Borough Council of

King's Lynn & West Norfolk

Local Air Quality Management

Air Quality Detailed/Further Assessments

TECHNICAL REPORT NO: BV/AQ/AGGX0919/EC/2554

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Executive Summary

The Detailed Assessment of Wootton Road/Gayton Road junction in Gaywood, King's Lynn was undertaken together with the Further Assessment of the Air Quality Management Area (AQMA) in King's Lynn town centre. Both assessments are required as part of the Local Air Quality Management regime following the previous rounds or air quality Review and Assessment.

The findings of this report are the following:

King's Lynn town centre AQMA

- The source apportionment shows that cars are the main contributors of the overall NO_x levels in the AQMA, followed by buses, HGVs and LGVs, while background pollution levels contribute significantly.

- The maximum reduction in NO_x concentrations in the AQMA required to comply with the AQS objectives is about 24µg/m^3 (equivalent to a 20% reduction in NO_x levels). This equates to about 6µg/m^3 reduction in NO_2 (12% reduction). Consequently, measures formulated in the Action Plan should aim to reduce the levels of NO_x / NO_2 within the AQMA by these amounts.

Wootton Road/Gayton Road/Lynn Road junction

- Both monitoring and modelled results show that the NO_2 annual mean AQS objective is likely to be breached at facades of properties close to the junction. **Therefore, it is recommended that an AQMA be declared at the Wootton Road/Gayton Road/Lynn Road junction.**

1 Introduction

1.1 Project Background

Part IV of the Environment Act, 1995, places a statutory duty on local authorities to periodically review and assess the air quality within their area. Bureau Veritas was commissioned by King's Lynn & West Norfolk Borough Council to undertake the air quality Detailed Assessment of Wootton Road in Gaywood, King's Lynn, and the Further Assessment of the Air Quality Management Area (AQMA) in Railway Road, King's Lynn.

The Detailed Assessment is a requirement of the third round of Review and Assessment for local authorities that have identified areas where there is a risk of exceedence of an Air Quality Strategy (AQS) objective. The air quality Progress Report 2007 concluded that a Detailed Assessment was required for NO_2, following an exceedence of the annual mean objective monitored at a roadside site in the Gaywood area.

The Further Assessment is a requirement of the third round of Review and Assessment for local authorities that have declared or amended an AQMA. It is intended to supplement information within the AQMA. The Council declared an AQMA for NO_2 in Railway Road in 2003, which was subsequently extended in 2007 following further monitored exceedences. A Further Assessment of the AQMA was required to confirm the extension of the AQMA.

1.2 Legislative Background

1.2.1 Local Air Quality Management

Part IV of the Environment Act places a statutory duty on local authorities to periodically 'review and assess' the air quality within their area under the LAQM regime. This involves consideration of present and likely future air quality against the Air Quality Strategy (AQS) objectives prescribed within the Air Quality Regulations. Where the LAQM Review and Assessment process finds that pollutant concentrations are unlikely to meet the AQS objectives by their target dates in areas where these objectives apply, the Local Authority is required to declare an Air Quality Management Area (AQMA) under Section 83(1) of the Environment Act 1995. The areas in which the objectives apply are defined in the AQS as locations outside buildings or other natural or man-made structures 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, schools and care homes for longer period (i.e. annual mean) pollutant objectives and high streets for short-term (i.e. 1-hour) pollutant objectives.

Guidelines for the 'Review and Assessment' of local air quality were first published in the 1997 National Air Quality Strategy (NAQS)[1] along with associated Policy Guidance and Technical Guidance. Within the first round of Review and Assessment, it was recommended that local authorities fulfil their statutory duty under the LAQM regime by undertaking a three-stage assessment, increasing in detail at each stage.

In 2000, Government reviewed the NAQS and published the revised AQS, to which an addendum was issued in February 2003. Associated revised LAQM Technical Guidance (LAQM.TG(03))[2]

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[1] DoE (1997) The United Kingdom Nation Air Quality Strategy The Stationery Office

[2] Defra (2003) Technical Guidance LAQM.TG(03), Part IV of the Environment Act 1995, Local Air Quality Management, The Stationery Office

and Policy Guidance (LAQM.PG(03))[3] were issued on behalf of Defra in January 2003. This guidance sets the framework for the requirements of air quality review and assessment for future years, taking account of experiences from the previous rounds of review and assessment. This current framework for the air quality review and assessment begins with an Updating and Screening Assessment (USA), which considers the likelihood of all the AQS objectives being achieved across the Local Authority's administrative area. If the USA identifies that an AQS objective may not be met, then the Local Authority must proceed to a Detailed Assessment for that pollutant, based on detailed dispersion modelling. If the results of the Detailed Assessment confirm that an AQS objective is unlikely to be met, the Local Authority is required to declare an AQMA.

Having declared an AQMA the Local Authority is required to confirm the findings of the Detailed Assessment work through further monitoring and modelling assessment (Further Assessment). The Further Assessment should provide information on the source-apportionment of the pollutant emissions in order to identify the main contributors and define the level of pollutant reduction required for the attainment of relevant AQS objectives. The second round of Review and Assessment (2003-2005) provided an opportunity for local authorities to update the findings of their first round. In doing so, local authorities were to take into consideration changes in AQS objectives and revised Technical Guidance (LAQM.TG(03)), new emission sources, and any significant proposed planning developments due to take place before the relevant AQS objective target date.

The third round of Review and Assessment (2006-ongoing) began with a new USA, which provided an update with respect to air quality issues for all local authorities, based on updated Frequently Asked Questions (FAQs) and LAQM tools. This included revised modelled background concentration maps for NO_2, NO_x and PM_{10}, updated future year calculation tools and updates on the assessment of specific sources (rail, shipping, poultry farms).

1.2.2 Air Quality Strategy Objectives

The latest Air Quality Strategy (AQS)[4] released in July 2007 provides the over-arching strategic framework for air quality management in the UK and contains national air quality standards and objectives established by the Government to protect human health. The objectives for ten pollutants (benzene, 1,3-butadiene, carbon monoxide, lead, nitrogen dioxide, sulphur dioxide, particulates - PM_{10} and $PM_{2.5}$, ozone and PAHs-Polycyclic Aromatic Hydrocarbons) have been prescribed with the Air Quality Strategy based on The Air Quality Standards (England) Regulations 2007[5]. The Objectives set out in the AQS for the protection of human health are presented in Table 1.1.

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[3] Defra (2003) Policy Guidance LAQM.PG(03), Part IV of the Environment Act 1995, Local Air Quality Management, The Stationery Office

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

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

Table 1.1: AQS Objectives and Standards for England

Pollutant	Objective	Concentration measured as	Date to be achieved by and maintained thereafter
Benzene	16.25 $\mu g/m^3$	running annual mean	31st December 2003
	5 $\mu g/m^3$	running annual mean	31st December 2010
1,3-Butadiene	2.25 $\mu g/m^3$	running annual mean	31st December 2003
Carbon monoxide	10 mg/m^3	maximum daily running 8 hour mean	31st December 2003
Lead	0.5 $\mu g/m^3$	annual mean	31st December 2004
	0.25 $\mu g/m^3$	annual mean	31st December 2008
Nitrogen dioxide	200 $\mu g/m^3$, not to be exceeded more than 18 times a year	hourly mean	31st December 2005
	40 $\mu g/m^3$	annual mean	31st December 2005
Particles (PM10)	50 $\mu g/m^3$, not to be exceeded more than 35 times a year	24 hour mean	31st December 2004
	40 $\mu g/m^3$	annual mean	31st December 2004
Particles (PM2.5)	25 $\mu g/m^3$	Annual mean	2020
	Target of 15% reduction in concentrations at urban background[6]	annual mean	In urban areas between 2010 and 2020
Sulphur dioxide	266 $\mu g/m^3$, not to be exceeded more than 35 times a year	15 minute mean	31st December 2005
	350 $\mu g/m^3$, not to be exceeded more than 24 times a year	hourly mean	31st December 2004
	125 $\mu g/m^3$, not to be exceeded more than 3 times a year	24 hour mean	31st December 2004
Polycyclic Aromatic Hydrocarbons	0.25 ng/m^3 B(a)P[7]	Annual average	31st December 2010
Ozone	100 $\mu g/m^3$, not to be exceeded more than 10 times a year	8 hour mean	31 December 2005

The Air Quality Standards (England) Regulations 2007[5] came into force on 15th February 2007. This brings together in one statutory instrument the Governments requirements to fulfil separate EU Daughter Directives through a single consolidated statutory instrument, which is fully aligned with the proposed new EU Air Quality Directive (CAFE – Clean Air For Europe)[8]. The Regulations

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[6] 25$\mu g/m^3$ is a concentration cap combined with a 15% reduction

[7] Benzo(a)Pyrene

[8] http://ec.europa.eu/environment/air/cafe/index.htm

2007 also include objectives for Arsenic, Cadmium and Nickel. These are required to be assessed by Member States in response to the proposed new EU Air Quality Daughter Directive (CAFE). However, the AQS does not contain objectives for these pollutants and local authorities are not currently required to assess against these. 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 at this stage have no statutory obligation to review and assess air quality against them.

1.3 Summary of the air quality Review and Assessment in the Borough

1.3.1 The first and second rounds of Review and Assessment

Between 1999 and 2003, King's Lynn & West Norfolk Borough Council 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 some locations in King's Lynn. As a result, the Council declared two AQMAs, one in South Quay (for PM_{10}) in April 2002, and the other one in Railway Road (NO_2) in November 2003. The South Quay AQMA was revoked in June 2006 following the effective application of an Air Quality Action Plan (AQAP) for the area.

The second round of Review and Assessment began with an Updating and Screening Assessment (USA), completed in August 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 (November 2004) recommended proceeding to a Detailed Assessment of NO_2, following new monitored exceedences of the objective outside the AQMA in King's Lynn. The Detailed Assessment (November 2005) confirmed that exceedences were likely to occur at several sites outside the AQMA, and as a result, recommended to extend the AQMA to encompass properties along Railway Road, Blackfriars Road and London Road.

1.3.2 The third round of Review and Assessment

The third round of Review and Assessment began with a new USA, completed in November 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))[9] 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 have since 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.

[9] Defra (2003) - Technical Guidance LAQM.TG(2003), Part IV of the Environment Act 1995, Local Air Quality Management, The Stationary Office

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 latest 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. The site is still monitored and new results will be reported in the next USA in 2009.

However, new available NO_2 monitoring results showed an exceedence of the objective at the 'Wootton Road 2' diffusion tube in the Gaywood 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.

1.4 Scope and Methodology of the Detailed and Further Assessments

1.4.1 Detailed Assessment

The approach to the Detailed Assessment is to provide the Local Authority with an opportunity to supplement the information they have gathered in their earlier review and assessment work and more accurately assess the impact of pollution sources on local receptors at identified hotspots through dispersion modelling. The aim of the dispersion modelling is to reflect the results from local monitoring sites across the whole assessment area and allow comparison of pollutant concentrations against the AQS objectives.

The Detailed Assessment will identify with reasonable certainty whether or not there is likely to be an exceedence of the AQS objectives and if so, define the extent and magnitude of the exceedence.

1.4.2 Further Assessment

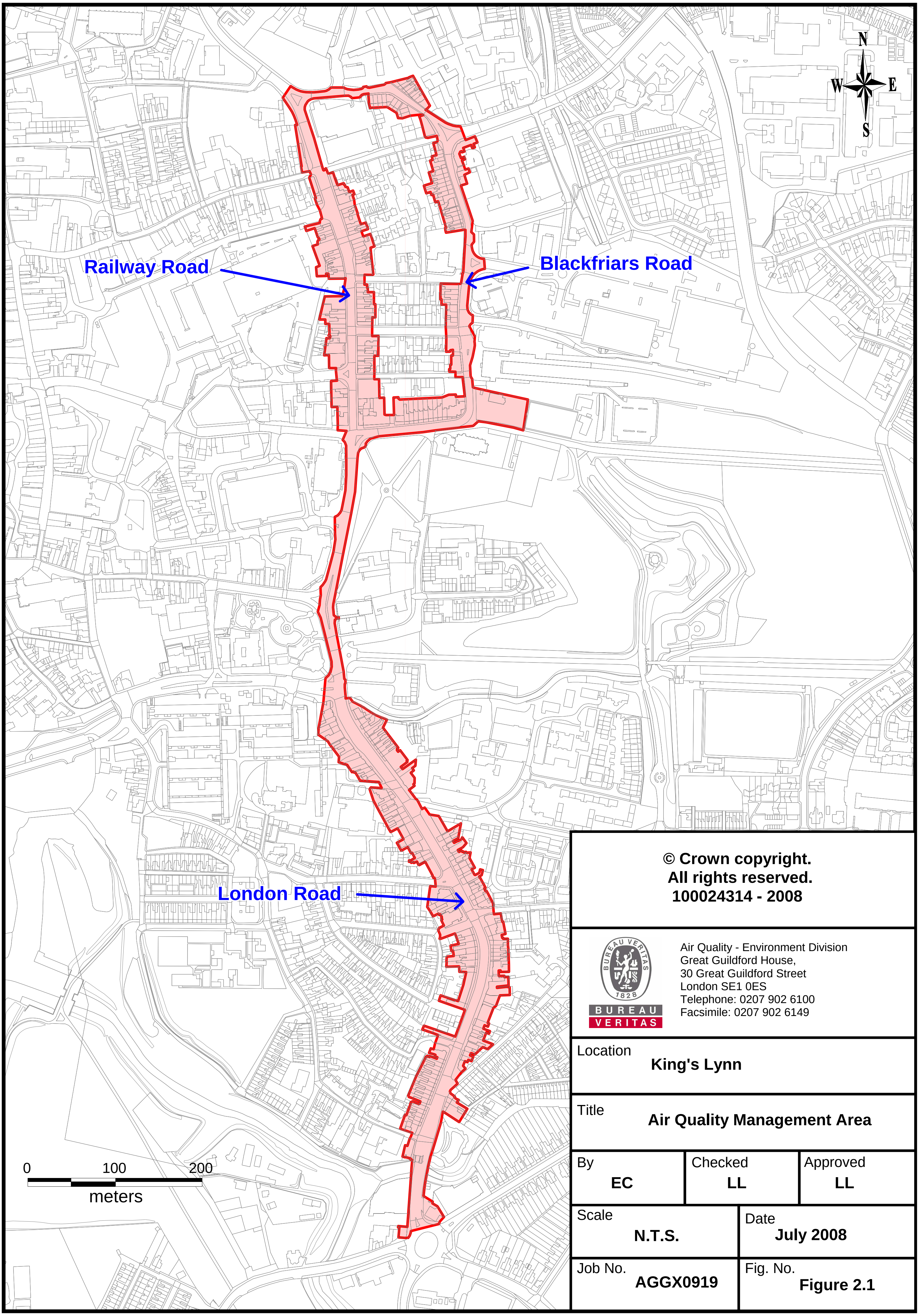
The approach of the Further Assessment is to confirm the extent of the AQMA and supplement information gathered in previous modelling works. The methodology is based on dispersion modelling and includes the following:

- Review of additional monitoring since the extension of the AQMA – including NO_2 continuous monitoring and diffusion tubes;
- Source apportionment of pollutants including relevance of background, industrial (if relevant), and different vehicle classification on the roads of concern;
- Identification of the reduction in pollutant concentrations required to meet the AQS objectives in the AQMA;
- Technical justification for measures to be taken within the action plan (provided measures have been identified);
- Identification of any additional policy measures that may have been implemented since the declaration; and
- Identification of any local developments, such as industrial, residential, retail or road schemes that may affect future air quality within the AQMA.

2 Baseline Information

2.1 King's Lynn Air Quality Management Area

In November 2003, King's Lynn & West Norfolk Borough Council declared an AQMA for NO_2 encompassing properties along Railway Road, between Stanley Street and Blackfriars Street in King's Lynn. Following updated monitoring data, the AQMA was further extended in February 2007 to include the one-way system in the town centre (Railway Road, Austin Street and Blackfriars Road), as well as St James Road and London Road, down to the South Gates roundabout. The current extent of the AQMA is provided in Figure 2.1.



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Location	**King's Lynn**		
Title	**Air Quality Management Area**		
By **EC**	Checked **LL**	Approved **LL**	
Scale **N.T.S.**		Date **July 2008**	
Job No. **AGGX0919**		Fig. No. **Figure 2.1**	

2.2 Traffic Data

Traffic data for year 2007 were provided by Norfolk County Council for the following roads: Blackfriars Road, Railway Road, St James Road, Blackfriars Street, London Road, Millfleet, Gaywood Road, and Gaytown Road. For the remaining modelled roads (Wootton Road, John Kennedy Road), data from the Council for year 2006 were projected to 2007. All data were also projected to 2010 as estimated pollution levels are required for this year to comply with the EU legislation.

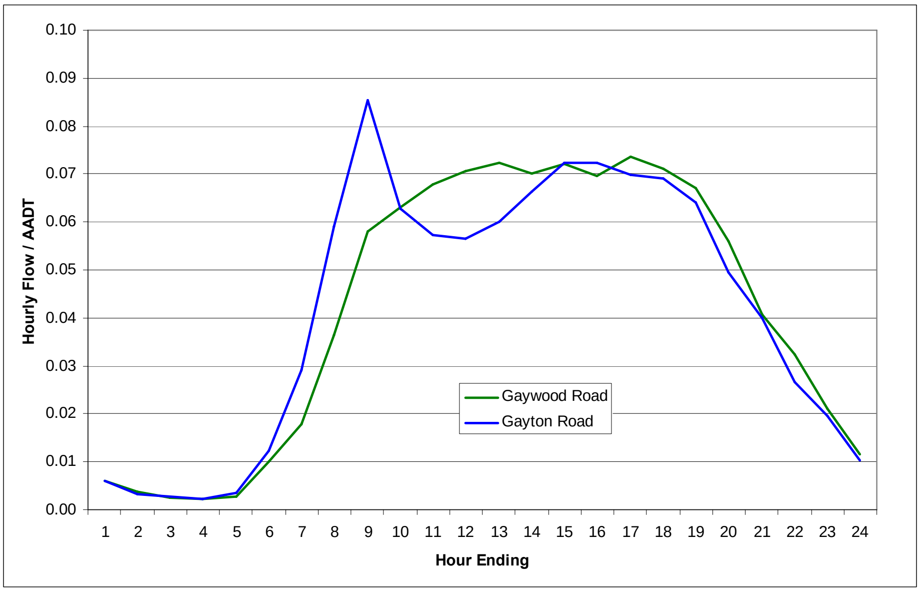
The percentage increase in traffic flows between 2006/2007, and 2007/2010) was derived based on the National Road Traffic Forecast (NRTF)[10] Central growth factor combined with regional adjustment factor for King's Lynn area derived from Tempro[11], in accordance with the methodology set out in Tempro Guidance Note April 2006.

Data were collated either from 24-hour automatic traffic counts (ATCs) or 12-hour manual turning counts, and included a detailed breakdown of vehicle categories: cars, light goods vehicles (LGVs), buses and coaches, heavy-goods vehicles(HGVs). AADT flows were obtained directly from ATCs, while a conversion factor of 1.26 was used to derive AADTs from 12-hour manual counts, as suggested by the County Council.

The hourly variations of traffic flows derived from available ATCs on the A148 Gaywood Road and A1076 Gayton Road were used to define diurnal patterns in the model, for all the assessed roads. Gaywood Road profile was used for Wootton Road and all the roads part of the AQMA. The diurnal profiles used in the model are shown in Figure 2.2 below.

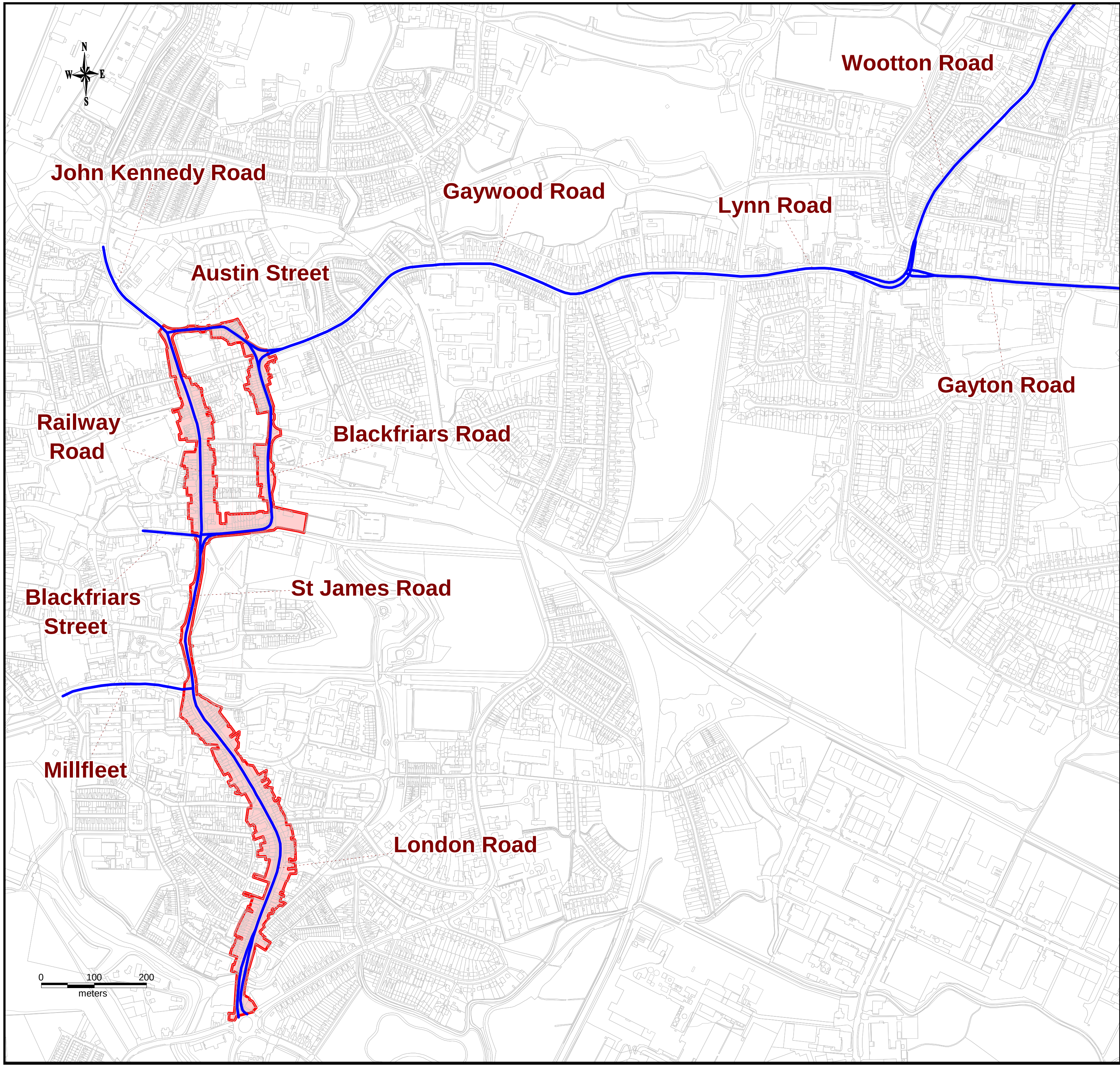
All modelled roads are illustrated in Figure 2.3. The traffic data are summarised in Appendix 1.

Figure 2.2 – Traffic Flow Diurnal Patterns



[10] DETR, National Road Traffic Forecasts (Great Britain) 1997

[11] Tempro (Trip End Model Presentation Program) version 5.0 , dataset v5.3, Department for Transport - The combined growth factor for urban roads was used in this assessment.



Legend

Modelled Roads

AQMA Boundaries

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Location	King's Lynn
Title	Modelled Roads

By	Checked	Approved
EC	LL	LL

Scale	Date
N.T.S.	July 2008

Job No.	Fig. No.
AGGX0919	Figure 2.3

2.3 Air Quality Data

2.3.1 NO_2 Continuous Monitoring

The Council installed a roadside air quality continuous monitoring station in Railway Road in 2002. The station includes a chemiluminescent NO_x/NO_2 automatic analyser. It is part of the National Automatic Monitoring Calibration Club, which follows the same QA/QC procedures as those defined for sites in the air quality Automatic Urban and Rural Network (AURN).

The station is located within the AQMA in Railway Road and co-located with triplicate diffusion tubes (see Figure 2.4). Table 2.1 shows the NO_x and NO_2 results for years 2006 and 2007.

Data capture was slightly below 90% in 2006, which still provides a reasonably suitable dataset, although in 2007 capture rate was significantly lower (77%). This was due to interruption of monitoring between end of July and end of September. However, if we discount this period, data capture was above 90%.

Both the hourly an annual mean AQS objectives were met over the past two years, with the annual mean being well below 40µg/m^3. As data capture was below 90% for both years, the 99.8th percentile of the NO_2 hourly means was calculated. The result was 84µg/m^3 for both years, this being well below the 200µg/m^3 limit set out in the AQS objective.

Projected NO_2 annual mean to 2010 (based on the 2007 figure and the Year Adjustment Calculator spreadsheet, provided on the UK Air Quality Archive website on behalf of Defra[12]) shows that the AQS objective should still be met by this date at the site.

Table 2.1: NO_x/NO_2 continuous monitoring results - 2006 - 2007

OS grid coordinates (m)	Year	NO_x annual mean (µg/m^3)	NO_2 annual mean (µg/m^3)	No. of NO_2 hourly means > 200µg/m^3	99.8th percentile of NO_2 hourly means (µg/m^3)	Data Capture (%)
562113, 320043	2006	78.3	31.3	0	84	87%
	2007	74.2	31.1	0	84	77%
	2008 (Jan to April)	87.7	35.7	0	-	95%
	2010 (projected)	-	27.8	-	-	-

2.3.2 NO_2 Diffusion Tubes

The Council has progressively installed a number of passive NO_2 diffusion tubes, building a monitoring network that covers the most sensitive areas in the Borough. In 2007, NO_2 concentration was monitored at 67 diffusion tubes and 61 sites across the Borough. The majority of the tubes are installed in King's Lynn town centre, including 28 tubes located in the AQMA.

[12] Based on the Year Adjustment calculator spreadsheet v2.2a available on the UK Air Quality Archive website (www.airquality.co.uk/archive/laqm/tools.php?tool=year04)

Triplicate diffusion tubes are co-located with the continuous monitoring analyser in Railway Road. Two background sites also have triplicate tubes installed at The Walks (Framinghams Hospital) and Kilham's Way (St Edmunds School) in King's Lynn.

Two tubes (57 and 58) were relocated in 2007 respectively from Low Road and Castle Rising Road in South Wootton, to Wootton Road and Lynn Road in Gaywood.

The diffusion tubes are supplied and analysed by Gradko Ltd and prepared using the 20% TEA[13] in water method. Gradko participates in the UK National Diffusion Tube Network and the Workplace Analysis Scheme for Efficiency (WASP).

LAQM.TG(03) and the Review and Assessment Helpdesk recommend the use of a local bias adjustment factor to correct raw data from diffusion tubes (where available). This is commonly based on results from tubes co-located with real-time analysers, which provide more accurate data than passive diffusion tubes. In the absence of a local bias adjustment factor, diffusion tube results can be corrected based on a national default bias adjustment factor derived from the diffusion tube co-location survey provided by the air quality Review and Assessment Helpdesk [14].

The Council has co-located diffusion tubes at the continuous monitoring station in Railway Station. A local bias correction factor of 0.86 could be derived from the 2007 results. This is consistent with the national bias correction factor for 2007 (0.89 - based on 17 studies). As data capture at the continuous monitoring site was only 77% in 2007, the national bias correction factor was used to adjust the diffusion tube results.

Data capture was very good at all sites, always above 10-month worth of data, and therefore it was not necessary to annualise average concentrations. Bias adjusted results for the past two years (2006 to 2007) are provided in Table 2.2. For the purpose of this assessment, results are reported only for the sites located within or close to the AQMA, or near the Gaywood Road/Wootton Road junction.

The NO_2 annual mean AQS objective of 40µg/m^3 was exceeded at twelve sites in King's Lynn in 2007. Eleven of these sites are located within the AQMA, while the last site exceeding the objective is installed in Wootton Road (site 45), near the busy junction with Lynn Road and Gayton Road.

All these sites already showed exceedences in 2006, except sites 25 (London Road 7) and 38 (Blackfriars 2) - although they were both close to the objective (38µg/m^3).

A number of sites were below but very close to the objective in 2007 (between 38µg/m^3 and 40µg/m^3): sites 4 and 35 (Railway Road), 5 (Bus station), 14, 23, 24 (London Road) 39 (Blackfriars Road), 42 (Littleport Street) and 48 (Lynn Road). All of these sites are within the AQMA, except sites 5 (not representative of long-term exposure as located near a bus stop in King's Lynn bus station) and 48. The latter is also close to the Wootton Road/Gayton Road junction, which is subject to the current Detailed Assessment.

Projections to 2010 (based on roadside NO_2 projection factors[12]) shows that the objective is still likely to be breached by this date at several sites in the AQMA (sites 2, 3 and 17) as well as at site 45 on Wootton Road. Moreover, other sites in the AQMA (1, 12, 30 and 51) should still be close to the objective of 40µg/m^3.

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[13] Triethanolamine

[14] www.uwe.ac.uk/aqm/review/diffusiontube230408.xls

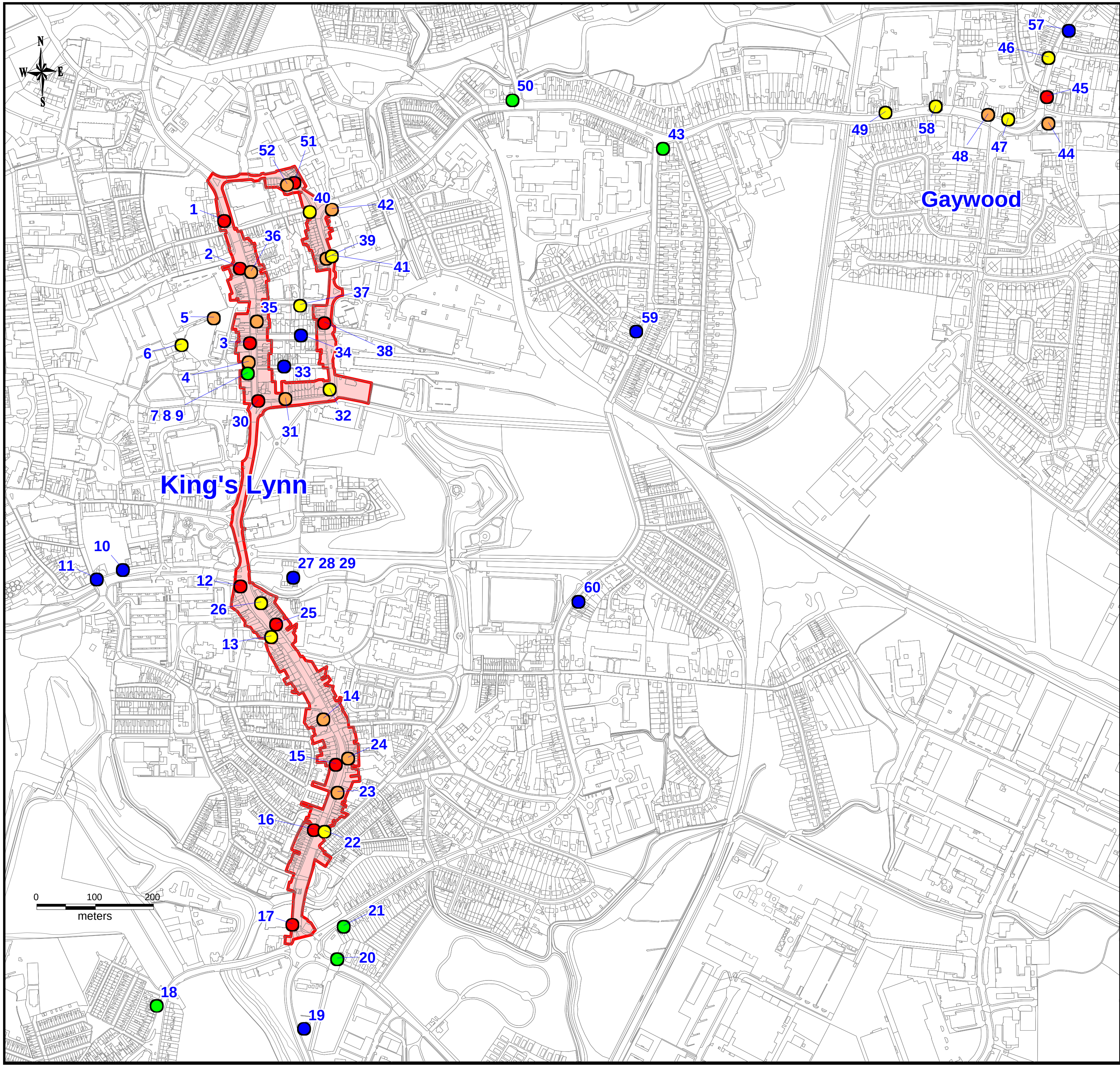
Table 2.2: King's Lynn NO_2 diffusion tube results– 2006- 2007

ID	Site Name	OS Coordinates (m)		Type	Used for model verification	Within AQMA ?	NO_2 Annual Mean (bias adjusted, µg/m^3)		Data Capture (months)	NO_2 Annual Mean 2010 (µg/m^3, projected)
		X	Y				2006	2007		
1	Railway Road 1	562073	320304	Kerbside	Y	Y	**44.0**	**44.0**	12	39.4
2	Railway Road 4	562100	320222	Roadside	Y	Y	**56.0**	**55.0**	12	**49.2**
3	Railway Road 5	562117	320095	Roadside	Y	Y	**51.0**	**50.4**	12	**45.1**
4	Railway Road 6	562115	320062	Kerbside	Y	Y	39.0	38.3	12	34.3
5	Bus Station 1	562055	320137	Bus Station	N	N	**43.0**	39.4	12	35.2
6	Bus Station 2	562000	320091	Bus Station	N	N	36.0	35.6	12	31.9
7 8 9	Railway Road Monitoring Station	562113	320043	Roadside	Y	Y	33.0	31.3	12	28.0
10	Mill Fleet 1	561900	319707	Roadside	N	N	26.0	26.7	12	23.9
11	Mill Fleet 2	561856	319691	Roadside	N	N	26.0	26.3	11	23.5
12	London Road 1	562101	319679	Roadside	Y	Y	**43.0**	**44.6**	12	39.9
13	London Road 2	562154	319594	Roadside	Y	Y	36.0	34.9	12	31.3
14	London Road 3	562242	319452	Roadside	Y	Y	39.0	39.2	12	35.1
15	London Road 4	562264	319375	Roadside	Y	Y	40.0	**40.5**	12	36.2
16	London Road 5	562226	319263	Roadside	Y	Y	**41.0**	**42.3**	12	37.9
17	Southgates	562190	319102	Kerbside	Y	Y	**43.0**	**47.1**	12	**42.1**
18	Wisbech Road 2	561958	318963	Roadside	N	N	27.0	28.2	12	25.2
19	NORA 1	562209	318924	Roadside	N	N	23.0	21.4	12	19.1
20	Hardwick Road	562266	319043	Roadside	N	N	31.0	31.7	12	28.3
21	Vancouver Avenue 1	562277	319098	Roadside	N	N	30.0	28.0	12	25.1
22	London Road 10	562244	319261	Kerbside	Y	Y	35.0	35.2	12	31.5
23	London Road 11	562267	319327	Roadside	Y	Y	**41.0**	39.9	10	35.7

ID	Site Name	OS Coordinates (m)		Type	Used for model verification	Within AQMA ?	NO_2 Annual Mean (bias adjusted, µg/m^3)		Data Capture (months)	NO_2 Annual Mean 2010 (µg/m^3, projected)
		X	Y				2006	2007		
24	London Road 6	562285	319386	Roadside	Y	Y	40.0	39.9	12	35.7
25	London Road 7	562162	319614	Roadside	Y	Y	38.0	**40.1**	11	35.8
26	London Road 8	562136	319651	Roadside	Y	Y	37.0	34.3	12	30.7
27 28 29	The Walks	562191	319695	Roadside	N	N	22.0	19.9	12	17.8
30	Railway Road 7	562131	319996	Roadside	Y	Y	**43.0**	**44.4**	12	39.7
31	St John's Terrace	562178	319999	Roadside	Y	Y	35.0	36.3	11	32.5
32	St John's Terrace / Blackfriars	562253	320016	Roadside	Y	Y	33.0	33.7	12	30.1
33	Waterloo Street	562175	320055	Kerbside	N	N	27.0	26.3	12	23.5
34	Portland Street	562204	320108	Kerbside	N	N	27.0	27.1	12	24.3
35	Railway Road 2	562129	320132	Kerbside	Y	Y	39.0	39.2	12	35.1
36	Railway Road 3	562119	320216	Roadside	Y	Y	38.0	36.6	12	32.8
37	Wellesley Street	562203	320159	Kerbside	N	N	36.0	35.8	12	32.1
38	Blackfriars 2	562244	320129	Roadside	Y	Y	38.0	**40.4**	12	36.2
39	Blackfriars 1	562248	320239	Roadside	Y	Y	37.0	38.3	12	34.2
40	Norfolk Street	562219	320319	Roadside	N	Y	37.0	35.7	12	31.9
41	Blackfriars 3	562257	320243	Roadside	Y	Y	**48.0**	34.1	11	30.5
42	Littleport Street	562257	320323	Roadside	Y	Y	36.0	39.5	11	35.3
43	Gaywood Road 2	562822	320427	Roadside	Y	N	31.0	29.7	12.0	26.6
44	The Swan Gayton Road	563480	320470	Roadside	Y	N	36.0	36.9	12.0	33.0
45	Wootton Road 2	563478	320515	Roadside	Y	N	**42.0**	**45.1**	12	**40.3**
46	Wootton Road 1	563480	320582	Roadside	Y	N	35.0	35.2	12	31.5
47	Lynn Road 1	563412	320477	Roadside	Y	N	33.0	34.6	12	30.9
48	Lynn Road 2	563377	320484	Roadside	Y	N	38.0	39.8	12	35.6

ID	Site Name	OS Coordinates (m)		Type	Used for model verification	Within AQMA ?	NO_2 Annual Mean (bias adjusted, µg/m^3)		Data Capture (months)	NO_2 Annual Mean 2010 (µg/m^3, projected)
		X	Y				2006	2007		
49	Lynn Road 3 (previously named Gaywood Road 3)	563202	320488	Roadside	Y	N	32.0	34.0	12.0	30.5
50	Gaywood Road 1	562565	320509	Roadside	Y	N	29.0	29.7	12.0	26.6
51	Austin Street 1	562193	320369	Roadside	Y	Y	**41.0**	**44.1**	12	39.5
52	Austin Street 2	562180	320365	Roadside	Y	Y	36.0	36.6	11	32.7
53	Dobby Drive (previously named Edward Benefer Way)	561881	320768	Roadside	N	N	25.0	25.0	12	22.4
54 55 56	Kilham's Way	562026	321615	Roadside	N	N	16.0	13.7	12	12.3
57	Wootton Road 3	563515	320628	Roadside	N	N	26.0	22.3	12.0	19.9
58	Lynn Road 4	563288	320499	Roadside	Y	N	23.0	33.2	12.0	29.7
59	Tennyson Avenue 1	562777	320115	Roadside	N	N	22.0	23.2	12	20.8
60	Tennyson Avenue 2	562678	319653	Roadside	N	N	24.0	25.1	12	22.4

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



Kings Lynn - NO2 Diffusion Tubes

Annual Mean 2007 - ug/m3

Above 40 (Exceeds AQS Objective)	(12)
36 to 40	(13)
32 to 36	(12)
28 to 32	(6)
Below 28	(11)

AQMA Boundaries

BUREAU VERITAS

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Location	King's Lynn
Title	NO2 Diffusion Tubes 2007

By	Checked	Approved
EC	LL	LL

Scale	N.T.S.
Date	July 2008
Job No.	AGGX0919
Fig. No.	Figure 2.4

2.3.3 Background air quality data

Local air quality monitoring and updated pollutant background maps[15] were considered to determine the most appropriate background concentrations for this assessment.

NO_2 concentration for year 2007 derived from the background maps[16] is 15.9µg/m^3 for King's Lynn town centre. However, as local data were available, they were preferred to the background map estimates.

Two sites in King's Lynn, St Edmunds School and The Walks, are representative of urban background conditions. Both sites monitor NO_2 concentrations based on triplicate diffusion tubes.

The monitoring site at The Walks (tubes 27, 28 and 29) is located about 80m from the junction of Millfleet and London Road, which is part of the AQMA. NO_2 annual mean was 19.9µg/m^3 at this site in 2007. The site near St Edmunds School (tubes 54, 55 and 56) is located 160m from the A1078 Edward Benefar Way, about 1.2km north of the AQMA. NO_2 annual mean was 13.7µg/m^3 at this site in 2007.

As The Walks is much closer to the AQMA, this site was deemed to represent the most appropriate local background levels in King's Lynn town centre. An equivalent background NO_x concentration of 29.9µg/m^3 was derived from the most up-to-date NO_x/NO_2 conversion method[17].

Background NO_x and NO_2 concentrations for year 2010 were derived based on the Year Adjustment Calculator spreadsheet[12].

Based on the above information, Table 2.3 shows the background NO_x and NO_2 concentrations that were used for this assessment for both years.

Table 2.3 - Background Concentrations for King's Lynn Town Centre

Pollutant	2007 Background (µg/m^3)	2010 Background (µg/m^3)
NO_2	19.9	18.3
NO_x	29.9	26.2

[15] Estimated background air pollution levels for the UK - www.airquality.co.uk/archive/laqm/laqm.php

[16] Based on average concentration of grid cells covering King's Lynn town centre (all 1km×1km square grid cell between southwest point X=561500, Y=319500 and northeast point X=564500 , Y=321500)

[17] From the Air Quality Archive website - www.airquality.co.uk/archive/laqm/tools/NOxfromNO2calculator2007.xls

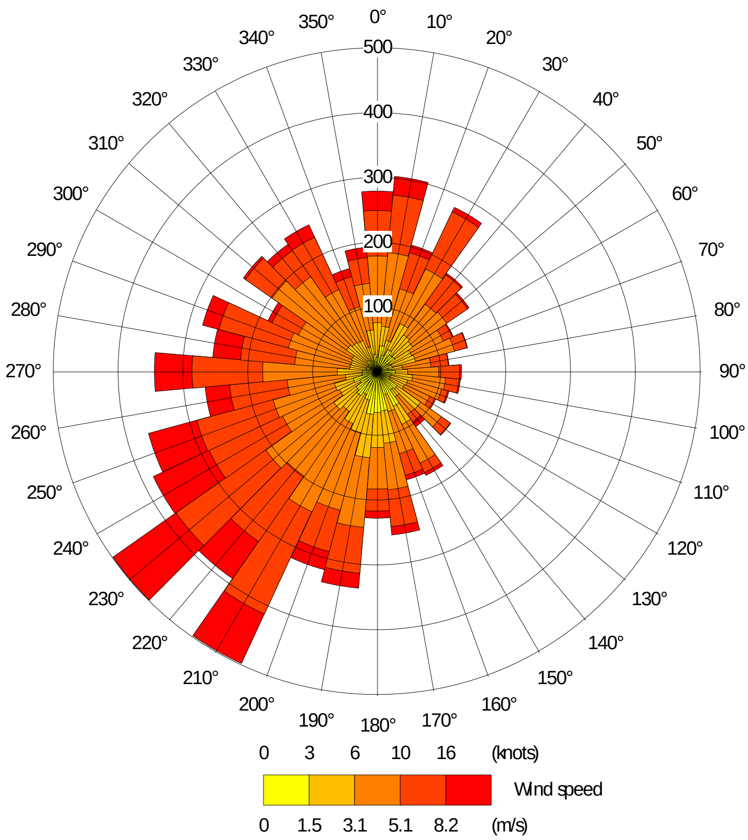
3 Dispersion Modelling Methodology

Detailed dispersion modelling of NO_x was undertaken based on the ADMS-Roads (version 2.2) advanced Gaussian air dispersion model, from Cambridge Environmental Research Consultants (CERC) Ltd. Conversion to NO_2 was carried out using the NO_X/NO_2 ratio based on the latest conversion method recommended by Defra[18].

ADMS-Roads 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. ADMS-Roads notably includes a module that takes into the account the effects of street canyons, which was used for several road links in the town centre (see Appendix 1 for details).

Dispersal of pollutant emissions is entirely dependent upon the prevailing meteorological conditions at the time of emissions release. Hourly sequential meteorological data for year 2007 from the closest Met Office station (Marham, 15 km South East of King's Lynn town centre) was used in this assessment. The wind rose derived from the meteorological data is shown in Figure 3.1.

Figure 3.1 – Marham 2007 Hourly Sequential Meteorological Data



[18] Local Authority Air Quality Support, 22nd April 2007 - www.laqmsupport.org.uk/faqs.php?action=response&faq_id=47 - This method supersedes the method described in LAQM.TG (03) – This is the same method implemented in the NO_x from NO_2 Calculator spreadsheet.

Traffic flow diurnal patterns described in Section 2.2 were applied to all modelled roads. A vehicle speed of 20km/h (speed limit) was assumed for all modelled roads in King's Lynn town centre, although reduced speed was considered at busy roads especially at the approach of junctions, to account for congestion and queuing. Emission data for different vehicle classes (cars, LGVs, HGVs, buses and coaches) were calculated with the Emission Factors Toolkit (EFT) available on the UK Air Quality Archive website[19].

[19] www.airquality.co.uk/archive/laqm/tools.php?tool=emission

4 Results

4.1 Model Verification and adjustment

Model verification at specific locations was carried out prior to predicting concentrations within the whole domain. 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 and monitored results was carried out based on local NO_2 monitoring data from 36 roadside diffusion tubes in King's Lynn. All diffusion tubes were assumed to be at 2m above ground level. Predicted NO_2 was derived from the latest NO_x/NO_2 conversion method recommended by Defra 18 (see details in Appendix 2).

During the verification process, Bureau Veritas aim to show that all final modelled NO_2 concentrations are within 25% of the monitored NO_2 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 canyons, road widths, receptor locations),
- Model limitations (treatment of roughness and meteorological data),
- Uncertainty in monitoring data (notably diffusion tubes, e.g. bias adjustment factors and annualisation of short-term data).

The above factors were all investigated as part of the model verification process to minimise the uncertainties as much as practicable. Especially, NO_x/NO_2 background concentrations were investigated, as mentioned in Section 2.3.3, to ensure that the chosen background data correctly reflect local conditions in King's Lynn town centre.

Vehicle speeds have also been verified to reflect traffic congestion in the town centre. Canyon width was adjusted to make sure that the diffusion tubes at facades were effectively within street canyons.

Although a single adjustment for NO_x was first investigated, the final model verification was based on two different adjustment factors; one for King's Lynn town centre and the AQMA (2.10), the other one for the Gaywood area (3.06) covering Gaywood Road/Lynn Road, Wootton Road and Gayton Road. This was deemed to minimise differences between modelled and monitored results, thus ensuring a good performance of the model across the whole area.

The model verification results are provided in Table 4.1. Overall, predicted concentrations are in good agreement with monitoring data, as almost all adjusted modelled NO_2 results are within 25% of monitored concentrations, and 23 sites out of 36 are within 10%. The model only under predicts by more than 25% at one monitoring site (tube 2 on Railway Road, which monitored 55µg/m^3, the highest concentration of all diffusion tubes). However, the model correctly predicts NO_2 levels monitored just across the road at tube 36 (36.3µg/m^3 modelled against 36.6µg/m^3 monitored).

The model over predicts by more than 25% at a single site on Blackfriars Road (tube 32). However, the model shows very good agreement with monitored levels at other sites on this road, with predicted results within 10% of monitoring at sites 30, 31 and 38.

Finally, there is a good agreement between modelled and monitored results outside the AQMA in the Gaywood area (sites 43 to 50, and 58), as all predicted results are within 25% of monitoring, and 7 out of 9 sites are within 10%. The model also correctly predicts the monitored exceedence of the AQS objective at site 45 on Wootton Road.

Table 4.1 – Model verification results at monitoring sites in King's Lynn

Name / Location	Within AQMA	Monitored NO_2 2007 (µg/m^3)	Predicted Total NO_2 2007(µg/m^3)	Difference predicted / monitored 2007 (µg/m^3)	Difference predicted / monitored 2007 (%)
1	Yes (King's Lynn town centre)	**44.0**	34.3	-9.7	-22%
2		**55.0**	35.7	-19.4	-35%
3		**50.4**	**43.2**	-7.2	-14%
4		38.3	31.3	-7.0	-18%
7_8_9		31.3	30.3	-0.9	-3%
12		**44.6**	**41.0**	-3.6	-8%
13		34.9	39.5	4.5	13%
14		39.2	**45.2**	6.0	15%
15		**40.5**	**41.0**	0.5	1%
16		**42.3**	**44.1**	1.7	4%
17		**47.1**	**45.7**	-1.4	-3%
22		35.2	**43.6**	8.3	24%
23		39.9	**42.1**	2.2	6%
24		39.9	34.7	-5.2	-13%
25		**40.1**	37.5	-2.5	-6%
26		34.3	33.7	-0.6	-2%
30		**44.4**	**40.5**	-3.9	-9%
31		36.3	36.0	-0.4	-1%
32		33.7	**46.2**	12.5	37%
35		39.2	**41.2**	2.0	5%
36		36.6	36.3	-0.3	-1%
38		**40.4**	**40.7**	0.3	1%
39		38.3	39.4	1.1	3%
41		34.1	39.1	4.9	14%
42		39.5	37.4	-2.1	-5%
51		**44.1**	**40.5**	-3.6	-8%
52		36.6	**40.8**	4.2	11%
43	No (Gaywood Area)	29.7	28.3	-1.4	-5%
44		36.9	**41.8**	4.9	13%
45		**45.1**	**40.2**	-4.8	-11%
46		35.2	35.8	0.6	2%
47		34.6	34.2	-0.3	-1%
48		39.8	37.9	-1.8	-5%
49		34.0	33.5	-0.5	-2%
50		29.7	31.2	1.5	5%
58		33.2	35.1	1.8	6%
Summary					
Number of sites	Within ±10%			23	
	Between ± 10-25%			11	
	Exceeds ±25%			2	
	Total			36	

In bold: exceedence of NO_2 annual mean AQS objective

4.2 Modelled NO_2 concentrations

Annual average NO_2 concentrations were predicted for the baseline year 2007 and future year 2010 at a number of specific receptors representing locations relevant of public exposure, located at the facade of properties. Additionally, predictions were made on a 4m-grid spacing across the assessment area to produce NO_2 concentration contour maps for year 2007. All results were predicted at 1.5m from the ground, except for a few receptors at the Gaywood Road/Wootton Road junction, where concentrations were predicted at 4.5m to estimate concentrations at first floor level, occupied by flats (ground floor is occupied by shops and therefore do not represent typical long-term public exposure).

Table 4.2 summarises predicted NO_2 results for years 2007 and 2010 at specific receptor locations and diffusion tubes (where representative of public exposure) in King's Lynn town centre and along Wootton Road, Lynn Road and Gayton Road in the Gaywood area. NO_2 concentration contours for year 2007 are also illustrated in Figure 4.1 (AQMA) and Figure 4.2 (Wootton Road/Gayton Road junction).

Table 4.2 – Predicted NO_2 annual mean concentrations – Specific receptors

ID	Area	X(m)	Y(m)	Z(m)	NO_2 2007 ($\mu g/m^3$)	NO_2 2010 ($\mu g/m^3$)
1	Kings Lynn town centre	562073	320304	2	34.3	32.4
2		562100	320222	2	35.7	33.6
3		562117	320095	2	**43.2**	**40.3**
4		562115	320062	2	31.3	29.8
7 8 9		562113	320043	2	30.3	28.9
12		562101	319679	2	**41.0**	38.3
13		562154	319594	2	39.5	36.9
14		562243	319452	2	**45.2**	**42.3**
15		562264	319375	2	**41.0**	38.0
16		562226	319263	2	**44.1**	**41.1**
17		562190	319102	2	**45.7**	**42.6**
22		562244	319261	2	**43.6**	**40.7**
23		562267	319327	2	**42.1**	39.0
24		562285	319386	2	34.7	32.5
25		562162	319614	2	37.5	35.0
26		562136	319651	2	33.7	31.6
30		562131	319996	2	**40.5**	38.0
31		562178	319999	2	36.0	33.8
32		562253	320016	2	**46.2**	**43.0**
35		562129	320132	2	**41.2**	38.6
36		562119	320216	2	36.3	34.1
38		562244	320129	2	**40.7**	38.4
39		562248	320239	2	39.4	36.9
41		562257	320243	2	39.1	36.7
42		562257	320323	2	37.4	35.8
JohnKennedyRd1		561934	320503	1.5	26.5	25.6
RailwayRd1		562102	320268	1.5	33.6	31.6
GaytonRd1	Gaywood Area	563515	320468	1.5	32.2	30.9
GaytonRd2		563757	320466	1.5	30.3	29.5
WoottonRd1		563458	320490	4.5	**47.9**	**45.5**
WoottonRd2		563478	320493	4.5	29.9	28.8

ID	Area	X(m)	Y(m)	Z(m)	NO_2 2007 ($\mu g/m^3$)	NO_2 2010 ($\mu g/m^3$)
WoottonRd3		563485	320549	1.5	36.8	34.8
WoottonRd4		563559	320678	1.5	27.4	26.4
WoottonRd5		563552	320701	1.5	26.3	25.4
WoottonRd6		563681	320834	1.5	26.0	25.2
WoottonRd8		563861	321203	1.5	26.7	25.8
WoottonRd7		563837	321175	1.5	25.7	24.9
GaytonRd3		564461	320349	1.5	24.2	23.8
LynnRd2		563295	320504	1.5	31.6	30.6
LynnRd1		563205	320466	1.5	30.5	29.6
GaywoodRd1		562313	320359	1.5	35.8	34.5
GaywoodRd2		562381	320371	1.5	35.6	34.3
GaywoodRd3		563121	320496	1.5	27.8	27.2
WoottonRd9		563923	321650	1.5	25.7	24.9
43		562822	320427	2	28.3	27.5
44		563480	320470	2	**41.8**	39.8
45		563478	320515	2	**40.2**	37.8
46		563480	320582	2	35.8	33.9
47		563412	320477	2	34.2	32.8
48		563377	320484	2	37.9	36.3
49		563202	320488	2	33.5	32.5
50		562565	320509	2	31.2	30.3
58		563288	320499	2	35.1	33.9

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

4.2.1 King's Lynn AQMA

Based on predicted results shown in Table 4.2 and Figure 4.1, a number of areas in the AQMA, representative of public exposure (facade of properties), were still exceeding the annual mean AQS objective in 2007 along Railway Road, Austin Street, Blackfriars Road and London Road. Predicted results for year 2010 show an average decrease of about 2µg/m^3 to 3µg/m^3 at all specific receptors/diffusion tube sites. The objective is still likely to be exceeded by this date at a few diffusion tube sites, although results are probably over estimated at some of these (monitoring sites 14, 22 and 32, as shown in the model verification results section 4.1). Overall, the results confirm that the current extents of the AQMA are appropriate.

4.2.2 Gaywood Area

Predicted results in the Gaywood area for year 2007 show an exceedence of the No_2 annual mean AQS objective at specific receptor (WoottonRd1) and diffusion tubes 44 and 45. Receptor WoottonRd1 is located at the façade of a property (first floor level) on Wootton Road, directly opposite the junction with Gayton Road. Monitoring sites 44 and 45 are also located at the Wootton Road/Lynn Road/Gayton Road junction. All other receptors/diffusion tube sites, located further away from the junction, are predicted to be below 40µg/m^3. However, result at monitoring site 48 on Lynn Road is predicted to be close to the objective (37.9µg/m^3), which is coherent with monitoring data at this site (39.8µg/m^3 in 2007). Figure 4.2 also shows that properties at the approach of the junction along Lynn Road, Wootton Road and Gayton Road are at risk of exceeding the objective.

Therefore, based on these results, **it is recommended to declare a new AQMA at the Wootton Road/Gayton Road/Lynn Road junction.** Both monitoring and modelled results for 2007 suggest that NO_2 levels decrease quickly on Wootton Road and Gayton Road further away from the junction, while properties along Lynn Road / Gaywood Road seem to be less at risk, as they lay further back from the road. Therefore, the AQMA should be limited to the properties close to the junction, based on results presented in Figure 4.2.

Predicted results for year 2010 suggest that the NO_2 annual mean AQS objective will still be exceeded by this date at receptor WoottonRd1, and very close to the objective at monitoring site 44.

NO2 Annual Mean
2007 - ug/m3

- under 28
- 28 to 32
- 32 to 36
- 36 to 40
- over 40

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Location: **King's Lynn**

Title: **NO2 Annual Mean 2007 - AQMA**

By	Checked	Approved
EC	**LL**	**LL**

Scale	Date
N.T.S.	**July 2008**

Job No.	Fig. No.
AGGX0919	**Figure 4.1**

NO2 Annual Mean
2007 - ug/m3

- under 28
- 28 to 32
- 32 to 36
- 36 to 40
- over 40

BUREAU VERITAS

Air Quality - Environment Division
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Telephone: 0207 902 6100
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Location	**King's Lynn**
Title	**NO2 Annual Mean 2007 Wootton Road**
By	**EC**
Checked	**LL**
Approved	**LL**
Scale	**N.T.S.**
Date	**July 2008**
Job No.	**AGGX0919**
Fig. No.	**Figure 4.2**

4.3 Source Apportionment

The breakdown of vehicle classification was taken into account in the model set-up. This allowed determining NO_x source apportionment at diffusion tube locations and other specific receptors in the AQMA in King's Lynn centre, as well as in the Gaywood area. The source apportionment was carried out for the following vehicle classes:

- Cars
- Light goods vehicles (LGVs)
- Heavy goods vehicles (HGVs)
- Buses and coaches

Table 4.3 summarises the results at receptors predicted to exceed the annual mean NO_2 AQS objective. The results at all modelled receptors are also provided in Appendix 3. The source apportionment for the AQMA in the AQMA indicates that:

- Background concentration account for 25% to 30% of the total NO_x concentration in areas of exceedences,
- Cars also account for 25% to 30% of the overall concentration at most of the receptors,
- Light-goods vehicles (LGVs) contribute around 10% to the total NO_x concentrations at all receptors,
- heavy-goods vehicles (HGVs) typically contribute to 15%-20% of the overall NO_x concentrations,
- Buses account for 20 to 25% of the total NO_x,
- Heavy-duty vehicles (the sum of HGVs and buses) contribute to 35% - 45% the overall NO_x concentrations. The contribution of HDVs in the total NO_x concentrations is quite significant especially if compared to the relatively small proportion of the vehicle fleet they represent; typically between 3.5% (London Road) and 7% (Railway Road).

The results for the Gaywood Area (Wootton Road) show similar results, although car contribution is above 30%, while LGVs and HGVs contribute around 5% and 15% respectively.

Table 4.3 - Source apportionment of NO_X concentrations at specific receptors

Receptor / Diffusion Tube	Area	Total Modelled NO_x 2007 (µg/m^3)	Total Modelled NO_2 2007 (µg/m^3)	NO_X Source Apportionment (%)					
				Background	Cars	LGVs	HGVs	Buses	HDVs
32	AQMA King's Lynn Centre	124.6	46.2	24%	28%	11%	15%	22%	37%
17		122.3	45.7	24%	26%	12%	19%	19%	38%
14		120.3	45.2	25%	26%	11%	18%	19%	37%
16		115.1	44.1	26%	26%	11%	18%	19%	37%
22		112.9	43.6	26%	26%	11%	18%	18%	36%
3		111.2	43.2	27%	20%	8%	21%	25%	46%
23		106.7	42.1	28%	27%	13%	16%	16%	32%
35		102.9	41.2	29%	19%	7%	20%	24%	44%
12		102.0	41.0	29%	25%	10%	19%	17%	36%
15		101.9	41.0	29%	27%	12%	15%	16%	31%
52		101.1	40.8	30%	24%	10%	17%	20%	36%
38		101.0	40.7	30%	24%	8%	16%	22%	38%
51		100.0	40.5	30%	24%	10%	16%	20%	36%
30		100.0	40.5	30%	19%	7%	21%	23%	44%
WoottonRd1	Gaywood area	132.2	47.9	23%	33%	5%	16%	22%	39%
44		105.4	41.8	28%	33%	3%	13%	23%	36%
45		99.0	40.2	30%	33%	7%	13%	16%	29%

4.4 NO_x reduction

A requirement of the Further Assessment is to determine the amount of NO_2 reduction required at the worst-case receptors within an AQMA. 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 has been to determine the levels of NO_x for the highest concentrations predicted at sensitive receptors (including diffusion tube sites, where relevant of public exposure). The results are shown in Table 4.4.

Although NO_x reduction is only required in AQMAs, the calculation was also carried out for the Wootton Road/Gayton Road/Lynn Road junction, since exceedences were predicted at this location.

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 a 98.0µg/m^3 NO_x concentration (based on the latest NO_x/NO_2 conversion method[18]).

AQMA King's Lynn town centre

The maximum predicted NO_x reduction required within the AQMA in King's Lynn town centre is 24.3µg/m^3 at monitoring site 17 in Southgates[20] (equivalent to a 20% improvement in NO_x). This equates to a 5.7µg/m^3 reduction in NO_2 (equivalent to 12% improvement in NO_2).

Wootton Road/Gayton Road/Lynn Road junction

The maximum predicted NO_x reduction required at this junction is 34.2µg/m^3, equivalent to a 26% reduction in NO_x. This equates to a 7.9µg/m^3 reduction in NO_2 (16% improvement). These figures are subject to more uncertainties, as they cannot be compared to monitoring data. A similar calculation based on monitoring results from site 45 in Wootton Road (45.1µg/m^3 annual mean 2007; equivalent to 120µg/m^3 NO_x) gives a NO_x reduction of 22µg/m^3 (18% NO_x reduction).

Table 4.4 – Required NO_x and NO_2 reduction

Site Name	Area	Total Modelled NO_x 2007 (µg/m^3)	NO_x (equiv to 40µg/m^3 NO_2) µg/m^3	Reduction required		Total Modelled NO_2 2007 (µg/m^3)	NO_2 AQS objective µg/m^3	Reduction required	
				µg/m^3	%			µg/m^3	%
32	AQMA King's Lynn town centre	124.6	98	26.6	21%	46.2	40	6.2	13%
17		122.3		24.3	20%	45.7		5.7	12%
14		120.3		22.3	19%	45.2		5.2	12%
16		115.1		17.1	15%	44.1		4.1	9%
22		112.9		14.9	13%	43.6		3.6	8%
3		111.2		13.2	12%	43.2		3.2	7%
23		106.7		8.7	8%	42.1		2.1	5%
35		102.9		4.9	5%	41.2		1.2	3%
12		102.0		4.0	4%	41.0		1.0	2%
15		101.9		3.9	4%	41.0		1.0	2%

[20] Predicted NO_x was slightly higher at monitoring site 32 (Belgrave Hotel), but this site was dismissed in the NO_x reduction calculation, as model verification showed that the model over predicted significantly at this location (see section 4.1).

Site Name	Area	Total Modelled NO_x 2007 (µg/m^3)	NO_x (equiv to 40µg/m^3 NO_2) µg/m^3	Reduction required		Total Modelled NO_2 2007 (µg/m^3)	NO_2 AQS objective µg/m^3	Reduction required	
				µg/m^3	%			µg/m^3	%
52		101.1		3.1	3%	40.8		0.8	2%
38		101.0		3.0	3%	40.7		0.7	2%
51		100.0		2.0	2%	40.5		0.5	1%
30		100.0		2.0	2%	40.5		0.5	1%
WoottonRd1	Wootton Road / Gayton Road / Lynn Road	132.2		34.2	26%	47.9		7.9	16%
44		105.4		7.4	7%	41.8		1.8	4%
45		99.0		1.0	1%	40.2		0.2	1%

5 Conclusions

As part of the Local Air Quality Management (LAQM) regime, a Detailed Assessment of Wootton Road in Gaywood, King's Lynn, was carried out following a monitored exceedence of the annual mean Air Quality Strategy (AQS) objective for nitrogen dioxide (NO_2) in 2006 and 2007. The Detailed Assessment is a requirement of the third round of Review and Assessment for local authorities that have identified areas where there is a risk of exceedence of an AQS objective, to determine whether an Air Quality Management Area (AQMA) is required.

This Detailed Assessment was combined with a Further Assessment of the Air Quality Management Area (AQMA) declared by the Council in 2003 for NO_2. The Further Assessment is also required as part of the third round of Review and Assessment for local authorities that have declared or amended an AQMA, with the objective to supplement information gathered in the previous assessments.

Both assessments were based on advanced atmospheric dispersion modelling of NO_2 traffic emissions, using updated background pollutant concentrations, monitoring, traffic and meteorological data for year 2007.

Source apportionment of pollutant contribution was carried out based on the following vehicle categories: cars, light goods vehicles (LGVs), buses, and heavy goods vehicles (HGVs). The NO_x reduction to comply with the NO_2 annual mean AQS objective was 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:

King's Lynn town centre AQMA

- Updated monitoring and modelled results confirm that the AQMA is still required in King's Lynn town centre, as the AQS objective is still likely to be exceeded in these areas. The results confirm that the extents of the AQMA are appropriate,

- The source apportionment shows that cars are the main contributors, and account for 25% to 30% of the total NO_x concentration in the AQMA. Buses contribute around 20% to 25%, HGVs between 15%-20% and LGVs around 10%. The contribution of buses varies depending on the roads, but is generally within 20% to 30% of the total NO_x levels. Background concentration represents around 25% to 30% of the total contribution.

- The maximum reduction in NO_x concentrations in the AQMA required to comply with the AQS objectives is about 24µg/m^3 (equivalent to a 20% reduction in NO_x levels). This equates to about 6µg/m^3 reduction in NO_2 (12% reduction). Consequently, measures formulated in the Action Plan should aim to reduce the levels of NO_x / NO_2 within the AQMA by these amounts.

Wootton Road/Gayton Road/Lynn Road junction

- Both monitoring and modelled results show that the NO_2 annual mean AQS objective of 40µg/m^3 is likely to be breached at facades of properties close to the junction. **Therefore, it is recommended that an AQMA be declared at the Wootton Road/Gayton Road/Lynn Road junction.**

- Results suggest that NO_2 levels decrease quickly on Wootton Road and Gayton Road further away from the junction, while properties along Lynn Road / Gaywood Road seem to be less at risk, as they lay further back from the road. Therefore, the AQMA should be limited to the properties close to the junction.

Appendix 1

Traffic Data

Road Link	Street Canyon	Speed (km/hr)	AADT 07	% Cars	% LGVs	% HGVs	% Buses and Coaches
GaywoodRd3_J	No	10	20640	94.0	2.9	1.0	2.0
GaywoodRd4	No	20	20640	94.0	2.9	1.0	2.0
GaywoodRd5_J	No	10	20640	94.0	2.9	1.0	2.0
GaywoodRd6	No	20	20640	94.0	2.9	1.0	2.0
LynnRd1_J	No	10	20640	94.0	2.9	1.0	2.0
WoottonRd1_SB_J	Yes	5	6061	88.9	9.3	0.8	1.0
GaytonRd2	No	20	15289	93.7	3.5	0.9	1.9
GaytonRd3	No	20	15289	93.7	3.5	0.9	1.9
WoottonRd4	No	20	12122	88.9	9.3	0.8	1.0
GaytonRd1_WB_J	Yes	5	7662	94.3	3.2	0.8	1.7
WoottonRd5	No	20	12122	88.9	9.3	0.8	1.0
LittleportSt2	No	20	20640	94.0	2.9	1.0	2.0
LittleportSt1_WB_J	Yes	10	10341	95.0	2.4	0.7	1.9
AustinSt3_SB_J	Yes	10	7169	70.0	24.0	2.7	3.3
BlackfriarsRd1	Yes	20	17510	84.7	11.3	1.5	2.5
BlackfriarsRd2_J	No	10	17510	84.7	11.3	1.5	2.5
RailwayRd6_J	No	10	14801	81.9	10.8	3.1	4.1
LittleportSt1_EB_J	No	10	10299	93.1	3.4	1.4	2.1
GaywoodRd1_J	No	10	20640	94.0	2.9	1.0	2.0
GaywoodRd2	No	20	20640	94.0	2.9	1.0	2.0
LondonRd4_J	Yes	10	29665	83.3	13.3	1.6	1.8
LondonRd5	Yes	20	29665	83.3	13.3	1.6	1.8
LondonRd7_SB	Yes	20	15034	84.3	12.5	1.5	1.7
LondonRd6_J	Yes	10	29665	83.3	13.3	1.6	1.8
LondonRd8_NB_J	Yes	10	14631	82.2	14.1	1.7	2.0
LondonRd7_NB	Yes	20	14631	82.2	14.1	1.7	2.0
LondonRd8_SB_J	No	10	15034	84.3	12.5	1.5	1.7
BlackfriarsRd3_J	Yes	10	17510	84.7	11.3	1.5	2.5
BlackfriarsRd6_NB_J	Yes	10	4805	84.7	11.3	1.5	2.5
BlackfriarsRd6_SB_J	No	10	12705	84.7	11.3	1.5	2.5
StJamesRd1_J	No	10	23881	82.3	12.0	3.1	2.5
StJamesRd2	No	20	23881	82.3	12.0	3.1	2.5
LondonRd1	Yes	20	29665	83.3	13.3	1.6	1.8
LondonRd2_J	Yes	10	29665	83.3	13.3	1.6	1.8
LondonRd3	Yes	20	29665	83.3	13.3	1.6	1.8
Millfleet1_J	No	10	9510	88.5	9.2	1.9	0.4
Millfleet2	No	20	9510	88.5	9.2	1.9	0.4
LynnRd2_EB_J	Yes	5	10299	93.1	3.4	1.4	2.1
RailwayRd5	Yes	20	14801	81.9	10.8	3.1	4.1
RailwayRd4	Yes	20	14801	81.9	10.8	3.1	4.1
RailwayRd3	Yes	20	14801	81.9	10.8	3.1	4.1
RailwayRd1	Yes	20	14801	81.9	10.8	3.1	4.1
RailwayRd2_J	Yes	10	14801	81.9	10.8	3.1	4.1
AustinSt0	No	20	17468	83.6	11.9	1.9	2.6
AustinSt2	Yes	20	17468	83.6	11.9	1.9	2.6
BlackfriarsRd4	Yes	20	17510	84.7	11.3	1.5	2.5
BlackfriarsRd5	Yes	20	17510	84.7	11.3	1.5	2.5

Road Link	Street Canyon	Speed (km/hr)	AADT 07	% Cars	% LGVs	% HGVs	% Buses and Coaches
WoottonRd2_J	Yes	10	12122	88.9	9.3	0.8	1.0
WoottonRd3_J	No	10	12122	88.9	9.3	0.8	1.0
StJamesRd3_J	No	10	23881	82.3	12.0	3.1	2.5
LondonRd0_J	Yes	10	29665	83.3	13.3	1.6	1.8
BlackfriarsSt1_J	Yes	10	4129	89.4	7.7	1.9	1.0
BlackfriarsSt2	No	20	4129	89.4	7.7	1.9	1.0
RailwayRd0_J	Yes	10	14801	81.9	10.8	3.1	4.1
StJamesRd0_J	No	10	13884	83.6	11.0	3.1	2.3
JohnKennedyRd0_J	No	10	16537	87.6	7.7	4.2	0.5
JohnKennedyRd1	No	20	16537	87.6	7.7	4.2	0.5
LynnRd2_WB_J	No	10	10341	95.0	2.4	0.7	1.9
GaytonRd1_EB_J	Yes	10	7627	93.1	3.8	1.0	2.1
WoottonRd1_NB_J	Yes	10	6061	88.9	9.3	0.8	1.0

Appendix 2

NO_x/NO_2 conversion

Following recent analysis of the NO_x/NO_2 ratio at a number of roadside and kerbside monitoring sites in the UK over the past 4 years, the methodology to convert NO_x to NO_2 and vice versa was reviewed in 2007[21]. This updated empirical relationship is based on monitoring data for years 2003 to 2006, collated from the AURN, Highways Agency and LAQN monitoring networks. The report highlights that the relationship described in guidance LAQM.TG(03) is no longer applicable, as comparison with monitoring data shows that it is likely to under predict NO_2 concentration by an average of 20%. Therefore, the NO_x to NO_2 conversion in this assessment was based on the new methodology, as described below. Results are summarized in Table A1 and Table A2.

1. First, both monitored and predicted road-NO_x concentrations are calculated by subtracting the background NO_x concentration as provided in Section 2.3.3. Monitored NO_x at diffusion tube sites was estimated based on the NO_x from NO_2 calculator spreadsheet available on the UK Air Quality Archive website[22]. The ratio between monitored road-NO_x and modelled road-NO_x is then calculated[23].

2. The predicted road-NO_x is adjusted based on this ratio, and the total predicted NO_x is obtained by adding the background NO_x concentration. Predicted road-NO_2 is then calculated using the following updated empirical NO_x/NO_2 relationship:

   $$\text{road-}NO_2 = (-0.0719 \times \text{Ln(total-NOx)} + 0.6248) \times \text{road-}NO_x$$

   Finally, the total predicted NO_2 is calculated by adding the local background NO_2 concentration (as mentioned in Section 2.3.3).

At first, a single road-NO_x adjustment was calculated both for the AQMA in King's Lynn centre and the Gaywood area (Wootton Road/Gayton Road/Lynn Road). However, tests showed that the best model adjustment was obtained if the two areas were treated separately. Therefore, two different model adjustments were carried out; one for each area. Graphs of modelled NO_2 versus monitored NO_2 in **Figure A1** and **Figure A2** show that the adjusted modelled results are in good agreement with the monitoring data.

[21] 'Deriving NO_2 from NO_x for Air Quality Assessments of Roads - Updated to 2006' - AQC, March 2007, www.uwe.ac.uk/aqm/review/NOx_NO2_Report_27_03_07.pdf

[22] www.airquality.co.uk/archive/laqm/tools/NOxfromNO2calculator2007.xls

[23] Based on the least square regression method – intercept at 0

Figure A1 - Adjusted Modelled NO_2 vs. Monitored NO_2 – King's Lynn town centre

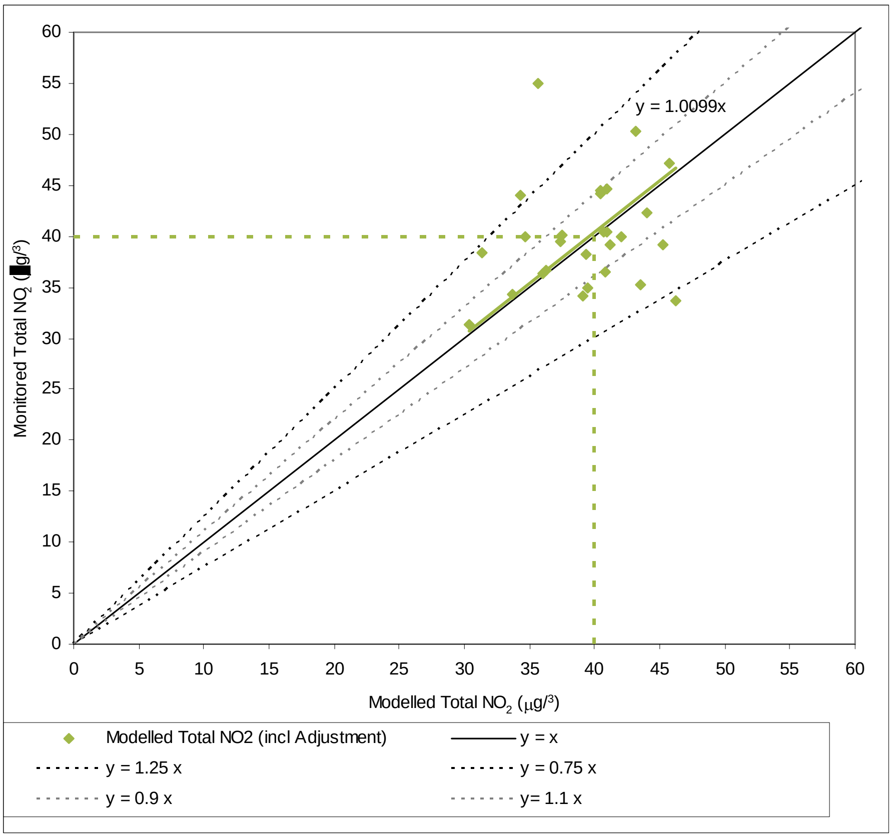

Figure A2 - Adjusted Modelled NO_2 vs. Monitored NO_2 – Gaywood area

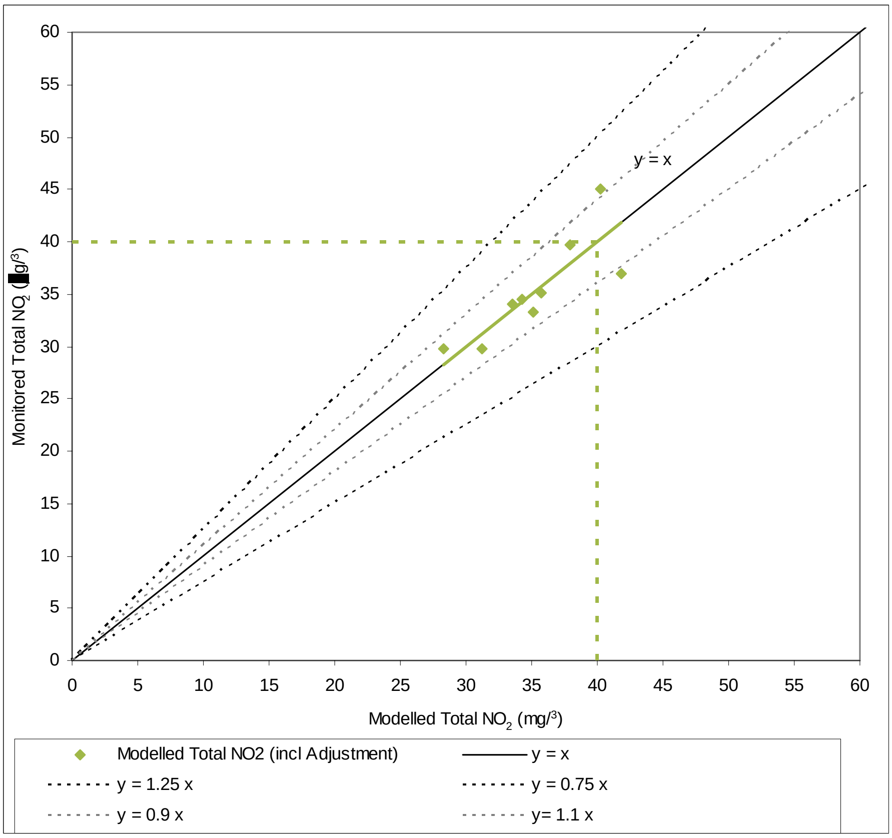

Table A1 – Model verification – King's Lynn town centre

Site ID	Background NO_2 (µg/m^3)	Background NO_x (µg/m^3)	Monitored Total NO_x (µg/m^3)	Monitored Road Contribution NO_x (µg/m^3)	Modelled Road Contribution NO_x (µg/m^3)	Ratio of Monitored Road NO_x /Modelled Road NO_x	Adjustment Factor (Regression) for Modelled Road NO_x Contribution	Adjusted Modelled Road Contribution NO_x (µg/m^3)	Adjusted Modelled Total NO_x (µg/m^3)	Modelled Total NO_2 (µg/m^3)	Monitored Total NO_2 (µg/m^3)	% Difference NO_2 [(Modelled - Monitored)/ Monitored]
1	19.9	29.9	114.7	84.8	21.9	3.88	2.105	46.0	75.9	34.3	44.0	-22%
2			166.6	136.7	24.2	5.64		51.0	80.9	35.7	55.0	-35%
3			143.7	113.8	38.6	2.95		81.3	111.2	43.2	50.4	-14%
4			91.3	61.4	16.8	3.67		35.3	65.2	31.3	38.3	-18%
7 8 9			65.0	35.1	15.1	2.32		31.8	61.7	30.3	31.3	-3%
12			117.3	87.4	34.3	2.55		72.1	102.0	41.0	44.6	-8%
13			78.1	48.2	31.3	1.54		65.9	95.8	39.5	34.9	13%
14			94.8	64.9	42.9	1.51		90.4	120.3	45.2	39.2	15%
15			100.0	70.1	34.2	2.05		72.0	101.9	41.0	40.5	1%
16			107.7	77.8	40.5	1.92		85.2	115.1	44.1	42.3	4%
17			128.5	98.6	43.9	2.25		92.4	122.3	45.7	47.1	-3%
22			79.2	49.3	39.4	1.25		83.0	112.9	43.6	35.2	24%
23			97.4	67.5	36.5	1.85		76.8	106.7	42.1	39.9	6%
24			97.6	67.7	22.5	3.00		47.4	77.3	34.7	39.9	-13%
25			98.2	68.3	27.7	2.47		58.2	88.1	37.5	40.1	-6%
26			75.6	45.7	20.7	2.21		43.6	73.5	33.7	34.3	-2%
30			116.6	86.7	33.3	2.60		70.1	100.0	40.5	44.4	-9%
31			83.4	53.5	24.8	2.16		52.2	82.1	36.0	36.3	-1%
32			73.5	43.6	45.0	0.97		94.7	124.6	46.2	33.7	37%
35			94.8	64.9	34.7	1.87		73.0	102.9	41.2	39.2	5%
36			84.6	54.7	25.4	2.15		53.6	83.5	36.3	36.6	-1%
38			99.7	69.8	33.8	2.07		71.1	101.0	40.7	40.4	1%
39			91.0	61.1	31.2	1.96		65.6	95.5	39.4	38.3	3%
41			75.2	45.3	30.6	1.48		64.4	94.3	39.1	34.1	14%
42			95.9	66.0	27.4	2.41		57.6	87.5	37.4	39.5	-5%
51			115.3	85.4	33.3	2.56		70.1	100.0	40.5	44.1	-8%
52			84.4	54.5	33.8	1.61		71.2	101.1	40.8	36.6	11%

Table A2 – Model verification – Gaywood area

Site ID	Background NO_2 (µg/m^3)	Background NO_x (µg/m^3)	Monitored Total NO_x (µg/m^3)	Monitored Road Contribution NO_x (µg/m^3)	Modelled Road Contribution NO_x (µg/m^3)	Ratio of Monitored Road NO_x /Modelled Road NO_x	Adjustment Factor (Regression) for Modelled Road NO_x Contribution	Adjusted Modelled Road Contribution NO_x (µg/m^3)	Adjusted Modelled Total NO_x (µg/m^3)	Modelled Total NO_2 (µg/m^3)	Monitored Total NO_2 (µg/m^3)	% Difference NO_2 [(Modelled - Monitored)/ Monitored]
43	19.9	29.9	59.6	29.7	8.1	3.65	3.061	24.9	54.8	28.3	29.7	-5%
44			85.8	55.9	24.7	2.27		75.5	105.4	41.8	36.9	13%
45			119.6	89.7	22.6	3.97		69.1	99.0	40.2	45.1	-11%
46			79.0	49.1	16.8	2.92		51.4	81.3	35.8	35.2	2%
47			76.7	46.8	14.9	3.14		45.6	75.5	34.2	34.6	-1%
48			96.9	67.0	19.5	3.43		59.8	89.7	37.9	39.8	-5%
49			74.8	44.9	14.0	3.20		43.0	72.9	33.5	34.0	-2%
50			59.6	29.7	11.4	2.61		34.8	64.7	31.2	29.7	5%
58			71.8	41.9	15.9	2.63		48.8	78.7	35.1	33.2	6%

Appendix 3

Source Apportionment Results

Table A 3: Source apportionment of NO_X concentrations at specific receptors

Receptor	Type	Area	Total Modelled NO_x 2007 ($\mu g/m^3$)	Total Modelled NO_2 2007 ($\mu g/m^3$)	NOX Source Apportionment (%)					
					Background	Cars	LGVs	HGVs	Buses	HDVs
1	DT	AQMA King's Lynn town centre	75.9	34.3	39%	17%	6%	18%	20%	38%
2	DT		80.9	35.7	37%	17%	6%	18%	21%	39%
3	DT		111.2	**43.2**	27%	20%	8%	21%	25%	46%
4	DT		65.2	31.3	46%	14%	5%	16%	18%	35%
5	DT		38.4	23.0	78%	7%	2%	6%	7%	13%
6	DT		35.5	22.0	84%	5%	2%	5%	4%	9%
7 8 9	DT		61.7	30.3	48%	14%	5%	15%	17%	33%
10	DT		39.9	23.5	75%	11%	4%	8%	3%	10%
11	DT		35.2	21.9	85%	6%	2%	4%	2%	7%
12	DT		102.0	**41.0**	29%	25%	10%	19%	17%	36%
13	DT		95.8	39.5	31%	25%	11%	17%	17%	33%
14	DT		120.3	**45.2**	25%	26%	11%	18%	19%	37%
15	DT		101.9	**41.0**	29%	27%	12%	15%	16%	31%
16	DT		115.1	**44.1**	26%	26%	11%	18%	19%	37%
17	DT		122.3	**45.7**	24%	26%	12%	19%	19%	38%
18	DT		31.1	20.3	96%	1%	1%	1%	1%	2%
19	DT		31.6	20.5	95%	2%	1%	1%	1%	3%
20	DT		33.9	21.4	88%	4%	2%	3%	3%	6%
21	DT		35.7	22.0	84%	6%	2%	4%	4%	8%
22	DT		112.9	**43.6**	26%	26%	11%	18%	18%	36%
23	DT		106.7	**42.1**	28%	27%	13%	16%	16%	32%
24	DT		77.3	34.7	39%	23%	10%	14%	14%	28%
25	DT		88.1	37.5	34%	25%	11%	15%	15%	30%
26	DT		73.5	33.7	41%	22%	10%	14%	14%	28%
27 28 29	DT		41.3	24.0	72%	9%	4%	8%	7%	14%
30	DT		100.0	**40.5**	30%	19%	7%	21%	23%	44%
31	DT		82.1	36.0	36%	22%	8%	14%	18%	33%
32	DT		124.6	**46.2**	24%	28%	11%	15%	22%	37%
33	DT		46.7	25.8	64%	11%	4%	10%	11%	21%
34	DT		44.3	25.0	67%	11%	4%	8%	10%	18%
35	DT		102.9	**41.2**	29%	19%	7%	20%	24%	44%
36	DT		83.5	36.3	36%	18%	7%	18%	21%	40%
37	DT		43.5	24.7	69%	10%	3%	8%	10%	18%
38	DT		101.0	**40.7**	30%	24%	8%	16%	22%	38%
39	DT		95.5	39.4	31%	25%	10%	14%	20%	34%
40	DT		59.8	29.8	50%	16%	6%	12%	15%	27%
41	DT		94.3	39.1	32%	25%	9%	14%	20%	34%
42	DT		87.5	37.4	34%	29%	4%	12%	21%	33%
51	DT		100.0	**40.5**	30%	24%	10%	16%	20%	36%
52	DT		101.1	**40.8**	30%	24%	10%	17%	20%	36%
JohnKennedyRd1	SR		49.0	26.5	61%	14%	4%	18%	3%	21%
RailwayRd1	SR		73.4	33.6	41%	16%	6%	17%	20%	37%
43	DT	Wootton Road / Gayton Road / Lynn Road	54.8	28.3	55%	21%	2%	8%	14%	23%
44	DT		105.4	**41.8**	28%	33%	3%	13%	23%	36%
45	DT		99.0	**40.2**	30%	33%	7%	13%	16%	29%
46	DT		81.3	35.8	37%	32%	8%	11%	13%	23%

Receptor	Type	Area	Total Modelled NO_x 2007 ($\mu g/m^3$)	Total Modelled NO_2 2007 ($\mu g/m^3$)	NOX Source Apportionment (%)					
					Background	Cars	LGVs	HGVs	Buses	HDVs
47	DT	Wootton Road / Gayton Road / Lynn Road	75.5	34.2	40%	26%	2%	13%	20%	32%
48	DT		89.7	37.9	33%	28%	3%	14%	22%	36%
49	DT		72.9	33.5	41%	27%	2%	11%	18%	29%
50	DT		64.7	31.2	46%	25%	2%	10%	17%	27%
58	DT		78.7	35.1	38%	28%	3%	12%	20%	31%
GaytonRd1	SR		68.3	7.0	44%	26%	3%	10%	17%	27%
GaytonRd2	SR		61.6	30.3	49%	27%	3%	8%	14%	22%
GaytonRd3	SR		42.0	24.2	71%	15%	2%	4%	8%	12%
GaywoodRd1	SR		81.6	35.8	37%	29%	3%	12%	19%	31%
GaywoodRd2	SR		80.9	35.6	37%	28%	3%	12%	20%	32%
GaywoodRd3	SR		53.3	27.8	56%	22%	2%	7%	12%	20%
LynnRd1	SR		62.3	30.5	48%	24%	2%	10%	16%	26%
LynnRd2	SR		66.0	31.6	45%	25%	2%	10%	17%	27%
WoottonRd1	SR		132.2	**47.9**	23%	33%	5%	16%	22%	39%
WoottonRd2	SR		60.1	29.9	50%	23%	3%	9%	15%	24%
WoottonRd3	SR		85.4	36.8	35%	32%	8%	11%	14%	25%
WoottonRd4	SR		51.8	27.4	58%	22%	6%	6%	8%	14%
WoottonRd5	SR		48.3	26.3	62%	20%	5%	6%	7%	13%
WoottonRd6	SR		47.4	26.0	63%	20%	6%	5%	6%	12%
WoottonRd7	SR		46.4	25.7	64%	19%	6%	5%	6%	11%
WoottonRd8	SR		49.7	26.7	60%	21%	6%	6%	7%	12%
WoottonRd9	SR		46.6	25.7	64%	19%	6%	5%	6%	11%

DT = Diffusion Tube; SR = Specific Receptor
In bold, concentrations above the NO_2 annual mean AQS objective (40µg/m^3)