Luton Borough Council

Dunstable Road, Luton

Detailed Assessment

May 2015

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Document Control Sheet

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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. For local authorities that have identified areas where there is a potential risk of exceedence of Air Quality Strategy (AQS) objectives, a Detailed Assessment is required.

Following the assessment of monitoring results for 2014 that indicate an exceedence of the annual mean AQS objective for nitrogen dioxide (NO_2), Bureau Veritas UK Ltd has been commissioned by Luton Borough Council to undertake a Detailed Assessment of the area surrounding Dunstable Road, Luton. The assessment is undertaken in accordance with the methodology agreed with the Council.

The area was modelled using the advanced atmospheric dispersion model ADMS-Roads (Version 3.2).

The model suggests the 40µg/m^3 annual mean AQS objective for NO_2 may be exceeded at a total of four receptor locations, with a further three locations within 10% of the objective.

The maximum annual mean NO_2 concentration at an existing receptor was predicted at '14 Dunstable Road', with a concentration of 54.6µg/m^3. The lowest annual mean NO_2 concentration at an existing receptor was predicted at '85 Park Street', with a concentration of 29.3µg/m^3.

On the basis of the model predicted annual mean NO_2 concentrations and the published empirical relationship with exceedences of the short-term AQS objective limit, it is considered unlikely that the short-term hourly mean NO_2 AQS objective would be exceeded given the concentrations modelled.

Following the results of the report, the below recommendations are made:

- That an Air Quality Management Area (AQMA) be declared in the area, the extent of which is proposed in Figure 6.
- Further monitoring in the area is recommended. However, Bureau Veritas is aware that Luton Borough Council has recently (October 2014) set up continuous analysers, monitoring PM_{10} and NO_2, at 508708, 221352. This was not included in the assessment as it had only 8% data capture in 2014. This station should, however, prove useful in the future assessment of air quality in the proposed AQMA.
- As alluded to in Section 6.1, traffic to the northern side of the town centre has recently been redirected along a new route, Gateway Link, connecting Hucklesby Way and Crescent Road. This has not been included in the current assessment as there was not perceived to be an air quality issue there. However, a number of new NO_2 diffusion tube monitoring locations were set up in this area in January 2015; if additional exceedences of the NO_2 annual mean AQS objective are recorded along these roads, it is recommended that a further Detailed Assessment be undertaken.
- An Air Quality Action Plan is drawn up to determine the best policies and intervention measures to put in place in order to reduce local NO_2 concentrations.
- Further Assessment of the area is conducted post implementation of the AQMA as part of the next round of LAQM reporting.

1 Introduction

1.1 Scope of Assessment

Luton Borough Council (The Council) has made two declarations of Air Quality Management Areas (AQMAs) under the existing Local Air Quality Management (LAQM) regime in relation to exceedences of the nitrogen dioxide (NO_2) annual mean Air Quality Strategy (AQS) objective of 40µg/m^3. The first, declared in November 2003, contained 24 dwellings in close proximity to the M1. On Further and Detailed Assessment, this was later extended in 2005 to include some 431 dwellings alongside junction 11 of the M1.

The 2013 Progress Report identified a further location within the town centre at Dunstable Road with a potential exceedence of the annual NO_2 AQS objective. At the time, it was decided that further monitoring was needed before determining if a Detailed Assessment was required. The exceedence was repeated in the 2014 Progress Report, and the Council therefore proceeded to a Detailed Assessment.

Bureau Veritas UK Ltd has been commissioned by Luton Borough Council to undertake the Detailed Assessment of the area surrounding Dunstable Road, specifically the A505 between Hatters Way and Windmill Road.

The roads considered in the assessment are as follows;

- A505 from Clifton road to Chapel Viaduct roundabout
- B579 from Kenilworth Road to A505
- A6 Telford way
- Cardigan Street
- B4540 between Windsor and Regent St
- Castle Street
- Park Viaduct A505
- Church/Park Street

The area considered as part of this study is illustrated in Figure 1. Guildford Street and the surrounding area have recently been pedestrianised and traffic has been redirected along a new road to the north of the town centre, Gateway Link. As this will greatly reduce emissions from road traffic in the Guildford Street area, it was not considered necessary by the Council to include this within the Detailed Assessment area. Additional monitoring conducted by the Council in 2015 will confirm any requirement to expand the area considered in a further Detailed Assessment.

It is the general purpose and intent of this assessment to determine, with reasonable certainty, the magnitude and geographical extent of any exceedence so that the Council can have confidence in the potential declaration of an AQMA.

The following are the main objectives of the assessment:

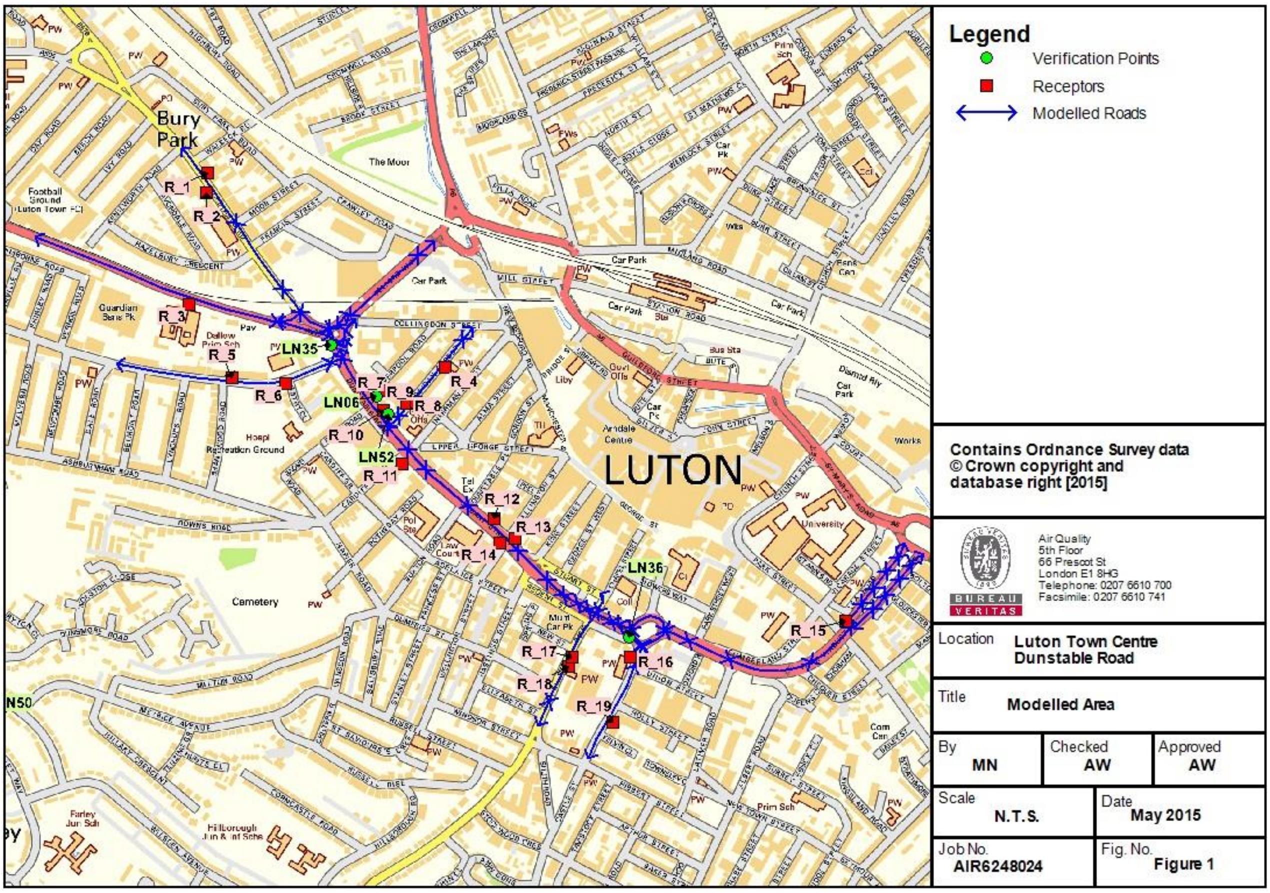
- To assess the air quality at selected locations (“receptors”) at the façades of the existing residential units, representative of worst-case exposure, based on modelling of emissions from road traffic on the local road network for 2014;
- To determine the geographical extent of the potential exceedence;

- To attempt to quantify the number of residents exposed to exceedences of the NO_2 annual mean AQS objective; and
- To put forward conclusions and recommendations as to the extent of any proposed AQMA and necessary future monitoring.

The approach adopted in this assessment to assess the impact of road traffic emissions on air quality utilised the atmospheric dispersion model ADMS Roads version 3.2, focusing on emissions of NO_2.

In order to provide consistency with the Council's own work on air quality, the guiding principles for air quality assessments as set out in the latest guidance and tools provided by Defra for air quality assessment (LAQM.TG(09)[1]) have been used.

Figure 1 – Modelled Area



[1] Local Air Quality Management Technical Guidance LAQM.TG(09). February 2009. Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland.

2 Air Quality – Legislative Context

2.1 Air Quality Strategy

The importance of existing and future pollutant concentrations can be assessed in relation to the national air quality standards and objectives established by Government. The Air Quality Strategy[2] (AQS) provides the over-arching strategic framework for air quality management 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 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 CAFE Directive[2] has been adopted and replaces all previous air quality Directives, except the 4th Daughter Directive[3]. The Directive introduces new obligatory standards for $PM_{2.5}$ for Government but places no statutory duty on local government to work towards achievement of these standards.

The Air Quality Standards (England) Regulations[4] 2010 came into force on 11 June 2010 in order to align and bring together in one statutory instrument the Government's obligations to fulfil the requirements of the new CAFE Directive.

The objectives for ten pollutants – benzene (C_6H_6), 1,3-butadiene (C_4H_6), carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulate matter - PM_{10} and $PM_{2.5}$, ozone (O_3) and Polycyclic Aromatic Hydrocarbons (PAHs), have been prescribed within the AQS[2].

The EU Limit Values are considered to apply everywhere with the exception of the carriageway and central reservation of roads and any location where the public do not have access (e.g. industrial sites). The AQS objectives apply at 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. Typically these include residential properties and schools/care homes for long-term (i.e. annual mean) pollutant objectives and high streets for short-term (i.e. 1-hour) pollutant objectives.

This assessment focuses on NO_2 as this is the pollutant of most concern within the Council's administrative area. Moreover, as a result of traffic pollution the UK has failed to meet the EU Limit Values for this pollutant by the 2010 target date. As a result, the Government has had to submit time extension applications for compliance with the EU Limit Values. Continued failure to achieve these limits may lead to EU fines. The AQS objectives for these pollutants are presented in Table 1.

[2] 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.

[3] Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic hydrocarbons in ambient air.

[4] The Air Quality Standards Regulations (England) 2010, Statutory Instrument No 1001, The Stationary Office Limited.

Table 1 – Relevant AQS Objectives for the Assessed Pollutants in England

Pollutant	AQS Objective	Concentration Measured as:	Date for Achievement
Nitrogen dioxide (NO_2)	200 µg/m³ not to be exceeded more than 18 times per year	1-hour mean	31 December 2005
	40 µg/m³	Annual mean	31 December 2005

2.2 Local Air Quality Management (LAQM)

Part IV of the Environment Act 1995 places a statutory duty on local authorities to periodically Review and Assess the current and future air quality within their area, and determine whether they are likely to meet the AQS objectives set down by Government for a number of pollutants – a process known a Local Air Quality Management (LAQM). The AQS objectives that apply to LAQM are defined for seven pollutants: benzene, 1,3-butadiene, carbon monoxide, lead, nitrogen dioxide, sulphur dioxide and particulate matter.

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 concentrations of pollution and exceedences of health-based standards.

Where an authority has declared an AQMA, and development is proposed to take place either within or near the declared area, further deterioration to air quality resulting from a proposed development can be a potential barrier to gaining consent for the development proposal. Similarly, where a development would lead to an increase of the population within an AQMA, the protection of residents against the adverse long-term impacts of exposure to existing poor air quality can provide the barrier to consent. As such, following an increased number of declarations across the UK, it has become standard practice for planning authorities to require an air quality assessment to be carried out for a proposed development (even where the size and nature of the development indicates that a formal Environmental Impact Assessment (EIA) is not required).

One of the objectives of the LAQM regime is for local authorities to enhance integration of air quality into the planning process. Current LAQM Policy Guidance[5] clearly recognises land-use planning as having a significant role in terms of reducing population exposure to elevated pollutant concentrations. Generally, the decisions made on land-use allocation can play a major role in improving the health of the population, particularly at sensitive locations – such as schools, hospitals and dense residential areas.

[5] LAQM Policy Guidance LAQM.PG(09) - February 2009. Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland.

3 Review and Assessment of Air Quality Undertaken by the Council

3.1 Local Air Quality Management

Luton Borough Council published its Stage 1 Review and Assessment in March 1999. It concluded that further investigation was required for carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter (PM_{10}) and sulphur dioxide (SO_2). The Stage 2 Review and Assessment, published in October 1999, considered these pollutants and concluded further investigation was only needed regarding NO_2 and PM_{10}.

Stage 3 Review and Assessment (2001) looked in greater detail at NO_2 and PM_{10} and found that the AQS objectives predicted to be exceeded were the annual mean NO_2 objective and the 24 hourly mean PM_{10} objective. However, after considering whether there was any relevant exposure, and following consultation, it was decided not to declare an AQMA.

In 2003, the Stage 4 Review & Assessment report[6] was used to inform an Action Plan. The assessment looked in detail at NO_2 and PM_{10} and concluded that; the PM_{10} annual average objective would not be exceeded anywhere in Luton; that the 24-hour mean objective for PM_{10} would only be exceeded on the M1 Motorway itself (where relevant exposure does not occur) and that the provisional annual average objective for PM_{10} of 20µg/m^3 by 2010 would not be exceeded, except perhaps within approximately 5m of the boundary of the M1.

The assessment also concluded that there was likely to be exceedences of the NO_2 annual mean objective at locations of relevant exposure. These locations were at 24 specified dwellings that are within a 50m band along the M1.

The 2003 Updating and Screening Assessment[7] concluded that Benzene, 1-3 Butadiene, CO, Lead, PM_{10} and SO_2 would meet relevant AQS objectives. However, it was concluded that there was likely to be an exceedence of the NO_2 annual mean objective at locations inside and outside of the AQMA declared in November 2003 (which contained the 24 dwellings determined to have relevant exposure in the Stage 4 Review and Assessment). Therefore a Detailed Assessment and Further Assessment were required to quantify and spatially redefine the exceedence area.

This Further and Detailed Assessment[8] concluded that the NO_2 annual mean AQS objective was likely to be exceeded over a much greater area than had been concluded by the Stage 3 and 4 Review and Assessments. An AQMA was subsequently declared in March 2005, which contained 431 dwellings.

The subsequent 2005 Progress Report indicated a downward trend in NO_2 concentrations in Luton at the monitoring locations. During 2004 the measured average annual concentration of NO_2 in Luton reduced at all locations compared to 2003. There was only one site exceeding the annual mean objective for NO_2; by Junction 11 of the M1. All other AQS pollutant concentrations fell consistently below the objective concentrations. As such, the 2006 USA concluded that Further Assessments or Detailed Assessments were not required for any of the AQS pollutants. This downward trend was continued through the 2007 Progress Report.

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[6] Air Quality Review and Assessment - Stage 4 for Luton Borough Council (2003) AEAT/ENV/R/1426/Issue 1- available at https://www.luton.gov.uk/Environment/Lists/LutonDocuments/PDF/Environmental%20and%20Consumer%20Services/Pollution/Air%20Quality%20Strategy/Air_Quality_Review.pdf

[7] Updating and Screening Assessment (2003), Luton Borough Council, available at http://www.luton.gov.uk/Environment/Environmental%20health/Air_pollution_2/Air%20Quality/pages/Pollution%20control%20-%20air_2.aspx

[8] Detailed and Further Assessment of Air Quality for Luton Borough Council (2004), FA-DA, AEAT-ENVR-1693 Issue 1 – available at: http://www.luton.gov.uk/Environment/Environmental%20health/ Air_pollution_2/Air%20Quality/pages/ Pollution%20control%20-%20air_2.aspx

The 2008 Progress Report showed that there had been no exceedence of the annual and/or short-term objectives for NO_2, PM_{10}, CO and SO_2. It was reported that diffusion tubes had been re-deployed within the declared AQMA in 2008. Two exceedences were identified at London Luton Airport, although no monitoring at locations of relevant exposure was being undertaken. This prompted monitoring of NO_2 to begin in areas of relevant exposure outside the northern boundary of London Luton Airport, but the decision was taken not to proceed to Detailed Assessment.

The 2010 Progress Report identified there was no need to proceed to any Detailed Assessments. Results from the automatic monitoring station LN01 showed no exceedences of the AQS objectives for any of the prescribed pollutants measured. Similarly, the 2011 Progress Report identified there was no need to proceed to any Detailed Assessments. Results from the automatic monitoring stations at LN01 and LA08 (see Table 2) showed no exceedences of the AQS objectives. Passive monitoring results did not show any exceedences of the annual average objective near relevant receptors for NO_2 in 2010.

The 2012 Updating and Screening Assessment again identified that there was no need to proceed to a Detailed Assessment. Results from the automatic monitoring stations showed no exceedences of the AQS objectives. Passive monitoring results did show a potential exceedence of the annual average objective near a relevant receptor on Dunstable Road for NO_2 in 2011. As a result, a further monitoring point was established on the façade of an additional residential property. No locations were identified with new or increased sources of pollution that would require a Detailed Assessment.

The 2013 Progress Report did not identify any locations within the AQMA that exceeded the objective for NO_2 or PM_{10}. However, one location within the town centre was identified with a potential exceedence of NO_2 however it was decided that further monitoring at this site was appropriate prior to undertaking a Detailed Assessment.

The 2014 Progress Report included a repeat of this exceedence, which prompted the Council to proceed to this Detailed Assessment.

3.2 Review of Air Quality Monitoring

Between January to October 2014, the Council operated an automatic air quality monitoring station at Challney Community College (LN01). An additional site, London Luton Airport (LA08), is run independently. Only one of these, LN01, monitored NO_2. However, LN01 was decommissioned in early October 2014. Recent results from these monitoring stations are shown in Table 2 below. This also demonstrates annual mean PM_{10} concentrations are well below the AQS objective, hence why this pollutant was not considered in this Detailed Assessment.

Table 2 – LAQM Automatic Monitoring Undertaken in the Council area

Site Number	Site Name	Site Type	OS Grid Ref	Pollutants Monitored	Annual Mean NO_2 Concentration ($\mu g/m^3$)			Annual Mean PM_{10} Concentration ($\mu g/m^3$)		
					2012	2013	2014	2011	2012	2013
LN01	Challney Community College	Urban background	505570, 222754	NO_2 PM_{10}	28	33	36*	21	20	20
LA08	London Luton Airport	Other	511871, 221142	PM_{10}	-	-	-	17	15	21

*Results annualised based on 74.9% data capture. For annualisation calculation, see Appendix 2

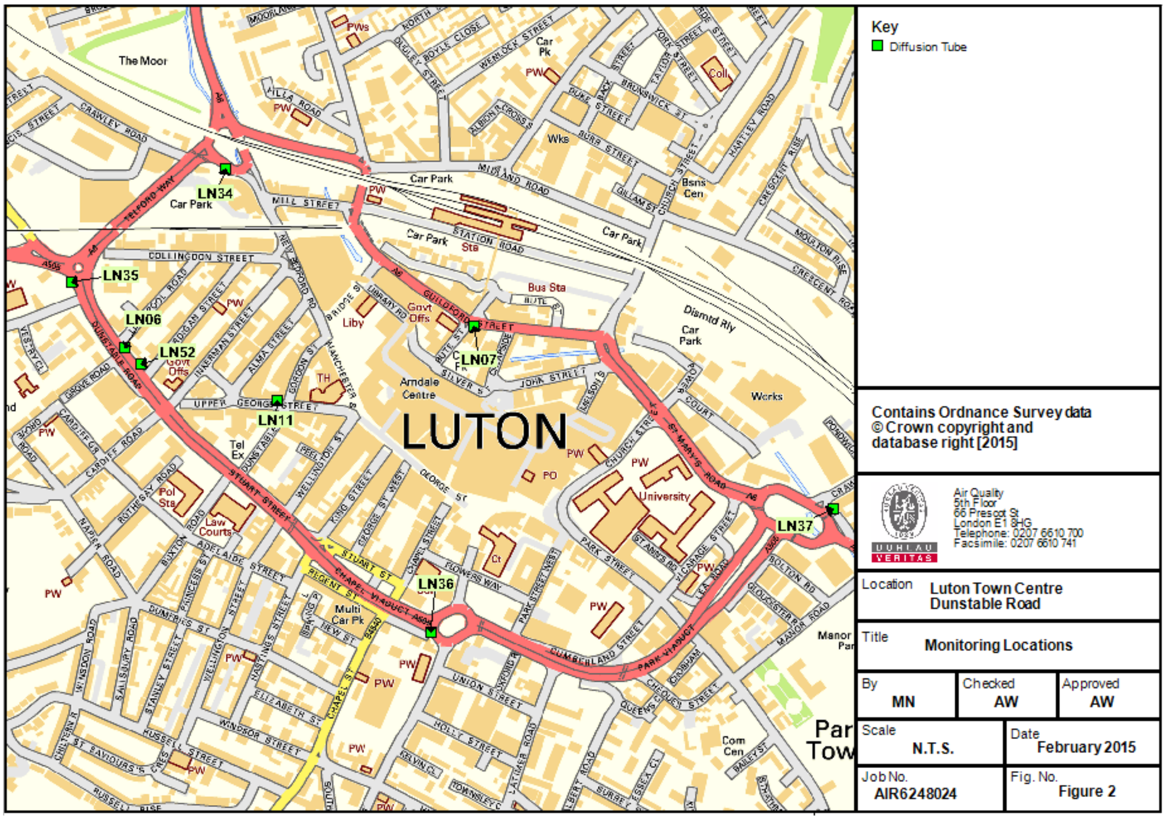
The Council carries out passive monitoring for NO_2 at 45 sites across the city. Recent monitoring results for the sites in the vicinity of the modelled area are shown in Table 3 and in Figure 2.

Table 3 – LAQM Diffusion Tube Monitoring undertaken for NO_2 in modelled area

Site Number	Site Name	Site Type	OS Grid Ref	Distance to Road (m)	Annual Mean NO_2 Concentration (µg/m^3)*		
					2012 Bias 0.77	2013 Bias 0.93	2014 Bias 1.04**
LN06	Liverpool Rd	Kerbside	508662, 221407	0.98	**46.8**	**53**	**58.4**
LN07	Guildford/Bute St	Kerbside	509226, 221441	0.35	**44.9**	**48**	**47.9**
LN11	Upper George St	Roadside	508909, 221321	2.65	31.2	39	**42.6**
LN34	Telford Way Rb	Roadside	508825, 221694	0.9	29.9	39	**44.5**
LN35	Dunstable/Hatters Rb	Roadside	508578, 221512	2	**47.2**	**56**	**66.8**
LN36	Chapel Viaduct Rb	Roadside	509157, 220946	2.72	**46.9**	**46**	**57.5**
LN37	Crawley Green Rb	Roadside	509805, 221145	3.7	**38.6**	**43**	**46.6**
LN52	Dunstable/Cardigan	Roadside	508689, 221379	4.25	**46.0**	**54**	**58.9**

In **bold**, exceedence of the annual mean NO_2 AQS objective of 40µg/m^3
*Bias Adjustment Factors listed with relevant year
** 2014 factor based on best available data. See Appendix 3

Figure 2 – Local Monitoring Locations



The monitoring results show that exceedences of the annual mean NO_2 objective have been recorded next to busy roads in the area. The 2014 monitoring data supports the Council's decision to progress with a Detailed Assessment, with several locations exceeding the 40µg/m^3 AQS objective for NO_2.

Defra maintains a nationwide model of existing and future background air quality concentrations at a 1km grid square resolution. The data sets include annual average concentration estimates for

NO_x, NO_2, PM_{10} and $PM_{2.5}$, using a base year of 2011. The model used is semi-empirical in nature; it uses the national atmospheric emissions inventory (NAEI) emissions to model-predict the concentrations of pollutants at the centroid of each 1km grid square, but then calibrates these concentrations in relation to actual monitoring data.

Annual mean background concentrations have been obtained from the Defra published background maps[9], based on the 1km grid squares which cover the modelled area and the affected road network. The Defra mapped background concentrations for 2014 are presented in Table 4.

Table 4 – Background Pollutant Concentrations (Defra Background Maps)

Grid Square (E,N)	2014 Annual Mean Concentration (µg/m^3)	
	NO_x	NO_2
508500, 221500	39.9	24.8
509500, 220500	33.2	21.3
509500, 221500	42.5	25.9
AQS objective	-	*40.0*

These mapped background levels are below the respective annual mean AQS objectives.

3.3 Background Concentrations used in the Assessment

The predicted annual mean road contributions are added to the relevant annual mean background concentration in order to predict the total pollutant concentration at each receptor location. The total pollutant concentration can then be compared against the relevant AQS objectives to determine the event of an exceedence.

Annual mean background concentrations for the pollutants of relevance to this assessment have been taken from the Defra published background maps. The concentrations for grid square 508500, 221500 have been applied across all receptors[10]. This is to negate against the introduction of artificial boundaries in background concentrations, as the modelled area encompasses three different 1km x 1km grid squares.

The concentrations monitored at site LN01 were also considered for use as background values. However, these were not implemented for the following reasons:

- The data for 2014 is below 75% data capture. Annualisation of the data is therefore required, introducing uncertainty.
- The site is located approximately three to four kilometres away from the area of study, so may not be representative of local conditions.
- Given the close proximity of the site to Junction 11 of the M1, an area highlighted by the Council in previous rounds of Review and Assessment to be high in terms of $NO_{2,}$ local emission sources are likely to affect the concentrations monitored. This means the concentrations are not representative of the urban background level.

[9] Defra Background Maps (2014). http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html

[10] This decision was taken as grid square 509500, 221500 contains the railway station, which is a source of emissions that was not deemed to influence the receptors modelled (the closest of which is 500m from the railway station), given they largely fall within grid square 508500, 221500

4 Assessment Methodology

The approach used in this assessment has been based on the following:

- Prediction of ambient NO_2 concentrations, to which existing receptors may be exposed and comparison with the relevant AQS objectives.
- Determination of the geographical extent of any potential exceedence.

4.1 Traffic Assessment

Emissions from road traffic have been predicted using version 6.0.2 of the Emissions Factor Toolkit[11]. Road-NO_x contributions at receptor locations were modelled using the ADMS-Roads (Version 3.2) atmospheric dispersion model developed by Cambridge Environmental Research Consultants (CERC).

4.1.1 Model Inputs

The ADMS-Roads assessment incorporates numbers of road traffic vehicles, vehicle speeds on the local roads and the composition of the traffic fleet. The traffic data for this assessment has been provided by the Council, supplemented by traffic count data taken from the Department for Transports (DfT), Traffic Counts web resource[12] and is outlined in Table 5.

Table 5 – Traffic Data used in the Detailed Assessment

Link Name	2014 24hr AADT	% Car	%LGV	% HGV	% Bus/Coach	% Motorcycle	Speed (kph)
ParkV_14_j[c]	28172	87.9	9.5	1.4	0.7	0.5	20.0
ParkV_13_q[c]	28172	87.9	9.5	1.4	0.7	0.5	20.0
ParkV_12_ff[c]	28172	87.9	9.5	1.4	0.7	0.5	58.4
ParkV_11_ff[c]	28172	87.9	9.5	1.4	0.7	0.5	58.4
ParkV_2_j[c]	14086	87.9	9.5	1.4	0.7	0.5	10.0
Castle_2_j[a]	15218	91.2	5.6	2.1	0.4	0.7	10.0
Dunstable_11_ff[a]	45245	90.0	0.7	1.0	7.4	0.9	38.9
Dunstable_12_ff[a]	45245	90.0	0.7	1.0	7.4	0.9	38.9
Viaduct_1_ff[a]	45245	90.0	0.7	1.0	7.4	0.9	38.9
Castle_3_ff[a]	15218	91.2	5.6	2.1	0.4	0.7	47.6
Dunstable_10_q[a]	45245	90.0	0.7	1.0	7.4	0.9	20.0
Hatters_3_j_s[a]	13792	96.5	1.2	1.0	1.0	0.3	10.0
Hatters_2_j_n[a]	13792	96.5	1.2	1.0	1.0	0.3	10.0
Dunstable_4_j[a]	17397	90.9	5.8	1.6	1.5	0.2	10.0
Dunstable_7_j[a]	45245	90.0	0.7	1.0	7.4	0.9	10.0
Dunstable_8_ff[a]	45245	90.0	0.7	1.0	7.4	0.9	38.9
Dunstable_9_q[a]	45245	90.0	0.7	1.0	7.4	0.9	20.0
Hatters_1_ff[a]	27584	96.5	1.2	1.0	1.0	0.3	58.4
A6_2_ff[a]	30646	91.4	1.4	1.5	4.6	1.1	49.4

[11] EFT_v6.0.2 available at - http://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

[12] Department for Transport – Traffic Counts (2014) http://www.dft.gov.uk/traffic-counts/

A6_1_j[a]	30646	91.4	1.4	1.5	4.6	1.1	10.0
Dunstable_1_ff[a]	17397	90.9	5.8	1.6	1.5	0.2	27.5
Dunstable_3_j[a]	17397	90.9	5.8	1.6	1.5	0.2	10.0
Cardigan_3_j[a]	639	94.3	3.9	0.0	0.5	1.3	10.0
Cardigan_2_ff[a]	639	94.3	3.9	0.0	0.5	1.3	20.9
Cardigan_1_j[a]	639	94.3	3.9	0.0	0.5	1.3	10.0
Dallow_2_j[a]	5891	90.3	5.9	0.1	0.6	3.1	10.0
Dallow_1_ff[a]	5891	90.3	5.9	0.1	0.6	3.1	32.5
A6_4_j_s[a]	15323	91.4	1.4	1.5	4.6	1.1	10.0
A6_3_j_n[a]	15323	91.4	1.4	1.5	4.6	1.1	10.0
Dunstable_5_j_n[a]	22622	90.0	0.7	1.0	7.4	0.9	10.0
Dunstable_6_j_s[a]	22622	90.0	0.7	1.0	7.4	0.9	10.0
Viaduct_2_ff[a]	45245	90.0	0.7	1.0	7.4	0.9	38.9
Viaduct_3_ff[a]	45245	90.0	0.7	1.0	7.4	0.9	38.9
Viaduct_4_ff[a]	45245	90.0	0.7	1.0	7.4	0.9	38.9
Viaduct_5_ff[a]	45245	90.0	0.7	1.0	7.4	0.9	38.9
Chapel_3_ff[b]	5097	90.2	7.5	0.1	1.2	1.0	27.8
Chapel_2_ff[b]	5097	90.2	7.5	0.1	1.2	1.0	27.8
Chapel_1_ff[b]	5097	90.2	7.5	0.1	1.2	1.0	27.8
Dunstable_2_ff[a]	17397	90.9	5.8	1.6	1.5	0.2	27.5
A6_5_ro[a]	45245	90.0	0.7	1.0	7.4	0.9	10.0
Viaduct_6_q[a]	45245	90.0	0.7	1.0	7.4	0.9	20.0
Viaduct_8_ro[a]	45245	90.0	0.7	1.0	7.4	0.9	10.0
ParkV_15_ro_s[c]	14086	87.9	9.5	1.4	0.7	0.5	10.0
Castle_1_ro[a]	15218	91.2	5.6	2.1	0.4	0.7	10.0
ParkV_1_jc[a]	14086	87.9	9.5	1.4	0.7	0.5	10.0
ParkV_3_ff[a]	14086	87.9	9.5	1.4	0.7	0.5	58.4
ParkV_5_ff_n[c]	14086	87.9	9.5	1.4	0.7	0.5	58.4
ParkV_7_ff_n[c]	14086	87.9	9.5	1.4	0.7	0.5	58.4
ParkV_9_ff_n[c]	14086	87.9	9.5	1.4	0.7	0.5	58.4
ParkV_10_ff_s[c]	14086	87.9	9.5	1.4	0.7	0.5	58.4
ParkV_8_ff_s[c]	14086	87.9	9.5	1.4	0.7	0.5	58.4
ParkV_6_ff_s[c]	14086	87.9	9.5	1.4	0.7	0.5	58.4
ParkV_4_ff[c]	14086	87.9	9.5	1.4	0.7	0.5	58.4
Viaduct_7_j[a]	45245	90.0	0.7	1.0	7.4	0.9	10.0

[a] Data provided by Council
[b] 2012 Data Tempro adjusted
[c] 2013 Data provided by Department for Transports (DfT), Traffic Counts Tempro adjusted

The following scenario has been assessed:

- 2014 Base Case

Background pollutant concentrations have been taken from the estimated background concentrations compiled by Defra[9], as discussed previously in Section 3. Background concentrations used in the assessment of road traffic emissions are shown in Table 6.

Table 6 – Background Concentrations used in the Assessment of Road Traffic Emissions

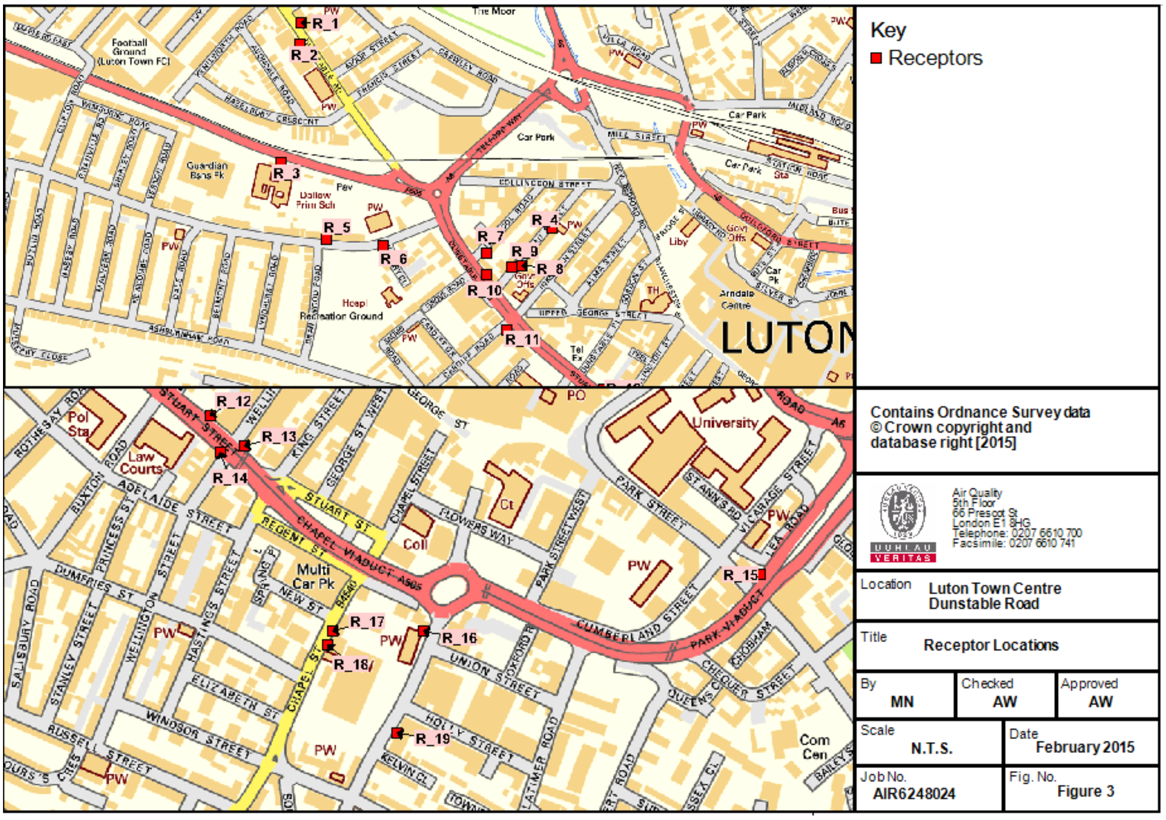
Year	Grid Square (E,N)	Annual Mean Concentration (µg/m^3)	
		NO_2	NO_x
2014	**508500, 221500**	24.8	39.9

The receptors considered in the assessment of emissions from road traffic are shown in Table 7, and their location illustrated in Figure 3. Concentrations were also modelled using intelligent gridding across the area, the results of which are presented in Figure 5. This should determine the geographical extent of any potential exceedence.

Table 7 – Receptor Locations considered in the Assessment of Emissions from Road Traffic

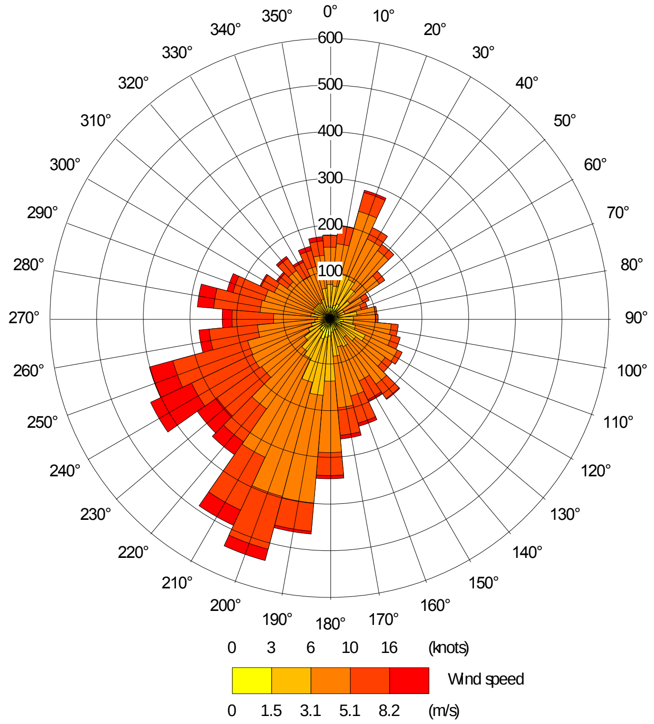
ID	Receptors	Coordinates		Height (m)
		X	Y	
Existing Receptors – all addresses approximate				
R_1	94 Dunstable Road	508340	221847	1.5
R_2	169 Dunstable Road	508338	221808	1.5
R_3	Dallow Primary School	508303	221592	1.5
R_4	31-33 Cardigan Street	508800	221470	1.5
R_5	30 Dallow Road	508387	221451	1.5
R_6	2 Dallow Road	508490	221438	1.5
R_7	65 Liverpool Road	508681	221426	1.5
R_8	69 Cardigan Street	508744	221402	1.5
R_9	74 Cardigan Street	508726	221400	1.5
R_10	14 Dunstable Road	508680	221386	1.5
R_11	3 Cardiff Road	508716	221283	1.5
R_12	32 Stuart Street	508894	221176	1.5
R_13	53 Wellington Street	508936	221138	1.5
R_14	66 Wellington Street	508907	221130	1.5
R_15	85 Park Street	509577	220978	1.5
R_16	43 Castle Street	509159	220908	1.5
R_17	31 Chapel Street	509047	220907	1.5
R_18	80 Chapel Street	509040	220890	1.5
R_19	61 Castle Street	509126	220782	1.5

Figure 3 – Receptor Locations considered in the Assessment of Emissions from Road Traffic



Meteorological data from a representative station is required by the dispersion model. 2014 meteorological data from Luton Airport's weather station, located approximately 3.5km to the east, has been used in this assessment. A wind rose for this site for the year 2014 is shown in Figure 4. Most dispersion models do not use meteorological data if they relate to calm winds conditions, as dispersion of air pollutants is more difficult to calculate in these circumstances. ADMS-Roads treats calm wind conditions by setting the minimum wind speed to 0.75m/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, to confirm the number of missing hours and calm hours that cannot be used by the dispersion model. This is important when considering predictions of high percentiles and the number of exceedences. LAQM.TG(09) recommends that meteorological data should only be used if the percentage of usable hours is greater than 75%, and preferably 90%. 2014 meteorological data from Luton Airport include 8,735 lines of usable hourly data out of the total 8,760 for the year, i.e. 99% usable data. This is therefore suitable for the dispersion modelling exercise.

Figure 4 – Wind rose for Luton Airport Meteorological Data 2014



4.1.2 Model Outputs

The background pollutant values available from Defra[9] have been used in the ADMS-Roads model to calculate predicted total annual mean concentrations of NO_x and NO_2. These background pollutant concentrations are based upon all of the sources of air pollutants in the 1km grid square and any air pollutants from adjacent grid squares which may be of relevance.

For the prediction of annual mean NO_2 concentrations for the modelled scenario, the output of the ADMS-Roads model for NO_x has been converted to NO_2 following the methodology in LAQM.TG(09)[1] and using the NO_x to NO_2 conversion tool developed on behalf of Defra. This tool also utilises the total background NO_x and NO_2 concentrations. This assessment has utilised version 4.1 (June 2014) of the NO_x to NO_2 conversion tool. The road contribution is then added to the appropriate NO_2 background concentration value to obtain an overall total NO_2 concentration.

For the prediction of short term NO_2 impacts, LAQM.TG(09)[1] advises that it is valid to assume that exceedences of the 1-hour mean AQS objective for NO_2 are only likely to occur where the annual mean NO_2 concentration is 60µg/m^3 or greater. This approach has thus been adopted for the purposes of this assessment.

Verification of the ADMS assessment has been undertaken using the local authority monitoring locations which are located adjacent to the affected road network. All NO_2 results presented in the assessment are those calculated following the process of model verification, using a factor of 2.57, as detailed in Appendix 2.

4.1.3 Uncertainty in Future Year NO_x and NO_2 Trends

Recent studies have identified analyses of historical monitoring data within the UK that show a disparity between measured concentration data and the projected decline in concentrations associated with emission forecasts for future years[13]. The report identifies that trends in ambient concentrations of NO_x and NO_2 in many urban areas of the UK have generally shown two characteristics; a decrease in concentration from about 1996 to 2002-2004, followed by a period of more stable concentrations from 2002-2004 up until 2009. This trend of more stable recent years is expected to continue in more recent years. Trends in more rural, less densely trafficked areas, tend to show downward trend in either NO_x or NO_2, which are more in line with those expected.

The reason for this disparity is currently not fully understood, but it is thought to be related to the actual on-road performance of vehicles, in particular diesel cars and vans, when compared with calculations based on the Euro emission standards. Preliminary studies suggest the following:

- NO_x emissions from petrol vehicles appear to be in line with current projections and have decreased by 96% since the introduction of 3-way catalysts in 1993;
- NO_x emissions from diesel cars, under urban driving conditions, do not appear to have declined substantially, up to and including Euro 5. There is limited evidence that the same pattern may occur for motorway driving conditions; and
- NO_x emissions from HDVs equipped with Selective Catalytic Reduction (SCR) are much higher than expected when driving at low speeds.

This disparity in the historical national data highlights the uncertainty of future year projections of both NO_x and NO_2.

Defra and the Devolved Administrations have investigated these issues and have since published an updated version of the Emissions Factor Toolkit (EFT Version 6.0.2) utilising COPERT 4 (v10) emission factors, which may go some way to addressing this disparity, but it is considered likely that a gap still remains. This assessment has utilised the latest EFT version 6.0.2 and associated tools published Defra to help minimise any associated uncertainty when forming conclusions from this assessment.

Given that the year of assessment is 2014, the uncertainty of future year NO_x/NO_2 predictions is a less significant issue than when assessing future years.

[13] Carslaw, D, Beevers, S, Westmoreland, E, Williams, M, Tate, J, Murrells, T, Steadman, J, Li, Y, Grice, S, Kent, A and Tsagatakis, I. 2011. Trends in NO_x and NO_2 emissions and ambient measurements in the UK. Prepared for DEFRA, 18th July 2011

5 Results

This assessment has considered emissions of NO_2 from road traffic at existing receptor locations. The results of the dispersion modelling are provided below, for those receptor locations detailed and illustrated in Table 7 and Figure 3 respectively.

Table 8 presents the annual mean NO_2 concentrations predicted at existing residential receptor locations for 2014.

The model suggests that the 40µg/m^3 annual mean AQS objective is observed to be exceeded at a total of four receptor locations, with a further three locations within 10% of the objective.

The maximum annual mean NO_2 concentration at an existing receptor was predicted at '14 Dunstable Road', with a predicted concentration of 54.6µg/m^3. The lowest annual mean NO_2 concentration at an existing receptor was predicted at '85 Park Street', with a predicted concentration of 29.3µg/m^3.

The empirical relationship given in LAQM.TG(09)[1] states that exceedences of the 1-hour mean objective for NO_2 are only likely to occur where annual mean concentrations are 60µg/m^3 or above. Annual mean NO_2 concentrations at all receptor locations are below this limit, and therefore short-term NO_2 exposure from road traffic emissions at the assessed receptor locations is not considered to be significant.

Table 8 – Predicted Annual Mean NO_2 Concentrations associated with Emissions from Road Traffic

ID	Receptors	Height (m)	Annual Mean NO_2 (µg/m^3)		% of AQS Objective
			AQS objective	2014	
Existing Receptors					
1	94 Dunstable Road	1.5	40	34.8	87%
2	169 Dunstable Road	1.5	40	32.2	80%
3	Dallow Primary School	1.5	40	31.1	78%
4	31-33 Cardigan Street	1.5	40	29.4	74%
5	30 Dallow Road	1.5	40	30.1	75%
6	2 Dallow Road	1.5	40	31.8	79%
7	65 Liverpool Road	1.5	40	38.5	96%
8	69 Cardigan Street	1.5	40	33.5	84%
9	74 Cardigan Street	1.5	40	35.4	88%
10	14 Dunstable Road	1.5	40	**54.6**	137%
11	3 Cardiff Road	1.5	40	39.9	99%
12	32 Stuart Street	1.5	40	**51.3**	128%
13	53 Wellington Street	1.5	40	**48.8**	122%
14	66 Wellington Street	1.5	40	**43.4**	109%
15	85 Park Street	1.5	40	29.3	73%
16	43 Castle Street	1.5	40	38.8	97%
17	31 Chapel Street	1.5	40	32.2	80%
18	80 Chapel Street	1.5	40	31.3	78%
19	61 Castle Street	1.5	40	31.4	78%

Annual mean NO_2 concentrations were also predicted at generic receptor locations within a grid with a minimum spatial resolution of 8m, covering the modelled area for the purposes of generating concentration isopleths. Figure 5 illustrates the annual mean NO_2 concentration isopleths. To mitigate against the uncertainty of modelled exceedences, both 40µg/m^3 and 36µg/m^3 concentration isopleths (i.e. within 10% of the AQS objective) are presented.

These predicted areas were used to determine the population exposure to potential exceedence of the annual mean NO_2 AQS objective, presented in Table 9. The Office for National Statistics[14] provides an average number of 2.4 people per UK household in 2014. Based on the number of properties located in the 36µg/m^3 and above area, and the average number of people per UK household, the number of people exposed to potential exceedences of the annual mean NO_2 is approximately 266.

Given the exceedences modelled and the relevant receptors exposed, an AQMA is required in the area, the extent of which is proposed in Figure 6.

Figure 5 – Annual Mean NO_2 Concentration Isopleths

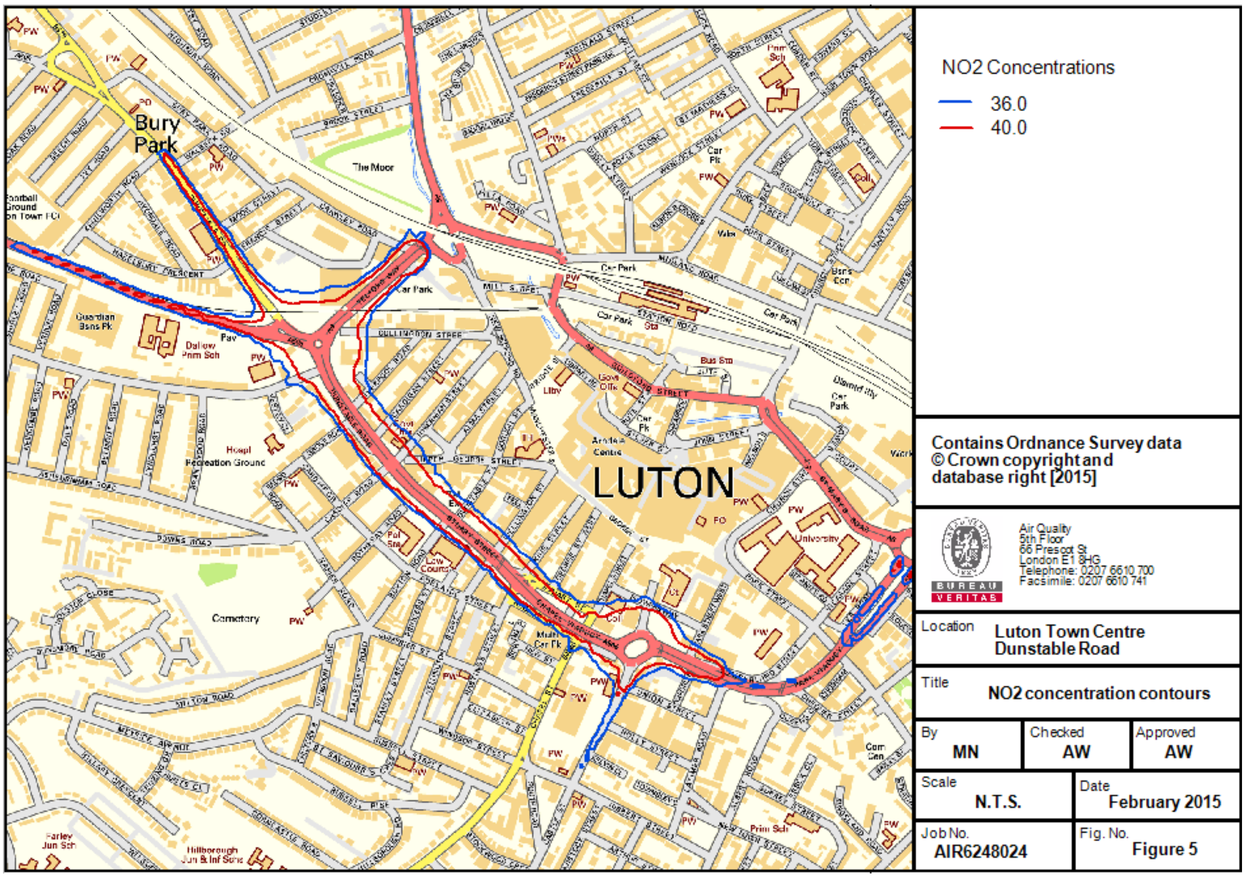
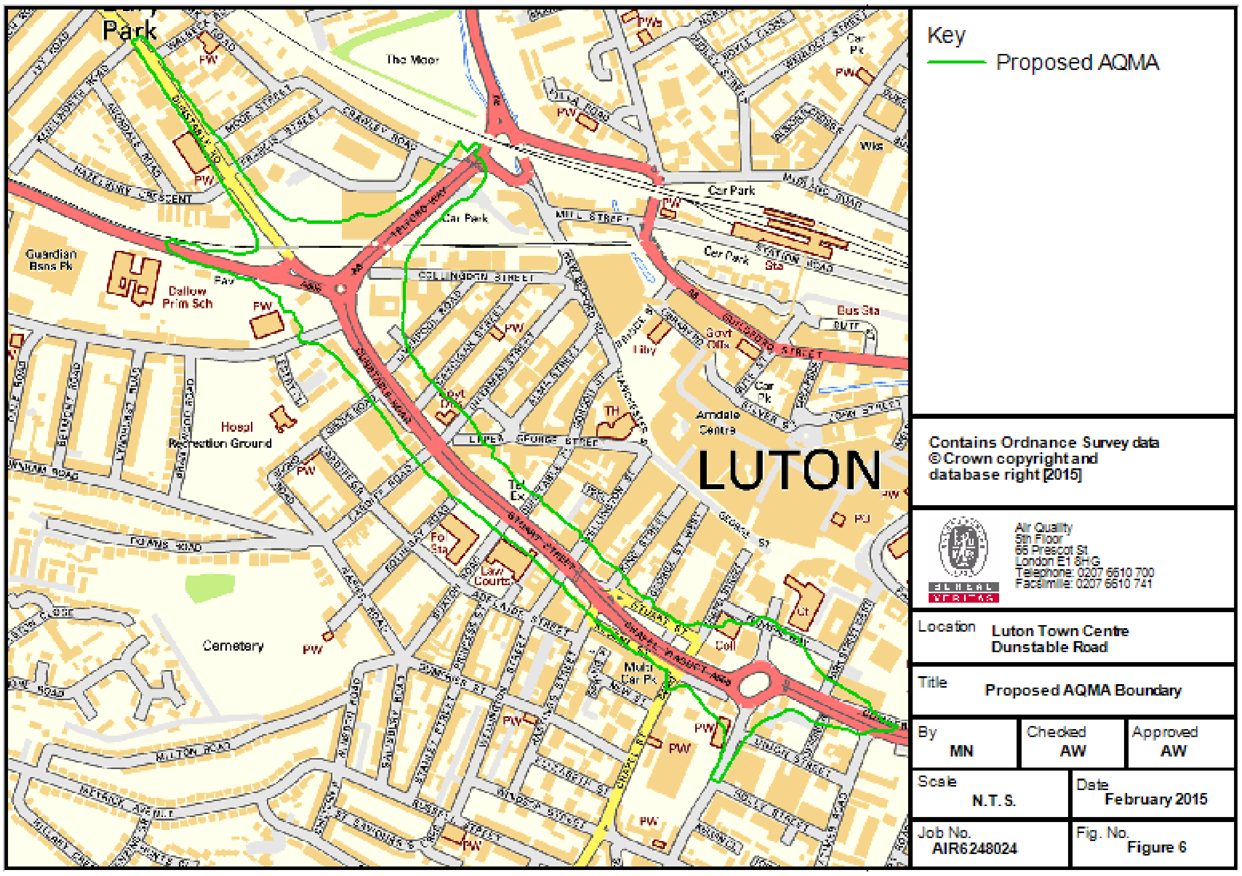


Table 9 – Estimated Population Exposure to NO_2 Exceedence

Number of Properties in Exceedence Area	Estimated Population Exposed
111	266

14 http://www.ons.gov.uk/ons/rel/family-demography/families-and-households/2014/index.html

Figure 6 – Proposed AQMA Boundary



6 Conclusions and Recommendations

Bureau Veritas UK Ltd, on behalf of Luton Borough Council, has produced a Detailed Assessment of the area surrounding Dunstable Road, Luton. The following section provides the conclusions of this assessment.

6.1 Predicted Concentrations

The ADMS-Roads dispersion model (version 3.2) has been used to determine the likely NO_2 concentrations at existing receptor locations.

Assessed locations included nineteen residential receptors around the main road link of concern (the A505), representative of worst-case exposure. Annual mean NO_2 concentrations were found to be exceeding the 40µg/m^3 annual mean AQS objective at four existing receptor locations. The highest modelled concentration was at 14 Dunstable Road, at 54.6µg/m^3. This is below the 60µg/m^3 limit, above which exceedences of the short-term NO_2 AQS objective are considered possible, and thus exceedences of the 1-hour mean AQS objective are considered unlikely.

The gridded output of the model demonstrates the geographical extent of the exceedence ranges from the Bury Park end to past the Chapel Viaduct Roundabout. The concentration isopleths terminate at the Telford Way Roundabout. Guildford Street has recently been pedestrianised and traffic has been redirected along a new road to the north of the town centre, Gateway Link. As this will greatly reduce emissions from road traffic in the Guildford Street area, it was not considered necessary by the Council to include this within the Detailed Assessment area.

In conclusion, this assessment has demonstrated that local air quality is in breach of the 40µg/m^3 annual mean AQS objective for NO_2, so the declaration of an AQMA is required. The suggested extent of this is demonstrated in Figure 6.

6.2 Future Recommendations

Following the above conclusions, the below recommendations are made:

- That an Air Quality Management Area (AQMA) be declared in the area, the extent of which is proposed in Figure 6.
- Further monitoring in the area is recommended. However, Bureau Veritas is aware that Luton Borough Council has recently (October 2014) set up continuous analysers, monitoring PM_{10} and NO_2, at 508708, 221352. This was not included in the assessment as it had only 8% data capture in 2014. This station should, however, prove useful in the future assessment of air quality in the proposed AQMA.
- As alluded to in Section 6.1, traffic to the northern side of the town centre has recently been redirected along a new route, Gateway Link, connecting Hucklesby Way and Crescent Road. This has not been included in the current assessment as there was not perceived to be an air quality issue there. However, a number of new NO_2 diffusion tube monitoring locations were set up in this area in January 2015; if additional exceedences of the NO_2 annual mean AQS objective are recorded along these roads, it is recommended that a further Detailed Assessment be undertaken.
- An Air Quality Action Plan is drawn up to determine the best policies and intervention measures to put in place in order to reduce local NO_2 concentrations.
- Further Assessment of the area is conducted post implementation of the AQMA as part of the next round of LAQM reporting.

Appendices

Appendix 1 – Background to Air Quality

Emissions from road traffic contribute significantly to ambient pollutant concentrations in urban areas. The main constituents of vehicle exhaust emissions, produced by fuel combustion are carbon dioxide (CO_2) and water vapour (H_2O). However, combustion engines are not 100% efficient and partial combustion of fuel results in emissions of a number of other pollutants, including carbon monoxide (CO), particulate matter (PM), Volatile Organic Compounds (VOCs) and hydrocarbons (HC). For HC, the pollutants of most concern are 1,3 - butadiene (C_4H_6) and benzene (C_6H_6). In addition, some of the nitrogen (N) in the air is oxidised under the high temperature and pressure during combustion; resulting in emissions of oxides of nitrogen (NO_x). NO_x emissions from vehicles predominately consist of nitrogen oxide (NO), but also contain nitrogen dioxide (NO_2). Once emitted, NO can be oxidised in the atmosphere to produce further NO_2.

The quantities of each pollutant emitted depend upon a number of parameters; including the type and quantity of fuel used, the engine size, the vehicle speed, and the type of emissions abatement equipment fitted. Once emitted, these pollutants disperse in the air. Where there is no additional source of emission, pollutant concentrations generally decrease with distance from roads, until concentrations reach those of the background.

This air quality assessment focuses on NO_2 and PM_{10} (PM of aerodynamic diameter less than 10µm) as these pollutants are least likely to meet their respective Air Quality Strategy (AQS) objectives near roads. This has been confirmed over recent years by the outcome of the Local Air Quality Management (LAQM) regime. The most recent statistics[15] regarding Air Quality Management Areas (AQMAs) show that, 601 AQMAs were declared in the UK, of which 562 include NO_2 and 99 include PM_{10} (a number of AQMAs have been declared for both pollutants). The majority (92%) of existing AQMAs have been declared in relation to road traffic emissions.

In line with these results, the reports produced by the Council under the LAQM regime have confirmed that road traffic within their administrative area is the main issue in relation to air quality.

An overview of these two pollutants, describing briefly the sources and processes influencing the ambient concentrations, is presented below.

Particulate Matter (PM_{10})

Particulate matter is a mixture of solid and liquid particles suspended in the air. There are a number of ways in which airborne PM may be categorised. The most widely used categorisation is based on the size of particles such as $PM_{2.5}$, particles of aerodynamic diameter less than 2.5µm (micrometre = 10^{-6} metre), and PM_{10}, particles of aerodynamic diameter less than 10µm. Generically, particulate residing in low altitude air is referred to as Total Suspended Particulate (TSP) and comprises coarse and fine material including dust.

Particulate matter comprises a wide range of materials arising from a variety of sources. Examples of anthropogenic sources are carbon (C) particles from incomplete combustion, bonfire ash, recondensed metallic vapours and secondary particles (or aerosols) formed by chemical reactions in the atmosphere. As well as being emitted directly from combustion sources, man-made particles can arise from mining, quarrying, demolition and construction operations, from brake and tyre wear in motor vehicles and from road dust resuspension from moving traffic or strong winds. Natural sources of PM include wind-blown sand and dust, forest fires, sea salt and biological particles such as pollen and fungal spores.

[15] Statistics from the UK AQMA website available at http://aqma.defra.gov.uk – Figures as of January 2013

The health impacts from PM depend upon size and chemical composition of the particles. For the purposes of the AQS objectives, PM_{10} or $PM_{2.5}$ is solely defined on size rather than chemical composition. This enables a uniform method of measurement and comparison. The short and long-term exposure to PM has been associated with increased risk of lung and heart diseases.PM may also carry surface-absorbed carcinogenic compounds. Smaller PM have a greater likelihood of penetrating the respiratory tract and reaching the lung to blood interface and causing the above adverse health effects.

In the UK, emissions of PM_{10} have declined significantly since 1980, and were estimated to be 114kt (kilotonne) in 2010[16]. Residential / public electricity and heat production and road transport are the largest sources of PM_{10} emissions. The road transport sector contributed 22% (25kt) of PM_{10} emissions in 2010. The main source within road transport is brake and tyre wear.

It is important to note that these estimates only refer to primary emissions, that is, the emissions directly resulting from sources and processes and do not include secondary particles. These secondary particles, which result from the interaction of various gaseous components in the air such as ammonia (NH_3), sulphur dioxide (SO_2) and NO_x, can come from further a field and impact on the air quality in the UK and vice versa.

Similarly to PM_{10}, emissions of $PM_{2.5}$ have declined since 1970, and were estimated to be 67kt in 2010, which makes over 58% of PM_{10} emissions. In 2010, the road transport sector emitted 28% (18kt) of the total $PM_{2.5}$ emissions in the UK.

Nitrogen Oxides (NO_x)

NO and NO_2, collectively known as NO_x, are produced during the high temperature combustion processes involving the oxidation of N. Initially, NO_x are mainly emitted as NO, which then undergoes further oxidation in the atmosphere, particularly with ozone (O_3), to produce secondary NO_2. Production of secondary NO_2 could also be favoured due to a class of compounds, VOCs, typically present in urban environments, and under certain meteorological conditions, such as hot sunny days and stagnant anti-cyclonic winter conditions.

Of NO_x, it is NO_2 that is associated with health impacts. Exposure to NO_2 can bring about reversible effects on lung function and airway responsiveness. It may also increase reactivity to natural allergens, and exposure to NO_2 puts children at increased risk of respiratory infection and may lead to poorer lung function in later life.

In the UK, emissions of NO_x have decreased by 62% between 1990 and 2010. For 2010, NO_x (as NO_2) emissions were estimated to be 1,106kt. The transport sector remained the largest source of NO_x emissions with road transport contribution 34% to NO_x emissions in 2010.

[16] National Atmospheric Emissions Inventory (NAEI) Summary Emission Estimate Datasets 2010. March 2012

Appendix 2 – ADMS Model Verification

The ADMS-Roads dispersion model has been widely validated for this type of assessment and is specifically listed in the Defra's LAQM.TG(09)[1] guidance as an accepted dispersion model.

Model validation undertaken by the software developer (CERC) will not have included validation in the vicinity of the proposed development site. It is therefore necessary to perform a comparison of modelled results with local monitoring data at relevant locations. This process of verification attempts to minimise modelling uncertainty and systematic error by correcting modelled results by an adjustment factor to gain greater confidence in the final results.

The predicted results from a dispersion model may differ from measured concentrations for a large number of reasons, including uncertainties associated with:

- Background concentration estimates;
- Source activity data such as traffic flows and emissions factors;
- Monitoring data, including locations; and
- Overall model limitations.

Model verification is the process by which these and other uncertainties are investigated and where possible minimised. In reality, the differences between modelled and monitored results are likely to be a combination of all of these aspects.

Model setup parameters and input data were checked prior to running the models in order to reduce these uncertainties. The following were checked to the extent possible to ensure accuracy:

- Traffic data;
- Distance between sources and monitoring as represented in the model;
- Speed estimates on roads;
- Background monitoring and background estimates; and
- Monitoring data.

Traffic data was obtained from the Highways Agency Traffic Counts Website[12] and the Council as detailed in Section 4.1.1. Separation distances between road sources and receptors were checked using electronic OS mapping data.

Luton Borough Council undertakes passive monitoring as part of its LAQM commitments at 45 locations, eight of which are located in proximity to the modelled road network. Of these eight locations, four have been used for the purpose of model verification. Sites LN07, LN11, LN34 and LN37 were not considered to be appropriate for model verification due to lack of traffic data on the adjacent roads and thus the model did not predict well at this location. Details of the four LAQM monitoring sites used for the purposes of model verification are presented in Table A1 below.

Table A1 – Local Monitoring Data Suitable for Model Verification

Site ID	Location	OS Grid Reference[a]	2014 Annual Mean NO_2 (µg/m^3)[b]
LN06	Liverpool Road	508662, 221407	**58.4**
LN35	Dunstable Way/Hatters Way Roundabout	508578, 221512	**66.8**
LN36	Chapel Viaduct Roundabout	509157, 220946	**57.5**
LN52	Dunstable Road/Cardigan Street residential	508689, 221379	**58.9**

[a] Taken from Luton Borough Council's 2014 Air Quality Progress Report.
[b] Bias Adjustment Factors taken from Local Bias Adjustment spreadsheet (1.04 for 2014).

Verification calculations

The verification of the modelling output was performed in accordance with the methodology provided in Annex 3 of LAQM.TG(09)[1].
For the verification and adjustment of NO_x/NO_2, the LAQM diffusion tube monitoring data was used as detailed above. Data capture for 2014 at the four sites was 100%. Table A2 below shows an initial comparison of the monitored and unverified modelled NO_2 results for the year 2014, in order to determine if verification and adjustment was required.

Table A2 – Comparison of Unverified Modelled and Monitored NO_2 Concentrations

Site ID	Site Type	Background NO_2	Monitored total NO_2 (µg/m^3)	Modelled total NO_2 (µg/m^3)	% Difference (modelled vs. monitored)
LN06	Kerbside	24.8	**58.4**	39.1	-33.0%
LN35	Roadside	24.8	**66.8**	**46.4**	-30.5%
LN36	Roadside	24.8	**57.5**	38.4	-33.3%
LN52	Roadside	24.8	**58.9**	36.5	-38.1%

The model was clearly under-predicting at each location and no further improvement of the modelled results could be obtained on this occasion. At all sites, the difference between modelled and monitored concentrations was greater than 25% and therefore adjustment of modelled results was necessary. The relevant data was then gathered to allow the adjustment factor to be calculated.

Model adjustment needs to be undertaken based on NO_x and not NO_2. For the diffusion tube monitoring results used in the calculation of the model adjustment, NO_x was derived from NO_2; these calculations were undertaken using a spreadsheet tool available from the LAQM website[17].

Table A3 provides the relevant data required to calculate the model adjustment based on regression of the modelled and monitored road source contribution to NO_x.

[17] http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxNO2calc

Table A3 – Data Required for Adjustment Factor Calculation

Site ID	Monitored total NO_2 (µg/m^3)	Monitored total NO_x (µg/m^3)	Background NO_2 (µg/m^3)	Background NO_x (µg/m^3)	Monitored road contribution NO_2 (total - background) (µg/m^3)	Monitored road contribution NO_x (total - background) (µg/m^3)	Modelled road contribution NO_x (excludes background) (µg/m^3)
LN06	**58.4**	125.3	24.8	39.9	33.5	85.4	31.7
LN35	**66.8**	153.1	24.8	39.9	42.0	113.2	50.4
LN36	**57.5**	122.5	24.8	39.9	32.7	82.6	29.9
LN52	**58.9**	126.9	24.8	39.9	34.1	87.0	25.4

Figure A1 provides a comparison of the Modelled Road Contribution NO_x versus Monitored Road Contribution NO_x, and the equation of the trend line based on linear regression through zero. The Total Monitored NO_x concentration has been derived by back-calculating NO_x from the NO_x/NO_2 empirical relationship using the spreadsheet tool available from Defra's website[9]. The equation of the trend lines presented in Figure A1 gives an adjustment factor for the modelled results of 2.57.

Figure A1 – Comparison of the Modelled Road Contribution NO_x versus Monitored Road Contribution NO_x

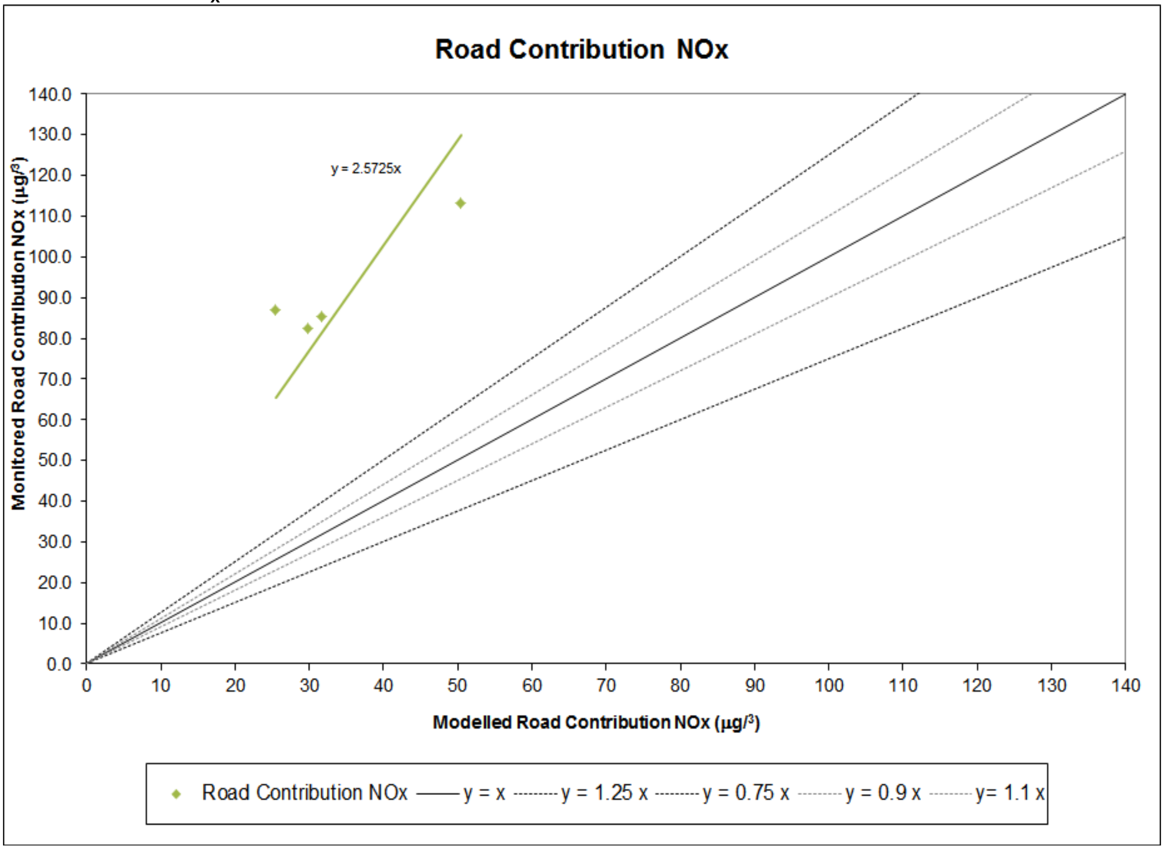
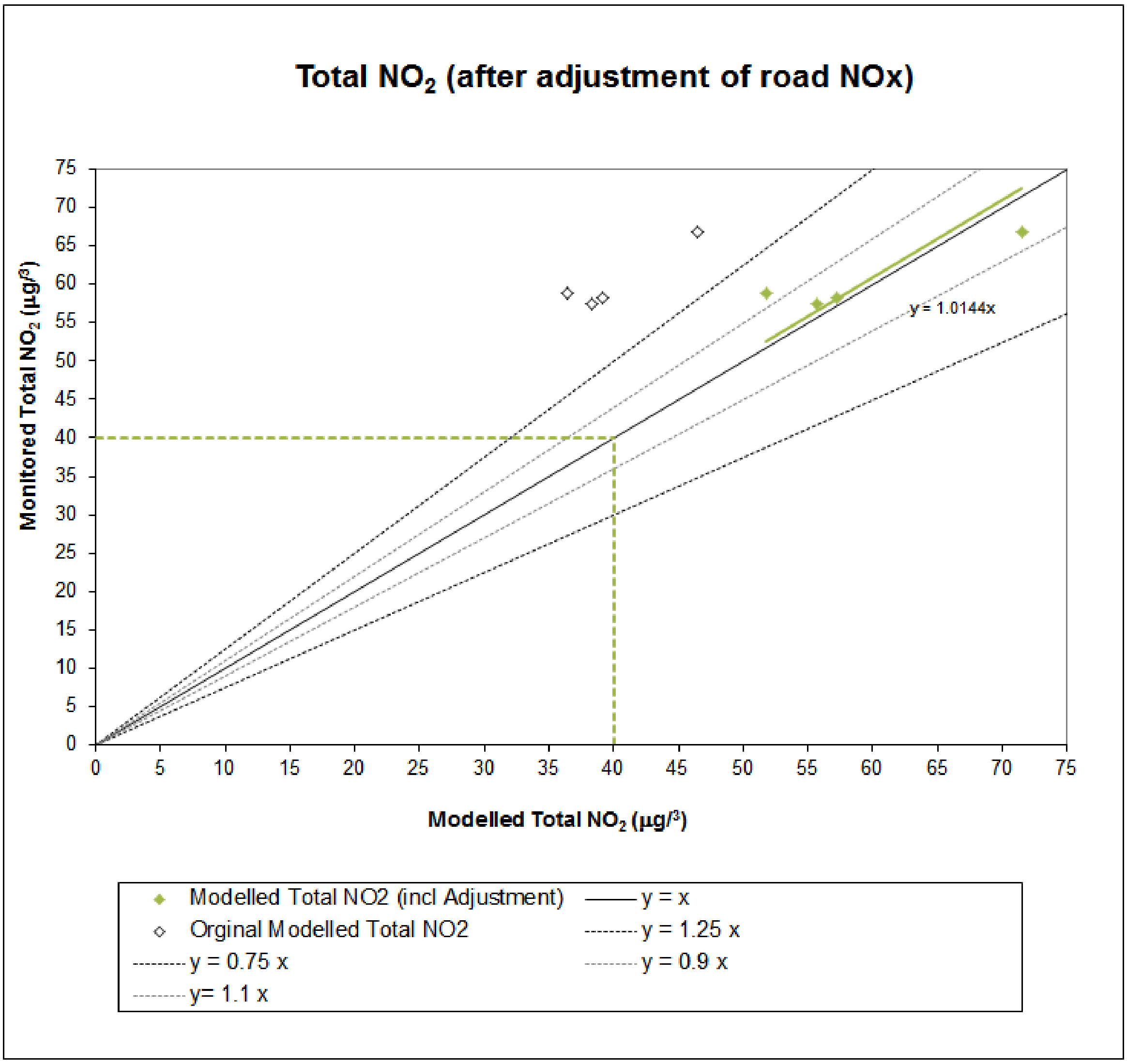


Table A4 and Figure A2 show the ratios between monitored and modelled NO_2 for each monitoring location. The four sites show acceptable agreement between the ratios of monitored and modelled NO_2 all being ±25%. A verification factor of 2.57 was therefore used to adjust the model results. A factor of 2.57 reduces the Root Mean Square Error (RMSE) from a value of 20.4 to 4.4.

Table A4 – Adjustment Factor and Comparison of Verified Results Against Monitoring Results

Site ID	Ratio of monitored road contribution NO_x / modelled road contribution NO_x	Adjustment factor for modelled road contribution NO_x	Adjusted modelled road contribution NO_x (µg/m^3)	Adjusted modelled total NO_x (including background NO_x) (µg/m^3)	Modelled total NO_2 (based upon empirical NO_x / NO_2 relationship) (µg/m^3)	Monitored total NO_2 (µg/m^3)	% Difference (adjusted modelled NO_2 vs. monitored NO_2)
LN06	2.7	2.572	81.6	121.5	**57.2**	**58.4**	-2.0%
LN35	2.2		129.8	169.7	**71.5**	**66.8**	7.0%
LN36	2.8		76.9	116.8	**55.7**	**57.5**	-3.3%
LN52	3.4		65.4	105.3	**51.8**	**58.9**	-12.1%

Figure A2 – Comparison of the Modelled NO_2 versus Monitored NO_2



The adjustment factor of 2.572 was applied to the road-NO_x concentrations predicted by the model to arrive at the final NO_2 concentrations.

All NO_2 results presented and discussed herein are those calculated following the process of model verification using an adjustment factor of 2.572.

Appendix 3 – Diffusion Tube Bias

Below are the supporting calculations for the 2014 diffusion tube bias adjustment factor used in the assessment of 1.04. Whilst this was based on only 9 months data, this meets the 75% minimum data capture criteria. Additionally, at the time of writing (February 2015) the national adjustment factor for 2014 was not available. Therefore, this factor is the most appropriate available.

Figure A3 – Diffusion Tube Bias Adjustment Factors Calculation

Checking Precision and Accuracy of Triplicate Tubes

AEA Energy & Environment
From the AEA group

	Diffusion Tubes Measurements									Automatic Method		Data Quality Check	
Period	Start Date dd/mm/yyyy	End Date dd/mm/yyyy	Tube 1 μgm^{-3}	Tube 2 μgm^{-3}	Tube 3 μgm^{-3}	Triplicate Mean	Standard Deviation	Coefficient of Variation	95% CI of mean	Period Mean	Data Capture (% DC)	Tubes Precision Check	Automatic Monitor Data
1	09/01/2014	04/02/2014	45.41	42.91	44.28	44	1.3	3	3.1	43.6	99.4	Good	Good
2	04/02/2014	06/03/2014	38.09	38.63	36.29	38	1.2	3	3.0	36.2	99.7	Good	Good
3	06/03/2014	02/04/2014	47.29	42.63	42.03	44	2.9	7	7.2	45.8	99.5	Good	Good
4	02/04/2014	30/04/2014	36.75	34.75	37.02	36	1.2	3	3.1	40.9	99.6	Good	Good
5	30/04/2014	29/05/2014	39.3	35.95	36.3	37	1.8	5	4.6	40.6	99.6	Good	Good
6	29/05/2014	03/07/2014	22.56	29.32		26	4.8	18	42.9	33	99.9	Good	Good
7	03/07/2014	30/0702014	29.04	29.16		29	0.1	0	0.8	27.8	99.5	Good	Good
8	30/07/2014	27/08/2014	34.51	34.46	33.06	34	0.8	2	2.0	31.8	99.3	Good	Good
9	27/08/2014	02/10/2014	33.97	30.98	33.05	33	1.5	5	3.8	34.5	99.2	Good	Good
10													
11													
12													
13													

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

Overall survey --> Good precision | Good Overall DC

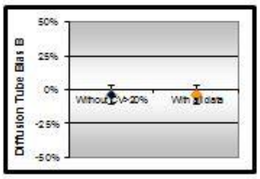
(Check average CV & DC from Accuracy calculations)

Site Name/ ID: Challney School CRAQM

Precision 9 out of 9 periods have a CV smaller than 20%

Accuracy (with 95% confidence interval)
without periods with CV larger than 20%
Bias calculated using 9 periods of data
Bias factor A 1.04 (0.97 - 1.12)
Bias B -4% (-11% - 3%)
Diffusion Tubes Mean: 36 μgm^{-3}
Mean CV (Precision): 5
Automatic Mean: 37 μgm^{-3}
Data Capture for periods used: 100%
Adjusted Tubes Mean: 37 (35 - 40) μgm^{-3}

Accuracy (with 95% confidence interval)
WITH ALL DATA
Bias calculated using 9 periods of data
Bias factor A 1.04 (0.97 - 1.12)
Bias B -4% (-11% - 3%)
Diffusion Tubes Mean: 36 μgm^{-3}
Mean CV (Precision): 5
Automatic Mean: 37 μgm^{-3}
Data Capture for periods used: 100%
Adjusted Tubes Mean: 37 (35 - 40) μgm^{-3}



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