Detailed Assessment of Air Quality 2013

Quarry Street/Duke Street junction,

Hamilton Town Centre, South Lanarkshire

Report for South Lanarkshire Council

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Executive summary

Ricardo-AEA have been commissioned by South Lanarkshire Council to undertake a Detailed Assessment of Air Quality for the area around the Duke Street/Quarry Street junction in Hamilton. The assessment has been undertaken to investigate the potential scale and extent of exceedances of the 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 at the study location. The assessment is being carried out based on the conclusions of the 2009 Updating and Screening Assessment.

This atmospheric dispersion modelling study, which has used the most recent traffic, monitoring and meteorological data for the area indicates that there are no exceedances of the NO_2 and PM_{10} annual mean objective occurring at locations with relevant exposure.

As there was no PM_{10} monitoring data with which to verify and adjust the model predictions there is however uncertainty in the predicted PM_{10} concentrations. It is therefore recommended that South Lanarkshire Council consider this again when preparing the 2015 Updating and Screening assessment and a full year of PM_{10} measurements are available from the Hamilton automatic monitoring site.

In light of this Detailed Assessment of Air Quality, South Lanarkshire Council are not required to declare an Air Quality Management Area at this time.

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1 Introduction

Ricardo-AEA has been commissioned by South Lanarkshire Council to undertake a Detailed Assessment of Air Quality for the Quarry Street/Duke Street junction in Hamilton, South Lanarkshire. 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 and PM_{10} Objectives 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
Particles (PM_{10}) (gravimetric) Authorities in Scotland only	50 $\mu g.m^{-3}$ not to be exceeded more than 7 times a year	24 hour mean
	18 $\mu g.m^{-3}$	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 and PM_{10} 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, PM_{10}	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
24-hr mean	PM_{10}	All locations where the annual mean objective would apply, together with hotels. Gardens of residential properties (should represent areas of the garden where relevant public exposure is likely)	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 and PM_{10} objectives at locations where relevant human exposure may occur within selected locations in the study area in Hamilton.

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 and PM_{10} concentrations at points of relevant exposure.
- Use dispersion modelling to produce contour plots of NO_2 and PM_{10} concentrations;
- Recommend if South Lanarkshire Council should declare an AQMA at any location within the study area 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.

1.5 Previous Air Quality Review and Assessment work

Updating and Screening Assessment (2009)

A review of roads traffic sources identified that annual mean PM_{10} concentrations at the Quarry Street/Duke Street junction may be in excess of the 2010 Scottish annual mean objective.

Annual mean PM_{10} concentrations predicted using the DMRB screening tool, using recorded traffic flows in the area, indicated that predicted annual means in 2010 at the Quarry Street receptors would be marginally below the objective. The report also noted that the DMRB predictions do not account accurately for the effect of street canyons or queuing traffic. The report therefore recommended that a Detailed Assessment of both NO_2 and PM_{10} concentrations in Hamilton town centre should be undertaken, accounting for the effect of street canyons and exposure at receptor locations above ground level.

Progress Report (2010)

The first year of diffusion tube monitoring at Brandon Street, Hamilton reported an annual mean NO_2 concentration in excess of the 40 $\mu g.m^{-3}$ objective. This reinforced the recommendation of the 2009 U&SA to conduct a Detailed Assessment of NO_2 within the Hamilton town centre.

South Lanarkshire Council was awarded additional funding from the Scottish Government to install an automatic monitoring station at Brandon Street, Hamilton.

Progress Report (2011)

The annual mean NO_2 concentration measured using a diffusion tube at Brandon Street, Hamilton during 2010 increased significantly between 2009 and 2010; and was in excess of the 60 $\mu g.m^{-3}$ threshold at which there may be a risk of the short-term NO_2 objective being exceeded.

The 2010 NO_2 monitoring data have confirmed the conclusions of the 2009 Updating and Screening Assessment and 2010 Progress Report, which recommended proceeding with a Detailed Assessment of NO_2 and PM_{10} concentrations at Brandon Street, Hamilton.

Updating and Screening assessment (2012)

The 2011 annual mean NO_2 concentration measured in Hamilton confirmed the requirement to conduct a Detailed Assessment of NO_2 in Hamilton town centre; the report noted that this assessment will be conducted when there is sufficient automatic monitoring data available to inform the study

Delays with completion of Detailed Assessment

The requirement to conduct a Detailed Assessment of NO_2 and PM_{10} at Hamilton was originally identified in the 2009 Updating and Screening assessment. Automatic monitoring commenced in Hamilton during 2011. Due to problems with site calibrations during the initial period of operation, it was not possible to ratify the data captured during 2011. Unfortunately another unforeseen problem

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

with the automatic-calibration system on each analyser during 2012 meant that again it was not possible to ratify the 2012 monitoring data.

Manual calibrations commenced at the automatic monitor in March 2013 allowing sufficient ratified monitoring data for the 2013 calendar year. Additional NO_2 diffusion tubes were also deployed in during September 2012 to supplement the monitoring data available for each study. The monitoring data used for this Detailed Assessment is therefore considered much better than was previously available.

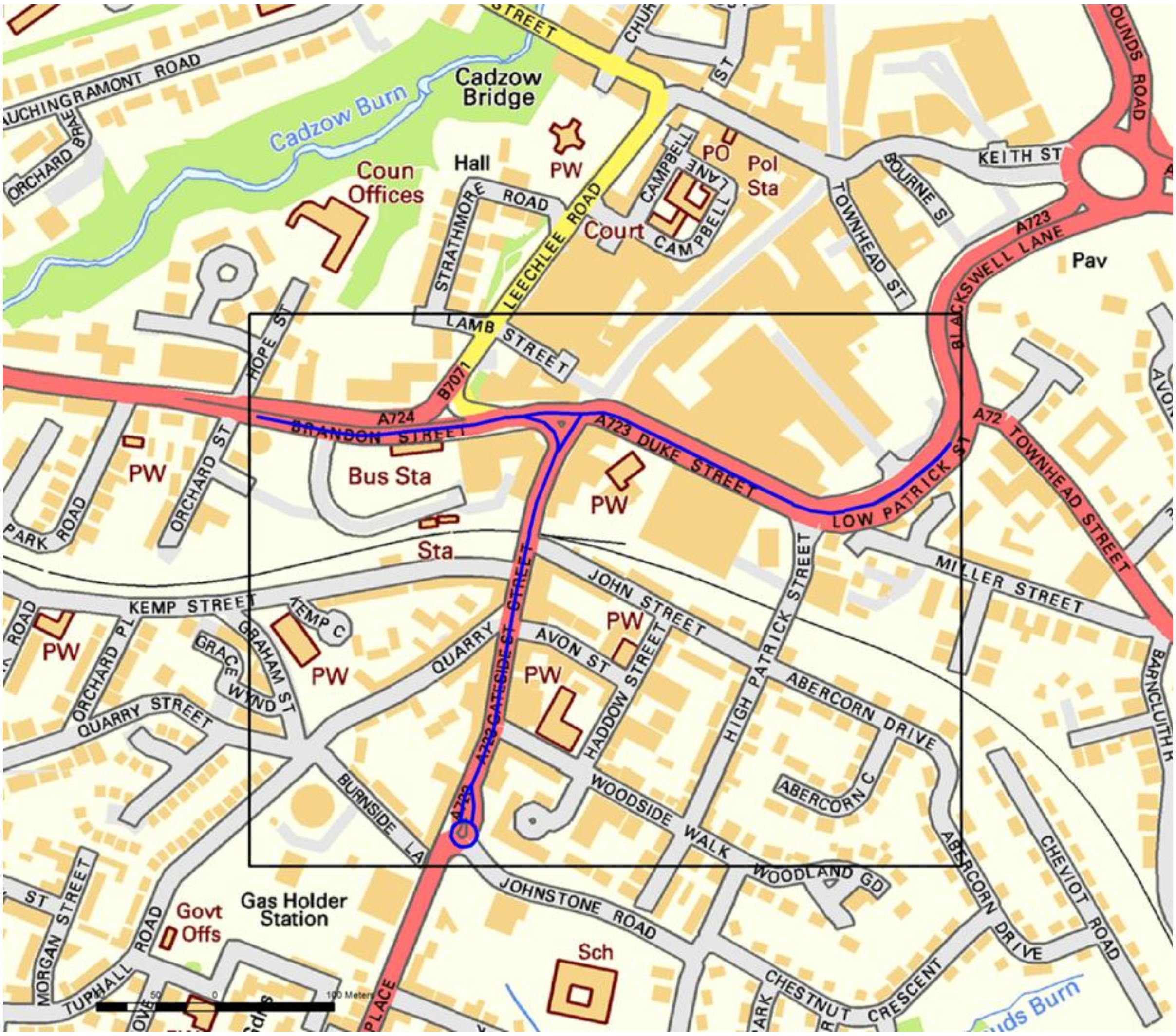
2 Detailed Assessment study area

Hamilton is a large town located in South Lanarkshire. The Detailed Assessment is concerned with the junction of Duke Street and Quarry Street in Hamilton town centre and the main roads that connect with the junction.

The assessment will consider road traffic emissions from the main roads in the study area and includes the effects of high-sided streets, which are 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 610 m by 450 m.

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 2014**

3 Information used to support this assessment

3.1 Maps

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 video traffic count study conducted in February 2012 at two locations on Brandon Street and Gateside Street. 2011 traffic count data from the Transport Scotland automatic count network was used for Duke Street. All AADT flows were factored forward to the 2013 study year using the NRTF Central growth forecast. A map showing the traffic count locations is presented in Figure 2. No measured speed data were available for the roads being modelled, vehicle speeds for road links were assumed based on local knowledge and professional judgement.

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 to the modelling.

Figure 2: Traffic count locations

Key:

SLC Feb. 2012 traffic count location

Transport Scotland Automatic traffic count location

Road to be modelled

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3.2.2 Congestion

During congested periods average vehicle speeds reduce when compared to the daily average; the combination of slower average vehicle speeds and more vehicles lead to higher pollutant emissions during peak hours; it's therefore important to account for this when modelling vehicle emissions to estimate pollutant concentrations.

No queue observation data from traffic surveys was available for the assessment. As an alternative indicative method of observing local traffic patterns, real time traffic flows were observed a number of times using the traffic layer on Google maps. These online maps are derived from real time GPS measurements so can be considered quite robust. The observations indicated that traffic becomes congested (i.e. very slow moving) occasionally at the Duke St/Quarry St junction but is more regularly slow than average during the morning/evening and late afternoon/evening peak periods.

The TG(09) guidance states that the preferred approach to representing the resulting increase in vehicle emissions during these peak periods is to calculate the emission rate for the affected roads for each hour of the day or week, on the basis of the average speeds and traffic flows for each hour of the day. The hourly specific emission rates can then be used to calculate a 24-hr diurnal emission profile which can be applied to that section of road. In this case an annual average diurnal profile of traffic flow across the study area was available from the local traffic count data but no speed measurement data was available. Peak periods in traffic flow were therefore accounted for in the model by applying the diurnal traffic flow profile to the average hourly emission rate. To account for speed reductions during peak traffic periods, assumed average speeds were reduced at road sections where slow moving traffic was observed.

3.2.3 Emission factors

The latest version of the Emissions Factors Toolkit[2] (EFT V5.2c Jan 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 reduce as newer vehicles are introduced. Any inaccuracy in the emissions factors contained in the EFT will be unavoidably carried forward into this modelling assessment.

3.2.4 Gradients

Hills with gradients may slow traffic significantly. As vehicles start to climb the hill, the power demand from the engine will increase, hence vehicle emissions will increase. However for vehicles going downhill, the opposite occurs and emissions decrease.

A method to derive the change in vehicles emissions attributable to a vehicle ascending or descending a hill is described in the LAQM technical guidance document TG(09)(Section A2.19). The

[2] http://laqm.defra.gov.uk/review-and-assessment/tools/emissions.html#eft

guidance recommends that for passenger cars and light diesel vehicles (LDVs) normal speed related emission factors should be used, taking into account that the average speed on the hill section may differ to that on the flatter sections.

For heavy diesel vehicles (HDVs) there are larger and more significant changes in emissions when ascending and descending a hill. Equations have been derived to calculate how gradients change emission rates; the equations are based on relationships developed from fitting speed related emission factors in the EMEP Corinair Emissions guidebook for gradients of +2%, +4% and +6%.

The topography at some locations within the study area in Hamilton is hilly with some of the roads being modelled having relatively steep gradients, particularly at Low Patrick Street. The gradient of various road sections throughout the study area was calculated using ground level altitudes extracted from digital elevation model (DEM) data; the percentage gradient between each height sample point was calculated using the measured distance between each point and the difference in altitude. For road sections where the gradient was greater than 2.5% a revised emission factor was calculated using the gradient adjustment equations provided in TG(09).

3.3 Meteorological data

Hourly sequential meteorological data (wind speed, direction etc.) for 2013 from the Glasgow Airport meteorological measurement site were used for the modelling assessment. The meteorological measurement site is located approximately 26.5 km WNW 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.

3.4 Background concentrations

Background NOx concentrations for a dispersion modelling study can be derived from either local monitoring data conducted at a background site or from the Scottish LAQM background maps[3].

The closest urban background NO_2 diffusion tube monitoring site is located at Low Quarry Gardens which is approximately 500m south west of the Duke St/Quarry St junction. The NO_2 annual mean measured at Low Quarry Gardens during 2013 was 12.2 $\mu g.m^{-3}$.

There are no urban background PM_{10} monitoring locations near to the study area, therefore the mapped background PM_{10} concentration was used in the study. A CSV file containing concentrations across the South Lanarkshire Council area was accessed from the Air Quality in Scotland website and the background PM_{10} concentration for the appropriate grid square extracted. The source contributions of background pollutant concentrations attributable to road traffic on the primary A roads within the study area have been subtracted from the total background to avoid double counting emissions from the roads.

The mapped annual mean PM_{10} background concentration for the relevant grid square during 2013 was 13.4 $\mu g.m^{-3}$. It should be noted that the 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.

[3] Air Quality in Scotland website(2014) http://www.scottishairquality.co.uk/maps

4 Ambient monitoring

South Lanarkshire Council currently measures NO_2 concentrations at one continuous analyser and various diffusion tubes in Hamilton. Within the study area for this Detailed Assessment there is an automatic analyser and four diffusion tube sites. A map showing the location of the monitoring sites is presented in Figure 3. Measurement of PM_{10} concentrations commenced in Hamilton during late 2013.

Details of the monitoring sites and the annual mean concentrations measured during 2013 are presented in Table 3. All diffusion tube results have been bias adjusted using a factor of 0.79 accessed from the latest National database of co-location factors[4]. Full details of bias adjustment factors applied to the diffusion tube results and QA/QC procedures are presented in South Lanarkshire Council's 2014 LAQM Progress Report.

An annual mean NO_2 concentration in excess of the 40 $\mu g.m^{-3}$ objective was measured at one diffusion tube site within the study area during 2013; at the Duke Street/Low Patrick Street site the measured annual mean was 51.3 $\mu g.m^{-3}$. The 2013 annual mean measured at the automatic analyser was 35 $\mu g.m^{-3}$.

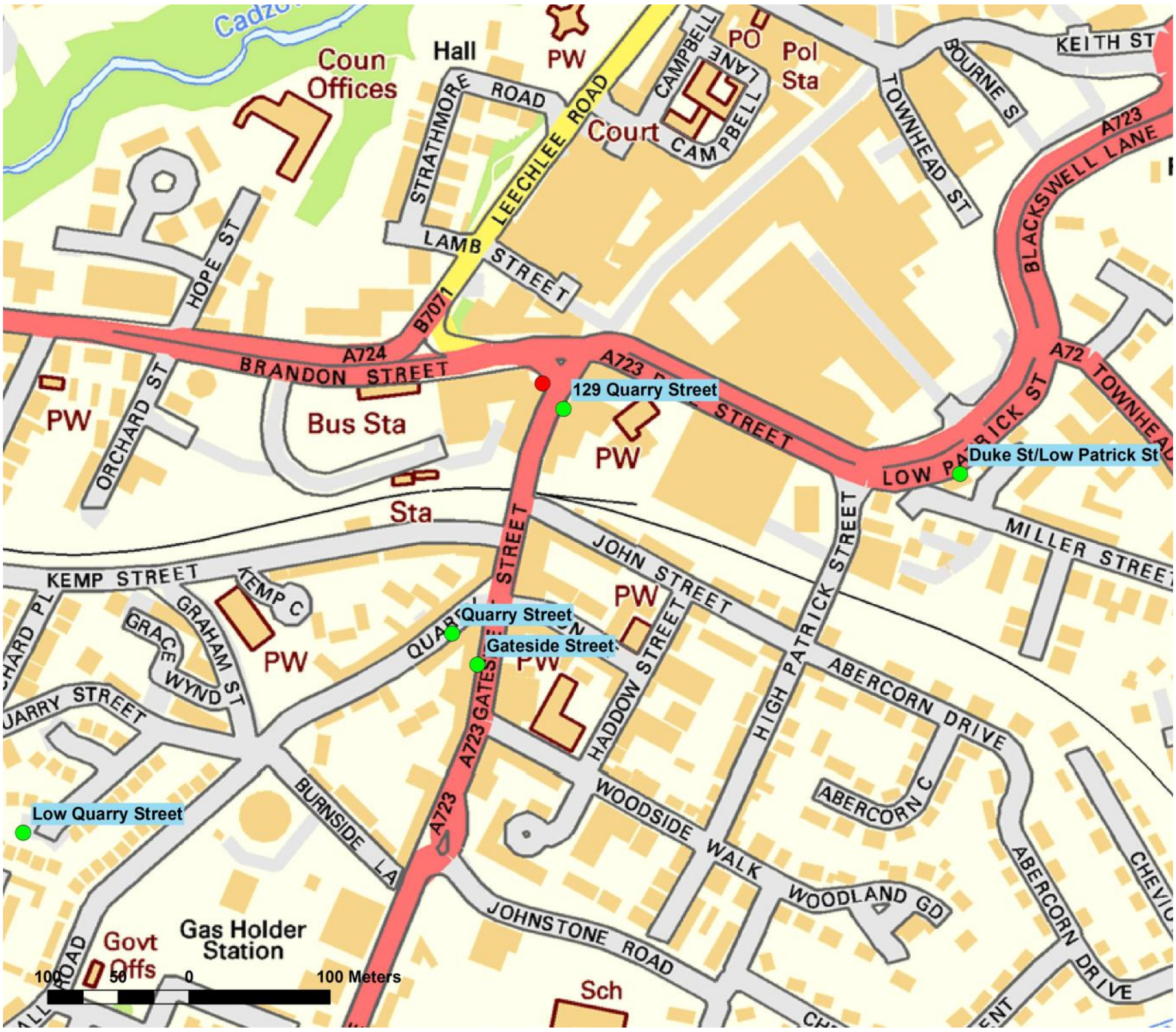
Table 3: NO_2 measurements 2013 - comparison with annual mean objective

Site	Type	OS Grid Ref.		Relevant exposure Y/N with distance (m)	Data Capture 2013 (%)	NO_2 Annual mean 2013 ($\mu g.m^{-3}$)
		Easting	Northing			
Hamilton automatic analyser	R	272310	655276	Yes (2m)	99.5%	35
179 Quarry Street	R	272246	655099	Yes (0 m)	100 %	25.5
129 Quarry Street	R	272325	655258	Yes (0.5 m)	92%	36.6
Duke Street/Low Patrick Street	R	272606	655212	Yes (1 m)	92%	**51.3**
Gateside Street	R	272264	655077	Yes (0 m)	100%	34.1
Low Quarry Gardens	UB	271942	654958	n/a	92%	12.2

Exceedances of the annual mean objective are highlighted in **bold**
R – Roadside monitoring location, 1-5m from the kerb of a busy road

[4] NPL(2013) Database_Diffusion_Tube_Bias_Factors-v03_14-Final-v2.xls (available to download at http://laqm.defra.gov.uk/ (accessed April 2014)

Figure 3: Hamilton NO_2 monitoring locations



Legend:

- Diffusion tube site
- Automatic Analyser

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5 Modelling

5.1 Modelling methodology

Annual mean concentrations of NO_2 and PM_{10} have been modelled within the study area using the atmospheric dispersion model ADMS Roads (version 3.2).

The model was verified by comparing the modelled predictions of road NOx with local monitoring results. The available measurements (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 monitoring results. Further information on model verification is provided in Section 5.1.3 and Appendix 3

A surface roughness of 1.5 m was used in the modelling to represent the large urban area 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 5m being used to represent concentrations further away from the road. The grid height was set at 4m to represent 1st floor height where residential properties are present above ground floor commercial premises within the study area. 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.

Slow moving traffic was treated in the model using the methodology described in Section 3.2.2 above. A time varying emissions file was used in the model to account for the daily variation in traffic flow.

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[5] 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 Council area in 2012 with the “All UK Traffic” option specified in the model, the NOx/NO_2 model estimates that 22.9% 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.

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

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.

5.1.3 Verification of the baseline model

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. Dispersion models of this nature carry a degree of uncertainty for the reasons explained in previous sections so it is important to check their performance against measurements and adjust their outputs accordingly. A full description of the model verification procedure for the baseline models is presented in Appendix 2.

A primary NOx adjustment factor (PAdj) of 1.4621 based on model verification using monitoring results covering the study period was applied to all modelled Road NOx data prior to calculating an NO_2 annual mean. 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 4 and Figure 4.

To evaluate the model performance and uncertainty, the Root Mean Square Error (RMSE) for the observed vs predicted NO_2 annual mean concentrations was calculated, as detailed in Technical Guidance LAQM.TG(09), Box A3.7, Appendix 3. Details of the RMSE calculation are presented in Appendix 2.

It is recommended that the RMSE is below 25% of the objective that the model is being compared against, but ideally under 10% of the objective i.e. 4 $\mu g.m^{-3}$ (NO_2 annual mean objective of 40 $\mu g.m^{-3}$). In this case the RMSE for the NO_2 annual mean was calculated at 1.23 $\mu g.m^{-3}$; the model uncertainty is therefore well within the recommended value and the model has performed very well for use within this assessment.

No PM_{10} monitoring data was available with which to verify the model predictions. The Road NOx adjustment factor of 1.4621 was therefore used to adjust the Road PM_{10} contribution before including the background contribution.

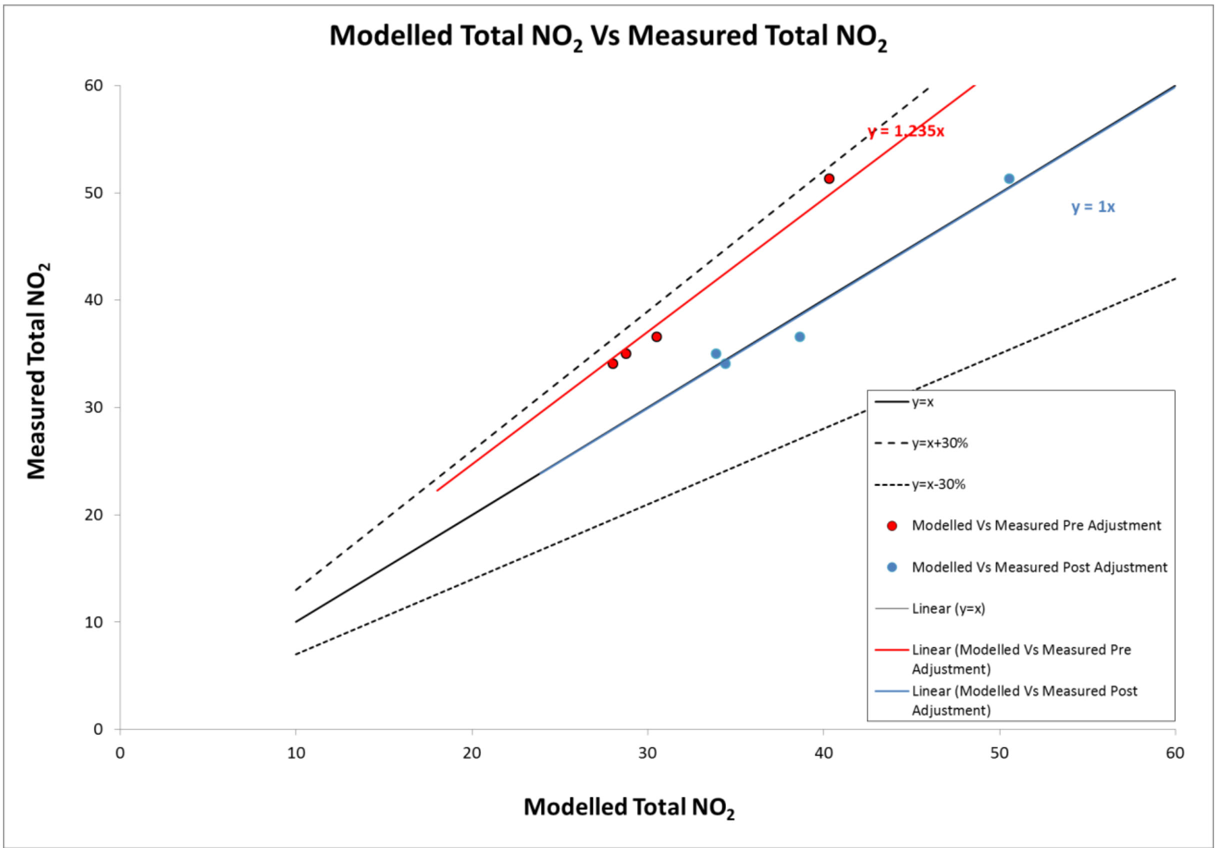
Verifying modelling data with diffusion tube monitoring data will always be subject to uncertainty due to the inherent limitations in such monitoring data (even data from continuous analysers has notable uncertainty). The model results should be considered in this context.

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

Table 4: Modelled vs. measured annual mean NO_2 concentrations 2013

Site	NO_2 annual mean concentration ($\mu g.m^{-3}$)	
	Measured	Modelled
Hamilton automonitor	35.0	33.9
DT6 129 Quarry St	36.6	38.6
DT9 Gateside St	34.1	34.4
DT8 Duke/Low Patrick St	51.3	50.5
	RMSE =	**1.23**

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



5.2 Modelling results

Annual mean NO_2 and PM_{10} concentrations have been predicted at a selection of receptor locations within the study area where relevant exposure is present at ground level. The receptors are located at the facade of residential buildings in the model domain where relevant exposure is present next to the roads sources being modelled. Most of the receptors have been modelled at 4m height to represent 1st floor level exposure at residential properties above commercial premises.

Pollutant concentrations have also been predicted across a grid of points at both ground level (1.5m) and 1st floor level (4m) to allow contour plots showing the spatial variation in pollutant concentrations to be created.

5.2.1 NO_2 Annual mean concentrations

The predicted annual mean NO_2 concentrations at each of the specified receptors during 2013 are presented in Table 5. Maps representing the predicted annual mean NO_2 concentrations at the specified receptors using graduated colours are presented in Figure 5 to Figure 7. No annual mean NO_2 concentrations in excess of the 40 $\mu g.m^{-3}$ objective were predicted at any of the specified receptor locations during 2013.

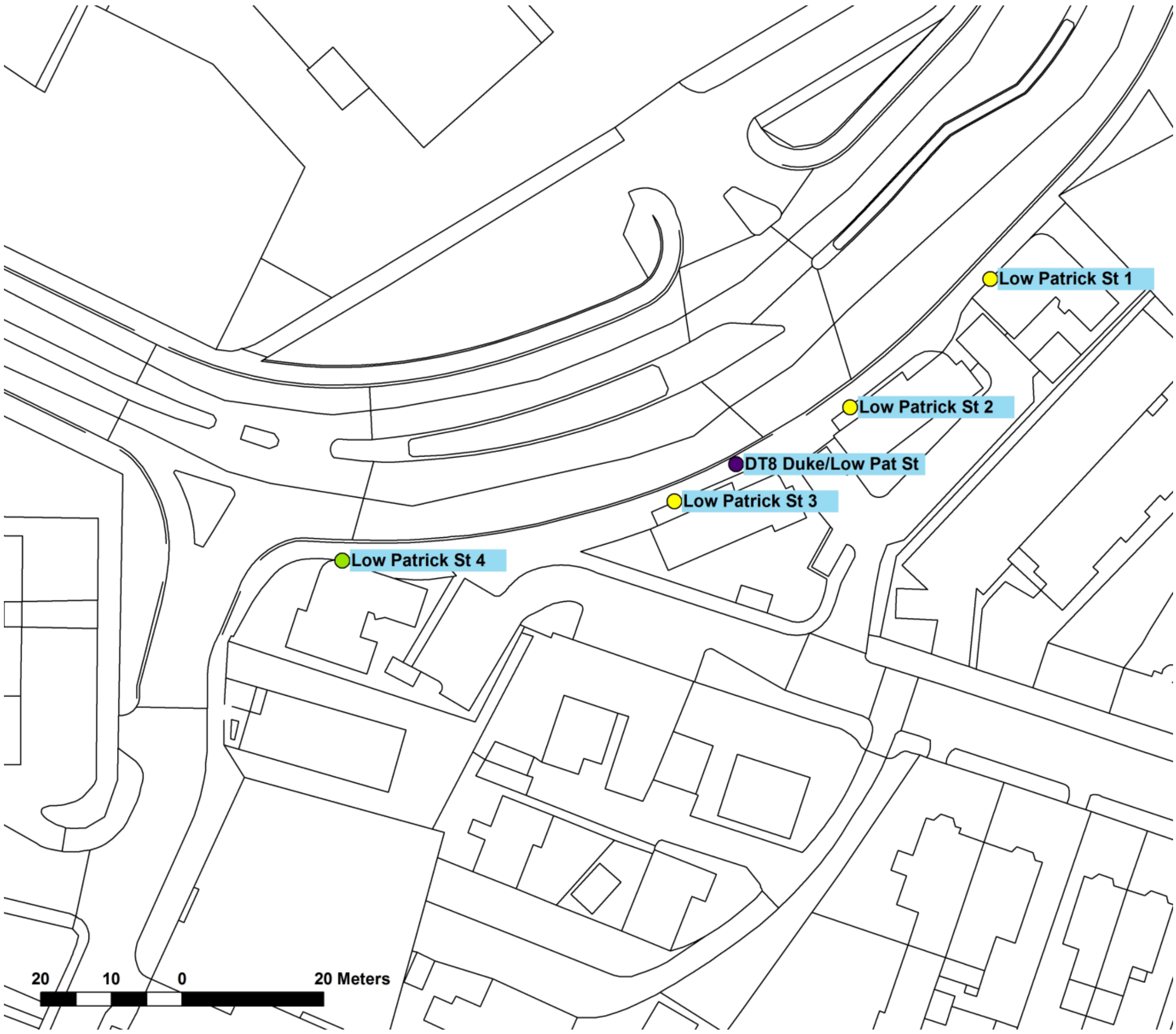
Figure 5 shows the location of the diffusion tube site at Low Patrick Street where the measured NO_2 annual mean during 2013 was exceeding the objective at 51.3 $\mu g.m^{-3}$. The modelled NO_2 annual means at first floor height where the residential property windows are present at this location are all less than the 40 $\mu g.m^{-3}$ objective.

A contour plot showing the predicted spatial variation in annual mean NO_2 concentrations is presented in Figure 8. The contour plot does not indicate that there are any locations of relevant exposure within the study area where annual mean NO_2 concentrations are in excess of the 40 $\mu g.m^{-3}$ objective. Concentrations close to the 40 $\mu g.m^{-3}$ objective appear to be occurring at the facades of the first floor flats at Low Patrick Street, the results at the specified receptors modelled at this location are however below the objective. This difference between the results at the specified receptor points and the same location on the contour plot is due to the averaging of concentrations over a grid spacing of approximately 4m when creating the contour plots using interpolation. The predicted concentrations at the specified receptor points are not affected in this way.

Table 5: Predicted annual mean NO_2 concentrations at specified receptors 2013

Receptor location	Height (m)	OS Grid reference		Annual mean NO_2 concentration ($\mu g.m^{-3}$)
		X	Y	
Low Patrick St 1	4	272311.9	655274.6	33.0
Low Patrick St 2	4	272325.7	655257.6	33.8
Low Patrick St 3	4	272264.0	655077.0	33.9
Low Patrick St 4	4	272606.0	655213.0	26.2
Duke St 1	4	272641.9	655239.2	26.8
Duke St 2	4	272622.2	655221.1	28.8
Quarry St 1	4	272597.3	655207.8	28.9
Quarry St 2	4	272550.3	655199.4	38.0
Quarry St 3	4	272375.9	655280.7	37.0
Quarry St 4	4	272353.6	655288.9	37.7
Quarry St 5	4	272342.0	655286.4	24.4
Gateside St 1	4	272328.5	655264.3	32.4
Gateside St 2	4	272318.8	655243.4	32.2
Gateside St 3	4	272277.2	655153.3	32.1
Gateside St 4	4	272290.0	655129.8	33.5
Gateside St 5	4	272266.9	655097.6	36.4
Gateside St 6	4	272284.9	655097.4	37.3
Gateside St 7	1.5	272261.9	655064.8	26.3

Figure 5: Predicted NO_2 annual mean at specified receptor locations - Low Patrick Street



Legend:

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

- < 30
- 30 - 36
- 36 - 40
- 40 - 44
- 44 - 50
- 50 - 50.5

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Figure 6: Predicted NO_2 annual mean at specified receptor locations - Duke St/Quarry St junction

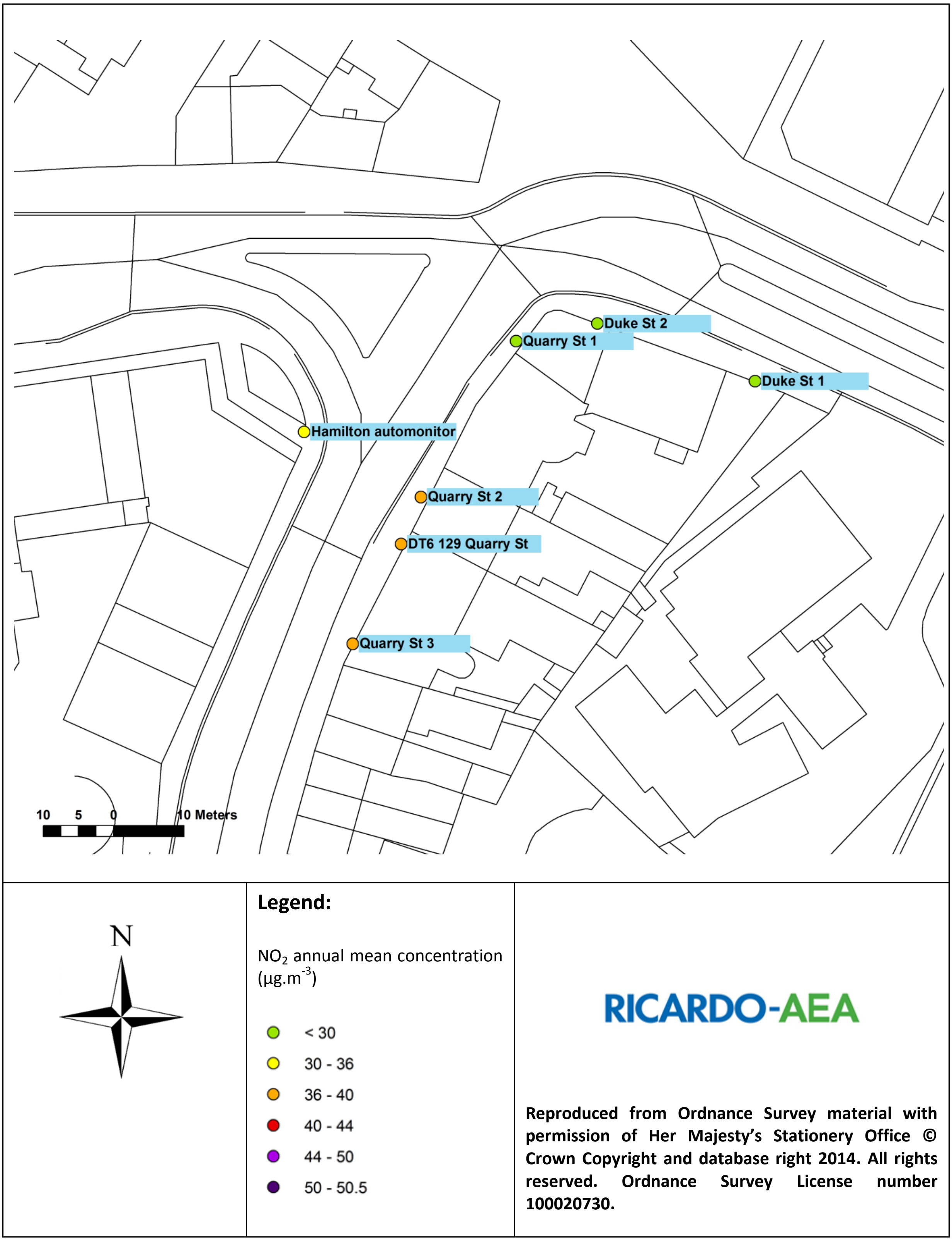
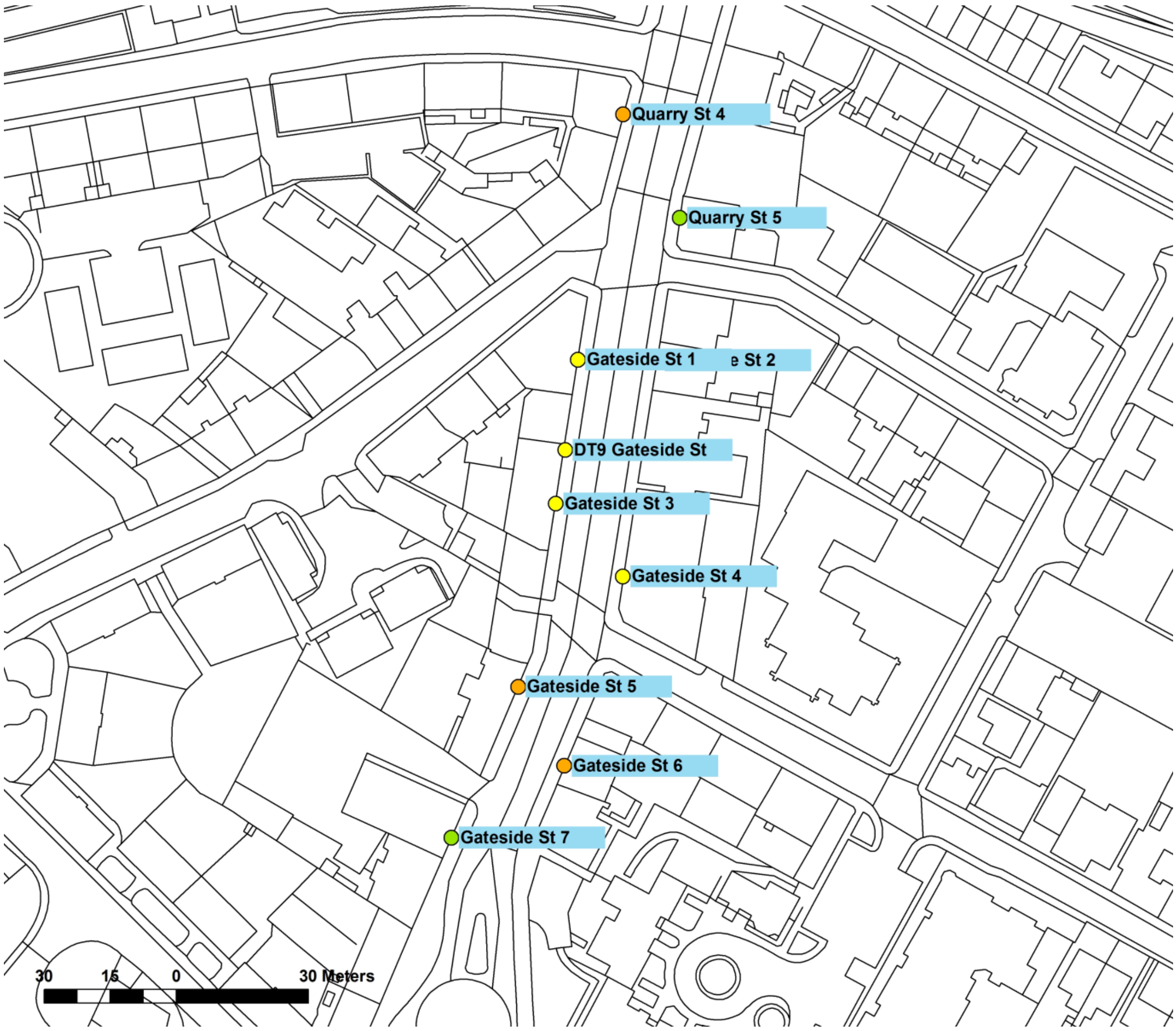


Figure 7: Predicted NO_2 annual mean at specified receptor locations – Gateside Street



Legend:

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

- < 30
- 30 - 36
- 36 - 40
- 40 - 44
- 44 - 50
- 50 - 50.5

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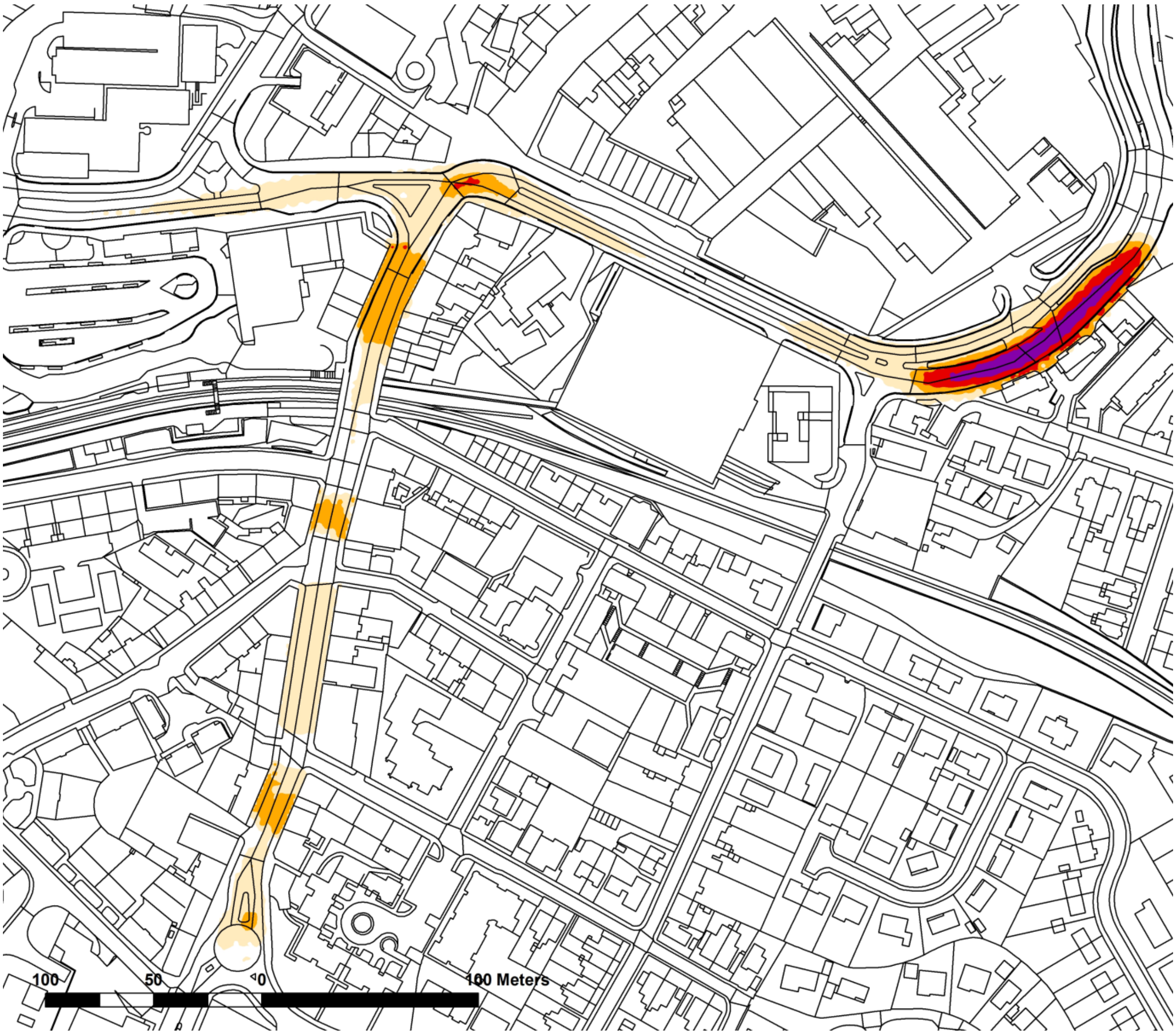
Figure 8: Predicted NO_2 annual mean concentration contour



Legend:

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

- < 30
- 30 - 36
- 36 - 40
- 40 - 44
- 44 - 46.8

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5.2.2 PM_{10} annual mean concentrations

The predicted annual mean PM_{10} concentrations at each of the specified receptors during the modelled year 2013 are presented in Table 6. Maps representing the predicted annual mean NO_2 concentrations at the specified receptors using graduated colours are presented in Figure 9 to Figure 11.

Annual mean PM_{10} concentrations in excess of the 18 µg.m^{-3} Scottish objective were not predicted at any of the specified receptor locations.

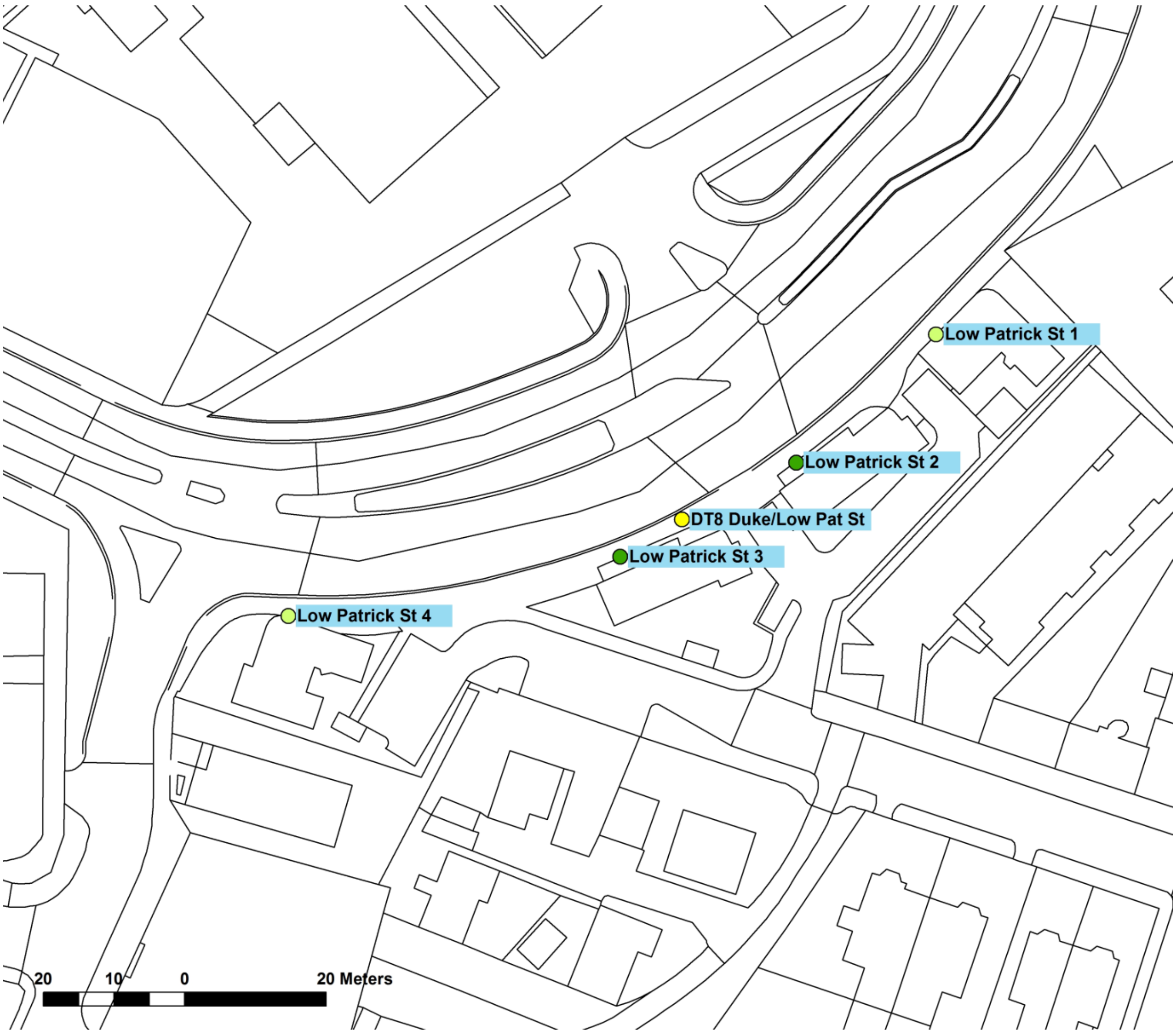
A contour plot showing the predicted spatial variation in annual mean PM_{10} concentrations at first floor height above commercial properties is presented in Figure 12. The contour indicates that annual mean PM_{10} concentrations just less than the 18 µg.m^{-3} Scottish objective are occurring at the facades of the first floor height residential properties at the section of Quarry Street close to the junction with Duke Street. The predicted concentrations at the specified receptor points at this location are also below the 18 µg.m^{-3} objective.

The predicted PM_{10} concentrations should be considered in context with the model error and uncertainty described in the model verification section of the report. It should be noted that the PM_{10} model predictions are likely to be much more uncertain than for NO_2 as there were no PM_{10} measurements available with which to verify the model predictions.

Table 6: Predicted annual mean PM_{10} concentrations at specified receptors (Sep 2012 – Aug 2013)

Receptor location	Height (m)	OS Grid reference		Annual mean PM_{10} concentration ($\mu g.m^{-3}$)
		X	Y	
Low Patrick St 1	4	272311.9	655274.6	15.0
Low Patrick St 2	4	272325.7	655257.6	15.0
Low Patrick St 3	4	272264.0	655077.0	15.0
Low Patrick St 4	4	272606.0	655213.0	14.6
Duke St 1	4	272641.9	655239.2	15.0
Duke St 2	4	272622.2	655221.1	15.2
Quarry St 1	4	272597.3	655207.8	15.3
Quarry St 2	4	272550.3	655199.4	17.4
Quarry St 3	4	272375.9	655280.7	17.3
Quarry St 4	4	272353.6	655288.9	17.2
Quarry St 5	4	272342.0	655286.4	15.0
Gateside St 1	4	272328.5	655264.3	16.5
Gateside St 2	4	272318.8	655243.4	16.5
Gateside St 3	4	272277.2	655153.3	16.8
Gateside St 4	4	272290.0	655129.8	17.0
Gateside St 5	4	272266.9	655097.6	17.1
Gateside St 6	4	272284.9	655097.4	17.2
Gateside St 7	1.5	272261.9	655064.8	15.0

Figure 9: Predicted PM_{10} annual mean at specified receptor locations – Low Patrick Street



Legend:

PM_{10} annual mean concentration ($\mu g.m^{-3}$)

- < 15
- 15 - 16
- 16 - 17
- 17 - 17.5

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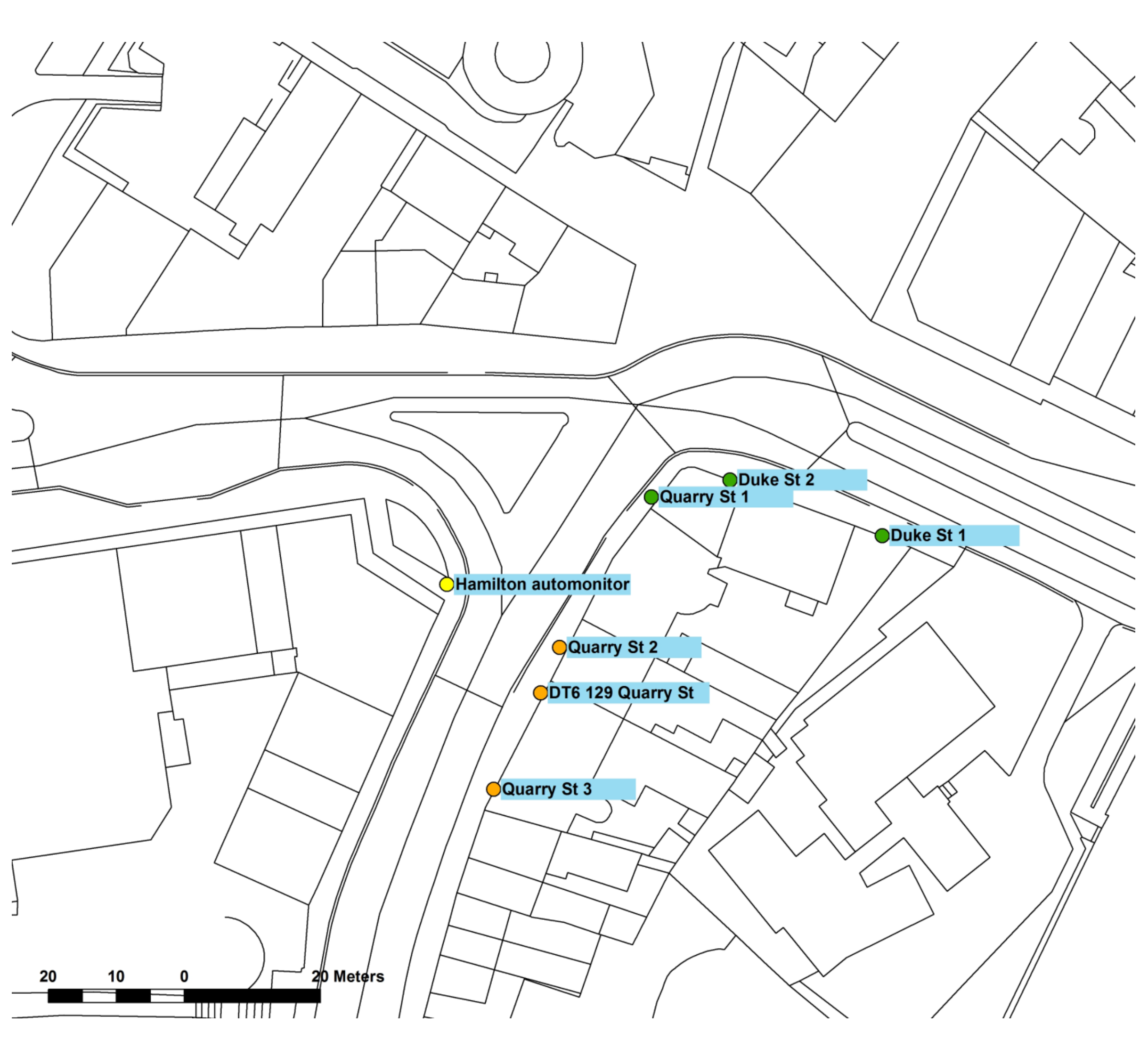
Figure 10: Predicted PM_{10} annual mean at specified receptor locations – Duke St/Quarry St junction



Legend:

PM_{10} annual mean concentration (µg.m^{-3})

- < 15
- 15 - 16
- 16 - 17
- 17 - 17.5

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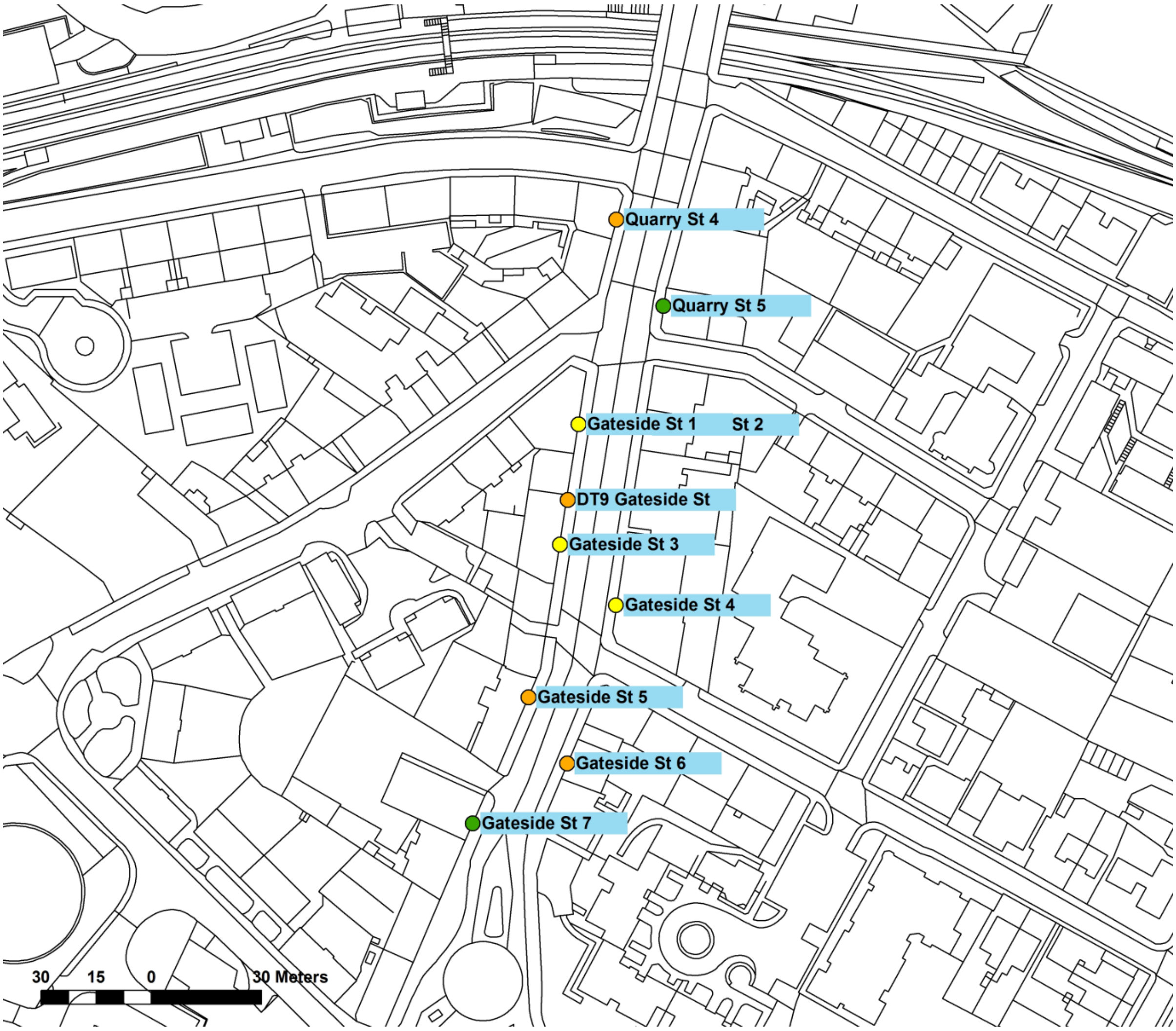
Figure 11: Predicted PM_{10} annual mean at specified receptor locations – Gateside Street



Legend:

PM_{10} annual mean concentration (µg.m^{-3})

- < 15
- 15 - 16
- 16 - 17
- 17 - 17.5

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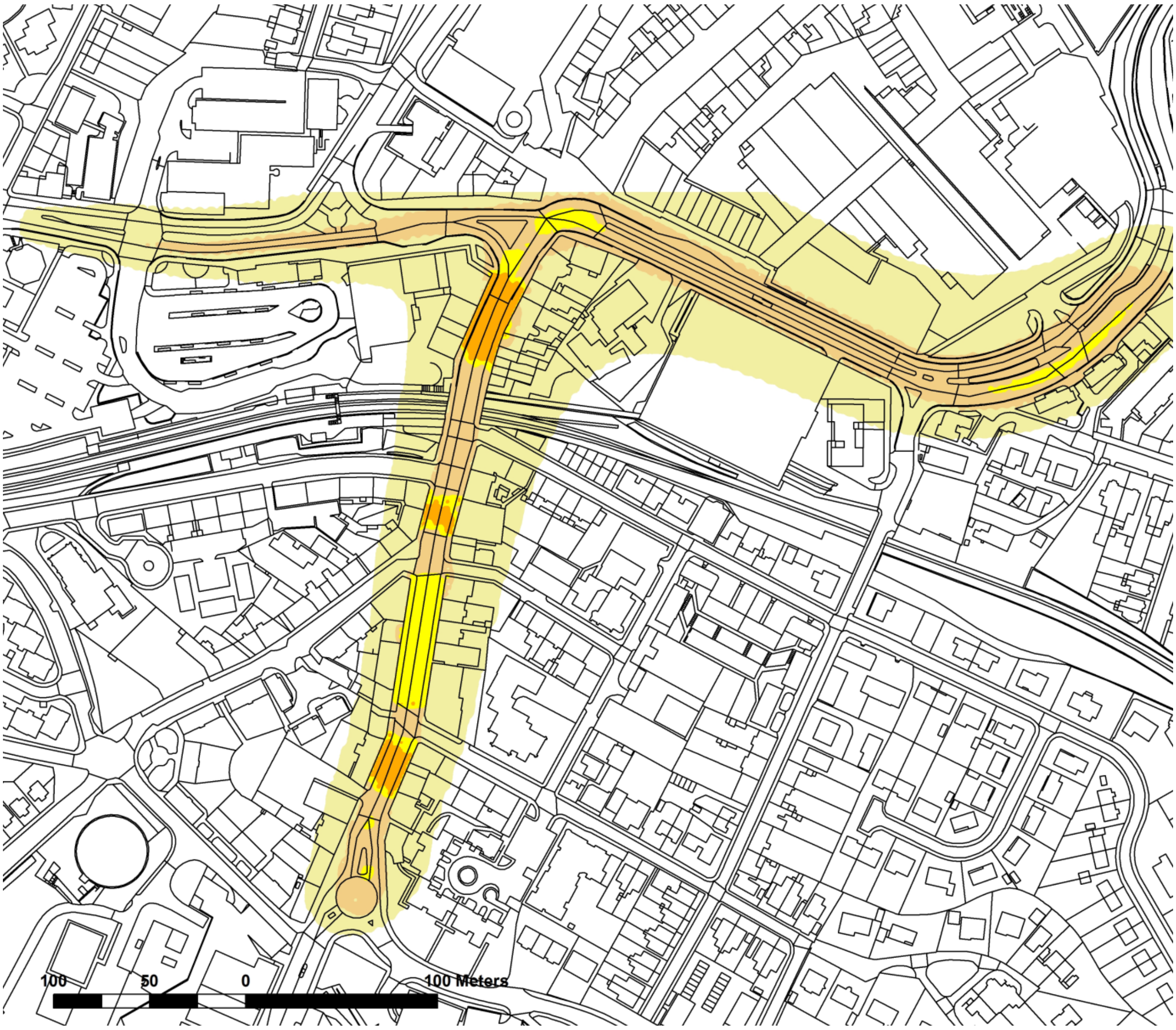
Figure 12: Predicted PM_{10} annual mean concentration contour – first floor height



Legend:

PM_{10} annual mean concentration ($\mu g.m^{-3}$)

- < 14
- 14 - 15
- 15 - 16
- 16 - 17
- 17 - 17.9

6 Conclusion

A dispersion modelling study of road traffic emission in the area around the Duke Street/Quarry Street junction in Hamilton, South Lanarkshire has been conducted to allow a detailed assessment of both NO_2 and PM_{10} concentrations at this location.

The modelling study, which has used the most recent traffic, monitoring and meteorological data for the study area indicates that there are no exceedances of the NO_2 or PM_{10} annual mean objective occurring at locations where there is relevant exposure.

As there was no PM_{10} monitoring data with which to verify and adjust the model predictions there is uncertainty in the predicted PM_{10} concentrations. It is therefore recommended that South Lanarkshire Council consider this again when preparing the 2015 Updating and Screening assessment and a full year of PM_{10} measurements are available from the Hamilton automatic monitoring site.

In light of this Detailed Assessment of Air Quality, South Lanarkshire Council are not required to declare an Air Quality Management Area at this time.

7 Acknowledgements

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Appendices

Appendix 1: Traffic data

Appendix 2: Meteorological data – Windrose

Appendix 3: Model Verification

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 growth adjusted forward to 2012 using the NRTF Central growth forecast for 2011 to 2016

Table A2.1: Annual Average Daily Flows - 2013

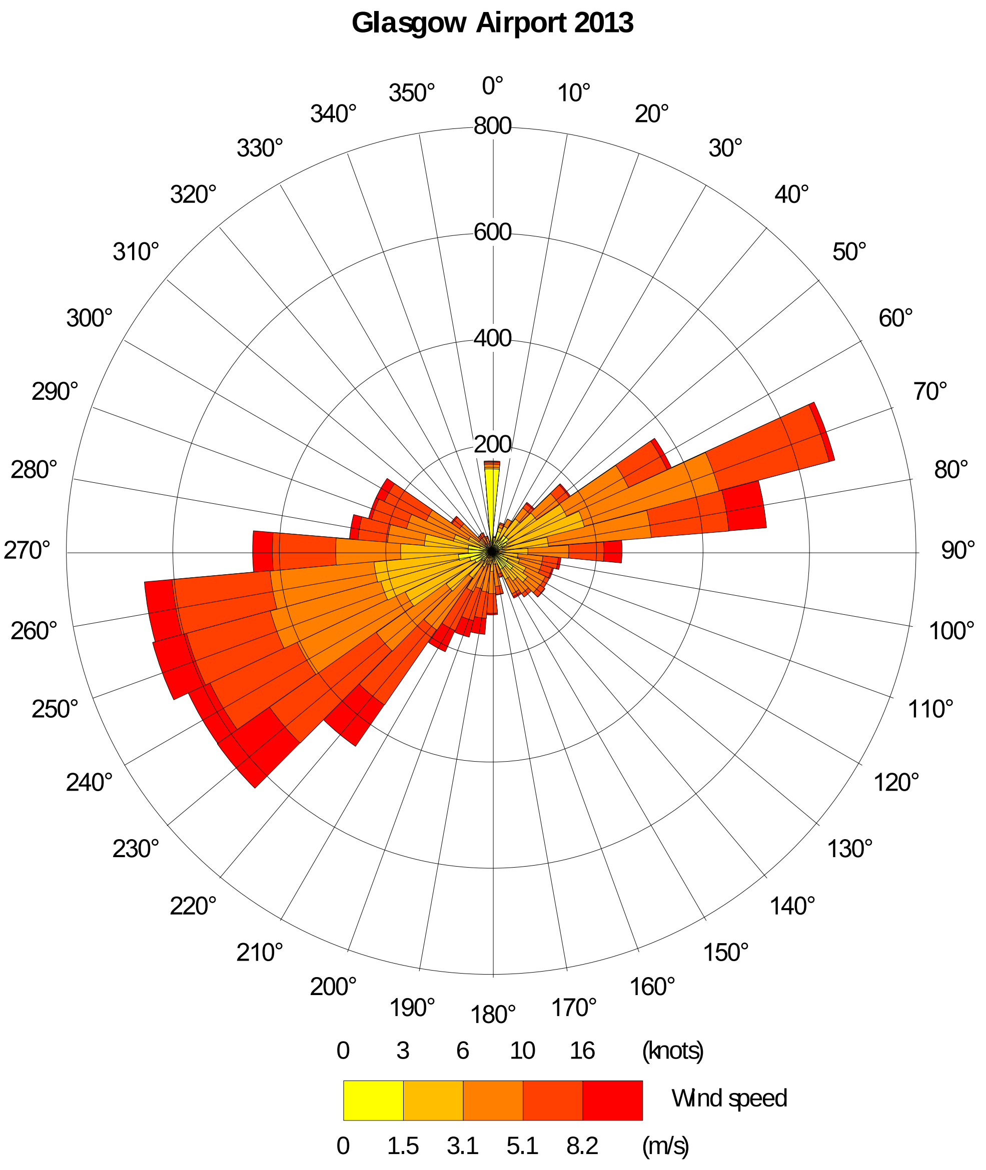
Street	%Cars	%LGV	%HGV	%Bus	%2WM	AADF 2013
Duke Street (eastbound)	86.8	9.0	2.1	1.9	0.3	7884
Duke Street (westbound)	82.6	8.8	2.0	6.3	0.2	13454
Brandon Street	72.1	9.4	2.7	15.7	0.2	9367
Quarry Street	85.2	10.0	2.6	2.1	0.1	20759

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

Appendix 2: Meteorological data – Windrose

The Wind Rose for the 2013 Glasgow Airport meteorological dataset is presented in Figure A2.1

Figure A2.1 Meteorological dataset windrose



Appendix 3: Model Verification

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. This can be followed by adjustment of the modelled results if required. LAQM.TG(09) recommends making the adjustment to the road contribution only and not the background concentration these are combined with.

NO_2

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

It is appropriate to verify the performance of the ADMS Roads model in terms of primary pollutant emissions of nitrogen oxides ($NOx = NO + NO_2$). To verify the model the predicted annual mean Road NOx concentrations were compared with concentrations measured at the monitoring sites during the study period.

The model output of Road NOx (the total NOx originating from road traffic) has been compared with the measured Road NOx, where the measured Road NOx contribution is calculated as the difference between the total NOx and the background NOx value. Total measured NOx for each diffusion tube was calculated from the measured NO_2 concentration using the latest version of the Defra NOx/NO_2 calculator.

The initial comparison of the modelled vs measured Road NOx identified that the model was under-predicting the Road NOx contribution and the relationship between the different measurement was not linear. Refinements were subsequently 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 NOx adjustment factor (PAdj) of **1.4621** based on model verification using the 2013 monitoring results was applied to all modelled Road NOx data prior to calculating an NO_2 annual mean. A plot comparing modelled and monitored NO_2 concentrations before and after adjustment during 2013 is presented in Figure A3.2.

PM_{10}

For PM_{10} there was no monitoring data available for 2013. As the best available alternative, the Road NOx adjustment factor has been applied to the Road PM_{10} contribution to account for underestimation in the road traffic contribution to PM_{10} concentration. Using this approach does however introduce considerable uncertainty into the PM_{10} predicted concentrations.

Figure A3.1 Comparison of modelled Road NO_x Vs Measured Road NO_x before and after adjustment

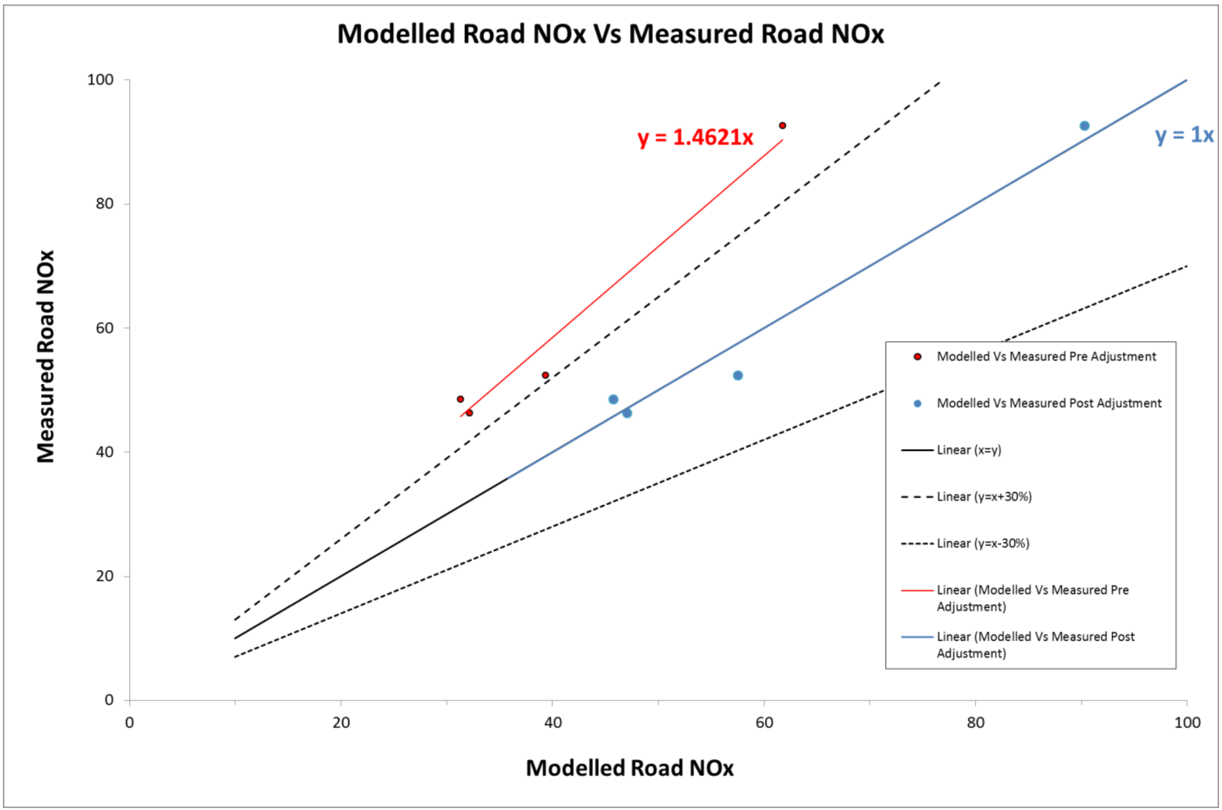
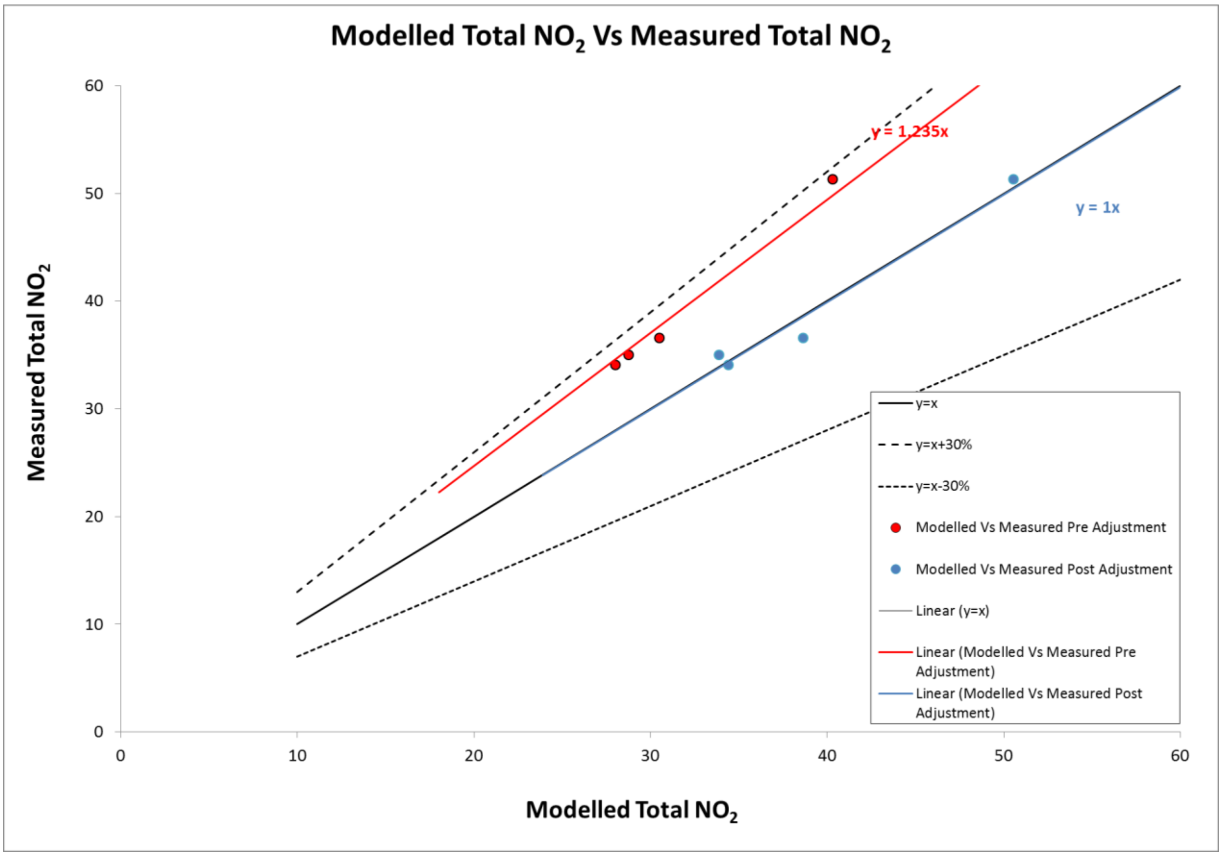


Figure A3.2: Linear regression analysis of modelled vs. monitored NO_2 annual mean 2013



To evaluate the model performance and uncertainty, the Root Mean Square Error (RMSE) for the observed vs predicted NO_2 annual mean concentrations was calculated, as detailed in Technical Guidance LAQM.TG(09), Box A3.7, Appendix 3. The calculated RMSE is presented in Table A3.1.

It is recommended that the RMSE is below 25% of the objective that the model is being compared against, but ideally under 10% of the objective i.e. 4 $\mu g.m^{-3}$ (NO_2 annual mean objective of 40 $\mu g.m^{-3}$). In this case the RMSE is calculated at 1.23 $\mu g.m^{-3}$; the model uncertainty is therefore considered acceptable and the model has performed sufficiently well for use within this assessment.

Table A3.1: Root mean square error

Site	NO_2 annual mean concentration ($\mu g.m^{-3}$)	
	Measured	Modelled
Hamilton automonitor	35.0	33.9
DT6 129 Quarry St	36.6	38.6
DT9 Gateside St	34.1	34.4
DT8 Duke/Low Patrick St	51.3	50.5
	RMSE =	**1.23**

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