North East Lincolnshire Council

Grimsby Town Centre

Local Air Quality Management - Detailed Assessment

September 2016

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Executive Summary

Part IV of the Environment Act 1995 places a statutory duty on local authorities to review and assess the air quality within their area. For local authorities that have identified areas where there is a potential risk of exceedence of Air Quality Strategy (AQS) objectives, a Detailed Assessment is required.

Following the assessment of monitoring results for the monitoring periods 2014 and 2015 indicating that two sites outside of an existing Air Quality Management Area (AQMA) have been close to or exceeding the annual mean AQS objective for nitrogen dioxide (NO_2), North East Lincolnshire Council commissioned Bureau Veritas UK Ltd to undertake a Detailed Assessment of the area in the vicinity of Victoria Mills, Victoria Street North and Town Hall Street, Grimsby, based on dispersion modelling of air pollutant emissions.

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.

The area was modelled using the advanced atmospheric dispersion model ADMS-Roads (version 4.0).

Modelling results suggest that the NO_2 annual mean AQS objective of 40µg/m^3 is likely to be exceeded at a total of three receptor locations, with two further locations below, but close to (within 10%) the objective. Only one of these receptors lies within the current AQMA.

The maximum annual mean NO_2 concentration was predicted at receptor R7 on Cleethorpe Road, with a modelled annual mean of 46.9µg/m^3, within the existing AQMA. This AQMA therefore remains valid, and does not require amendment, as discussed in Section 5.1.

NO_2 concentration isopleths indicate a number of locations are modelled to be in exceedence or within 10% of the NO_2 annual mean AQS objective outside of the current AQMA. Namely, these are; Corporation Bridge crossroads; A180 crossroads with Park Street (receptor R28); A180 crossroads with Victor/Humber Street; and on Town Hall Street (receptors R52 and R53). NELC confirms that there is no exposure relevant to the annual mean AQS objective at ground floor level (1.5m), the height at which exceedences were predicted, in any of these locations. When modelled at first floor level (4.5m), the height at which residential exposure exists, concentrations are well below the objective. Therefore there is no need to declare or extend the existing AQMA to encompass these areas.

However, modelling results also indicate an exceedence of the NO_2 annual mean objective at the properties to the north of the A16/A1136 intersection. There is potential residential exposure at ground floor level in this location, at receptor R4. As no monitoring currently exists in this location, NELC will commence monitoring immediately to confirm concentrations. If annualised monitored concentrations confirm the risk of exceedence as determined by the dispersion modelling, NELC will progress to declaration of a new AQMA, the extent of which is suggested in Figure 13.

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

Therefore, on the basis of the above, it can be concluded that:

[1] Local Air Quality Management Technical Guidance LAQM.TG(16). April 2016. Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland.

a) The current Cleethorpe Rd AQMA remains in place without need for amendment.

b) One further AQMA may be required along Victoria St South, subject to confirmation of monitoring.

Source apportionment of both NO_x and NO_2 concentrations at general level, and at three different selections of the modelled locations (average across all modelled locations; average across all locations with NO_2 Concentration greater than 40µg/m^3; and at the location with maximum road NO_x/NO_2 Concentration) was also conducted.

For NO_x, regional background (the concentrations over which the Council is not expected to have any influence), account for only 23% of total concentrations. As such local policy should have an influence on pollutant concentrations.

For NO_x and NO_2, vehicle emissions represent the largest proportion of total concentrations at locations with NO_2 concentrations greater than 40µg/m^3, at 60.4% and 51.1% respectively. Within that, cars represent the largest source of emissions for a specific vehicle type, at 47.4% of total vehicle emissions at locations with NO_2 concentrations greater than 40µg/m^3.

Following the above conclusions, the following recommendations are made:

- Keep the current Cleethorpe Road AQMA in place without amendment.

- Commence monitoring near receptor R4 in Victoria Street South immediately, to confirm whether there is at risk of exceedence of the annual mean AQS objective of 40µg/m^3. If monitoring confirms modelled concentrations, declare a new AQMA at this location. Following any potential declaration, create a new AQAP.

- Monitor and/or restrict the use of the ground floor of Town Hall Street for residential usage. If residential exposure is introduced at this height, it will be necessary to declare a new AQMA, as shown by the dispersion modelling results.

- Based on source apportionment results, any future intervention measures should be targeted at reducing vehicle emissions, with cars the largest contributors to total vehicle emissions.

- Consider NO_2 monitoring near receptor R14 on Cleethorpe Road, where there is residential exposure at ground floor level within 15m of isopleths indicating potential for exceedence of the annual mean AQS objective, though modelled concentrations at this specific point are only 29.3µg/m^3.

- Consider NO_2 monitoring at receptor R24 on Cleethorpe Road, where there is residential exposure at ground floor level within 10m of isopleths indicating potential for exceedence of the annual mean AQS objective, though the modelled concentration at this specific point is 31.4µg/m^3. This could either be through re-location of the NEL18 monitoring site opposite, or the addition of a new monitoring location.

1 Introduction

1.1 Scope of Assessment

The conclusions of North East Lincolnshire Council's (NELC) Updating and Screening Assessment (USA) 2015, conducted as part of the Local Air Quality Management (LAQM) regime indicated that the Council was required to undertake a Detailed Assessment for two areas within Grimsby, at Victoria Mills and Town Hall Street, for NO_2 (nitrogen dioxide).

NELC currently has one Air Quality Management Areas (AQMA) under the LAQM regime, which was designated because of exceedences of the NO_2 annual mean Air Quality Strategy (AQS) objective of 40µg/m^3 and encompasses a stretch of Cleethorpe Road. A second AQMA, declared for the Particulate Matter (PM_{10}) 24-Hour mean AQS objective on Kings Road, in Immingham, was revoked in January 2016.

Following the assessment of monitoring results for the monitoring periods 2014 and 2015 indicating that two sites outside of the existing AQMAs were close to or exceeding the annual mean AQS objective for NO_2, NELC commissioned Bureau Veritas UK Ltd to undertake a Detailed Assessment of the area in the vicinity of Victoria Mills, Victoria Street North and Town Hall Street, Grimsby, based on dispersion modelling of air pollutant emissions.

The area considered as part of this study is illustrated in Figure 1. This Detailed Assessment is based on the guiding principles for air quality assessments, as set out in the latest LAQM guidance provided by Defra (LAQM.TG(16)[1])

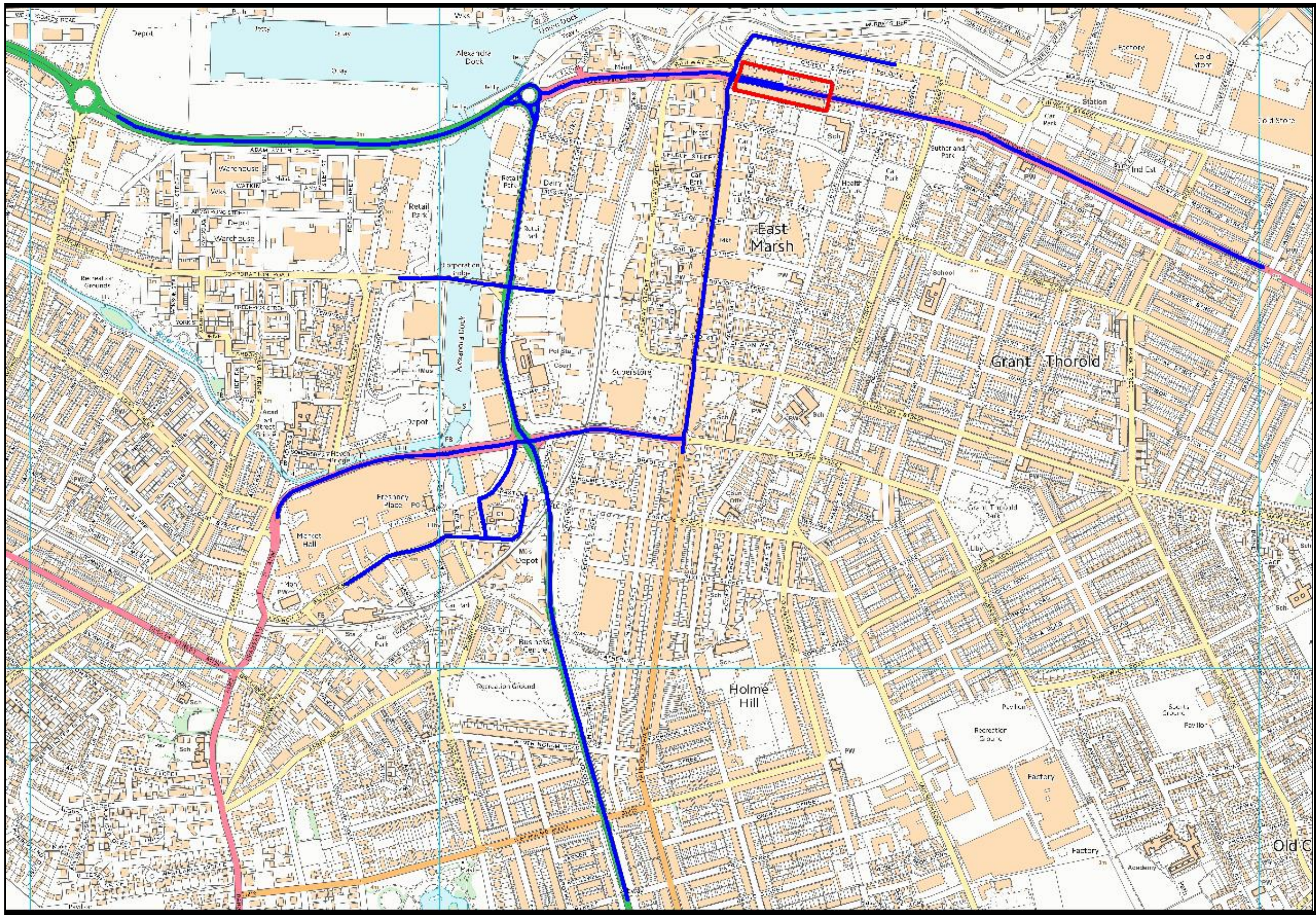
The general purpose and intent of this assessment is to determine, with reasonable certainty, the magnitude and geographical extent of any exceedence so that NELC can have confidence in the potential declaration or extension of an AQMA, if required.

The following are the main objectives of the assessment:

- To assess the air quality at selected locations ("receptors") at the façades of existing residential units, representative of worst-case exposure, based on dispersion modelling of emissions from road traffic on the local road network;
- To determine the geographical extent of the potential exceedence of the AQS objectives;
- To determine the relative contributions of the main sources of pollution to the overall pollutant concentrations through source apportionment;
- To attempt to quantify the number of residents exposed to exceedences of the NO_2 annual mean AQS objective; and
- To put forward conclusions and recommendations as to the extent of any proposed AQMA and potential future air quality monitoring if deemed necessary.

The approach adopted in this assessment to assess the impact of road traffic emissions on air quality has been based on the atmospheric dispersion model ADMS Roads (version 4.0), focusing on emissions of NO_2.

Figure 1 – Modelled Area



Legend

Modelled Roads

AQMA

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Location	
Grimsby Town Centre	
Title	
Modelled Area	
By	**Approved**
MN	EC
Scale	**Job Ref**
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2 Air Quality – Legislative Context

2.1 Air Quality Strategy

The importance of existing and future air 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 1 taken from guidance 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 as this is the pollutant of most concern for NELC in Grimsby. Moreover, due to road traffic pollution the UK has failed to meet the EU Limit Values for this pollutant by the 2010 target date. As a result, the Government has had to submit time extension applications for compliance with the EU Limit Values. Continued failure to achieve these limits may lead to EU fines. The AQS objectives for this pollutant are presented in Table 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.

Table 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 – Relevant AQS Objectives for the Assessed Pollutants in England

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

2.2 Local Air Quality Management (LAQM)

Part IV of the Environment Act 1995 places a statutory duty on local authorities to periodically review and assess 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). Guidance documents[1] and online resources[6] have been produced on behalf of Defra to aid local authorities in these duties.

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[1], the core of LAQM reporting is now based around three pollutant objectives; 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 Air Quality Management Area (AQMA) – a geographic area defined by high concentrations of pollution and exceedences 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.

3 Review and Assessment of Air Quality Undertaken by the Council

3.1 Local Air Quality Management

Table 3 provides a detailed summary of the LAQM statutory reports produced by NELC since 2003.

NELC designated an AQMA in Immingham in October 2006 following exceedence of the particulate matter (PM_{10}) 24 hour mean objective in 2004 and 2005, but this has since been revoked in January 2016. The AQMA encompassed a residential area on Kings Road and Pelham Road, Immingham, and was outside of the modelled area of this report.

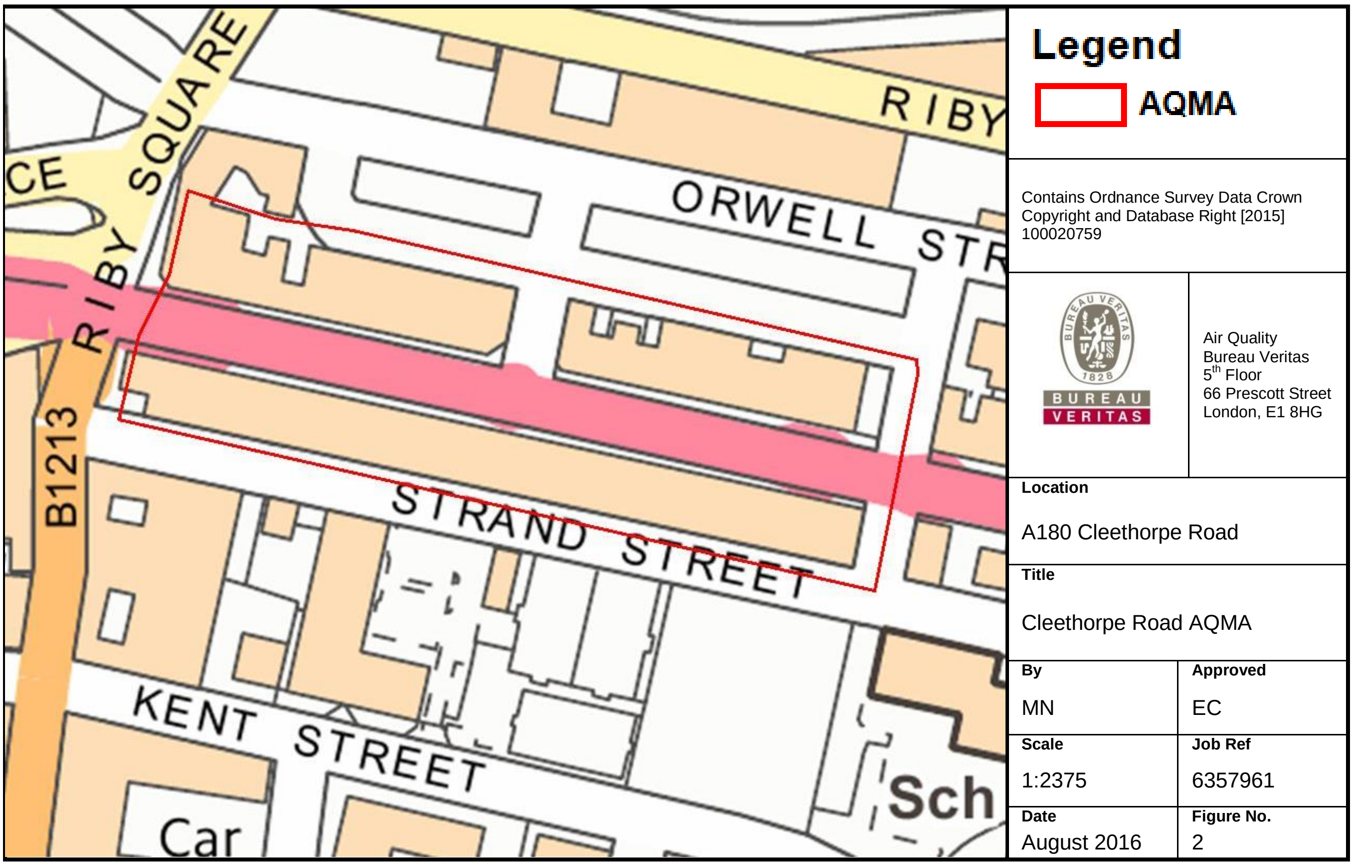
NELC declared a further AQMA in September 2010 for an exceedence of the annual mean NO_2 objective. The AQMA encompasses a section of Cleethorpe Road between Freeman Street and Nacton Street, and encompasses the properties at 100-176 and 103-177 Cleethorpe Road, as highlighted in Figure 2. The properties are predominantly commercial premises, although there are a number of residential properties present.

[6] http://laqm.defra.gov.uk/

Table 3 – Summary of LAQM work in NELC

Year	Report	Area	Pollutant	Result
2015	USA	Borough Wide	All	Detailed Assessment required (Grimsby)
2014	Progress Report	Borough Wide	All	No action
2013	Progress Report	Borough Wide	All	No action
2012	Action Plan	Cleethorpe Road	NO_2	N/A
2012	USA	Borough Wide	All	No action
2012	Further Assessment	Cleethorpe Road Grimsby	NO_2	N/A
2011	Progress Report	Borough Wide	All	No action
2010	Progress Report	Borough Wide	All	No action
2009	Detailed Assessment	Cleethorpe Road Grimsby	NO_2	AQMA confirmed
2009	USA	Borough Wide	All	No action
2008	Detailed Assessment	Fryston House, Grimsby	NO_2	AQMA not required
2008	Detailed Assessment	Humber & Lindsey Refineries	PM_{10}, SO_2	No action
2008	Progress Report	Borough Wide	All	No action
2008	Action Plan & Further Assessment	Kings Road Immingham	PM_{10}	N/A
2007	Progress Report	Borough Wide	All	No action
2006	Detailed Assessment	Immingham Port	PM_{10}, NO_2, SO_2	AQMA confirmed for PM_{10}
2006	USA	Borough Wide	All	AQMA required (Immingham)
2005	Detailed Assessment	Grimsby	NO_2	No action
2004	Detailed Assessment	Riby Square, Immingham	NO_2	No action
2003	USA	Borough Wide	All	No action

Figure 2 – Cleethorpe Road AQMA



3.2 Review of Air Quality Monitoring

In 2014, NELC had four automatic air quality monitoring stations located at Fryston House, Grimsby (CM1), Cleethorpe Road, Grimsby (CM4), Kings Road, Immingham (CM2) and Woodlands Avenue, Immingham (CM3). One of these sites, CM4, is within the modelled domain and has been considered in this assessment. The urban background site CM3 only monitors PM_{10} so cannot be used to determine background NO_2 concentrations. The other stations have not been considered in the assessment, as they are outside of the modelled area.

During 2014 NELC's non-automatic monitoring network comprised of 31 NO_2 diffusion tubes. Three tubes were removed at the start of that year: Pasture Street & Thomas Street, Grimsby; 94 Cromwell Road, Grimsby; and Pennell's, Cleethorpes. These were relocated respectively to: Victoria Mills B; Victoria Street North; and 1 & 8 Town Hall Street, all in Grimsby. The Town Hall Street locations, while based on limited data capture, monitored concentrations above the annual mean objective in 2014, so a Detailed Assessment was required.

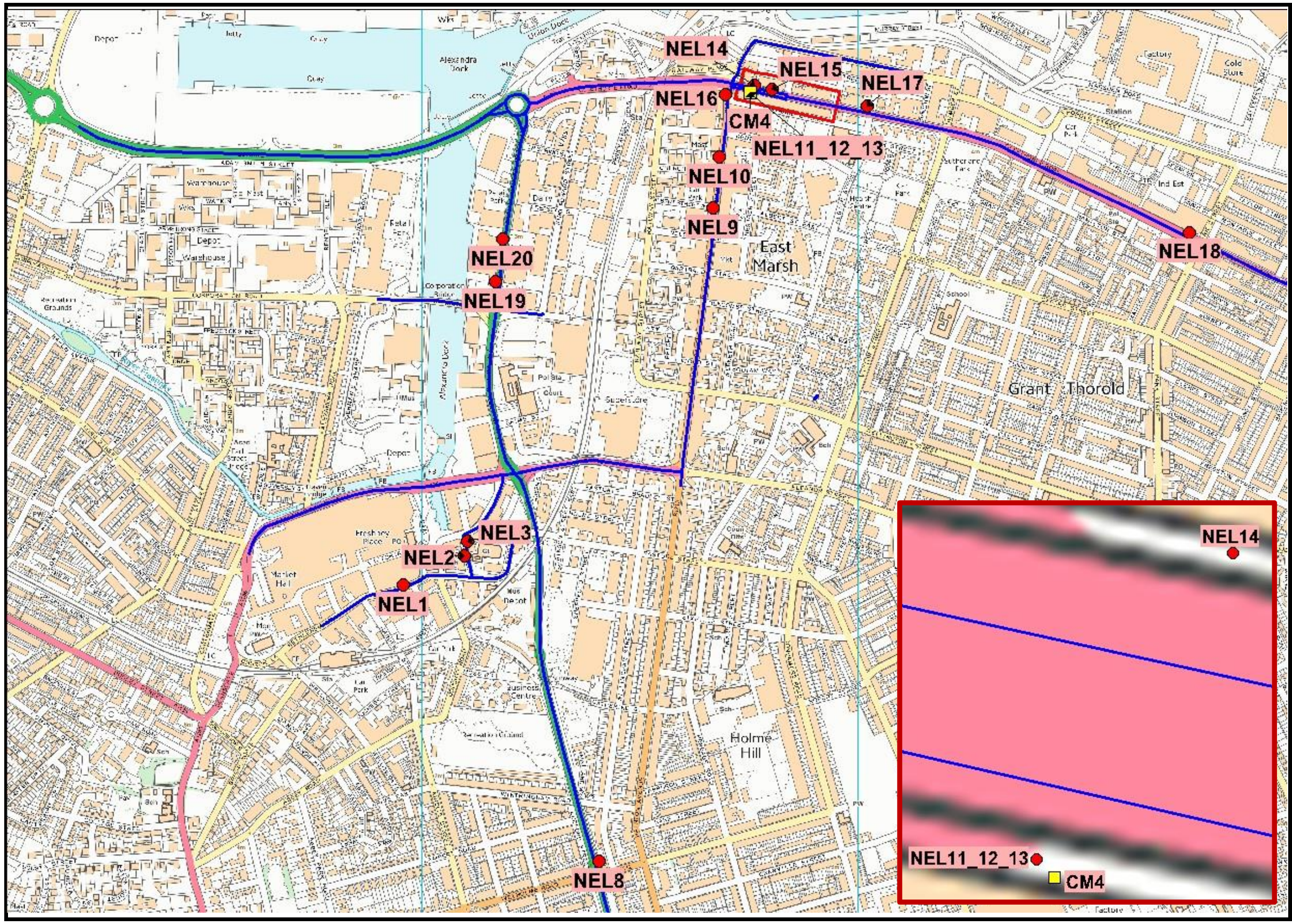
As data capture improved in 2015 at each new site, 2015 has been used as the assessment year. Three exceedences of the annual mean NO_2 objective were monitored in 2015, one of which (8 Town Hall Street) was outside of the current AQMA. The details of the LAQM monitoring relevant to this assessment are presented in Table 4, and the locations illustrated in Figure 3.

Table 4 – LAQM Monitoring undertaken for NO_2 in modelled area

Site ID	Site Location	Monitoring Type	OS Grid Ref (X,Y)*	In AQMA ?	Height (m)	Annual Mean NO_2 Concentration ($\mu g/m^3$) 2015	Data Capture 2015
NEL1	Victoria Street West, The Friary PH	Diffusion Tube	526953, 409300	No	1.5	29.2	100%
NEL2	8 Town Hall Street	Diffusion Tube	527095, 409367	No	1.5	**40.1**	100%
NEL3	1 Town Hall Street	Diffusion Tube	527100, 409400	No	1.5	35.5	92%
NEL8	Peaks Parkway & Welholme Road, Grimsby	Diffusion Tube	527403, 408666	No	1.5	31.8	100%
NEL9	76 Freeman Street, Grimsby	Diffusion Tube	527665, 410164	No	2	20.7	100%
NEL10	42 Freeman Street, Grimsby	Diffusion Tube	527680, 410281	No	2	25.1	100%
NEL11, 12,13	112 Cleethorpe Road, Grimsby	Diffusion Tube	527750, 410429	Yes	1	**43.8**	97%
NEL14	113 Cleethorpe Road, Grimsby	Diffusion Tube	527761, 410446	Yes	1	35.6	100%
NEL15	123 Cleethorpe Road, Grimsby	Diffusion Tube	527802, 410436	Yes	1	31.5	92%
NEL16	6 Freeman Street, Riby Sq.	Diffusion Tube	527693, 410423	No	1.5	29.6	92%
NEL17	197 Cleethorpe Road, Grimsby	Diffusion Tube	528020, 410398	No	1	27.6	67%
NEL18	Ramsdens, Grimsby	Diffusion Tube	528761, 410108	No	1	25.2	100%
NEL19	Victoria Street North, Victoria Mills A	Diffusion Tube	527165, 409995	No	2	32.5	92%
NEL20	Victoria Street North, Victoria Mills B	Diffusion Tube	527182, 410092	No	1	35.5	83%
CM4	112 Cleethorpe Road	Continuous	527751, 410428	Yes	1.5	**46.4**	98%

In **bold**, exceedence of the NO_2 annual mean AQS objective of 40 $\mu g/m^3$
* Monitoring site coordinates were audited and contain some minor alterations from locations included Council's 2015 USA.
**All diffusion tube results bias corrected to a factor of 0.81

Figure 3 – Local Monitoring Locations



Legend

- Diffusion Tube
- Continuous Monitor
- Modelled Roads
- AQMA

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Location	
Grimsby Town Centre	
Title	
Local Monitoring Locations	
By	**Approved**
MN	EC
Scale	**Job Ref**
1:9000	6357961
Date	**Figure No.**
August 2016	3

3.3 Background Concentrations used in the Assessment

Defra maintains a nationwide model of existing and future background air pollutant concentrations at a 1km grid square resolution. The data sets include annual average concentration estimates for NO_x, NO_2, PM_{10} and $PM_{2.5}$, using a base year of 2011. The model used is semi-empirical in nature; it uses the National Atmospheric Emissions Inventory (NAEI) emissions to model concentrations of pollutants at the centroid of each 1km grid square, then calibrates these concentrations with actual monitoring data from the AURN (UK Automatic Urban and Rural Network).

Annual mean background concentrations have been obtained from the Defra published background maps[7], based on the 1km grid squares which cover the modelled area and the affected road network. It is necessary to remove certain source contributions from the mapped background values to avoid double counting of emissions. In this case, the "Primary_A_Rd_In" source contribution has been removed from each grid square, as these emissions have been directly modelled in ADMS-Roads. The Defra mapped background unadjusted and adjusted (following removal of the primary A road component) concentrations for 2015 are presented in Table 5.

[7] Defra Background Maps (2015). http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html

Table 5 – Background Pollutant Concentrations (Defra Background Maps)

Grid Square (E,N)	2015 Unadjusted Annual Mean Concentration (µg/m^3)		NO_x road contribution removed (µg/m^3)	2015 Adjusted Annual Mean Concentration (µg/m^3)	
	NO_x	NO_2		NO_x	NO_2
528500, 410500	37.9	24.7	2.0	35.9	23.6
527500, 409500	31.7	21.2	1.8	29.8	20.1
527500, 410500	34.4	23	2.6	31.8	21.4
527500, 408500	29.4	19.9	2.3	27.1	18.5
526500, 409500	31	20.8	1.1	29.9	20.1
AQS objective	-	*40*	-	-	*40*

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

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

4 Assessment Methodology

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

- Prediction of ambient NO_2 concentrations, to which existing receptors may be exposed and comparison with the relevant AQS objectives;

- Quantification of the relative contribution of sources to overall pollutant concentration; and

- Determination of the geographical extent of any potential exceedence.

4.1 Traffic Assessment

Emissions from road traffic have been predicted using version 6.0.2 of the Emissions Factor Toolkit[8], set up under 'Detailed Option 1'. To enable source apportionment of Road-NO_x emissions, the 'breakdown by vehicle' and 'source apportionment' additional outputs have also been utilised.

Road-NO_x contributions for each source type at receptor locations were modelled using the ADMS-Roads (Version 4.0) atmospheric dispersion model developed by Cambridge Environmental Research Consultants (CERC).

4.1.1 Model Inputs

The ADMS-Roads assessment incorporates numbers of road traffic vehicles as AADT (Annual Average Daily Traffic flows), vehicle speeds on the local roads and the composition of the traffic fleet. The traffic data for this assessment has been collated using a combination of manual count data provided by NELC and growthed figures taken from Department for Transports (DfT), Traffic Counts web resource[9] and is outlined in Table 6. Traffic speed data was taken from the provided data where possible. Where speed data was not available, the speed limit has been assumed on free flowing links. Where appropriate, the speeds have been reduced to simulate queues at junctions and traffic lights.

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

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

Table 6 – Traffic Data used in the Detailed Assessment

Source ID	Traffic Flow (AADT)	% Car	% LGV	% HGV	% Bus/ Coach	% Motorcycle	Speed (kph)
Cleethorpe8_J1	21,668	80.6	16.0	2.1	0.5	0.7	10.0
Cleethorpe9_FF	21,668	80.6	16.0	2.1	0.5	0.7	48.3
Cleethorpe9_J	21,668	80.6	16.0	2.1	0.5	0.7	10.0
Cleethorpe10_FF	21,668	80.6	16.0	2.1	0.5	0.7	48.3
Cleethorpe11_J	21,668	80.6	16.0	2.1	0.5	0.7	10.0
Cleethorpe4_FF	27,514	80.6	16.0	2.1	0.5	0.7	80.5
Cleethorpe5_FF	27,514	80.6	16.0	2.1	0.5	0.7	80.5
Cleethorpe6_FF	27,514	80.6	16.0	2.1	0.5	0.7	80.5
Cleethorpe7_J	27,514	80.6	16.0	2.1	0.5	0.7	10.0
PeaksP4_FF	16,255	82.6	13.3	2.9	0.6	0.6	35.4
PeaksP5_FF	16,255	82.6	13.3	2.9	0.6	0.6	35.4
PeaksP6_FF	16,255	82.6	13.3	2.9	0.6	0.6	35.4
PeaksP7_FF	16,255	82.6	13.3	2.9	0.6	0.6	35.4
PeaksP9_J	16,255	82.6	13.3	2.9	0.6	0.6	10.0
PeaksP10_J	16,255	82.6	13.3	2.9	0.6	0.6	10.0
PeaksP11_FF	16,255	82.6	13.3	2.9	0.6	0.6	35.4
Ellis2_FF	17,171	81.4	12.8	1.1	4.0	0.7	48.3
Ellis3_J	17,171	81.4	12.8	1.1	4.0	0.7	10.0
Westgate6_FF	34,101	75.9	17.6	5.4	0.3	0.8	80.5
Cleethorpe2_FF	27,514	80.6	16.0	2.1	0.5	0.7	80.5
VictoriaNorth2_FF	16,668	79.3	12.6	6.3	1.1	0.7	48.3
VictoriaNorth3_J	8,334	79.3	12.6	6.3	1.1	0.7	10.0
VictoriaNorth4_J	8,334	79.3	12.6	6.3	1.1	0.7	10.0
Cleethorpe1_J	27,514	80.6	16.0	2.1	0.5	0.7	10.0
Cleethorpe3_FF	27,514	80.6	16.0	2.1	0.5	0.7	80.5
VictoriaRB	39,142	78.6	15.4	4.6	0.6	0.8	10.0
Westgate8_J	17,051	75.9	17.6	5.4	0.3	0.8	10.0
Westgate9_J	17,051	75.9	17.6	5.4	0.3	0.8	10.0
Westgate7_FF	34,101	75.9	17.6	5.4	0.3	0.8	80.5
Westgate5_FF	34,101	75.9	17.6	5.4	0.3	0.8	80.5
EastSt4_J	1,600	85.3	9.0	4.8	0.1	0.9	10.0
VictoriaSouth1_J	20,503	79.9	13.0	5.3	1.0	0.8	10.0
PeaksP1_J	16,255	82.6	13.3	2.9	0.6	0.6	10.0
PeaksP2_FF	16,255	82.6	13.3	2.9	0.6	0.6	35.4
PeaksP3_C	16,255	82.6	13.3	2.9	0.6	0.6	35.4
Ellis1_J	17,171	81.4	12.8	1.1	4.0	0.7	10.0
Frederick4_J	12,591	82.3	13.8	2.0	1.1	0.8	10.0
VictoriaSt3_J	8,199	79.6	8.6	3.7	7.3	0.8	10.0
VictoriaSt2_FF	8,199	79.6	8.6	3.7	7.3	0.8	36.1
VictoriaSt1_J	8,199	79.6	8.6	3.7	7.3	0.8	10.0
TownHall4_J	6,599	74.0	8.3	2.6	14.5	0.6	10.0
EastSt2_FF	1,600	85.3	9.0	4.8	0.1	0.9	32.2
EastSt1_J	1,600	85.3	9.0	4.8	0.1	0.9	10.0
Osborne1_J	6,569	74.0	8.2	2.6	14.6	0.6	10.0
VictoriaSouth2_FF	20,503	79.9	13.0	5.3	1.0	0.8	64.4
VictoriaSouth3_J	20,503	79.9	13.0	5.3	1.0	0.8	10.0
VictoriaNorth1_J	16,668	79.3	12.6	6.3	1.1	0.7	10.0
TownHall1_J	6,599	74.0	8.3	2.6	14.5	0.6	10.0
Frederick3_FF	12,591	82.3	13.8	2.0	1.1	0.8	36.1
Frederick2_J	12,591	82.3	13.8	2.0	1.1	0.8	10.0
TownHall2_FF	6,599	74.0	8.3	2.6	14.5	0.6	32.2
Osborne2_FF	6,569	74.0	8.2	2.6	14.6	0.6	48.3

Source ID	Traffic Flow (AADT)	% Car	% LGV	% HGV	% Bus/ Coach	% Motorcycle	Speed (kph)
Osborne3_J	6,569	74.0	8.2	2.6	14.6	0.6	10.0
Frederick1_FF	12,591	82.3	13.8	2.0	1.1	0.8	36.1
Osborne4_FF	6,569	74.0	8.2	2.6	14.6	0.6	48.3
Westgate2_FF	34,101	75.9	17.6	5.4	0.3	0.8	80.5
Westgate4_FF	34,101	75.9	17.6	5.4	0.3	0.8	80.5
Westgate3_FF	34,101	75.9	17.6	5.4	0.3	0.8	80.5
Westgate1_FF	34,101	75.9	17.6	5.4	0.3	0.8	80.5
EastSt3_FF	1,600	85.3	9.0	4.8	0.1	0.9	32.2
PeaksP8_FF	16,255	82.6	13.3	2.9	0.6	0.6	35.4
CorpBridge3_J	9,952	83.9	11.9	2.9	0.3	1.0	10.0
CorpBridge2_FF	9,952	83.9	11.9	2.9	0.3	1.0	48.3
CorpBridge1_J	9,952	83.9	11.9	2.9	0.3	1.0	10.0
MarketSt1_J	8,380	83.5	13.2	2.5	0.0	0.8	10.0
MarketSt2_FF	8,380	83.5	13.2	2.5	0.0	0.8	48.3
TownHall3_FF	6,599	74.0	8.3	2.6	14.5	0.6	32.2
Cleethorpe12_FF	21,668	80.6	16.0	2.1	0.5	0.7	48.3
Riby1_J	1,839	80.1	11.3	8.1	0.0	0.5	10.0
Riby2_FF	1,839	80.1	11.3	8.1	0.0	0.5	48.3
Freeman1_J	3,661	80.8	10.2	3.5	4.7	0.8	10.0
Freeman2_FF	3,661	80.8	10.2	3.5	4.7	0.8	32.2
Freeman3_J	3,661	80.8	10.2	3.5	4.7	0.8	10.0
Freeman4_FF	3,661	80.8	10.2	3.5	4.7	0.8	32.2
Freeman5_J	3,661	80.8	10.2	3.5	4.7	0.8	10.0
Freeman6_FF	3,661	80.8	10.2	3.5	4.7	0.8	32.2
Freeman7_J	3,661	80.8	10.2	3.5	4.7	0.8	10.0
Freeman8_FF	3,661	80.8	10.2	3.5	4.7	0.8	32.2
Freeman9_J	3,661	80.8	10.2	3.5	4.7	0.8	10.0
Freeman10_FF	3,661	80.8	10.2	3.5	4.7	0.8	32.2
Freeman11_J	3,661	80.8	10.2	3.5	4.7	0.8	10
Cleethorpe8_J2	21,668	80.6	16.0	2.1	0.5	0.7	10.0
Cleethorpe8_FF1	21,668	80.6	16.0	2.1	0.5	0.7	48.3
Cleethorpe8_Q	21,668	80.6	16.0	2.1	0.5	0.7	10.0
Cleethorpe8_FF2	21,668	80.6	16.0	2.1	0.5	0.7	48.3

The assessment has assumed traffic flows and background monitoring information for the year 2015.

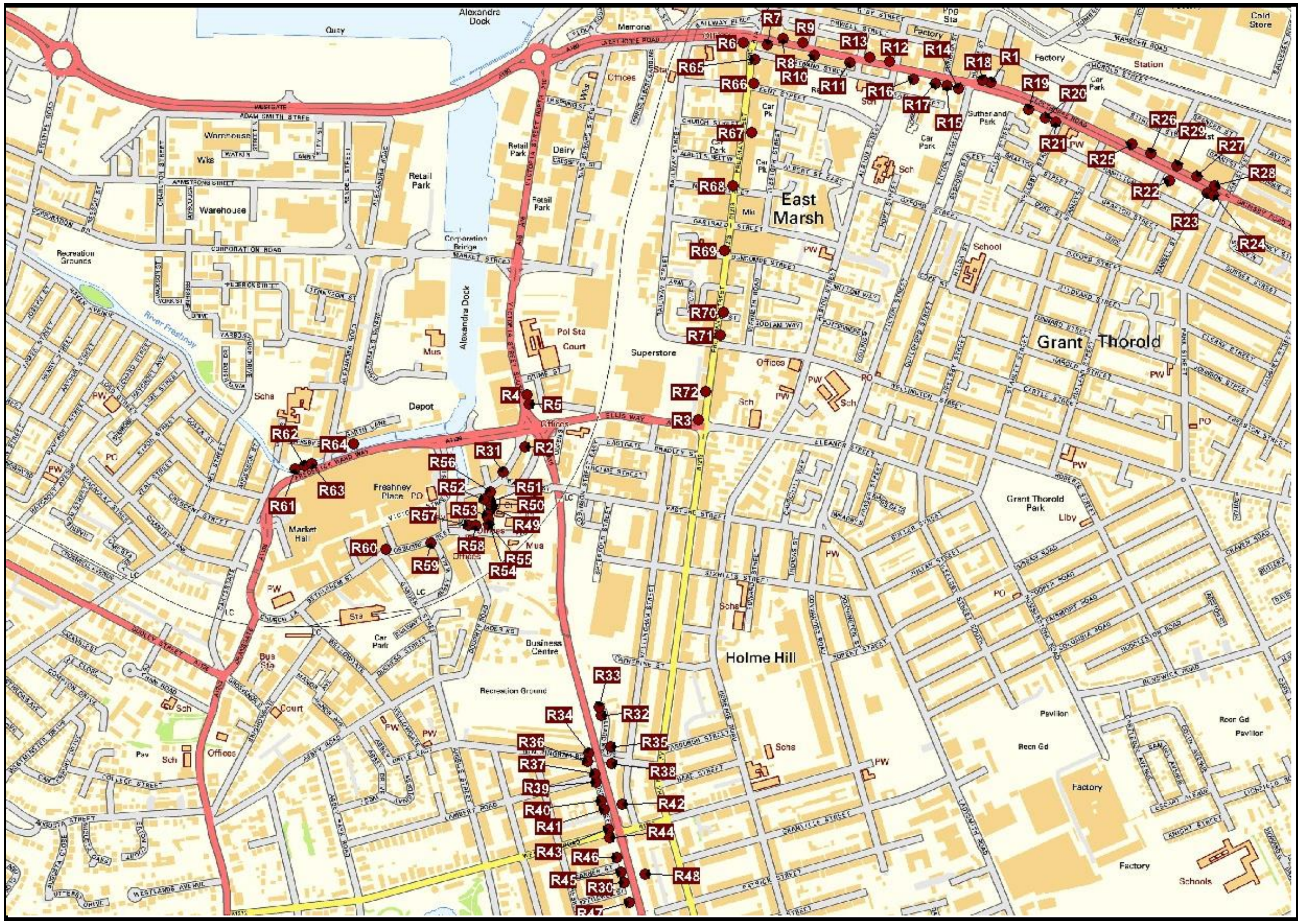
The receptors considered in the assessment of emissions from road traffic are shown in Table 7, and their location illustrated in Figure 4. Where annual mean exposure is at ground floor level at the location, the receptor is modelled at 1.5m. Where exposure is at first floor level and above, the receptor is modelled at 4.5m. Concentrations were also modelled across a regular gridded area to allow the mapping of exceedence areas. To improve the accuracy of modelled results along the roads, additional receptor points were added close to the modelled road links, using the intelligent gridding tool in ADMS Roads.

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

Receptor ID	Street Name	OS Grid X	OS Grid Y	Height (m)
R1	Cleethorpe Road	528245	410345	4.5
R2	Victoria Street	527182	409514	1.5
R3	Freeman Street	527579	409574	4.5
R4	Victoria Street South	527187	409632	1.5
R5	Victoria Street South	527193	409612	4.5
R6	Cleethorpe Road	527681	410436	4.5
R7	Cleethorpe Road	527735	410431	1.5
R8	Cleethorpe Road	527772	410444	4.5
R9	Cleethorpe Road	527818	410435	4.5
R10	Cleethorpe Road	527844	410407	4.5
R11	Cleethorpe Road	527923	410391	4.5
R12	Cleethorpe Road	528013	410393	4.5
R13	Cleethorpe Road	527968	410403	4.5
R14	Cleethorpe Road	528170	410331	1.5
R15	Cleethorpe Road	528145	410337	1.5
R16	Cleethorpe Road	528069	410353	1.5
R17	Cleethorpe Road	528120	410342	1.5
R18	Cleethorpe Road	528226	410348	4.5
R19	Cleethorpe Road	528330	410283	1.5
R20	Cleethorpe Road	528368	410264	4.5
R21	Cleethorpe Road	528393	410253	4.5
R22	Cleethorpe Road	528651	410120	1.5
R23	Cleethorpe Road	528739	410092	1.5
R24	Cleethorpe Road	528753	410087	1.5
R25	Cleethorpe Road	528565	410205	1.5
R26	Cleethorpe Road	528610	410183	1.5
R27	Cleethorpe Road	528714	410129	1.5
R28	Cleethorpe Road	528755	410110	1.5
R29	Cleethorpe Road	528668	410154	1.5
R30	Cleethorpe Road	527409	408520	1.5
R31	Victoria Street	527134	409456	4.5
R32	A16 Peaks Parkway	527357	408901	1.5
R33	A16 Peaks Parkway	527353	408920	1.5
R34	A16 Peaks Parkway	527329	408816	1.5
R35	A16 Peaks Parkway	527379	408830	1.5
R36	A16 Peaks Parkway	527327	408798	1.5
R37	A16 Peaks Parkway	527342	408768	1.5
R38	A16 Peaks Parkway	527380	408792	1.5
R39	A16 Peaks Parkway	527346	408750	1.5
R40	A16 Peaks Parkway	527358	408705	1.5
R41	A16 Peaks Parkway	527363	408686	1.5
R42	A16 Peaks Parkway	527404	408699	1.5
R43	A16 Peaks Parkway	527374	408643	1.5
R44	A16 Peaks Parkway	527377	408624	1.5
R45	A16 Peaks Parkway	527402	408545	1.5
R46	A16 Peaks Parkway	527394	408579	1.5
R47	A16 Peaks Parkway	527421	408475	1.5
R48	A16 Peaks Parkway	527456	408541	1.5

Receptor ID	Street Name	OS Grid X	OS Grid Y	Height (m)
R49	Town Hall Street	527106	409376	4.5
R50	Town Hall Street	527105	409382	4.5
R51	Town Hall Street	527104	409389	4.5
R52	Town Hall Street	527090	409394	1.5
R53	Town Hall Street	527097	409360	1.5
R54	Town Hall Street	527099	409349	1.5
R55	Town Hall Street	527101	409338	1.5
R56	Victoria Street	527105	409411	4.5
R57	Osborne Street	527056	409336	1.5
R58	Osborne Street	527072	409335	1.5
R59	Osborne Street	526968	409293	4.5
R60	Osborne Street	526866	409281	4.5
R61	Frederick Ward Way	526660	409463	1.5
R62	Frederick Ward Way	526682	409470	1.5
R63	Frederick Ward Way	526697	409475	1.5
R64	Frederick Ward Way	526794	409521	1.5
R65	Freeman Street	527707	410397	4.5
R66	Freeman Street	527706	410343	4.5
R67	Freeman Street	527700	410230	4.5
R68	Freeman Street	527657	410108	4.5
R69	Freeman Street	527638	409962	4.5
R70	Freeman Street	527636	409821	4.5
R71	Freeman Street	527630	409767	4.5
R72	Freeman Street	527595	409639	4.5

Figure 4 – Receptor Locations considered in the Assessment of Emissions from Road Traffic



Legend

● **Receptor Location**

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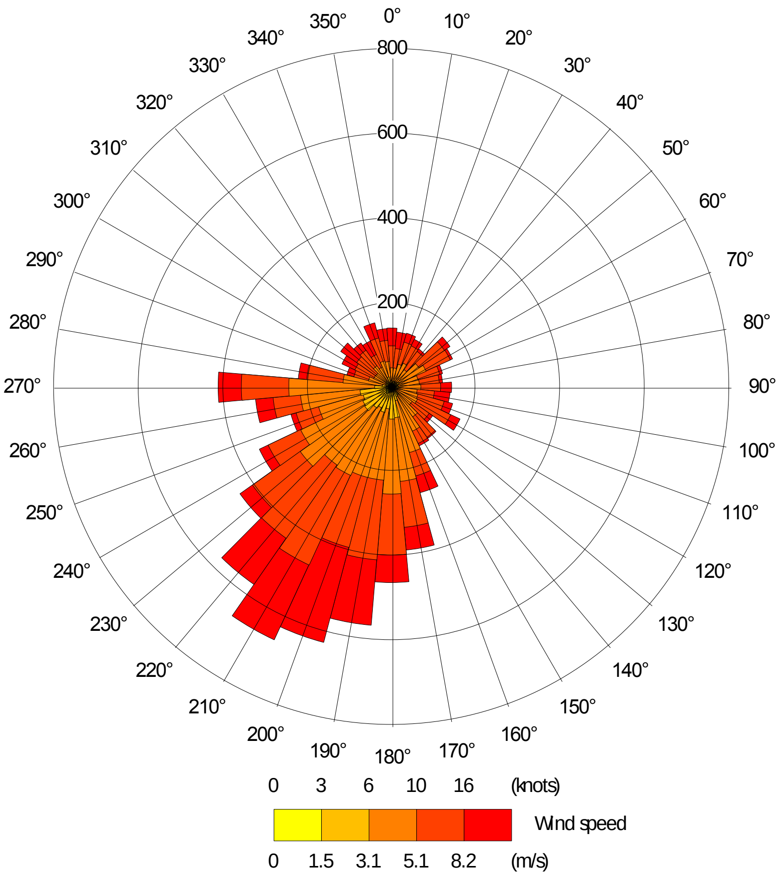
Air Quality
Bureau Veritas
5th Floor
66 Prescott Street
London, E1 8HG

Location	
Grimsby Town Centre	
Title	
Receptor Locations	
By	**Approved**
MN	EC
Scale	**Job Ref**
1:9000	6357961
Date	**Figure No.**
August 2016	4

Meteorological data from a representative station is required by the dispersion model. 2015 meteorological data from Donna Nook weather station has been used in this assessment. A wind rose for this site for the year 2015 is shown in Figure 5. 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) that the meteorological data file be tested within a dispersion model and the relevant output log file checked, to confirm the number of missing hours and calm hours that cannot be used by the dispersion model. This is important when considering predictions of high percentiles and the number of exceedences. LAQM.TG(16) recommends that meteorological data should only be used if the percentage of usable hours is greater than 75%, and preferably 90%. 2015 meteorological data from Donna Nook include 8,735 lines of usable hourly data out of the total 8,760 for the year, i.e. 99.7% usable data. This is therefore suitable for the dispersion modelling exercise.

Figure 5 – Wind rose for Donna Nook Meteorological Data 2015



4.1.2 Model Outputs

Background pollutant concentrations, as discussed in Section 3.3, have been added to the ADMS-Roads modelled output to calculate predicted total annual mean concentrations of NO_x and NO_2.

To predict annual mean NO_2 concentrations, the output of the ADMS-Roads model for NO_x has been converted to NO_2 following the methodology in LAQM.TG(16)[1]; using the NO_x to NO_2 conversion tool (version 4.1) published by Defra. This tool also utilises the total background NO_x and NO_2 concentrations. The NO_2 road contribution was then added to the appropriate NO_2 background concentration value to obtain an overall total NO_2 concentration.

Source apportionment was carried out for the following vehicle classes, for both NO_x and NO_2:

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

For the prediction of short term NO_2 impacts, LAQM.TG(16)[1] advises that it is valid to assume that exceedences of the 1-hour mean AQS objective for NO_2 are only likely to occur where the annual mean NO_2 concentration is 60µg/m^3 or greater. This approach has thus been adopted for the purposes of this assessment.

Verification of the dispersion modelling results has been undertaken using the local authority air quality monitoring data from sites adjacent to the affected road network. All NO_2 results presented in the assessment are those calculated following the process of model verification, using a factor of 2.30 to correct road-NO_x concentrations, as detailed in Appendix 2.

5 Results

The results of the dispersion modelling are provided below, for those receptor locations detailed and illustrated in Table 7 and Figure 4 respectively.

Table 8 presents the annual mean NO_2 concentrations predicted at existing residential receptor locations for 2015.

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

The maximum annual mean NO_2 concentration was predicted at receptor R7 on Cleethorpe Road, with a predicted result of 46.9µg/m^3.

Since annual mean NO_2 concentrations at all receptor locations are well below 60µg/m^3, as discussed in Section 4.1.2, the 1-hour mean objective for NO_2 is unlikely to be exceeded at any receptor.

Table 8 – Predicted Annual Mean NO_2 Concentrations for 2015

Receptor ID	Street Name	OS Grid X	OS Grid Y	Height (m)	Annual Mean NO_2 (µg/m^3)		% of AQS objective
					AQS objective	2015	
R1	Cleethorpe Road	528245	410345	4.5	*40*	31.2	77.9%
R2	Victoria Street	527182	409514	1.5	*40*	34.7	86.6%
R3	Freeman Street	527579	409574	4.5	*40*	28.1	70.2%
R4	Victoria Street South	527187	409632	1.5	*40*	**44.4**	110.9%
R5	Victoria Street South	527193	409612	4.5	*40*	33.1	82.6%
R6	Cleethorpe Road	527681	410436	4.5	*40*	27.3	68.1%
R7	Cleethorpe Road	527735	410431	1.5	*40*	**46.9**	117.1%
R8	Cleethorpe Road	527772	410444	4.5	*40*	29.0	72.4%
R9	Cleethorpe Road	527818	410435	4.5	*40*	27.5	68.6%
R10	Cleethorpe Road	527844	410407	4.5	*40*	25.4	63.4%
R11	Cleethorpe Road	527923	410391	4.5	*40*	25.1	62.9%
R12	Cleethorpe Road	528013	410393	4.5	*40*	29.1	72.8%
R13	Cleethorpe Road	527968	410403	4.5	*40*	27.1	67.7%
R14	Cleethorpe Road	528170	410331	1.5	*40*	29.3	73.2%
R15	Cleethorpe Road	528145	410337	1.5	*40*	28.3	70.6%
R16	Cleethorpe Road	528069	410353	1.5	*40*	27.4	68.5%
R17	Cleethorpe Road	528120	410342	1.5	*40*	27.7	69.2%
R18	Cleethorpe Road	528226	410348	4.5	*40*	32.3	80.8%
R19	Cleethorpe Road	528330	410283	1.5	*40*	27.1	67.8%
R20	Cleethorpe Road	528368	410264	4.5	*40*	26.2	65.6%
R21	Cleethorpe Road	528393	410253	4.5	*40*	26.2	65.6%
R22	Cleethorpe Road	528651	410120	1.5	*40*	26.1	65.2%
R23	Cleethorpe Road	528739	410092	1.5	*40*	30.2	75.6%
R24	Cleethorpe Road	528753	410087	1.5	*40*	31.4	78.6%
R25	Cleethorpe Road	528565	410205	1.5	*40*	31.8	79.5%
R26	Cleethorpe Road	528610	410183	1.5	*40*	32.0	79.9%
R27	Cleethorpe Road	528714	410129	1.5	*40*	34.4	86.0%
R28	Cleethorpe Road	528755	410110	1.5	*40*	**41.5**	103.8%
R29	Cleethorpe Road	528668	410154	1.5	*40*	33.0	82.5%
R30	Cleethorpe Road	527409	408520	1.5	*40*	21.2	53.1%
R31	Victoria Street	527134	409456	4.5	*40*	27.2	67.9%

Receptor ID	Street Name	OS Grid X	OS Grid Y	Height (m)	Annual Mean NO_2 ($\mu g/m^3$)		% of AQS objective
					AQS objective	2015	
R32	A16 Peaks Parkway	527357	408901	1.5	*40*	22.1	55.2%
R33	A16 Peaks Parkway	527353	408920	1.5	*40*	22.1	55.2%
R34	A16 Peaks Parkway	527329	408816	1.5	*40*	21.3	53.2%
R35	A16 Peaks Parkway	527379	408830	1.5	*40*	21.7	54.2%
R36	A16 Peaks Parkway	527327	408798	1.5	*40*	20.8	51.9%
R37	A16 Peaks Parkway	527342	408768	1.5	*40*	21.3	53.2%
R38	A16 Peaks Parkway	527380	408792	1.5	*40*	22.5	56.2%
R39	A16 Peaks Parkway	527346	408750	1.5	*40*	21.2	52.9%
R40	A16 Peaks Parkway	527358	408705	1.5	*40*	21.5	53.6%
R41	A16 Peaks Parkway	527363	408686	1.5	*40*	21.8	54.5%
R42	A16 Peaks Parkway	527404	408699	1.5	*40*	24.3	60.8%
R43	A16 Peaks Parkway	527374	408643	1.5	*40*	22.4	55.9%
R44	A16 Peaks Parkway	527377	408624	1.5	*40*	22.1	55.2%
R45	A16 Peaks Parkway	527402	408545	1.5	*40*	21.4	53.5%
R46	A16 Peaks Parkway	527394	408579	1.5	*40*	22.2	55.5%
R47	A16 Peaks Parkway	527421	408475	1.5	*40*	20.9	52.3%
R48	A16 Peaks Parkway	527456	408541	1.5	*40*	21.9	54.7%
R49	Town Hall Street	527106	409376	4.5	*40*	35.0	87.5%
R50	Town Hall Street	527105	409382	4.5	*40*	35.1	87.6%
R51	Town Hall Street	527104	409389	4.5	*40*	35.8	89.5%
R52	Town Hall Street	527090	409394	1.5	*40*	39.3	98.2%
R53	Town Hall Street	527097	409360	1.5	*40*	39.0	97.5%
R54	Town Hall Street	527099	409349	1.5	*40*	30.8	77.0%
R55	Town Hall Street	527101	409338	1.5	*40*	33.0	82.4%
R56	Victoria Street	527105	409411	4.5	*40*	27.8	69.5%
R57	Osborne Street	527056	409336	1.5	*40*	26.1	65.1%
R58	Osborne Street	527072	409335	1.5	*40*	26.6	66.4%
R59	Osborne Street	526968	409293	4.5	*40*	23.5	58.8%
R60	Osborne Street	526866	409281	4.5	*40*	24.1	60.2%
R61	Frederick Ward Way	526660	409463	1.5	*40*	23.9	59.6%
R62	Frederick Ward Way	526682	409470	1.5	*40*	24.2	60.4%
R63	Frederick Ward Way	526697	409475	1.5	*40*	24.4	61.0%
R64	Frederick Ward Way	526794	409521	1.5	*40*	23.3	58.1%
R65	Freeman Street	527707	410397	4.5	*40*	25.5	63.9%
R66	Freeman Street	527706	410343	4.5	*40*	24.8	62.0%
R67	Freeman Street	527700	410230	4.5	*40*	23.5	58.7%
R68	Freeman Street	527657	410108	4.5	*40*	23.9	59.8%
R69	Freeman Street	527638	409962	4.5	*40*	22.2	55.5%
R70	Freeman Street	527636	409821	4.5	*40*	22.7	56.6%
R71	Freeman Street	527630	409767	4.5	*40*	23.2	58.0%
R72	Freeman Street	527595	409639	4.5	*40*	23.2	58.1%

In Bold – exceedences of the AQS objective

Annual mean NO_2 concentrations were also predicted at generic receptor locations within a grid with a minimum spatial resolution of 90m x 70m, covering the modelled area. However, the intelligent gridding option in ADMS-Roads is utilised, which leads to a much higher resolution close to road sources.

Figure 6 and Figure 7 illustrate the annual mean NO_2 concentration isopleths based on modelled concentrations on the receptor grid. To mitigate against the uncertainty of modelled exceedences, 40µg/m^3 and 36µg/m^3 concentration isopleths (i.e. ±10% of the AQS objective) are presented. These are also presented at two different heights, 1.5m (representative of average adult breathing zone height and ground floor exposure) and 4.5m (representative first floor exposure).

5.1 Discussion of Modelled Concentrations

Modelled exceedences remain within the Cleethorpe Road AQMA at the receptors modelled, and at both 1.5m and 4.5m in height. Therefore the existing AQMA should remain.

Figure 8 suggests concentrations in the region of 36µg/m^3 at 1.5m height on the corner of Cleethorpe Road and Riby Square outside Noble House, which is below but close to the objective. However, the property is office use at ground floor level and residential only at first floor and above, at which height a modelled concentration of 27.3µg/m^3 is predicted for R6. Moreover, the monitored concentration of 29.6µg/m^3 at nearby site NEL16 confirms that the AQMA should not require extension to encompass this location.

In five additional areas outside of the existing AQMA, annual mean NO_2 concentrations at 1.5m are marginally above 40µg/m^3 at building facades, namely around; Corporation Bridge crossroads; the A180 crossroads with Park Street; the A180 crossroads with Victor/Humber Street; the junction of A16 and A1136; and the junction of Town Hall Street and New Street.

These areas are further discussed below:

- Corporation Bridge crossroads – The facades of the properties comprising Palace Court and Rix House along Market Street and Victoria St North are modelled above 40µg/m^3 but are all commercial use (see Figure A3. 1), where the annual mean AQS objective does not apply. Concentrations are well below 60µg/m^3 though, which means that, according to LAQM.TG(16)[1], there should be no risk of exceedence of the 1-hour mean AQS objective which would apply. Therefore no AQMA should be required at this location.

- A180 crossroads with Park Street – A concentration of 41.5µg/m^3 is modelled at R28 at ground level. However, with the location being a shopping complex (see Figure A3. 2), the annual mean objective does not apply here. Monitoring is also in place within 10 metres of this location, at NEL18, where a concentration of 25.2µg/m^3 was recorded in 2015, which is well below the objective. As discussed in Appendix 2, this roadside site shows very low concentrations, close to the background concentrations in the area. This suggests a low contribution from the road traffic at this location, at odds with results (modelled or monitored) along other main roads in the modelled area. Although the annual mean objective for NO_2 is unlikely to be exceeded in this area, concentrations may be higher than suggested by site NEL18, as shown by modelled results at residential receptors R23 and R24 just opposite receptor R28, which indicate an NO_2 concentration 30.2µg/m^3 and 31.4µg/m^3 respectively. As concentrations are well below 60µg/m^3, it is also not considered likely that the 1-hour mean objective would be exceeded. Based on modelled concentrations, it would be pertinent to move the monitoring site NEL18 to the location of either R23 or R24 to further assess the residential exposure.

- A180 crossroads with Victor/Humber Street – The isopleths in Figure 7 indicate possible exceedence at receptors R1 and R18. Figure A3. 3 confirms that long term exposure would occur at first floor level, but not at ground level. When the height of exposure is taken into account, as per the modelled height of 4.5m of R1 and R18 and in Figure 10, no exceedence of the annual mean AQS objective is predicted in this location. Again, although the modelled concentration at receptor R14 (29.3µg/m^3) is well below the objective it may be prudent to consider NO_2 monitoring in the vicinity of the property, as there is residential exposure at ground floor level.

- A16 and A1136 – This area encompasses a row of properties including various solicitors and a bed and breakfast, around receptor R4. For the majority of the properties, exposure is likely to be at no lower than first floor level (see Figure A3. 4), where modelled concentrations are markedly below 40µg/m^3 (as per Figure 10). However, NELC have identified[10] possible residential usage at the ground floor of the 'Pink Butterfly' B&B, which means that the annual mean objective for NO_2 should apply at this location. As no monitoring currently exists in this area, NELC will implement monitoring immediately to confirm concentrations. Should annualised measured concentrations confirm a risk of exceedence, then the Council should progress to declaring an AQMA at this location, which is likely to encompass the 5 properties shown in Figure 13. Concentrations at 1.5m are well below 60µg/m^3, therefore there should be no risk of exceedence of the 1-hour mean AQS objective at this location.

- Town Hall Street – A marginal exceedence was monitored at NEL2, 8 Town Hall Street, in 2015. This is reflected in the modelled concentrations demonstrated in Figure 9. Monitoring, and receptors R52 and R53, were at 1.5m. There are four residential properties on Town Hall Street; all at first floor level or above[11] (see Figure A3. 5). The Figure 12 isopleth, modelled at 4.5m, shows a smaller area of possible exceedence (within 10% of AQS objective), which does not overlap with any receptor and remains confined to the road width. Therefore, it is considered that, while the current circumstance of no residential use at ground floor level persists, no AQMA should be required.

The isopleths in Figure 8 were used to determine the population exposure to potential exceedence of the annual mean NO_2 AQS objective. The Office for National Statistics[12] provides an average number of 2.4 people per UK household in 2015. Based on the number of properties located within the 40µg/m^3 and above area, the number of people exposed to potential exceedences of the annual mean NO_2 is approximately 17 within the current AQMA, and a possible 12 along Victoria Street South.

[10] Discussion dated 16/06/16

[11] Confirmed by the Council on 08/06/16. For reference these locations are: Flat 1, 8 Town Hall Street upper floor, Flat 2, 8 Town Hall Street upper floor, Front flat 1st floor 2 Town Hall Street and Rear flat 1st floor 2a Town Hall Street.

[12] http://www.ons.gov.uk/ons/rel/family-demography/families-and-households/2015/index.html

Figure 6 – Annual Mean NO_2 Concentration Isopleths ($\mu g/m^3$) Grimsby (west): at 1.5m height

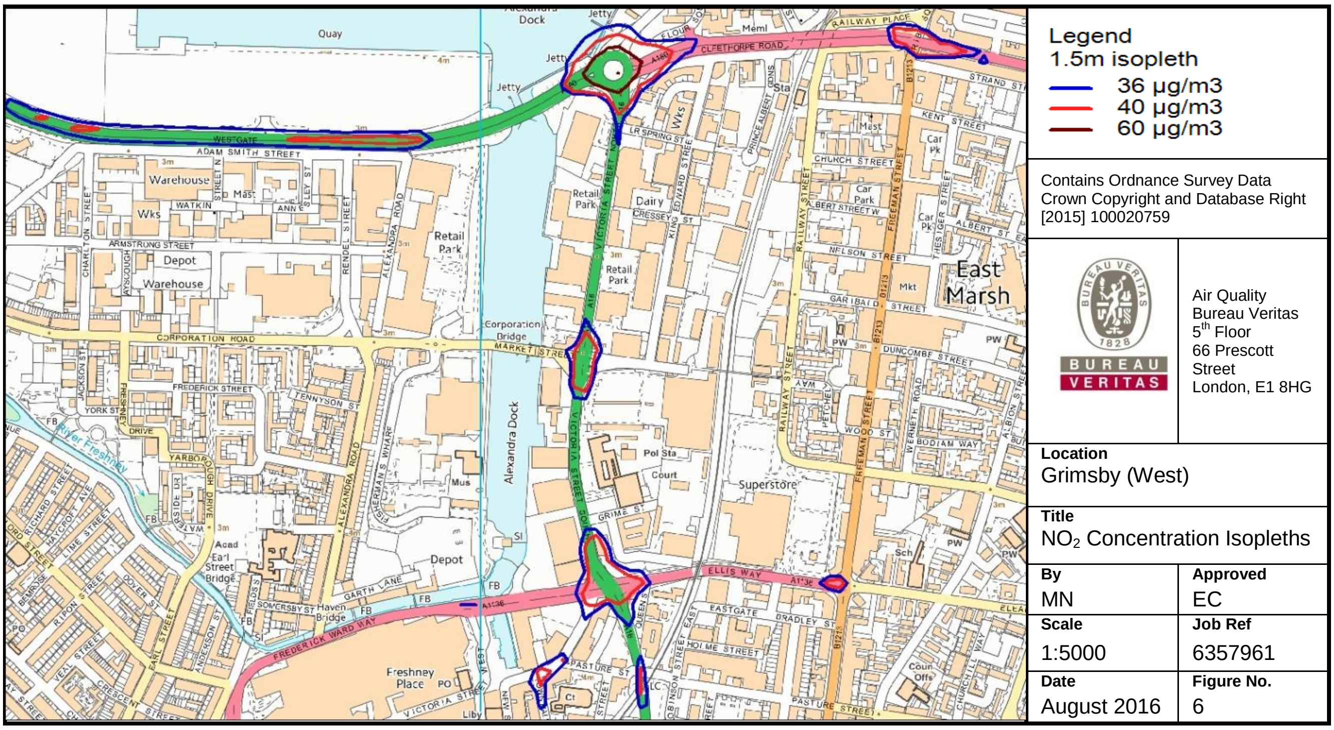


Figure 7 – Annual Mean NO_2 Concentration Isopleths ($\mu g/m^3$) Cleethorpe Road: at 1.5m height

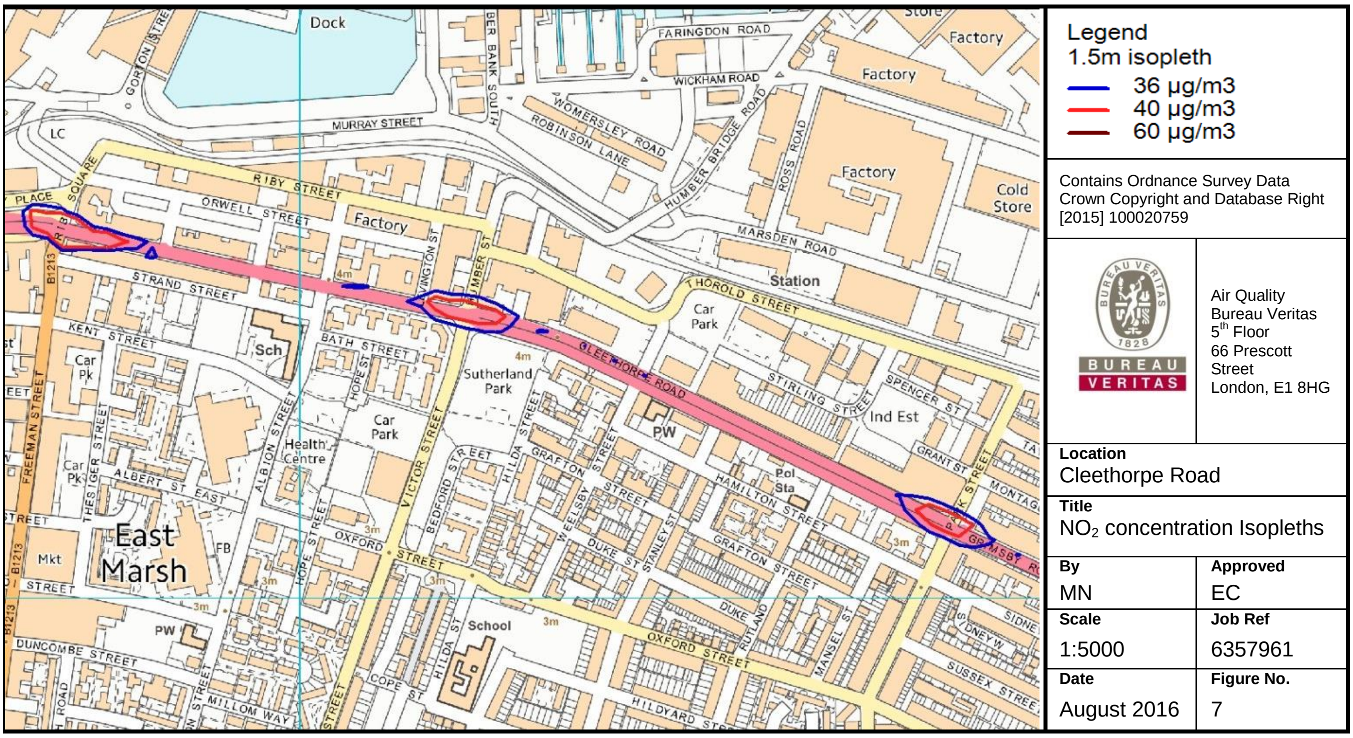


Figure 8 – Annual Mean NO_2 Concentration Isopleths ($\mu g/m^3$) Cleethorpe Road AQMA: at 1.5m height

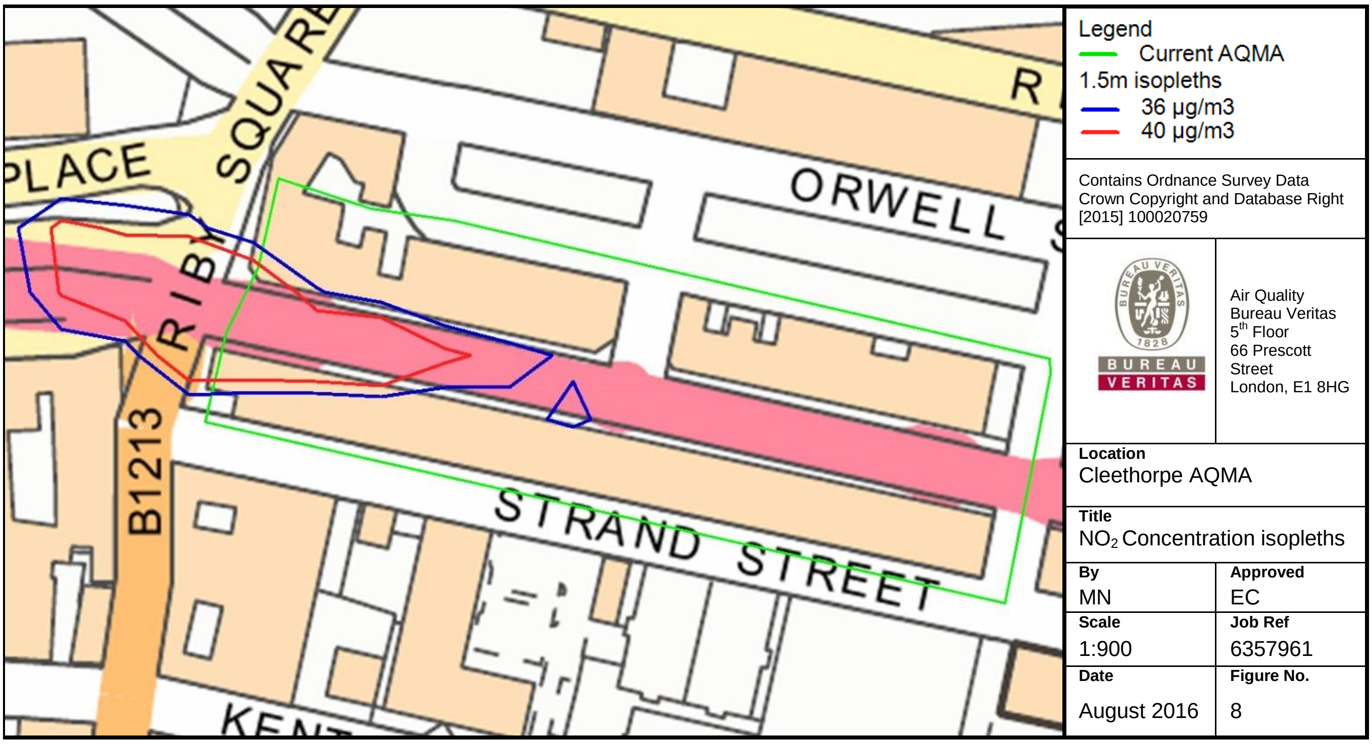


Figure 9 – Annual Mean NO_2 Concentration Isopleths ($\mu g/m^3$) Town Hall Street: at 1.5m height

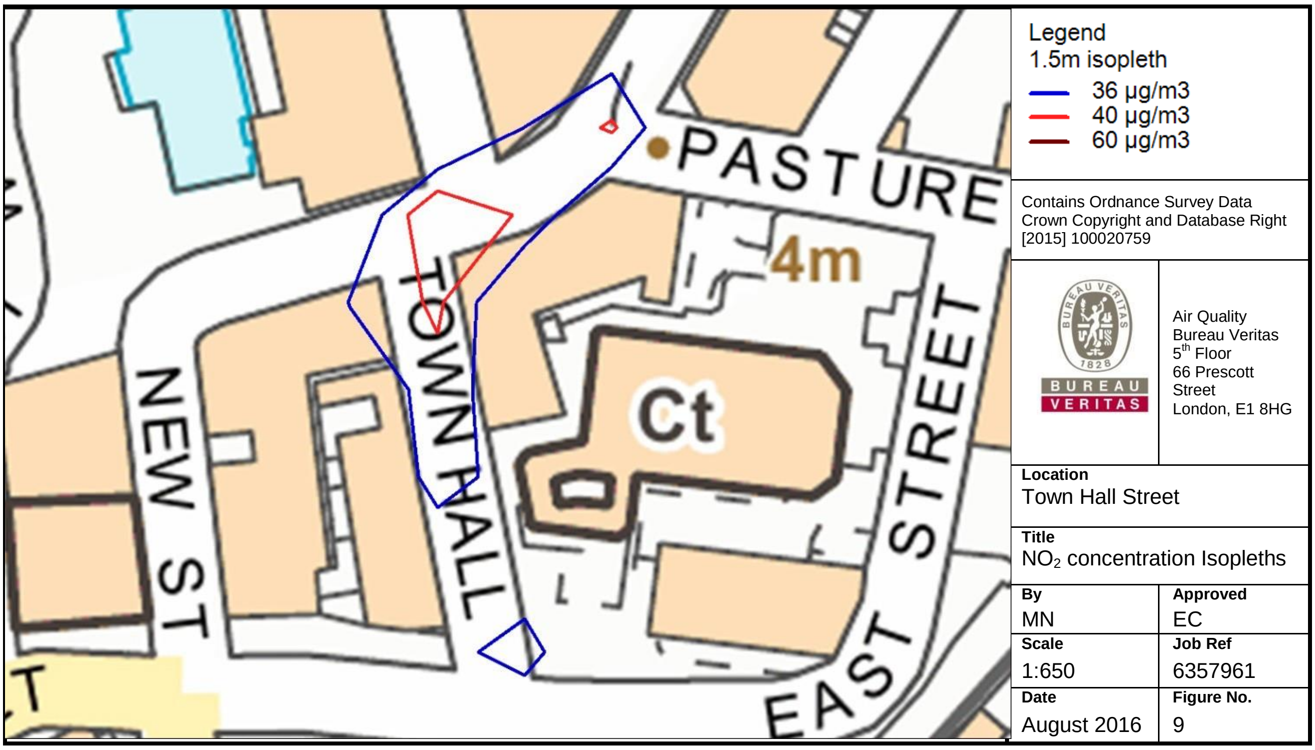


Figure 10 – Annual Mean NO_2 Concentration Isopleths (μg/m^3) Grimsby: at 4.5m height

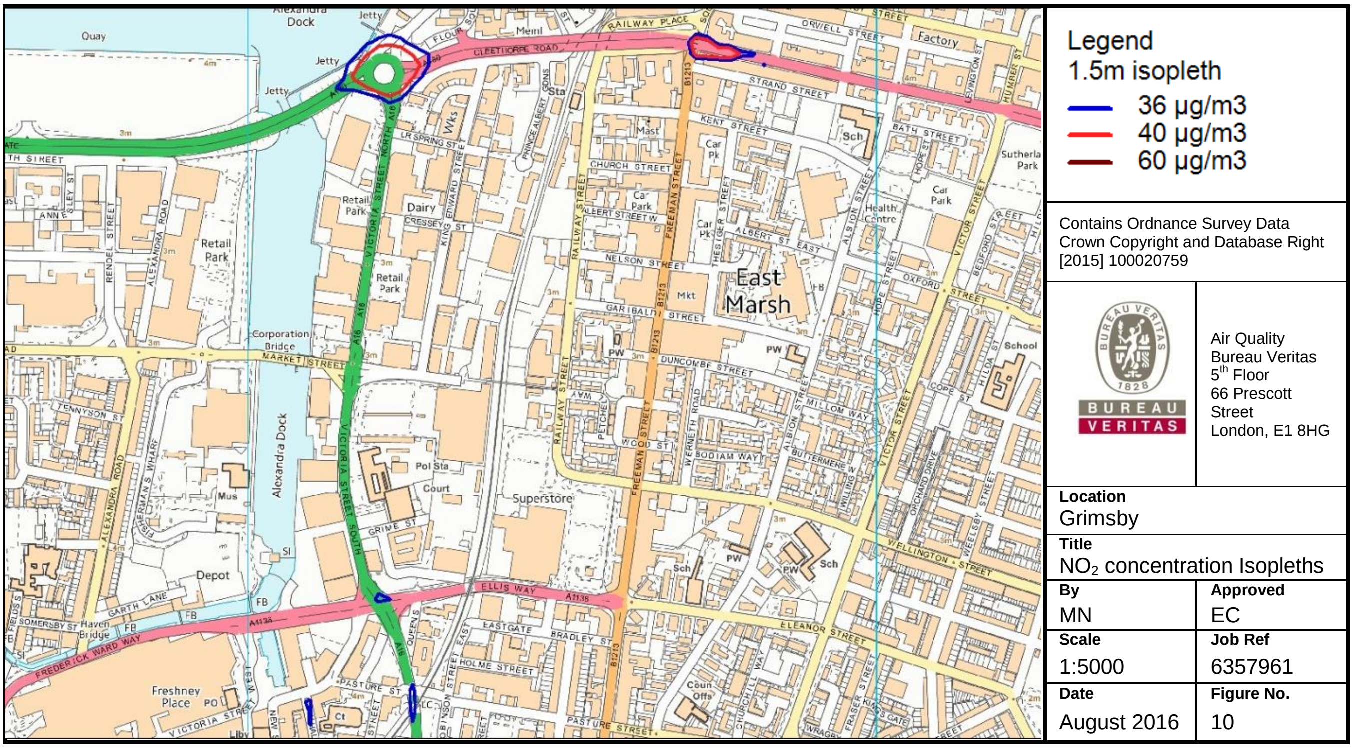


Figure 11 – Annual Mean NO_2 Concentration Isopleths (μg/m^3) Cleethorpe Road AQMA: at 4.5m height

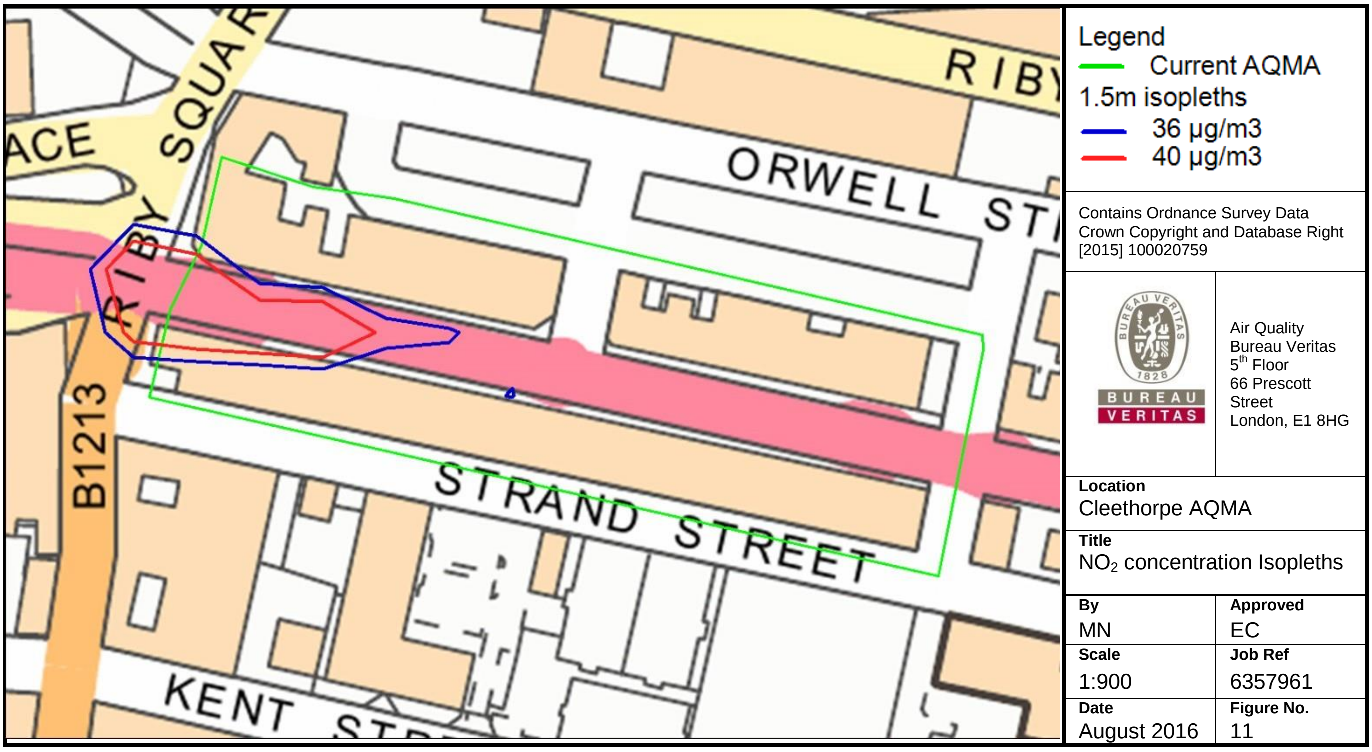


Figure 12 – Annual Mean NO_2 Concentration Isopleths (µg/m^3) Town Hall Street: at 4.5m height

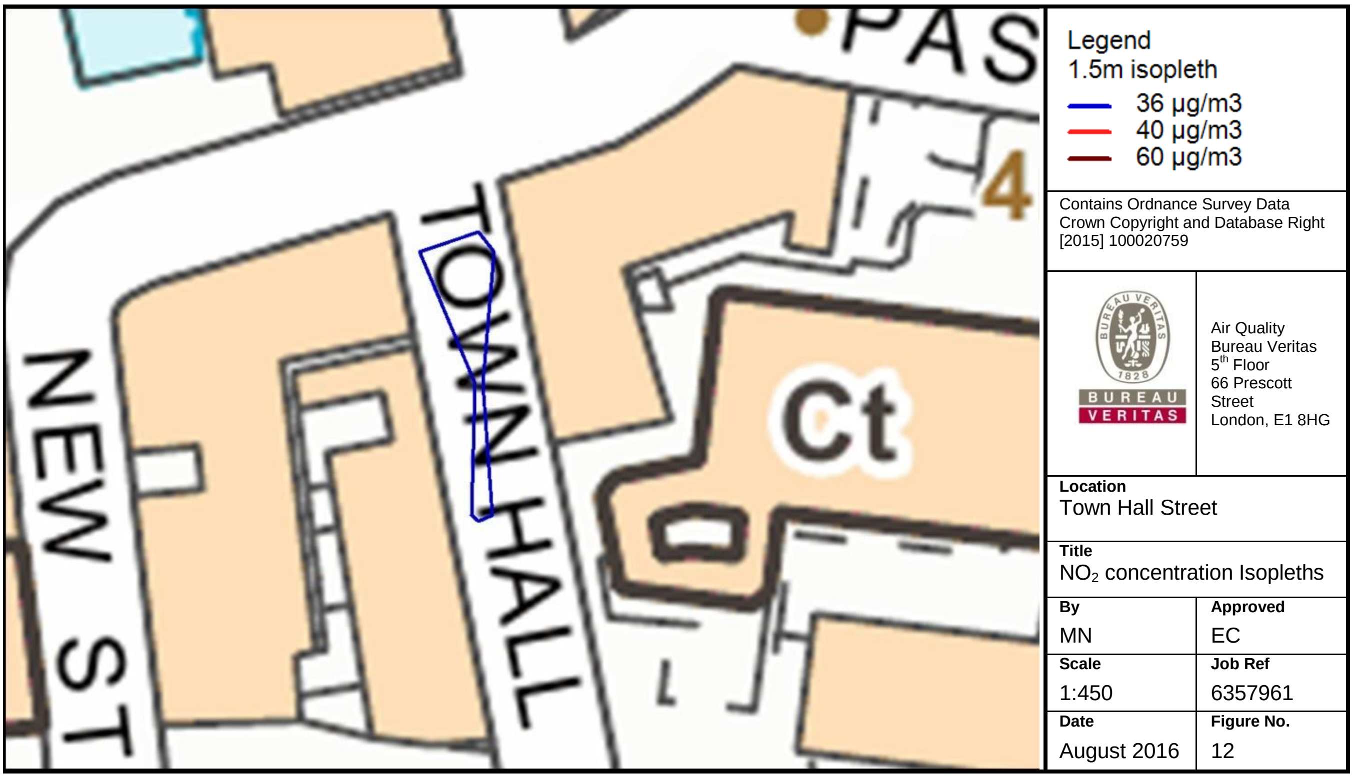
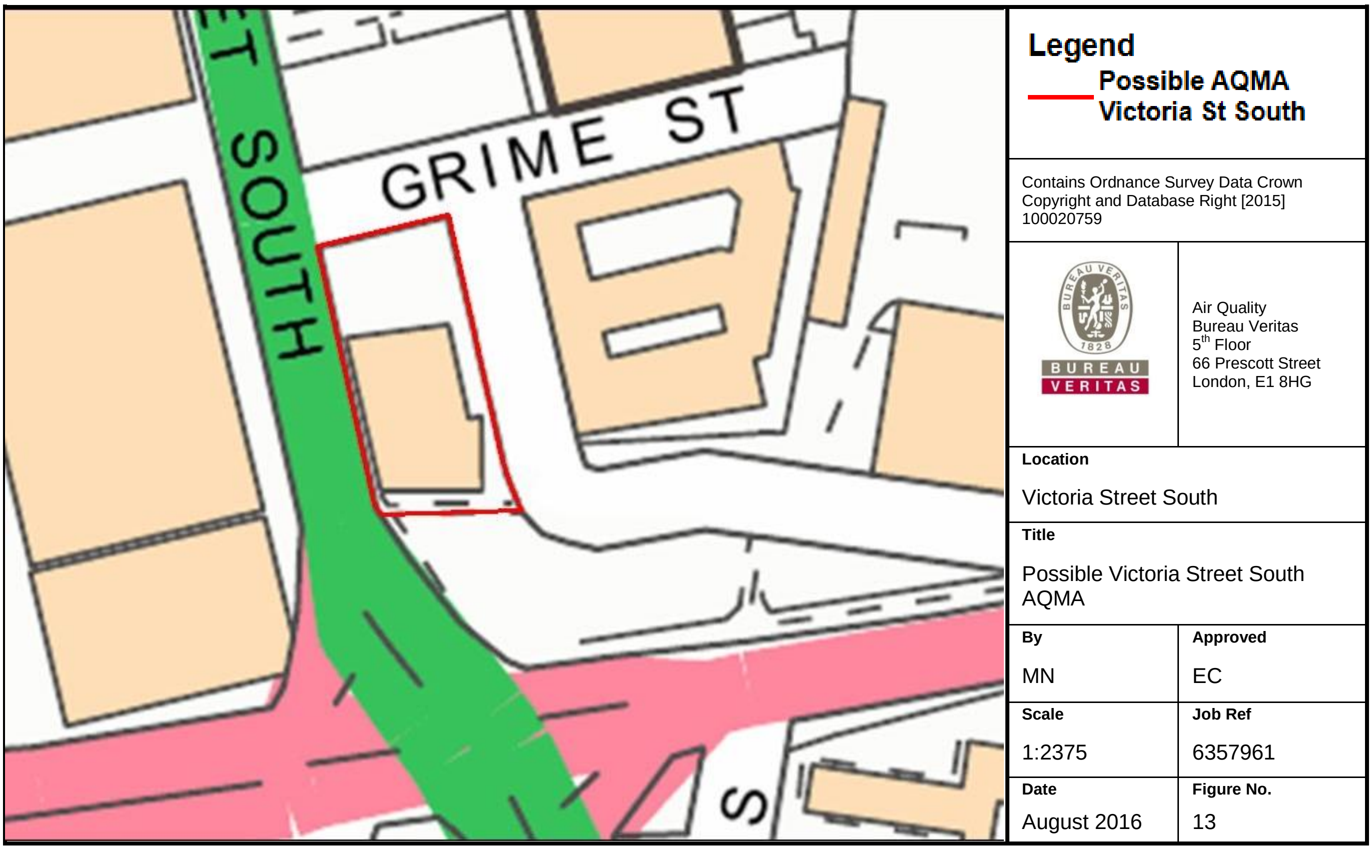


Figure 13 – Possible New Victoria Street South AQMA



5.2 Source Apportionment

To better understand the contribution of the main sources of pollution to the total annual mean NO_2 concentrations, a source apportionment exercise was undertaken, for both NO_x and NO_2.

NO_x

Source apportionment results for modelled NO_x concentrations are presented in the section below, as follows:

- Figure 14 illustrates the general breakdown of NO_x concentrations averaged across all modelled locations, providing information regarding:
  - the regional background, which NELC is unable to influence;
  - the local background, which NELC should have some influence over; and
  - other local sources (explicitly modelled), which NELC should have full control over.
- Figure 15 and Table 9 provide a more detailed breakdown of the local sources contribution to NO_x concentrations, based on:
  - the average 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 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; and
  - the location where the maximum road NO_x concentration has been predicted. This is likely to be in the area of most concern 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.

Figure 14 – Average NO_x contribution Across All Modelled Locations - General Breakdown

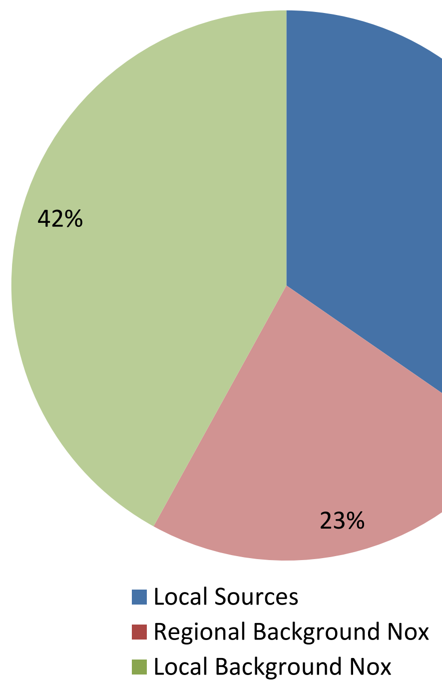
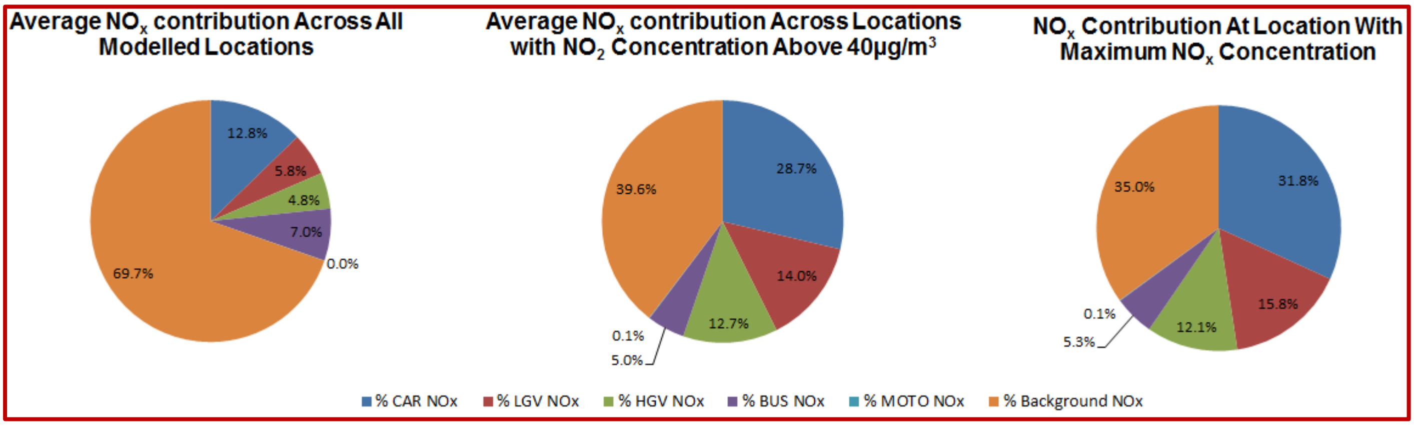


Table 9 – Source Apportionment of NO_x

Results	All Vehicles	Car	LGV	HGV	Bus	Moto	Background
	Average across all modelled locations						
NO_x Concentration (µg/m^3)	16.5	6.8	3.1	2.6	3.9	<0.1	31.1
Percentage	30.3%	12.8%	5.8%	4.8%	7.0%	<0.1%	69.7%
Percentage Road Contribution	100.0%	41.4%	18.7%	15.9%	23.8%	0.1%	-
	Average across all locations with NO_2 Concentration greater than 40µg/m^3						
NO_x Concentration (µg/m^3)	51.0	24.2	11.8	10.7	4.3	0.1	32.8
Percentage	60.4%	28.7%	14.0%	12.7%	5.0%	0.1%	39.6%
Percentage Road Contribution	100.0%	47.4%	23.1%	21.0%	8.4%	0.1%	-
	At Receptor with maximum road NO_x Concentration (Receptor 7)						
NO_x Concentration (µg/m^3)	59.1	28.9	14.3	11.0	4.8	0.1	35.9
Percentage	65.0%	31.8%	15.8%	12.1%	5.3%	0.1%	35.0%
Percentage Road Contribution	100	48.9%	24.3%	18.5%	8.2%	0.1%	-

Figure 15 – Source Apportionment of NO_x - Detailed Breakdown



Of the contributors to NO_x concentrations, Local background is the largest at 42%, followed by Local Sources at 35%, then Regional Background at 23%. This means NELC should be able to influence 77% of total NO_x concentrations with intervention policies.

When considering the average breakdown of NO_x concentration across all modelled locations in more detail, road traffic accounts for 16.5µg/m^3 (30.3%) of total NO_x (47.6µg/m^3). Of this total average NO_x, Cars account for the most (12.8%) of any of the vehicle types on average, followed by Buses (7%).

When considering the average NO_x concentration at locations with an NO_2 concentration greater than 40µg/m^3, road traffic contribution is much higher, accounting for 51µg/m^3 (60.4%) of total NO_x (83.8µg/m^3). Of this total average NO_x, Cars account for the most (28.7%) of any of the vehicle types, followed by LGVs (14%) and HGVs (12.7%).

At the receptor where the maximum road NO_x concentration has been predicted (95µg/m^3, predicted at receptor R7), road traffic accounts for 65.0% of the overall NO_x. Of this total NO_x, Cars account for the most (31.8%) of any of the vehicle types, followed by LGVs (15.8%) and HGVs (12.1%).

NO_2

Figure 16, Figure 17 and Table 10 present source apportionment results for NO_2 concentrations using the same approach as was undertaken for NO_x, as follows:

- general breakdown averaged across all modelled locations; and
- detailed breakdown based on the average across all modelled locations, the average at all locations with NO_2 concentration greater than 40µg/m^3; and at the location where the maximum road NO_2 concentration has been predicted.

Figure 16 – Average NO_2 Contribution Across All Modelled Locations - General Breakdown

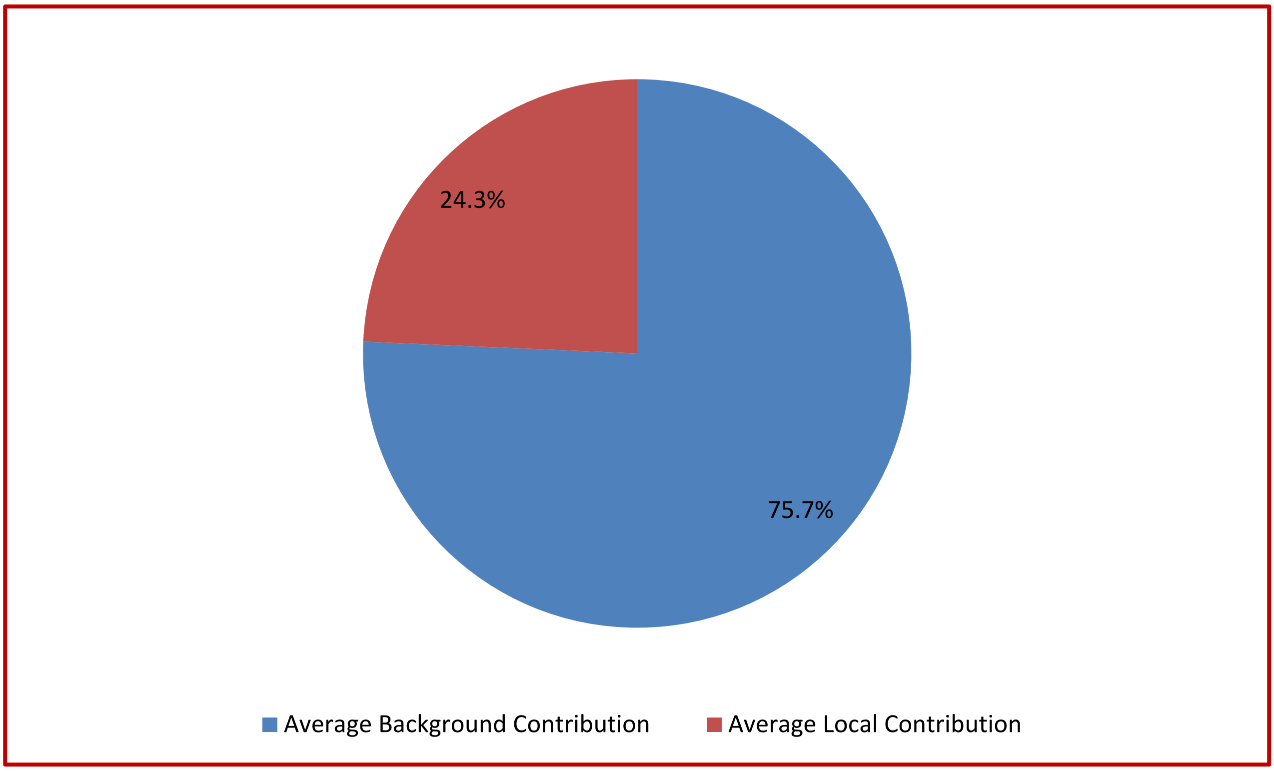
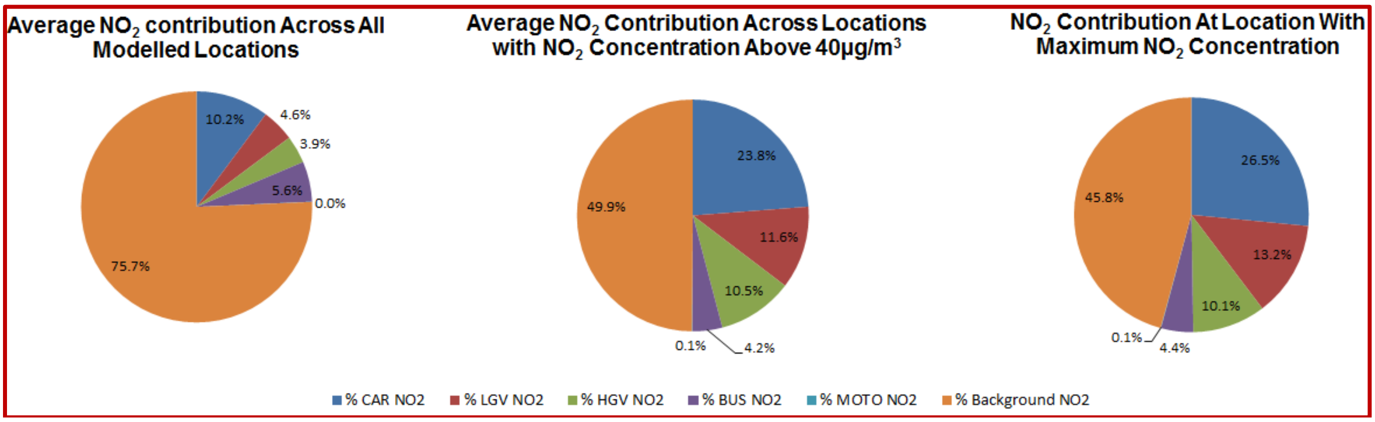


Table 10 – Source Apportionment of NO_2

Results	All Vehicles	Car	LGV	HGV	Bus	Moto	Background
	Average across all modelled receptors						
NO_2 Concentration (µg/m^3)	7.7	3.2	1.4	1.2	1.8	0.1	20.9
Percentage	24.3%	10.2%	4.6%	3.9%	5.6%	<0.1%	75.7%
Percentage Road Contribution	100.0%	41.4%	18.7%	15.9%	23.8%	0.1%	-
	Average across all receptors with NO_2 Concentration greater than 40µg/m^3						
NO_2 Concentration (µg/m^3)	22.3	10.6	5.1	4.7	1.9	0	21.9
Percentage	51.1%	23.8%	11.6%	10.5%	4.2%	0.1%	49.9%
Percentage Road Contribution	100.0%	47.4%	23.1%	21.0%	8.4%	0.1%	-
	At Receptor with maximum road NO_2 Concentration (Receptor 7)						
NO_2 Concentration (µg/m^3)	25.4	12.4	6.2	4.7	2.1	0	21.5
Percentage	54.2%	26.5%	13.2%	10.1%	4.4%	0.1%	45.8%
Percentage Road Contribution	100.0%	48.9%	24.3%	18.5%	8.2%	0.1%	-

Figure 17 – Source Apportionment of NO_2 - Detailed Breakdown



Of the contributors to NO_2 concentrations, Background is the largest at 75.7%, followed by Local Sources at 24.3%.

When considering the average breakdown of NO_2 concentrations across all modelled locations in more detail, road traffic accounts for 7.7µg/m^3 (24.3%) of total NO_2 (28.6µg/m^3). Of this total average NO_2, Cars account for the most (10.2%) of any of the vehicle types on average, followed by Buses (5.6%).

When considering the average NO_2 concentration at locations with an NO_2 concentration greater than 40µg/m^3, the road traffic contribution is much higher, accounting for 22.3µg/m^3 (51.1%) of total NO_2 (44.2µg/m^3). Of this total average NO_2, Cars account for the most (23.8%) of any of the vehicle types, followed by LGVs (11.6%) and HGVs (10.5%).

At the location where the maximum road NO_2 concentration has been predicted (46.9µg/m^3, predicted at receptor R7), road traffic accounts for 54.2% of the overall NO_2. Of this total NO_2, Cars account for the most (26.5%) of any of the vehicle types, followed by LGVs (13.2%) and HGVs (10.1%).

6 Conclusions and Recommendations

Following the assessment of monitoring results for the monitoring periods 2014 and 2015 indicating that two sites outside of the existing AQMAs were close to or exceeding the annual mean AQS objective for nitrogen dioxide (NO_2), North East Lincolnshire Council (NELC) commissioned Bureau Veritas UK Ltd to undertake a Detailed Assessment of the area in the vicinity of Victoria Mills, Victoria Street North and Town Hall Street, Grimsby, based on dispersion modelling of air pollutant emissions.

6.1 Predicted Concentrations

The ADMS-Roads dispersion model (version 4.0) has been used to determine the likely NO_2 concentrations at existing receptor locations.

Modelling results suggest that the NO_2 annual mean AQS objective of 40µg/m^3 is likely to be exceeded at a total of three receptor locations, with two further locations below, but close to (within 10%) the objective. Only one of these receptors lies within the current AQMA.

The maximum annual mean NO_2 concentration was predicted at receptor R7 on Cleethorpe Road, with a modelled annual mean of 46.9µg/m^3, within the existing AQMA. This AQMA therefore remains valid, and does not require amendment, as discussed in Section 5.1.

NO_2 concentration isopleths indicate a number of locations are modelled to be in exceedence or within 10% of the NO_2 annual mean AQS objective outside of the current AQMA. Namely, these are; Corporation Bridge crossroads; A180 crossroads with Park Street (receptor R28); A180 crossroads with Victor/Humber Street; and on Town Hall Street (receptors R52 and R53). NELC confirms that there is no exposure relevant to the annual mean AQS objective at ground floor level (1.5m), the height at which exceedences were predicted, in any of these locations. When modelled at first floor level (4.5m), the height at which residential exposure exists, concentrations are well below the objective. Therefore there is no need to declare or extend the existing AQMA to encompass these areas.

However, modelling results also indicate an exceedence of the NO_2 annual mean objective at the properties to the north of the A16/A1136 intersection. There is potential residential exposure at ground floor level in this location, at receptor R4. As no monitoring currently exists in this location, NELC will commence monitoring immediately to confirm concentrations. If annualised monitored concentrations confirm the risk of exceedence as determined by the dispersion modelling, NELC will progress to declaration of a new AQMA, the extent of which is suggested in Figure 13.

Based on the predicted annual mean NO_2 concentrations, and exceedence of the short-term (hourly mean) NO_2 AQS objective is considered unlikely at every location modelled.

Therefore, based on the above, it can be concluded that:

a) The current Cleethorpe Road AQMA should remain in place without need for amendment.

b) One further AQMA may be required along Victoria Street South, subject to confirmation of exceedence based on local monitoring to be carried out by NELC at this.

6.2 Source Apportionment

Detailed source apportionment of both NO_x and NO_2 concentrations was also conducted.

For NO_x, regional background (the concentrations over which NELC is not expected to have any influence), account for only 23% of total concentrations. As such local policy should have a significant influence on NO_x concentrations.

For NO_x and NO_2, vehicle emissions represent the largest proportion of total concentrations at locations with NO_2 concentrations greater than 40µg/m^3, at 60.4% and 51.1% respectively. Considering road traffic only, cars represent the largest contribution for a specific vehicle type, at 47.4% of total vehicle emissions at locations where NO_2 concentrations exceed the annual mean objective.

6.3 Future Recommendations

Following the above conclusions, the following recommendations are made:

- Keep the current Cleethorpe Road AQMA in place without amendment

- Commence monitoring near receptor R4 in Victoria Street South immediately, to confirm whether there is at risk of exceedence of the annual mean AQS objective of 40µg/m^3. If monitoring confirms modelled concentrations, declare a new AQMA at this location. Following any potential declaration, create a new AQAP.

- Monitor and/or restrict the use of the ground floor of Town Hall Street for residential usage. If residential exposure is introduced at this height, it will be necessary to declare a new AQMA, as shown by the dispersion modelling results.

- Based on source apportionment results, any future intervention measures should be targeted at reducing vehicle emissions, with cars the largest contributors to total vehicle emissions.

- Consider NO_2 monitoring near receptor R14 on Cleethorpe Road, where there is residential exposure at ground floor level within 15m of isopleths indicating potential for exceedence of the annual mean AQS objective, though modelled concentrations at this specific point are only 29.3µg/m^3.

- Consider NO_2 monitoring at receptor R24 on Cleethorpe Road, where there is residential exposure at ground floor level within 10m of isopleths indicating potential for exceedence of the annual mean AQS objective, though the modelled concentration at this specific point is 31.4µg/m^3. This could either be through re-location of the NEL18 monitoring site opposite, or the addition of a new monitoring location.

Appendices

Appendix 1 – Background to Air Quality

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

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

This air quality assessment focuses on NO_2 as this pollutant is the least likely to meet the respective Air Quality Strategy (AQS) objectives near roads. This has been confirmed over recent years by the outcome of the Local Air Quality Management (LAQM) regime. Recent statistics[13] regarding Air Quality Management Areas (AQMAs) show that approximately 640 AQMAs are declared in the UK. The majority of existing AQMAs have been declared in relation to road traffic emissions.

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

An overview of this pollutant, describing briefly the sources and processes influencing the ambient concentrations, is presented below.

Nitrogen Oxides (NO_x)

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

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

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

[13] Statistics from the UK AQMA website available at http://aqma.defra.gov.uk – Figures as of April 2016

Appendix 2 – ADMS Model Verification

The ADMS-Roads dispersion model has been widely validated for this type of assessment, and as such is regularly used for LAQM purposes by a large number of local authorities.

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;
- Local weather conditions;
- Monitoring data, including locations; and
- Overall model limitations.

Model verification is the process by which these 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 model 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 concentrations; and
- Local air quality monitoring data.

The traffic data for this assessment has been collated using a combination of manual count data provided by NELC and growthed figures taken from Department for Transports (DfT), Traffic Counts web resource as outlined in Section 4.1.1.

NELC undertakes passive diffusion tube monitoring at thirty-one locations and continuous monitoring at four locations as part of its LAQM commitments. Fifteen of these locations are located along roads within the modelled area, and have therefore been considered for the purpose of model verification.

The details of these monitoring sites are presented in Table 4 of the main report.

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 LAQM diffusion tube monitoring data was used as in Table 4. Data capture for 2015 was generally good, with the exception of 'NEL 17', which was below the threshold where LAQM.TG(16)[1] recommends the need for annualisation. At time of writing, the annualisation adjustment has not been carried out. Table A2.1 below shows an initial comparison of the monitored and unverified modelled NO_2 results for the year 2014, in order to determine if an adjustment was required.

Table A2.1 – Comparison of Unverified Modelled and Monitored NO_2 Concentrations

Site ID	Background NO_2 (µg/m^3)	Monitored total NO_2 (µg/m^3)	Unverified Modelled total NO_2 (µg/m^3)	% Difference (modelled vs. monitored)
NEL1	20.1	29.2	24	-17.8
NEL2	20.1	**40.1**	28.7	-28.6
NEL3	20.1	35.5	28.4	-19.9
NEL8	18.5	31.8	24.3	-23.6
NEL9	21.4	20.7	22.9	10.4
NEL10	21.4	25.1	23	-8.3
NEL11, 12, 13	21.4	**43.8**	33.1	-24.5
NEL14	21.4	35.6	28.1	-21
NEL15	21.4	31.5	27.8	-11.9
NEL16	21.4	29.6	25	-15.7
NEL17	23.6	27.6	26.8	-2.8
NEL18	23.6	25.2	31.6	25.2
NEL19	20.1	32.5	24.4	-24.9
NEL20	21.4	35.5	26.3	-25.9
CM4	21.4	**46.5**	32.9	-29.2

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

The model was over predicting at some locations (notably NEL18 and NEL9), but generally under predicting in most cases, and no further improvement of the modelled results could be obtained on this occasion. At a number of sites, the difference between modelled and monitored concentrations was greater than or close to 25%, meaning adjustment of the results was necessary, as per LAQM.TG16 guidance. 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 diffusion tube monitoring results used in the calculation of the model adjustment, NO_x was derived from NO_2; using NOx/NO_2 calculator tool published by Defra and available from the LAQM website[14].

Table A2.2 provides the relevant data required to calculate a model adjustment factor, based on regression of the modelled and monitored road source contribution to NO_x.

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

Table A2.2 – Data Required for Adjustment Factor Calculation

Site ID	Monitored total NO_2 (µg/m^3)	Monitored total NO_x (µg/m^3)	Background NO_2 (µg/m^3)	Background NO_x (µg/m^3)	Monitored road contribution NO_2 (total - background) (µg/m^3)	Monitored road contribution NO_x (total - background) (µg/m^3)	Modelled road contribution NO_x (excludes background) (µg/m^3)
NEL1	29.2	48.8	20.1	29.9	9.1	18.9	7.9
NEL2	40.1	74.3	20.1	29.8	20.0	44.4	17.7
NEL3	35.5	63.0	20.1	29.8	15.4	33.2	17.2
NEL8	31.8	55.1	18.5	27.1	13.3	27.9	11.6
NEL9	20.7	30.4	21.4	31.8	-0.7	-1.5	2.8
NEL10	25.1	39.2	21.4	31.8	3.7	7.4	3.2
NEL11, 12, 13	43.8	82.7	21.4	31.8	22.4	50.9	24.7
NEL14	35.6	62.3	21.4	31.8	14.2	30.5	13.7
NEL15	31.5	53.0	21.4	31.8	10.1	21.2	13.0
NEL16	29.6	48.8	21.4	31.8	8.2	17.0	7.1
NEL17	27.6	44.1	23.6	35.9	4.0	8.2	6.6
NEL18	25.2	39.1	23.6	35.9	1.6	3.2	16.7
NEL19	32.5	56.1	20.1	29.8	12.4	26.2	8.7
NEL20	35.5	62.1	21.4	31.8	14.1	30.3	9.9
CM4	46.5	89.9	21.4	31.8	25.1	58.1	24.4

Figure A2.1 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 A2.1 gives an adjustment factor for the modelled results of 1.95.

Figure A2.1 – Comparison of the Modelled Road Contribution NO_x versus Monitored Road Contribution NO_x

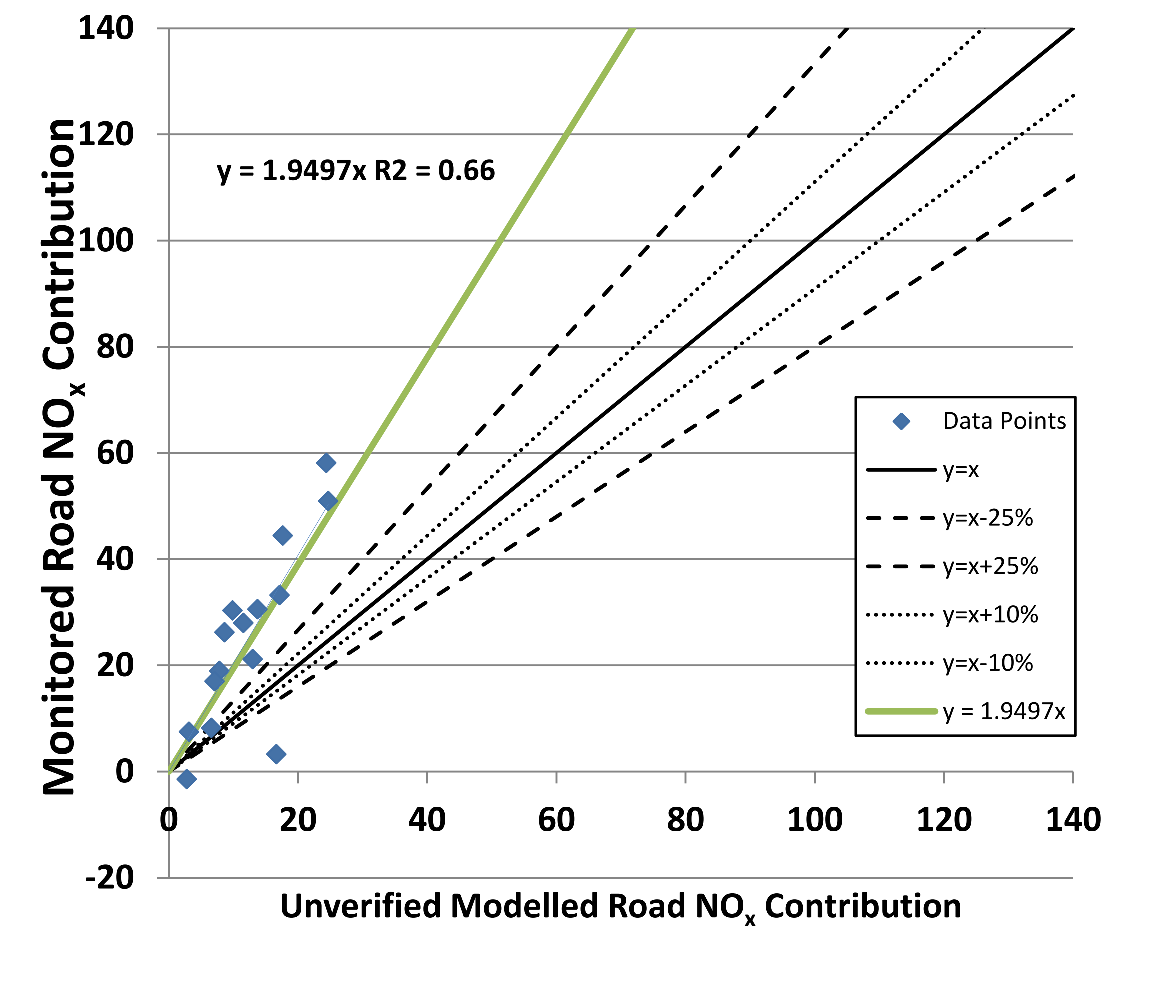


Table A2.3 shows the ratios between monitored and modelled NO_2 for each monitoring location based on the above adjustment factor. There is a significant variation between the monitored/modelled ratios across the verification sites, mainly due to inconsistencies in monitored concentrations across similar monitoring types/adjacent monitoring sites (for example in NEL 9 and 10, where concentrations vary by 4.4µg/m^3, or around 25%, without an obvious change in source contributions). Using a factor of 1.95 to adjust all modelled results would lead to an over prediction of concentrations at some of these monitoring locations by up to 52.6%. In order to provide more confidence in the model predictions, the majority of results should be within 25%, ideally within 10%, of the monitored, and consequently 1.95 is not a suitable verification factor.

Table A2.3 – Adjustment Factor and Comparison of Verified Results Against Monitoring Results

Site ID	Ratio of monitored road contribution NO_x / modelled road contribution NO_x	Adjustment factor for modelled road contribution NO_x	Adjusted modelled road contribution NO_x (µg/m^3)	Adjusted modelled total NO_x (including background NO_x) (µg/m^3)	Modelled total NO_2 (based upon empirical NO_x / NO_2 relationship) (µg/m^3)	Monitored total NO_2 (µg/m^3)	% Difference (adjusted modelled NO_2 vs. monitored NO_2)
NEL1	2.4	1.950	15.4	45.2	27.6	29.2	-5.6
NEL2	2.5		34.4	64.3	36.0	40.1	-10.2
NEL3	1.9		33.5	63.3	35.6	35.5	0.3
NEL8	2.4		22.6	49.7	29.4	31.8	-7.5
NEL9	-0.5		5.5	37.3	24.2	20.7	16.8
NEL10	2.3		6.2	38.0	24.5	25.1	-2.4
NEL11_12_13	2.1		48.2	80.0	42.8	43.8	-2.4
NEL14	2.2		26.8	58.6	34.0	35.6	-4.5
NEL15	1.6		25.3	57.1	33.4	31.5	5.9
NEL16	2.4		13.9	45.7	28.2	29.6	-4.8
NEL17	1.2		12.9	48.8	29.8	27.6	8.0
NEL18	0.2		32.6	68.5	38.5	25.2	52.6
NEL19	3.0		16.9	46.7	28.3	32.5	-13.0
NEL20	3.1		19.3	51.1	30.7	35.5	-13.6
CM4	2.4		47.6	79.4	42.5	46.5	-8.6

A number of monitoring sites, deemed as outliers, have therefore been removed from the verification process. A summary of the reasons behind each removal from the process is given in Table A2.4. This results in an increase of the model verification factor and increased alignment between monitored and modelled values as shown in Table A2.5 and Figure A2.2. The equation of this new trend line presented gives an increased adjustment factor for the modelled results of 2.30.

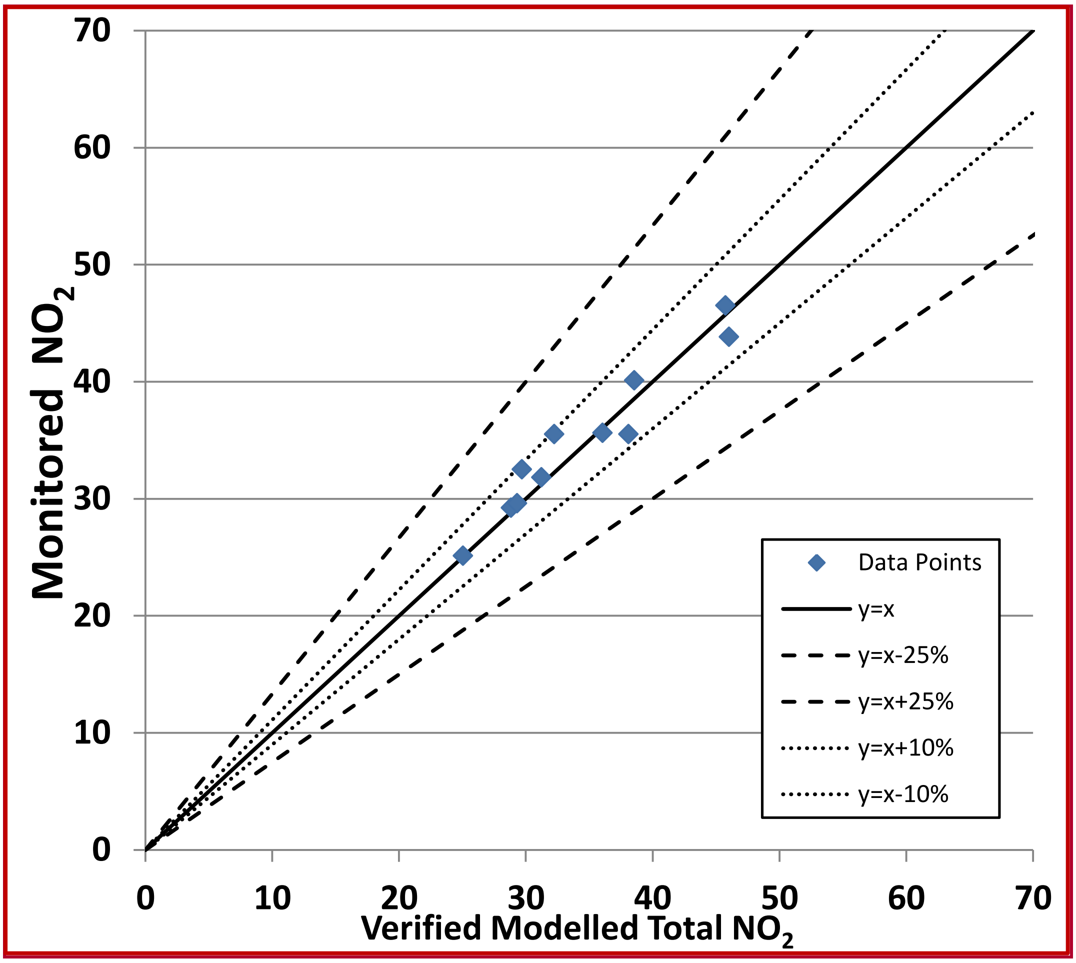
Table A2.4 – Monitoring sites removed from Verification Process

Site ID	Ratio of monitored road contribution NO_x / modelled road contribution NO_x	Monitored total NO_2 (µg/m^3)	Reason for removal of Site from Verification
NEL9	-0.5	20.7	Monitored NO_2 below assumed background value despite being a roadside site, which yields artificially negative ratio.
NEL15	1.6	31.5	Low ratio as compared to other similar monitoring sites (NEL11/12/13 and NEL14). Also a significant reduction in NO_2 compared to a monitored 2014 concentration of 38.2µg/m^3. Considered to be anomalous
NEL17	1.2	27.6	Data capture below 75%, affecting annual mean concentration and yielding potentially artificially low ratio
NEL18	0.2	25.2	Peripheral to model domain and monitored concentration very close to assumed background value, despite being a roadside site; so yields artificially negative ratio.

Table A2.5 – Adjustment Factor and Comparison of Verified Results Against Monitoring Results after Removal of Four Verification Points

Site ID	Ratio of monitored road contribution NO_x / modelled road contribution NO_x	Adjustment factor for modelled road contribution NO_x	Adjusted modelled road contribution NO_x (µg/m^3)	Adjusted modelled total NO_x (including background NO_x) (µg/m^3)	Modelled total NO_2 (based upon empirical NO_x / NO_2 relationship) (µg/m^3)	Monitored total NO_2 (µg/m^3)	% Difference (adjusted modelled NO_2 vs. monitored NO_2)
NEL1	2.40	2.300	18.1	48.0	28.9	29.2	-1.2
NEL2	2.52		40.6	70.5	38.6	40.1	-3.8
NEL3	1.93		39.5	69.3	38.1	35.5	7.4
NEL8	2.41		26.7	53.8	31.3	31.8	-1.7
NEL10	2.34		7.3	39.1	25.0	25.1	-0.2
NEL11_12_13	2.06		56.9	88.7	46.0	43.8	5.1
NEL14	2.22		31.6	63.4	36.1	35.6	1.3
NEL16	2.38		16.4	48.2	29.3	29.6	-0.9
NEL19	3.03		19.9	49.8	29.7	32.5	-8.6
NEL20	3.06		22.8	54.6	32.2	35.5	-9.2
CM4	2.38		56.1	87.9	45.8	46.5	-1.6

Figure A2.2 – Comparison of the Modelled NO_2 versus Monitored NO_2



The adjustment factor of 2.30 was applied to the road-NO_x concentrations predicted by the model before using the NOx/NO_2 calculator tool to estimate total NO_2 concentrations. All sites show an acceptable agreement between the monitored and modelled NO_2, with modelled concentrations being well within ±10% of the measured concentrations. A factor of 2.30 also reduces the Root Mean Square Error (RMSE) from a value of 8.5 to 1.8.

All NO_2 results presented and discussed herein are those calculated following the process of model verification using an adjustment factor of 2.30.

Appendix 3 – Locations Exceeding the NO_2 Annual Mean AQS Objective

Figure A3. 1 – Corporation Bridge crossroads

Figure A3. 2 – A180 crossroads with Park Street – 'R28'

Figure A3. 3 – A180 crossroads with Victor/Humber St – 'R1' and 'R18'

Figure A3. 4 – A16 - A1136 Victoria St South – 'R4'

Figure A3. 5 – Townhall Street - 'R52' and 'R53'