Hall Road where the façade of residential lie within a metre of the kerb. This new diffusion tube location showed that despite traffic queuing, especially at peak times, the annual mean was well below the objective level at 27µg/m^3.

Heigham Street has frequent queuing traffic at traffic lights adjacent to a bridge of the River Wensum. A new diffusion tube here again showed that despite this congestion and residential within one metre of the kerb, the annual mean was 27µg/m^3.

Duke Street suffers queuing traffic feeding onto the traffic light regulated St Crispins roundabout. Major new developments are proposed for this area which will see traffic from the adjacent St Marys Works development feeding directly onto Duke Street close to this junction. The purpose of this new tube location was to assess NO_2 levels pre and post development. Present levels were found to be well below the objective level at 30µg/m^3.

Another new location was 24 St Stephens Road which lies close to the busy St Stephens roundabout. This tube is outside the AQMA and was proposed to test if the AQMA boundary was still appropriate. This road takes a lot of bus traffic but more importantly traffic from 2 main arterial routes into the city, the A11 & A140, both feed directly into St Stephens Road. The tube is located on the façade of a residential building situated within 1 metre of the kerb and close to a bus stop. Reassuringly the annaul mean fell comfortably within the objective level at 34µg/m^3.

Particulate Matter (PM_{10})

Table A5 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 27µg/m^3 which is below the annual mean objective of 40µg/m^3. There were 8 exceedances of the 24-hour mean of 50µg/m^3 (35 allowed), and the maximum daily mean recorded was 70µg/m^3 (92% 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 1 exceedance of the 24-hour mean, the maximum being 90 µg/m^3. The annual mean concentration was 16µg/m^3 (86% data capture).

3.2.2 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 covering the last 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. There is, however, 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 A.3 in Appendix A shows the annual mean concentrations at both sites and 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 and that levels for both sites are not dissimilar.

It must be noted that the meeting of $PM_{2.5}$ target levels is not in regulatory standards for local authorities.

There has been an overall steady reduction in the annual average at Lakenfields since 2010, which is in line with the EU target value of 15% reduction at background urban locations between 2010 and 2020, also demonstrated by Figure A.3. In addition, in 2018 the World Health Organisation recommended guideline value of 10µg/m^3 was met at both Lakenfields and Castle Meadow.

It is considered that in seeking to reduce the concentration levels of other pollutants, namely NO_2 from road traffic, a beneficial impact on $PM_{2.5}$ concentrations will also likely occur. Our historic monitoring data will be of considerable assistance in assessing such impacts. Although it must be noted that residual particulates and salt are the main source of $PM_{2.5}$ in Norwich - reference Figure A.4

3.2.3 Ozone

Ozone monitoring is carried out at the Norwich Lakenfields site. There are no regulatory objective levels for ozone. The following statistics were recorded for 2018;

Annual mean - 48µg/m^3 (99% data capture).

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	PM10, NOx, NO2, PM2.5	Y	Chemiluminescent (Ambirak); TEOM	N/A	1	2.5
CM2	Lakenfields	Urban Background	623637	306940	O3, PM10, NOx, NO2, PM2.5	N	Chemiluminescent (Thermo); FDMS	20	N/A	2.5

Notes:

(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 ie monitoring location, CM1, is far enough away from the nearest relevant exposure that other factors would then influence pollution levels.

Table A.2 – Details of Non-Automatic 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	307678.6	NO2	Y	0	3.5	N	1.5
DT4	Lakenfields	Urban Background	623681.24	307015.82	NO2	N	20	1.5	Y	2.5
DT5	Chalk Hill Road	Roadside	623906.97	308596.92	NO2	Y	0	7	N	2.5
DT6	130 Magdalen Street	Roadside	623160.89	309550.43	NO2	Y	0	4	N	2.5
DT9	13 St Augustines St	Kerbside	622905.81	309496.11	NO2	Y	1	1.5	N	2.5
DT11	52 St Augustines St	Kerbside	622825.87	309573.17	NO2	Y	0	1	N	2.5
DT13	Castle Meadow	Roadside	623141.06	308606.69	NO2	Y	N/A	2.5	N	2.5
DT16	Zipfel House	Roadside	623185.69	309649.68	NO2	Y	0	3	N	2.5
DT19	Cattlemarket Street	Roadside	623320.58	308430.88	NO2	Y	0	2	N	2.5
DT21	Rotary House	Roadside	623879.53	307658.91	NO2	Y	3	2	N	1.5
DT22	Carrow Bridge House	Roadside	623900.96	307709.56	NO2	Y	0	5	N	1.5
DT25	24 Bargate Court	Roadside	623422.42	309388.23	NO2	Y	0	4	N	2.5
DT26	3 Riverside	Roadside	623870.26	308515.77	NO2	Y	0	3	N	2.5

	Road									
DT29	4 Chapelfield North	Kerbside	622532.23	308490.36	NO2	Y	1.5	1	N	2.5
DT31	Quantrell Hs, 199-203 Queens Rd	Kerbside	623380	307700	NO2	N	0	3	N	3
DT32	8 Hall Road	Kerbside	623399	307664	NO2	N	0	1	N	3
DT33	8 Winnalls Yd, Queens Rd	Kerbside	622986	307936	NO2	Y	0.5	4	N	3
DT34	41 St Stephens St	Kerbside	622898	308114	NO2	Y	6	0.5	N	3
DT35	24 St Stephens Rd	Kerbside	622755	307932	NO2	N	0	1	N	3
DT36	219 Heigham St	Kerbside	621910	309751	NO2	N	0	1	N	3
DT37	Adj. 7A Gunns Ct, Cleveland Rd	Kerbside	622492	308520	NO2	Y	3	2.5	N	3
DT38	69 Bethel St	Kerbside	622590	308555	NO2	Y	0	2	N	3
DT39	49 Duke St	Kerbside	622884	309082	NO2	Y	0	1	N	3

Notes:

(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 ie DT13 is on residential façade but non-opening windows. Monitoring location is also far enough away from next nearest relevant exposure it would not be applicable as other factors would influence pollution levels.

Table A.3 – Annual Mean NO_2 Monitoring Results

Site ID	Site Name	Site Type	Monitoring Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2018 (%) (2)	NO_2 Annual Mean Concentration (µg/m^3) (3)				
						2014	2015	2016	2017	2018
CM1	Castle Meadow	Roadside	Automatic	90.3	90.3	**66**	**55**	**56**	**51**	**54**
CM2	Lakenfields	Urban Background	Automatic	99	99	14	12	14.2	13	12
DT1	256 King St	Roadside	Diffusion tube	100	100	**41.5**	36.2	37.7	36.3	33.30
DT4	Lakenfield AQS	Urban Background	Diffusion tube	100	100	12.5	11.8	12.9	13.9	11.82
DT5	Chalk Hill Rd	Roadside	Diffusion tube	92	100	32.9	29.2	29.9	31.3	29.18
DT6	130 Magdalen St	Roadside	Diffusion tube	100	100	30.9	28.4	29.6	31.2	27.06
DT9	13 St Augustines Street	Kerbside	Diffusion tube	100	100	**41.9**	37.6	**40.2**	**41.5**	37.38
DT11	52 St Augustines	Kerbside	Diffusion tube	100	100	**48.6**	**53.5**	**50.7**	**53.6**	**44.40**
DT13	Castle Meadow mid	Roadside	Diffusion tube	92	100	**56.3**	**56.4**	**45.9**	**48.5**	**44.86**
DT16	Zipfel House	Roadside	Diffusion tube	100	100	39	34.8	38.6	39.9	33.41
DT19	27 Cattle Market St	Roadside	Diffusion tube	100	100	**46**	37.9	39.1	37.7	36.09
DT21	Rotary House, King St	Roadside	Diffusion tube	83	100	36.6	34.3	32.9	32.5	29.10

DT22	Carrow Bridge House	Roadside	Diffusion tube	100	100	24.7	21.6	23.3	25.3	31.07
DT25	24 Bargate Court	Roadside	Diffusion tube	100	100	35.1	34.2	35	32.7	29.56
DT26	3 Riverside Rd	Roadside	Diffusion tube	100	100	**51.2**	**47.2**	**46.7**	**44.2**	39.25
DT29	4 Chapelfield North	Kerbside	Diffusion tube	100	100	38.1	**43**	**45.8**	37.1	**41.25**
DT31	Quantrell House, Queens Road	Roadside	Diffusion tube	100	100					37.24
DT32	8 Hall Road	Roadside	Diffusion tube	92	100					27.17
DT33	8 Winnals Yard, Queens Road	Roadside	Diffusion tube	75	100					28.22
DT34	41 St Stephens Road	Roadside	Diffusion tube	92	100					**41.22**
DT35	24 St Stephens Road	Roadside	Diffusion tube	92	100					34.18
DT36	219 Heigham St	Roadside	Diffusion tube	92	100					27.17
DT37	7A Gunns St, Cleveland Road	Roadside	Diffusion tube	100	100					29.86

DT38	69 Bethel St	Roadside	Diffusion tube	100	100					22.44
DT39	49 Duke St	Roadside	Diffusion tube	100	100					30.00

☒ **Diffusion tube data has been bias corrected**

☒ **Annualisation has been conducted where data capture is <75%**

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 Boxes 7.9 and 7.10 in LAQM.TG16 if valid data capture for the full calendar year is less than 75%. See Appendix C for details.

Figure A. 1 – Trends in Annual Mean NO_2 Concentrations

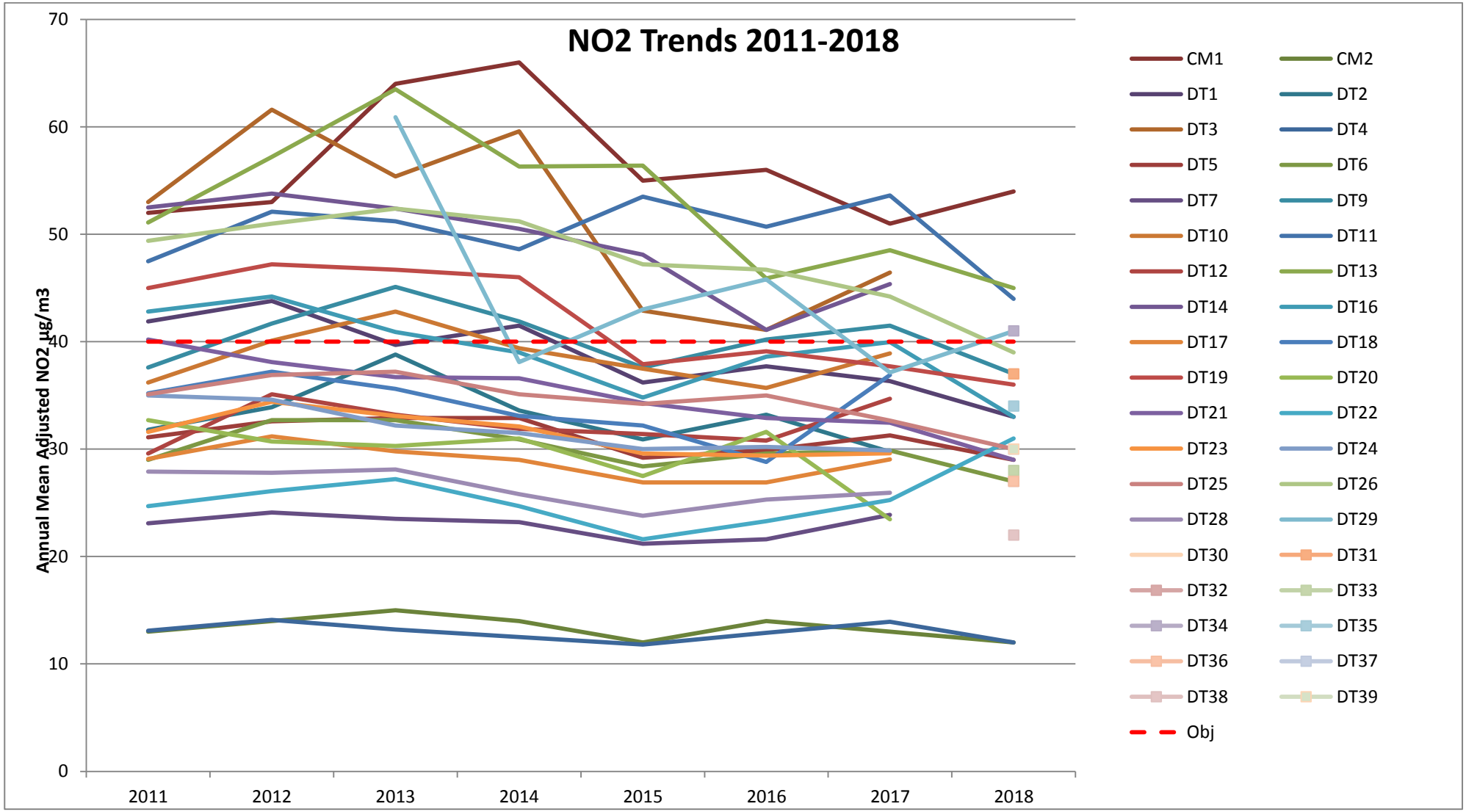


Figure A. 2 – NO_2 Monthly Averages Jan 2016 – Jan 2019

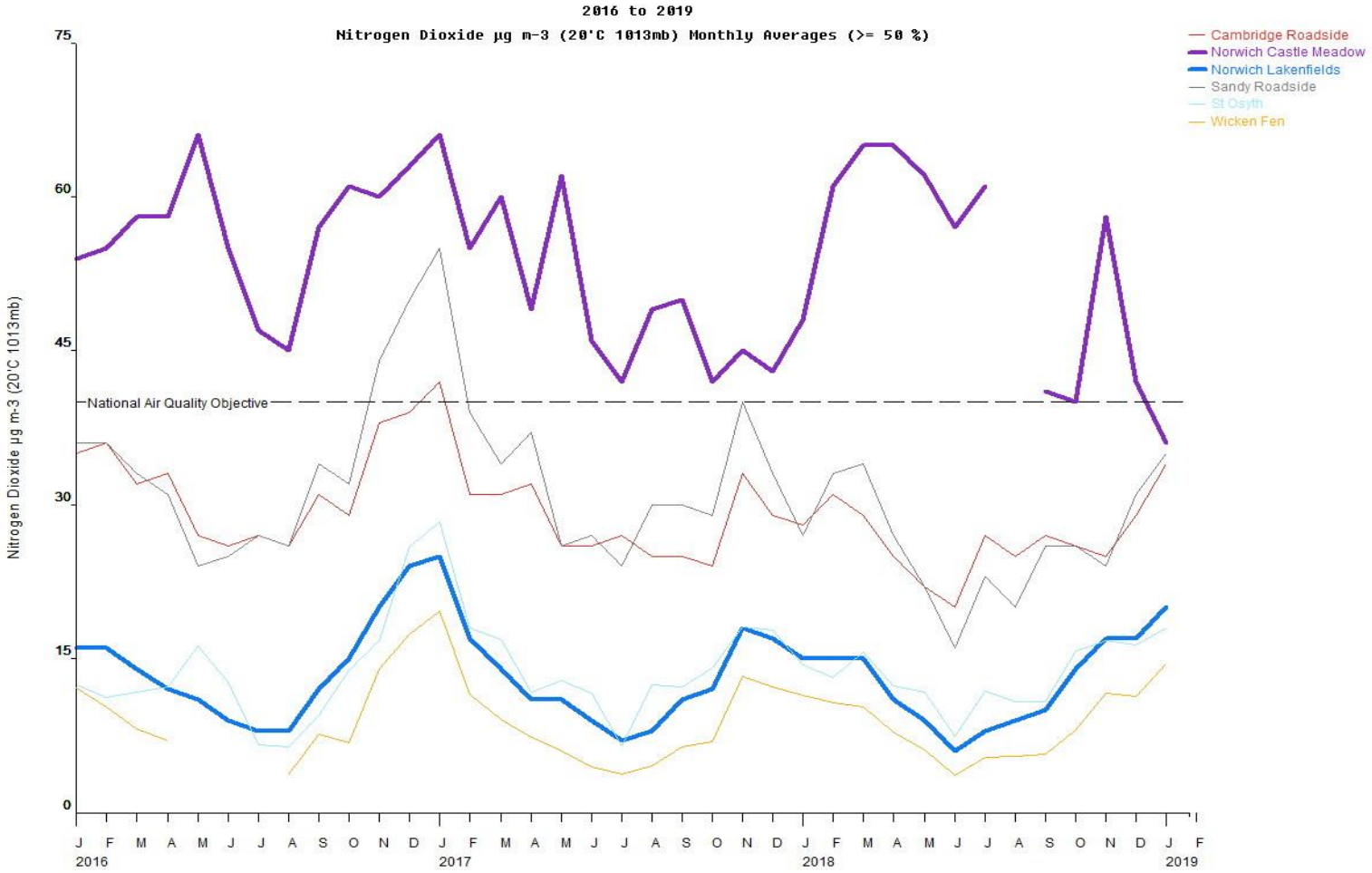


Table A.4 – 1-Hour Mean NO_2 Monitoring Results

Site ID	Site Type	Monitoring Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2018 (%) (2)	NO_2 1-Hour Means > 200µg/m^3 (3)				
					2014	2015	2016	2017	2018
CM1	Kerbside	Automatic	90.3	90.3	**57**	6	4	1	**19**
CM2	Urban Background	Automatic	99	99	**0**	0 (55)	0	0	**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 – PM_{10} Annual Mean Monitoring Results

Site ID	Site Type	Valid Data Capture for Monitoring Period (%) (1)	Valid Data Capture 2018 (%) (2)	PM_{10} Annual Mean Concentration ($\mu g/m^3$) (3)				
				2014	2015	2016	2017	2018
CM1	Kerbside	91.6	91.6	21	21	20	23	27
CM2	Urban Background	86	86	16	15	16	16	16

☒ **Annualisation has been conducted where data capture is <75%**

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 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 2018 (%) (2)	PM_{10} 24-Hour Means > 50µg/m^3 (3)				
				2014	2015	2016	2017	2018
CM1	Kerbside	91.6	91.6	**9**	6	4	4	8
CM2	Urban Background	86	86	**0**	5	1 (27)	5	1

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 2018 (%) (2)	$PM_{2.5}$ Annual Mean Concentration ($\mu g/m^3$) (3)				
				2014	2015	2016	2017	2018
CM1	Kerbside	86.3	86.3	12	9	11	15	10
CM2	Urban Background	89	89	12	12	11	12	10

☒ **Annualisation has been conducted where data capture is <75%**

Notes:

(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 LAQM.TG16, valid data capture for the full calendar year is less than 75%. See Appendix C for details.

Figure A. 3 – Trends in Annual Mean $PM_{2.5}$ Concentrations

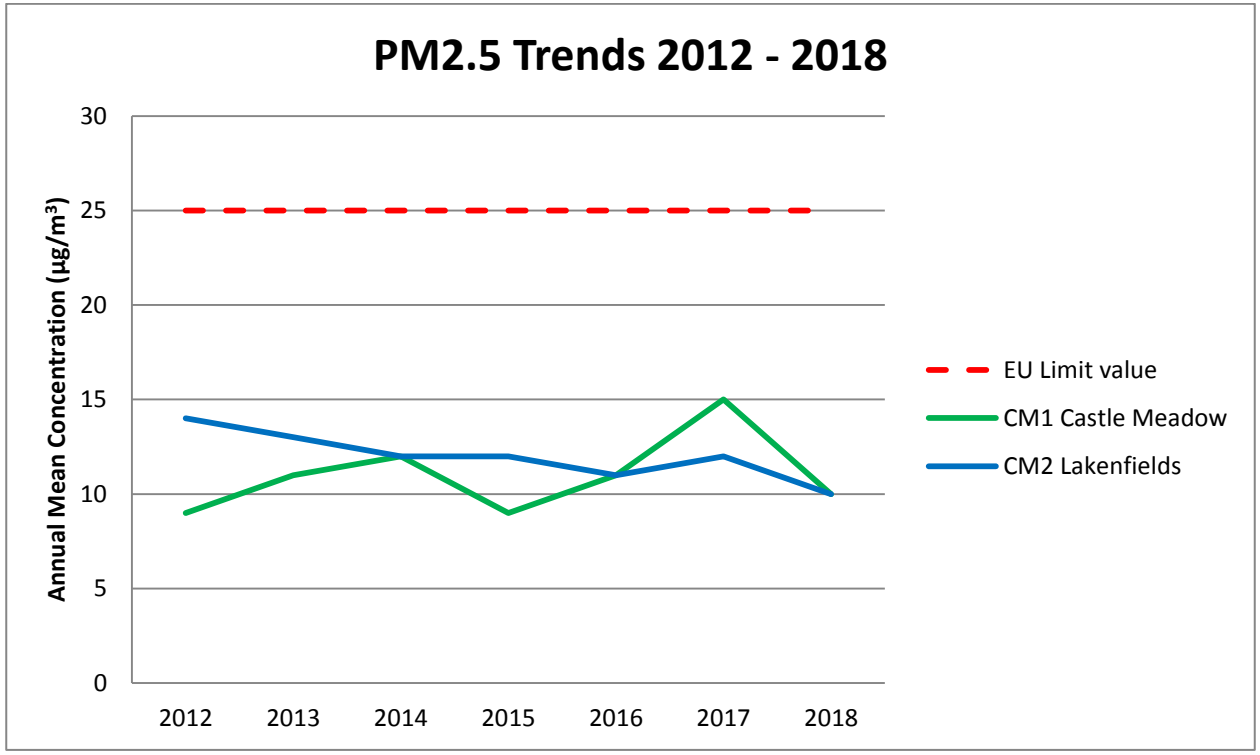
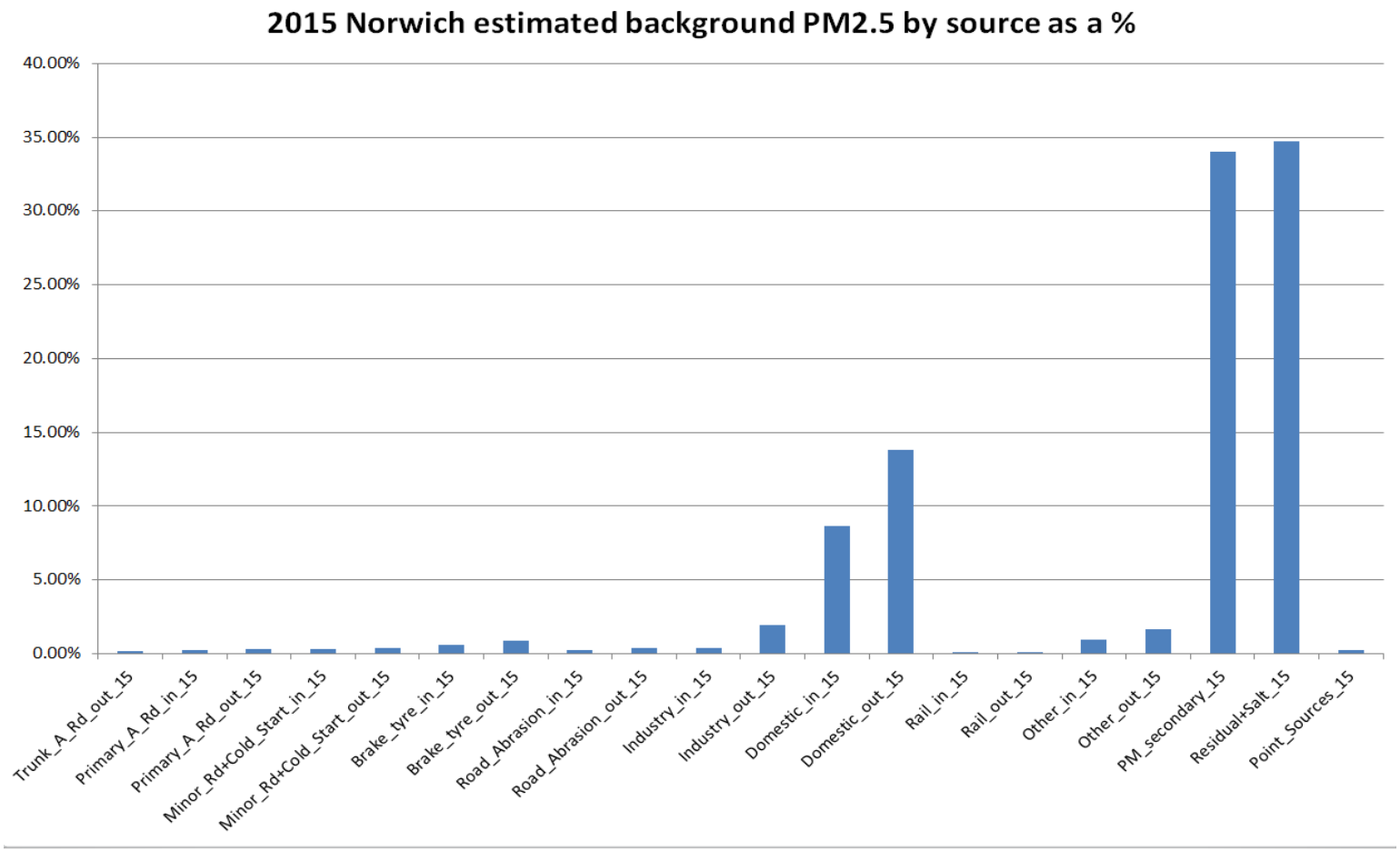


Figure A. 4 – $PM_{2.5}$ Source Apportionment for Norwich 2015 (from Defra UK-Air website)



Appendix B: Full Monthly Diffusion Tube Results for 2018

Table B.1 – NO_2 Monthly Diffusion Tube Results - 2018

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 (0.86) and Annualised (1)	Distance Corrected to Nearest Exposure (2)
DT1	35.75	33.84	38.13	28.39	27.99	24.37	29.64	32.74	31.09	44.31	37.34	35.59	38.72	33.30	_
DT4	22.01	15.26	12.74	9.71	7.64	6.44	8.40	9.13	10.25	13.18	14.45	14.50	13.75	11.82	_
DT5	27.34	25.34	28.47	40.53	25.80	19.30	23.82	27.45		28.05	35.11	39.79	33.93	29.18	_
DT6	29.61	26.09	28.19	27.46	25.26	22.63	22.41	28.39	24.45	31.85	27.08	31.25	31.46	27.06	_
DT9	36.22	34.44	39.91	41.66	49.18	37.38	37.43	33.33	26.28	38.87	35.31	38.59	43.47	37.38	****31
DT11	62.52	38.18	47.92	24.10	43.23	36.95	46.45	50.90	34.12	44.06	49.88	54.47	51.62	**44.40**	**44.4**
DT13	41.17	43.38	46.24	35.00	50.21	49.48	46.46	43.34	43.46	49.33	48.13	42.12	52.16	**44.86*** **	_
DT16	44.36	32.55	41.95	28.01	26.01	24.57	28.93		30.61	33.62	37.03	39.92	38.85	33.41	_
DT19	33.61	38.74	41.73	25.92	43.69	31.17	39.32	34.29	32.89	33.50	44.10	34.07	41.96	36.09	_
DT21	33.19	31.24	30.29	22.84	26.89	24.76	30.13		26.83		33.20	31.67	33.84	29.10	_
DT22	29.32	28.57	26.98	30.09	31.29	25.15	23.19	27.71	51.05	31.25	36.73	31.50	36.13	31.07	_
DT25	31.07	26.56	30.58	23.53	37.74	27.14	24.30	30.25	29.68	31.06	30.70	32.06	34.37	29.56	_
DT26	37.91	39.83	44.45	35.87	36.95	31.08	46.68	41.76	36.32	41.28	39.00	39.83	45.64	39.25	39.25
DT29	35.50	36.63	39.20	33.71	49.34	35.68	44.91	41.72	45.00	49.44	38.48	45.39	47.97	**41.25**	36.8*
DT31	42.24	35.48	51.64	34.03	30.47	24.83	34.28	38.62	32.76	37.98	42.44	40.73	43.30	37.24	37.24

DT32	32.27	30.00	31.91	9.23	34.38	24.75	25.21	25.57	26.44	31.56	27.57		31.60	27.17	_
DT33	22.90	25.83	28.46	32.14	36.25	27.93			22.70	29.12		28.64	32.81	28.22	_
DT34	44.91	35.79	44.13	43.37	43.09	39.69	40.68	36.05		36.18	48.55	40.94	47.93	**41.22**	28**
DT35	29.94	31.93	38.33	35.69	41.05	35.17	37.94	29.52	29.74		34.24	32.45	39.75	34.18	_
DT36		25.63	29.48	24.25	20.57	17.86	21.97	27.67	44.78	27.68	27.61	31.36	31.59	27.17	_
DT37	31.86	31.97	34.15	41.86	23.68	16.42	22.13	28.24	27.43	30.48	38.09	32.05	34.72	29.86	_
DT38	28.02	22.96	20.98	27.42	14.20	12.57	15.28	22.28	19.25	28.28	25.20	32.84	26.09	22.44	_
DT39	25.64	33.24	31.94	35.01	39.88	29.27	31.67	22.79	19.83	30.05	34.14	26.59	34.89	30.00	_

☒ **Local bias adjustment factor used**

☐ **National bias adjustment factor used**

☒ **Annualisation has been conducted where data capture is <75%**

☒ **Where applicable, data has been distance corrected for relevant exposure**

* Diffusion Tube at 4 Chapelfield North (DT29) was moved for 2018 due to foliage on house façade no longer meeting guidance in TG(16), hence distance correction required this year.

** Previously 41 St Stephens Street (DT34) was not relevant exposure but due to conversion of neighbouring building from commercial to residential, relevant exposure commences at first floor level, shops remaining on ground level. The diffusion tube was moved to closest position to the, still unoccupied, residential units. Hence now distance correction is appropriate.

*** On Castle Meadow Mid (DT13) residential is located above commercial but residential have non-opening windows so not relevant exposure.

**** Flats above commercial at 13 St Augustines Street (DT9) are now occupied and hence distance correction appropriate.

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.

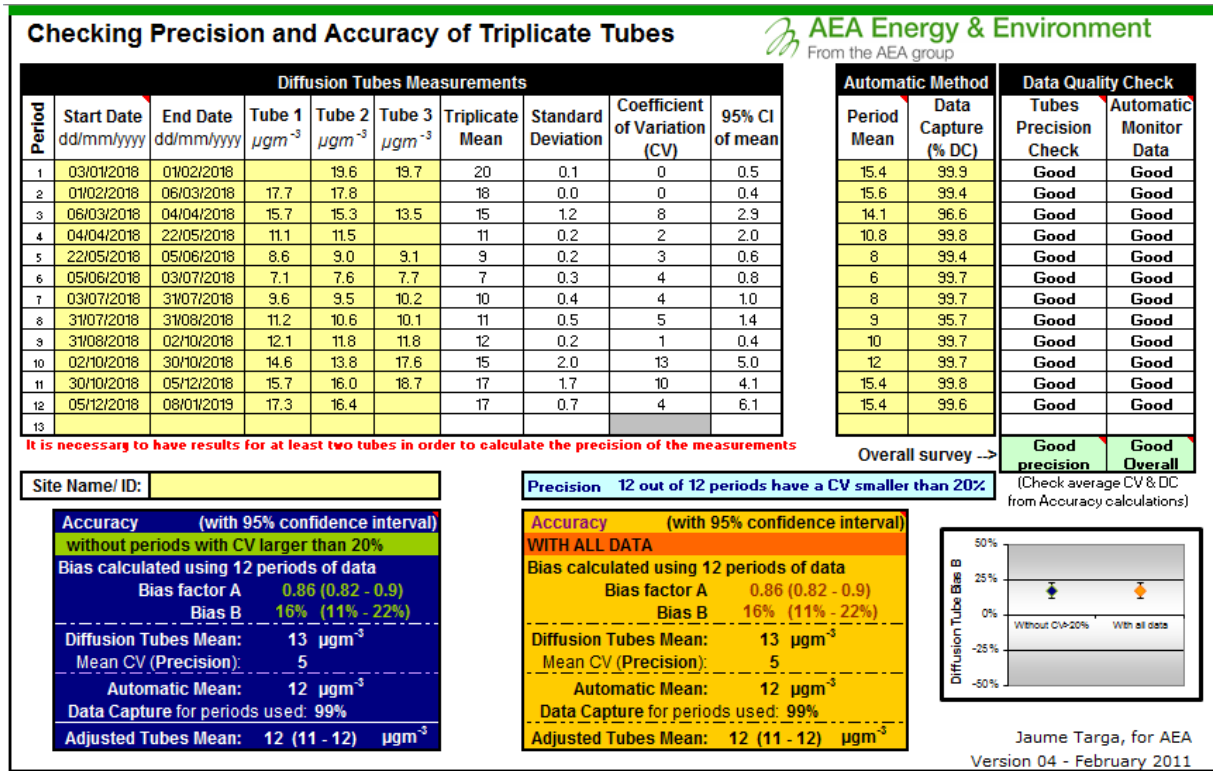
(2) Distance corrected to nearest relevant public exposure.

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 v03/19): **0.92** (8 studies)

Factor from Local Co-location Studies (Local Bias Adjustment Factor)
Norwich Lakenfields urban background AURN site **(based on 11 periods of data)**
Bias Factor A**: 0.86** (0.82 - 0.9)
Bias B: 16% (11% - 22%)
Diffusion Tubes Mean: 13µg/m³
Automatic Mean: 12µg/m³
Data Capture for periods used: 99%
Adjusted Tubes Mean: 12 (11-12) 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

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
1	03/01/2018	01/02/2018		19.6	19.7	20	0.1	0	0.5
2	01/02/2018	06/03/2018	17.7	17.8		18	0.0	0	0.4
3	06/03/2018	04/04/2018	15.7	15.3	13.5	15	1.2	8	2.9
4	04/04/2018	22/05/2018	11.1	11.5		11	0.2	2	2.0
5	22/05/2018	05/06/2018	8.6	9.0	9.1	9	0.2	3	0.6
6	05/06/2018	03/07/2018	7.1	7.6	7.7	7	0.3	4	0.8
7	03/07/2018	31/07/2018	9.6	9.5	10.2	10	0.4	4	1.0
8	31/07/2018	31/08/2018	11.2	10.6	10.1	11	0.5	5	1.4
9	31/08/2018	02/10/2018	12.1	11.8	11.8	12	0.2	1	0.4
10	02/10/2018	30/10/2018	14.6	13.8	17.6	15	2.0	13	5.0
11	30/10/2018	05/12/2018	15.7	16.0	18.7	17	1.7	10	4.1
12	05/12/2018	08/01/2019	17.3	16.4		17	0.7	4	6.1
13									

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

Automatic Method		Data Quality Check	
Period Mean	Data Capture (% DC)	Tubes Precision Check	Automatic Monitor Data
15.4	99.9	Good	Good
15.6	99.4	Good	Good
14.1	96.6	Good	Good
10.8	99.8	Good	Good
8	99.4	Good	Good
6	99.7	Good	Good
8	99.7	Good	Good
9	95.7	Good	Good
10	99.7	Good	Good
12	99.7	Good	Good
15.4	99.8	Good	Good
15.4	99.6	Good	Good
	Overall survey -->	Good precision	Good Overall

(Check average CV & DC from Accuracy calculations)

Site Name/ ID:

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

Accuracy (with 95% confidence interval)
without periods with CV larger than 20%
Bias calculated using 12 periods of data
Bias factor A 0.86 (0.82 - 0.9)
Bias B 16% (11% - 22%)
Diffusion Tubes Mean: 13 µgm⁻³
Mean CV (Precision): 5
Automatic Mean: 12 µgm⁻³
Data Capture for periods used: 99%
Adjusted Tubes Mean: 12 (11 - 12) µgm⁻³

Accuracy (with 95% confidence interval)
WITH ALL DATA
Bias calculated using 12 periods of data
Bias factor A 0.86 (0.82 - 0.9)
Bias B 16% (11% - 22%)
Diffusion Tubes Mean: 13 µgm⁻³
Mean CV (Precision): 5
Automatic Mean: 12 µgm⁻³
Data Capture for periods used: 99%
Adjusted Tubes Mean: 12 (11 - 12) µgm⁻³

Jaume Targa, for AEA
Version 04 - February 2011

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 used to contribute to

the national study and also to derive a local bias correction factor to be considered and applied if appropriate.

In accordance with the Technical Guidance (TG16) the locally derived bias adjustment factor has been applied as the triplicate co-located diffusion tubes showed good precision, as demonstrated in the AEA Checking Precision & Accuracy of Triplicate Tubes table above.

The locally derived bias adjustment factor of 0.86 has therefore been applied.

The Spreadsheet of National Bias Adjustment Factors (v.03/19) is shown below. At the time of writing 8 studies had been used to derive the national bias correction factor for Gradko 50% TEA in Acetone of 0.92.

National Diffusion Tube Bias Adjustment Factor Spreadsheet — Spreadsheet Version Number: 03/19

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 June 2019
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[5] (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[6]	Bias Adjustment Factor (A) (Cm/Dm)
Lambeth Scientific Services	50% TEA in acetone	2018	R	Reigate and Banstead BC (Note tubes set up	10	30	31	-4.2%	G	**1.04**
SOCOTEC Didcot	50% TEA in acetone	2018	UB	Slough Borough Council	10	38	31	25.6%	G	**0.80**
SOCOTEC Didcot	50% TEA in acetone	2018	SU	Slough Borough Council	11	32	22	46.7%	G	**0.68**
SOCOTEC Didcot	50% TEA in acetone	2018	R	Slough Borough Council	11	39	32	22.5%	G	**0.82**
Staffordshire Scientific Services	20% TEA in water	2018	R	Stoke-on-Trent City Council	10	57	56	2.7%	G	**0.97**
Staffordshire Scientific Services	20% TEA in water	2018	UB	Stoke-on-Trent City Council	11	28	23	19.1%	G	**0.84**
SOCOTEC Didcot	50% TEA in acetone	2018	R	Vale of Glamorgan	12	39	25	57.8%	G	**0.63**
Staffordshire Scientific Services	20% TEA in water	2018	UB	Wigan Council	10	26	16	61.3%	G	**0.62**
SOCOTEC Didcot	20% TEA in water	2018	KS	Marylebone Road Intercomparison	9	96	87	9.6%	G	**0.91**
SOCOTEC Glasgow	20% TEA in water	2018	KS	Marylebone Road Intercomparison	9	92	87	5.1%	G	**0.95**
SOCOTEC Glasgow	50% TEA in acetone	2018	KS	Marylebone Road Intercomparison	9	89	87	2.1%	G	**0.98**
SOCOTEC Didcot	50% TEA in acetone	2018	KS	Marylebone Road Intercomparison	9	95	87	9.1%	G	**0.92**
Lambeth Scientific Services	50% TEA in acetone	2018	R	Elmbridge Borough Council	12	29	33	-11.8%	G	**1.13**
Lambeth Scientific Services	50% TEA in acetone	2018	R	Elmbridge Borough Council	12	33	38	-11.2%	G	**1.13**
Aberdeen Scientific Services	20% TEA in water	2018		**Overall Factor[3] (7 studies)**					**Use**	**0.81**
Edinburgh Scientific Services	50% TEA in acetone	2018		**Overall Factor[3] (2 studies)**					**Use**	**0.96**
Glasgow Scientific Services	20% TEA in water	2018		**Overall Factor[3] (9 studies)**					**Use**	**0.86**
Gradko	20% TEA in water	2018		**Overall Factor[3] (30 studies)**					**Use**	**0.93**
Gradko	50% TEA in acetone	2018		**Overall Factor[3] (8 studies)**					**Use**	**0.92**
Lambeth Scientific Services	50% TEA in acetone	2018		**Overall Factor[3] (7 studies)**					**Use**	**1.03**
Milton Keynes Council	20% TEA in water	2018		**Overall Factor[3] (4 studies)**					**Use**	**0.77**
SOCOTEC Didcot	20% TEA in water	2018		**Overall Factor[3] (2 studies)**					**Use**	**0.74**
SOCOTEC Didcot	50% TEA in acetone	2018		**Overall Factor[3] (21 studies)**					**Use**	**0.76**
SOCOTEC Glasgow	20% TEA in water	2018		**Overall Factor[3] (1 study)**					**Use**	**0.95**
SOCOTEC Glasgow	50% TEA in acetone	2018		**Overall Factor[3] (1 study)**					**Use**	**0.98**
Somerset County Council	20% TEA in water	2018		**Overall Factor[3] (3 studies)**					**Use**	**0.89**
South Yorkshire Air Quality Samplers	50% TEA in acetone	2018		**Overall Factor[3] (4 studies)**					**Use**	**0.95**
Staffordshire Scientific Services	20% TEA in water	2018		**Overall Factor[3] (13 studies)**					**Use**	**0.87**
Tayside Scientific Services	20% TEA in water	2018		**Overall Factor[3] (5 studies)**					**Use**	**0.80**
West Yorkshire Analytical Services	50% TEA in acetone	2018		**Overall Factor[3] (8 studies)**					**Use**	**0.80**

Distance Correction

Table A2 lists diffusion tube locations and distance to relevant exposure. Where a “0” has been entered in the table, the tube/s is located on the façade of a building of relevant exposure.
Table B1 presents the annual mean NO_2 level at each DT location and then the distance corrected level. A footnote has been added to the table to explain the circumstances as to why the location has been distance corrected this year as opposed to the previous year and, in the case of Castle Meadow mid, why distance correction is still not appropriate.

Distance correction has been calculated where NO_2 levels are over 40 µg/m³ or within 10% of it.

Whether distance correction is appropriate or not has been determined in accordance with Paragraphs 7.77-7.79 of LAQM.TG16.

Where DT NO_2 annual mean levels are over 40 µg/m³ or within 10% but are located on the façade of buildings of relevant exposure, the bias corrected annual mean has just been repeated in the distance correction column ie a distance correction of zero applied.

Distance correction has been calculated using the “NO_2 fall off with distance calculator” available on the LAQM website and found at;

https://laqm.defra.gov.uk/tools-monitoring-data/no2-falloff.html

Where appropriate either the single or multiple tube calculator has been used.

Annualisation

As all data, continuous and passive, met the 75% or over data capture, there has been no requirement to apply an annualisation factor as described in Boxes 7.9 and 7.10 of LAQM.TG16.

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.

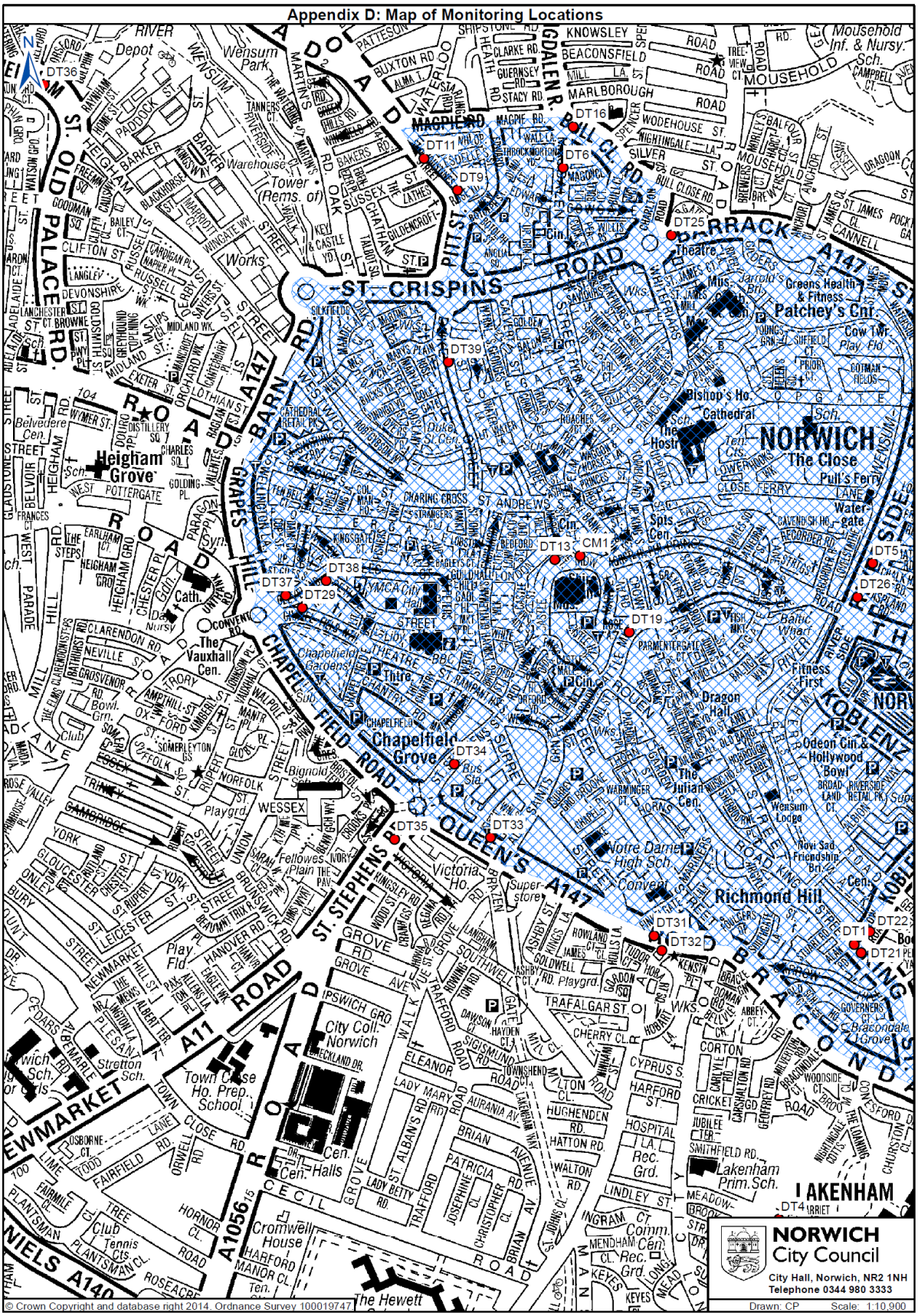
QA/QC of Diffusion Tube Monitoring

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(s) of Monitoring Locations and AQMAs



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 microgrammes 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
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
…	…

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Air Quality Action Plan 2015, Norwich City Council
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Annual Status Report 2018, Norwich City Council
Norfolk County Council website – major projects and improvement plans - Norwich https://www.norfolk.gov.uk/roads-and-transport/major-projects-and-improvement-plans/norwich

DEFRA LAQM website – Air Quality Information Resource

http://uk-air.defra.gov.uk

https://laqm.defra.gov.uk/tools-monitoring-data/no2-falloff.html

https://fingertips.phe.org.uk/profile/public-health-outcomes-framework/data#page/3/gid/1000043/pat/102/par/E10000020/ati/101/are/E07000148/iid/30101/age/230/sex/4

Estimated Background Air Pollution Maps (base year 2015), downloaded from

https://uk-air.defra.gov.uk/data/laqm-background-home