Cheltenham Borough Council

Cheltenham

Detailed Modelling Study

October 2019

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Contact Details		
Company Name	Bureau Veritas UK Limited	Cheltenham Borough Council
Contact Name	Antony Wiatr	Alex Mason
Position	Technical Director	Environmental Health Officer
Address	2nd Floor, Atlantic House Atlas Business Park Simonsway Manchester M22 5PR	Municipal Offices Promenade Cheltenham GL50 9SA
Telephone	0161 446 4747	07920 560600
e-mail	antony.wiatr@uk.bureauveritas.com	Alex.Mason@cheltenham.gov.uk
Websites	www.bureauveritas.co.uk	https://www.cheltenham.gov.uk/

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	Name	Job Title	Signature
Prepared By	T Campbell	Senior Consultant	
Approved By	A Wiatr	Technical Director	

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Executive Summary

Bureau Veritas have been commissioned by Cheltenham Borough Council (the Council) to complete a Detailed Modelling Study of the Council's existing borough-wide Air Quality Management Area (AQMA) and adjacent arterial road network. The aim of the Detailed Modelling Study is to increase the Councils' understanding of pollutant concentrations within Cheltenham to determine if there is a requirement to amend the AQMA boundary, and if required, provide technical input into an updated Air Quality Action Plan (AQAP).

The Council currently has one borough-wide AQMA (Cheltenham Whole Borough AQMA), declared in November 2011 for the exceedance of the Nitrogen Dioxide (NO_2) annual mean UK Air Quality Strategy (AQS) of 40µg/m^3. This AQMA was declared in response to an assessment undertaken in 2011 which evaluated the monitored NO_2 annual mean exceedances across Cheltenham. As a result of the findings an AQAP was published in 2014. However, within the past few years through the Review and Assessment annual reporting submittal process, NO_2 annual mean concentrations across the Borough appear to have stabilised below the AQS objective limit, with exceedances localised to the north of the Town Centre, specifically along the A4019 (Tewkesbury Road and High Street) during 2018. Therefore, this has resulted in a requirement to re-parameterise NO_2 concentrations within Cheltenham via dispersion modelling to understand the full extent of exceedances, aiding potential amendments to the current AQMA boundary, to appropriately manage areas of exceedance.

This Detailed Modelling Assessment focusses on the road network across Cheltenham to establish any changes in the spatial extent of NO_2 concentrations in order to identify any areas that are above, or within 10%, of the AQS annual mean objective. The area was modelled using the advanced atmospheric dispersion model ADMS-Roads (Version 4.1.1) and latest emissions from the Emissions Factor Toolkit (Version 9.0), with annual mean NO_2 concentration outputs produced at 245 discrete receptor locations, and across a number of receptor grids.

Results show that the NO_2 annual mean AQS objective is observed to be exceeded at a total of 9 (3.7%) receptor locations, with 15 (6.1%) further locations within 10% of the objective.

As expected, all discrete receptor locations which report annual mean NO_2 concentrations to be above or within 10% of the AQS objective, are located within the existing borough-wide AQMA, limited to roadside locations of junctions where key arterial roads meet. Notable roads include: A40 Gloucester Road, A4013 Princess Elizabeth Way. This highlights the need to condense the existing AQMA boundary.

The highest annual mean concentrations of NO_2 was recorded at Receptor 60 with a concentration of 52.6µg/m^3. Receptor 60 is located along a façade of a residential property which immediately fronts onto a stretch of the A4019 – High Street susceptible to congestion due to the convergence of high capacity and town centre roads (M5, A4019 – Tewkesbury Road, A4019 – High Street, A4019 – Swindon Road and High Street). The junction's role as a major strategic connection within the region is believed to be the cause of the elevated NO_2 annual mean concentrations predicted at Receptor 60.

The empirical relationship given in LAQM.TG(16)[1] states that exceedances of the 1-hour mean objective for NO_2 is only likely to occur where annual mean concentrations are 60µg/m^3 or above. Given the NO_2 annual mean concentration recorded at Receptor 60 is below the hourly exceedance indicator (60µg/m^3) – this suggests that hourly exceedance of the NO_2 AQS objective is unlikely.

The following areas were identified to report a modelled exceedance or near exceedance of the annual mean NO_2 AQS objective. These are:

- Location A - Continuous stretch of road, spanning A4019 Tewkesbury Road, A4019 Poole Way and A4019 Swindon Road – north of the Town Centre;

- Location B - A40 Gloucester Road / A4013 Princess Elizabeth Way roundabout, adjacent to GCHQ;
- Location C - A46 London Road / Berkeley Street intersection; and
- Along stretches of arterial roads connecting to the Town Centre (Prestbury Road, London Road and A46 Shurdington Road).

In-line with the consistent monitored exceedance of the annual mean NO_2 AQS objective limit reported at Sites 4 and 5 within Location A, preference was to pursue declaration of an AQMA for this area - spanning A4019 Tewkesbury Road to A4019 Swindon Road (via A4019 Poole Way) – north of the Town Centre. To facilitate this process, further gridded analysis was completed to provide a higher resolution of the predicted annual mean concentrations of NO_2 within Location A.

Based on the conclusions of the assessment above, the following recommendations are made:

- Amend the current Borough-wide AQMA based on the proposed AQMA illustrated in Figure 6.1, spanning A4019 Tewkesbury Road to A4019 Swindon Road (via A4019 Poole Way). The proposed AQMA boundary covers the entirety of residential premises where sections, such as façades, are found to be above or within 10% of the NO_2 annual mean AQS objective limit;
- Deploy and/or relocate existing monitoring within the Borough to locations predicted to be in exceedance, or near exceedance, of the NO_2 annual mean AQS objective limit in order to validate modelled findings. These locations include:
    - Location B - A40 Gloucester Road / A4013 Princess Elizabeth Way roundabout, adjacent to GCHQ;
    - Location C - A46 London Road / Berkeley Street intersection; and
    - Along stretches of arterial roads connecting to the Town Centre (Prestbury Road, London Road and A46 Shurdington Road).
    - Continue to monitor NO_2 across the Borough, focussing on areas newly defined as being within or just outside of the revised AQMA boundary, such as adjacent to the B4633 Gloucester Road / A4019 Tewkesbury Road intersection; and
- Based on source apportionment results, any future intervention measures should be targeted at reducing vehicle emissions from all vehicle types, notably Cars and LGVs, which are both observed to be the two largest contributors to total vehicle emissions in areas of exceedance.

1 Introduction

Bureau Veritas have been commissioned by Cheltenham Borough Council (the Council) to complete a Detailed Modelling Study of the Council's existing borough-wide Air Quality Management Area (AQMA) and adjacent arterial road network. The aim of the Detailed Modelling Study is to increase the Councils' understanding of pollutant concentrations within Cheltenham to determine if there is a requirement to amend the AQMA boundary, and if required, provide technical input into an updated Air Quality Action Plan (AQAP) as a consequence of the findings.

The Council currently has one borough-wide AQMA (Cheltenham Whole Borough AQMA), declared in November 2011 for the exceedance of the Nitrogen Dioxide (NO_2) annual mean UK Air Quality Strategy (AQS) of 40µg/m^3. This AQMA was declared in response to an assessment undertaken in 2011 which evaluated the monitored NO_2 annual mean exceedances across Cheltenham. As a result of the findings, an AQAP was published in 2014. However, within the past few years through the Review and Assessment annual reporting submittal process, NO_2 annual mean concentrations across the Borough appear to have stabilised below the AQS objective limit, with exceedances localised to the north of the Town Centre, specifically along the A4019 (Tewkesbury Road and High Street) during 2018. Therefore, this has resulted in a requirement to re-assess NO_2 concentrations within Cheltenham through the undertaking of a complementary dispersion modelling study to understand the full extent of exceedances, aiding potential amendments to the current AQMA boundary and facilitating the appropriate management of areas of exceedance.

This report details the findings of this analysis and provides for recommendation on matters related to NO_2 exceedances to aid potential boundary amendments to the Cheltenham Whole Borough AQMA, and if required inform additional consideration to the update of the AQAP and associated measures aimed at reducing emissions and improving air quality in future years.

1.1 Scope of Assessment

It is the general purpose and intent of this assessment to determine, with reasonable certainty, the magnitude and geographical extent of any exceedances of the AQS objectives for NO_2, enabling the Council to provide for a focused consideration on updating measures as part of the revision of the AQAP.

The following are the objectives of the assessment:

- To assess the air quality at selected locations ("receptors") representative of worst-case exposure relative to the averaging period of focus (i.e. annual objective - façades of the existing residential units), based on modelling of emissions from road traffic on the local road network;
- To establish the spatial extent of any likely exceedances of the UK annual mean NO_2 AQS objective limit, and to identify the spatial extent of any areas within 10%;
- To establish the required reduction in emissions to comply with the UK AQS objectives;
- To determine the relative contributions of various source types to the overall pollutant concentrations through source apportionment; and
- To put forward recommendations in relation to the re-assessment of the current AQMA boundary.

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 4.1.1, focusing on emissions of oxides of nitrogen (NO_x), which comprise of nitric oxide (NO) and nitrogen dioxide (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 provided by Defra for air quality assessment (LAQM.TG(16))[1], have been used.

[1] LAQM Technical Guidance LAQM.TG(16) – February 2018. 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[3] has been adopted and replaces all previous air quality Directives, except the 4th Daughter Directive[4]. 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[5] 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. Table 2.1 taken from LAQM TG(16)[1] provides an indication of those locations that may or may not be relevant for each averaging period.

This assessment focuses on NO_2 due to the significance this pollutant holds within the Council's administrative area - evidenced by declared borough-wide AQMA. 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, which has since passed and its continued failure to achieve these limits is currently giving rise to infraction procedures being implemented. The UK is not alone as the challenge of NO_2 compliance at EU level includes many other Member States.

In July 2017, the Government published its plan for tackling roadside NO_2 concentrations[6], to achieve compliance with EU Limit Values. This sets out Government policies for bringing NO_2

[2] Defra (2007), The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.

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

[4] 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.

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

[6] Defra, DfT (2017), UK plan for tackling roadside nitrogen dioxide concentrations

concentrations within statutory limits in the shortest time period possible. Furthermore, the Clean Air Strategy was published in 2019, which outlines how the UK will meet international commitments to significantly reduce emissions of five damaging air pollutants by 2020 and 2030 under the adopted revised National Emissions Ceiling Directive (NECD).

The AQS objectives for these pollutants are presented in Table 2.2.

Table 2.1 – Examples of where the Air Quality Objectives should apply

Averaging Period	Objectives should apply at:	Objectives should generally not apply at:
Annual mean	All locations where members of the public might be regularly exposed. Building facades of residential properties, schools, hospitals, care homes etc.	Building facades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term
24-hour mean and 8-hour mean	All locations where the annual mean objectives would apply, together with hotels. Gardens or residential properties[1].	Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term.
1-hour mean	All locations where the annual mean and 24 and 8-hour mean objectives would apply. Kerbside sites (e.g. pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where the public might reasonably be expected to spend one hour or more. Any outdoor locations at which the public may be expected to spend one hour or longer.	Kerbside sites where the public would not be expected to have regular access.
15-minute mean	All locations where members of the public might reasonably be expected to spend a period of 15 minutes or longer.	

Note [1] For gardens and playgrounds, such locations should represent parts of the garden where relevant public exposure is likely, for example where there is seating or play areas. It is unlikely that relevant public exposure would occur at the extremities of the garden boundary, or in front gardens, although local judgement should always be applied.

Table 2.2 – 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	31st December 2005
	40 µg/m³	Annual mean	31st December 2005

2.2 Local Air Quality Management (LAQM)

Part IV of the Environment Act 1995[7] places a statutory duty on local authorities to periodically review and assess 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 as Local Air Quality Management (LAQM). The AQS objectives that apply to LAQM are defined for seven pollutants: benzene, 1,3-butadiene, CO, Pb, NO_2, SO_2 and PM_{10}.

Local Authorities were formerly required to report on all of these pollutants, but following an update to the regime in 2016, the core of LAQM reporting is now focussed around the objectives of three pollutants; NO_2, PM_{10} and SO_2. Where the results of the Review and Assessment process highlight that problems in the attainment of the health-based objectives pertaining to the above pollutants will arise, the authority is required to declare an AQMA – a geographic area defined by high concentrations of pollution and exceedances of health-based standards.

The areas in which the AQS objectives apply are defined in the AQS as locations outside (i.e. at the façade) of buildings or other natural or man-made structures above or below ground where members of the public are regularly present and might reasonably be expected to be exposed [to pollutant concentrations] over the relevant averaging period of the AQS objective.

Following any given declaration, the Local Authority is subsequently required to develop an Air Quality Action Plan (AQAP), which will contain measures to address the identified air quality issue, and bring the location into compliance with the relevant objective as soon as possible.

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[8] recognises land-use planning as having a significant role in term 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.

[7] http://www.legislation.gov.uk/ukpga/1995/25/part/IV

[8] Local Air Quality Management Policy Guidance LAQM.PG(16). April 2016. 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

The most recent LAQM report completed by the Council was the 2019 Annual Status Report (ASR)[9]. The 2019 ASR reported pollutant monitoring completed, and progress made towards lowering pollutant concentrations within Cheltenham, throughout the preceding year of 2018.

The Council currently has one borough-wide AQMA (Cheltenham Whole Borough AQMA), declared in November 2011 for the exceedance of the NO_2 annual mean UK AQS of 40µg/m^3. This AQMA was declared in response to an assessment undertaken in 2011 which evaluated monitored data and found several locations across Cheltenham to exceed the AQS objective limit. The borough-wide AQMA has been declared largely due to traffic emissions from private vehicles along several key high capacity arterial routes which span the entirety of Cheltenham, carrying with them the main volume of traffic within the Borough. Notably, these are: A40 Lansdown Road, A40 Gloucester Road, A4013 Princess Elizabeth Way, A4019 Swindon Road, A46 Fairview Road and A435 London Road.

The 2019 ASR recognises the need to review the current borough-wide AQMA boundary as a main priority, as a result of monitored annual mean NO_2 concentrations over the past several years, demonstrating localisation of exceedances to the north of the Town Centre. This assessment is a part of this process, and the modelling results presented herein will aid potential boundary amendments to the Cheltenham Whole Borough AQMA.

3.2 Review of Air Quality Monitoring

3.2.1 Local Automatic Air Quality Monitoring

During 2018, the Council undertook automatic (continuous) monitoring at one site within Cheltenham (CM1). CM1 is located north of the Town Centre along the A4019 – Swindon Road, adjacent to the St George's Street intersection. CM1 solely monitors NO_2 via a chemiluminescent analyser.

Details of CM1 are provided in Table 3.1 and 2018 monitoring results are presented in Table 3.2, whilst the location of the monitoring site is illustrated in Figure 3.2 – Local Monitoring Locations.

Table 3.1 – Automatic Monitor CM1

Site ID	Site Location	Site Type	OS Grid Ref (E, N)	In AQMA	Pollutants Monitored	Inlet Height (m)
CM1	St Georges Street	Kerbside	394760, 222878	Yes	NO_2	1.3

Table 3.2 – Automatic Monitor CM1: NO_2 Annual Mean Concentrations

Site ID	Valid Data Capture for 2018 (%)	NO_2 Annual Mean Concentration (µg/m^3)				
		2014	2015	2016	2017	2018
CM1	89.4%	35.0	35.0	34.0	36.0	32.7

[9] Cheltenham Borough Council (2019), 2019 Annual Status Report

Table 3.3 – Automatic Monitor CM1: Number of NO_2 Hourly Means Exceedances

Site ID	Valid Data Capture for 2018 (%)	Hourly Means in Excess of the 1-hour Objective (200 µg/m³)				
		2014	2015	2016	2017	2018
CM1	89.4	0	0	0	0	0

Between 2014 and 2018, there were no recorded exceedances of either the annual mean or short term AQS objectives for NO_2 at CM1. Annual mean NO_2 concentrations have remained stable with a maximum movement of ± 2.3µg/m³ observed since 2014 – bordering on being within 10% of the AQS objective limit in 2017. Hourly mean NO_2 concentrations recorded at CM1 have not reported an exceedance of 200µg/m³ within the past five years.

3.2.2 Local Non-Automatic Air Quality Monitoring

During 2018, the Council's non-automatic monitoring programme consisted solely of recording NO_2 concentrations using a network of 29 passive diffusion tubes – comprising 27 sites (with the provision of a triplicate colocation site). 25 of these locations are roadside sites and the remaining 2 are kerbside sites. The details of the diffusion tube monitoring within Cheltenham for 2018 are shown in Table 3.4, whereas results are presented in Table 3.5.

Table 3.4 – Cheltenham Borough Council LAQM Diffusion Tube Monitoring

Site ID	Site Location	Site Type	In AQMA	OS Grid Ref (X, Y)
1	Municipal Offices (Front)	R	Y	394757, 222320
2	Municipal Offices (Back)	R	Y	394724, 222320
3	Ladies College	R	Y	394621, 222215
4	2 Gloucester Road	R	Y	394235, 223055
5	422 High St	R	Y	394350, 222923
6	New Rutland	R	Y	394738, 222888
7,8,9	CM1 Co-location Study	R	Y	394760, 222878
10	2 Swindon Road	K	Y	394830, 222845
11	Portland Street	R	Y	395110, 222670
12	Winchcombe/Fairview	R	Y	395210, 222618
13	Albion Street (outside no. 54)	K	Y	395207, 222465
14	2 London Road	R	Y	395362, 222000
15	YMCA - High St	R	Y	395182, 222183
16	8a Bath Road	R	Y	395146, 222149
17	Clarence Parade (opp no. 6)	R	Y	394801, 222454
18	81 London Road	R	Y	395660, 221670
19	264 Gloucester Road	R	Y	393296, 222170
20	340 Gloucester Road	R	Y	392912, 221862
21	14 Imperial Square	R	Y	394809, 222060
22	Hatherley Lane	R	Y	391179, 221640
23	St James Square	R	Y	394577, 222424
24	St Gregorys Church	R	Y	394566, 222600
25	St Georges Street	R	Y	394708, 222763
26	St Pauls Road	R	Y	394902, 223004
27	St Lukes College Road	R	Y	395156, 221866

Site ID	Site Location	Site Type	In AQMA	OS Grid Ref (X, Y)
28	Princess Elizabeth Way North	R	Y	393081, 223643
29	Princess Elizabeth Way South	R	Y	392066, 222540

Table 3.5 – Cheltenham Borough Council LAQM Diffusion Tube Monitoring

Site ID	Valid Data Capture for 2018 (%)	Annual Mean NO_2 Concentration (µg/m³)				
		2014	2015	2016	2017	2018
1	100.0%	-	-	-	26.4	22.9
2	100.0%	-	-	-	32.9	28.0
3	100.0%	33.9	36.6	33.8	32.8	27.5
4	100.0%	**41.7**	**46.5**	**43.2**	**45.4**	**41.2**
5	100.0%	**46.5**	**47.3**	**45.5**	**49.9**	**45.2**
6	100.0%	**42.1**	**42.4**	**40.8**	**41.6**	37.9
7,8,9	91.7%	34.4	34.6	33.3	36.4	32.9
10	100.0%	38.8	37.9	38.2	39.4	35.6
11	100.0%	35.2	36.8	35.7	35.9	32.6
12	91.7%	39.3	33.0	32.2	32.8	31.8
13	100.0%	-	-	-	34.8	31.3
14	100.0%	**40.1**	**40.0**	38.0	37.1	37.4
15	100.0%	35.2	34.5	32.9	31.9	29.1
16	100.0%	**40.8**	**41.1**	38.4	38.0	34.5
17	100.0%	-	-	-	33.8	31.5
18	100.0%	**41.8**	**41.4**	39.6	38.4	37.3
19	58.3%	34.0	36.7	32.2	34.4	30.6
20	100.0%	36.3	38.7	35.9	38.6	35.3
21	100.0%	-	-	-	-	23.4
22	100.0%	-	-	-	-	34.9
23	100.0%	-	-	-	-	30.9
24*	66.7%	-	-	-	-	27.9
25*	41.7%	-	-	-	-	31.9
26*	41.7%	-	-	-	-	29.0
27*	41.7%	-	-	-	-	24.8
28*	41.7%	-	-	-	-	38.4
29*	41.7%	-	-	-	-	31.2

Notes
* Annualisation performed due to data capture >75%
All values reported are bias adjusted as required and represent the monitoring location (i.e. absence of distance correction calculations)

Two monitoring locations (Site 4 and 5) reported annual mean NO_2 concentrations to exceed 40µg/m³ in 2018. Sites 4 and 5 have consecutively reported annual mean NO_2 concentrations to be above 40µg/m³ for the previous four years (2014 – 2017). Both sites are located immediately north of Cheltenham Town Centre, along stretches of the A4019 – Tewkesbury Road and A4019 – High Street which connect to form a key arterial route to the M5.

Site 5 reported the highest annual mean NO_2 concentration within Cheltenham for 2018 (45.2µg/m^3) – a trend consistent since 2014, with concentrations peaking at 49.9µg/m^3 in 2017. Site 5 is situated along a façade of a residential property which immediately fronts onto a stretch of the A4019 – High Street, susceptible to congestion due to the convergence of high capacity and town centre roads (M5, A4019 – Tewkesbury Road, A4019 – High Street, A4019 – Swindon Road and High Street).

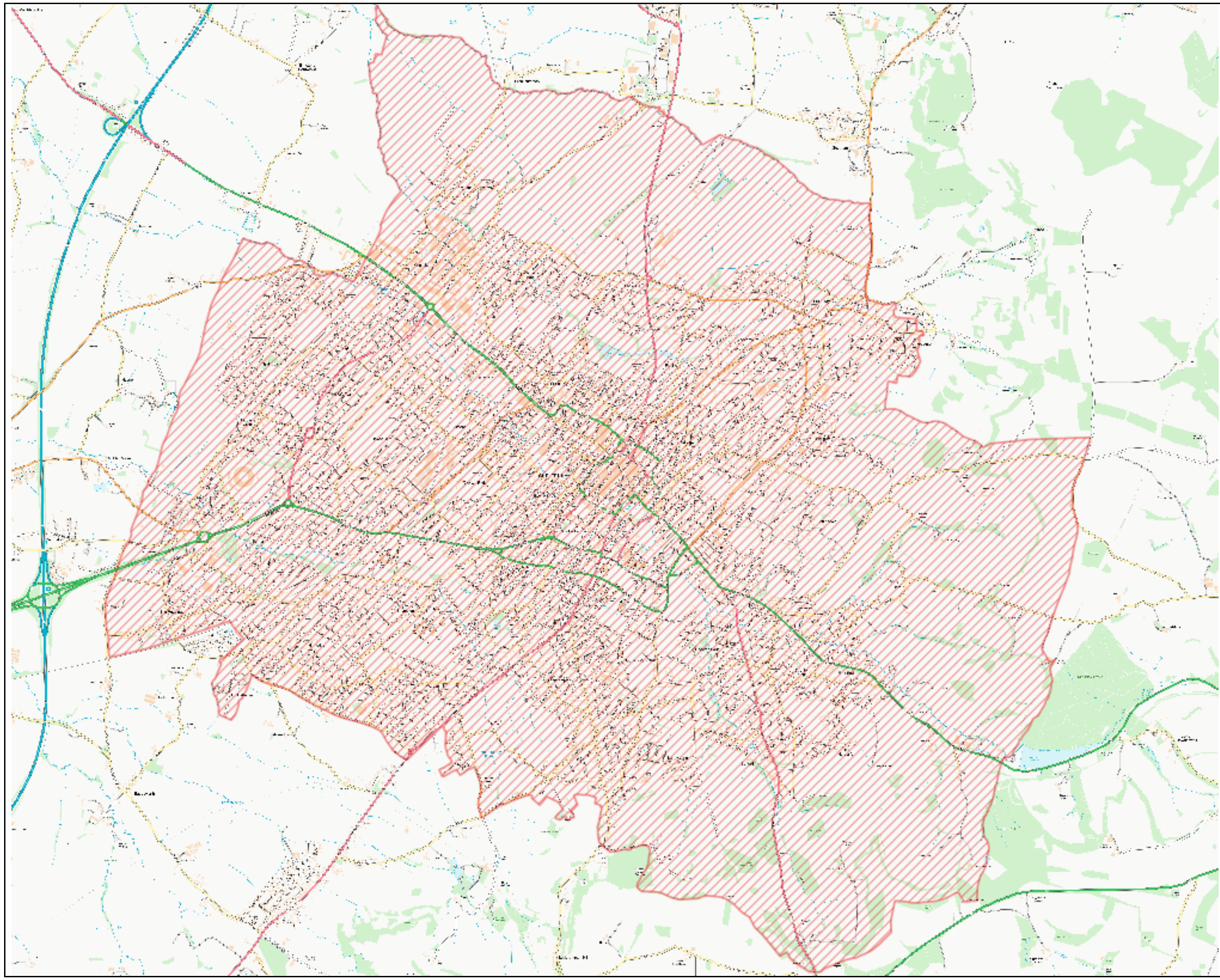
The empirical relationship given in LAQM.TG(16)[1] states that exceedances of the 1-hour mean objective for NO_2 is only likely to occur where annual mean concentrations are 60µg/m^3 or above at a location of relevant exposure (Table 2.1). This indicates that an exceedance of the 1-hour mean objective is unlikely to have occurred at these sites between 2014 and 2018.

Four monitoring locations (Site 6, 14, 18 and 28) report annual mean NO_2 concentrations to be within 10% of the AQS objective limit for 2018. All four diffusion tubes are located adjacent to stretches of Cheltenham's main arterial road network (A4019 - Swindon Road, A435 - London Road, A46 – Old Bath Road and A4013 – Princess Elizabeth Way).

The results from the Council's 2018 monitoring programme demonstrate NO_2 annual mean concentrations across the borough-wide AQMA to have stabilised below the AQS objective limit, with exceedances localised to the north of the Town Centre, specifically along the A4019 (Tewkesbury Road and High Street) for the previous three years. This has resulted in the need to view the current borough-wide AQMA boundary as a main priority – reaffirming the priorities established within the Councils' 2019 ASR.

The borough-wide AQMA boundary, alongside all 2018 council operated monitoring locations, are presented in Figure 3.1 - Cheltenham Whole Borough AQMA Boundary and Figure 3.2 – Local Monitoring Locations, respectively.

Figure 3.1 - Cheltenham Whole Borough AQMA Boundary



Legend

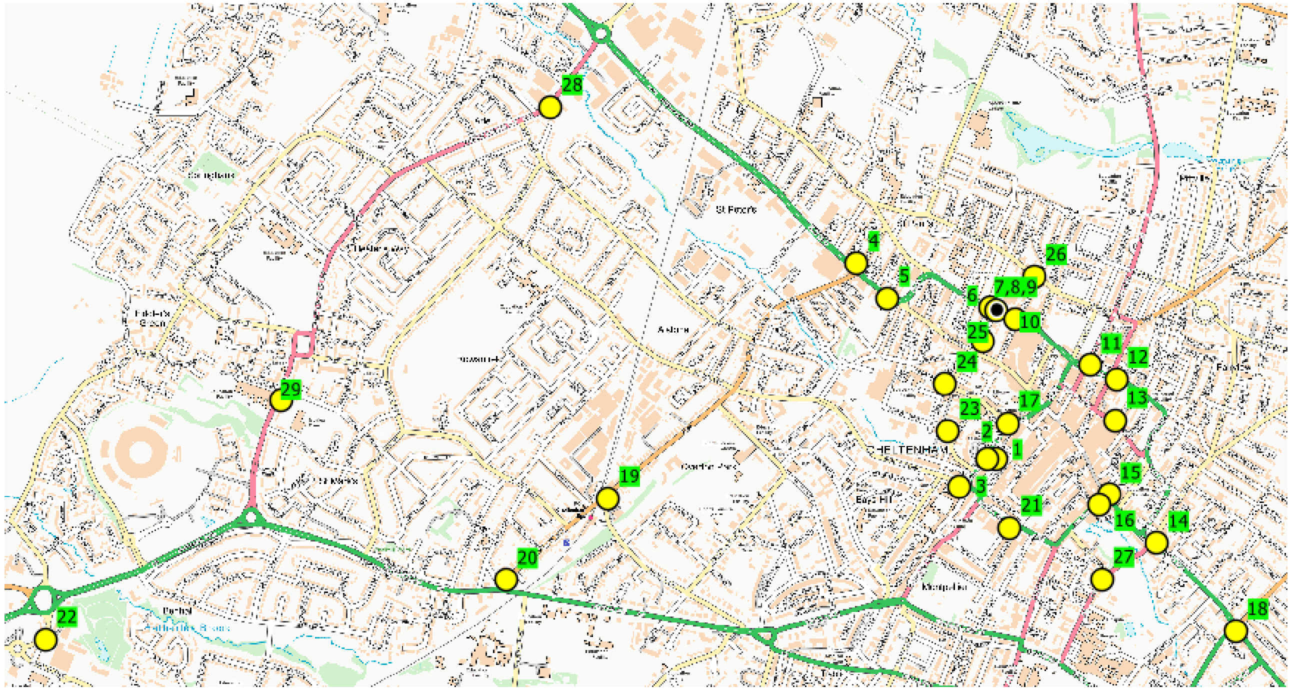
AQMA

Air Quality

Bureau Veritas
5th Floor
66 Prescot Street
London, E1 8HG

Location Cheltenham	
Title Cheltenham Whole Borough AQMA Boundary	
By BT	**Approved** AW
Scale Not to Scale	**Job Ref** 6481827
Date September 2019	**Figure No.** 3.1

Figure 3.2 – Local Monitoring Locations



Legend

- ● Automatic Monitor
- ○ Diffusion Tube

Air Quality

Bureau Veritas
5th Floor
66 Prescot Street
London, E1 8HG

Location	
Cheltenham	
Title	
Local Monitoring Locations	
By	**Approved**
TC	AW
Scale	**Job Ref**
Not to Scale	6481827
Date	**Figure No.**
October 2019	3.2

3.3 Defra Background Concentration Estimates

Defra maintains a nationwide model of existing and future background air pollutant concentrations at a 1km x 1km grid square resolution. This data includes annual average concentration for NO_x, NO_2, PM_{10} and $PM_{2.5}$, using a base year of 2017 (the year in which comparisons between modelled and monitoring are made). The model used to determine the background pollutant levels is semi-empirical in nature: it uses the National Atmospheric Emissions Inventory (NAEI) emissions to model 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, based on the 1km grid squares which cover the modelled area and the affected road network. The Defra mapped background concentrations for base year of 2018, which cover the modelled domain, are presented in Table A5 within Appendix 2.

All of the mapped background concentrations presented are well below the respective annual mean AQS objectives.

Due to the absence of local background monitoring within Cheltenham, pollutant background concentrations used for the purposes of this assessment have been obtained from the Defra supplied background NO_2 maps for the relevant 1km x 1km grid squares covering the modelled domain for the year 2018. The relevant annual mean background concentration will be added to the predicted annual mean road contributions in order to predict the total pollutant concentration at each receptor location. The total pollutant concentration can then be compared against the relevant AQS objective to determine the event of an exceedance.

In order to avoid duplication of road sources within the model, contributions from 'Trunk A Roads' and 'Primary A Roads' have been removed from the overall background concentrations. As the relationship between NO_2 and NO_x is not linear, the NO_2 Adjustment for NO_x Sector Removal Tool[10] has been used. No adjustment for background concentration variability with height has been made.

[10] Defra NO_2 Adjustment for NO_x Sector Removal Tool version 7.0 (2018), available at https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxsector

4 Assessment Methodology

To predict pollutant concentrations of road traffic emissions the atmospheric model ADMS Roads version 4.1.1 was utilised. The following scenario has been modelled reflecting NO_2 concentrations in 2018:

- 2018 Baseline (2018 B) – Baseline year predictions.

In order to provide consistency with the Council's previous 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(16)[1] have been used.

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

- Prediction of NO_2 concentrations to which existing receptors may be exposed and comparison with the relevant AQS objectives;
- Quantification of relative NO_2 contribution of sources to overall NO_2 pollutant concentration; and
- Determination of the geographical extent of any potential exceedances in regards to the existing AQMA boundaries and proposed boundary changes stated in the previous assessment.

4.1 Traffic Inputs

Traffic flows and vehicle class compositions for the 2018 baseline scenario were taken from the Gloucestershire County Council (GCC) roads traffic database and the Department for Transport (DfT) traffic count point database. The GCC monitoring programme comprises both permanent Automatic Traffic Count (ATC) and temporary count points. Where necessary, traffic flows have been annualised to account for seasonal variation and growthed to 2018 by GCC using local factors derived from the permanent ATC points with corresponding datasets.

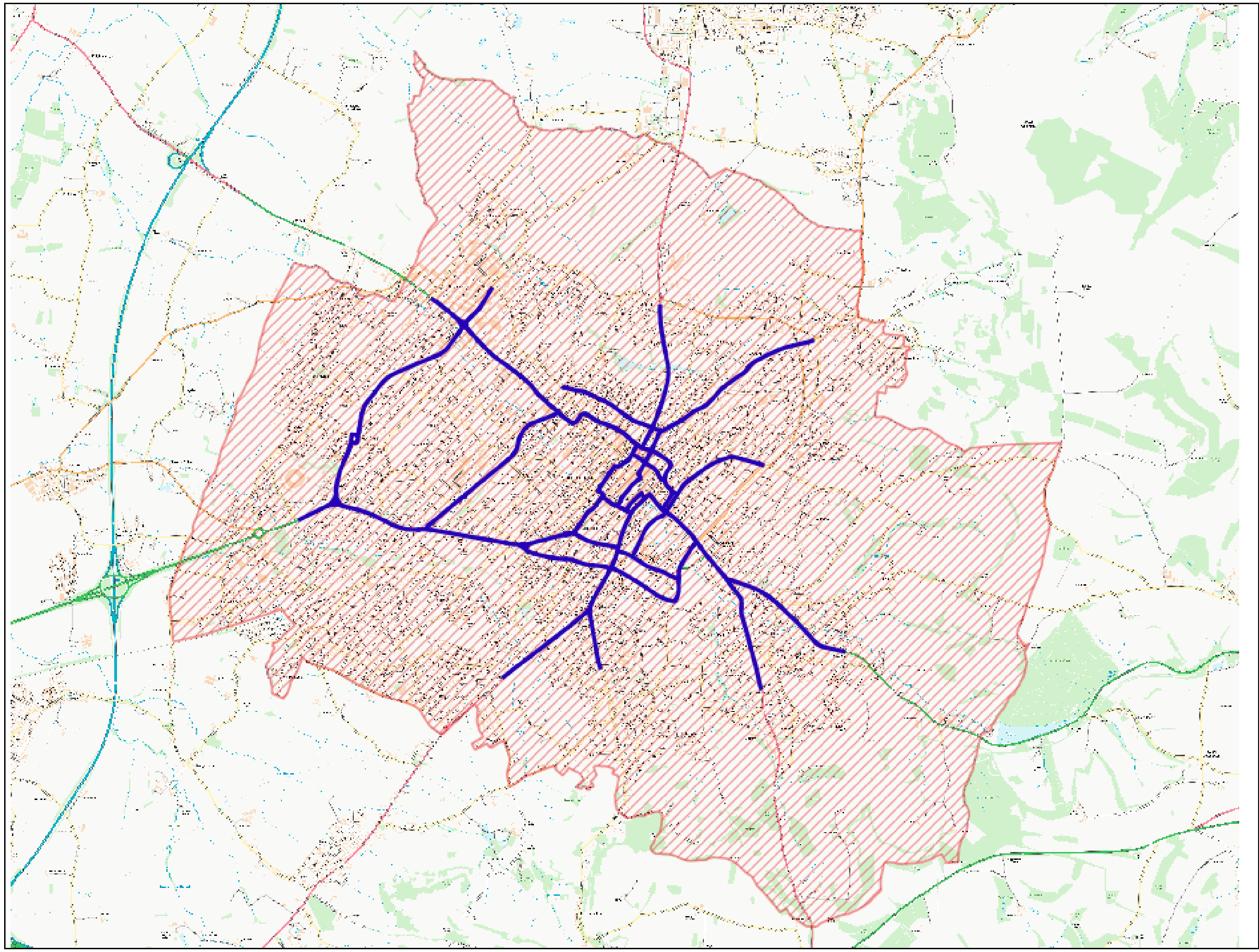
Traffic speeds were modelled at either the relevant speed limit for each road or, where available, monitored vehicle speeds. Where appropriate, vehicle speeds have been reduced to simulate queues at junctions, traffic lights and other locations where queues or slower traffic are known to be an issue – in accordance with LAQM TG(16)[1]. Consultation with the Council has been undertaken throughout this process to identify areas where congestion is considered to be prevalent.

The Emissions Factors Toolkit (EFT) version 9.0 developed by Defra[11] has been used to determine vehicle emission factors for input into the ADMS-Roads model. The emission factors are based upon the traffic data inputs.

Details of the traffic flows used in this assessment are provided in Appendix 2 in Table A6, the entire modelled road network across Cheltenham is presented in Figure 4.1.

[11] Defra, Emissions Factors Toolkit (2019). https://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

Figure 4.1 – City Wide Modelled Road Network



Legend

Modelled Roads

AQMA

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Air Quality

Bureau Veritas
5th Floor
66 Prescot Street
London, E1 8HG

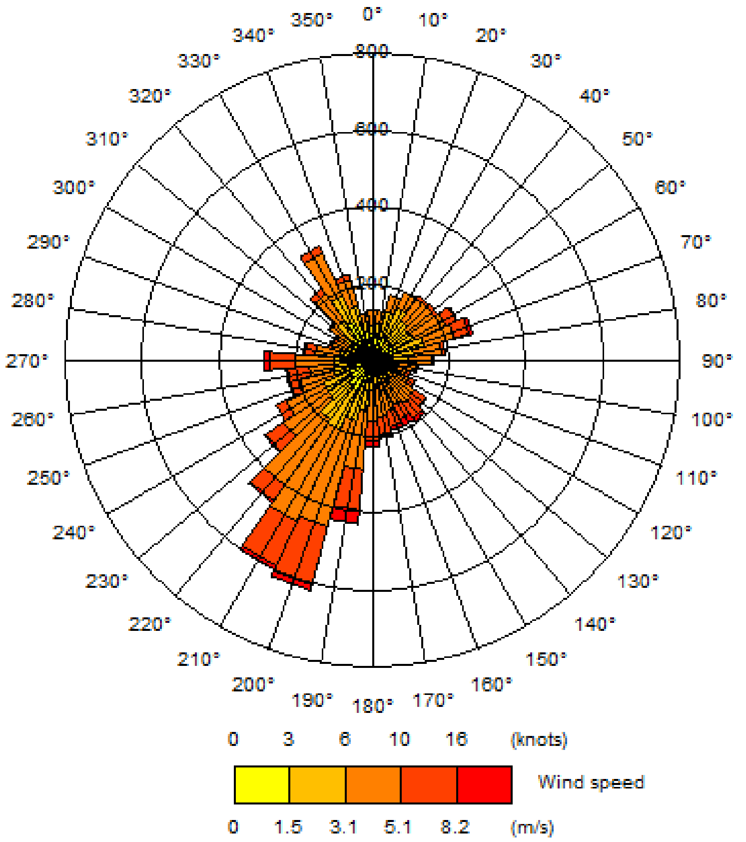
Location Cheltenham	
Title Modelled Roads In Cheltenham	
By BT	**Approved** AW
Scale Not to Scale	**Job Ref** 6481827
Date August 2019	**Figure No.** 4.1

4.2 General Model Inputs

A site surface roughness value of 0.75m was entered into the ADMS-roads model, consistent with the urban nature of Cheltenham Town Centre.

One year of hourly sequential meteorological data from a representative synoptic station is required by the dispersion model. 2018 meteorological data from Pershore weather station, located approximately 16.5km northwest of Cheltenham, has been used in this assessment. Due to the availability of data recorded at Gloucester weather station for 2018 (52.7%), Pershore weather station was considered an appropriate source of meteorological data for use within the assessment. A wind rose for this site for the year 2018 is shown in Figure 4.2.

Figure 4.2 – Wind rose for Pershore Meteorological Data 2018



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(16)[1] 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 exceedances. LAQM.TG(16)[1] recommends that meteorological data should have a percentage of usable hours greater than 85%. If the data capture is less than 85% short-term concentration predictions should be expressed as percentiles rather than as numbers of exceedances. 2018 meteorological data from Pershore includes 8,432 lines of usable hourly data out of the total 8,760 for the year, i.e. 96.3% usable data. This is therefore suitable for the dispersion modelling exercise.

4.3 Sensitive Receptors

A total of 245 specific receptors were included within the assessment to represent locations of relevant exposure. Details of the receptors are presented within Appendix 3 in Table A7, and their locations are illustrated in Figure 4.3.

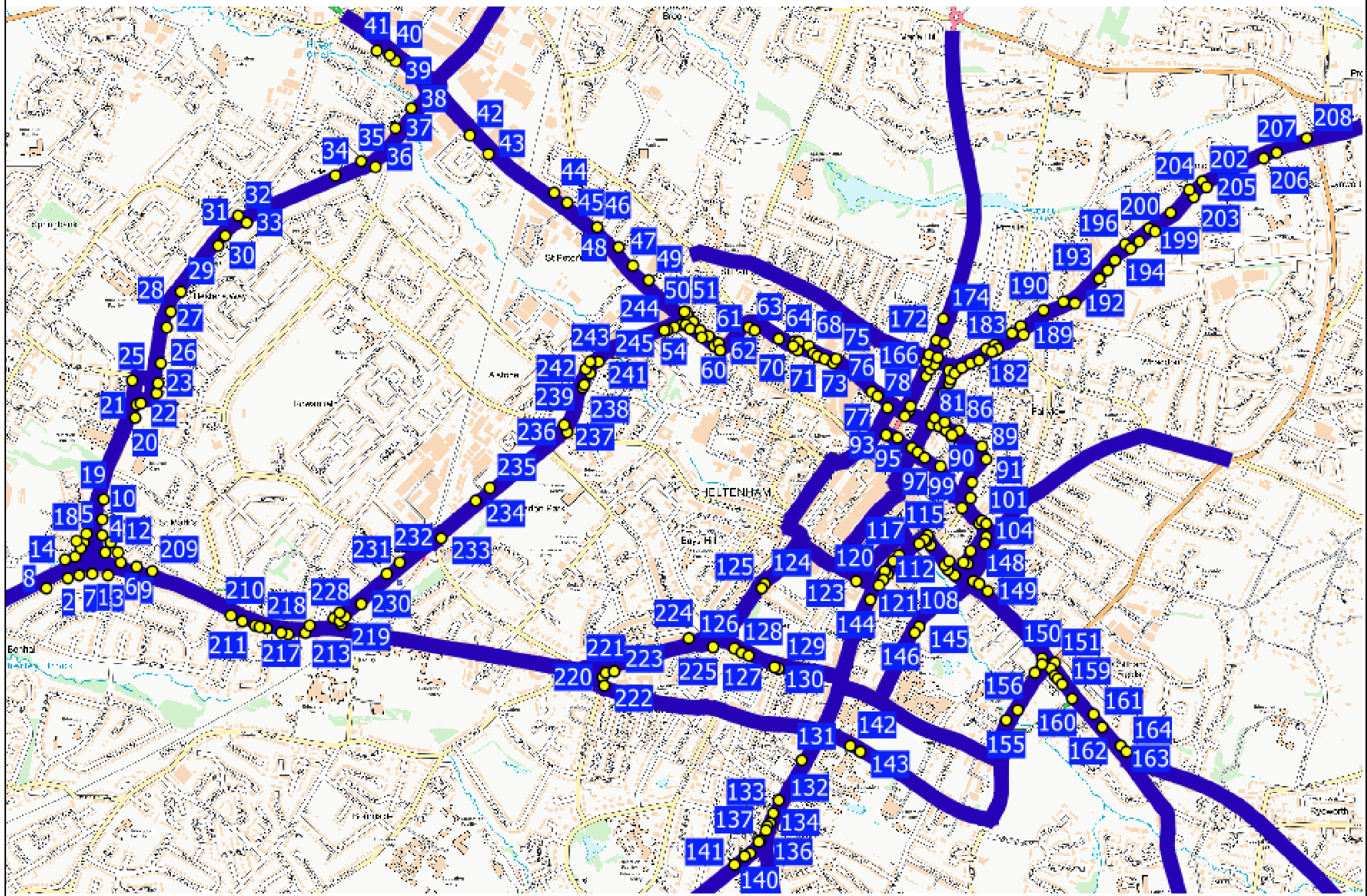
The majority of the receptors (165) were included at a height of 1.5m to represent ground level exposure, whereas the remainder were included at various heights to represent relevant exposure relative to the adjacent modelled road link (Table 4.1).

Concentrations were also modelled across a regular gridded area at a standardised height of 1.5m, initially covering the full extent of the model domain, and later supplemented with further gridded model runs, focussing on key areas of interest for air quality. The intelligent gridding option was applied to the ADMS-roads model meaning additional points were added at locations close to the roads for greater output resolution.

Table 4.1 – Number of Receptors Included at Various Heights

Height (m)	Number of Receptors
0.0	53
1.0	1
1.5	165
3.5	20
4.0	6

Figure 4.3 – Receptor Locations Considered in the Assessment



Legend

- Receptor Location
- Modelled Road Link

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BUREAU VERITAS	Air Quality Bureau Veritas 5th Floor 66 Prescot Street London, E1 8HG
Location Cheltenham	
Title Receptor Locations and Modelled Roads	
By TC	**Approved** AW
Scale Not to Scale	**Job Ref** 6481827
Date October 2019	**Figure No.** 4.3

4.4 Model Outputs

The background pollutant values discussed in Section 3.3 have been used in conjunction with the concentrations predicted by the ADMS-Roads model to calculate predicted total annual mean concentrations of NO_x.

For the prediction of annual mean NO_2 concentrations for the modelled scenarios, the output of the ADMS-Roads model for road NO_x contributions has been converted to total NO_2 following the methodology in LAQM.TG(16)[1], 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 7.1 (May 2019) of the NO_x to NO_2 conversion tool[12]. 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(16)[1] advises that it is valid to assume that exceedances 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.

In addition to annual mean concentrations, source apportionment was carried out for the following vehicle classes, for both NO_x and NO_2:

- Cars;
- Light-Goods Vehicles (LGVs);
- Heavy-Goods Vehicles (HGVs);
- Bus and Coaches; and
- Motorcycles.

Verification of the ADMS-Roads assessment has been undertaken using a number of local authority diffusion tube monitoring locations. All NO_2 results presented in the assessment are those calculated following the process of model verification - using a factor of 3.784. Full details of the verification process are provided in Appendix 1.

4.5 Uncertainty

Due to the number of inputs that are associated with the modelling of the study area there is a level of uncertainty that has to be taken into account when drawing conclusions from the predicted concentrations of NO_2. The predicted concentrations are based upon the inputs of traffic data, background concentrations, emission factors, street canyon calculations, meteorological data, modelling terrain limitations and the availability of monitoring data from the assessment area(s).

4.5.1 Uncertainty in NO_x and NO_2 Trends

Recent studies have identified historical monitoring data within the UK that shows a disparity between measured concentration data and the projected decline in concentrations associated with emission forecasts for future years[13]. Ambient concentrations of NO_x and NO_2 have shown two distinct trends over the past twenty five years: (1) a decrease in concentrations from around 1996

[12] Defra NO_x to NO_2 Calculator (2017), available at https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxNO2calc

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

to 2002/04, followed by (2) a period of more stable concentrations from 2002/04 rather than the further decline in concentrations that was expected due to the improvements in vehicle emissions standards.

The reason for this disparity is 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 EFT (version 9.0) utilising COPERT 5 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 9.0 and associated tools published by Defra to help minimise any associated uncertainty when forming conclusions from the results.

5 Results

5.1 Modelled Concentrations

5.1.1 2018 Baseline Concentrations

The assessment has considered emissions of NO_2 from road traffic at 245 existing receptor locations representing locations of relevant exposure and across a series of generic output grids covering the modelled area. The intelligent gridding option was applied to the ADMS-roads model meaning further points were added at locations close to the roads for greater output resolution.

Table 5.1 provides a summary of the modelled receptors split into groups based on the predicted annual mean NO_2 concentration. It can be seen that of the 245 discrete receptors, 9 (3.7%) are predicted to be above the NO_2 annual mean AQS objective limit, with a further 15 (6.1%) to be within 10%.

Table 5.1 – Summary of 2018 Modelled Receptor Results NO_2

Modelled NO_2 Concentration (µg/m^3)	Number of Receptors	Reference to the AQS Objective	Number of Receptors	% of Receptors
>44	**4**	**Above 40µg/m^3 AQS Objective**	**9**	**3.7**
40 - 44	**5**			
36 - 40	15	Within 10% of AQS Objective	15	6.1
32 - 36	43	Below 36µg/m^3 AQS Objective	218	90.2
<32	178			

The highest annual mean concentrations of NO_2 was recorded at Receptor 60 with a concentration of 52.6µg/m^3. Receptor 60 is located along a façade of a residential property which immediately fronts onto a stretch of the A4019 – High Street susceptible to congestion due to the convergence of high capacity and town centre roads (M5, A4019 – Tewkesbury Road, A4019 – High Street, A4019 – Swindon Road and High Street). The junction's role as a major strategic connection within the region is believed to be the cause of the elevated NO_2 annual mean concentrations predicted at Receptor 60.

The empirical relationship given in LAQM.TG(16)[1] states that exceedances of the 1-hour mean objective for NO_2 is only likely to occur where annual mean concentrations are 60µg/m^3 or above. Given the NO_2 annual mean concentration recorded at Receptor 60 is below the hourly exceedance indicator (60µg/m^3). In addition, on review of the annual mean NO2 concentration isopleth presented in Figure 5.2 covering the modelled domain, there are no locations with a modelled annual mean NO_2 concentration above 60µg/m^3 (i.e. indicative exceedance of the 1-hour mean NO_2 AQS objective limit). This suggests that an exceedance of the hourly NO_2 AQS objective is unlikely across the modelled area.

Figure 5.1 shows the locations of those receptors which are exceeding the 40µg/m^3 annual mean AQS objective and those receptors which are within 10% of the annual mean AQS objective (36 to 40µg/m^3). Based on these results, the following observations were made:

- All receptors reporting modelled NO_2 annual mean concentrations to be above or within 10% of the AQS objective are located within the existing Borough-wide AQMA;
- Areas of exceedance or near exceedance of the annual mean NO_2 AQS objective were concentrated to roadside locations near junctions where key arterial roads meet, confirming vehicular traffic to be the main contributor to elevated levels of NO_2 concentrations within Cheltenham. Notable roads include: A40 Gloucester Road, A4013 Princess Elizabeth Way, A4019 Tewkesbury Road, A4019 Swindon Road and A46 London Road; and

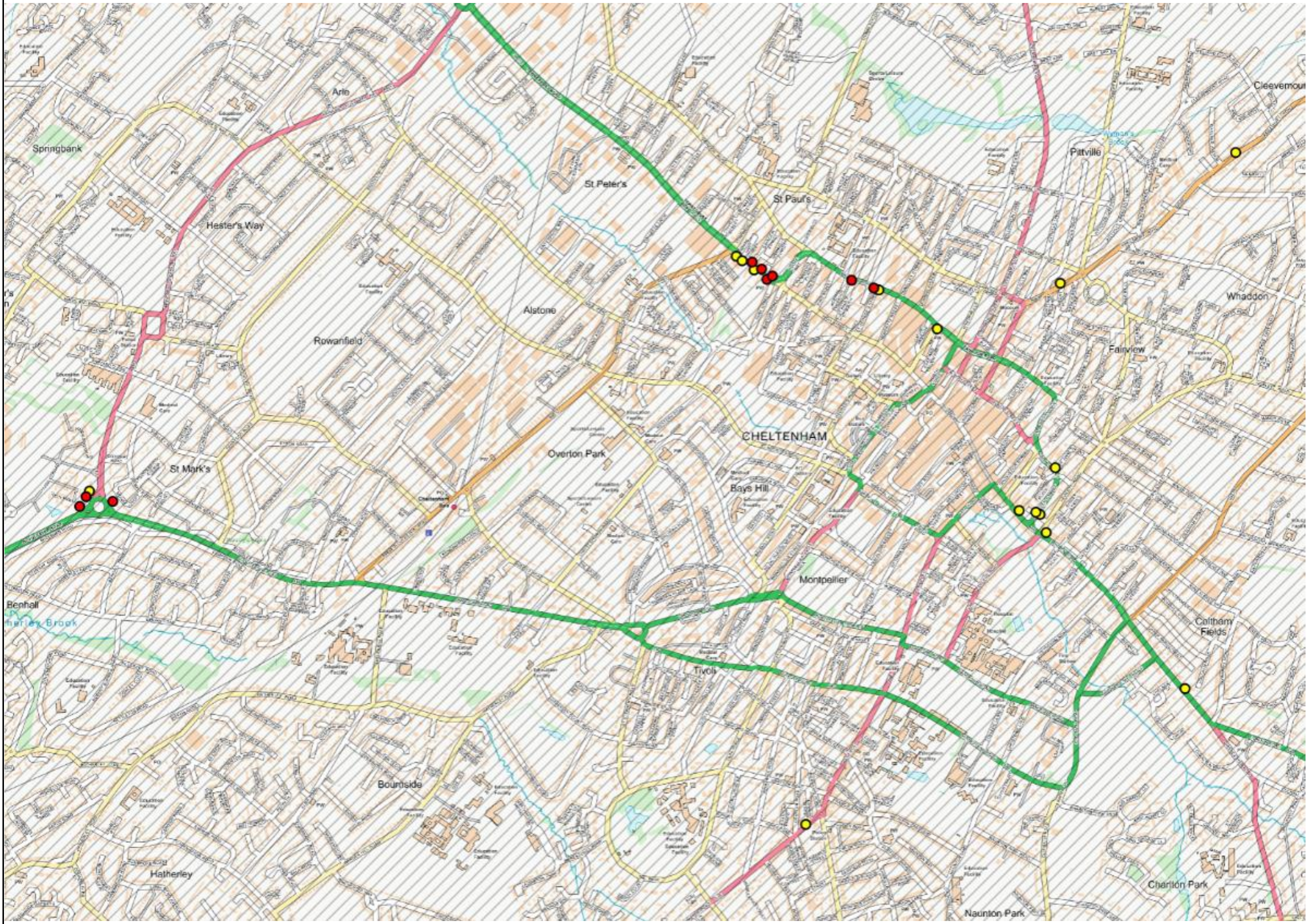
- The following areas were identified to report a modelled exceedance or near exceedance of the annual mean NO_2 AQS objective. These are:
  - Location A - Continuous stretch of road, spanning A4019 Tewkesbury Road, A4019 Poole Way and A4019 Swindon Road – north of the Town Centre;
  - Location B - A40 Gloucester Road / A4013 Princess Elizabeth Way roundabout, adjacent to GCHQ;
  - Location C - A46 London Road / Berkeley Street intersection; and
  - Along stretches of arterial roads connecting to the Town Centre (Prestbury Road, London Road and A46 Shurdington Road).

In-line with the consistent monitored exceedance of the annual mean NO_2 AQS objective limit reported at Sites 4 and 5 within Location A, preference was to pursue declaration of an AQMA for this area - spanning A4019 Tewkesbury Road to A4019 Swindon Road (via A4019 Poole Way) – north of the Town Centre. To facilitate this process, annual mean NO_2 concentrations were predicted at generic receptor locations (Figure 5.3).

Monitoring within and/or adjacent to the remainder of the locations identified to have a modelled exceedance and/or near exceedance will be reviewed in order to validate modelled findings.

A full set of concentration results for the receptors used within the assessment is provided in Table A7 in Appendix 4.

Figure 5.1 – Location of Discrete Receptors Predicted to be within 10% or Above the NO_2 Annual Mean AQS Objective



Legend

NO2 Concentrations

> 40 µg/m3

36 - 40 µg/m3

AQMA

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Air Quality

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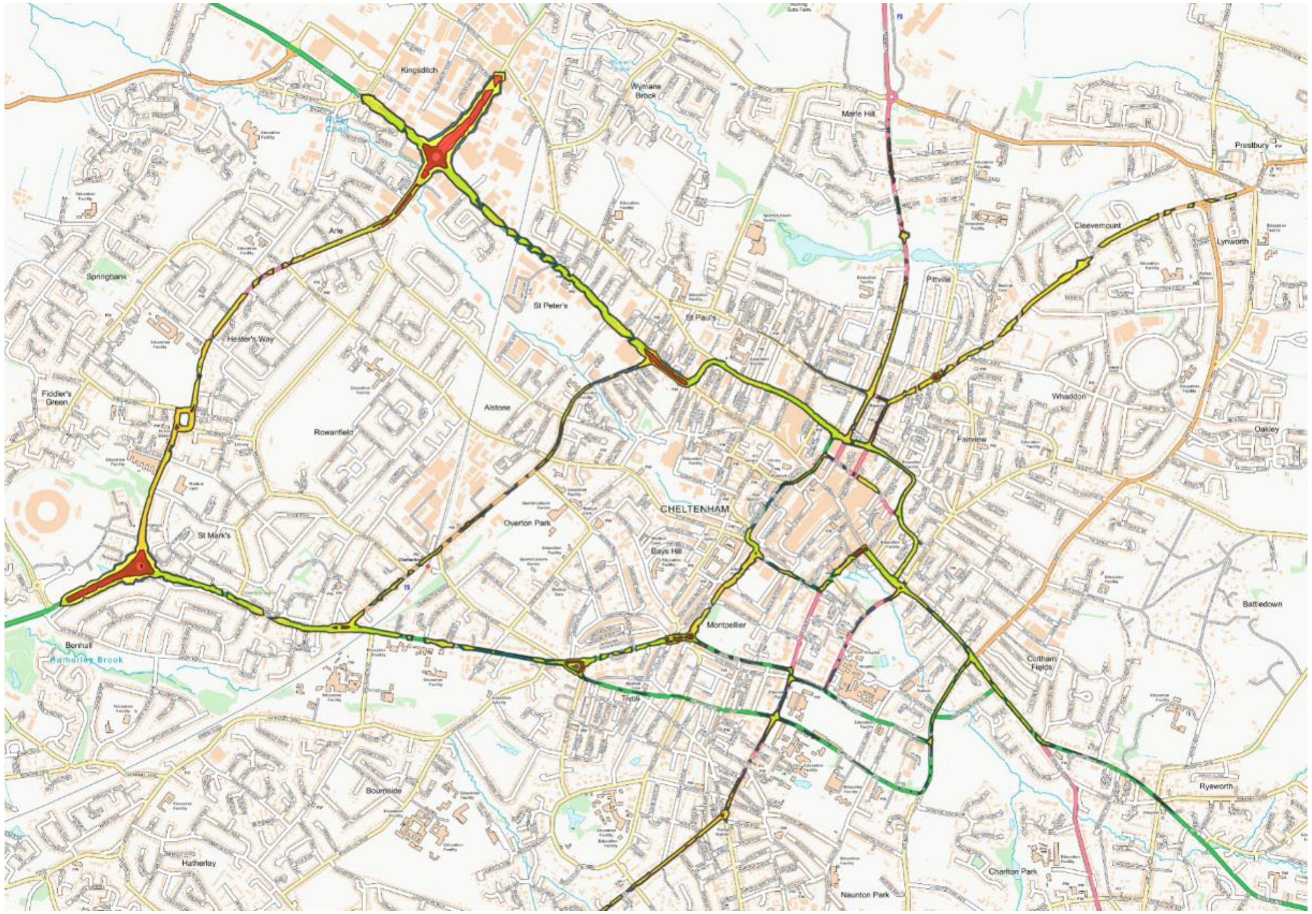
5th Floor
66 Prescot Street
London, E1 8HG

Location	
Cheltenham	
Title	
Discrete Receptors Above or Within 10% of the AQS NO_2 Annual Mean Limit	
By	**Approved**
BT	AW
Scale	**Job Ref**
Not to Scale	6481827
Date	**Figure No.**
August 2019	5.1

Figure 5.2 – Annual Mean NO_2 Concentration Isopleths: Cheltenham



Legend

Annual Mean NO2 Concentration (μg/m3)

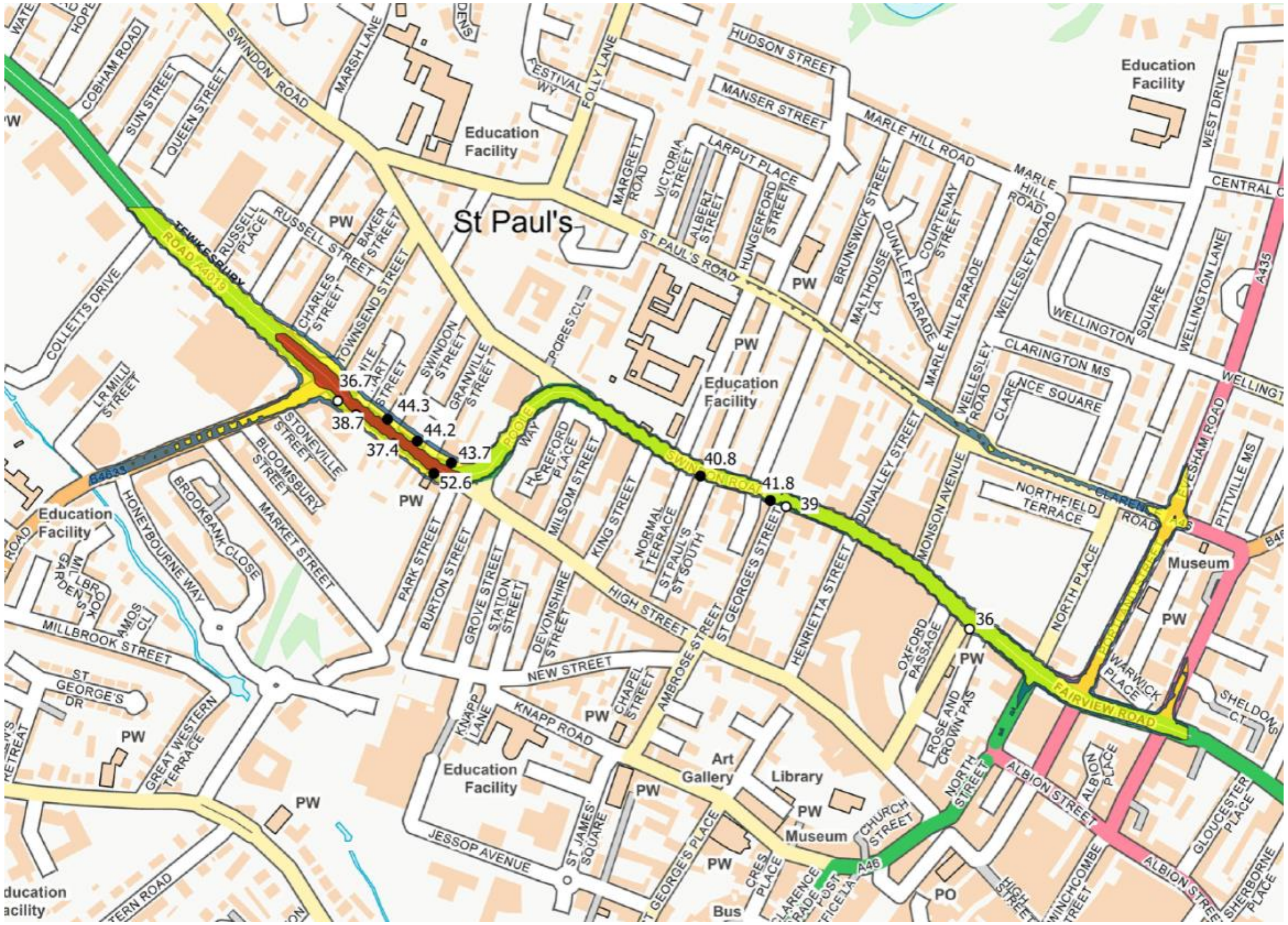
- 36.0 - 40.0
- 40.0 - 60.0
- >60.0

Air Quality

Bureau Veritas
5th Floor
66 Prescot Street
London, E1 8HG

Location	
Cheltenham	
Title	
Annual Mean NO_2 Concentration Isopleths: Cheltenham	
By	**Approved**
BT	AW
Scale	**Job Ref**
Not to Scale	6481827
Date	**Figure No.**
August 2019	5.2

Figure 5.3 – Location A: Annual Mean NO_2 Concentration Isopleths and Model Predictions at Discrete Receptor Locations



Legend

Discrete Receptors
- ○ 36.0 - 40.0µg/m3
- ● > 40.0µg/m3

Gridded Receptors
- 36.0 - 40.0µg/m3
- 40.0 - 60.0µg/m3
- > 60.0µg/m3

Air Quality

Bureau Veritas
5th Floor
66 Prescot Street
London, E1 8HG

Location
Cheltenham

Title
Location A: Annual Mean NO_2 Concentration Isopleths and Model Predictions at Discrete Receptor Locations

By	**Approved**
BT	AW
Scale	**Job Ref**
Not to Scale	6481827
Date	**Figure No.**
September 2019	5.4

5.2 Estimated Year of Compliance

Following the identification of exceedances of the AQS objectives, it is useful to provide an estimate of the year by which concentrations at the identified locations of exceedances will become compliant with the relevant AQS objective. This is initially provided below assuming only the trends for future air quality, as currently predicted by Defra, are realised. The implementation of specific intervention measures to mitigate the local air quality issues, as are currently being developed by the Council within a revised AQAP, would then be considered most likely to bring forwards the estimated date of compliance.

Following the methodology outlined in LAQM.TG(16)[1] paragraph 7.70 onward, the year by which concentrations at the identified locations of exceedances will become compliant with the NO_2 annual mean AQS objective has been estimated. This has been completed using the predicted modelled NO_2 concentrations from the 2018 B scenario.

As a worst-case approach, the projection is based upon the receptor predicted as having the maximum annual mean NO_2 concentration, which in this case is Receptor 60. The appropriate roadside NO_2 projection factors, as provided on the LAQM Support website[14], are then applied to this concentration value to ascertain the estimated NO_2 annual mean reduction per annum, and hence the anticipated year of compliance. In this case, roadside projection factors for 'HDV >10% Rest of UK' have been applied, consistent with the worst-case receptor location.

The projected NO_2 annual mean concentrations following the above approach are presented in Table 5.2.

Table 5.2 – Projected Annual Mean NO_2 Concentrations

Receptor 60									
2018 Annual Mean Concentration (µg/m^3)	Predicted Annual Mean Concentration (µg/m^3)								
	2019	2020	2021	2022	2023	2024	2026	2027	2028
52.6	**50.7**	**48.3**	**45.7**	**43.3**	**41.2**	39.2	37.3	35.6	34.1
In **bold**, exceedance of the NO_2 annual mean AQS objective of 40µg/m^3 Vehicle Adjustment Factor = HDV <10% Rest of UK									

Table 5.2 indicates that the first year by which Receptor 60 will be exposed to a concentration below the annual mean NO_2 AQS objective will be 2024. Additionally, it is expected that concentrations are expected to below 10% of the annual mean NO_2 AQS objective by 2028. 2024 is therefore considered the predicted year of compliance for those receptors used within the model, which are believed to represent worst case exposure within Cheltenham, in the absence of the implementation of any specific intervention measures to further bring forward local air quality improvements in the area.

5.3 Source Apportionment

To help inform the development of measures as part of the action plan stage of the project, NO_x source apportionment exercise was undertaken for the following vehicle classes:

- Cars;

[14] https://laqm.defra.gov.uk/tools-monitoring-data/roadside-no2-projection-factor.html

- Light-Goods Vehicles (LGVs);
- Heavy-Goods Vehicles (HGVs);
- Bus and Coaches; and
- Motorcycles.

This will provide vehicle emission proportions of NO_x that will allow the Council to design specific AQAP measures targeting a reduction in emissions from specific vehicle types.

It should be noted that emission sources of NO_2 are dominated by a combination of direct NO_2 (f-NO_2) and oxides of nitrogen (NO_x), the latter of which is chemically unstable and rapidly oxidised upon release to form NO_2. Reducing levels of NO_x emissions therefore reduces levels of NO_2. As a consequence, the source apportionment study has considered the emissions of NO_x which are assumed to be representative of the main sources of NO_2.

Table 5.3 and Table 5.4 detail the source apportionment results for **NO_x** concentrations for each of the five different selections of the modelled receptors, whilst Figure 5.4 and Figure 5.5 provide pie charts accompanying each scenario:

- The average NO_x contributions across all modelled locations. This provides useful information when considering possible action measures to test and adopt. It will however understate road NO_x concentrations in problem areas;
- The average NO_x contributions across all locations with NO_2 concentration greater than 40µg/m^3. This provides an indication of source apportionment in areas known to be a problem (i.e. only where the AQS objective is exceeded). As such, this information should be considered with more scrutiny when testing and adopting action measures;
- The average NO_x contributions within Location A, where receptors predicted NO_2 concentrations to be greater than 40µg/m^3. This will inform potential prominent NO_x contributors present within the identified area of exceedance; and
- The location where the maximum road NO_x concentration has been predicted within Location A. This is likely to be in the area of most concern within the proposed AQMA and so a good place to test and adopt action measures. Any gains predicted by action measures are however likely to be greatest at this location and so would not represent gains across the whole modelled area.

When considering the average NO_x concentration across all modelled locations, the following observations were found:

- Road traffic accounts for 33.2µg/m^3 (62.6%) of total NO_x (53.0µg/m^3), with background accounting for 19.8µg/m^3 (37.4%);
- Of the total road NO_x, Cars are highest contributing vehicle class accounting for 53.7% (17.9µg/m^3);
- LGVs are found to be the second highest contributing vehicle class accounting for 25.8% (8.6µg/m^3);
- HGVs and Buses account for similar total road NO_x (HGVs – 10.3% (3.4µg/m^3) and Buses 10.0% (3.3µg/m^3)); and
- Whereas, motorcycles are found to contribute <1%.

When considering the average NO_x concentration at locations with an NO_2 concentration greater than 40µg/m^3 the following observations were found:

- The road traffic NO_x predicted percentage contribution is much higher in comparison to all receptor locations, accounting for 76% (66.5µg/m^3) of the total NO_x (87.6µg/m^3), with the background component percentage contribution subsequently reduced to 20% (21.0µg/m^3);

- Of the total road NO_x, Cars account for a slightly reduced contribution in comparison to contributions modelled at all receptor locations, but are still found to be the highest contributing vehicle class accounting for 50.5% (33.6µg/m^3);

- LGVs are similarly found to be the second highest contributing vehicle class, with a consistent percentage weighting observed (25.9% (17.3µg/m^3));

- Percentage contributions from HGVs were found to increase slightly in comparison to contributions modelled for all receptor locations, however remain third in terms of overall ranking (12.4% (8.2µg/m^3)) - suggesting a marginal influence of HGVs in exceedance areas across the modelled domain; and

- Percentage contributions from Buses and Motorcycles remain stable in comparison to contributions modelled at all receptor locations (Buses – 10.9% (7.3µg/m^3) and Motorcycles <1%).

When considering the average NO_x concentration within Location A at receptors where NO_2 concentrations were predicted to be greater than 40µg/m^3 the following observations were found:

- Road traffic accounts for 73.9% (64.0µg/m^3) of the total averaged NO_x (86.7µg/m^3) – highlighting contributions from road traffic to be the core component in areas of exceedance;

- Of the total road NO_x, Cars are found to be the highest contributing vehicle class accounting for 47.7% (30.5g/m^3). However, as found whilst considering all receptors where NO_2 concentrations were predicted to be greater than 40µg/m^3 in comparison to contributions modelled at all receptors, Cars account for a further reduction in contribution of the total road NO_x – suggesting influence from other vehicle classes in areas of exceedance;

- LGVs are found to be the second highest contributing vehicle class accounting for 24.8% (15.9µg/m^3). This observed percentage contribution is consistent with observations found in previous scenarios;

- HGVs account for 13.9% (8.9µg/m^3) of the total road NO_x. As observed at receptor locations where NO_2 concentrations were predicted to be greater than 40µg/m^3, the percentage contribution from HGVs continues to increase comparison to the wider domain – suggesting an influence on exceedance within Location A and other areas of exceedance;

- Buses account for 13.4% (8.6µg/m^3) of the total road NO_x – a increase in percentage contribution in comparison to the wider domain - suggesting an influence on exceedance within Location A; and

- Motorcycles are similarly found to contribute <1%.

When considering receptors where the maximum road NO_x concentration was predicted in Location A, the following observations were found:

- Road traffic accounts for 79% of the total NO_x (85.1µg/m^3);

- Of the total road NO_x, Cars are similarly found to be the highest contributing vehicle class accounting for 44.1% (37.6µg/m^3). As observed at receptors reporting NO_2 annual mean concentrations to be above 40µg/m^3 within Location A, the percentage contribution to total road NO_x appears to be lower in comparison to the wider domain – suggesting a reduced influence within this area;

- LGVs are found to be the second highest contributing vehicle class accounting for 23.5% (20.0µg/m^3) – consistent with previous scenarios. The percentage contribution from LGVs to total Road NO_x is observed to be slightly lower in comparison to previous scenarios, and the wider domain, however absolute NO_x concentration contributions are higher;

- Buses are found to be the third highest contributing vehicle class accounting for 17.3% (14.7µg/m^3) – inconsistent with previous scenarios. In comparison to the wider modelled domain, percentage contributions from Buses were found to increase – a trend similarly visible at receptors reporting NO_2 annual mean concentrations to be above 40µg/m^3 within Location A. Receptor 60 is located roadside of the A4019 – High Street – an arterial road connecting to the Town Centre, with frequent bus routes in operation;

- Percentage contributions from HGVs were found to increase slightly in comparison to the wider modelled area, however are ranked fourth in terms of overall contribution to total road NO_x; and

- Motorcycles are similarly found to contribute <1%.

The NO_x source apportionment exercise demonstrates a largely consistent ranking of contributing vehicle classes exhibited throughout all scenarios (Cars, LGVs, HGVs, Buses and Coaches and Motorcycles), where Cars primarily (alongside LGVs) are found to be the main contributors to total road NO_x concentrations across Cheltenham.

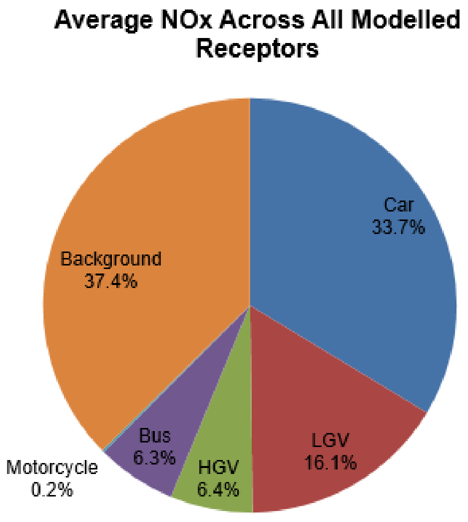
Whilst comparing modelled contributions at identified receptor location within Location A, against the wider modelled domain, Cars were observed to employ a reduced influence to total road NO_x concentrations within Location A. Subsequent increases to total road NO_x contributions from both Buses and HGVs were observed - with the former vehicle class demonstrating a larger degree of influence. Increases to both Bus and HGV total road NO_x contributions within Location A is owed to the strategic road network the area of exceedance is centred on (i.e. the A4019 – Tewkesbury Road, A4019 – High Street, A4019 – Swindon Road and High Street) – which connects the M5 (among other high capacity roads) to the Town Centre.

However, whilst taking the above into consideration, the observed variance in percentage contributions between vehicle classes largely didn't disrupt the observed ranking of contributing vehicle class exhibited throughout all scenarios. This suggests volume of traffic is considered to be the key contributor to elevated levels of NO_2 annual mean concentrations within Location A – reflecting the responsibility this area has upon the wider strategic road infrastructure.

Table 5.3 – Detailed Source Apportionment of NO_x Concentrations Covering the Entirety of the Modelled Domain

Results	All Vehicles	Cars	LGV	HGV	Bus & Coach	Motorcycle	Background
Average across all modelled locations							
NO_x Concentration (µg/m^3)	33.2	17.9	8.6	3.4	3.3	0.1	19.8
Percentage of total NO_x	62.6%	33.7%	16.1%	6.4%	6.3%	0.2%	37.4%
Percentage Road Contribution to total NO_x	100.0%	53.7%	25.8%	10.3%	10.0%	0.2%	-
Average across all locations with NO_2 Concentration greater than 40µg/m^3							
NO_x Concentration (µg/m^3)	66.5	33.6	17.3	8.2	7.3	0.2	21.0
Percentage of total NO_x	76.0%	38.4%	19.7%	9.4%	8.3%	0.2%	24.0%
Percentage Road Contribution to total NO_x	100.0%	50.5%	25.9%	12.4%	10.9%	0.2%	-

Figure 5.4 – Detailed Source Apportionment of NO_x Concentrations



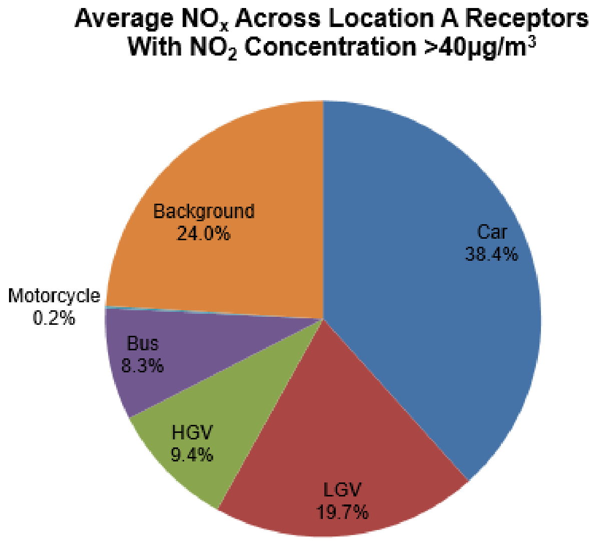
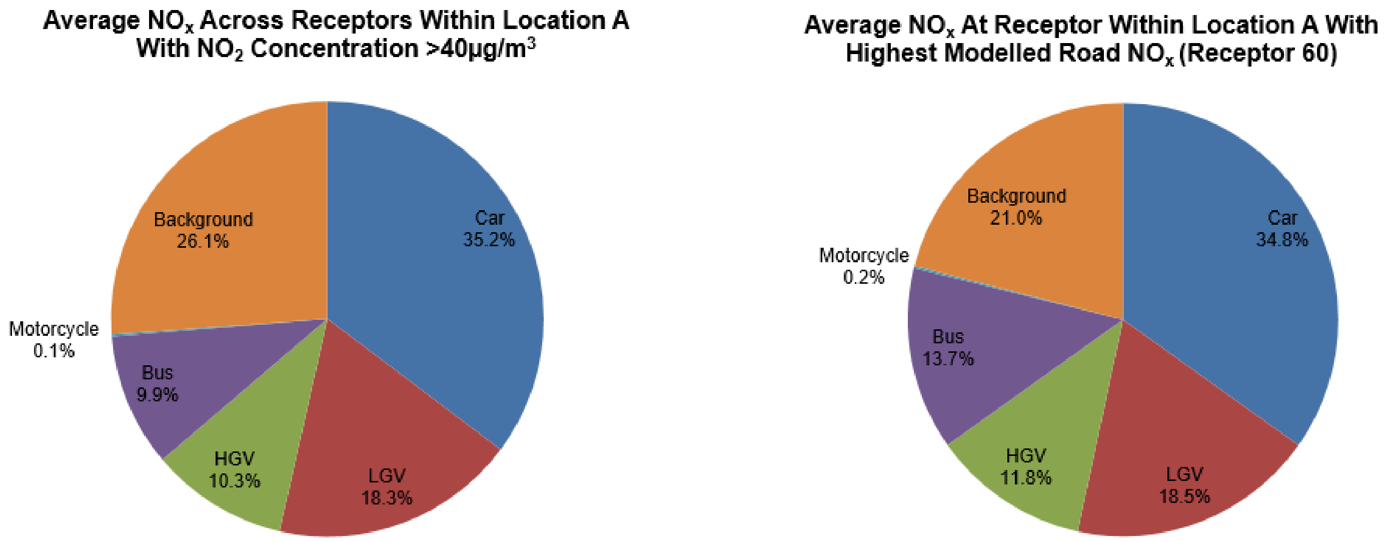


Table 5.4 – Detailed Source Apportionment of NO_x Concentrations Covering Location A

Results	All Vehicles	Cars	LGV	HGV	Bus & Coach	Motorcycle	Background
Average Across Modelled Receptors Within Location A Reporting NO_2 Annual Mean Concentrations to be Above 40µg/m³							
NO_x Concentration (µg/m³)	64.0	30.5	15.9	8.9	8.6	0.1	22.6
Percentage of total NO_x	73.9%	35.2%	18.3%	10.3%	9.9%	0.1%	26.1%
Percentage Road Contribution to total NO_x	100.0%	47.7%	24.8%	13.9%	13.4%	0.2%	-
At Location within Location A with Maximum Road NO_x Concentration (Receptor 60)							
NO_x Concentration (µg/m³)	85.1	37.6	20.0	12.7	14.7	0.2	22.6
Percentage of total NO_x	79.0%	34.8%	18.5%	11.8%	13.7%	0.2%	21.0%
Percentage Road Contribution to total NO_x	100.0%	44.1%	23.5%	14.9%	17.3%	0.2%	-

Figure 5.5 – Detailed Source Apportionment of NO_x Concentrations Focussing on Locations A and B respectively



6 Conclusions and Recommendations

The dispersion modelling exercise undertaken has provided the following updated perspective on NO_2 challenges within Cheltenham Town Centre and its associated strategic roads.

6.1 Predicted Concentrations

The model suggests that the 40µg/m^3 NO_2 annual mean AQS objective is exceeded at a total of 9 (3.7%) receptor locations, with 15 (6.1%) further locations within 10% of the objective.

All of receptors reporting NO_2 annual mean concentrations to be above or within 10% of the AQS objective limit are located within the existing Borough-wide AQMA, and are concentrated to roadside locations of junctions where key arterial roads meet and form the main transportation network within the region. Notable roads include: A40 Gloucester Road, A4013 Princess Elizabeth Way, A4019 Tewkesbury Road, A4019 Swindon Road and A46 London Road.

The highest annual mean concentrations of NO_2 was recorded at Receptor 60 with a concentration of 52.6µg/m^3. Receptor 60 is located along a façade of a residential property which immediately fronts onto a stretch of the A4019 – High Street. This location is susceptible to congestion due to the convergence of high capacity and town centre roads (M5, A4019 – Tewkesbury Road, A4019 – High Street, A4019 – Swindon Road and High Street).

The empirical relationship given in LAQM.TG(16)[1] states that exceedances of the 1-hour mean objective for NO_2 is only likely to occur where annual mean concentrations are 60µg/m^3 or above at a location of relevant exposure (Table 2.1). Given the NO_2 annual mean concentration recorded at all receptors is below 60µg/m^3 exceedances of the hourly NO_2 AQS objective are unlikely.

The following areas were identified to report a modelled exceedance or near exceedance of the annual mean NO_2 AQS objective. These are:

- Location A - Continuous stretch of road, spanning A4019 Tewkesbury Road, A4019 Poole Way and A4019 Swindon Road – north of the Town Centre;
- Location B - A40 Gloucester Road / A4013 Princess Elizabeth Way roundabout, adjacent to GCHQ;
- Location C - A46 London Road / Berkeley Street intersection; and
- Along stretches of arterial roads connecting to the Town Centre (Prestbury Road, London Road and A46 Shurdington Road).

In-line with the monitored exceedance of the annual mean NO_2 AQS objective limit reported at Sites 4 and 5 within Location A, the council propose to declare an AQMA for this area. The boundary of which would span A4019 Tewkesbury Road to A4019 Swindon Road (A4019 Poole Way) as illustrated in Figure 6.1. To facilitate this process, further gridded analysis was completed to provide a higher resolution of the predicted annual mean concentrations of NO_2 within Location A.

6.2 Source Apportionment

To help inform the development of measures as part of a future Air Quality Action Plan (AQAP), a NO_x source apportionment exercise was undertaken to provide an understanding of any potential similarities in vehicle emission contributors within the proposed AQMA (i.e. Location A).

The NO_x source apportionment exercise demonstrates a largely consistent ranking of contributing vehicle class exhibited throughout all scenarios (Cars, LGVs, HGVs, Buses and Coaches and

Motorcycles), where Cars primarily (alongside LGVs) are found to be the main contributors to total road NO_x concentrations across Cheltenham.

Whilst comparing modelled contributions at identified receptor location within Location A, against the wider modelled domain, Cars were observed to employ a reduced influence to total road NO_x concentrations within Location A. Whilst increases to total road NO_x contributions from both Buses and HGVs were observed. Increases to both Bus and HGV total road NO_x contributions within Location A is owed to the arterial network the area of exceedance is centred on (i.e. the A4019 – Tewkesbury Road, A4019 – High Street, A4019 – Swindon Road and High Street) – which connects the M5 (among other high capacity roads) to the Town Centre.

6.3 Future Recommendations

Following the completion of the detailed modelling assessment, the following recommendations are made:

- Amend the current Borough-wide AQMA based on the proposed AQMA illustrated in Figure 6.1, spanning A4019 Tewkesbury Road to A4019 Swindon Road (via A4019 Poole Way). The proposed AQMA boundary covers the entirety of residential premises where sections, such as façades, are found to be above or within 10% of the NO_2 annual mean AQS objective limit;

- Deploy and/or relocate existing monitoring within the Borough to locations predicted to be in exceedance, or near exceedance, of the NO_2 annual mean AQS objective limit in order to validate modelled findings. These locations include:

  - Location B - A40 Gloucester Road / A4013 Princess Elizabeth Way roundabout, adjacent to GCHQ;

  - Location C - A46 London Road / Berkeley Street intersection; and

  - Along stretches of arterial roads connecting to the Town Centre (Prestbury Road, London Road and A46 Shurdington Road).

  - Continue to monitor NO_2 across the Borough, focussing on areas newly defined as being within or just outside of the revised AQMA boundary, such as adjacent to the B4633 Gloucester Road / A4019 Tewkesbury Road intersection; and

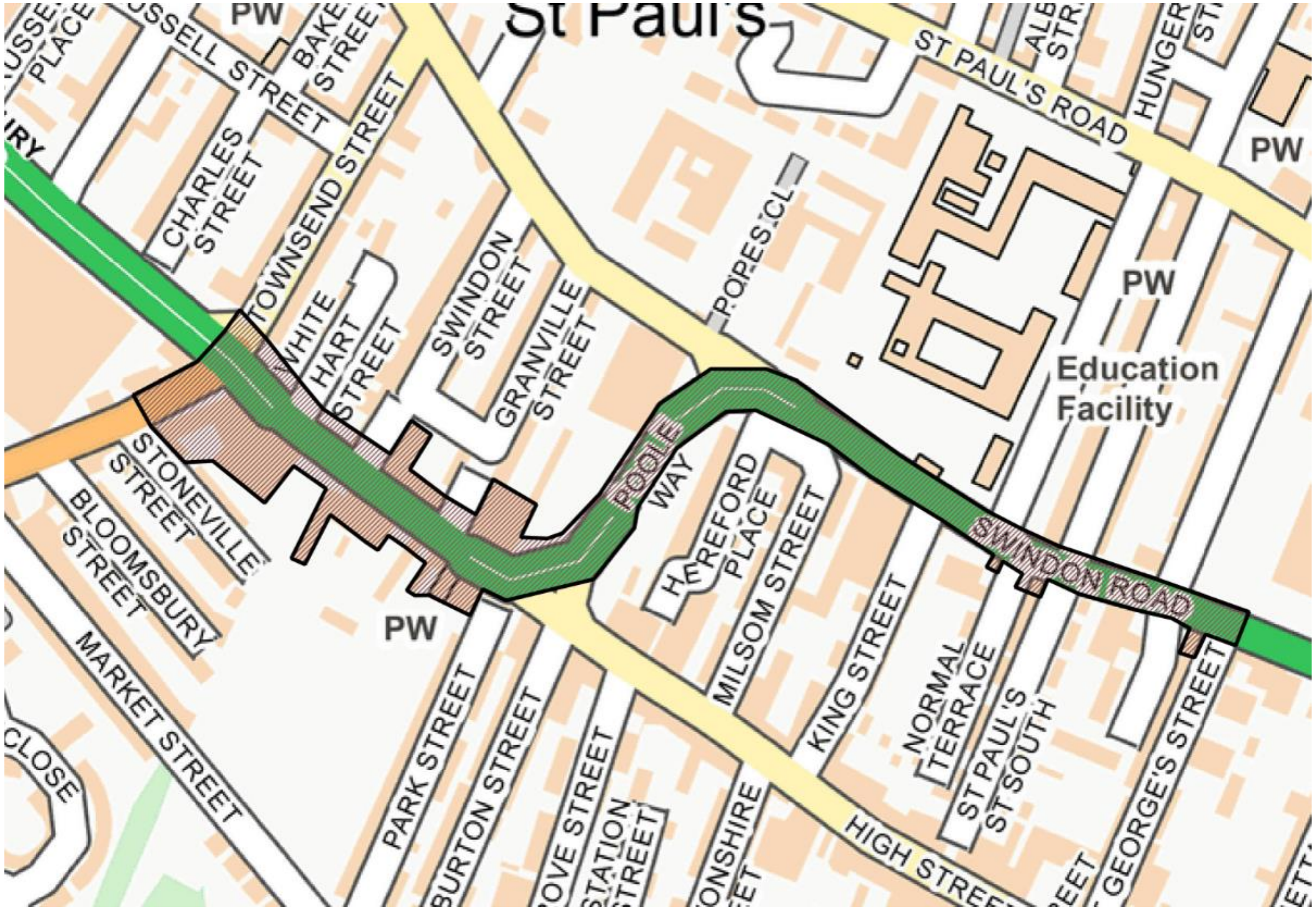
- Based on source apportionment results, any future intervention measures should be targeted at reducing vehicle emissions from all vehicle types, notably Cars and LGVs, which are both observed to be the two largest contributors to total vehicle emissions in areas of exceedance.

Following the undertaking of this modelling exercise, it is hoped that the following topics can be discussed with air quality stakeholders to aid development of the AQAP;

- Possible action plan measures being considered by the Council; and

- Ability to test the effects of these using the current dispersion model set up.

Figure 6.1 – Proposed AQMA Boundary



Legend	
Proposed AQMA - Location A	
Contains Ordnance Survey Data © Crown Copyright and database right 2018. Ordnance Survey 100049046.	
BUREAU VERITAS	Air Quality Bureau Veritas 5th Floor 66 Prescot Street London, E1 8HG
Location Cheltenham	
Title Proposed AQMA Boundary	
By BT	**Approved**
Scale Not to Scale	**Job Ref** 6475940
Date September 2019	**Figure No.** 6.1

Appendices

Appendix 1 – 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(16)[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.

The traffic data for this assessment has been collated using a combination of data provided by the highways department at GCC and DfT traffic count data, as outlined in Section 4.1.

Concentrations of NO_2 are monitored at 27 sites across Cheltenham, comprising 29 diffusion tubes and one continuous monitor (CM1), with the provision of a triplicate colocation study (Table A1) – all undertaken at roadside/kerbside locations. The following six passive monitoring locations tubes were sited outside of the modelled road network so were therefore removed from the verification:

- Site 1;
- Site 3;
- Site 22;
- Site 23;

- Site 24; and
- Site 25.

The details of the LAQM monitoring sites considered for the purposes of model verification are presented in Table A1.

Table A1 – Local Monitoring Data Available for Model Verification

Site ID	OS Grid Reference		2018 Annual Mean NO_2 (µg/m^3)	2018 Data Capture (%)
	X	Y		
2	394724	222320	28.0	100.0%
4	394235	223055	41.2	100.0%
5	394350	222923	45.2	100.0%
6	394738	222888	37.9	100.0%
7,8,9	394760	222878	32.9	91.7%
10	394830	222845	35.6	100.0%
11	395110	222670	32.6	100.0%
12	395210	222618	31.8	91.7%
13	395207	222465	31.3	100.0%
14	395362	222000	37.4	100.0%
15	395182	222183	29.1	100.0%
16	395146	222149	34.5	100.0%
17	394801	222454	31.5	100.0%
18	395660	221670	37.3	100.0%
19	393296	222170	30.6	58.3%
20	392912	221862	35.3	100.0%
21	394809	222060	23.4	100.0%
26	394902	223004	29.0	41.7%
27	395156	221866	24.8	41.7%
28	393081	223643	38.4	41.7%
29	392066	222540	31.2	41.7%
CM1	394760	222878	32.7	89.4%

NO_2 Verification calculations

The verification of the modelling output was performed in accordance with the methodology provided in Chapter 7 of LAQM.TG(16)[1].

For the verification and adjustment of NO_x/NO_2, the 2018 monitoring data presented in Table A1 was used. Five passive monitoring locations reported data capture to be below 75% for the duration of 2018, with annualisation subsequently performed to derive the reported NO_2 annual mean concentration. On the basis of the added uncertainty annualisation adds to monitored values, all five sites were removed from the verification process. These include:

- Site 19;
- Site 26;
- Site 27;
- Site 28; and
- Site 29.

In addition, passive monitoring location 7,8,9 has also been removed from the verification process due to being co-located with CM1. As a bias adjustment factor derived from CM1 was used to adjust all diffusion tubes in 2018 it is considered that the NO_2 concentration recorded by CM1 is considered more representative of the location than that at 7,8,9.

Verification was completed using the 2018 (2017 reference year) Defra background mapped concentrations for the relevant 1km x 1km grid squares within Cheltenham (i.e. those within which the model verification locations are located), as displayed in Table A5 in Appendix 2.

Table A2 below shows an initial comparison of the monitored and unverified modelled NO_2 results for the year 2018, in order to determine if verification and adjustment was required.

Table A2 – Comparison of Unverified Modelled and Monitored NO_2 Concentrations

Site ID	Background NO_2	Monitored total NO_2 (µg/m^3)	Unverified Modelled total NO_2 (µg/m^3)	% Difference (modelled vs. monitored)
2	15.9	28.0	18.7	-33.1
4	13.6	41.2	23.5	-43.0
5	15.9	45.2	23.6	-47.8
6	15.9	37.9	20.4	-46.3
10	15.9	35.6	20.5	-42.4
11	14.8	32.6	20.7	-36.4
12	14.8	31.8	19.0	-40.2
13	14.8	31.3	18.6	-40.6
14	12.9	37.4	19.8	-47.0
15	14.8	29.1	20.8	-28.7
16	14.8	34.5	21.2	-38.6
17	15.9	31.5	19.2	-38.9
18	12.9	37.3	19.8	-46.8
20	13.6	35.3	19.1	-45.9
21	15.9	23.4	18.5	-21.0
CM1	15.9	32.7	21.4	-34.4

The model was solely under predicting at all verification points, with the highest under prediction between the modelled and monitored concentrations observed at Site 5 (-47.8%). Following a review of the model inputs including road widths, prominence of urban canyons and monitoring locations no further improvement of the modelled results could be obtained on this occasion. At all sites apart from Site 21, the difference between modelled and monitored concentrations was greater than ±25%, meaning adjustment of the results was necessary. The relevant data was then gathered to allow the adjustment factor to be calculated.

Model adjustment needs to be undertaken based for NO_x and not NO_2. For the Council operated 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[15].

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.

[15] 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/m³)	Monitored total NO_x (µg/m³)	Background NO_2 (µg/m³)	Background NO_x (µg/m³)	Monitored road contribution NO_2 (total - background) (µg/m³)	Monitored road contribution NO_x (total - background) (µg/m³)	Modelled road contribution NO_x (excludes background) (µg/m³)
2	28.0	46.8	15.9	22.6	12.1	24.2	5.5
4	41.2	77.9	13.6	19.0	27.6	58.8	19.3
5	45.2	86.5	15.9	22.6	29.3	63.8	15.1
6	37.9	68.8	15.9	22.6	22.0	46.1	8.6
10	35.6	63.6	15.9	22.6	19.8	40.9	9.0
11	32.6	57.2	14.8	20.8	17.8	36.3	11.5
12	31.8	55.5	14.8	20.8	17.1	34.7	8.1
13	31.3	54.3	14.8	20.8	16.5	33.5	7.3
14	37.4	69.0	12.9	17.9	24.5	51.2	13.2
15	29.1	49.6	14.8	20.8	14.4	28.8	11.6
16	34.5	61.4	14.8	20.8	19.7	40.5	12.3
17	31.5	54.3	15.9	22.6	15.6	31.7	6.4
18	37.3	68.8	12.9	17.9	24.4	50.9	13.3
20	35.3	63.9	13.6	19.0	21.7	44.9	10.5
21	23.4	37.4	15.9	22.6	7.6	14.7	5.0
CM1	32.7	57.0	15.9	22.6	16.8	34.3	10.8

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 equation of the trend lines presented in Figure A1 gives an adjustment factor for the modelled results of 3.688.

Figure A2 and Table A4 show the ratios between monitored and modelled NO_2 for each monitoring locations whilst using an adjustment factor of 3.688. All sites considered show acceptable agreement between the ratios of monitored and modelled NO_2 all being within 25%, with 12 within ±10%. A verification factor of 3.688 was therefore used to adjust the model results. A factor of 3.688 reduces the Root Mean Square Error (RMSE) from a value of 14.3 to 3.4, within the recommended limit (4.0) highlighting there are consistencies in the model performance at all verification locations.

The adjustment factor of 3.688 was applied to the road-NOx concentrations predicted by the model to arrive at the final NO_2 concentrations.

Figure A1 – Comparison of the Modelled Road Contribution NO_x versus Monitored Road Contribution NO_x across all verification points

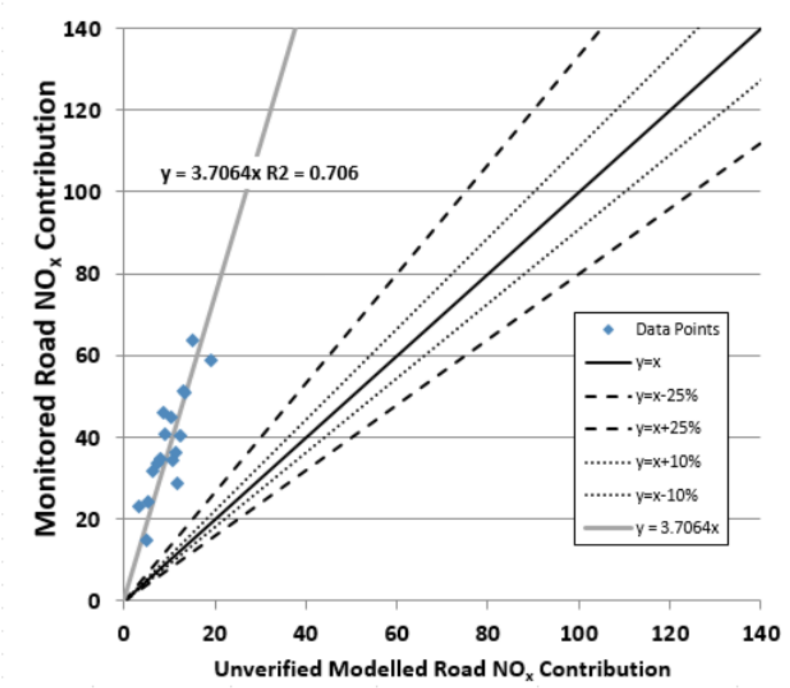


Figure A2 – Comparison of the Verified Modelled Total NO_2 versus Monitored NO_2

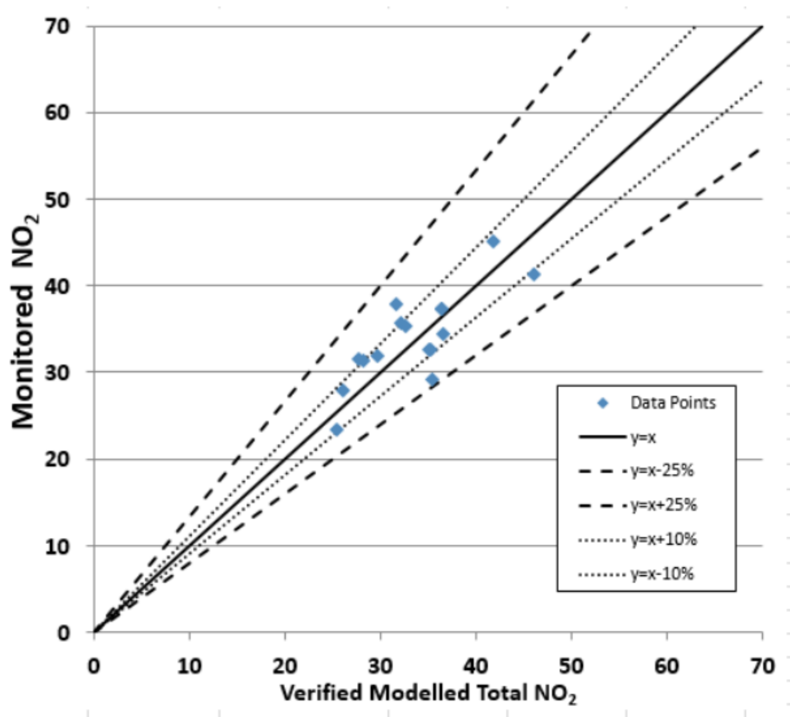


Table A4 – Adjustment Factor and Comparison of Verified Results against Monitoring Results

Site ID	Ratio of monitored road contribution NO_x / modelled road contribution NOx	Adjustment factor for modelled road contribution NO_x	Adjusted modelled road contribution NO_x (µg/m³)	Adjusted modelled total NO_x (including background NO_x) (µg/m³)	Modelled total NO_2 (based upon empirical NO_x / NO_2 relationship) (µg/m³)	Monitored total NO_2 (µg/m³)	% Difference (adjusted modelled NO_2 vs. monitored NO_2)
2	4.43	3.688	20.1	42.8	26.1	28.0	-6.9
4	3.06		71.0	90.1	46.1	41.2	11.8
5	4.23		55.6	78.3	41.9	45.2	-7.4
6	5.34		31.9	54.5	31.6	37.9	-16.7
10	4.56		33.1	55.8	32.1	35.6	-9.8
11	3.17		42.2	63.1	35.2	32.6	8.1
12	4.26		30.0	50.9	29.7	31.8	-6.7
13	4.61		26.8	47.6	28.2	31.3	-9.9
14	3.87		48.8	66.7	36.4	37.4	-2.7
15	2.49		42.7	63.5	35.4	29.1	21.5
16	3.29		45.3	66.2	36.6	34.5	6.1
17	4.93		23.7	46.3	27.8	31.5	-11.8
18	3.84		48.9	66.7	36.4	37.3	-2.3
20	4.27		38.8	57.8	32.6	35.3	-7.7
21	2.92		18.6	41.3	25.3	23.4	8.2
CM1	3.19		39.7	62.4	35.1	32.7	7.3

Appendix 2 – Background Concentrations Used

Table A5 – Defra Background Pollutant Concentrations Covering the Modelled Domain

Grid Square (E,N)	2018 Annual Mean Background Concentration (µg/m³)				
	NO_x			NO_2	
	Total Background[1]	Contribution to Remove	Revised Background[2]	Total Background[1]	Revised Background[3]
391500, 220500	15.9	0.0	15.9	11.6	11.6
392500, 220500	15.7	0.0	15.7	11.5	11.5
393500, 220500	15.4	0.8	14.6	11.4	10.8
394500, 220500	15.7	0.6	15.1	11.5	11.1
395500, 220500	14.2	0.0	14.2	10.5	10.5
396500, 220500	14.5	0.9	13.5	10.7	10.1
397500, 220500	12.6	0.8	11.8	9.4	8.8
391500, 221500	21.6	2.0	19.6	15.3	14.0
392500, 221500	20.2	1.1	19.0	14.4	13.6
393500, 221500	18.4	1.3	17.2	13.3	12.5
394500, 221500	21.3	2.4	19.0	15.1	13.6
395500, 221500	20.2	2.3	17.9	14.4	12.9
396500, 221500	17.1	0.7	16.4	12.4	11.9
397500, 221500	12.7	0.0	12.7	9.5	9.5
391500, 222500	18.8	1.1	17.7	13.5	12.8
392500, 222500	19.5	1.4	18.1	14.0	13.1
393500, 222500	21.5	0.0	21.5	15.2	15.2
394500, 222500	24.4	1.7	22.6	16.9	15.9
395500, 222500	22.9	2.1	20.8	16.1	14.8
396500, 222500	17.8	0.0	17.8	12.9	12.9
397500, 222500	13.4	0.0	13.4	10.0	10.0
391500, 223500	15.6	0.0	15.6	11.4	11.4
392500, 223500	18.7	1.5	17.2	13.5	12.5
393500, 223500	22.4	2.0	20.4	15.7	14.5
394500, 223500	19.5	0.4	19.0	13.9	13.6
395500, 223500	18.9	0.8	18.1	13.6	13.1
396500, 223500	20.7	0.0	20.7	14.7	14.7
397500, 223500	14.8	0.0	14.8	10.9	10.9
391500, 224500	15.9	0.6	15.2	11.7	11.2
392500, 224500	17.6	1.4	16.2	12.8	11.9
393500, 224500	22.8	0.3	22.4	15.8	15.7
394500, 224500	17.1	0.0	17.1	12.4	12.4
395500, 224500	16.4	0.9	15.6	12.0	11.4
396500, 224500	14.8	0.0	14.8	10.9	10.9
397500, 224500	14.2	0.0	14.2	10.5	10.5

Notes:
[1] Values obtained from the 2018 NO_x and NO_2 Defra Mapped Background estimates for the relevant 1km x 1km grid squares covering the modelled domain
[2] Revised NO_x background = Total NO_x background – Sum of identified road NO_x contributions
[3] Revised NO_2 background = Accounts for the removal of the identified road NO_x contributions, calculated using the NO_2 adjustment for NO_x sector removal tool (V7.0) due to the nonlinear relationship between NO_x and NO_2.

Appendix 3 – Traffic Inputs

Table A6 – Traffic Data used in the Detailed Assessment

Road Name	AADT	Car (%)	LGV (%)	HGV (%)	Bus and Coaches (%)	Motorcycles (%)	Average Speed (kph)
Tewkesbury Road	22322	-	-	6.3	-	-	64.4
Evesham Road	12557	-	-	4.2	-	-	48.3
High Street	14656	-	-	2.0	-	-	38.3
Prestbury Road	10847	-	-	15.2	-	-	48.3
Princess Elizabeth Way	18742	-	-	2.1	-	-	48.3
Saint Georges Road	13517	-	-	4.7	-	-	48.3
Princess Elizabeth Way	25456	-	-	2.1	-	-	48.3
Kingsditch Lane	22146	-	-	36.4	-	-	48.3
Rodney Road	5832	-	-	0.4	-	-	48.3
Winchcombe Street	1881	-	-	0.4	-	-	32.2
Wellington Street	954	-	-	1.8	-	-	48.3
Bath Street	856	-	-	1.8	-	-	38.3
Royal Well Road	7579	-	-	4.7	-	-	48.3
Princess Elizabeth Way	17764	-	-	2.1	-	-	48.3
Winchcombe Street	2159	-	-	0.4	-	-	38.3
Leckhampton Road	10175	91.2	5.4	2.3	0.4	0.7	48.3
Hewlett Road	5347	93.2	4.2	1.7	0.1	0.8	48.3
Suffolk Road	9794	87.5	8.5	3.0	0.2	0.9	48.3
Cirencester Road	7193	90.1	6.2	2.7	0.3	0.7	48.3
Gloucester Road	13059	92.4	3.7	2.5	0.2	1.2	48.3
Winchcombe Street	7137	85.7	9.4	3.6	0.5	0.8	48.3
Albion Street	5081	91.9	5.6	1.8	0.2	0.6	25.9
Tewkesbury Road	26503	81.9	14.2	2.6	0.6	0.7	64.4
Poole Way	14244	82.4	13.9	2.5	0.6	0.6	32.2
Bath Road	12465	85.1	12.1	1.3	0.3	1.1	48.3
Montpellier	11801	85.6	11.5	1.3	0.7	0.9	48.3
Albion Street	6183	83.5	12.2	1.4	2.0	0.9	48.3
Clarence Road	8901	85.0	11.6	1.6	1.4	0.4	48.3
A40	18207	86.0	9.9	1.2	2.1	0.8	54.4
A46	8704	85.0	11.6	1.6	1.4	0.4	33.6
A46	7825	78.3	14.1	1.9	5.1	0.5	38.3
A40	11490	85.5	12.2	1.1	0.8	0.5	48.3

Road Name	AADT	Car (%)	LGV (%)	HGV (%)	Bus and Coaches (%)	Motorcycles (%)	Average Speed (kph)
A40	17374	84.2	12.2	2.1	0.9	0.6	48.3
A435	14057	82.8	14.5	1.8	0.5	0.4	48.3
A4019	14595	82.4	13.9	2.5	0.6	0.6	28.0
A46	10752	85.6	11.5	1.3	0.7	0.9	48.3
A40	11910	87.3	10.0	1.2	0.4	1.0	48.3
A40	9994	86.7	10.7	1.4	0.6	0.6	43.8
A46	6452	85.0	12.8	1.4	0.1	0.8	48.3
A40	11804	85.6	12.0	1.4	0.4	0.7	48.3
A4015	14569	81.1	13.3	1.2	3.8	0.6	48.3
A40	10624	84.3	13.3	1.5	0.4	0.6	48.3
A46	10785	83.5	13.4	1.2	0.3	1.7	48.3
A46	14260	81.9	15.5	1.4	0.5	0.7	48.3
A46	7938	83.5	12.2	1.4	2.0	0.9	32.2
A40	24134	84.1	11.4	1.9	1.7	0.9	64.4
A46	4570	82.3	13.2	2.7	1.1	0.7	32.2
A46	12200	82.6	14.6	2.2	0.3	0.3	48.3
A40	11773	78.3	18.3	2.2	0.7	0.4	64.4
A46	17219	87.1	10.4	1.0	1.0	0.5	54.6
A40	51895	83.9	12.0	2.5	0.6	1.0	64.4
A435	12281	85.0	9.7	2.0	2.7	0.6	48.3
A46	9515	87.2	10.8	0.6	1.0	0.5	38.3
A46	13910	82.3	14.2	1.9	0.8	0.8	48.3

Notes

Traffic flows and vehicle class compositions were taken from the GCC roads traffic database and the DfT traffic count point database

Traffic speeds were modelled at either the relevant speed limit for each road or where available monitored vehicle speeds

Where appropriate, vehicle speeds have been reduced to simulate queues at junctions, traffic lights and other locations where queues or slower traffic are known to be an issue – in accordance with LAQM TG(16)[1]

Appendix 4 – Receptor Locations and Corresponding Modelled Predictions

Table A7 – Predicted Annual Mean Concentrations of NO_2 at Discrete Receptor Locations: 2018 B

Receptor ID	Within AQMA?	X	Y	Height	Closest address/post code	2018 Annual Mean NO_2 Concentration (µg/m^3)
1	Y	391956	222037	1.5	Edgeworth Miserden Road, Cheltenham, GL51 6BW	33.5
2	Y	391862	222021	1.5	15 Miserden Road, Cheltenham, GL51 6BP	31.9
3	Y	392013	222033	1.5	5 Miserden Road, Cheltenham, GL51 6BN	27.2
4	Y	392006	222119	1.5	Gloucester Road, Cheltenham, GL51 7	43.2
5	Y	391990	222184	1.5	80 Monkscroft, Cheltenham, GL51 7TX	34.3
6	Y	392064	222078	1.5	47 Monkscroft, Cheltenham, GL51 7TT	30.3
7	Y	391905	222033	1.5	9 Miserden Road, Cheltenham, GL51 6BP	35.8
8	Y	391777	221979	1.5	25 Miserden Road, Cheltenham, GL51 6BP	28.9
9	Y	392123	222065	1.5	42 Wasley Road, Cheltenham, GL51 7TW	26.7
10	Y	391994	222245	1.5	34 Cowper Road, Cheltenham, GL51 7ST	27.1
11	Y	392027	222160	1.5	112 Monkscroft, Cheltenham, GL51 7TY	27.7
12	Y	392053	222120	1.5	11 Monkscroft, Cheltenham, GL51 7TS	25.6
13	Y	391887	222101	0.0	Aston Court Sotherby Drive, Cheltenham, GL51 0FS	51.1
14	Y	391851	222092	0.0	Bentley Court Sotherby Drive, Cheltenham, GL51 0FQ	35.6
15	Y	391922	222156	0.0	Corinne Court, Cheltenham, GL51 0	36.2
16	Y	391932	222189	0.0	Princess Elizabeth Way, Cheltenham, GL51 0	30.4
17	Y	391910	222136	0.0	Aston Court, Cheltenham, GL51 0	40.3
18	Y	391891	222162	0.0	Carver Court Sotherby Drive, Cheltenham, GL51 0FT	26.8
19	Y	391999	222324	1.5	30 Australia House Princess Elizabeth Way, Cheltenham, GL51 7SW	26.2
20	Y	392118	222637	1.5	Tasmania House Princess Elizabeth Way, Cheltenham, GL51 7SG	24.9
21	Y	392126	222688	4.0	Gresham Court Princess Elizabeth Way, Cheltenham, GL51 7SQ	27.9
22	Y	392140	222696	4.0	Franklyn Court Edinburgh Place, Cheltenham, GL51 7SF	28.3
23	Y	392201	222734	1.5	217 Princess Elizabeth Way, Cheltenham, GL51 7RS	28.9
24	Y	392206	222770	1.5	223 Princess Elizabeth Way, Cheltenham, GL51 7RS	28.8
25	Y	392106	222783	1.5	Marsland Road, Cheltenham,	26.5

Receptor ID	Within AQMA?	X	Y	Height	Closest address/post code	2018 Annual Mean NO_2 Concentration (µg/m^3)
					GL51 0	
26	Y	392217	222852	1.5	Annecy Court Queens Place, Cheltenham, GL51 7NZ	29.0
27	Y	392241	222986	1.5	Eastnor House Princess Elizabeth Way, Cheltenham, GL51 7PX	26.0
28	Y	392260	223050	1.5	Berkeley House Princess Elizabeth Way, Cheltenham, GL51 7PT	25.7
29	Y	392297	223125	1.5	143 Orchard Avenue, Cheltenham, GL51 7NJ	27.5
30	Y	392443	223306	1.5	38 Bramley Road, Cheltenham, GL51 7LT	24.7
31	Y	392471	223340	1.5	23 Bramley Road, Cheltenham, GL51 7LR	25.9
32	Y	392518	223418	1.5	Princess Elizabeth Way, Cheltenham, GL51 0	25.3
33	Y	392549	223394	1.5	Telford House Princess Elizabeth Way, Cheltenham, GL51 7PN	25.0
34	Y	392895	223576	1.5	5 Princess Elizabeth Way, Cheltenham, GL51 7PF	31.7
35	Y	392995	223628	1.5	12 Princess Elizabeth Way, Cheltenham, GL51 7PE	28.3
36	Y	393052	223608	1.5	56 Princess Elizabeth Way, Cheltenham, GL51 7NY	26.8
37	Y	393127	223760	1.5	1 Frank Brookes Road, Cheltenham, GL51 0UW	27.7
38	Y	393186	223833	1.5	29 Frank Brookes Road, Cheltenham, GL51 0UW	32.5
39	Y	393125	224021	1.5	69 Glynbridge Gardens, Cheltenham, GL51 0BZ	30.3
40	Y	393103	224039	1.5	61 Glynbridge Gardens, Cheltenham, GL51 0BZ	29.7
41	Y	393057	224059	1.5	43 Glynbridge Gardens, Cheltenham, GL51 0BZ	25.0
42	Y	393415	223732	1.5	2 Brook Road, Cheltenham, GL51 9DZ	29.0
43	Y	393487	223659	1.5	8 Tewkesbury Road, Cheltenham, GL51 9EH	28.2
44	Y	393740	223507	1.5	111 Tewkesbury Road, Cheltenham, GL51 9DP	29.2
45	Y	393793	223471	1.5	105 Tewkesbury Road, Cheltenham, GL51 9DN	28.7
46	Y	393909	223378	1.5	79 Tewkesbury Road, Cheltenham, GL51 9BN	28.1
47	Y	394048	223227	1.5	43 Tewkesbury Road, Cheltenham, GL51 9AR	29.3
48	Y	393989	223296	1.5	2 Sun Street, Cheltenham, GL51 9AS	29.2
49	Y	394109	223171	1.5	2 Russell Place, Cheltenham, GL51 9HR	28.8
50	Y	394259	223038	1.5	3 Townsend Street, Cheltenham, GL51 9HA	34.9
51	Y	394248	223050	1.5	6 Townsend Street, Cheltenham, GL51 9HD	34.8
52	Y	394281	223013	1.5	2 White Hart Street, Cheltenham, GL51 9ER	33.5
53	Y	394233	223001	3.5	Honeybourne Gate, 2 Gloucester Road,	32.1

Receptor ID	Within AQMA?	X	Y	Height	Closest address/post code	2018 Annual Mean NO_2 Concentration ($\mu g/m^3$)
					Cheltenham, GL51 8DW	
54	Y	394205	222989	1.5	4 Gloucester Road, Cheltenham, GL51 8PQ	32.1
55	Y	394250	223000	3.5	Honeybourne Gate, 2 Gloucester Road, Cheltenham, GL51 8DW	36.7
56	Y	394271	222984	3.5	2 White Hart Street, Cheltenham, GL51 9ER	38.7
57	Y	394307	222979	1.5	1 Rembridge Court Swindon Street, Cheltenham, GL50 3HZ	44.3
58	Y	394341	222954	1.5	Chelone House, 443 High Street, Cheltenham, GL50 3HX	44.2
59	Y	394314	222951	3.5	446a High Street, Cheltenham, GL50 3JA	37.4
60	Y	394360	222917	1.5	416 High Street, Cheltenham, GL50 3JA	52.6
61	Y	394380	222929	1.5	Churchill Court 433-435 High Street, Cheltenham, GL50 3HU	43.7
62	Y	394384	222898	1.5	GL50 3NZ	34.3
63	Y	394497	222986	1.5	GL50 4BE	27.9
64	Y	394609	222942	1.5	GL50 4AS	34.3
65	Y	394519	222978	1.5	GL50 4BD	25.4
66	Y	394670	222934	1.5	GL50 4AH	31.2
67	Y	394691	222931	1.5	GL50 4AH	28.8
68	Y	394727	222916	1.5	GL50 4AH	30.6
69	Y	394684	222901	1.5	GL50 4AH	31.2
70	Y	394665	222914	1.5	GL50 4AS	40.8
71	Y	394745	222886	1.5	GL50 4AL	41.8
72	Y	394763	222879	1.5	GL50 4AL	39.0
73	Y	394788	222866	1.5	GL50 4AL	33.7
74	Y	394823	222852	1.5	GL50 4AL	35.5
75	Y	394835	222868	4.0	GL50 4FF	27.9
76	Y	394973	222739	1.5	GL50 4FB	36.0
77	Y	394994	222723	1.5	GL50 4DZ	35.2
78	Y	395033	222681	1.5	GL50 4FH	33.2
79	Y	395116	222668	3.5	GL52 2NB	31.0
80	Y	395101	222643	3.5	GL52 2NB	28.8
81	Y	395204	222614	1.5	GL52 2NY	33.7
82	Y	395231	222606	1.5	GL52 2NY	34.0
83	Y	395213	222640	1.5	GL52 2NN	32.3
84	Y	395260	222588	1.5	GL52 2AT	31.0
85	Y	395252	222625	1.5	GL52 2AT	28.3
86	Y	395311	222590	1.5	GL52 2JL	25.3
87	Y	395280	222567	1.5	GL52 2AD	25.8
88	Y	395284	222575	3.5	GL52 2AD	26.5
89	Y	395396	222527	1.5	GL52 2EH	24.8
90	Y	395360	222389	1.5	116 Tom Price Close, Cheltenham, GL52 2LF	27.0
91	Y	395413	222477	1.5	87 Fairview Road, Cheltenham, GL52 2EX	25.3
92	Y	395352	222332	1.5	65 Tom Price Close, Cheltenham, GL52 2LE	27.7
93	Y	395026	222573	3.5	1 Albion Street, Cheltenham,	26.5

Receptor ID	Within AQMA?	X	Y	Height	Closest address/post code	2018 Annual Mean NO_2 Concentration ($\mu g/m^3$)
					GL52 2LH	
94	Y	395072	222561	3.5	12 Albion Street, Cheltenham, GL52 2LP	26.1
95	Y	395127	222521	3.5	30a Albion Street, Cheltenham, GL52 2LP	26.3
96	Y	395146	222509	3.5	32 Albion Street, Cheltenham, GL52 2RQ	25.9
97	Y	395178	222487	3.5	44 Albion Street, Cheltenham, GL52 2RQ	25.2
98	Y	395236	222449	1.5	70a Albion Street, Cheltenham, GL52 2RW	26.8
99	Y	395322	222292	1.5	Albion House, 103 Albion Street, Cheltenham, GL52 2UG	26.2
100	Y	395385	222232	1.5	Mill House 121-123 Albion Street, Cheltenham, GL52 2SW	33.3
101	Y	395398	222240	1.5	1 St Annes Road, Cheltenham, GL52 2SS	36.6
102	Y	395415	222228	1.5	136 Albion Street, Cheltenham, GL52 2SU	31.3
103	Y	395416	222180	1.5	7 Berkeley Street, Cheltenham, GL52 2SY	31.0
104	Y	395407	222154	1.5	Saxthorpe Berkeley Street, Cheltenham, GL52 2SY	29.1
105	Y	395353	222127	1.5	2 Berkeley Street, Cheltenham, GL52 6	29.8
106	Y	395343	222072	1.5	9 Berkeley Place, Cheltenham, GL52 6GA	36.6
107	Y	395328	222080	1.5	15 Berkeley Place, Cheltenham, GL52 6DB	36.9
108	Y	395290	222028	1.5	20 High Street, Cheltenham, GL50 1DZ	33.8
109	Y	395267	222053	1.5	30 High Street, Cheltenham, GL50 1DZ	34.0
110	Y	395252	222069	1.5	36 High Street, Cheltenham, GL50 1EE	33.2
111	Y	395268	222086	1.5	3 Berkeley Court High Street, Cheltenham, GL52 6DA	36.1
112	Y	395196	222149	3.5	58 High Street, Cheltenham, GL50 1EE	32.4
113	Y	395184	222161	3.5	64 High Street, Cheltenham, GL50 1EE	32.1
114	Y	395187	222183	4.0	63a High Street, Cheltenham, GL50 1DU	28.9
115	Y	395175	222170	3.5	68 High Street, Cheltenham, GL50 1EE	33.5
116	Y	395152	222150	3.5	8a Bath Road, Cheltenham, GL53 7HA	30.9
117	Y	395078	222109	1.5	Park Gate, 25 Bath Road, Cheltenham, GL53 7HG	31.6
118	Y	395052	222086	1.5	39 Bath Road, Cheltenham, GL53 7HG	29.6
119	Y	395035	222036	1.5	Gainsborough House, 42 Bath Road, Cheltenham, GL53 7HW	31.1
120	Y	395021	222049	0.0	43 Bath Road, Cheltenham, GL53 7HG	34.2
121	Y	395018	222016	1.5	Playhouse Court Bath Road, Cheltenham, GL53 7HJ	30.1

Receptor ID	Within AQMA?	X	Y	Height	Closest address/post code	2018 Annual Mean NO_2 Concentration ($\mu g/m^3$)
122	Y	395000	221994	0.0	Arlington House 54-56 Bath Road, Cheltenham, GL53 7HJ	28.3
123	Y	394909	222010	1.5	Oriel House Oriel Road, Cheltenham, GL50 1XP	25.2
124	Y	394557	221997	4.0	GL50 1NN	26.6
125	Y	394544	221981	4.0	GL50 1SA	26.2
126	Y	394438	221748	0.0	GL50 1US	28.8
127	Y	394470	221731	0.0	GL50 1UX	26.5
128	Y	394496	221718	0.0	GL50 1UX	26.2
129	Y	394614	221673	0.0	GL50 2XH	25.9
130	Y	394595	221677	0.0	GL50 2XL	25.0
131	Y	394702	221314	1.5	GL53 7LS	25.2
132	Y	394614	221161	1.5	GL53 7LY	25.3
133	Y	394588	221111	1.5	GL53 7LZ	25.8
134	Y	394577	221075	1.5	GL53 7ND	33.1
135	Y	394569	221063	0.0	GL53 7NA	30.1
136	Y	394563	221045	0.0	GL53 7NA	30.6
137	Y	394542	221004	3.5	GL53 0JB	30.3
138	Y	394536	220998	1.5	GL53 0JB	31.8
139	Y	394500	220958	1.5	GL53 0JA	38.3
140	Y	394481	220947	1.5	GL53 0JA	30.3
141	Y	394440	220913	1.5	GL50 2DP	29.5
142	Y	394888	221370	1.5	GL53 7AA	25.4
143	Y	394926	221349	1.5	GL53 7AA	25.9
144	Y	394966	221934	1.5	GL53 7JT	25.1
145	Y	395154	221832	0.0	GL53 7HX	25.2
146	Y	395139	221810	0.0	GL53 7HX	26.1
147	Y	395365	222007	0.0	GL52 6DE	36.1
148	Y	395385	221995	0.0	GL52 6DF	29.0
149	Y	395420	221969	0.0	GL52 6DF	27.8
150	Y	395631	221711	1.5	GL52 6DF	27.9
151	Y	395679	221690	0.0	GL52 6DF	32.1
152	Y	395661	221670	1.5	GL52 6DF	33.9
153	Y	395632	221689	1.5	GL52 6EW	27.5
154	Y	395604	221656	0.0	GL52 6EW	25.5
155	Y	395491	221471	1.5	GL52 6EW	24.7
156	Y	395539	221509	1.0	GL52 6EW	28.8
157	Y	395679	221645	0.0	GL52 6EW	30.9
158	Y	395690	221629	0.0	GL52 6EH	28.9
159	Y	395706	221612	0.0	GL52 6EH	30.4
160	Y	395745	221555	0.0	GL52 6EH	26.4
161	Y	395830	221496	1.5	GL52 6EH	27.8
162	Y	395865	221446	0.0	GL52 6EH	36.2
163	Y	395934	221371	1.5	GL52 6SD	29.1
164	Y	395955	221350	0.0	GL52 6SD	28.8
165	Y	395121	222686	3.5	Friends Meeting House, Warwick Place, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2NP, United Kingdom	30.4
166	Y	395183	222799	0.0	Trinity, Portland Street, Sandford, Pittville, Cheltenham, Gloucestershire, South West England,	30.3

Receptor ID	Within AQMA?	X	Y	Height	Closest address/post code	2018 Annual Mean NO_2 Concentration (µg/m^3)
					England, GL52 2NB, United Kingdom	
167	Y	395200	222829	0.0	Portland Street Car Park, Portland Street, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2NB, United Kingdom	30.6
168	Y	395213	222847	1.5	7, Clarence Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2AY, United Kingdom	31.8
169	Y	395183	222858	0.0	Clarence Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2AU, United Kingdom	31.5
170	Y	395195	222885	0.0	2, Evesham Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2AB, United Kingdom	33.0
171	Y	395227	222872	0.0	Blenheim House, Evesham Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2AA, United Kingdom	33.7
172	Y	395218	222939	0.0	16, Evesham Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2AB, United Kingdom	28.3
173	Y	395252	222929	0.0	GL52 2AA	26.8
174	Y	395249	223022	0.0	36, Evesham Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2AB, United Kingdom	25.6
175	Y	395251	222732	0.0	Robert Harvey House, Winchcombe Street, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2NL, United Kingdom	28.8
176	Y	395271	222773	0.0	Robert Harvey House, Winchcombe Street, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2NL, United Kingdom	28.5
177	Y	395278	222788	0.0	Robert Harvey House, Winchcombe Street, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2NL, United	28.7

Receptor ID	Within AQMA?	X	Y	Height	Closest address/post code	2018 Annual Mean NO_2 Concentration ($\mu g/m^3$)
					Kingdom	
178	Y	395272	222823	1.5	1, Clarence Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2AZ, United Kingdom	30.7
179	Y	395292	222811	1.5	Dream Doors, 1, Prestbury Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2PN, United Kingdom	29.2
180	Y	395323	222836	3.5	Pittville Motorcycles, 11-17, Prestbury Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2PN, United Kingdom	30.1
181	Y	395351	222850	3.5	Smith & Mann, 19-23, Prestbury Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2PN, United Kingdom	29.8
182	Y	395386	222859	1.5	Pittville Chips & Indian Balti, 27, Prestbury Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2PP, United Kingdom	28.5
183	Y	395416	222903	0.0	18, Prestbury Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2PW, United Kingdom	36.3
184	Y	395448	222922	0.0	30, Prestbury Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2PW, United Kingdom	35.0
185	Y	395457	222904	0.0	Pittville Circus, Prestbury Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2PN, United Kingdom	34.8
186	Y	395437	222893	0.0	2b, Albert Place, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2HP, United Kingdom	34.2
187	Y	395516	222968	1.5	Southend House, 32, Prestbury Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2BY, United Kingdom	33.0

Receptor ID	Within AQMA?	X	Y	Height	Closest address/post code	2018 Annual Mean NO_2 Concentration (µg/m^3)
188	Y	395550	222994	0.0	36, Prestbury Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2BZ, United Kingdom	29.6
189	Y	395559	222958	0.0	49, Prestbury Road, Sandford, Pittville, Cheltenham, Gloucestershire, South West England, England, GL52 2BZ, United Kingdom	27.0
190	Y	395636	223055	0.0	56, Prestbury Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 3EP, United Kingdom	26.7
191	Y	395714	223088	1.5	66, Prestbury Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 3EP, United Kingdom	28.3
192	Y	395758	223082	1.5	M&S Simply Food, 80-86, Prestbury Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 2DJ, United Kingdom	25.8
193	Y	395853	223178	1.5	Prestbury Cars of Cheltenham, Prestbury Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 3EP, United Kingdom	28.0
194	Y	395915	223249	1.5	Cromwell Road, Shaw Green, Whaddon, Cheltenham, Gloucestershire, South West England, England, GL52 5DW, United Kingdom	28.2
195	Y	395883	223208	1.5	Prestbury Cars of Cheltenham, Prestbury Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 3EP, United Kingdom	25.9
196	Y	395954	223309	1.5	Shaw Green, Cleevemount, Cheltenham, Gloucestershire, South West England, England, GL52 2DU, United Kingdom	29.6
197	Y	395973	223295	1.5	Fox and Hounds, Prestbury Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 3EP, United Kingdom	27.6

Receptor ID	Within AQMA?	X	Y	Height	Closest address/post code	2018 Annual Mean NO_2 Concentration (µg/m^3)
198	Y	396009	223322	1.5	2, Prestbury Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 3EP, United Kingdom	29.0
199	Y	396047	223373	1.5	Chelbury Mews, Prestbury Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 3EP, United Kingdom	37.7
200	Y	396066	223362	1.5	Chelbury Mews, Prestbury Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 3EP, United Kingdom	27.3
201	Y	396128	223430	1.5	Welland Lodge Rd, Prestbury Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 3EP, United Kingdom	31.6
202	Y	396251	223555	1.5	The Prestbury Centre, Prestbury Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 3EP, United Kingdom	30.0
203	Y	396218	223491	1.5	Hannah Boote House, Whaddon Footpath, Shaw Green, Whaddon, Cheltenham, Gloucestershire, South West England, England, GL52 5ED, United Kingdom	26.4
204	Y	396201	223518	1.5	Welland Lodge Rd, Prestbury Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 3EP, United Kingdom	27.3
205	Y	396268	223530	1.5	The Prestbury Centre, Prestbury Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 3EP, United Kingdom	25.1
206	Y	396486	223639	1.5	Coronation Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 3DA, United Kingdom	25.3
207	Y	396540	223662	1.5	Prestbury Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 3DB, United Kingdom	26.3

Receptor ID	Within AQMA?	X	Y	Height	Closest address/post code	2018 Annual Mean NO_2 Concentration (µg/m^3)
208	Y	396653	223717	1.5	The Laurels, 312, Prestbury Road, Shaw Green, Prestbury, Cheltenham, Gloucestershire, South West England, England, GL52 3DB, United Kingdom	34.5
209	Y	392187	222049	1.5	Benhall Gardens, Monkscroft Estate, St Mark's, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	25.6
210	Y	392490	221878	1.5	Gloucester Road, St Mark's, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	27.1
211	Y	392536	221855	1.5	Gloucester Road, St Mark's, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	27.2
212	Y	392585	221837	1.5	Granley Road, Gloucester Road, St Mark's, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	27.4
213	Y	392776	221809	1.5	T.G.I. Fridays, 374, Gloucester Road, St Mark's, Cheltenham, Gloucestershire, South West England, England, GL51 7AY, United Kingdom	31.6
214	Y	392798	221834	1.5	T.G.I. Fridays, 374, Gloucester Road, St Mark's, Cheltenham, Gloucestershire, South West England, England, GL51 7AY, United Kingdom	34.6
215	Y	392713	221806	0.0	Londis, Gloucester Road, St Mark's, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	27.4
216	Y	392684	221810	0.0	Londis, Gloucester Road, St Mark's, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	27.5
217	Y	392629	221823	1.5	Granley Road, St Mark's, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	27.7
218	Y	392603	221831	1.5	Granley Road, Gloucester Road, St Mark's, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	27.5
219	Y	392917	221841	1.5	Lansdown Road, St Mark's,	33.4

Receptor ID	Within AQMA?	X	Y	Height	Closest address/post code	2018 Annual Mean NO_2 Concentration (µg/m³)
					Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	
220	Y	393932	221637	1.5	Sandford, Tivoli, Cheltenham, Gloucestershire, South West England, England, GL50 2TR, United Kingdom	33.5
221	Y	393942	221655	1.5	Lansdown Road, Sandford, Tivoli, Cheltenham, Gloucestershire, South West England, England, GL50 2HY, United Kingdom	32.9
222	Y	393934	221604	1.5	Andover Road, Sandford, Tivoli, Cheltenham, Gloucestershire, South West England, England, GL50 2TL, United Kingdom	34.0
223	Y	393975	221659	0.0	Lansdown Road, Sandford, Montpellier, Cheltenham, Gloucestershire, South West England, England, GL50 2HT, United Kingdom	25.0
224	Y	394260	221789	0.0	Lansdown Road, Sandford, Montpellier, Cheltenham, Gloucestershire, South West England, England, GL50 2HT, United Kingdom	25.1
225	Y	394355	221753	0.0	Suffolk Square, Sandford, Montpellier, Cheltenham, Gloucestershire, South West England, England, GL50 2QG, United Kingdom	29.8
226	Y	392888	221866	0.0	Church Road, St Mark's, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	28.4
227	Y	392910	221854	1.5	Church Rd, Gloucester Road, Lansdown, Cheltenham, Gloucestershire, South West England, England, GL51 7AE, United Kingdom	35.9
228	Y	392932	221871	1.5	Lansdown Castle Drive, Gloucester Road, Lansdown, Cheltenham, Gloucestershire, South West England, England, GL51 7AE, United Kingdom	31.4
229	Y	392910	221884	1.5	Church Rd, Gloucester Road, Lansdown, Cheltenham, Gloucestershire, South West England, England, GL51 7AE, United Kingdom	28.2
230	Y	392996	221920	1.5	Lansdown Castle Drive, Gloucester Road, Lansdown, Cheltenham, Gloucestershire, South West England, England, GL51 7AE, United Kingdom	26.3

Receptor ID	Within AQMA?	X	Y	Height	Closest address/post code	2018 Annual Mean NO_2 Concentration ($\mu g/m^3$)
231	Y	393092	222036	1.5	Cheltenham Spa Railway Station, Gloucester Road, Lansdown, Cheltenham, Gloucestershire, South West England, England, GL51 7AE, United Kingdom	26.7
232	Y	393143	222083	1.5	Libertus Road, Rowanfield, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	25.1
233	Y	393306	222175	1.5	Ladyzone Gym Cheltenham, Gloucester Road, Alstone, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	25.3
234	Y	393438	222318	0.0	The Vineyards, Gloucester Road, Alstone, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	27.3
235	Y	393494	222366	1.5	The Vineyards, Gloucester Road, Alstone, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	25.3
236	Y	393791	222585	1.5	St Georges Gate, Saint Georges Road, Sandford, Alstone, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	24.9
237	Y	393783	222613	1.5	King's Arms, Gloucester Road, Alstone, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	29.8
238	Y	393854	222754	1.5	Millbrook Street, Sandford, Alstone, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	26.3
239	Y	393861	222768	1.5	Millbrook Street, Sandford, Alstone, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	26.0
240	Y	393880	222809	1.5	Cheltenham Orthodontics, Gloucester Road, Alstone, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	26.5
241	Y	393913	222853	1.5	Gloucester Road Primary School, Gloucester Road, Alstone, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	25.9

Receptor ID	Within AQMA?	X	Y	Height	Closest address/post code	2018 Annual Mean NO_2 Concentration (µg/m^3)
242	Y	393865	222830	1.5	Cheltenham Orthodontics, Gloucester Road, Alstone, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	26.6
243	Y	393883	222855	1.5	Gloucester Road Primary School, Gloucester Road, Alstone, Cheltenham, Gloucestershire, South West England, England, GL51, United Kingdom	27.6
244	Y	394179	222979	1.5	8, Gloucester Road, Sandford, St Paul's, Cheltenham, Gloucestershire, South West England, England, GL51 8LN, United Kingdom	30.1
245	Y	394170	222975	1.5	12, Gloucester Road, Sandford, St Paul's, Cheltenham, Gloucestershire, South West England, England, GL51 8LN, United Kingdom	29.4