Derry City Council
Local Air Quality Management

Dispersion Modelling and Quantitative Appraisal

March 2014

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Executive Summary

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

Bureau Veritas has been commissioned by Derry City Council to carry out a dispersion modelling assessment of nitrogen dioxide (NO_2) concentrations in five Air Quality Management Areas (AQMAs) within the city. The following results are reported:

- Creggan Road – Exceedences of the annual mean objective continue to the west of the Creggan Road/Infirmary Road Junction.
- Dale's Corner – Exceedences of the annual mean objective continue across the AQMA.
- Buncrana Road – Exceedences of the annual mean objective are localised around the junction with Racecourse Road.
- Spencer Road – Monitored and modelled exceedences of the annual mean objective are experienced across the AQMA.
- Strand Road - Exceedences of the annual mean objective have not been monitored in the AQMA.

As no exceedences have been monitored in the Strand Road AQMA for three years, including at sites introduced for 2013, it is recommended that this AQMA be revoked. The area of exceedence in the Creggan Road and Buncrana Road AQMAs is smaller than when they were declared, therefore amended AQMA boundaries have been recommended. Similarly, most of the properties in the Spencer Road AQMA have been determined not to be relevant receptors for the annual mean objective, therefore an amended AQMA boundary has been recommended. There is no need to declare an AQMA for the short-term NO_2 objective in the Creggan Road AQMA as this objective has not been breached.

Modelling has also show that if the Euro II and III buses in Derry could be replaced by Euro VI buses, NO_2 concentrations could be reduced by up to 2.7 µg/m^3. These changes are of a magnitude that would reduce the area of exceedence of the annual mean objective significantly. It is therefore recommended that Air Quality Action Plan measures aimed at bus fleet renewal are prioritised.

1 Introduction

Derry City Council (the Council) has commissioned Bureau Veritas to undertake dispersion modelling of nitrogen dioxide (NO_2) concentrations in five Air Quality Management Areas (AQMAs) in the city. Quantitative appraisal of bus fleet scenarios aimed at working towards compliance with relevant objectives in the AQMAs has also been carried out. The AQMAs are shown in Figure 1 to Figure 5. The Council has declared the AQMAs as a result of exceedences of the annual mean NO_2 objective.

This report provides the scope, methodology and outcome of this modelling work. It is based on dispersion modelling of air pollutant emissions from road-traffic in the area. Modelling was carried out based on the latest Local Air Quality Management (LAQM) technical guidance LAQM.TG (09) and associated tools such as the NO_x/NO_2 converter, local air pollution monitoring and road-traffic emission factors, using the ADMS-Roads™ dispersion model.

Figure 1 - Map of AQMA boundary, Creggan Road

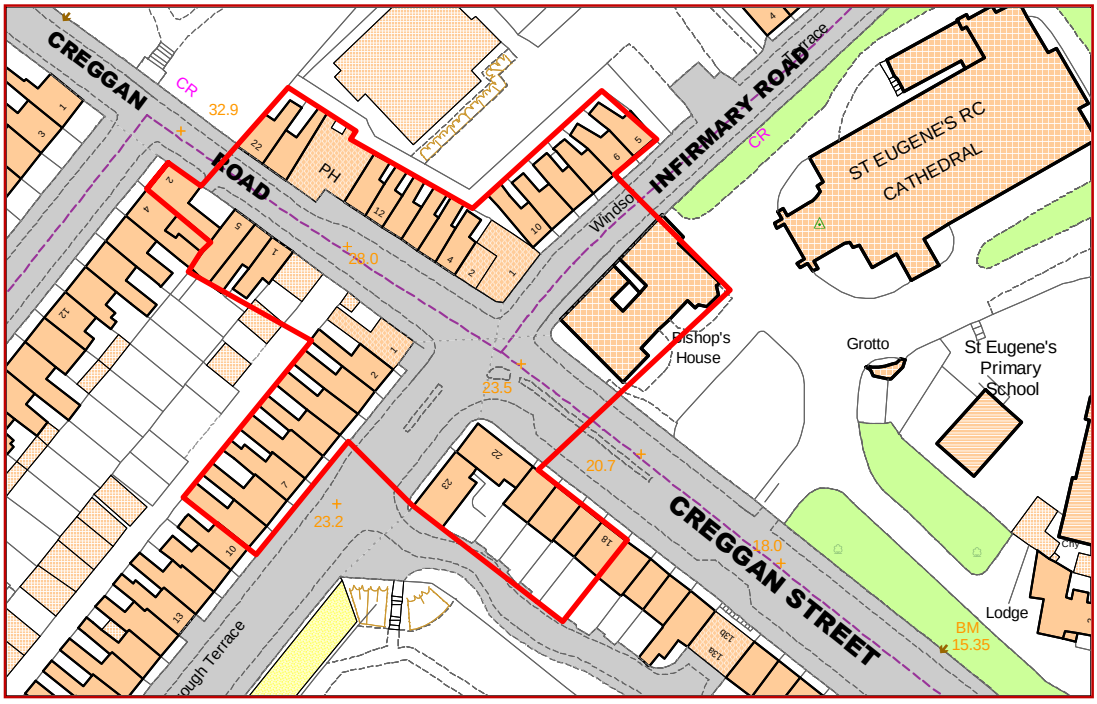

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Figure 2 - Map of AQMA boundary, Dale's Corner

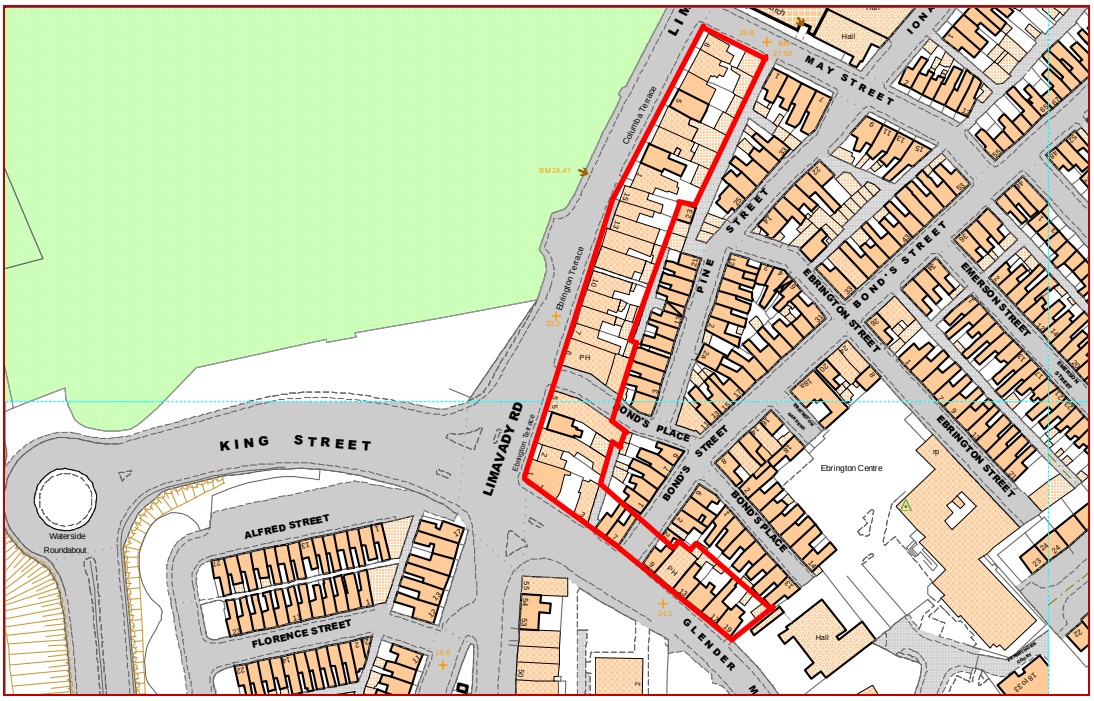

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Figure 3 - Map of AQMA boundary, Buncrana Road

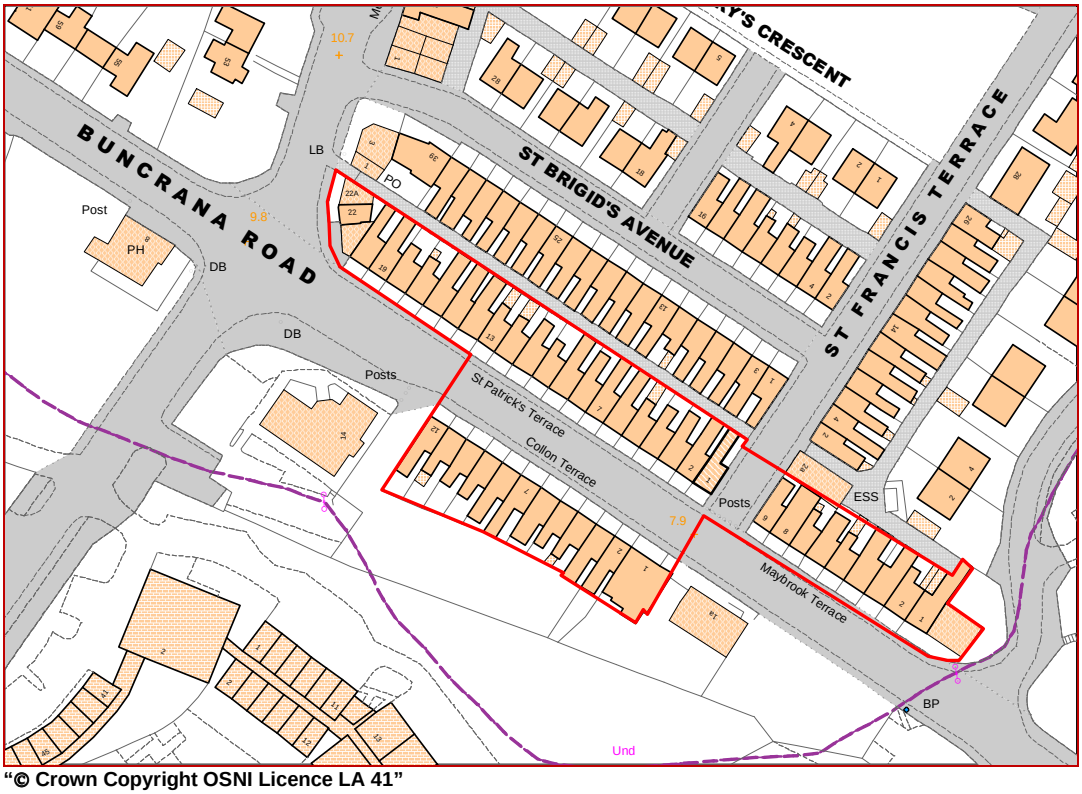

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Figure 4 - Map of AQMA boundary, Spencer Road

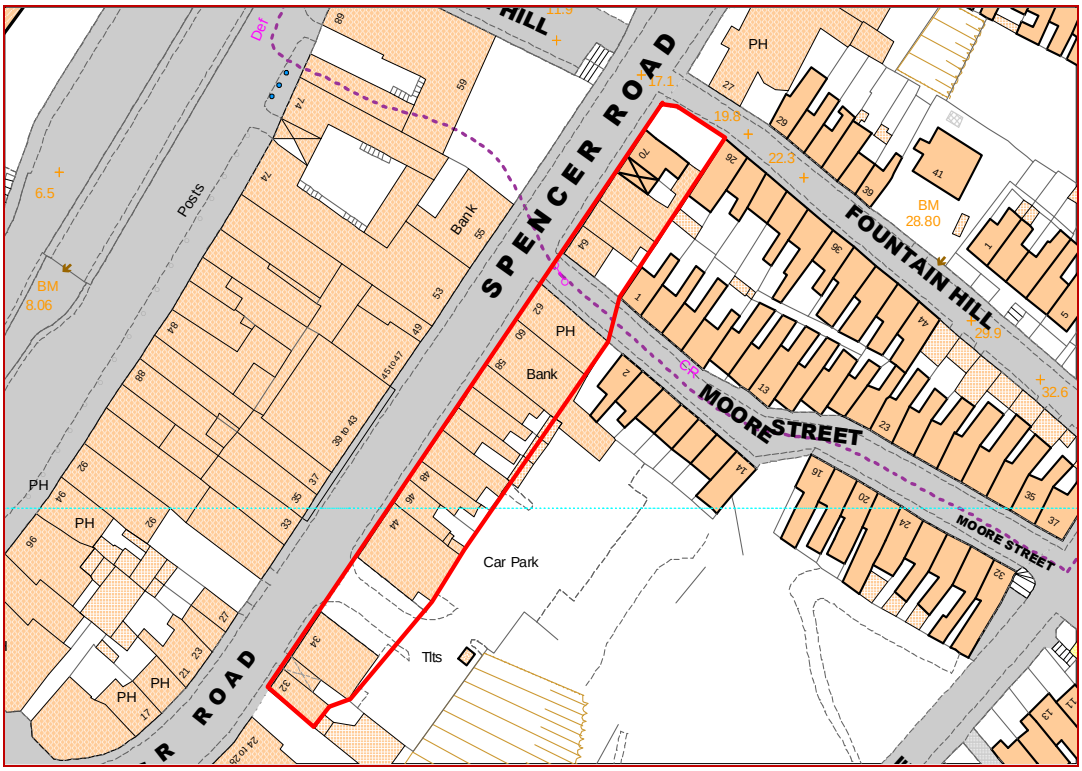

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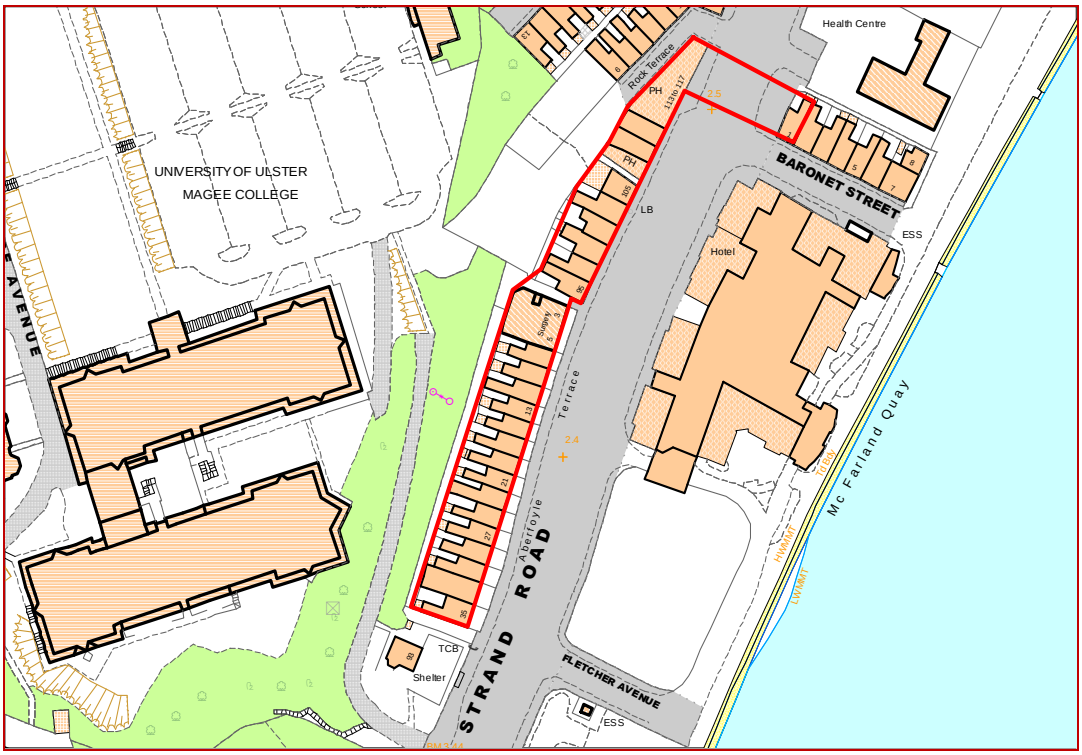
Figure 5 - Map of AQMA boundary, Strand Road



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1.1 Legislative Background

The significance of existing and future pollutant levels are assessed in relation to the national air quality standards and objectives, established by Government. The revised Air Quality Strategy (AQS)[1] for the UK (released in July 2007) provides the over-arching strategic framework for air quality in the UK and contains national air quality standards and objectives established by the UK Government and devolved administrations to protect human health. The air quality objectives incorporated in the AQS and the UK Legislation are derived from the Limit Values prescribed in the EU Directives transposed into national legislation by member states.

The CAFE (Clean Air for Europe) programme was initiated in the late 1990s to draw together previous directives into a single EU Directive on air quality. The Directive 2008/50/EC[2] introduces new obligatory standards for $PM_{2.5}$ for the EU states but places no statutory duty on local Government to work towards achievement.

The Air Quality Standards Regulations (Northern Ireland) 2010 came into force to align and bring together in one statutory instrument the Government's obligations to fulfil the requirements of the CAFE Directive. 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), particulates (PM_{10} and $PM_{2.5}$), ozone (O_3) and Polycyclic Aromatic Hydrocarbons (PAHs)), have been prescribed within the Air Quality Strategy[1].

This assessment focuses on NO_2, in respect of pollutant sources affecting air quality within the Council's administrative area. The objectives set out for NO_2 included in the Air Quality Regulations for the purpose of Local Air Quality Management are presented in Table 1.

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 of the AQS objective. Typically, these include residential properties and schools/care homes for longer period (i.e. annual mean) pollutant objectives and high streets for short-term (i.e. 1-hour) pollutant objectives.

Table 1 – AQS Objectives for NO_2 Included in the Regulations for LAQM in Northern Ireland

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Nitrogen dioxide (NO_2)	200 µg/m^3 not to be exceeded more than 18 times a year	1-hour mean	31.12.2005
	40 µg/m^3	Annual mean	31.12.2005

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

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

2 Methodology and Assessment Criteria

The approach used in this assessment is based on quantifying the ambient NO_2 concentrations in the assessment area in the baseline and resulting from the proposed interventions.

The concentrations of NO_2 for the baseline year (2013) have been predicted and adjusted as part of the model verification, based on available local air quality data from the Council's monitoring network. The results from the intervention scenario have then been compared with the baseline scenario results to assess their impact.

The following sections provide details of the assessment methodology used to predict NO_2 concentrations based on dispersion modelling.

2.1 Dispersion Modelling Overview

Detailed dispersion modelling of NO_x emissions due to road-traffic was undertaken based on the ADMS-Roads (version 3.1) atmospheric dispersion model, developed by Cambridge Environmental Research Consultants (CERC), using the latest vehicle emission factors released by Defra in 2013.

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

Conversion of NO_x to NO_2 was based on the latest NO_x/NO_2 conversion model released by Defra in 2012 as part of the updated LAQM tools. The calculator is based on a new approach that takes into account O_3 concentrations and changes in the proportion of primary NO_2 and in regional NO_x and NO_2 in the future years. Concentrations of NO_2 measured in 2013 at monitoring site locations within each of the assessment areas have been used to verify the model results.

2.2 Modelled Area

NO_2 concentrations have been modelled in each of the AQMAs. These have been modelled at monitoring locations and across a 5m resolution receptor grid at a height of 1.5m, to produce concentration isopleths for appraisal of the AQMAs.

Where street canyons have been identified, these have been incorporated into the model to represent the restricted dispersion at those locations.

2.3 Comparison with AQS objectives

Annual mean NO_2 concentrations have been predicted based on dispersion modelling, and compared to the long-term AQS objective. However, short-term concentrations (1-hour mean) have also been considered in the assessment.

For NO_2, the 1-hour mean AQS objective is 200 µg/m^3, not to be exceeded more than 18 times per year. Analysis of UK continuous NO_2 monitoring data has shown that it is unlikely that the 1-hour

mean objective would be exceeded where the annual mean objective is marginally below 60 µg/m^3[3]. Therefore, potential exceedences of the 1-hour mean objective have been identified based on this criterion.

2.4 Input Data

To predict the contribution of road traffic emissions to the total pollutant concentrations, the model requires various input data such as meteorological data, traffic data, and background pollutant concentrations. The following sections describe the input data used for this assessment.

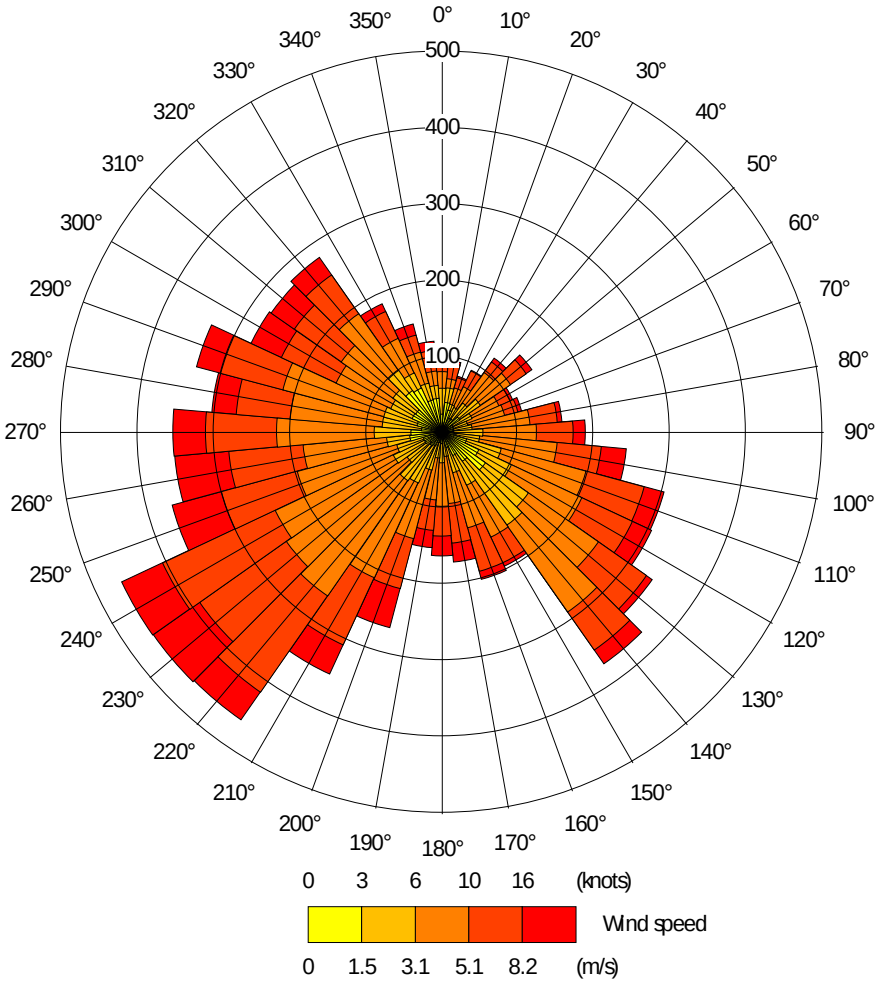
2.4.1 Meteorological Data

Hourly sequential meteorological data for the year of assessment (2013) from the nearest representative meteorological station (Derry) was used in this assessment. The wind rose for meteorological data is provided in Figure 6, where the dominant south-westerly winds can be clearly identified. Most dispersion models do not use meteorological data if they relate to calm wind 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 0.75 m/s.

LAQM.TG(09) recommends that the meteorological data file be tested within a dispersion model and the relevant output log file checked to confirm the number of missing hours and calm hours that cannot be used by the dispersion model. This is important when considering predictions of high percentiles and the number of exceedences. LAQM.TG(09) recommends that meteorological data should only be used if the percentage of usable hours is greater than 75%, and preferably 90%; the 2013 meteorological data used in this assessment includes 8,450 lines of usable hourly data out of the total 8,760 for the year, i.e. 97% usable data. This is above the 90% threshold, and is therefore adequate for the dispersion modelling.

[3]AEAT (May 2008) - Analysis of the relationship between annual mean nitrogen dioxide concentration and exceedences of the 1-hour mean AQS Objective. A report produced for Defra, the Scottish Government, the Welsh Assembly Government and the Department of the Environment in Northern Ireland.

Figure 6 – Derry 2013 Hourly Sequential Meteorological Data



2.4.2 Traffic Data

The Council has provided baseline traffic counts for all the main roads in the AQMAs. Data included 7-day Automatic Traffic Count (ATC) results and peak hour turning counts with vehicle class splits. The peak hour turning count data was used to derive estimates of 24-hour flows using factors derived from the ATC results. For the purpose of this assessment, vehicle speed was reduced near junctions and congested areas to 20km/h to account for stop / start emissions, which is in line with recommendations from LAQM.TG(09). Details of traffic data used for this assessment are provided in Appendix 2.

The Emission Factor Toolkit (EFT)[4] has been used to derive NO_x emissions for each road link, based on the traffic data provided. The EFT, published by Defra, allows users to calculate road traffic emissions based on vehicle fleet composition, traffic speeds and road type.

Information on the age and Euro emission class of buses operating in the city has also been provided. These are shown in Table 2.

[4]Emission Factor Toolkit, Version 5.2c, January 2013 – Available at http://laqm.defra.gov.uk/review-and-assessment/tools/emissions.html#eft

Table 2 – Euro Emission Classes of Derry Buses

Class	Number	%
Euro II	12	8.16%
Euro III	70	47.62%
Euro IV	33	22.45%
Euro V	32	21.77%
Total	147	100.00%

2.4.3 Modelled Scenarios

The following scenarios have been considered in this assessment:

- 2013 - current baseline - to verify the model against the latest monitoring data;
- Scenario 1 - impact of fleet improvement - all Euro II and III buses replaced by Euro VI buses at Dale's Corner; and
- Scenario 2 - impact of fleet improvement - all Euro II and III buses replaced by Euro VI buses at Buncrana Road.

2.4.4 Background Concentrations

The ADMS-Roads dispersion model was used to calculate the pollutant concentrations due to local road-traffic emissions only. Background concentrations (arising from local sources other than road-traffic, and more distant sources) were then added to predict the total pollutant concentrations at the receptors of concern.

Background concentrations can either be obtained from appropriate monitoring stations or from Defra modelled maps of background pollutant concentrations. These maps, available from the LAQM Support website[5] operated by Bureau Veritas, provide background concentrations at a 1km x 1km resolution across the UK for years 2010 to 2030. As the mapped background concentration compares well with the concentration monitored at the Brooke Park urban background monitoring station (grid reference: 242962, 417217; 2013 NO_2 concentration: 13.7µg/m^3) the UK background maps have been used to account for varying backgrounds across the modelled area. The concentrations used are provided in Table 3.

Table 3 – Background Concentrations Used for the Assessment (µg/m^3)

Grid Square	NO_x	NO_2
242500_417500	14.3	10.6
243500_417500	17.5	12.8
244500_416500	17.0	12.4
243500_419500	17.9	12.9
243500_418500	22.7	16.0
243500_416500	17.4	12.7
243500_415500	10.8	8.2

[5] http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html - As of February 2013

2.5 Model Verification and Adjustment

Model verification, an assessment of the accuracy of the model, can be undertaken where monitoring sites are located within the modelled area. The objectives of the model verification are to evaluate model performance and to provide confidence in the assessment.

Modelled NO_2 concentrations were compared with local monitoring data from the local diffusion tubes. Modelled road-NO_x concentrations were adjusted accordingly. Predicted NO_2 was then derived based on the latest NO_x/NO_2 conversion model released by Defra in September 2012[6].

During the verification process, Bureau Veritas aim to ascertain whether modelled concentrations are within 25% of the monitored concentrations. Reasons why modelled results may not compare so well with observed monitoring results at some locations include:

- Discrepancies in traffic flow and speed data estimates;
- Model setup (including street canyons, road widths, receptor locations);
- Model limitations (treatment of roughness and meteorological data);
- Uncertainty in monitoring data (notably diffusion tubes, e.g. bias adjustment factors and annualisation of short-term data); and
- Uncertainty in emissions / emission factors.

The above factors were investigated as part of the model verification process to minimise the uncertainties as far as practicable. Results of the model verification for each modelled area are provided in Section 3.2.

2.6 Impact Significance

The significance of the air quality impacts due to the modelled intervention scenarios have been described based on the predicted change in the annual mean NO_2 concentrations.

The methodology described in the latest Environmental Protection UK (EPUK) guidance document[7] has been followed to determine the significance of the impacts, which takes into account:

- The magnitude of the change (% change for annual mean concentrations – see Table 4);
- The concentration relative to the AQS objective (above or below the relevant air quality objective); and
- The direction of change (adverse - increase with scheme - or beneficial - decrease with scheme).

Taking account of these changes, the significance of impacts was described at each receptor as either *Negligible*, *Slight*, *Moderate* or *Substantial*, and whether the change was *Beneficial* or *Adverse*. The impact significance is applicable only to those receptors, which are locations where the relevant objectives apply.

[6] http://laqm.defra.gov.uk/tools-monitoring-data/no-calculator.html

[7] Development Control: Planning for Air Quality, (2010 Update), EPUK, 2010

Table 4 – Definition of Impact Magnitude for NO_2 Annual Mean

Annual Mean	Impact Magnitude
Increase/decrease >10%	Large
Increase/decrease 5-10%	Medium
Increase/decrease 1-5%	Small
Increase/decrease <1%	Imperceptible

The explanation of impacts significance descriptors for the annual mean NO_2 applicable in this case is provided below respectively in Table 5 as recommended by the EPUK guidance document[8]. The effectiveness of each option will also be considered in reference to a score derived from the number of receptors experiencing beneficial impacts minus the number experiencing adverse impacts. An additional metric considered will be the change in concentration at all receptors exceeding the annual mean objective of 40µg/m^3 in the baseline or with measure scenarios as these are considered to be the key concentration changes.

[8] For NO_2, Table 5 of the guidance; For PM_{10}, Table 19 Appendix 3 of the guidance, specific to the PM_{10} AQS annual mean objective for Scotland

Table 5 – Impact Descriptors for Annual Mean NO_2

Absolute Concentration in Relation to AQS Objective	Magnitude			
	Imperceptible	Small	Medium	Large
Increase With Scheme				
Above Objective *With* Scheme (>40µg/m³)	Negligible	Slight Adverse	Moderate Adverse	Substantial Adverse
Just Below Objective *With* Scheme (36-40µg/m³)	Negligible	Slight Adverse	Moderate Adverse	Moderate Adverse
Below Objective *With* Scheme (30-36µg/m³)	Negligible	Negligible	Slight Adverse	Slight Adverse
Well Below Objective *With* Scheme <30µg/m³)	Negligible	Negligible	Negligible	Slight Adverse
Decrease With Scheme				
Above Objective *Without* Scheme (>40µg/m³)	Negligible	Slight Beneficial	Moderate Beneficial	Substantial Beneficial
Just Below Objective *Without* Scheme (36-40µg/m³)	Negligible	Slight Beneficial	Moderate Beneficial	Moderate Beneficial
Below Objective *Without* Scheme (30-36µg/m³)	Negligible	Negligible	Slight Beneficial	Slight Beneficial
Well Below Objective *Without* Scheme <30µg/m³)	Negligible	Negligible	Negligible	Slight Beneficial

3 Baseline Conditions

3.1 Monitoring Results

There are currently three automatic monitoring sites which provide the Council with real time air quality data. Passive monitoring is additionally carried out at a number of locations. The details of both the automatic monitoring sites and passive monitoring locations within the study areas are provided in Table 6 to Table 10 below. Locations are shown in Appendix 4.

Table 6 – Continuous monitoring site details

Site Name	Site Type	X OS Grid Reference	Y OS Grid Reference	Pollutants Monitored	In AQMA?	Monitoring Technique	Relevant Exposure? *(Y/N with distance (m) to relevant exposure)*	Distance to Kerb of Nearest Road *(N/A if not applicable)*	Does this location represent worst-case exposure?
Brooke Park (AURN)	Urban Background	242962	417217	O_3, NO_2, NO_X, SO_2, PM_{10}, $PM_{2.5}$	N	FDMS and chemiluminescence monitor	N (approx. 50m, background site)	N/A	N/A
Dale's Corner	Roadside	244178	416760	NO_2, NO_x	N	chemiluminescence monitor	Y 1.5m	2m	Y
Marlborough Street	Roadside	242900	417152	NO_2, NO_x	Y	chemiluminescence monitor	Y 1m	2m	Y

Table 7 – Results of NO_2 monitoring at Continuous Monitors – Comparison with the Annual Mean Objective

Site ID	Site Type	Within AQMA?	Valid Data Capture for Period of Monitoring %	Valid Data Capture 2013 %	Annual Mean Concentration (µg/m^3) Exceedences shown in Bold						
					2007	2008	2009	2010	2011	2012	2013
Brooke Park	Urban Background	N	97	97	12.6	18.5	15.8	19.2	15.6	15.0	13.7
Dale's Corner	Roadside	N	97	97	38.5	**40.2**	39.0	**43.2**	33.6	34.5	30.3
Marlborough Street	Roadside	Y	91	91	-	-	-	-	**71.3**	**63.4**	**63.7**

Table 8 – Results of NO_2 Continuous Monitor – Comparison with 1- hour Mean Objective

Site ID	Site Type	Within AQMA?	Valid Data Capture for Period of Monitoring %	Valid Data Capture 2012 %	Number of 1-Hour Means > 200 µg/m^3 (if % data > 90% the 99.8th percentile shown in brackets)						
					2007	2008	2009	2010	2011	2012	2013
Brooke Park	Urban Background	N	97	97	0 (63)	0	0 (79.6)	0	0	0	0
Dale's Corner	Roadside	N	97	97	0 (155)	11	0	8 (138)	1	0	0
Marlborough Street	Roadside	Y	91	91	-	-	-	-	0 (181)	3	3

Table 9 – Diffusion tube monitoring details

Site ID	Site Name	Site Type	X OS Grid Reference	Y OS Grid Reference	In AQMA?	Is Monitoring Collocated with a Continuous Analyser (Y/N)	Relevant Exposure? *(Y/N with distance (m) to relevant exposure)*	Distance to Kerb of Nearest Road *(N/A if not applicable)*	Does this Location Represent Worst-case Exposure?
Cathedral									
C1-2	3 Creggan Road	Roadside	242913	417144	Y	N	Y- 0m	2m	Y
C3-4	6 Marlborough Terrace	Roadside	242921	417101	Y	N	Y- 0m	4.5m	Y
C5-6	22A Creggan Street	Urban Background	242959	417102	Y	N	Y-0m	5.5m	Y
C7-8	1 Windsor Terrace	Roadside	243017	417191	N	N	Y -0m	3m	Y
C9-10	14 Creggan Road	Roadside	242928	417148	Y	N	Y-0m	4m	Y
C11-13	2 Marlborough Street	Roadside	244238	416708	Y	Y	Y- 0m	2m	Y
Dale's Corner									
D1-3 (triplicate collocated	Monitor	Roadside	244178	416760	N	Y	Y-1.5m	3m	Y
D4-5	52 Clooney Terrace	Urban Centre	244210	416714	N	N	Y-0m	6.5m	Y
D6-7	5 Glendermott Road	Roadside	244238	416753	Y	N	Y-0m	2m	Y

Site ID	Site Name	Site Type	X OS Grid Reference	Y OS Grid Reference	In AQMA?	Is Monitoring Collocated with a Continuous Analyser (Y/N)	Relevant Exposure? *(Y/N with distance (m) to relevant exposure)*	Distance to Kerb of Nearest Road *(N/A if not applicable)*	Does this Location Represent Worst-case Exposure?
D8-9	Glendermott Road	Roadside	244283	416718	Y	N	Y- 0m	3m	Y
D10-11	4 Ebrington Terrace	Roadside	244219	416794	Y	N	Y-0m	4m	Y
D12-13	12 Ebrington Terrace	Roadside	244240	416856	Y	N	Y-0m	3m	Y
D14-15	9 Columba Terrace	Roadside	244277	416931	Y	N	Y-0m	6m	Y
D16-17	17 Melrose Terrace	Roadside	244178	416760	N	N	Y-0m	3m	Y
Pennyburn									
P1-2	53 Messines Park	Suburban	243449	419013	N	N	Y-0m	14m	Y
P3-4	57 Messines Park	Suburban	243418	419016	N	N	Y-0m	11m	Y
P5-6	8 Maybrook Terrace	Roadside	243571	418910	Y	N	Y-0m	5m	Y
P7-8	19 St Patricks Terrace	Roadside	243480	418970	Y	N	Y-0m	5m	Y
P9-10	1 Collon Terrace	Roadside	243539	418908	Y	N	Y-0m	5m	Y
P11-12	5 Collon Terrace	Roadside	243519	418921	Y	N	Y-0m	5m	Y
Strand Road									

Site ID	Site Name	Site Type	X OS Grid Reference	Y OS Grid Reference	In AQMA?	Is Monitoring Collocated with a Continuous Analyser (Y/N)	Relevant Exposure? *(Y/N with distance (m) to relevant exposure)*	Distance to Kerb of Nearest Road *(N/A if not applicable)*	Does this Location Represent Worst-case Exposure?
S1-2	99 Strand Road	Roadside	243522	417894	Y	N	Y-0m	3m	Y
S3-4	Rockmills	Urban Centre	243607	418037	Y	N	Y-0m	10m	Y
S5-6	1 Baronet Street		243557	417907					
S7-8	35 Aberfoyle Terrace		243940	415969					
S9-10	1 Rock Terrace		243527	417928					
Spencer Road									
SP1-2	32 Spencer Road	Roadside	243949	415989	Y	N	Y-0m	2m	Y
SP3-4	48 Spencer Road	Roadside	243485	417798	Y	N	Y-0m	2m	Y
SP5-6	70 Spencer Road	Roadside	244011	416068	Y	N	Y-0m	2m	Y

Table 10 – Diffusion tube monitoring results 2009 - 2013

Site ID	Site Name	Site Type	X OS Grid Reference	Y OS Grid Reference	2009 (Local Bias Adjustment Factor = 0.93)	2010 (Local Bias Adjustment Factor = 0.99)	2011 (Local Bias Adjustment Factor = 0.80)	2012 (Local Bias Adjustment Factor = 0.86)	2013 (Local Bias Adjustment Factor = 0.88)
Cathedral									
C1-2	3 Creggan Road	Roadside	242913	417144	**64**	**94**	**68.1**	**62.0**	**62.1**
C3-4	6 Marlborough Terrace	Roadside	242921	417101	37	**48**	34.8	39.2	35.2
C5-6	22A Creggan Street	Urban Background	242959	417102	**42**	**54**	**41.5**	**41.8**	36.9
C7-8	1 Windsor Terrace	Roadside	243017	417191	23	23	26.4	23.3	23.5
C9-10	14 Creggan Road	Roadside	242928	417148	**41**	**63**	39.8	**46.3**	**41.2**
C11-13	2 Marlborough Street	Roadside	244238	416708	-	-	-	**54.2**	**52.8**
Dale's Corner									
D1-3 (triplicate collocated	Monitor	Roadside	244178	416760	35	**44**	33.5	32.8	32.5
D4-5	52 Clooney Terrace	Urban Centre	244210	416714	30	**41**	28	27.0	29.6
D6-7	5 Glendermott Road	Roadside	244238	416753	**48**	**71**	**44**	**50.0**	**50.9**
D8-9	Glendermott Road	Roadside	244283	416718	-	-	**50.4**	**53.2**	**56.1**
D10-11	4 Ebrington Terrace	Roadside	244219	416794	**54**	**68**	**46.6**	**51.9**	**50.4**

Site ID	Site Name	Site Type	X OS Grid Reference	Y OS Grid Reference	2009 (Local Bias Adjustment Factor = 0.93)	2010 (Local Bias Adjustment Factor = 0.99)	2011 (Local Bias Adjustment Factor = 0.80)	2012 (Local Bias Adjustment Factor = 0.86)	2013 (Local Bias Adjustment Factor = 0.88)
D12-13	12 Ebrington Terrace	Roadside	244240	416856	-	-	37.6	35.4	**41.4**
D14-15	9 Columba Terrace	Roadside	244277	416931	-	-	31.8	32.6	33.2
D16-17	17 Melrose Terrace	Roadside	244178	416760	27	**41**	32	31.9	33.7
Pennyburn									
P1-2	53 Messines Park	Suburban	243449	419013	27	29	21.8	21.4	22.6
P3-4	57 Messines Park	Suburban	243418	419016	28	**41**	25.8	27.6	28.1
P5-6	8 Maybrook Terrace	Roadside	243571	418910	-	-	25.2	27.0	29.2
P7-8	19 St Patricks Terrace	Roadside	243480	418970	28	**51**	32.4	33.0	36.7
P9-10	1 Collon Terrace	Roadside	243539	418908	-	-	37.4	33.7	38.8
P11-12	5 Collon Terrace	Roadside	243519	418921	**42**	**52**	**45.7**	39.8	**44.5**
Strand Road									
S1-2	99 Strand Road	Roadside	243522	417894	37	**52**	39.5	37.3	37.3
S3-4	Rockmills	Urban Centre	243607	418037	37	**48**	33.2	30.0	32.2
S5-6	1 Baronet Street		243557	417907	-	-	-	-	31.0
S7-8	35 Aberfoyle Terrace		243940	415969	-	-	-	-	30.8

Site ID	Site Name	Site Type	X OS Grid Reference	Y OS Grid Reference	2009 (Local Bias Adjustment Factor = 0.93)	2010 (Local Bias Adjustment Factor = 0.99)	2011 (Local Bias Adjustment Factor = 0.80)	2012 (Local Bias Adjustment Factor = 0.86)	2013 (Local Bias Adjustment Factor = 0.88)
S9-10	1 Rock Terrace		243527	417928	-	-	-	-	32.1
Spencer Road									
SP1-2	32 Spencer Road	Roadside	243949	415989	**40**	**51**	**42.3**	38.2	**43.7**
SP3-4	48 Spencer Road	Roadside	243485	417798	-	-	-	-	**40.5**
SP5-6	70 Spencer Road	Roadside	244011	416068	-	-	-	-	37.6

Exceedences shown in **Bold**.

The diffusion tube results presented above are taken from the 2013 Annual Progress Report, with the exception of 2013. Bias adjustment for 2013 was undertaken using the local bias adjustment factor of 0.88 calculated as the regression of the three available local co-locations carried out in 2013. This is based on provisional automatic monitoring data.

3.2 Model Verification and Adjustment

The results of the verification and adjustment process are summarised in Table 11. Full details are provided in Appendix 3. Following the adjustment process, 21 of the 24 modelled NO_2 concentrations are within 25% of monitored concentrations. The exceptions are two tube locations in the Creggan Road area (C3/4 and C5/6) where the concentration has been under-predicted by the model and P5/6 in the Buncrana Road AQMA, where the concentration has been over-predicted by the model. Modelling in the Creggan Road AQMA is considered acceptable as concentrations at sites where the annual mean objective is exceeded are all within 8%. The over-prediction at P5/6 is not a major concern as an exceedence is not predicted.

Table 11 – Verification Summary

Site	Modelled Total NO_2 (Not Adjusted) ($\mu g/m^3$)	Monitored Total NO_2 ($\mu g/m^3$)	% Difference NO_2 [(Modelled - Monitored) / Monitored]	Adjusted Modelled Total NO_2 ($\mu g/m^3$)	Monitored Total NO_2 ($\mu g/m^3$)	% Difference NO_2 [(Modelled - Monitored) / Monitored]		
C1	23.3	63.6	-63.4%	62.3	62.1	0.3%	Within +10%	6
C3	13.6	36.0	-62.1%	25.5	35.2	-27.5%	Within -10%	4
C5	14.0	37.8	-63.1%	26.9	36.9	-27.0%	**Within +-10%**	10
C9	18.2	42.2	-57.0%	44.4	41.2	7.8%	Within +10 to 25%	4
Marlborough St	24.2	63.7	-62.1%	65.1	63.7	2.2%	Within -10 to 25%	7
S1	19.8	38.2	-48.2%	37.2	37.3	-0.4%	**Within +-10 to 25%**	11
S5	19.2	32.4	-40.6%	35.4	31.0	14.3%	Over +25%	1
S9	16.7	32.2	-48.2%	27.1	32.1	-15.8%	Under -25%	2
S7	14.2	31.7	-55.3%	29.3	30.8	-4.8%	**Greater +-25%**	3
P1	18.1	23.1	-21.5%	24.0	22.6	6.5%	**Within +-25%**	21
P3	17.6	28.8	-38.9%	22.9	28.1	-18.7%	**Total**	24
P5	26.2	28.4	-7.8%	37.0	29.2	26.6%		
P7	28.3	37.6	-24.7%	41.1	36.7	11.8%		
P9	25.5	38.7	-34.1%	35.7	38.8	-8.1%		
P11	25.5	45.5	-44.1%	35.6	44.5	-19.9%		
Dales Corner	17.9	30.2	-40.8%	31.9	30.2	5.4%		
D4	15.8	30.4	-48.1%	24.7	29.6	-16.6%		
D6	21.0	52.1	-59.7%	41.5	50.9	-18.5%		
D10	21.6	51.7	-58.2%	43.2	50.4	-14.4%		
D12	21.9	42.5	-48.5%	44.0	41.4	6.2%		
D14	20.7	34.0	-39.0%	40.7	33.2	22.5%		
SP1	18.1	38.7	-53.2%	38.4	43.7	-12.2%		
SP5	18.0	43.4	-58.6%	43.1	37.6	14.7%		
SP3	17.7	40.9	-56.8%	40.6	40.9	-0.8%		

4 Assessment Results

Annual mean NO_2 concentrations were predicted at receptor grids across the five modelled areas. The concentration isopleths are shown in Appendix 4. The following conclusions can be drawn in reference to the five modelled AQMAs:

- Creggan Road – Exceedences of the annual mean objective continue to the west of the Creggan Road/Infirmary Road Junction. There are around 24 properties that may be exposed to exceedences of the annual mean objective of 40µg/m^3 (when considered using the 36µg/m^3 isopleth, to account for model uncertainty). Whilst there are modelled and monitored concentrations greater than 60µg/m^3, it is not recommended that this area is declared as an AQMA for the short-term NO_2 objective as only 3 hourly exceedences of 200µg/m^3 were recorded in 2013, with 18 allowed. Whilst the 60µg/m^3 concentration is a guide to whether the short-term objective may be exceeded, in this case it has not.

- Dale's Corner – Exceedences of the annual mean objective continue across the AQMA. There are around 30 properties that may be exposed to exceedences of the annual mean objective of 40µg/m^3 (when considered using the 36µg/m^3 isopleth, to account for model uncertainty).

- Buncrana Road – Exceedences of the annual mean objective are localised around the junction with Racecourse Road. There are around 28 properties that may be exposed to exceedences of the annual mean objective of 40µg/m^3 (when considered using the 36µg/m^3 isopleth, to account for model uncertainty).

- Spencer Road - There are around 8 properties that may be exposed to exceedences of the annual mean objective of 40µg/m^3 (when considered using the 36µg/m^3 isopleth, to account for model uncertainty). As monitored exceedences are marginal, these are not all picked up by the concentration isopleths, so exceedences are likely to occur across the AQMA. However, further investigation of the properties within the AQMA has shown that those in the south west of the AQMA are not residential and are therefore not relevant receptors requiring an AQMA.

- Strand Road - Exceedences of the annual mean objective have not been monitored in the AQMA. When considering concentrations using the 36µg/m^3 isopleth, to account for uncertainty, around 10 properties may be exposed to exceedences of the annual mean objective.

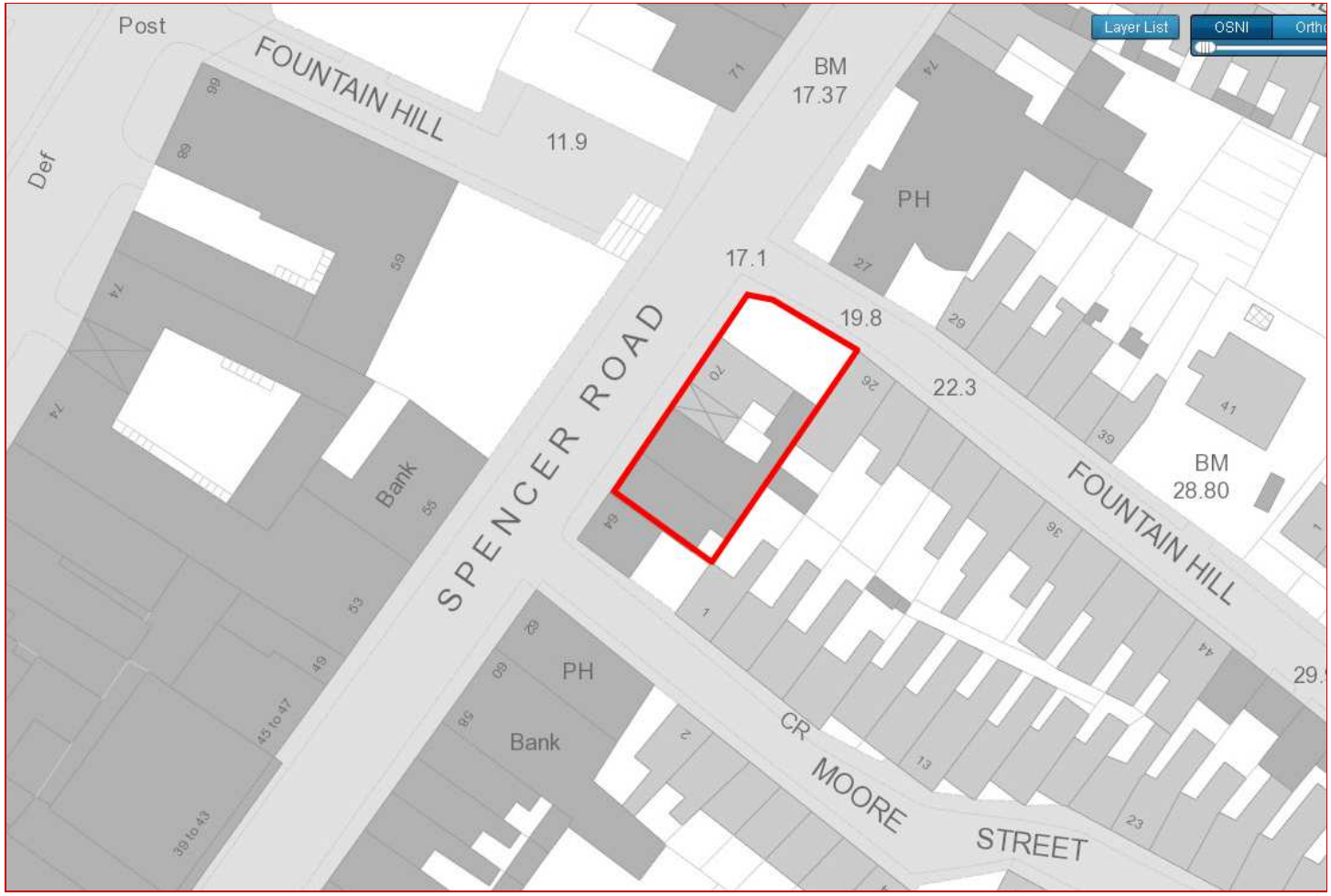
Based on these findings, the amended AQMA boundaries shown in Figure 7 are recommended for Creggan Road, Buncrana Road and Spencer Road.

Figure 7 – Recommended AQMA Boundaries

Creggan Road

Buncrana Road

Spencer Road



The results from the concentrations predicted under the modelled scenarios at monitoring sites, which are representative of the public exposure, are shown in Table 12 below (concentration isopleths are shown in Appendix 4). The results indicate that if the Euro II and III buses in Derry were replaced by Euro VI buses, NO_2 concentrations could be reduced by up to 2.7 µg/m^3. In view of the NO_2 concentrations in the areas, these changes are considered to be of moderate beneficial significance, and they are of sufficient magnitude to potentially reduce the area of exceedence of the annual mean objective.

Table 12 – NO_2 Results

Site	Baseline NO_2 (µg/m^3)	After Intervention NO_2 (µg/m^3)	Change (µg/m^3)	Magnitude of Change	Impact Descriptor
D1	31.9	30.4	-1.5	Small	Negligible
D4	24.7	23.6	-1.1	Small	Negligible
D6	41.5	39.1	-2.4	Medium	Moderate Beneficial
D10	43.2	41.4	-1.9	Small	Slight Beneficial
D12	44.0	42.5	-1.6	Small	Slight Beneficial
D14	40.7	39.3	-1.4	Small	Slight Beneficial
P1	24.0	23.0	-1.1	Small	Negligible
P3	22.9	22.0	-0.8	Small	Negligible
P5	37.0	34.7	-2.3	Medium	Moderate Beneficial
P7	41.1	38.4	-2.7	Medium	Moderate Beneficial
P9	35.7	33.6	-2.2	Medium	Slight Beneficial
P11	35.6	33.5	-2.2	Medium	Slight Beneficial

5 Conclusions and Recommendations

Exceedences of the annual mean Air Quality Strategy objective of 40µg/m^3 for NO_2 continue across large areas of the five existing AQMAs, with the exception of the Strand Road AQMA. As no exceedences have been monitored in this AQMA for three years, including at sites introduced for 2013, it is recommended that this AQMA be revoked. The area of exceedence in the Creggan Road and Buncrana Road AQMAs is smaller than when they were declared, therefore amended AQMA boundaries have been recommended. Similarly, most of the properties in the Spencer Road AQMA have been determined not to be relevant receptors for the annual mean objective, therefore an amended AQMA boundary has been recommended. There is no need to declare an AQMA for the short-term NO_2 objective as this objective has not been breached.

Modelling has also show that if the Euro II and III buses in Derry could be replaced by Euro VI buses, NO_2 concentrations could be reduced by up to 2.7 µg/m^3. These changes are of a magnitude that would potentially reduce the area of exceedence of the annual mean objective significantly. It is therefore recommended that Air Quality Action Plan measures aimed at bus fleet renewal are prioritised.

Appendices

Appendix 1 – Glossary

Term	Definition
AADT	Annual Average Daily Traffic
ADMS	Atmospheric Dispersion Modelling Software
AQAP	Air Quality Action Plan
AQMA	Air Quality Management Area
AQS	Air Quality Strategy
BRE	Building Research Establishment
C_4H_6	1,3 –butadiene
C_6H_6	Benzene
CAFÉ	Clean Air for Europe
CCS	Considerate Constructors Scheme
CERC	Cambridge Environmental Research Consultants
CO	Carbon Monoxide
CO_2	Carbon Dioxide
Defra	Department of Environment, Food and Rural Affairs
EFT	Emissions Factor Toolkit
EIA	Environmental Impact Assessment
EPA	Environmental Protection Act
GLA	Greater London Authority
HC	Hydrocarbons
HGVs	Heavy-Goods Vehicles
kt	kilotonne
LAEI	London Atmospheric Emissions Inventory
LAQM	Local Air Quality Management
LAQM.TG(09)	Local Air Quality Management Technical Guidance 2009
LGVs	Light-Goods Vehicles
NH_3	Ammonia

Term	Definition
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_x	Oxides of Nitrogen
O_3	Ozone
PAH	Polycyclic Aromatic Hydrocarbons
PM	Particulate Matter
PM_{10}	Particulate Matter (10µm aerodynamic diameter)
$PM_{2.5}$	Particulate Matter (2.5µm aerodynamic diameter)
SO_2	Sulphur Dioxide
TSP	Total Suspended Particulate
VOCs	Volatile Organic Compounds
µ	Prefix denoting one millionth of corresponding unit

Appendix 2 – Traffic Data Used in the Assessment

SourceID	Traffic Flow	% Car	% LGV	% Rigid HGV	% Artic HGV	% Bus and Coach	% Motorcycle	Speed(kph)
1_Buncrana_2	24807	87.09	7.91	1.46	0.69	2.85	0.00	48
1_BuncranaE_1	24807	87.09	7.91	1.46	0.69	2.85	0.00	20
1_BuncranaW_1	22020	86.65	9.05	2.03	0.81	1.46	0.00	20
1_BuncranaW_2	22020	86.65	9.05	2.03	0.81	1.46	0.00	48
1_Penny_1	8989	75.85	13.88	2.73	1.30	6.23	0.00	20
1_Penny_2	8989	75.85	13.88	2.73	1.30	6.23	0.00	48
1_Racecourse_1	18636	87.87	8.14	1.60	0.26	2.13	0.00	20
1_Racecourse_2	18636	87.87	8.14	1.60	0.26	2.13	0.00	48
2_Clooney_1	8989	89.55	6.71	1.64	0.05	2.05	0.00	48
2_Clooney_2	8989	89.55	6.71	1.64	0.05	2.05	0.00	20
2_Glender_1	17055	88.70	6.12	2.46	0.44	2.28	0.00	20
2_Glender_2	17055	88.70	6.12	2.46	0.44	2.28	0.00	48
2_King_1	22738	85.90	7.39	2.79	1.90	2.01	0.00	48
2_King_2	22738	85.90	7.39	2.79	1.90	2.01	0.00	20
2_Limvardy_1	17923	85.83	7.46	2.85	2.39	1.47	0.00	48
2_Limvardy_2	17923	85.83	7.46	2.85	2.39	1.47	0.00	20
3_CregRD_1	12418	93.21	5.46	1.01	0.03	0.29	0.00	48
3_CregRD_2	12418	93.21	5.46	1.01	0.03	0.29	0.00	20
3_CregST_1	8112	92.62	5.44	1.20	0.12	0.62	0.00	20
3_CregSt_2	8112	92.62	5.44	1.20	0.12	0.62	0.00	48
3_Infirm_1	7947	92.99	5.43	0.86	0.00	0.71	0.00	20
3_Infirm_2	7947	92.99	5.43	0.86	0.00	0.71	0.00	48
3_LoneMor_1	12426	91.26	6.72	1.20	0.06	0.75	0.00	20
3_LoneMor_2	12426	91.26	6.72	1.20	0.06	0.75	0.00	48
3_LoneMor_3	12426	91.26	6.72	1.20	0.06	0.75	0.00	48

SourceID	Traffic Flow	% Car	% LGV	% Rigid HGV	% Artic HGV	% Bus and Coach	% Motorcycle	Speed(kph)
4_Strand_1	30211	90.23	2.80	4.28	1.96	0.52	0.20	48
5_Strand_1	30211	90.23	2.80	4.28	1.96	0.52	0.20	48
5_Strand_2	30211	90.23	2.80	4.28	1.96	0.52	0.20	20
7_Spencer_1	10207	93.51	2.63	2.60	0.70	0.09	0.48	20
7_Spencer_2	10207	93.51	2.63	2.60	0.70	0.09	0.48	48
7_Spencer_3	10207	93.51	2.63	2.60	0.70	0.09	0.48	48
7_Spencer_4	10207	93.51	2.63	2.60	0.70	0.09	0.48	48
7_Spencer_5	10207	93.51	2.63	2.60	0.70	0.09	0.48	48
7_Spencer_6	10207	93.51	2.63	2.60	0.70	0.09	0.48	48
7_Spencer_7	10207	93.51	2.63	2.60	0.70	0.09	0.48	48

Appendix 3 – Verification

Creggan Road

Before Adjustment

Site	Background NO_2 ($\mu g/m^3$)	Background NO_x ($\mu g/m^3$)	Modelled Road Contribution NO_x (Not Adjusted) ($\mu g/m^3$)	Modelled Total NO_2 (Not Adjusted) ($\mu g/m^3$)	Monitored Total NO_2 ($\mu g/m^3$)	% Difference NO_2 [(Modelled - Monitored) / Monitored]
C1	10.6	14.3	25.2	23.3	62.1	-62.5%
C3	10.6	14.3	5.7	13.6	35.2	-61.2%
C5	10.6	14.3	6.3	14.0	36.9	-62.2%
C9	10.6	14.3	14.6	18.2	41.2	-55.9%
Marlborough St	10.6	14.3	27.1	24.2	63.7	-62.1%

After Adjustment

Site	Monitored Road Contribution NO_x ($\mu g/m^3$)	Modelled Road Contribution NO_x ($\mu g/m^3$)	Ratio of Monitored Road NO_x/Modelled Road NO_x	Adjustment Factor for Modelled Road Contribution	Adjusted Modelled Road Contribution NO_x ($\mu g/m^3$)	Adjusted Modelled Total NO_x ($\mu g/m^3$)	Adjusted Modelled Total NO_2 ($\mu g/m^3$)	Monitored Total NO_2 ($\mu g/m^3$)	% Difference NO_2 [(Modelled - Monitored) / Monitored]
C1	131.2	25.2	5.2	5.226	131.9	146.2	62.3	62.1	0.3%
C3	52.2	5.7	9.1		29.9	44.2	25.5	35.2	-27.5%
C5	56.7	6.3	8.9		33.1	47.4	26.9	36.9	-27.0%
C9	67.7	14.6	4.6		76.3	90.7	44.4	41.2	7.8%
Marlborough St	136.6	27.1	5.0		141.5	155.8	65.1	63.7	2.2%

Uncertainties Assessment	Before Adjustment	After Adjustment
Correlation	0.977	0.967
RMSE (µg/m^3)	30.294	6.411
Fractional Bias	0.878	0.064

Strand Road

Before Adjustment

Site	Background NO_2 (µg/m^3)	Background NO_x (µg/m^3)	Modelled Road Contribution NO_x (Not Adjusted) (µg/m^3)	Modelled Total NO_2 (Not Adjusted) (µg/m^3)	Monitored Total NO_2 (µg/m^3)	% Difference NO_2 [(Modelled - Monitored) / Monitored]
S1	12.8	17.5	13.7	19.8	37.3	-47.0%
S5	12.8	17.5	12.6	19.2	31.0	-37.9%
S9	12.8	17.5	7.5	16.7	32.1	-48.0%
S7	8.2	10.8	11.3	14.2	30.8	-54.0%

After Adjustment

Site	Monitored Road Contribution NO_x (µg/m^3)	Modelled Road Contribution NO_x (µg/m^3)	Ratio of Monitored Road NO_x/Modelled Road NO_x	Adjustment Factor for Modelled Road Contribution	Adjusted Modelled Road Contribution NO_x (µg/m^3)	Adjusted Modelled Total NO_x (µg/m^3)	Adjusted Modelled Total NO_2 (µg/m^3)	Monitored Total NO_2 (µg/m^3)	% Difference NO_2 [(Modelled - Monitored) / Monitored]
S1	52.9	13.7	3.9	3.838	52.5	70.0	37.2	37.3	-0.4%

S5	37.8	12.6	3.0		48.2	65.7	35.4	31.0	14.3%
S9	40.4	7.5	5.4		28.9	46.5	27.1	32.1	-15.8%
S7	46.9	11.3	4.1		43.4	54.2	29.3	30.8	-4.8%

Uncertainties Assessment	Before Adjustment	After Adjustment
Correlation	0.609	0.585
RMSE (µg/m^3)	15.494	3.449
Fractional Bias	0.610	0.018

Buncrana Road

Before Adjustment

Site	Background NO_2 (µg/m^3)	Background NO_x (µg/m^3)	Modelled Road Contribution NO_x (Not Adjusted) (µg/m^3)	Modelled Total NO_2 (Not Adjusted) (µg/m^3)	Monitored Total NO_2 (µg/m^3)	% Difference NO_2 [(Modelled - Monitored) / Monitored]
P1	12.9	17.9	10.1	18.1	22.6	-19.6%
P3	12.9	17.9	9.0	17.6	28.1	-37.4%
P5	16.0	22.7	20.6	26.2	29.2	-10.4%
P7	16.0	22.7	25.3	28.3	36.7	-22.8%
P9	16.0	22.7	19.2	25.5	38.8	-34.3%
P11	16.0	22.7	19.1	25.5	44.5	-42.7%

After Adjustment

Site	Monitored Road Contribution NO_x ($\mu g/m^3$)	Modelled Road Contribution NO_x ($\mu g/m^3$)	Ratio of Monitored Road NO_x/Modelled Road NO_x	Adjustment Factor for Modelled Road Contribution	Adjusted Modelled Road Contribution NO_x ($\mu g/m^3$)	Adjusted Modelled Total NO_x ($\mu g/m^3$)	Adjusted Modelled Total NO_2 ($\mu g/m^3$)	Monitored Total NO_2 ($\mu g/m^3$)	% Difference NO_2 [(Modelled - Monitored) / Monitored]
P1	19.0	10.1	1.9	2.192	22.1	40.0	24.0	22.6	6.5%
P3	30.9	9.0	3.4		19.7	37.5	22.9	28.1	-18.7%
P5	27.2	20.6	1.3		45.1	67.8	37.0	29.2	26.6%
P7	44.5	25.3	1.8		55.4	78.0	41.1	36.7	11.8%
P9	49.7	19.2	2.6		42.1	64.8	35.7	38.8	-8.1%
P11	64.2	19.1	3.4		41.9	64.6	35.6	44.5	-19.9%

Uncertainties Assessment	Before Adjustment	After Adjustment
Correlation	0.697	0.681
RMSE ($\mu g/m^3$)	11.162	5.725
Fractional Bias	0.344	0.018

Dales

Before Adjustment

Site	Background NO_2 ($\mu g/m^3$)	Background NO_x ($\mu g/m^3$)	Modelled Road Contribution NO_x (Not Adjusted) ($\mu g/m^3$)	Modelled Total NO_2 (Not Adjusted) ($\mu g/m^3$)	Monitored Total NO_2 ($\mu g/m^3$)	% Difference NO_2 [(Modelled - Monitored) / Monitored]
Dales Corner Auto	12.4	17.0	10.7	17.9	30.2	-40.8%
D4	12.4	17.0	6.5	15.8	29.6	-46.8%
D6	12.4	17.0	17.0	21.0	50.9	-58.7%
D10	12.4	17.0	18.2	21.6	50.4	-57.2%
D12	12.4	17.0	18.8	21.9	41.4	-47.2%
D14	12.4	17.0	16.4	20.7	33.2	-37.5%

After Adjustment

Site	Monitored Road Contribution NO_x ($\mu g/m^3$)	Modelled Road Contribution NO_x ($\mu g/m^3$)	Ratio of Monitored Road NO_x/Modelled Road NO_x	Adjustment Factor for Modelled Road Contribution	Adjusted Modelled Road Contribution NO_x ($\mu g/m^3$)	Adjusted Modelled Total NO_x ($\mu g/m^3$)	Adjusted Modelled Total NO_2 ($\mu g/m^3$)	Monitored Total NO_2 ($\mu g/m^3$)	% Difference NO_2 [(Modelled - Monitored) / Monitored]
Dales Corner Auto	36.9	10.7	3.4	3.800	40.7	57.7	31.9	30.2	5.4%
D4	35.6	6.5	5.5		24.7	41.7	24.7	29.6	-16.6%
D6	90.9	17.0	5.4		64.4	81.4	41.5	50.9	-18.5%

D10	89.6	18.2	4.9		69.1	86.1	43.2	50.4	-14.4%
D12	64.4	18.8	3.4		71.3	88.3	44.0	41.4	6.2%
D14	43.8	16.4	2.7		62.4	79.4	40.7	33.2	22.5%

Uncertainties Assessment	Before Adjustment	After Adjustment
Correlation	0.747	0.742
RMSE (µg/m^3)	20.852	6.204
Fractional Bias	0.660	0.043

Spencer Road

Before Adjustment

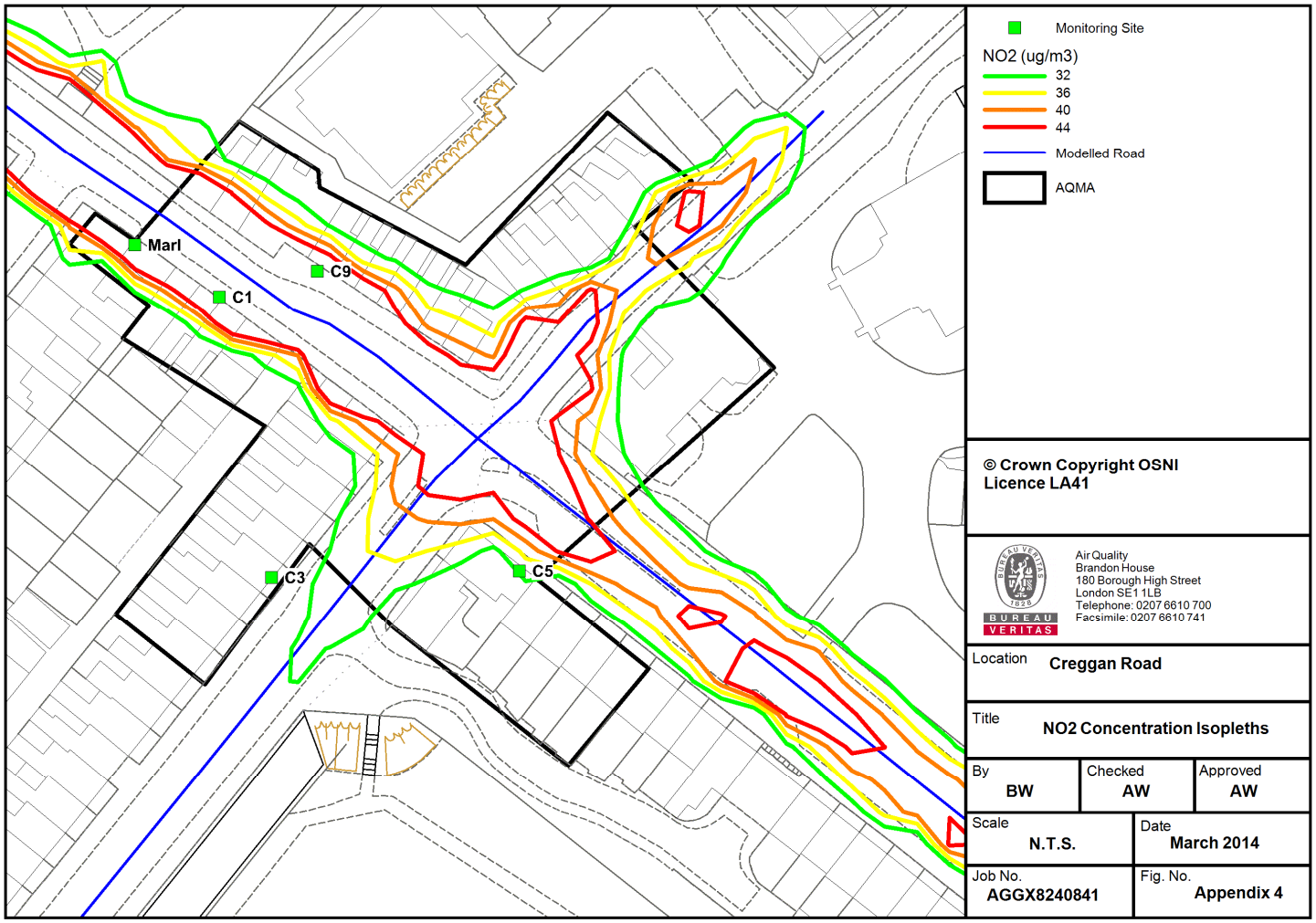
Site	Background NO_2 (µg/m^3)	Background NO_x (µg/m^3)	Modelled Road Contribution NO_x (Not Adjusted) (µg/m^3)	Modelled Total NO_2 (Not Adjusted) (µg/m^3)	Monitored Total NO_2 (µg/m^3)	% Difference NO_2 [(Modelled - Monitored) / Monitored]
SP1	8.2	10.8	10.3	13.6	43.7	-68.8%
SP5	12.4	17.0	10.8	18.0	37.6	-52.3%
SP3	12.7	17.4	9.6	17.7	40.9	-56.8%

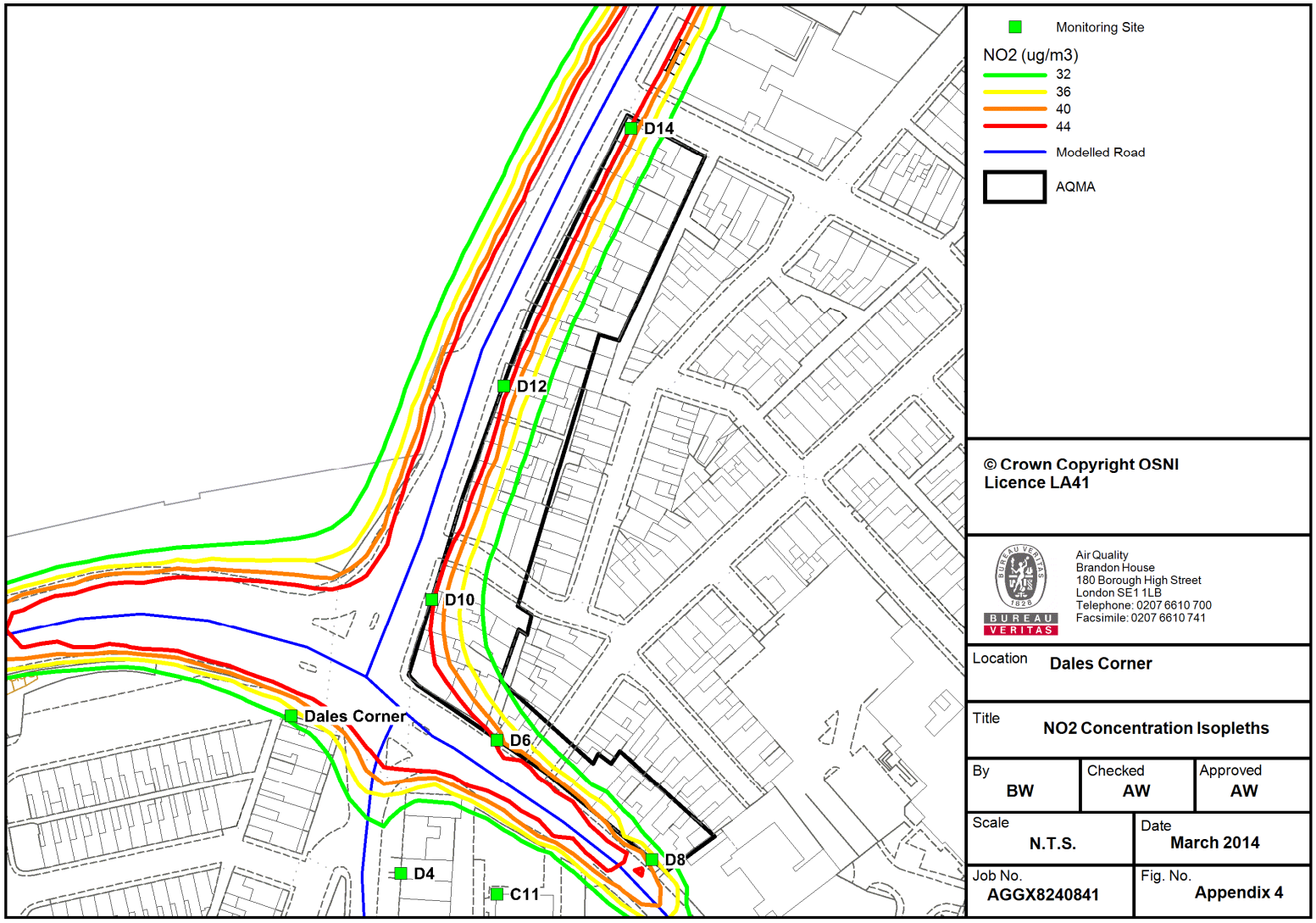
After Adjustment

Site	Monitored Road Contribution NO_x ($\mu g/m^3$)	Modelled Road Contribution NO_x ($\mu g/m^3$)	Ratio of Monitored Road NO_x/Modelled Road NO_x	Adjustment Factor for Modelled Road Contribution	Adjusted Modelled Road Contribution NO_x ($\mu g/m^3$)	Adjusted Modelled Total NO_x ($\mu g/m^3$)	Adjusted Modelled Total NO_2 ($\mu g/m^3$)	Monitored Total NO_2 ($\mu g/m^3$)	% Difference NO_2 [(Modelled - Monitored) / Monitored]
SP1	80.0	10.3	7.8	6.382	65.7	76.5	38.4	43.7	-12.2%
SP5	54.5	10.8	5.0		68.9	85.9	43.1	37.6	14.7%
SP3	62.2	9.6	6.5		61.4	78.8	40.6	40.9	-0.8%

Uncertainties Assessment	Before Adjustment	After Adjustment
Correlation	-0.869	-1.000
RMSE ($\mu g/m^3$)	24.698	4.437
Fractional Bias	0.851	0.001

Appendix 4 – Concentration Isopleths




D14
D12
D10
D6
D8
D4
C11
Dales Corner
Monitoring Site
NO2 (ug/m3)
32
36
40
44
Modelled Road
AQMA
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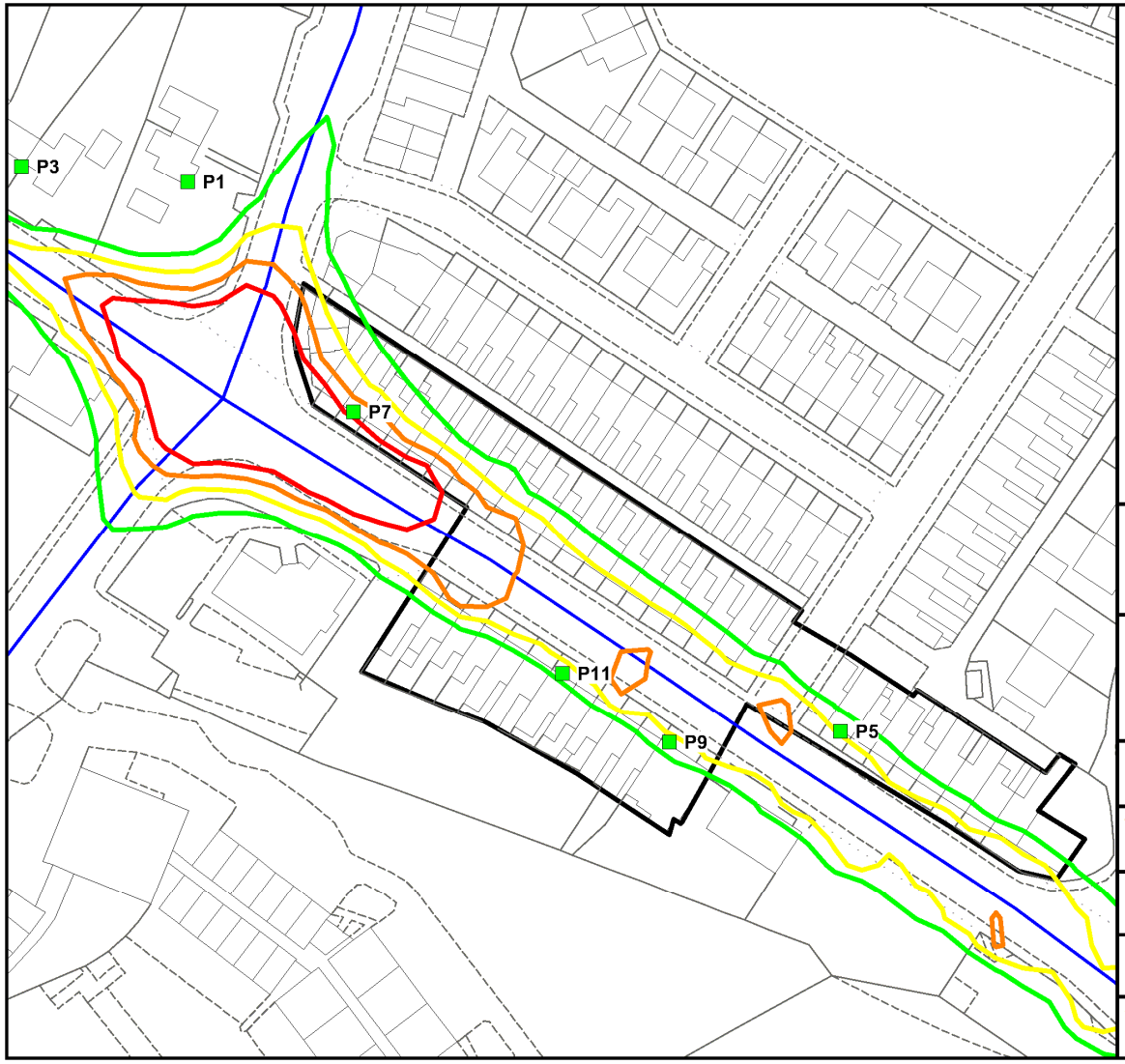
Air Quality
Brandon House
180 Borough High Street
London SE1 1LB
Telephone: 0207 6610 700
Facsimile: 0207 6610 741
Location
Dales Corner
Title
NO2 Concentration Isopleths
By
BW
Checked
AW
Approved
AW
Scale
N.T.S.
Date
March 2014
Job No.
AGGX8240841
Fig. No.
Appendix 4



Monitoring Site

NO2 (ug/m3)
32
36
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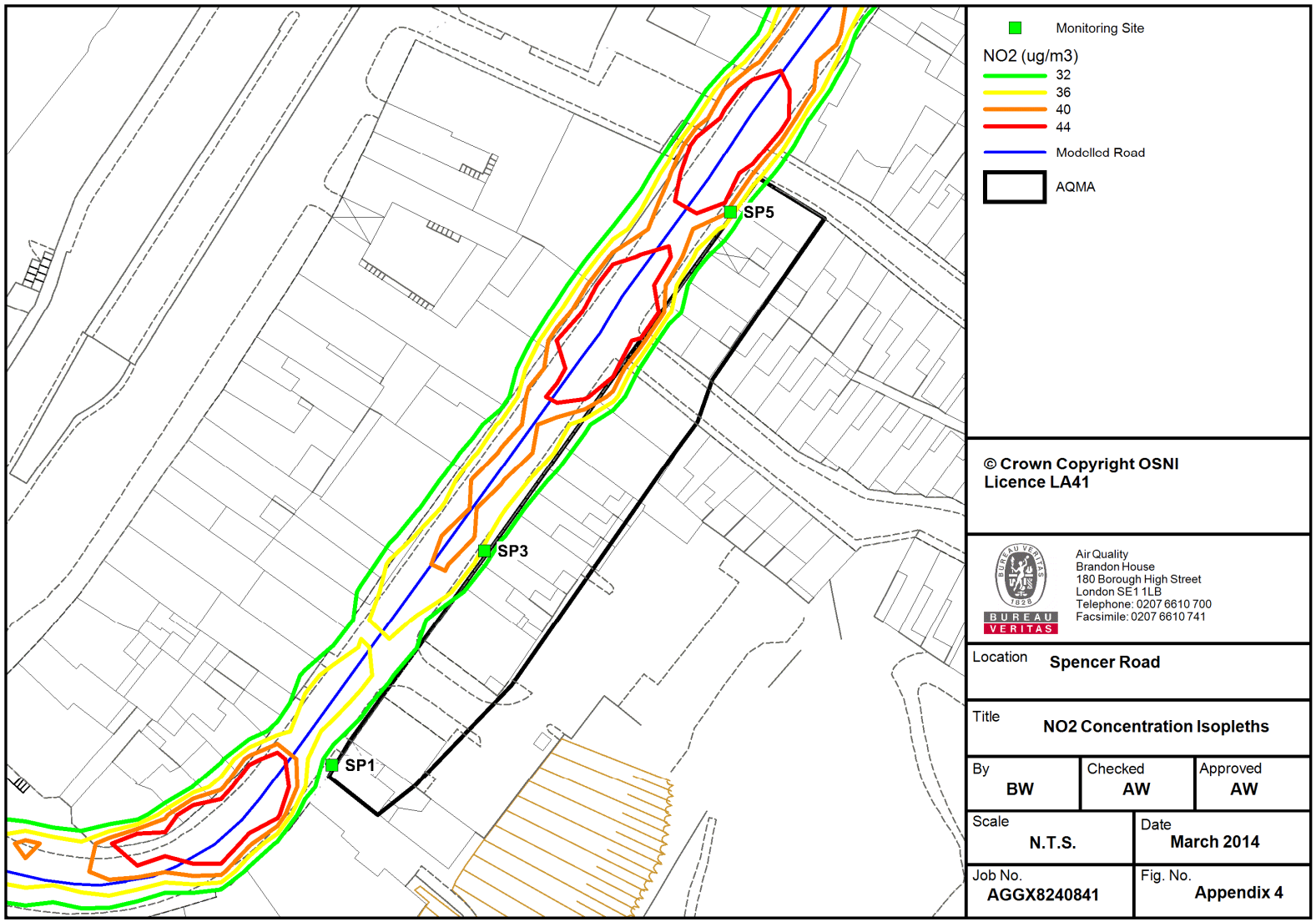
44

Modelled Road

AQMA

Air Quality
Brandon House
180 Borough High Street
London SE1 1LB
Telephone: 0207 6610 700
Facsimile: 0207 6610 741

Location	Buncrana Road		
Title	NO2 Concentration Isopleths		
By: BW	Checked: AW	Approved: AW	
Scale: N.T.S.	Date: March 2014		
Job No.: AGGX8240841	Fig. No.: Appendix 4		


SP5
SP3
SP1
Monitoring Site
NO2 (ug/m3)
32
36
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44
Modelled Road
AQMA
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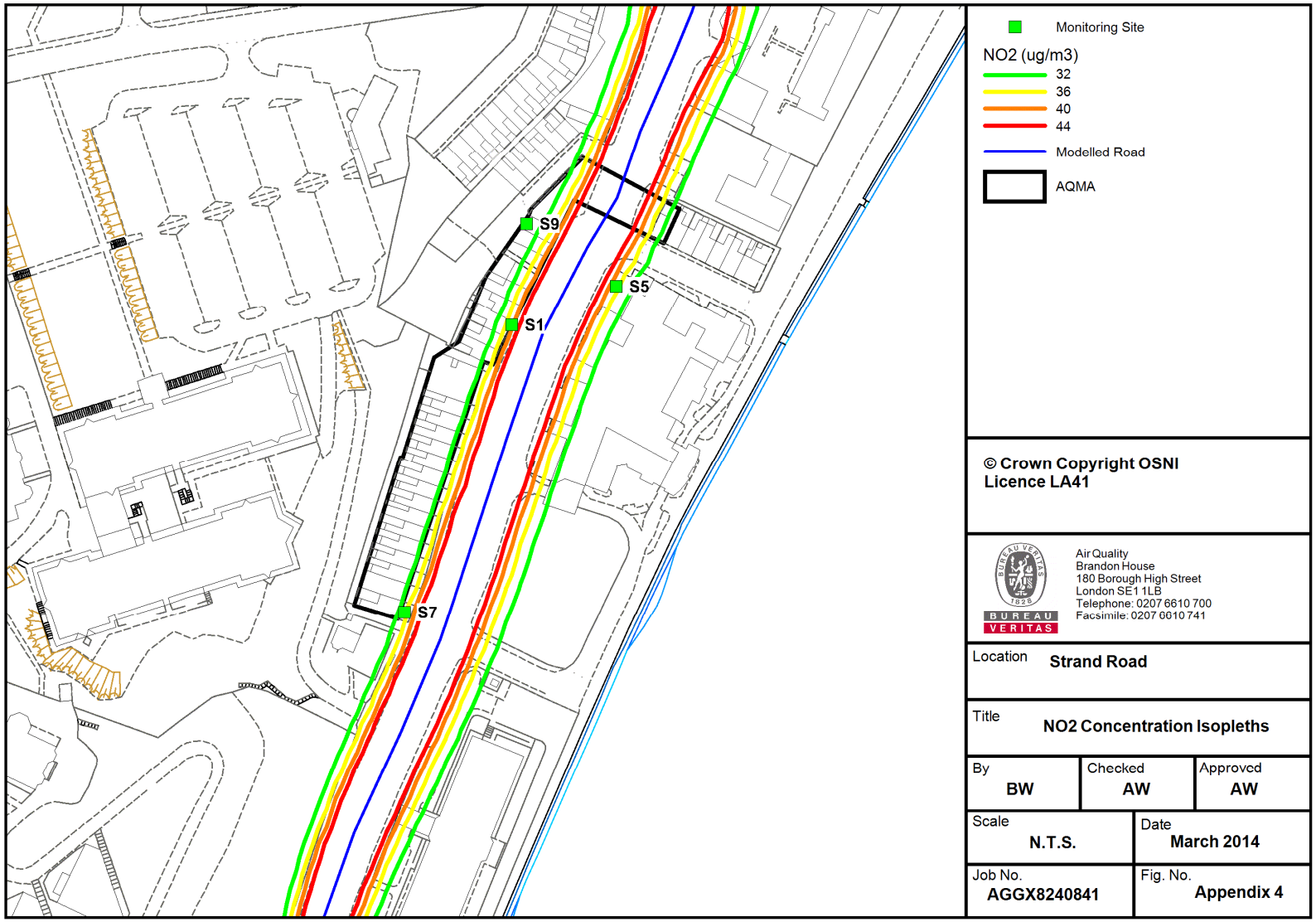
Air Quality
Brandon House
180 Borough High Street
London SE1 1LB
Telephone: 0207 6610 700
Facsimile: 0207 6610 741
Location
Spencer Road
Title
NO2 Concentration Isopleths
By
BW
Checked
AW
Approved
AW
Scale
N.T.S.
Date
March 2014
Job No.
AGGX8240841
Fig. No.
Appendix 4


S9
S5
S1
S7
Monitoring Site
NO2 (ug/m3)
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36
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44
Modelled Road
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Facsimile: 0207 6610 741
Location
Strand Road
Title
NO2 Concentration Isopleths
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AW
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Date
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Fig. No.
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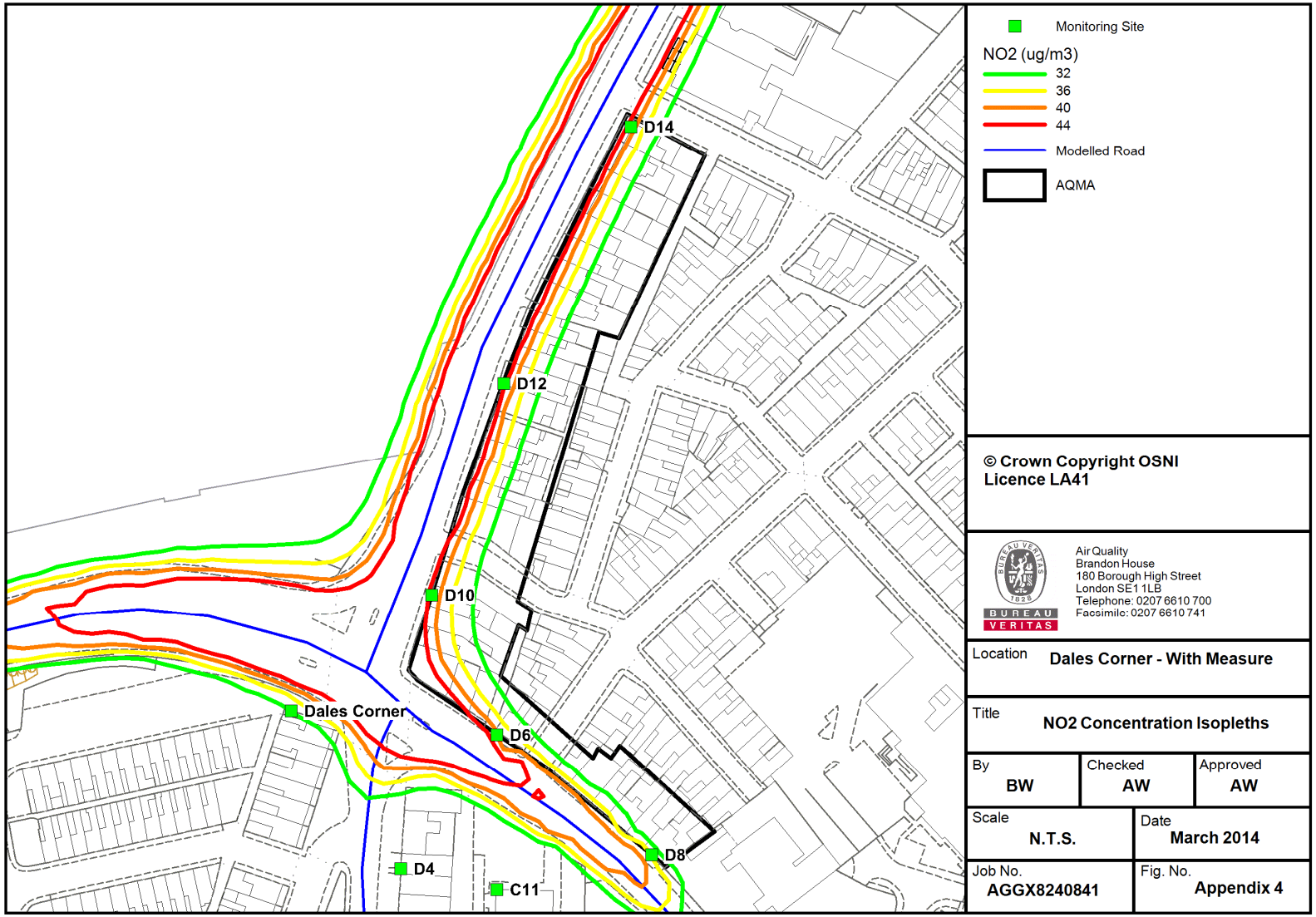
D14
D12
D10
D6
D8
D4
C11
Dales Corner
Monitoring Site
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36
40
44
Modelled Road
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Air Quality
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London SE1 1LB
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Facsimile: 0207 6610 741
Location
Dales Corner - With Measure
Title
NO2 Concentration Isopleths
By
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AW
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AW
Scale
N.T.S.
Date
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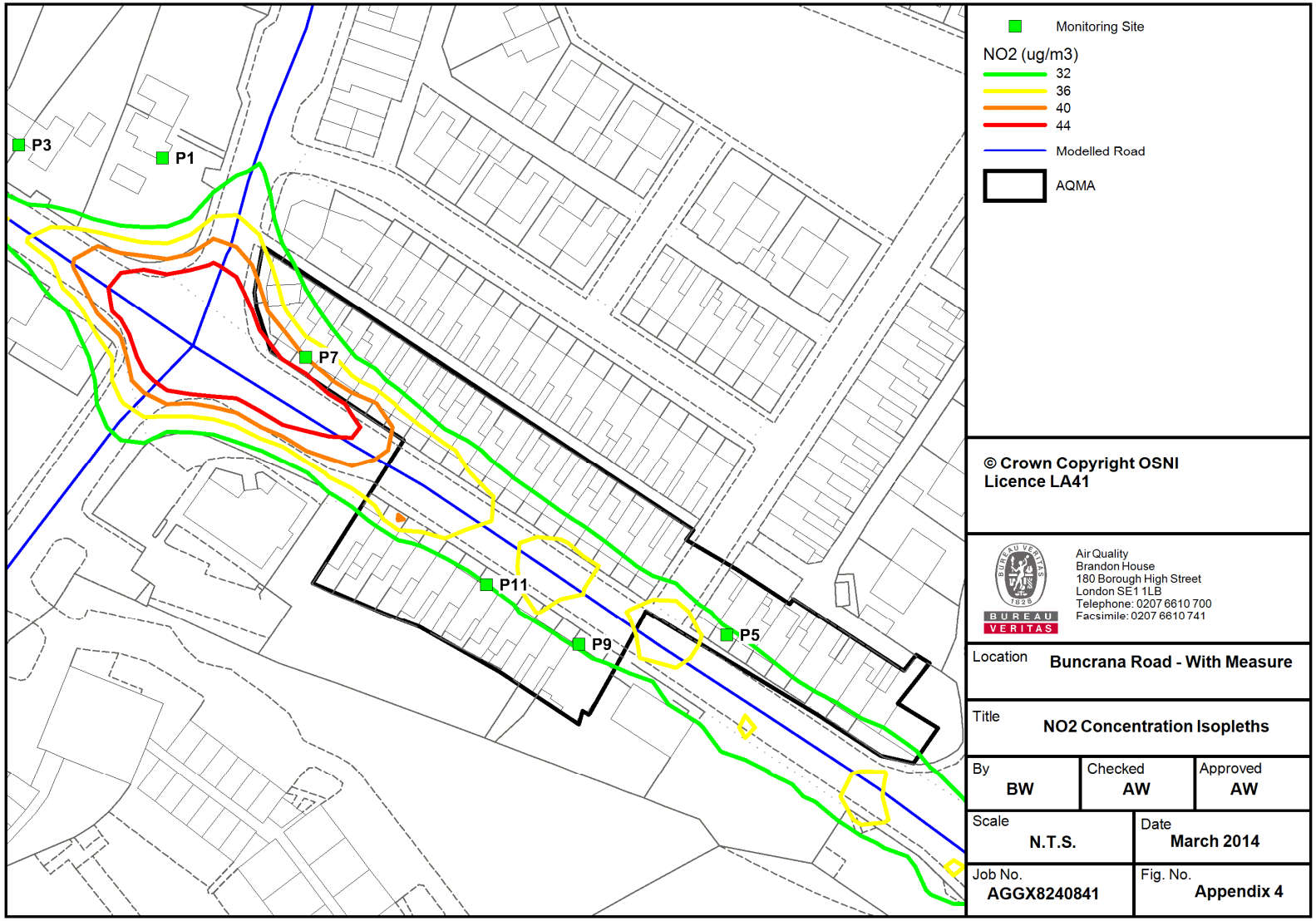
Fig. No.
Appendix 4


P3
P1
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P11
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