Detailed Assessment of Air Quality 2012

Town Centre, Lanark, South Lanarkshire

Report for South Lanarkshire Council

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Contact:

Andy Lewin
Ricardo-AEA Ltd
Gemini Building, Harwell, Didcot, OX11 0QR
t: 0123575 3189
e: andrew.lewin@ricardo-aea.com
Ricardo-AEA is certificated to ISO9001 and ISO14001

Author:

Andy Lewin

Approved By:

Dr Scott Hamilton

Date:

13 February 2014

Signed:

Executive summary

Ricardo-AEA has been commissioned to undertake a Detailed Assessment of Air Quality within Lanark town centre by South Lanarkshire Council. The assessment has been undertaken to investigate the potential scale and extent of exceedances of Air Quality Objectives in the study area. This Detailed Assessment will allow South Lanarkshire Council to decide whether or not an Air Quality Management Area is required within the study area.

The modelling study, which has used the most recent traffic, monitoring and meteorological data for the area indicates that there are exceedances of the NO_2 annual mean objective at locations with relevant exposure.

The exceedance area encompasses stretches of Bannatyne Street at both ground floor and 1st floor level.

In light of this Detailed Assessment of Air quality, South Lanarkshire Council should declare an Air Quality Management Area encompassing all areas of exceedance of the NO_2 annual mean objective predicted in this study. We would also recommend that the Council expand their NO_2 diffusion tube network to include sections of West Port and Bloomgate where residential properties are present at ground level. Additional monitoring will improve the quality of the Further Assessment that should be completed following declaration of the AQMA.

Given the findings of this study in relation to NO_2, South Lanarkshire Council should also consider monitoring of PM_{10} concentrations within Lanark town centre to establish if there is a risk of the Scottish PM_{10} objectives being exceeded at locations of relevant exposure.

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1 Introduction

Ricardo-AEA has been commissioned by South Lanarkshire Council to undertake a Detailed Assessment of Air Quality for Lanark town centre. The assessment has been undertaken to investigate the scale and extent of potential exceedances of the Air Quality Objectives within the study area. The Detailed Assessment will allow South Lanarkshire Council to decide whether or not an Air Quality Management Area is required at this location.

1.1 Policy background

The Environment Act 1995 placed a responsibility on UK Government to prepare an Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland. The most recent version of the strategy (2007) sets out the current UK framework for air quality management and includes a number of air quality objectives for specific pollutants.

The 1995 Act also requires that Local Authorities "Review and Assess" air quality in their areas following a prescribed timetable. The Review and Assessment process is intended to locate and spatially define areas where the AQS objectives are not being met. In such instances the Local Authority is required to declare an Air Quality Management Area (AQMA), carry out a Further Assessment of Air Quality, and develop an Air Quality Action Plan (AQAP) which should include measures to improve air quality so that the objectives may be achieved in the future. The timetables and methodologies for carrying out Review and Assessment studies are prescribed in Defra and the devolved administrations' Technical Guidance- LAQM.TG(09).

Table 1 lists the objectives relevant to this assessment that are included in the Air Quality (Scotland) Regulations 2000 (Scottish SI 2000 No 97) and the Air Quality (Scotland) (Amendment) Regulations 2002 (Scottish SI 2002 No 297) for the purposes of Local Air Quality Management (LAQM).

Table 1: NO_2 Objective for the purpose of Local Air Quality Management

Pollutant	Air Quality Objective	
	Concentration	Measured as
Nitrogen dioxide	200 $\mu g.m^{-3}$ not to be exceeded more than 18 times a year	1 hour mean
	40 $\mu g.m^{-3}$	annual mean

1.2 Locations where the objectives apply

When carrying out the review and assessment of air quality it is only necessary to focus on areas where the public are likely to be regularly present and are likely be exposed over the averaging period of the objective. Table 2 summarises examples of where air quality objectives for NO_2 should and should not apply.

Table 2: Examples of where the NO_2 Air Quality Objectives should and should not apply

Averaging Period	Pollutants	Objectives *should* apply at …	Objectives should *not* generally apply at …
Annual mean	NO_2	All locations where members of the public might be regularly exposed. Building façades 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
1-hour mean	NO_2	All locations where the annual mean and 24 and 8-hour mean objectives apply. Kerbside sites (e.g. pavements of busy shopping streets). Those parts of car parks and railway stations etc. which are not fully enclosed. Any outdoor locations to which the public might reasonably be expected to have access.	Kerbside sites where the public would not be expected to have regular access.

1.3 Purpose of this Detailed Assessment

This study is a Detailed Assessment, which aims to assess the magnitude and spatial extent of any exceedances of the NO_2 objectives at locations where relevant human exposure may occur within selected locations in Lanark.

1.4 Overview of the Detailed Assessment

The general approach taken to this Detailed Assessment was:

- Collect and interpret data from previous Review and Assessment reports.
- Collect and analyse recent traffic, monitoring, meteorological and background concentration data for use in a dispersion modelling study.
- Use dispersion modelling to produce numerical predictions of NO_2 concentrations at points of relevant exposure.
- Use dispersion modelling to produce contour plots of NO_2 concentrations;
- Recommend if South Lanarkshire Council should declare an AQMA at any location within Lanark and suggest its spatial extent.

The modelling methodologies provided for Detailed Assessments outlined in Defra Technical Guidance LAQM.TG(09)[1] were used throughout this study.

[1] Local Air Quality Management Technical Guidance LAQM.TG(09), Defra, 2009

1.5 Previous Air Quality Review and Assessment

1.5.1 Progress Report (2008)

The 2008 progress report concluded that the 2007 annual mean NO_2 concentration measured with the diffusion tube at Bannatyne Street Lanark 1N was in excess of the 40 µg.m^{-3} objective, this is a roadside location within a narrow, congested, street canyon.

Further monitoring of NO_2 concentrations was recommended at other locations of relevant public exposure within Lanark.

1.5.2 Updating and Screening Assessment (2009)

The Updating and Screening Assessment recommended that a Detailed Assessment of NO_2 concentrations in Lanark town centre should be undertaken, accounting for the influence of the narrow streets and queuing traffic.

1.5.3 Progress Report (2010)

The measured NO_2 annual mean concentration in 2009 at Bannatyne Street, Lanark of 47 µg.m^{-3} was in excess of the 40 µg.m^{-3} objective and had increased since 2008. The monitoring data reinforced the recommendation of the 2009 U&SA to conduct a Detailed Assessment of NO_2 in Lanark town centre.

1.5.4 Progress Report (2011)

Automatic monitoring of NOx and NO_2 concentrations commenced at Bannatyne Street, Lanark in September 2010. The data capture at this site was however too low to provide a realistic indication of annual mean NO_2 concentrations at this automatic monitoring site in 2010. An annual mean NO_2 concentration of 50 µg.m^{-3} was measured at the diffusion tube site at Bannatyne Street in 2010. The report acknowledged that a detailed assessment was to be conducted at this location later in 2011

1.5.5 Updating and Screening assessment (2012)

The Updating and Screening assessment reported NO_2 concentrations measured during 2011. The 2011 results are presented in Section 4 below. In general measured NO_2 concentrations had decreased since 2010.

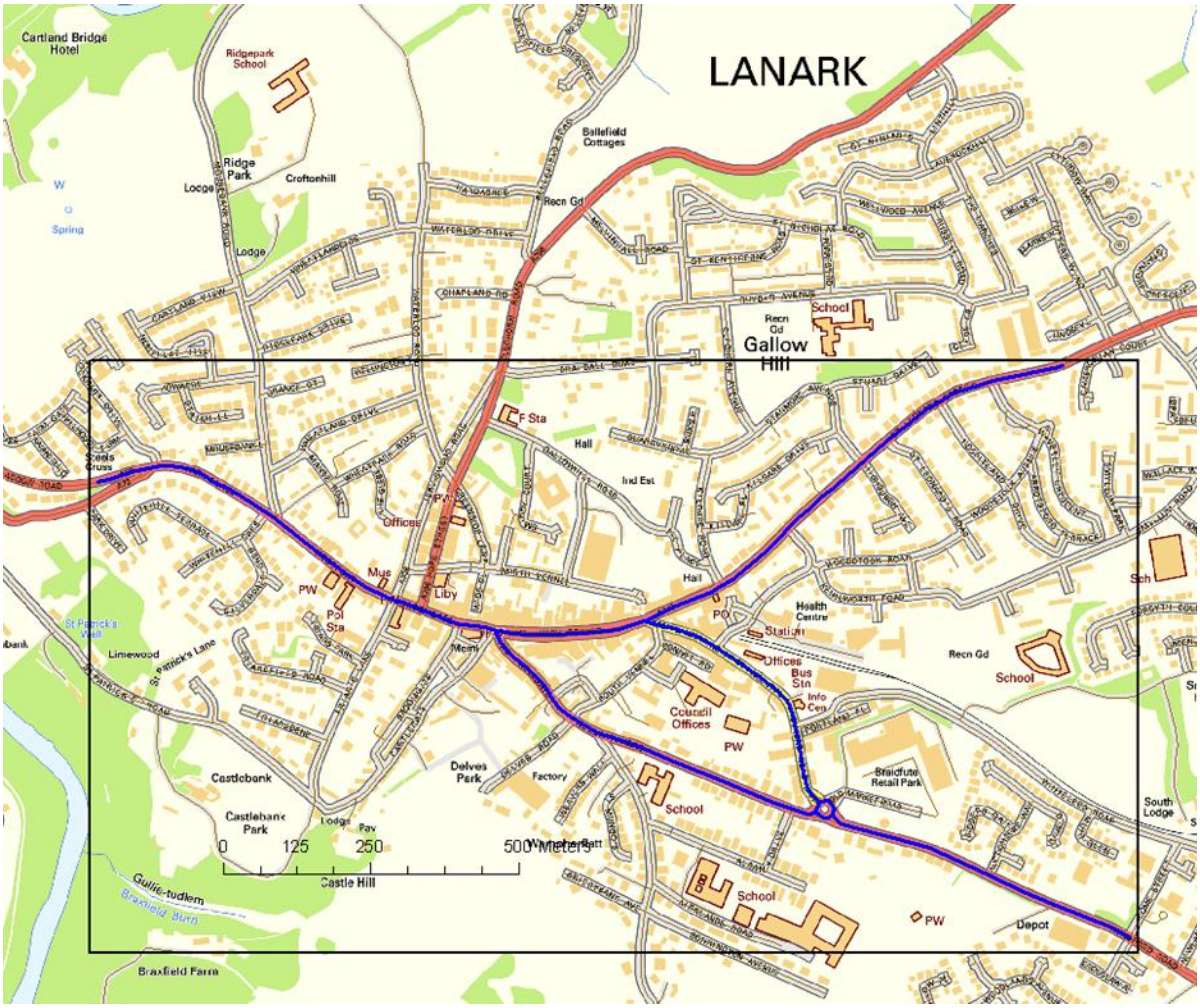
2 Detailed Assessment study area

Lanark is a small town located in central South Lanarkshire with a population of approximately 8,200.

The Detailed Assessment is concerned with an area encompassing Lanark Town Centre and three of the main roads that connect the town centre to the east and west. The assessment will consider road traffic emissions from the main roads in the study area and include the effects of the narrow, relatively high sided streets, which will be modelled as street canyons where they are present.

The study area, including the roads modelled and the extent of the detailed assessment is presented in Figure 1 below. The size of the study area is approximately 1.7 km by 1 km.

Figure 1: Detailed Assessment study area



N	**Legend:** Study area boundary Road to be modelled	RICARDO-AEA **Contains Ordnance Survey data © Crown copyright and database right 2013**

3 Information used to support assessment

3.1 Mapping

Ordnance Survey based GIS data of the model domain and a road centreline GIS dataset were used in the assessment. This enabled accurate road widths and the distance of the housing to the kerb to be determined in ArcMap.

3.2 Road traffic data

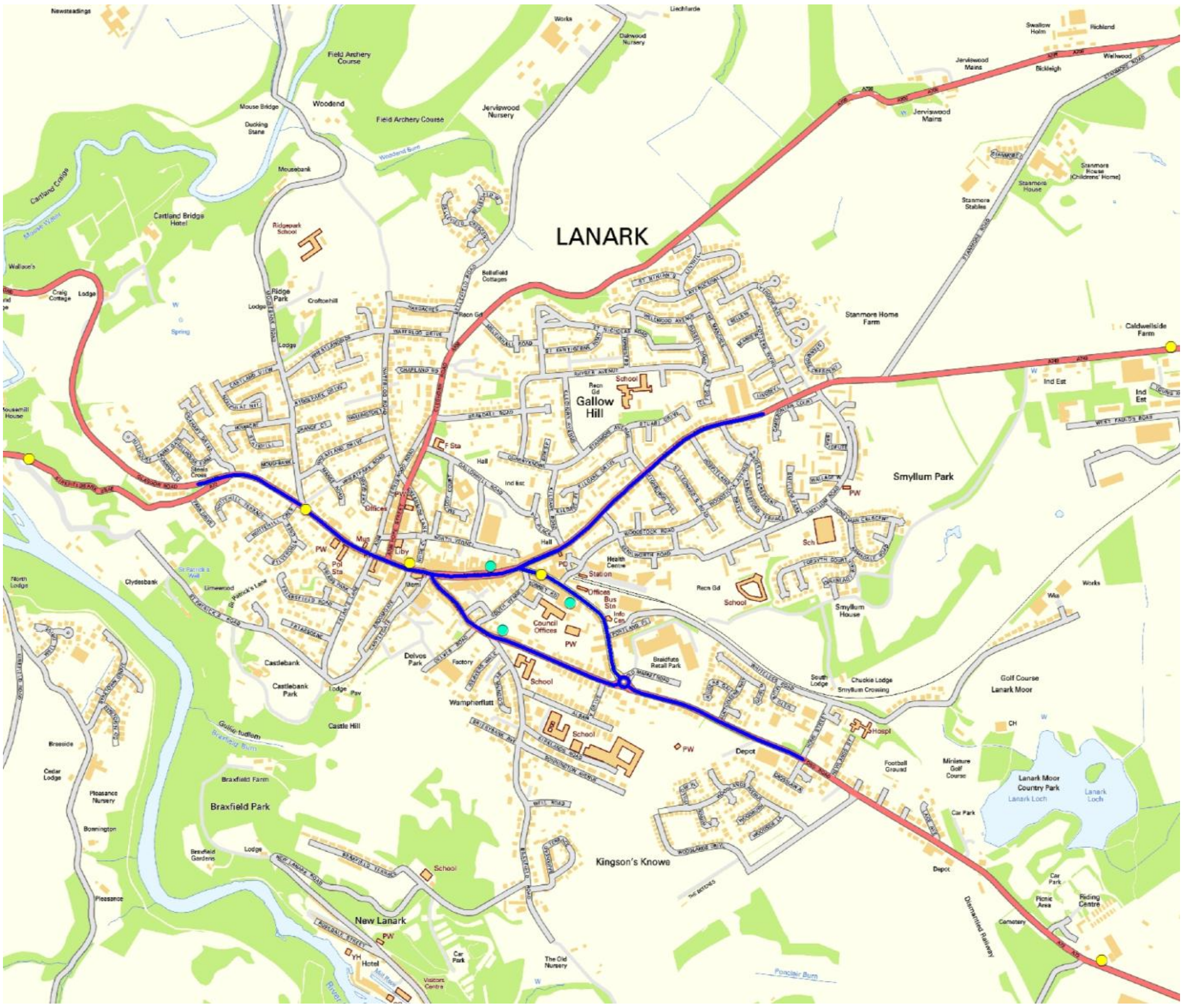
3.2.1 Average flow, speed and fleet split

South Lanarkshire Council provided annual average daily traffic (AADT) flow data containing percentage splits for various vehicle classes from a traffic count study conducted over one week in November 2011 at three locations; High Street, Wellgate and Bannatyne Street. Where available, 2011 traffic count data available for download from Transport Scotland were used for the roads out-with Lanark town centre. A map showing the traffic count locations is presented in Figure 2.

Appendix 1 summarises all of the traffic flow data used and the road links modelled.

It should be noted that traffic patterns in urban locations are complex and it is not possible to fully represent these in atmospheric dispersion models. By attempting to describe these complex traffic patterns using quite simple metrics (AADT, average speed and vehicle split composition) a degree of uncertainty is introduced into the modelling.

Figure 2: Traffic count locations



Legend:

SLC Dec 2011 traffic count location

Transport Scotland Automatic traffic count location

Road to be modelled

3.3 Emission factors

The most recent version of the Emissions Factors Toolkit[2] (EFT V5.2 January 2013 release) was used in this assessment to calculate pollutant emissions factors for each road link modelled. The calculated emission factors were then imported in to the ADMS-Roads model.

Parameters such as traffic volume, speed and fleet composition are entered into the EFT, and an emissions factor in grams of NOx/kilometre/second is generated for input into the dispersion model. In the latest version of the EFT, NOx emissions factors previously based on DFT/TRL functions have been replaced by factors from COPERT 4 v8.1. These emissions factors were published in May 2011 through the European Environment Agency and are widely used for the purpose of calculating emissions from road traffic in Europe.

The latest version of the EFT also includes addition of road abrasion emission factors for particulate matter; and changes to composition of the vehicle fleet in terms of the proportion of vehicle km travelled by each Euro standard, technology mix, vehicle size and vehicle category.

Vehicle emission projections are based largely on the assumption that emissions from the fleet will fall as newer vehicles are introduced. Any inaccuracy in the emissions factors contained in the EFT will be unavoidably carried forward into this modelling assessment.

3.4 Ambient monitoring

During the study year 2012 South Lanarkshire Council measured NO_2 concentrations within Lanark at one automatic monitoring site; and a network of three diffusion tubes at various roadside and urban background locations. Further details of these monitoring locations and recent measured concentrations are provided in Section 4. Two additional diffusion tube sites were deployed in Lanark in late 2012.

No monitoring of PM_{10} is currently conducted in Lanark.

3.5 Meteorological data

Hourly sequential meteorological data (wind speed, direction etc.) for 2012 from the Glasgow, Bishopton site was obtained from a third party supplier and used for the modelling assessment. The meteorological measurement site is located approximately 45 km to the north west of the study area and has good data quality for the period of interest.

Meteorological measurements are subject to their own uncertainty which will unavoidably carry forward into this assessment.

3.6 Background Concentrations

Background NOx concentrations for a dispersion modelling study can be accessed from either local monitoring data conducted at a background site or from the Scottish background maps[3]. The Scottish background maps are the outputs of a national scale dispersion model provided at a 1km x 1km resolution and are therefore subject to a degree of uncertainty.

Background concentrations of NOx from the relevant grid square of the Scottish background maps and the available local background diffusion tube monitoring locations were compared to establish which were most suitable for use in the modelling study. Annual mean NO_2 concentrations

[2]Defra (2013) Emission Factors Toolkit for Vehicle Emissions V5.2; available for download at http://laqm.defra.gov.uk/review-and-assessment/tools/emissions.html#eft
[3] http://www.scottishairquality.co.uk/maps.php

measured using diffusion tubes were converted to annual mean NOx concentrations using the Defra NOx to NO_2 calculator tool[4].

A comparison of the results is presented in Table 3.

Table 3: Background NOx and NO_2 concentrations in Lanark 2012

Source of data	NO_2 annual mean ($\mu g.m^{-3}$)	NOx annual mean ($\mu g.m^{-3}$)
Scottish background maps grid square 287500, 643500	10	12.8
Background diffusion tube Hospitland Drive, 6N	17	33.2

Of the available background data, the measured concentration from the Scottish background maps was considered the most representative background annual mean NOx concentration. This was identified during the model verification stage of the assessment where it became apparent that using the background concentration measured at the diffusion tube at Hospitland Drive led to the model over-predicting NO_2 concentration at the road side diffusion tube monitoring locations within the study area. This indicated that the measurement at Hospitland Drive may not be representative of the background NOx/NO_2 concentrations across the whole study area.

[4] Defra (2010) NOx to NO_2 conversion spreadsheet; Available at http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php

4 Monitoring data

South Lanarkshire Council currently monitors NO_2 in Lanark using one automatic analyser and three diffusion tubes sites. Automatic monitoring of NOx and NO_2 concentrations commenced at Bannatyne Street, Lanark in September 2010. A map showing the locations of the monitoring sites is presented in Figure 3.

Table 4 lists the current NO_2 diffusion tube monitoring sites and automatic analyser in Lanark. A bias adjustment factor of 0.86 was applied to all of the reported 2012 diffusion tube results as specified on the most recent summary spreadsheet of co-location studies[5]. South Lanarkshire Council has used the National bias adjustment factor in preference to bias factors derived from a local co-location study in recent years.

A summary of the 2012 measurement is presented in Table 3.

Table 4: Annual mean NO_2 concentrations measured in Lanark during 2012

Site	Type	OS Grid Ref.		Data Capture 2012 (%)	NO_2 annual mean ($\mu g.m^{-3}$)
		Easting	Northing		
Lanark High Street automatic analyser	Roadside	288427	643700	99.8%	28.6
Bannatyne Street Diffusion Tube	Roadside	288466	643677	100%	**48.3**
Hospitland Drive Diffusion Tube	Urban background	289000	643900	83%	17
Wellgate Diffusion Tube	Roadside	288213	642659	100%	24.3
Exceedences of the annual mean objective in **bold**					
Kerbside, 0-1m from the kerb of a busy road Roadside, 1-5m from the kerb					

[5] (National Physical Laboratory, 2013) Summary spreadsheet of co-location studies v0313 available at http://laqm.defra.gov.uk/bias-adjustment-factors/bias-adjustment.html

Figure 3: Lanark NO_2 monitoring locations

 	**Legend:**	RICARDO-AEA Contains Ordnance Survey data © Crown copyright and database right 2013

5 Modelling

5.1 Modelling methodology

Annual mean concentrations of NO_2 during 2012 have been modelled within the study area using the atmospheric dispersion model ADMS Roads (version 3.1).

The model was verified by comparing the modelled predictions of road NO_x with local monitoring results. The available automatic and diffusion tube NO_2 measurements within the study area (described in Section 4 above) were used to verify the annual mean road NOx model predictions.

Following initial comparison of the modelled concentrations with the available monitoring data, refinements were made to the model input to achieve the best possible agreement with the measurements. Further information on model verification is provided in Section 5.1.3 and Appendix 3.

A surface roughness of 0.5 m was used in the modelling to represent the sub-urban conditions in the model domain. A limit for the Monin-Obukhov length of 10 m was applied to represent a small town.

The source-oriented grid option was used in ADMS-Roads this option provides finer resolution of predicted pollutant concentrations along the roadside, with a wider grid spaced at approximately 3 metres being used to represent concentrations further away from the road. The predicted concentrations were interpolated to derive values between the grid points using the Spatial Analyst tool in the GIS software ArcMap 10. This allows contours showing the predicted spatial variation of pollutant concentrations to be produced and added to the digital base mapping. It should be noted that any dispersion modelling study has a degree of uncertainty associated with it; all reasonable steps have been taken to reduce this where possible.

5.1.1 Treatment of modelled NOx road contribution

It is necessary to convert the modelled NOx concentrations to NO_2 for comparison with the relevant objectives.

The Defra NOx/NO_2 model[6] was used to calculate NO_2 concentrations from the NOx concentrations predicted by ADMS-Roads. The model requires input of the background NOx, the modelled road contribution and accounts for the proportion of NOx released as primary NO_2. For the South Lanarkshire area in 2012 with the “All other UK urban Traffic” option in the model, the NOx/NO_2 model estimates that 22% of NOx is released as primary NO_2.

5.1.2 Validation of ADMS-Roads

Validation of the model is the process by which the model outputs are tested against monitoring results at a range of locations and the model is judged to be suitable for use in specific applications; this is usually conducted by the model developer.

CERC have carried out extensive validation of ADMS applications by comparing modelled results with standard field, laboratory and numerical data sets, participating in EU workshops on short range dispersion models, comparing data between UK M4 and M25 motorway field monitoring data, carrying out inter-comparison studies alongside other modelling solutions such as DMRB and CALINE4, and carrying out comparison studies with monitoring data collected in cities throughout the UK using the extensive number of studies carried out on behalf of local authorities and Defra.

[6] Defra (2012) NOx NO_2 Calculator v3.2 released September 2012; Available at http://laqm.defra.gov.uk/tools-monitoring-data/no-calculator.html

5.1.3 Verification of the model

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. This helps to identify how the model is performing at the various monitoring locations. The verification process involves checking and refining the model input data to try and reduce uncertainties and produce model outputs that are in better agreement with the monitoring results. LAQM.TG(09) recommends making the adjustment to the road contribution of the pollutant only and not the background concentration these are combined with.

The approach outlined in Example 2 of LAQM.TG(09) has been used in this case.

The modelled NOx concentrations were verified using the available measurements from the roadside automatic and diffusion tube monitoring sites in the study area.

Following various refinements to the model input; the modelled Road NOx contribution required adjustment by an average factor of 1.1 to bring the predicted NO_2 concentrations within close agreement of those results obtained from the monitoring data. This factor was applied to all Road NOx concentrations predicted by the model; the adjusted total NO_2 concentrations were then calculated using the Defra NOx/NO_2 calculator.

After the NOx/NO_2 model was run no further adjustments were made to the data. Model agreement for the NO_2 monitoring data after adjustment is presented in Table 5 and Figure 4. Full model verification data is provided in Appendix 3.

Model uncertainty can be estimated by calculating the root mean square error (RMSE). In this case the calculated RMSE was 0.8 $\mu g.m^{-3}$ after adjustment which is within the suggested value (10% of the objective being assessed) in LAQM.TG(09). The model has therefore been assessed to perform sufficiently well for use within this assessment. Ideally, verification of the model using more monitoring locations would give greater confidence in the results across the whole of the model domain.

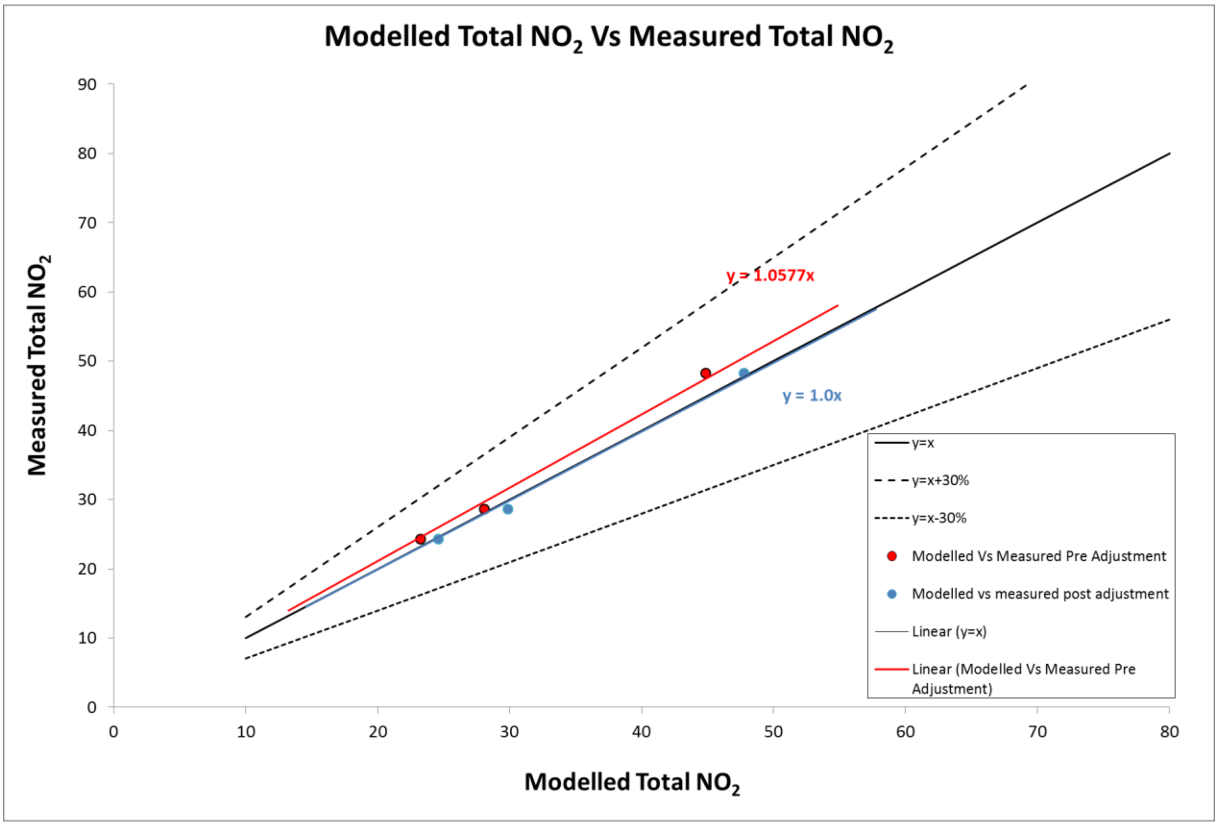
Verifying modelling data with diffusion tube monitoring data will always be subject to uncertainty due to the inherent limitations in such monitoring data (even data from continuous analysers has notable uncertainty). The model results should be considered in this context.

Further information on the verification process including the linear regression analysis is provided in Appendix 3.

Table 5: Modelled vs. measured annual mean NO_2 concentrations 2012

Site	NO_2 annual mean concentration ($\mu g.m^{-3}$)	
	Modelled NO_2	Measured
Lanark High Street automatic analyser	29.9	28.6
Bannatyne Street diffusion tube	47.8	48.3
Wellgate diffusion tube	24.6	24.3

Figure 4: Linear regression analysis of modelled vs. monitored NO_2 annual mean 2012



5.2 Model results

5.2.1 Modelling results – contour plots

A contour plots showing the spatial variation of the predicted 2012 annual mean NO_2 concentrations across the study area at 1.5m height is presented in Figure 5. Examination of the contour plot indicates that the 40 µg.m^{-3} NO_2 annual mean objective is being exceeded at the building facades at ground level within Bannatyne Street. The annual mean objective however does not apply at these locations as there is no relevant exposure at ground level; all of the properties at ground level are used as commercial premises.

A contour plot showing the predicted annual mean NO_2 concentrations within Bannatyne Street at a height of 4m is presented in Figure 6. This plot indicates that NO_2 annual mean concentrations close to, or in excess of, the 40 µg.m^{-3} objective are occurring at first floor height (approximately 4m) where residential properties are present.

The predicted NO_2 concentrations at this location have been modelled taking account of potential canyon effects attributable to poor mixing and recirculation of air within the narrow, relatively high sided streets. This is why the predicted concentrations are greater at 1st floor height than in other areas of the model domain. It was necessary to model canyon effects at this location to achieve good agreement with the 2012 Bannaytyne Street diffusion tube measurement. Canyon effects were also modelled at Bloomgate and Wellgate; predicted concentrations were below the objective value at those locations.

5.2.2 Modelling results at specified receptor locations

Annual mean NO_2 concentrations have also been predicted at a selection of the residential receptors within Bannatyne Street where annual mean NO_2 concentrations close to, or in excess of the 40 $\mu g.m^{-3}$ objective are indicated on the contour plots. This aims to eradicate uncertainties introduced when interpolating the predicted concentrations across the modelled grid; it provides predicted concentrations at discrete locations i.e. the building façade at first floor height (4m). All ground floor premises at these locations are understood to be commercial properties. There are also residential properties located at addresses 1, 2, 3, 4, 11, 13, 21, 33, 36 and 38 Bannatyne Street. The locations of the selection of specified receptors included in the model are shown on Figure 7.

The predicted annual mean NO_2 concentrations at each of the specified receptors in Bannatyne Street are presented in Table 6.

Table 6: Predicted annual mean NO_2 concentrations at specified receptors

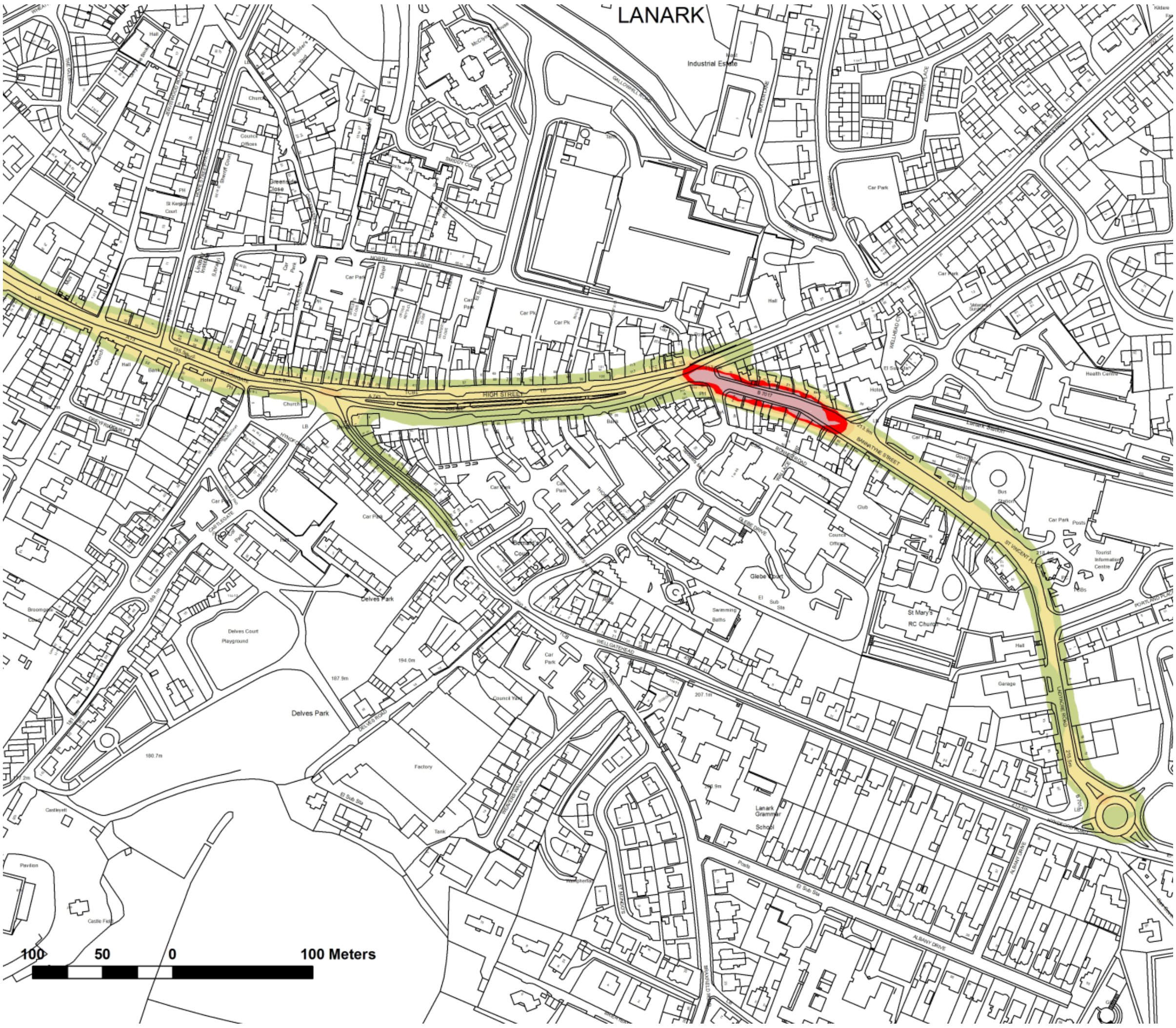
Receptor location	Receptor height (m)	OS Grid reference		Predicted annual mean NO_2 concentration ($\mu g.m^{-3}$)
		X	Y	
4 Bannatyne St	4m	288448	643673	**41.4**
15 Bannatyne St	4m	288473	643676	**40.9**
22 Bannatyne St	4m	288486	643662	**41.0**
3 Bannatyne St	4m	288447	643682	**41.2**

Concentrations in excess of the 40 $\mu g.m^{-3}$ objective are predicted at all of the specified receptor at first floor height within the canyon modelled; this indicates that the NO_2 annual mean objective is being exceeded at first floor height within Bannatyne Street and that it is necessary to declare an air quality management area for NO_2 at this location.

There are other locations within Lanark where poor dispersion of traffic emissions may be caused by the narrow, high sided streets. It is difficult however to represent this in a dispersion model without suitable NO_2 measurements with which to verify the modelling results and confirm if pollutant dispersion is being effected by the building topography.

It is recommended that additional NO_2 monitoring is conducted along the section of West Port and Bloomgate where residential properties are present at ground level. This section of road is on an upward gradient for traffic heading west into Lanark and some sections of the street have high buildings on both sides. Although this study indicates that annual mean NO_2 concentrations will not be in excess of the 40 $\mu g.m^{-3}$ objective, assumptions have been made and canyon effects have not been modelled at all locations where they could be occurring. Measurements will help confirm if the model results are a good indication of actual concentrations at these locations of relevant exposure.

Figure 5: Predicted annual mean NO_2 concentrations in Lanark 2012 (1.5m height)



Legend:

NO_2 annual mean concentration at 1.5m height ($\mu g.m^{-3}$)

- < 25
- 25 - 30
- 30 - 36
- 36 - 40
- 40 - 44
- 44 - 50
- > 50

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Figure 6: Predicted annual mean NO_2 concentrations in Bannatyne Street 2012 (4m height)

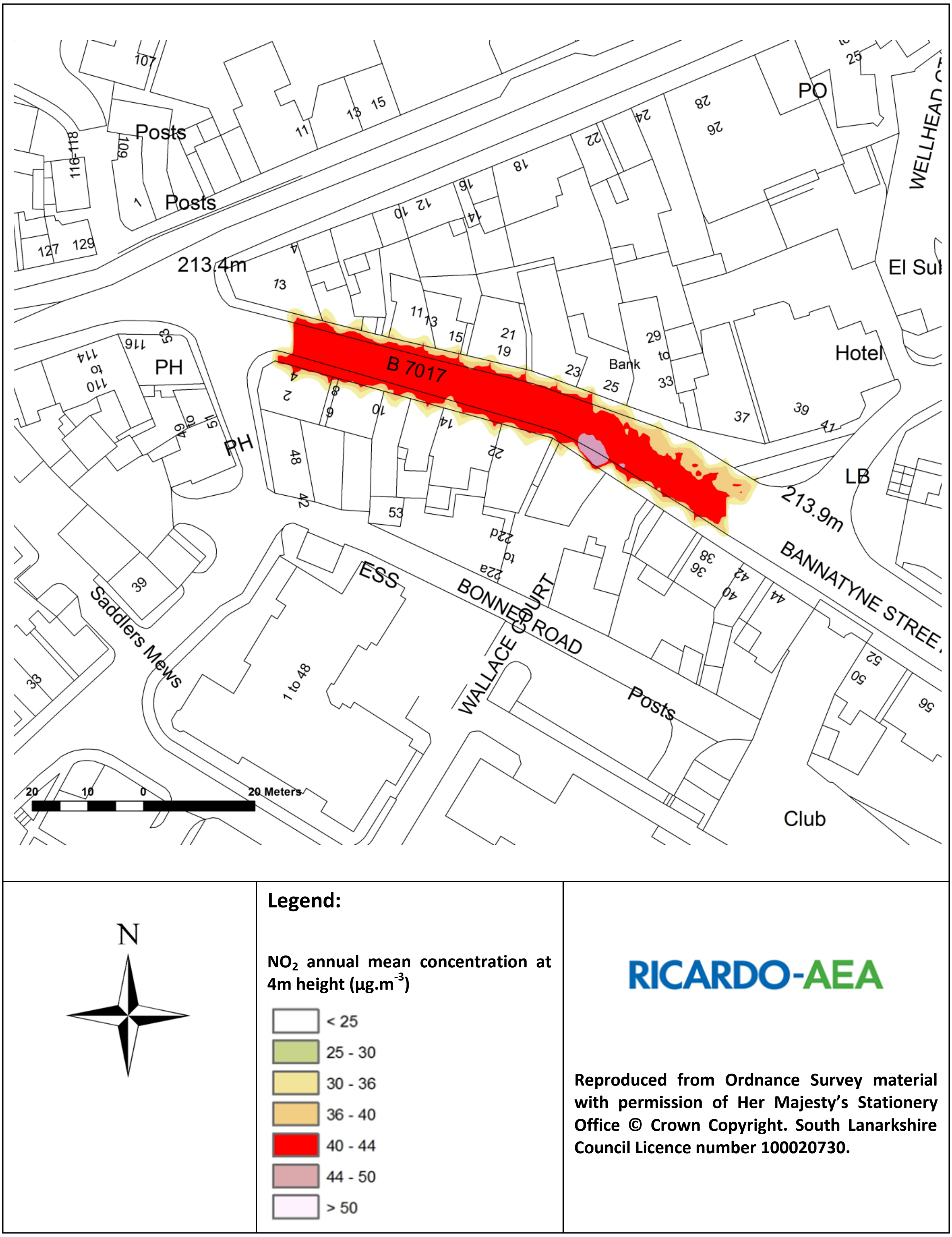
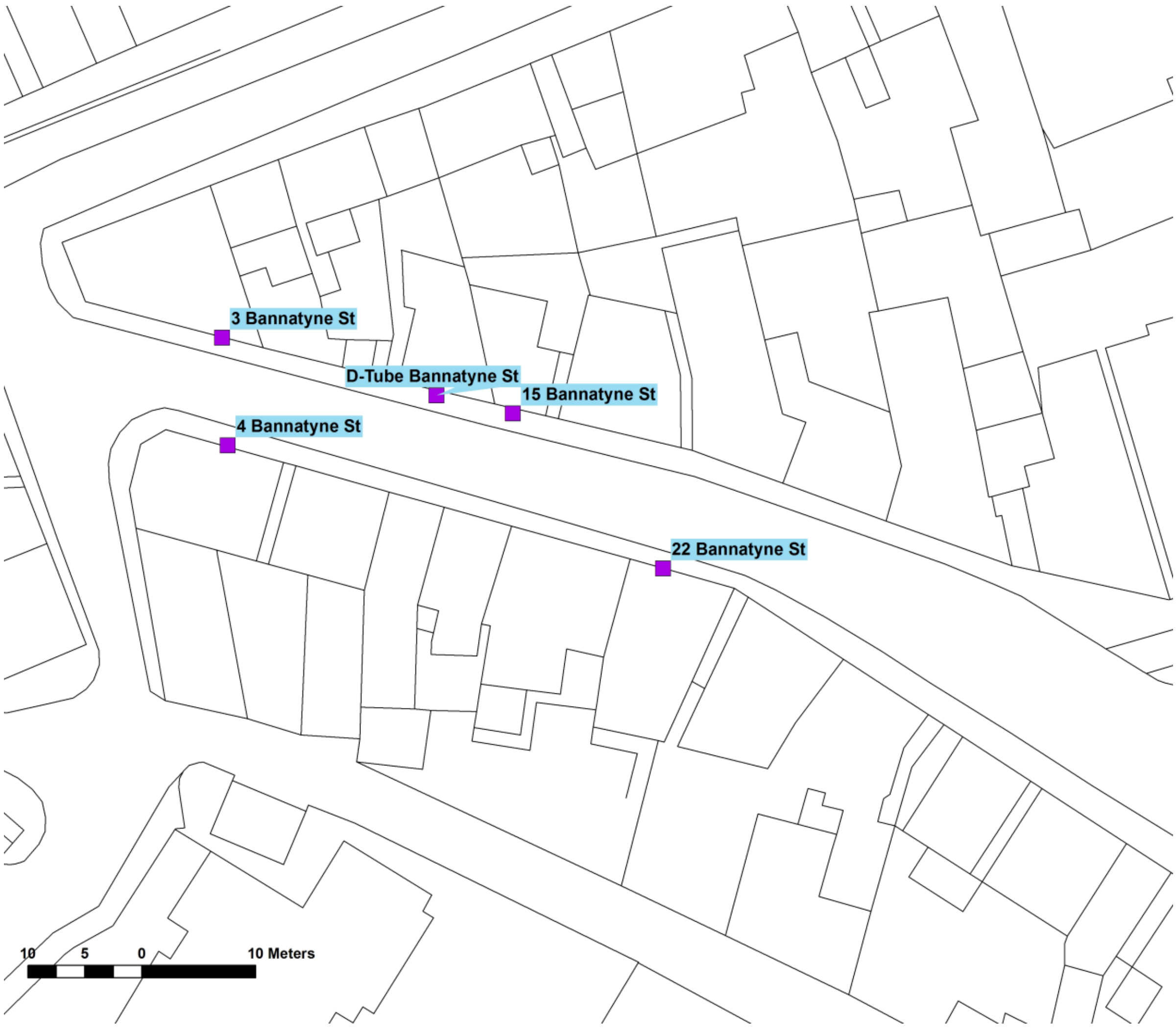


Figure 7: Specified receptor locations



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Legend:

ADMS Receptor

RICARDO-AEA

6 Conclusion

A dispersion modelling study of road traffic emission in Lanark town centre has been conducted to allow a detailed assessment of nitrogen dioxide concentrations at this location.

The modelling study, which has used the most recent traffic, monitoring and meteorological data for Lanark town centre indicates that there are exceedances of the NO_2 annual mean objective at locations with relevant exposure.

The exceedance area encompasses stretches of Bannatyne Street and is predicted at both ground and 1st floor level.

In light of this Detailed Assessment of Air quality, South Lanarkshire Council should declare an Air Quality Management encompassing all areas of exceedance of the NO_2 annual mean objective predicted in this study. We would also recommend that the Council expand their NO_2 diffusion tube network to improve the quality of the Further Assessment that should be completed following declaration.

7 Acknowledgements

Ricardo-AEA gratefully acknowledges the support received from Bronah Byrne, Ann Crossar and Andrew Smith of South Lanarkshire Council when completing this assessment.

Appendices

Appendix 1: Traffic data

Appendix 2: Wind Rose

Appendix 3: Model verification

Appendix 4: Monitoring data QA/QC

Appendix 1 – Traffic data

Table A2.1 summarises the Annual Average Daily Traffic (AADT) counts and fleet compositions used within the model. Traffic data were not growth adjusted forward to 2012.

Table A2.1: Lanark Annual Average Daily Flows - 2011

Street	Data source	Percentage vehicle fleet split (%)					
		Cars	LGV	HGV	Bus	2WM	AADF
High Street	Streetwise count Nov 2011	82.0	10.3	4.8	2.9	0.1	14250
Bannatyne Street	Streetwise count Nov 2011	83.8	8.6	4.0	3.6	0.1	12615
Bloomgate	DfT/Transport Scotland 2011	84.2	10.3	2.9	2.2	0.3	17301
Hyndford Road	DfT/Transport Scotland 2011	82.7	9.2	6.1	1.4	0.6	5847
St Leonard Street	DfT/Transport Scotland 2011	74.3	19.5	3.9	2.0	0.3	4652
Wellgate	Streetwise count Nov 2011	86.1	8.5	4.7	0.6	0.1	4830
Westport	DfT/Transport Scotland 2011	74.3	19.5	3.9	2.0	0.3	15551

LGV – Light Goods Vehicles
HGV – Heavy Goods Vehicles (Articulate and Rigid)
2WM - Motorcycles

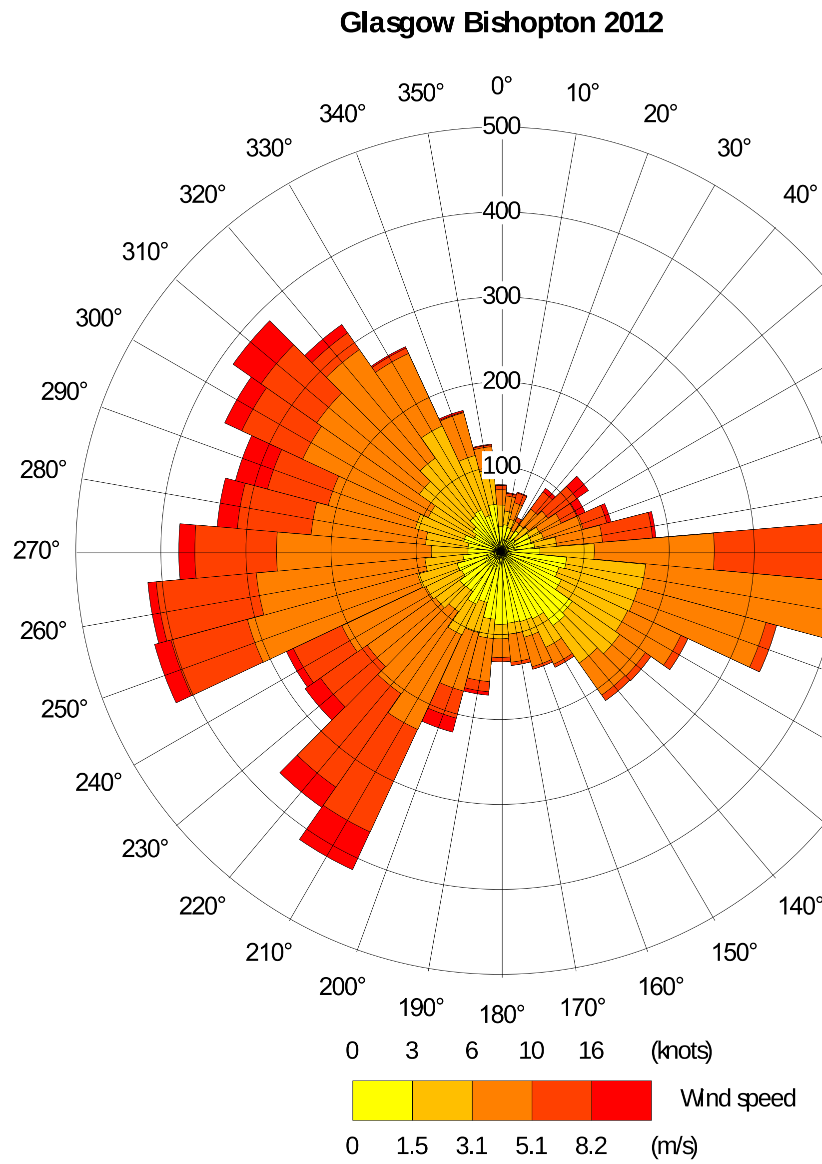
Traffic Speeds

As stated in Technical Guidance LAQM.TG(09), the speed of traffic on a road will change when approaching a junction. As such the speed of traffic was changed linearly between the maximum "open road" speed to the "close to a junction" speed approximately 50m from the junctions. As no traffic speed data were available, local speed limits were used for average "open road" speeds with speeds close to junctions and known congested areas varying from 5 km h^{-1} to 15 km h^{-1}.

Appendix 2 – Meteorological dataset

The Wind Rose for the 2012 Glasgow Bishopton meteorological dataset is presented in Figure A2.1

Figure A2.1 Meteorological dataset windrose



Appendix 3 – Model verification

It is appropriate to verify the ADMS Roads model in terms of primary pollutant emissions of nitrogen oxides (NO_x = NO + NO_2). The model has been run to predict annual mean Road NO_x concentrations during the 2011 calendar year at the diffusion tube sites in the study area.

The model output of Road NO_x (the total NO_x originating from road traffic) has been compared with the measured Road NO_x, where the measured Road NO_x contribution is calculated as the difference between the total NO_x and the background NO_x value. Total measured NO_x for each diffusion tube was calculated from the measured NO_2 concentration using the 2012 version of the Defra NO_x/NO_2 calculator. Exact monitoring site locations and heights were confirmed with South Lanarkshire Council and refinements made to the model where required.

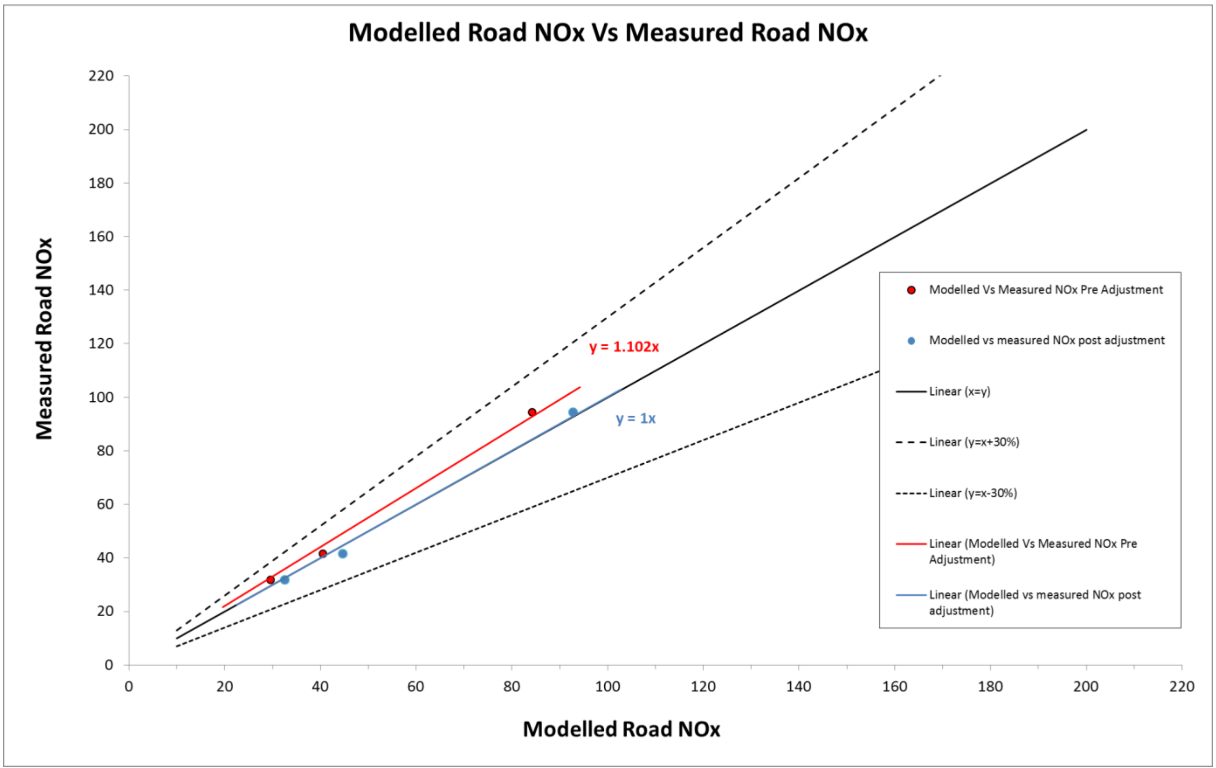
The initial comparison of the modelled vs measured Road NOx identified that the model was under-predicting the Road NOx contribution. Subsequently, various refinements were made to the model input to improve the overall model performance.

The gradient of the best fit line for the modelled Road NOx contribution vs. measured Road NOx contribution was then determined using linear regression and used as the adjustment factor. This factor was then applied to the modelled Road NOx concentration for each modelled point to provide adjusted modelled Road NOx concentrations. A linear regression plot comparing modelled and monitored Road NOx concentrations before and after adjustment is presented in Figure A3.1.

The background NOx concentration was then added to determine the adjusted total modelled NOx concentrations. The total annual mean NO_2 concentrations were then determined using the NOx/NO_2 calculator.

A primary adjustment factor (PAdj) of 1.102 was applied to all modelled Road NOx data.

Figure A3.1: Comparison of unadjusted modelled Road NO_x Vs Measured Road NO_x



Model uncertainty can be estimated by calculating the root mean square error (RMSE). In this case the calculated RMSE was 0.8 $\mu g.m^{-3}$ after adjustment which is within the suggested value (10% of the objective being assessed) in LAQM.TG(09). The model has therefore been assessed to perform sufficiently well for use within this assessment.

Appendix 4 - Monitoring data QA/QC

Automatic monitoring data

South Lanarkshire Council's automatic sites are part of the Scottish Air Quality database network, whereby monitoring data are managed to the same procedures and standards as AURN sites by Ricardo-AEA Technology.

Diffusion tube monitoring data

All passive diffusion tubes (PDT) for NO_2 measurement were prepared and analysed by Edinburgh Scientific Services. The PDTs were prepared using the 50% triethanolamine (TEA) in water method.

Edinburgh Scientific Services is a UKAS accredited laboratory with documented Quality Assurance/Quality Control (QA/QC) procedures for diffusion tube analysis. Edinburgh Scientific Services participates in the WASP scheme that is managed by the Health & Safety Laboratory and a monthly inter-comparison exercise that is managed by Ricardo-AEA.

The tube precision for Edinburgh Scientific Services for the only co-location study data from 2012 available at the time of writing[7] is shown in Table A4.1 The results show good precision in the study. The most recently available bias adjustment factor for this laboratory based on the Marylebone Road Inter-comparison study was 0.86. A summary of the information is presented in Table A2.

Table A4.1: 2012 bias correction factors for NO_2 diffusion tubes

Site Name	Study duration (months)	Tube precision	Bias correction factor
Marylebone Road inter-comparison	12	Good	0.86

[7] (National Physical Laboratory, 2013) Summary spreadsheet of co-location studies v0313 available at http://laqm.defra.gov.uk/bias-adjustment-factors/bias-adjustment.html

RICARDO-AEA

The Gemini Building
Fermi Avenue
Harwell
Didcot
Oxfordshire
OX11 0QR

Tel: 0870 190 1900
Fax: 0870 190 6318

www.ricardo-aea.com