BOROUGH COUNCIL OF KING'S LYNN AND WEST NORFOLK

LAQM FURTHER ASSESSMENT OF THE GAYWOOD CLOCK AQMA

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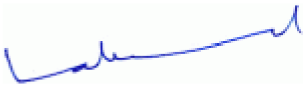
Signature				
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Executive Summary

Part IV of the Environment Act 1995 places a statutory duty on local authorities to review and assess the air quality within their area and take account of Government guidance when undertaking such work.

Based on the findings of the Detailed Assessment produced in July 2008, the Borough Council of King's Lynn and West Norfolk designated an Air Quality Management Area (AQMA) for the NO_2 annual mean objective in King's Lynn in the Gaywood Clock area, encompassing properties at the junction of Wootton Road, Gayton Road and Lynn Road. The AQMA was designated on 6th April 2009.

Bureau Veritas has been commissioned by the Council to carry out a Further Assessment of air quality within the Gaywood Clock AQMA, required as part of the Local Air Quality Management regime. The Further Assessment will provide technical input to the Air Quality Action Plan being prepared by the Council.

The Further Assessment has been undertaken in accordance with Defra's Technical Guidance LAQM.TG(09)[1] methodology, taking into account recent changes in air quality tools such as new road traffic emission factors from DfT included in the Emissions Factor Toolkit (EFT) and updated UK background concentration maps and NO_x / NO_2 conversion tool released in early 2010. The Further Assessment aims, through assessment of monitoring data and modelled predictions:

- to confirm the original assessment of air quality in the AQMA against the prescribed objective;
- to calculate more accurately how much of an improvement in air quality would be needed to deliver the air quality objectives within the AQMA;
- to refine knowledge of the sources of pollution so that the air quality action plan measures can be properly targeted.

The information from the Further Assessment is required to assist the preparation of action plan measures for the AQMA in order that the measures may be targeted and focused, thereby prioritising the most cost-effective approach to reducing air pollutant concentrations in the AQMA.

The findings of this report are the following:

- Monitoring data from diffusion tube monitoring sites indicate that exceedences of the annual mean NO_2 objective continue to be measured within the Gaywood Clock AQMA.
- Updated modelled results confirm the risk of exceedences of the annual mean NO_2 objective within the AQMA at the façade of residential properties.
- Although there is no need to extend the AQMA, monitoring of NO_2 outside the AQMA should continue to ensure concentrations comply with the objective in the future.
- A maximum reduction of 17% in the NO_2 annual mean concentration (equivalent to 26% reduction in NO_x) is required within the AQMA at the worst-case location to comply with the AQS objective. All other locations relevant for public exposure should require a lower reduction of NO_x and NO_2.
- Source apportionment of NO_x indicates that road traffic emissions are the main contributors to total NO_x concentrations, with cars and buses accounting for around 35% and 24% respectively, followed by light-goods vehicles (LGVs - 10%) and heavy-goods vehicles (HGVs - 6%).

[1] Defra (2009), Local Air Quality Management Technical Guidance LAQM.TG(09)

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1 Introduction

1.1 Project Background

Part IV of the Environment Act 1995 places a statutory duty on local authorities to review and assess the air quality within their area and take account of Government guidance when undertaking such work. The Further Assessment is a requirement of the Third Round of Review and Assessment for local authorities that have declared an Air Quality Management Area (AQMA). It is intended to supplement information in the AQMA gathered in the previous Detailed Assessment. Bureau Veritas was commissioned by the Borough Council of King's Lynn and West Norfolk to undertake the Further Assessment of the Gaywood Clock AQMA declared in King's Lynn for nitrogen dioxide (NO_2) on 6th April 2009.

1.2 Air Quality Objectives

The significance of existing and future pollutant levels is assessed in relation to the national air quality standards and objectives, established by the Government. The revised Air Quality Strategy (AQS)[2] for the UK (released in July 2007) provides the over-arching strategic framework for air quality in the UK and contains national air quality standards and objectives established by the UK Government and devolved administrations to protect human health. The air quality objectives incorporated in the AQS and the UK Legislation are derived from the Limit Values prescribed in the EU Directives transposed into national legislation by member states.

The CAFE (Clean Air for Europe) programme was initiated in the late 1990s to draw together previous directives into a single EU Directive on air quality. The Directive 2008/50/EC[3] introduces new obligatory standards for $PM_{2.5}$ for Government but places no statutory duty on local Government to work towards achievement.

The Air Quality Standards (England) Regulations 2007[4] came into force on 15th February 2007 in order to align and bring together in one statutory instrument the Government's obligations to fulfil the requirements of the CAFE Directive.

The objectives for ten pollutants (benzene, 1,3-butadiene, carbon monoxide, lead, nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulates - PM_{10} and $PM_{2.5}$, ozone and Polycyclic Aromatic Hydrocarbons (PAHs) have been prescribed within the Air Quality Strategy[2] based on The Air Quality Standards (England) Regulations 2007.

The objectives set out for pollutants in the AQS and Air Quality Regulations for the purpose of Local Air Quality Management[5] are presented in Table 1. The UK Government and the Devolved Administrations have also set new national air quality objectives for $PM_{2.5}$. These objectives have not been incorporated into LAQM Regulations, and authorities have no statutory obligation to review and assess air quality against them.

The locations where the AQS objectives apply are defined in the AQS as locations outside buildings or other natural or man-made structures above or below ground where members of the public are regularly present and might reasonably be expected to be exposed [to pollutant concentrations] over the relevant averaging period of the AQS objective. Typically these include residential properties and schools/care homes for longer period (i.e. annual mean) pollutant objectives and high streets for short-term (i.e. 1-hour) pollutant objectives.

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[2] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (2007), Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland

[3] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe

[4] The Air Quality Standards Regulations 2007, Statutory Instrument No 64, The Stationary Office Limited

[5] The Air Quality (England) (Amendments) Regulations 2002 (Statutory Instrument 3043)

Table 1 - Air Quality Objectives included in Regulations for the purpose of LAQM in England

Pollutant	Concentration	Measured As	Date to Be Achieved By
Benzene	16.25 µg/m^3	Running annual mean	31.12.2003
	5.00 µg/m^3	Running annual mean	31.12.2010
1,3-Butadiene	2.25 µg/m^3	Running annual mean	31.12.2003
Carbon monoxide (CO)	10.0 mg/m^3	Running 8-hour mean	31.12.2003
Lead	0.5 µg/m^3	Annual mean	31.12.2004
	0.25 µg/m^3	Annual mean	31.12.2008
Nitrogen dioxide (NO_2)	200 µg/m^3 not to be exceeded more than 18 times a year	1-hour mean	31.12.2005
	40 µg/m^3	Annual mean	31.12.2005
Particles (PM_{10}) (gravimetric)	50 µg/m^3, not to be exceeded more than 35 times a year	24-hour mean	31.12.2004
	40 µg/m^3	Annual mean	31.12.2004
Sulphur Dioxide (SO_2)	350 µg/m^3, not to be exceeded more than 24 times a year	1-hour mean	31.12.2004
	125 µg/m^3, not to be exceeded more than 3 times a year	24-hour mean	31.12.2004
	266 µg/m^3, not to be exceeded more than 35 times a year	15-minute mean	31.12.2005

1.3 Local Air Quality Management (LAQM) Review and Assessment

As established by the Environment Act 1995 Part IV, all local authorities in the UK are under a statutory duty to undertake an air quality assessment within their area and determine whether they are likely to meet the air quality objectives set down by the Government for a number of pollutants. The process of review and assessment of air quality undertaken by local authorities is set out under the Local Air Quality Management (LAQM) regime and involves a phased three yearly assessment of local air quality. Where the results of the review and assessment process highlight that problems in the attainment of health-based objectives for air quality will arise, the authority is required to declare an Air Quality Management Area (AQMA) – a geographic area defined by high levels of pollution and exceedences of AQS objectives.

The LAQM regime was first set down in the 1997 National Air Quality Strategy (NAQS)[6] and introduced the idea of local authority 'Review and Assessment'. The Government subsequently published policy and technical guidance related to the review and assessment processes in 1998. This guidance has since been reviewed and the latest documents include Policy Guidance (LAQM.PG (09))[7] and Technical Guidance (LAQM.TG (09))[8]. The guidance lays down a progressive, but continuous, framework for the local authorities to carry out their statutory duties to monitor, assess and review air quality in their area and produce action plans to meet the air quality objectives.

Defra and the Devolved Administrations released the latest Policy and Technical Guidance in February 2009, in anticipation of the fourth round of review and assessment. The fourth round began with the Updating and Screening Assessment required to be completed by local authorities by the end of April 2009.

1.4 Purpose of Further Assessment

The approach of the Further Assessment is to provide the Local Authority with an opportunity to supplement the information gathered in the previous LAQM reports and confirm whether the AQMA is still required or if its extent needs to be amended (increased or reduced).

The methodology is based on dispersion modelling and includes the following:

- Review of additional monitoring since the Detailed Assessment – including continuous monitoring and diffusion tubes,
- Assessment of the reduction in pollutant concentrations that is required to meet the AQS objectives in the AQMA,
- Source apportionment of pollutants; including relevance of background contributions and the different vehicle classification on the roads of concern.

This was carried out based on detailed dispersion modelling using the ADMS-Roads (v2.3) atmospheric dispersion model. Monitoring results from nitrogen dioxide diffusion tubes installed in the assessment area were used to verify the modelled results. The concentrations of NO_x and NO_2 were predicted for the baseline (verification) year 2009, and future year 2010. The dispersion modelling was undertaken in accordance with the methodologies provided in the Technical Guidance (LAQM.TG(09)) for Detailed and Further Assessments.

[6] DoE, 1997, 'The United Kingdom National Air Quality Strategy', The Stationary Office

[7] Policy Guidance LAQM.PG(09) (2009), Part IV of the Environment Act 1995, Local Air Quality Management, Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland, The Stationery Office

[8] Technical Guidance LAQM.TG (09) (2009), Part IV of the Environment Act 1995, Local Air Quality Management, Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland, The Stationery Office

1.5 Summary of Previous Review and Assessments

Between 1999 and 2003, the Borough Council of King's Lynn & West Norfolk undertook its first round of Review and Assessment of air quality, which concluded that PM_{10} and NO_2 levels were likely to exceed the AQS objectives at a number of locations in King's Lynn. As a result, the Council declared two AQMAs, one in South Quay (for PM_{10}) in April 2002, and another one in Railway Road (for NO_2) in November 2003. The South Quay AQMA was revoked in June 2006 following the effective implementation of an Air Quality Action Plan for the area.

The second round of Review and Assessment began with an Updating and Screening Assessment (USA), completed in 2003. The report concluded that there had been no significant changes since the first round and that it was not necessary to carry out a Detailed Assessment at that time. However, the subsequent Progress Report (2004) recommended proceeding to a Detailed Assessment of NO_2, following new monitored exceedences of the annual mean objective outside the AQMA in King's Lynn. The Detailed Assessment (2005) confirmed that exceedences were likely to occur at several sites outside the AQMA, and as a result, made a recommendation to extend the AQMA to encompass properties along Railway Road, Blackfriars Road and London Road.

The third round of Review and Assessment began with the USA, completed in 2006. The report provided an update with respect to air quality issues within the Borough since the previous round. A number of changes made to the technical guidance for the Review and Assessment process since the second round (Technical Guidance LAQM.TG(03)) were taken into account for this assessment. Having considered each pollutant, the USA concluded that the AQS objectives for benzene, 1,3-butadiene, carbon monoxide, lead, PM_{10} and sulphur dioxide were still being met and that no further assessment was required for these pollutants.

The report also recommended (following the conclusions of the Detailed Assessment 2005) that monitoring of NO_2 be continued in the Borough to validate the proposal to extend the Railway Road AQMA in King's Lynn. The Council approved a variation order (February 2007) to extend the AQMA, which now includes all of Railway Road, Austin Street, Blackfriars Road, St James Road and London Road.

Modelling undertaken by a neighbouring Local Authority, Fenland District Council, also predicted potential exceedences of the NO_2 annual mean AQS objective along Elm High Road in Wisbech. The area lies on the border of the Borough of King's Lynn & West Norfolk; therefore, both local authorities deployed additional diffusion tubes in the area to confirm the modelling results.

The Progress Report carried out in 2007 confirmed that NO_2 concentrations were still exceeding the objective at the majority of the monitoring sites in the AQMA; justifying its extension. It also concluded that a Detailed Assessment for NO_2 in Wisbech was not required, as new monitoring results were below the AQS objective. However, new available NO_2 monitoring results showed an exceedence of the objective at the 'Wootton Road 2' diffusion tube in the Gaywood Clock area of King's Lynn. This site is located about 1200m east of the extended AQMA in the town centre; therefore, it was recommended that a Detailed Assessment be carried out in this area.

The Detailed Assessment, which also included the Further Assessment of the Railway Road AQMA, was completed in 2008. The report concluded that a new AQMA in the Gaywood Clock area was required, as both updated monitoring data and predicted NO_2 concentrations confirmed that the AQS annual mean objective was likely to be exceeded. The new AQMA was declared in April 2009, for an area encompassing properties at the junction of Wootton Road, Gayton Road and Lynn Road. The Gaywood Clock AQMA is shown in Figure A1, Appendix 3.

The Further Assessment confirmed that the extended Railway Road AQMA in King's Lynn Town Centre was still valid and should remain, as both monitoring and modelling confirmed exceedences of the AQS objective. The source apportionment results showed that cars are the main contributors with respect to high levels of NO_2 in the AQMA, followed by buses, HGVs and LGVs, while background pollution levels also contribute significantly.

The USA 2009 took into consideration changes to the Technical Guidance LAQM.TG(09) and concluded that although exceedences of NO_2 were still recorded in the Borough, these were confined to the existing AQMAs. Pollutant concentrations outside the AQMAs met the objectives and no Detailed Assessment was required.

The Progress Report 2010, which provides an update to air quality monitoring, new developments and air quality policies since the USA 2009, was completed early 2010. The report concluded that, although two sites exceeded the NO_2 annual mean AQS objectives outside King's Lynn AQMAs, these are not representative of public exposure and there is no requirement to proceed to a Detailed Assessment for these sites at this stage. All other pollutants assessed showed compliance with the AQS objectives.

2 Baseline Information

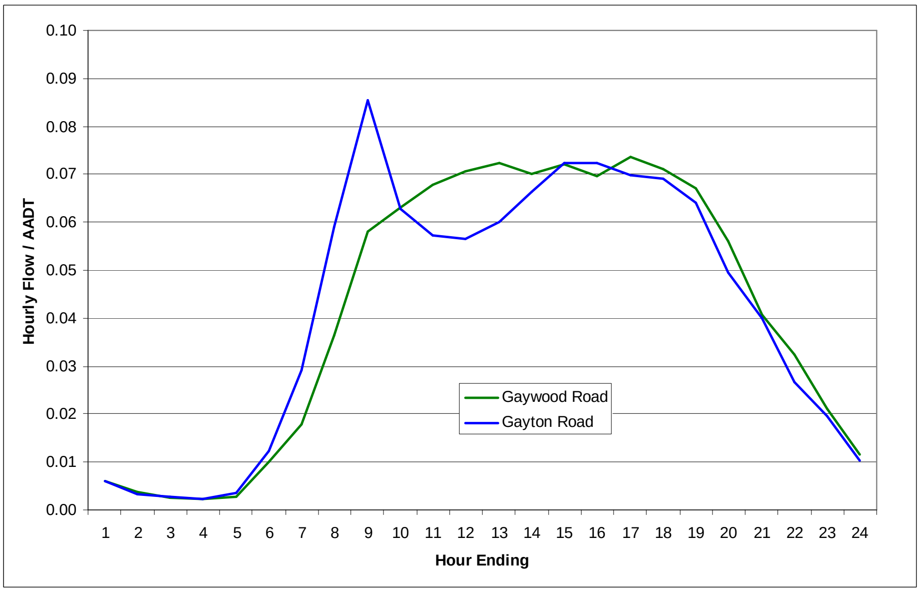
2.1 Traffic Data

Traffic data for the assessment were collated from Department for Transport's website, which provides traffic flows for all A-roads and motorways in Great Britain[9] for the latest year available (2008). The data provide a break down of traffic flows for the following vehicle classes: cars, LGVs, buses, HGVs and motorcycles for the A148 Lynn Road, the A1076 Gayton Road and the A148 Wootton Road.

Traffic data were projected to the baseline year 2009 and 2010, using growth factors from Tempro[10] and NTM (National Traffic Model) adjusted for the King's Lynn area.

The same diurnal profiles used in the Detailed Assessment 2008, derived from ATCs on the A148 and the A1076 were used in this assessment (see Figure 1 below). The traffic data are summarised in Appendix 1 and modelled roads illustrated in Figure A1 in Appendix 3.

Figure 1 - Traffic Flow Diurnal Patterns (7-Day Average)



[9] www.dft.gov.uk/matrix/

[10] Tempro (Trip End Model Presentation Program) version 6.2, 5.4 datasets, Department for Transport

2.2 Air Quality Monitoring Data

The Council monitors NO_2 at a number of sites across the Borough, most of them in King's Lynn town centre. Eight of these sites, located at roadside sites within or near the Gaywood Clock AQMA, have been used in this Further Assessment. These are illustrated in Figure A1 in Appendix 3.

The diffusion tubes are supplied and analysed by Gradko Ltd and prepared using the 20% TEA[11] in water method. Gradko participates in the UK National Diffusion Tube Network and the Workplace Analysis Scheme for Efficiency (WASP).

A bias adjustment factor has been applied to the data, which is an estimate of the difference between diffusion tube concentrations and continuous monitoring concentrations, the latter assumed to be a more accurate method of monitoring. For 2007 and 2008 results, the bias adjustment factors have been taken from the Council's previous LAQM annual reports. All adjustment factors are derived from the triplicate diffusion tube results co-located with the continuous monitoring site in King's Lynn Southgates, located 2km southwest of the junction in King's Lynn town centre AQMA. Details of the bias adjustment factor calculation are given in Appendix 2.

Data capture was good at all sites, with a minimum of 10-month worth of data; therefore it was not necessary to annualise the results.

Bias adjusted monitoring results for the past 3 years for the sites located within or near the Gaywood Clock AQMA are provided in Table 2.

Only one diffusion tube (site 41 Wootton Road 2) recorded annual mean concentrations which exceed the 40µg/m³ objective in 2009. This tube, located within the AQMA on Wootton Road, has been exceeding the objective consistently over the past few years. Two other sites within the AQMA (sites 40, The Swan, Gayton Road, and 44 Lynn Road 2) were also close to the objective (within 38 - 39µg/m^3) in 2009.

The annual mean at site 52 Lynn Road 3 was also close to the objective in 2009 (37µg/m^3). This site is located just 30m further west of the AQMA.

Results at site 45 on Lynn Road, Gaywood, and 51 on Wootton Road, both outside the AQMA, are well below the AQS objective, which confirms that NO_2 levels drop off away from the A148 / A1076 junction.

With regard to the NO_2 short term objective; there is a potential risk of exceedence where the annual mean concentration is greater than 60µg/m³. There are no monitoring locations which recorded such concentrations and therefore it is expected that the short-term objective is being met.

[11] Triethanolamine

Table 2 - NO_2 Monitoring Results near Gaywood Clock AQMA – 2007- 2009

Site ID	Location / Name	OS Grid Ref		Type	Within AQMA?	Data Capture 2009 (Month)	Annual Mean Concentrations (µg/m^3)		
							2007 (Bias: 0.89)	2008 (Bias: 0.88)	2009 (Bias: 0.97)
40	The Swan Gayton Road	563480	320470	Roadside	Y	11	36.9	36.6	39.0
41	Wootton Road 2	563478	320515	Roadside	Y	12	**45.1**	**40.4**	**45.1**
42	Wootton Road 1	563480	320582	Roadside	Y	12	35.2	31.6	35.4
43	Lynn Road 1	563412	320477	Roadside	Y	11	34.6	30.0	32.7
44	Lynn Road 2	563377	320484	Roadside	Y	11	39.8	34.1	38.6
45	Gaywood 3	563202	320488	Roadside	N	11	34.0	30.8	33.3
51	Wootton Road 3	563515	320628	Roadside	N	12	22.3	21.4	23.6
52	Lynn Road 3	563288	320499	Roadside	N	10	33.2	30.7	37.0

In bold, exceedence of the NO_2 annual mean AQS objective of 40µg/m^3

2.3 Background Concentrations

The latest local air quality monitoring and updated national background pollution maps[12] were considered to determine the most appropriate background concentrations for this assessment.

NO2 concentration for year 2009 derived from the latest background maps[13] is 14.5µg/m^3 for the Gaywood Clock area.

The Council also monitors NO_2 levels at several background sites; the closest being site S8/9 located in The Parks High School off Queen Mary Road, 500m south of the Gaywood Clock AQMA. The NO_2 annual mean at this site was 17.9µg/m^3 in 2009. Local background has been preferred to the UK background maps as it would be more representative as well as more conservative. Based on the ratio between NO_x and NO_2 from the background maps for the area, the equivalent background NO_x concentration is determined to be 28.0µg/m^3.

Background NO_x and NO_2 concentrations for 2010 were derived based on the methodology described in LAQM.TG(09), using the ratio of 2010 NO_2 concentrations to 2009 from the background maps. Table 3 shows the background pollutant concentrations used in this assessment.

Table 3 - Background Concentrations Used in the Assessment

Pollutant	2009 Background (µg/m^3)	2010 Background (µg/m^3)
NO_x	28.0	25.7
NO_2	17.9	16.6

[12] Estimated background air pollution levels for the UK – Available online at http://laqm1.defra.gov.uk/review/tools/background.php

[13] Based on the nearest 1km×1km square grid cell covering Gaywood Clock area (X= 563500, Y= 320500)

3 Dispersion Modelling Methodology

Detailed dispersion modelling of NO_x was undertaken based on ADMS-Roads (version 2.3) atmospheric dispersion model from Cambridge Environmental Research Consultants (CERC), using the latest emissions factors released by DfT in 2009 and incorporated by Defra in the latest Emission Factors Toolkit (EFT)[14]. Conversion to NO_2 was based on the updated NO_X/NO_2 conversion model released by Defra in January 2010 as part of updated LAQM tools.

ADMS-Roads is an advanced Gaussian dispersion model, which has been extensively used in local air quality management and has formed the basis for many AQMA declarations. A number of validation studies have been completed, showing overall good agreement between model outputs and observations at continuous monitoring sites.

The model set up has taken into account the influence of street canyons on the dispersion of pollutants in the assessment area. The street canyon height has been set as 7m, which is consistent with previous assessment work. Vehicle speed has been reduced at the junction, as recommended in LAQM.TG(09).

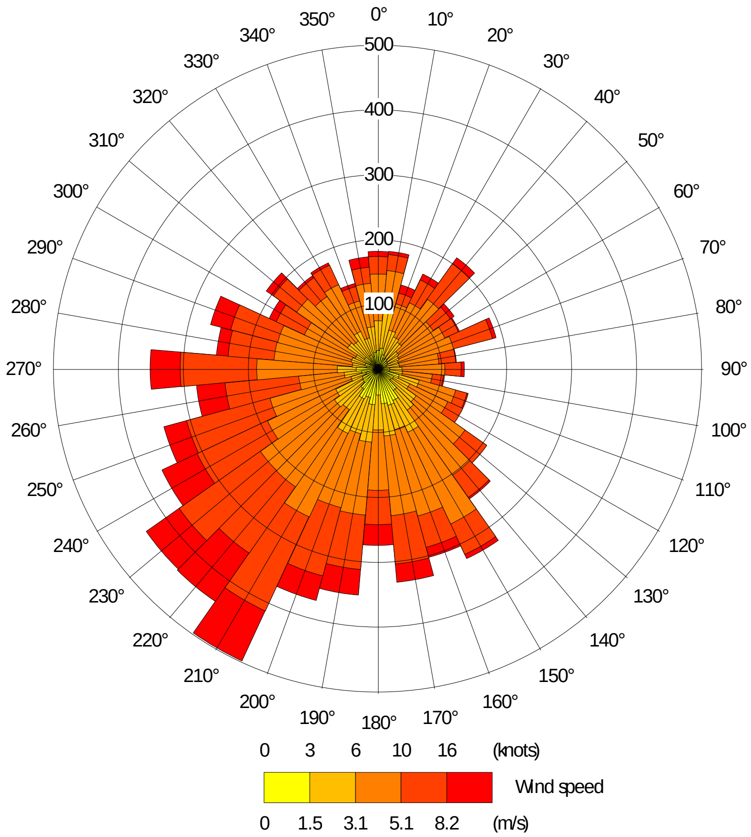
Dispersal of pollutant emissions is dependent (amongst other factors like topography and street canyon effects) upon the prevailing meteorological conditions at the time of emissions release. Hourly sequential meteorological data from an appropriate meteorological station (Marham, 15 km South East of King's Lynn town centre) was used in this assessment, based on year 2009. The wind rose for meteorological data showing the dominant south-westerly wind direction is shown in

Figure 2.

Most Gaussian-type models do not use the lines in the meteorological data set, which have calm winds in its calculations. ADMS-Roads treats calm wind conditions by setting the minimum wind speed to 0.75 m/s. It is recommended in LAQM.TG(09) that the meteorological data file be tested within a dispersion model and the relevant output log file checked, as this will confirm the number of missing hours and calm hours calculated by the dispersion model. This is important especially when considering predictions of high percentiles and the number of exceedences. The Marham 2009 meteorological file has 8745 lines of useable data out of a total of 8760 for the year i.e. more than 99% data capture. Calm conditions are applied to 216 lines of data, which represents 2.5% of the meteorological data.

[14] Emission Factors Toolkit EFT 4.2 – June 2010 - Available online at http://laqm1.defra.gov.uk/review/tools/emissions.php

Figure 2 - Wind Rose Hourly Sequential Meteorological Data – Marham Weather Station 2009



4 Results

4.1 Model Verification and Adjustment

Model verification at monitoring sites in the Gaywood Clock area was carried out prior to predicting concentrations within the AQMA. The objectives of the model verification are:

- to evaluate model performance,
- to show that the baseline is well established, and
- to provide confidence in the assessment

Comparison of the modelled road-NO_x concentrations with monitored data was carried out based on local monitoring data from roadside NO_2 monitoring sites. Predicted NO_2 was derived from predicted NO_x concentrations based on the latest NO_x/NO_2 conversion model released by Defra in January 2010[15].

During the verification process, Bureau Veritas aim to ascertain whether all final modelled concentrations are within 25% of the monitored concentrations. Modelled results may not compare as well at some locations for a number of reasons including:

- Errors in traffic flow and speed data estimates,
- Model setup (including street canyon, road width, receptor location),
- Model limitations (treatment of roughness and meteorological data),

[15] Available online at http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php

- Uncertainty in monitoring data (notably diffusion tubes, e.g. bias adjustment factors and annualisation of short-term data),
- Uncertainty in emissions or emission factors.

The above factors were investigated as part of the model verification process to minimise the uncertainties as far as practicable. The model verification results are provided in Table 4. The full verification methodology is shown in Appendix 4.

Table 4 - NO_2 Model Verification Results

Site ID	Monitored NO_2 2009 (µg/m^3)	Predicted Total NO_2 2009 (µg/m^3)	Difference Predicted / Monitored 2009 (µg/m^3)	Difference Predicted / Monitored 2009 (%)
40	39.0	**40.6**	1.6	4.0%
41	**45.1**	38.6	-6.5	-14.4%
42	35.4	35.1	-0.3	-0.8%
43	32.7	34.1	1.4	4.3%
44	38.6	38.3	-0.3	-0.7%
45	33.3	36.5	3.2	9.7%
51	23.6	27.1	3.5	14.6%
52	37.0	38.1	1.1	3.0%
Summary				
Number of Sites	Within ±10%		6	
	Between ± 10-25%		2	
	Exceeds ±25%		0	
	Total		8	

In bold: exceedence of the NO_2 annual mean AQS objective (40µg/m^3)

Overall, predicted concentrations are in good agreement with monitoring data, with all predicted concentrations within ±25% of the monitoring results and the majority within ±10%.

The model over predicts NO_2 concentrations by 14% at site 51, located 30m north of the AQMA on Wootton Road, although both monitored and predicted results are below 30µg/m^3 at this location.

Although vehicle speed was reduced on the southbound section of Wootton Road near the junction in the AQMA, the model still under predicts by 14% at nearby site 41.

4.2 Modelled NO_2 Concentrations

Annual average NO_2 concentrations were predicted for the years 2009 and 2010 at a number of specific receptors representing relevant public exposure, located at the facade of properties adjacent to the modelled roads. Only receptors relevant of public exposure have been considered. Predictions were also made at a 5m-grid spacing across the exceedence area to produce a concentration contour map for the year 2009. NO_2 concentrations were modelled at a height of 1.5m above ground, which represents the average respirable height of an adult, apart from those receptors representing the façade of properties at 1st floor level.

Predicted NO_2 concentrations at specific receptors are provided in Table 5. The location of all specific receptors is shown in Figure A1, Appendix 3.

Figure A2 in Appendix 5 also provides the NO_2 concentration contours for 2009, showing the predicted areas of exceedence of the annual mean AQS objective (> 40µg/m^3).

The highest concentration is predicted for receptor WoottonRd1 located in the AQMA at the A148/A1076 junction with a predicted annual mean of 48.2µg/m^3 in 2009, which is above the AQS objective. The NO_2 annual mean at all other receptors within the AQMA is predicted to be below the AQS objective, although receptor LynnRd3 is relatively close (38.1µg/m^3).

There is no exceedence of the objective predicted at receptors outside the AQMA along Wootton Road, Lynn Road and Gayton Road, as concentrations are predicted to be below 30µg/m^3.

Predicted results for year 2010 show a slight reduction in concentrations at modelled receptors. This is due to predicted decrease in background concentrations and road traffic emissions, which compensates for expected traffic growth. The NO_2 annual mean objective is still predicted to be exceeded at receptors WoottonRd1 in 2010, which is within the boundaries of the actual AQMA. No receptor is predicted to exceed the objective outside the AQMA for 2010.

Table 5 - Predicted NO_2 Concentrations at Specific Receptors

Receptor ID	X(m)	Y(m)	Z(m)	Within AQMA?	NO_2 2009 ($\mu g/m^3$)	NO_2 2010 ($\mu g/m^3$)
GaytonRd1	563515	320468	1.5	N	29.3	27.5
LynnRd1	563205	320466	1.5	N	29.8	28.0
LynnRd2	563295	320504	1.5	N	33.7	31.8
LynnRd3	563319	320499	1.5	Y	38.1	36.2
LynnRd4	563317	320470	1.5	N	27.2	25.5
WoottonRd1	563458	320490	4.5	Y	**48.2**	**46.3**
WoottonRd2	563478	320493	4.5	Y	28.6	26.8
WoottonRd3	563485	320549	1.5	Y	36.5	34.5
WoottonRd4	563559	320678	1.5	N	24.3	22.6
WoottonRd5	563552	320701	1.5	N	23.6	22.0
WoottonRd6	563489	320599	1.5	Y	29.3	27.5
WoottonRd7	563482	320606	1.5	N	24.2	22.6

In bold, exceedence of the NO_2 annual mean AQS objective (40µg/m^3)

4.3 NO_x Source Apportionment

The breakdown of vehicle classification was taken into account in the model set-up. This allows the calculation of NO_x source apportionment at specific (worst case) receptors, where exceedences were predicted. The source apportionment was carried out for the following vehicle classes:

- cars,
- light goods vehicles (LGVs),
- buses/coaches,
- heavy goods vehicles (HGVs), and
- motorcycles.

The break down of NO_x background concentrations by source as provided in the national background maps, combined with the actual background NO_x used for this assessment (as provided in Section 2.3) have been used to estimate the contribution of each background component to the total background NO_x in the assessment area. The 1 x 1km grid square relevant to the assessment is x= 563500, y= 320500.

Table 6 and Table 7 summarise the results at the worst case receptor representing public exposure in the exceedence area. The source apportionment indicates that, at the worst-case receptor:

- Road traffic emissions are the main contributor to NO_x, as they account for 75% of the total NO_x concentration;
- Of the road traffic sources, cars and buses are the most significant contributors, as they account for respectively 35% and 24% of the total NO_x concentration. The contribution of buses to the total NO_x concentration is quite significant especially if compared to the proportion of the vehicle fleet they represent (1-2% of overall traffic);
- Light goods vehicles (LGVs) contribute around 10% to the total NO_x concentration;
- Heavy-goods vehicles (HGVs) contribute around 6% to the total NO_x concentration;

- Background concentrations account for nearly 25% of the total NO_x concentration, including 10% due to the “regional” background concentration outside the local authority’s influence;
- Similar to NO_x, the source apportionment of NO_2 indicates road traffic emissions to be the most significant source, contributing 63% to overall NO_2 concentration at the worst-case receptor. Of these, cars and buses are the biggest contributors, accounting for respectively about 30% and 20% of the overall NO_2 concentration.

Table 6 - Source Apportionment of NO_X Concentrations at Worst-Case Receptor

Receptor (Maximum Modelled Concentration) (µg/m^3)	WoottonRd1
Total NO_x 2009 (Total Background + Local Road Source)	114.2
NO_x Total Background (Local + Regional)	28.0
▪ NO_x Local Background	16.1
▪ NO_x Regional Background	11.9
Local Road Source Contributions (LDV + HDV)	86.2
▪ NO_x CAR	39.7
▪ NO_x LGV	11.9
▪ NO_x HGV	7.2
▪ NO_x BUS	27.0
▪ NO_x MOTORCYCLE	0.3
Contribution as Percentage of Total NO_x Concentration	
% Total Background (Local + Regional)	24.5%
▪ % Local background	14.1%
▪ % Regional background	10.4%
% Road traffic	75.5%
▪ % due to CAR traffic	34.8%
▪ % due to LGV traffic	10.5%
▪ % due to HGV traffic	6.3%
▪ % due to BUS traffic	23.6%
▪ % due to MOTORCYCLE traffic	0.3%
▪ % CAR contribution of total road traffic	46.1%
▪ % LGV contribution of total road traffic	13.8%
▪ % HGV contribution of total road traffic	8.4%
▪ % BUS contribution of total road traffic	31.3%
▪ % MOTORCYCLE contribution of total road traffic	0.3%

Table 7 - Source Apportionment of NO_x Local Background Concentrations

NO_X Local Background in µg/m^3 Includes:	NO_X Concentration - µg/m^3	% of Local Background NO_X	% of Total NO_X
Road sources (minor roads + A-Roads outside modelled area) Primary roads have been included in the model road source contribution	4.65	28.8%	4.1%
Industry (combustion in industry, energy production, extraction of fossil fuel, and waste)	3.52	21.8%	3.1%
Domestic	3.46	21.4%	3.0%
Rail	0.03	0.2%	0.0%
Other (ships, offroad and other emissions)	3.46	21.4%	3.0%
Point sources	1.02	6.3%	0.9%

Table 8 - Source Apportionment of NO_2 Concentrations at Worst-Case Receptor

Receptor (Maximum Modelled Concentration) (µg/m^3)	WoottonRd1
Total NO_2 2009 (Total Background + Local Road Source)	48.2
NO_2 Total Background (Local + Regional)	17.9
▪ NO_2 Local Background	10.3
▪ NO_2 Regional Background	7.6
Local Road Source Contributions (LDV + HDV)	30.3
▪ NO_2 CAR	14.0
▪ NO_2 LGV	4.2
▪ NO_2 HGV	2.5
▪ NO_2 BUS	9.5
▪ NO_2 MOTORCYCLE	0.1
Contribution as Percentage of Total NO_2 Concentration	
% Total Background (Local + Regional)	37.1%
▪ % Local background	21.4%
▪ % Regional background	15.7%
% Road traffic	62.9%
▪ % due to CAR traffic	29.0%
▪ % due to LGV traffic	8.7%
▪ % due to HGV traffic	5.3%
▪ % due to BUS traffic	19.7%
▪ % due to MOTORCYCLE traffic	0.2%
▪ % CAR contribution of total road traffic	46.1%
▪ % LGV contribution of total road traffic	13.8%
▪ % HGV contribution of total road traffic	8.4%
▪ % BUS contribution of total road traffic	31.3%
▪ % MOTORCYCLE contribution of total road traffic	0.3%

4.4 NO_x / NO_2 Required Reduction

A requirement of the Further Assessment is to determine the amount of NO_2 reduction required at the worst-case receptors within the exceedence areas. This approach highlights the maximum reduction in NO_2 required (as NO_x, in µg/m^3) to comply with the AQS objective, and assumes that other receptors will require less of a reduction. For the current assessment, the approach to estimate the required NO_2 reduction was to determine the levels of NO_x for the highest concentrations predicted at sensitive receptors relevant of public exposure. The results are shown in Table 9.

In order to determine the required reduction in NO_x, the NO_2 annual mean AQS objective of 40µg/m^3 was calculated to be equivalent to 84.7µg/m^3 NO_x concentration (based on local background NO_x and the NO_x/NO_2 conversion converter).

The maximum predicted NO_x reduction required within the Gaywood Clock AQMA to comply with the NO_2 AQS objective is 29.5µg/m^3 (equivalent to 26% decrease in NO_x). This equates to a 8.2µg/m^3 reduction in NO_2 (equivalent to a 17% decrease in NO_2). This is at the worst-case location in the AQMA at the junction of Wootton Road/Lynn Road and Gayton Road.

Consequently, the formulation of the Action Plan should aim to reduce the levels of NO_x/NO_2 in the AQMA by these amounts.

Table 9 - Required NO_x and NO_2 Reduction to Comply with AQS Objective

Receptor ID	Modelled NO_x 2009 (µg/m^3)	Equivalent NO_x Objective (µg/m^3)	NO_x Reduction Required (µg/m^3)	NO_x % Reduction Required	Modelled NO_2 (µg/m^3)	NO_2 AQS objective (µg/m^3)	NO_2 Reduction Required (µg/m^3)	NO_2 % Reduction Required
Wootton Rd1	114.2	84.7	29.5	25.8%	48.2	40	8.2	17.0%

5 Conclusions and Recommendations

As part of the Local Air Quality Management (LAQM) regime, a Further Assessment based on detailed dispersion modelling has been carried out for the Gaywood Clock Air Quality Management Area (AQMA) in King's Lynn. The AQMA was declared at the junction of the A148 Lynn Road/Wootton Road and the A1076 Gayton Road for nitrogen dioxide (NO_2) in April 2009 due to predicted exceedences of the NO_2 annual mean Air Quality Strategy objective.

This assessment is based on advanced atmospheric dispersion modelling of NO_x traffic emissions, relying on background pollutant concentrations, monitoring data, traffic and meteorological data for the year 2009.

Source apportionment of pollutant contribution has been carried out to determine contributions of vehicle emissions and other sources to NO_x and NO_2 concentrations in the Gaywood Clock AQMA. The NO_x reduction would be required to comply with the AQS objectives has been calculated based on the highest concentration results at sensitive receptors relevant of public exposure (facades of properties).

The findings of this report are the following:

- Monitoring data from diffusion tube monitoring sites indicate that exceedences of the annual mean NO_2 objective are still being measured within the AQMA.
- Updated modelled results confirm the monitoring data, as they indicate that there is a risk of exceedence of the annual mean NO_2 objective at a number of residential properties within the Gaywood Clock AQMA.
- In the light of these results, the AQMA should remain but it is not required to extend its boundaries as neither monitoring nor modelling results show that there is a risk of exceeding the objectives outside the AQMA. However, monitoring of NO_2 outside the AQMA should continue to ensure concentrations still comply with the AQS objectives in the future.
- A maximum reduction of 26% (30µg/m^3) in overall NO_x annual mean concentration is required within the AQMA to comply with the NO_2 AQS objective, equivalent to 17% (8µg/m^3) improvement in NO_2. This is the worst-case modelled location. All other modelled receptors require a lower reduction of NO_x/NO_2. Consequently, the formulation of the Action Plan should aim to reduce the levels of NO_x/NO_2 within the AQMA by up to this amount.
- Source apportionment of NO_x indicates that road traffic emissions are the main contributors, as they account for 75% of the total NO_x concentrations at the worst-case receptor. Cars and buses contribute respectively around 35% and 24% to the total NO_x concentrations at the worst-case receptor. The contribution of buses is quite significant given their low proportion within the overall vehicle fleet.

Appendices

Appendix 1: Traffic Data

Table A1 - Traffic Data Used in the Assessment

Road	AADT 2009	AADT 2010	Speed (kph) (1)	% Car	% LGV	% HGV	% Bus	% Motorcycle
A1076 Gayton Road	14955	15028	30	88.1%	8.9%	1.1%	1.4%	0.5%
A148 Wootton Road	11544	11601	30	86.9%	10.3%	0.8%	0.8%	1.2%
A148 Lynn Road	23437	23552	30	86.8%	8.9%	0.6%	2.1%	1.6%

(1) Speed was reduced at the approach of the junction in line with guidance LAQM.TG(09)

Appendix 2: Diffusion Tube Bias Adjustment Factor and QA/QC

Factor from Local Co-location Studies

Tubes are co-located at the Southgates continuous monitoring station. The summary of the bias calculations is shown in Table A2 below.

Table A2 - Summary of Bias Adjustment Calculation

Kings Lynn Southgates (based on 10 periods of data)	
Bias Factor A	0.97 (0.86 – 1.13)
Bias B	3% (-11% - 17%)
Diffusion Tubes Mean:	31 µg/m³
Mean CV (Precision):	6
Automatic Mean:	30 µg/m³
Data Capture for Periods Used:	97%
Adjusted Tubes Mean:	30 (26.35) µg/m³

Discussion of Choice of Factor to Use

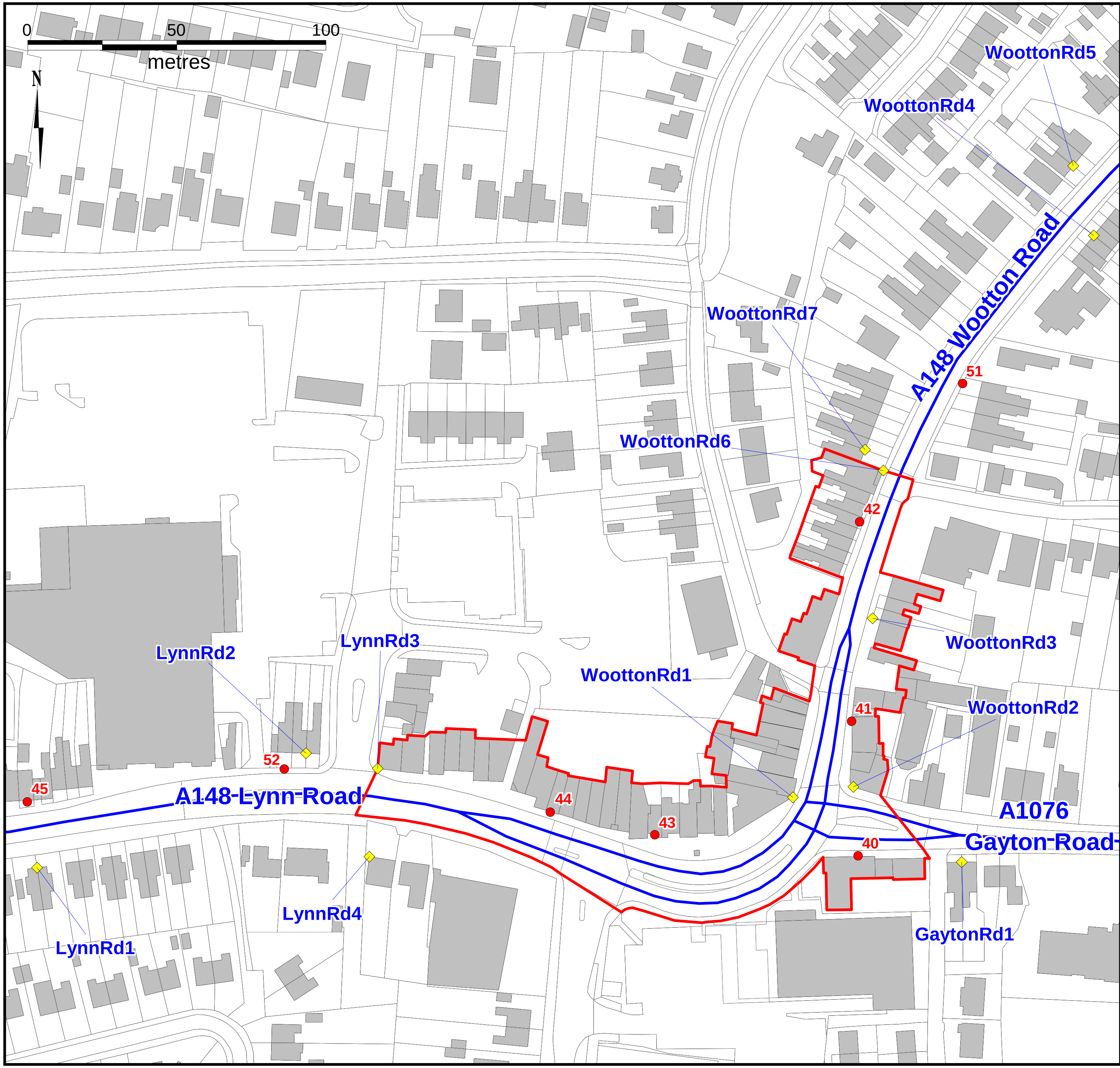
With regard to the application of a bias adjustment factor for the diffusion tubes, Technical Guidance LAQM.TG(09) and the Review and Assessment Helpdesk recommend the use of a local bias adjustment factor where available and relevant to diffusion tube sites. The co-location site, as in previous review and assessment stages, has been used to derive a local bias correction factor. The default bias correction from the Review and Assessment spreadsheet (version 310310) is 0.90. The local factor of 0.97 would suggest the tubes have only slightly over estimated the ambient concentration of NO_2. The locally derived bias correction provides a degree of conservatism i.e. is a more worse-case result.

QA/QC of Diffusion Tube Monitoring

Gradko Laboratories participate in the Workplace Analysis Scheme for Proficiency (WASP) for NO_2 diffusion tube analysis and the Annual Field Inter-Comparison Exercise. These provide strict performance criteria for participating laboratories to meet, thereby ensuring NO_2 concentrations reported are of a high calibre. The latest rounds of the WASP scheme relied on a z-score (graded: Satisfactory, Adequate, or Unsatisfactory) rather than an overall score and the assessment rated the laboratory as “Satisfactory”. The AEA intercomparison rated Gradko as “Good”.

The laboratory follows the procedures set out in the Harmonisation Practical Guidance.

Appendix 3: Gaywood Clock Modelled Area Map



Legend

- AQMA Boundaries
- NO2 Diffusion Tube
- Modelled Receptor
- Modelled Road

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Location	Borough of King's Lynn and West Norfolk
Title	Gaywood Clock Modelled Area

By	Checked	Approved
EC	EC	LL

Scale	Date
N.T.S.	July 2010

Job No.	Fig. No.
AGGX4042177	Figure A1

Appendix 4: Model Verification

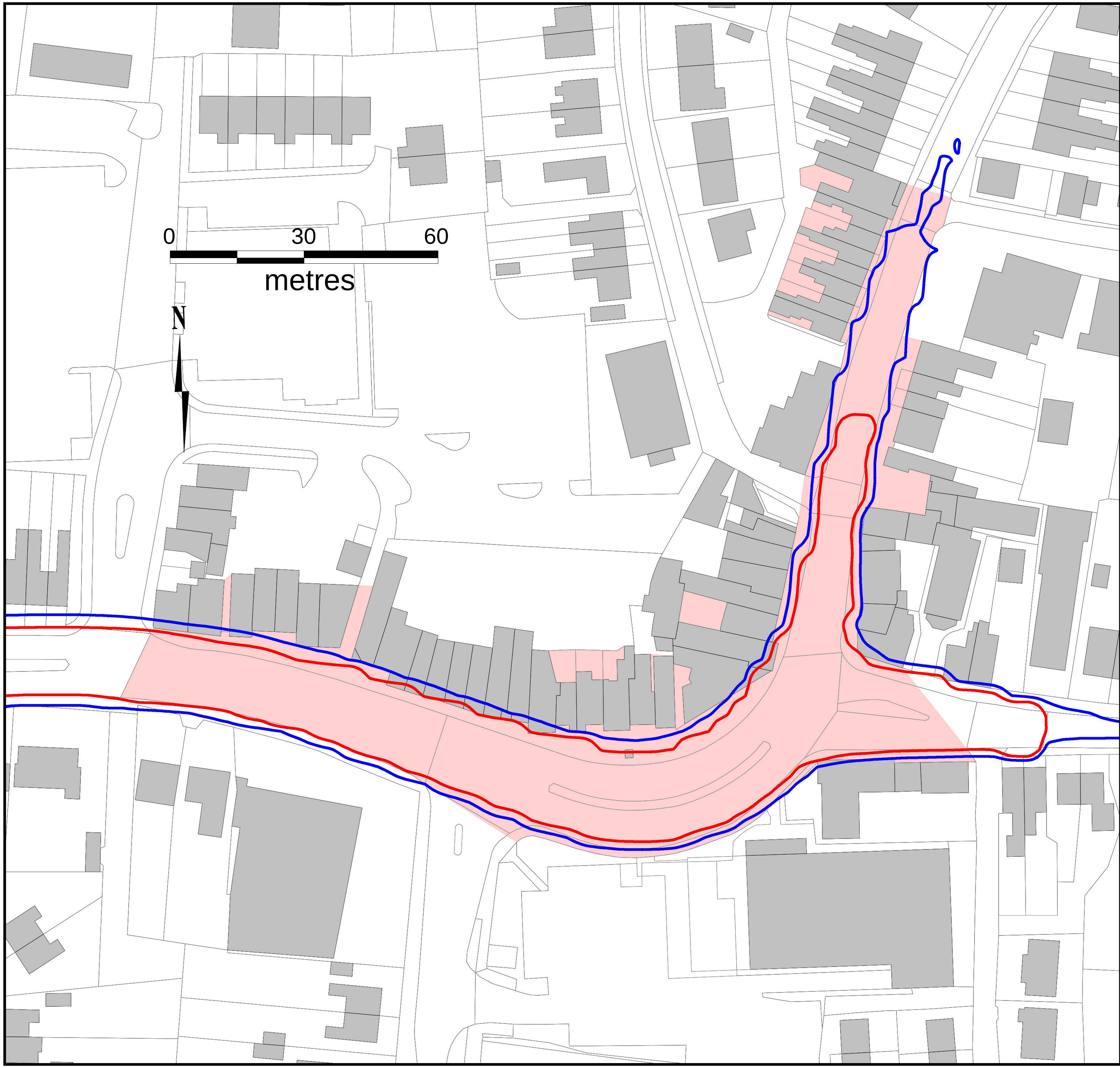
Table A3 – Model Verification Results

Site	Background NO_2 (µg/m³)	Background NO_x (µg/m³)	Monitored Total NO_x (µg/m³)	Monitored Road Contribution NO_x (µg/m³)	Modelled Road Contribution NO_x (µg/m³)	Ratio of Monitored Road NO_x/Modelled Road NO_x	Adjustment Factor (Regression) for Modelled Road Contribution	Adjusted Modelled Road Contribution NO_x (µg/m³)	Modelled Total NO_2 (µg/m³)	Monitored Total NO_2 (µg/m³)	% Difference NO_2 [(Modelled - Monitored)/ Monitored]
40	17.9	28.0	81.6	53.5	19.6	2.73	2.986	58.5	**40.6**	39.0	4.0%
41	17.9	28.0	101.9	73.8	17.5	4.21		52.4	38.6	**45.1**	-14.4%
42	17.9	28.0	70.8	42.8	14.1	3.05		42.0	35.1	35.4	-0.8%
43	17.9	28.0	63.3	35.3	13.1	2.69		39.1	34.1	32.7	4.3%
44	17.9	28.0	80.3	52.3	17.2	3.03		51.5	38.3	38.6	-0.7%
45	17.9	28.0	64.9	36.9	15.4	2.39		46.0	36.5	33.3	9.7%
51	17.9	28.0	40.6	12.5	6.9	1.81		20.7	27.1	23.6	14.6%
52	17.9	28.0	75.5	47.5	17.0	2.79		50.8	38.1	37.0	3.0%

In bold, exceedence of the NO_2 annual mean AQS objective of 40µg/m³

NO_2 annual mean derived from latest NO_x/NO_2 converter - using traffic mix option "All other urban UK traffic" for King's Lynn 2009

Appendix 5: NO_2 Concentration Contour Map



Legend

Gaywood Clock AQMA

NO2 Concentration Contour

Annual Mean 2009

36 ug/m3

40 ug/m3

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Location: **Borough of King's Lynn and West Norfolk - Gaywood Clock**

Title: **NO2 Annual Mean Concentration Contour - 2009**

By	Checked	Approved
EC	LL	LL

Scale	Date
N.T.S.	July 2010

Job No.	Fig. No.
AGGX4042177	Figure A2