Detailed assessment to the revocation of Lanark AQMA, South Lanarkshire

Report for South Lanarkshire Council

Customer:

South Lanarkshire Council

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Contact:

Andy Lewin
Ricardo Energy & Environment
Gemini Building, Harwell, Didcot, OX11 0QR, United Kingdom

t: +44 (0) 1235 75 3189
e: Andrew.Lewin@ricardo.com

Ricardo is certificated to ISO9001, ISO14001 and OHSAS18001

Authors:

Ashleigh Norrie

Approved By:

Andy Lewin

Date:

28 January 2022

Ricardo Energy & Environment reference:

Ref: ED12832128- Issue Number 1

Executive summary

Ricardo Energy & Environment have been commissioned by South Lanarkshire Council to undertake a Detailed Assessment of Air Quality at Lanark, South Lanarkshire.

An Air Quality Management Area (AQMA) encompassing the whole town of Lanark was declared in June 2016 due to likely breaches of the Nitrogen Dioxide (NO_2) hourly mean and annual mean air quality objectives.

Measured NO_2 concentrations have declined over recent years; on this basis, South Lanarkshire Council are currently considering revocation of the Lanark AQMA. This Detailed Assessment aims to provide evidence that will aid the Council in deciding if revocation is appropriate, or if an AQMA is still required in Lanark or may be required in the future.

The assessment includes the following main elements:

- A review of measured NO_2 concentrations within the AQMA over recent years.
- Detailed dispersion modelling of NO_2 concentrations for the most recent year of 2019
- A sensitivity analysis of potential fluctuations in annual mean pollutant concentrations attributable to meteorological conditions.
- Detailed dispersion modelling of NO_2 concentrations in a future year (with estimates of road traffic emissions attributable to future housing allocations in/around the AQMA included).
- A review and detailed dispersion model of $PM_{2.5}$ in 2019 and future years. Although Lanark does not have an AQMA declaration for exceedance of $PM_{2.5}$, the pollutant was included in this assessment to avoid the possibility of re-declaring an AQMA for $PM_{2.5}$ at a future date.

The review of pollutant measurements over the last ten years has concluded:

- An annual mean in excess of the NO_2 40 $\mu g.m^{-3}$ objective was measured once at the Bloomgate diffusion tube in 2013. Since then, measured concentrations have in general declined at all measurement sites. In 2019, all measured concentrations were significantly less than the 40$\mu g.m^{-3}$ objective.
- For $PM_{2.5}$, annual mean concentrations have been consistently below the Scottish objective of 10 $\mu g.m^{-3}$ since monitoring began in 2015.

The dispersion modelling study of current and future road traffic NO_2 and $PM_{2.5}$ emissions indicated that:

- In 2019, the NO_2 and $PM_{2.5}$ annual mean objectives were not exceeded at any locations where relevant human exposure is present within the study area.
- The sensitivity analysis conducted using meteorological dataset from 2009 through to 2019 indicates that is unlikely that exceedances of the NO_2 or $PM_{2.5}$ annual mean objective will occur at these receptor locations due to inter-annual variability in weather conditions.
- In 2025, when likely traffic growth and inter-annual variability in weather conditions are considered, the NO_2 and $PM_{2.5}$ annual mean are not predicted to exceed the Scottish objectives at any locations where relevant human exposure is present within the study area.
- In 2025 with future developments, the NO_2 and $PM_{2.5}$ annual means are not predicted to exceed the Scottish objectives at any locations where relevant human exposure is present within the study area

In light of the conclusions of this Detailed Assessment of Air Quality, South Lanarkshire Council may wish to consider revocation of the Lanark Air Quality Management Area at this time.

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Appendices

1 Introduction

An Air Quality Management Area (AQMA) encompassing the town of Lanark, South Lanarkshire was declared in 2016 due to exceedances of the nitrogen dioxide annual mean air quality objective at locations where there is likely to be relevant human exposure. The boundary of the AQMA included the whole town to ensure a holistic approach to action planning.

Measured NO_2 concentrations have declined over recent years. On this basis, South Lanarkshire Council are currently considering revocation of the Lanark AQMA and have commissioned Ricardo Energy & Environment to undertake a Detailed Assessment of Air Quality.

Although Lanark does not have an AQMA declaration for exceedance of $PM_{2.5}$, the pollutant was included in this assessment to avoid the possibility of re-declaring an AQMA for $PM_{2.5}$ at a future date.

This Detailed Assessment aims to provide evidence that will aid the Council in deciding if revocation is appropriate at this time; or if an AQMA is still required or may be required in the future when any planned nearby housing and/or commercial developments become operational.

The assessment includes:

- A review of recent trends in pollutant measurements (NO_2 and $PM_{2.5}$) in Lanark
- Detailed dispersion modelling of current and future year emissions to establish if NO_2 concentrations are likely to be in excess of the Scottish annual mean objective at locations where relevant human exposure is present. This includes the assessment of emissions associated with traffic generated by planned nearby developments in future years.
- An analysis of potential fluctuations in annual mean pollutant concentrations attributable to meteorological conditions.
- The potential for exceedances of the Scottish annual mean objective for the $PM_{2.5}$ fraction of particulate matter (objective to be achieved by 2020).

Further information on each of these elements of the assessment is provided later in the report.

1.1 Policy background

The Environment Act 1995 placed a responsibility on the 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 several 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's Technical Guidance - LAQM.TG(16)[1]. Table 1 lists the objectives relevant to this assessment that are included in the Air Quality Regulations 2000 and (Amendment) Regulations 2002 for the purposes of Local Air Quality Management (LAQM).

[1] Defra and the devolved administrations (2018) Part IV of the Environment Act 1995 Environment (Northern Ireland) Order 2002 Part III; Local Air Quality Management Technical Guidance (TG16); February 2018

Table 1: Objectives included in the Air Quality Regulations and subsequent Amendments for the purpose if the Local Air Quality Management

Pollutant	Air Quality Objective Concentration	Measured as
Nitrogen dioxide (NO_2)	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
Particulate matter ($PM_{2.5}$)	10 $\mu g.m^{-3}$	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 present and are likely to be exposed over the averaging period of the objective. Table 2 summarises examples of where the air quality objectives for NO_2 and $PM_{2.5}$ should and should not apply.

Table 2: Where Air Quality Objectives should and should not apply

Averaging Period	Objectives should apply at:	Objectives should not generally apply at:
Annual mean	All locations where members of the public might be regularly exposed. Building façades of residential properties, schools, hospitals, care homes etc.	Building façades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term.
24-hour mean	All locations where the annual mean objective would apply, together with hotels. Gardens of residential properties[2]	Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term
1-hour mean	All locations where the annual mean and 24-hour mean objectives apply. Kerbside sites (for example, pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where members of the public might reasonably be expected to spend one hour or more. Any outdoor locations where members of the public might reasonably be expected to spend one hour or longer	Kerbside sites where the public would not be expected to have regular access

[2] Such locations should represent parts of the garden where relevant public exposure is likely, for example where there are seating or play areas.

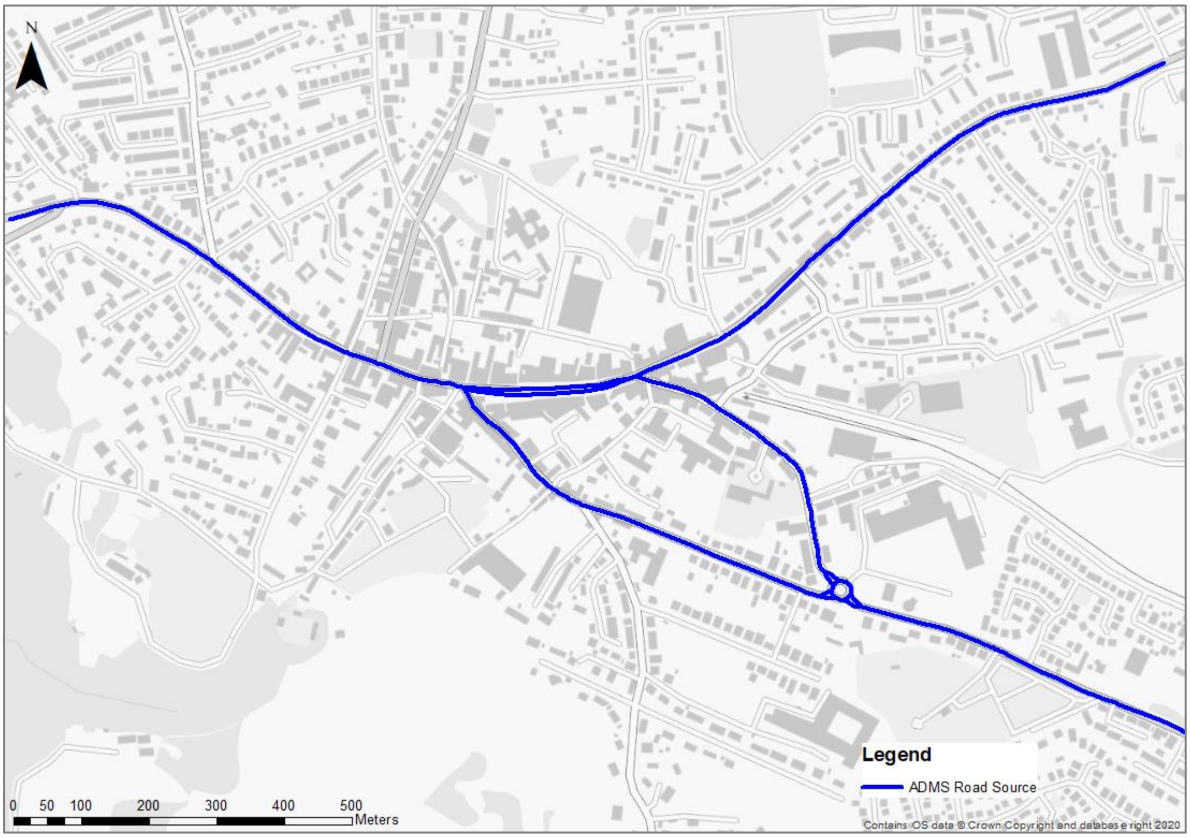
2 Detailed Assessment Study Area

Lanark is a small town located in central South Lanarkshire with a population of approximately 9,500.

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, all within the Lanark AQMA. The assessment considers road traffic emissions from the main roads in the study area and include the effects of the narrow, relatively high sided streets, which are modelled as street canyons where they are present.

Lanark town centre comprises a mix of both commercial and residential properties with many locations where residential properties are present at first floor height above shops. The study area, including the roads modelled is presented in Figure 1 below. The size of the study area is approximately 1.8 km by 1.0 km.

Figure 1: Detailed Assessment Study Area

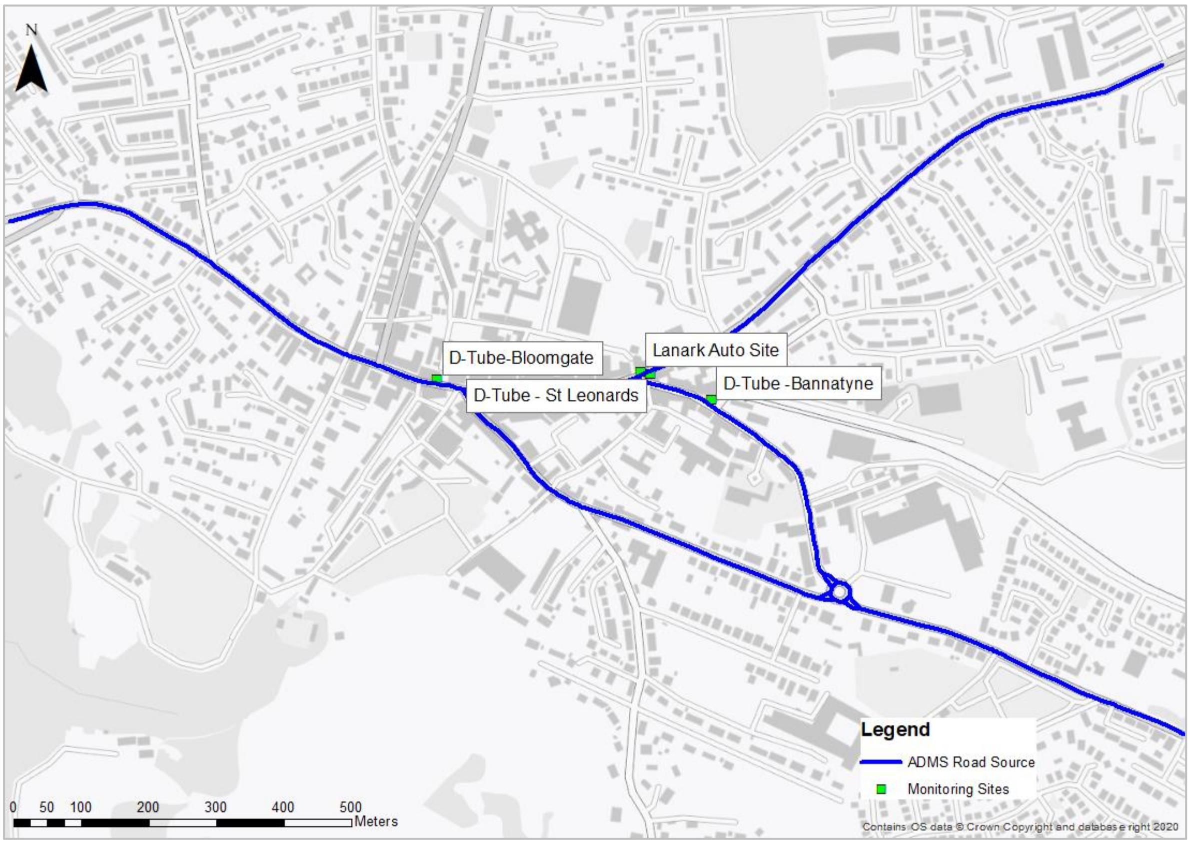


3 Pollutant monitoring data in recent years

South Lanarkshire Council currently measure NO_2, PM_{10} and $PM_{2.5}$ concentrations within the Lanark AQMA at one continuous analyser and four NO_2 diffusion tube sites. A map showing the site locations is presented in **Error! Reference source not found.** (note that one diffusion tube, Friar's Lane, has been excluded from this assessment as it is a background diffusion tube). Further details regarding annual data capture and QA/QC information are available in the various South Lanarkshire Council LAQM Annual Progress Reports published in recent years[3].

The LAQM guidance recommends; when considering revocation of an AQMA; authorities should examine measurements carried out over several years or more. The minimum requirement as evidence of continued compliance would normally be three consecutive years where measured concentrations are below the objectives of concern.

Figure 2: NO_2 and $PM_{2.5}$ measurement site locations – Lanark



3.1 NO_2 measurements

Measured annual mean NO_2 concentrations from 2009 to 2019 are presented in Table 3. An annual mean in excess of the 40 µg.m^{-3} objective was measured once at the Bloomgate diffusion tube in 2013. Since then, measured concentrations have in general declined at all measurement sites. In 2019 all measured concentrations were significantly less than the 40µg.m^{-3} objective.

[3]Available at http://www.scottishairquality.scot/news/reports?view=laqm

Table 3: NO_2 annual mean measurements 2009 to 2019

Site ID	Site Name	Site Type	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
SL03	Lanark	K	17	30	29	25	22	21	24	20	19	19
DT6	Bloomgate	R	-	-	34	**40.3**	34.1	38.2	36	36.1	37.3	31.2
DT4	St Leonards	K	-	-	-	-	-	34	34	29.7	30.3	27.8
DT40	Bannatyne	R	-	-	-	-	-	-	-	27.7	24.4	20.3
DT5	Friars Lane	UB	-	-	-	-	-	6.6	12	7.2	6.6	6.1

K = kerbside; R = roadside; UB = urban background

3.2 $PM_{2.5}$ measurements

South Lanarkshire Council began monitoring $PM_{2.5}$ at the Lanark automatic analyser in 2015. Annual mean concentrations have been consistently below the Scottish objective of 10 µg.m^{-3} since monitoring began. The measurement data is presented in Table 4.

Table 4: $PM_{2.5}$ annual mean measurements 2015 to 2019

Site ID	Site Name	Site Type	2015	2016	2017	2018	2019
SL03	Lanark	Kerbside	6	6	6	6	6

4 Dispersion modelling assessment

In addition to the review of pollutant measurement data over recent years. The Detailed Assessment includes a dispersion modelling assessment of road traffic emissions in Lanark. This aims to establish if NO_2 and $PM_{2.5}$ concentrations are likely to be in excess of the air quality objectives at locations where pollutant measurements are not being conducted but relevant human exposure is present.

This includes the assessment of emissions associated with traffic generated by any planned developments in future years; and an analysis of potential fluctuations and extremes in annual mean pollutant concentrations based on historical variability in meteorological conditions. The aim being to identify if there is a risk of the air quality objectives being exceeded again in Lanark in future years.

4.1 Modelling method and supporting data

Annual mean pollutant concentrations have been modelled within the study area using the atmospheric dispersion model ADMS Roads (version 5). The model domain covers the study area described in section 2 above. The modelling methodologies provided for Detailed Assessments outlined in Defra Technical Guidance LAQM.TG(16) were used throughout this study.

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.

4.1.1 Background concentrations

Background pollutant concentrations for a modelling study within an urban environment in Scotland can be sourced from either a local urban background monitoring location, or the background maps provided by the Scottish Government[4]. The background maps provide estimates of annual mean background concentrations of key pollutants at a resolution of 1 x 1km for Scotland projected from a base year of 2015 and can be projected forward to future years up to 2030. UK wide $PM_{2.5}$ background maps are available from the Defra LAQM support website.

In this case as there are no local background measurement sites in Lanark, the background maps were considered most appropriate to use. For the baseline year of 2019 and the future year assessed 2025, the Scottish (NOx) and UK ($PM_{2.5}$) background maps were used to provide estimated background annual mean concentrations of each pollutant for the 1km grid squares covering the study area. The sector contributions from road traffic emissions on A Class Roads were subtracted from the total background concentrations to avoid double counting of Road NO_x and PM from the road sources being explicitly modelled. The brake & tyre wear and road abrasion contributions were also discounted from the $PM_{2.5}$ maps as these particulate emissions are calculated along with tailpipe emissions when using the emission factor toolkit (EFT) to calculate vehicle emission rates.

Table 5: Mapped 2019 background $PM_{2.5}$ and NO_x concentrations ($\mu g.m^{-3}$)

Grid Square	NO_x	$PM_{2.5}$
288500, 643500	6.93	5.4

Table 6: Mapped 2025 background $PM_{2.5}$ and NO_x concentrations ($\mu g.m^{-3}$)

Grid Square	NO_x	$PM_{2.5}$
288500, 643500	5.56	4.97

[4] Background maps available at: http://www.scottishairquality.co.uk/data/mapping?view=data

4.1.2 Meteorological observations and model parameters

Hourly sequential meteorological data (wind speed, direction etc.) for 2019 from the Glasgow Airport site was used for the baseline modelling assessment. The meteorological measurement site is located approximately 56 km to the northwest of the study area and has excellent data quality for the period of interest. Meteorological measurements are subject to their own uncertainty which will unavoidably carry forward into this assessment.

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

4.1.3 Mapping

Ordnance survey Master Map datasets were used in the assessment. This enabled accurate road widths and the distance of the housing to the kerb to be determined using a GIS.

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4.1.4 Treatment of modelled NO_x road contribution

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

The Defra NO_x/NO_2 calculator[5] was used to calculate NO_2 for comparison from the NO_x concentrations predicted by ADMS-Roads. The model requires input of the background NO_x, the modelled road contribution and accounts for the proportion of NO_x released as primary NO_2. For Lanark, South Lanarkshire area in 2019 with the "All other UK urban traffic" option in the model, the NO_x/NO_2 model estimates that 29% of NO_x from local road vehicles is released as primary NO_2.

4.1.5 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.

Cambridge Environmental Research Consultants (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 comparison studies on behalf of local authorities and Defra.

4.2 Road traffic data

4.2.1 Average flow, speed and fleet split

Average daily traffic flow and vehicle type fleet split data were collated from the following sources:

- Seven-day automatic traffic count survey – commissioned by South Lanarkshire Council - Tracsis September 2019 automatic traffic count data

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

- The freely available Department for Transport Traffic 2019 count data[6]

Appendix 1 summarises the traffic flow and fleet split data used for the road links modelled.

Typical journey time estimates (between the start and end nodes of ADMS road links) accessed using the Google Distance Matrix API were used to calculate indicative observed average vehicle speeds.

It should be noted that traffic patterns can be 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.

4.2.1.1 Congestion

Traffic can be slow moving in Lanark town centre. 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. The LAMQ.TG(16) guidance states that the preferred approach to representing the increase in vehicle emissions during peak periods is to calculate the emission rate for the affected roads for each hour of the day or week, using average speeds and traffic flow observations for each hour of the day. The hourly specific emission rates can then be used to calculate a 24-hour diurnal emission profile which can be applied to that section of road.

In this case there was insufficient hourly resolution average speed data to calculate a 24-hour diurnal emission profile; we were however able to calculate an average diurnal traffic flow profile. To account for speed reductions during peak traffic periods, assumed average daily speeds were reduced at road sections where slow moving traffic is known to occur regularly.

4.2.2 Vehicle emission factors

The current (2020) version of the Emissions Factor Toolkit[7] (EFT V10.1) was used in this assessment to calculate pollutant emission factors for each road link modelled. The calculated emission factors were then imported into 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 pollutants/kilometre/second is generated for input into the dispersion model. The latest version of the EFT, NO_x and PM are taken from the European Monitoring and Evaluation Programme Environment Agency (EEA) Air Pollutant Emission Inventory Guidebook 2019, which is consistent with the EMISIA COPERT 5.3 emission calculation tool, released September 2019. These emission factors are widely used for the purpose of calculating emissions from road traffic in Europe. Defra recognises these as the current official emission factors for road traffic sources when conducting local, regional and national scale dispersion modelling assessments.

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. Much of the supporting data in the EFT is provided by the Department of Transport (DfT), Highways Agency and Transport Scotland.

Vehicle emission projections are based largely on the assumption that emissions from the fleet will fall as newer vehicles are introduced at a renewal rate forecast by the DfT. Any inaccuracy in the projections

[6] www.roadtraffic.dft.gov.uk
[7] https://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

or the COPERT 5 emissions factors contained in the EFT will unavoidably be carried forward into this modelling assessment.

4.3 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 model results if required to gain good agreement. LAQM.TG(16) 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 Box 7.15 of LAQM.TG(16) has been used in this case.

Modelled road NO_x concentrations were verified using 2019 measurements at the automatic analyser and two available roadside diffusion tube measurements. The 'St Leonards' diffusion tube was excluded from verification as it is a kerbside site. Model agreement was reasonable at all other measurement sites, a Road NO_x adjustment factor of **1.0532** was derived.

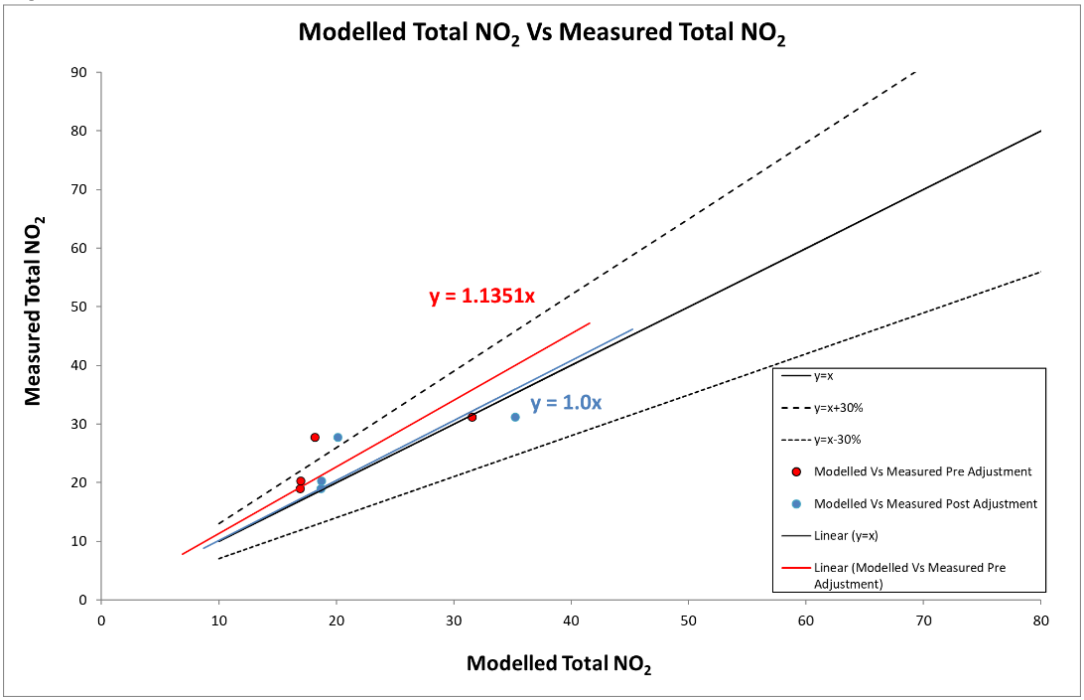
Model uncertainty was evaluated by calculating the root mean square error (RMSE) of the modelled vs measured annual mean NO_2 concentrations. The LAQM.TG(16) guidance suggests that an RMSE value of less than 10% of the objective being assessed indicates acceptable model performance. The RMSE for NO_2 was 2.17 $\mu g.m^{-3}$, the model has therefore performed sufficiently well for this type of assessment.

The adjustment factor was applied to all modelled road NO_x concentrations, and total NO_2 concentrations were then calculated using the Defra NO_x/NO_2 calculator. After the NO_x/NO_2 model was run no further adjustments were made to the data. Model agreement for modelled vs measured NO_2 monitoring data after adjustment is presented in Figure 3. Further information regarding model verification is presented in Appendix 3.

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

For $PM_{2.5}$ the model was over-predicting concentrations at the automatic analyser whereby the ratio of measured to modelled Road $PM_{2.5}$ was 0.74. This could be attributable to uncertainty with either the $PM_{2.5}$ measurements, background map estimates or road traffic emissions. No adjustment was applied to modelled Road $PM_{2.5}$ and background concentrations were added to calculate annual mean results. The $PM_{2.5}$ results may therefore represent an overestimation and should be considered in this context.

Figure 3: Modelled vs. measured annual mean NO_2 concentrations 2019



4.4 Model results

This section of the report presents results for the following aspects of the Detailed Assessment:

- Assessment of the most recent year with available measurements (2019).
- A sensitivity analysis of inter-annual variability in predicted annual mean pollutant concentrations attributable to meteorological conditions at a selection of receptors.
- Future year (2025) assessment of emissions associated with traffic that may be generated by planned nearby developments in addition to baseline traffic growth.

The AQMA in Lanark was declared for exceedances of the NO_2 annual mean objective. The local measurement data described in Section 3.1 and Section 3.2 provide reasonably good evidence that there is little risk of the NO_2 and $PM_{2.5}$ objectives being exceeded in Lanark.

Modelled annual mean pollutant concentrations have been presented using two methods.

- Contour plots showing the spatial variation of predicted concentrations across the study area. Concentrations are predicted across a grid of points covering the entire study area at a resolution of approximately 1.5m and then interpolated to produce the pollutant contours.

Sensitive receptors placed at locations where the pollutant hotspots are identified from the contour plots. This aims to represent worst-case locations at the façade of buildings where relevant human exposure is likely to be present close to the road sources being modelled. The receptors (Figure 4, Figure 5 and

- Figure 6) have been modelled at both ground level (1.5m) and first floor level exposure (4m).

Figure 4: ADMS receptor locations, west of town centre

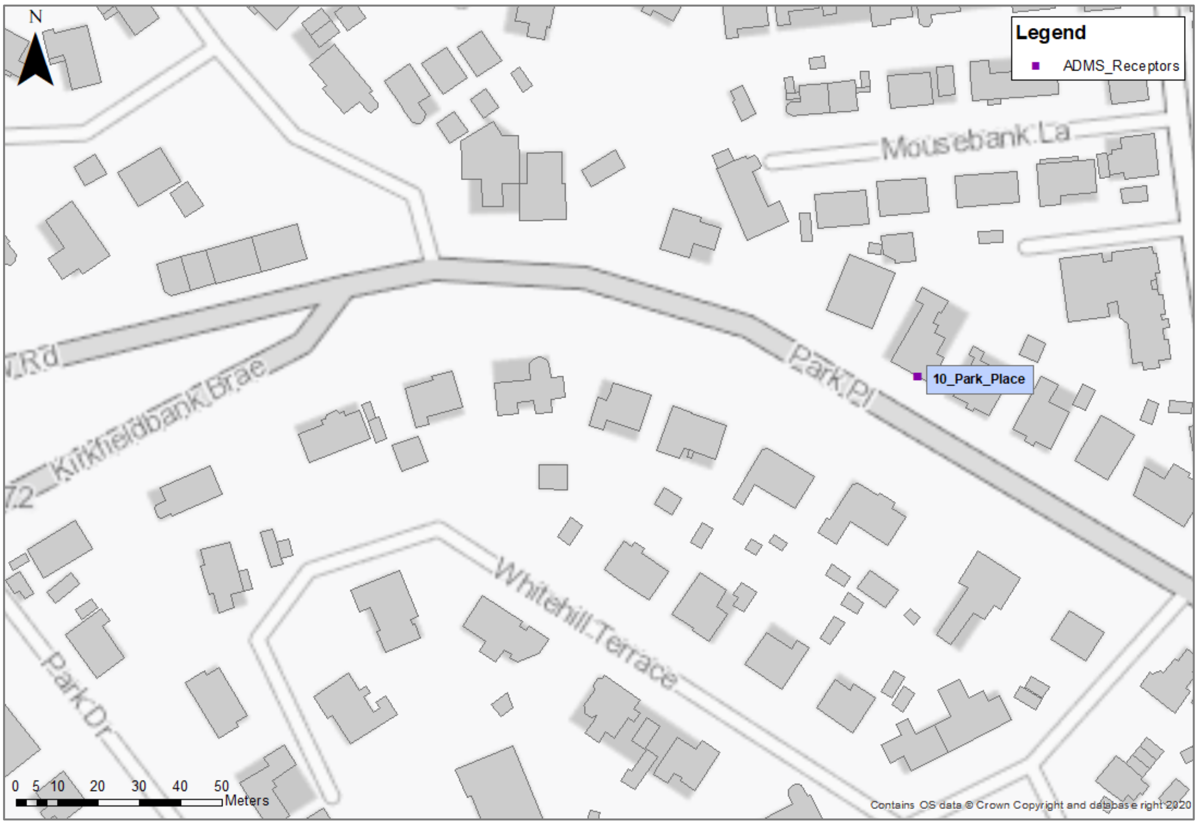


Figure 5: ADMS sensitive receptor locations, central town centre

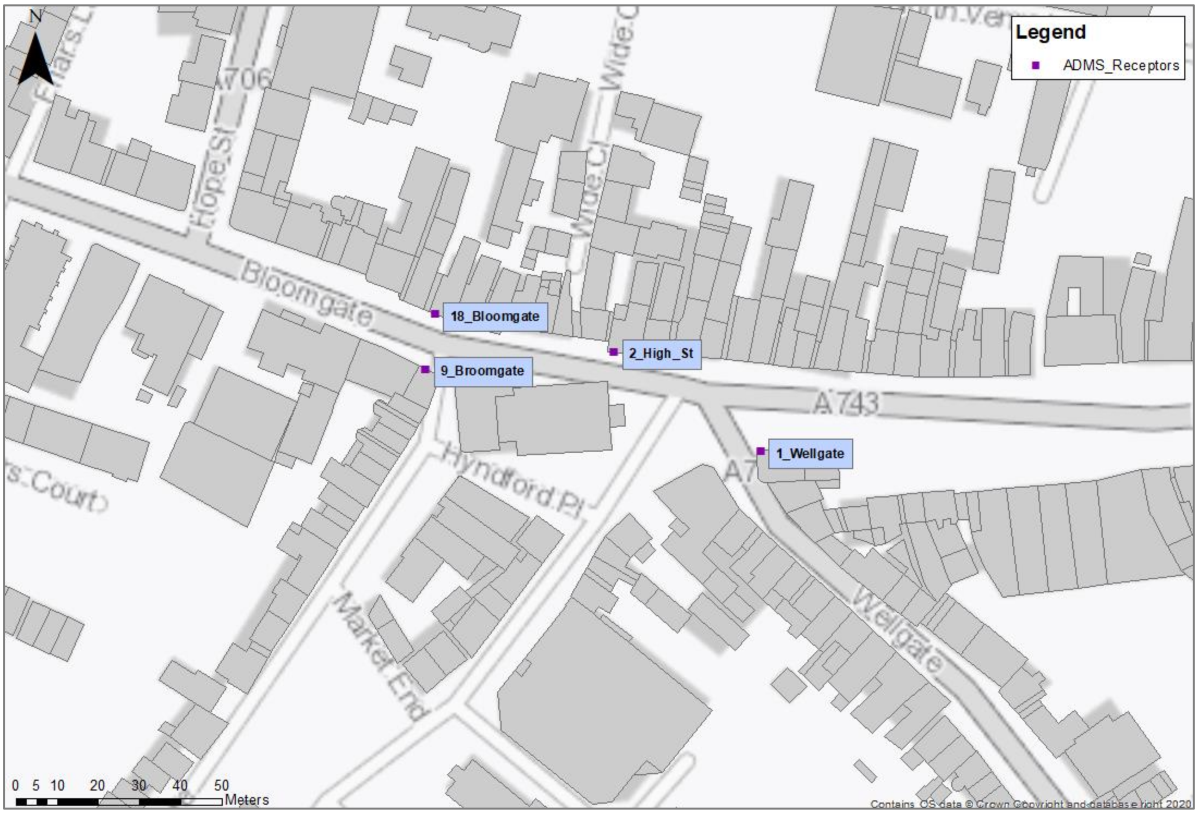
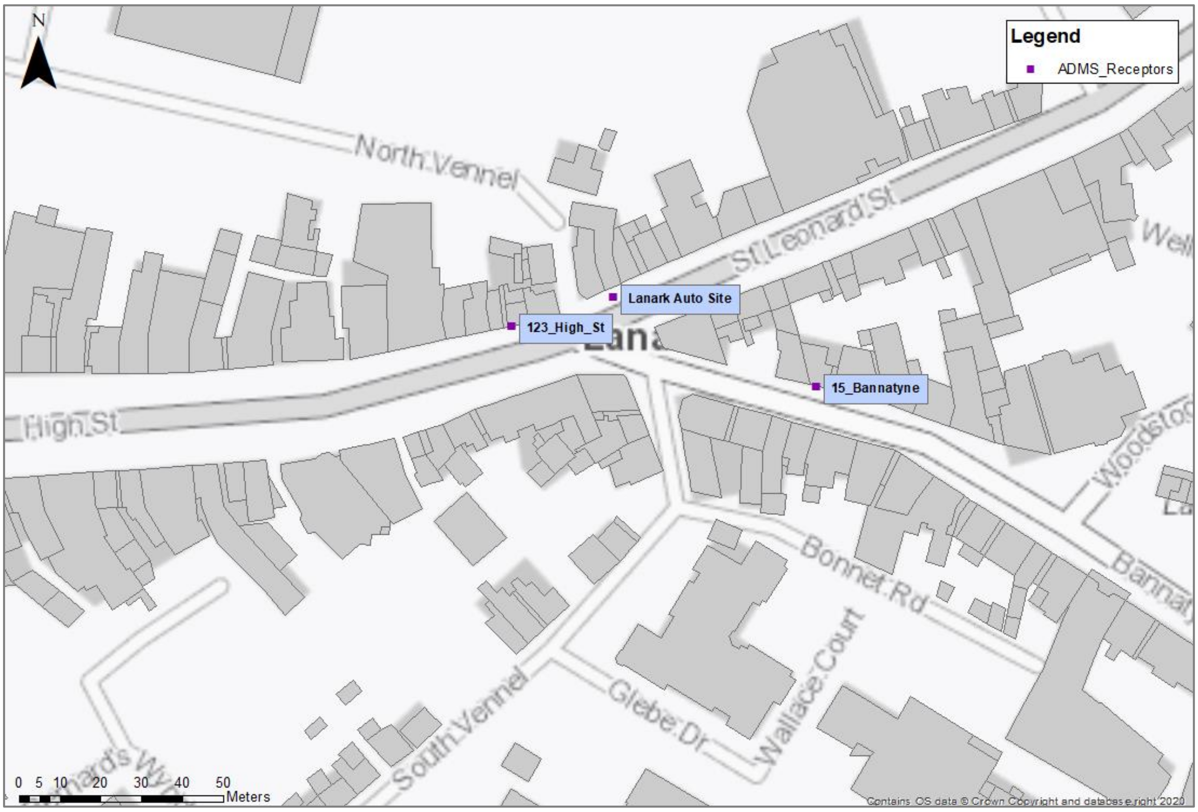


Figure 6: ADMS sensitive receptor locations, east of town centre



4.4.1 Assessment of the most recent year with available measurements (2019)

4.4.1.1 NO_2 results - 2019

Contour plots showing the spatial variation of the predicted 2019 annual mean NO_2 concentrations across the study area at ground floor level (1.5m) are presented in Figure 7 and Figure 8; and at first floor level (4m) in

Figure 9.

Modelled NO_2 annual mean concentrations at receptor locations are presented in Table 7.

The contours and numerical results indicate that the Scottish 40 µg.m^{-3} annual mean NO_2 objective was not being exceeded at any locations within Lanark during 2019.

Table 7: Predicted annual mean NO_2 concentrations at ADMS sensitive receptors 2019

Receptor	Easting	Northing	Height (m)	NO_2 annual mean (µg.m^{-3})
10_Park_Place	287707	643920	1	14.2
2_High_St	288138	643681	4	36
1_Wellgate	288173	643657	4	12.9
18_Bloomgate	288094	643691	4	31.6
15_Bannatyne	288473	643676	4	25.4
123_High_St	288398	643691	4	16.5
9_Broomgate	288092	643677	4	7.1

Figure 7: Modelled 2019 NO_2 annual mean concentrations at ground floor level (µg.m^{-3})

Figure 8: Close up of modelled 2019 NO_2 annual mean concentrations at ground floor level (µg.m^{-3})

Figure 9: Modelled 2019 NO_2 annual mean concentrations at first floor level ($\mu g.m^{-3}$)

4.4.1.2 $PM_{2.5}$ results - 2019

Contour plots showing the spatial variation of the predicted 2019 annual mean $PM_{2.5}$ concentrations across the study area at ground floor level (1.5m) are presented in Figure 10 and Figure 11; and at first floor level (4m) in Figure 12.

Modelled $PM_{2.5}$ annual mean concentrations at receptor locations are presented in **Error! Reference source not found.**.

The contours and numerical results indicate that the Scottish 10 $\mu g.m^{-3}$ annual mean $PM_{2.5}$ objective was not being exceeded at any of these receptor locations within Lanark during 2019.

Table 8: Predicted annual mean $PM_{2.5}$ concentrations at ADMS sensitive receptors 2019

Receptor	Easting	Northing	Height (m)	$PM_{2.5}$ annual mean ($\mu g.m^{-3}$)
10_Park_Place	287707	643920	1	6.2
2_High_St	288138	643681	4	7.7
1_Wellgate	288173	643657	4	6
18_Bloomgate	288094	643691	4	7.5
15_Bannatyne	288473	643676	4	6.9
123_High_St	288398	643691	4	6.3
9_Broomgate	288092	643677	4	5.6

Figure 10: Modelled 2019 $PM_{2.5}$ annual mean concentrations at ground floor level ($\mu g.m^{-3}$)

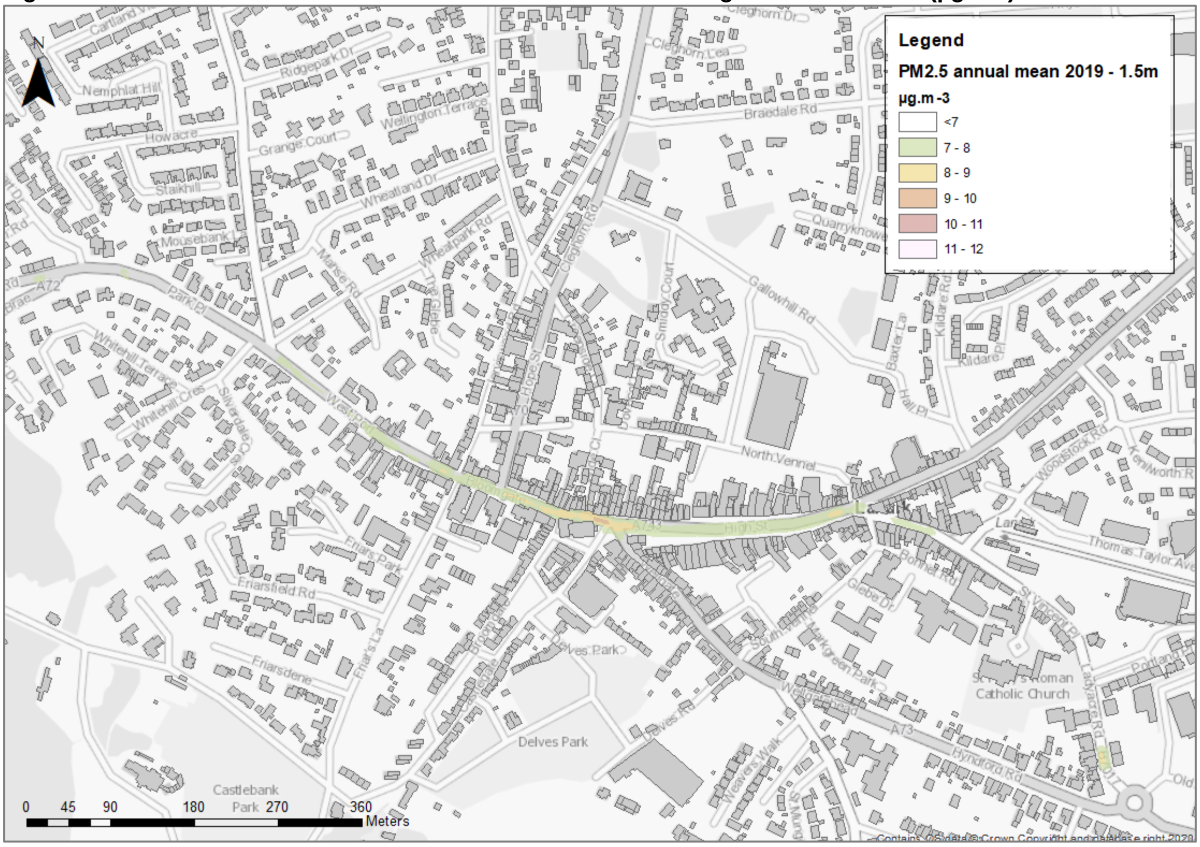


Figure 11: Close up of modelled 2019 $PM_{2.5}$ annual mean concentrations at ground floor level ($\mu g.m^{-3}$)

Figure 12: Modelled 2019 $PM_{2.5}$ annual mean concentrations at first floor level ($\mu g.m^{-3}$)

4.4.2 Meteorological Sensitivity Analysis

The TG(16) guidance acknowledges that pollutant concentrations may vary significantly from one year to the next, due to the influence of meteorological conditions. The guidance goes on to state that it is important that authorities avoid cycling between declaring, revoking and declaring again, due simply to these variations. Before revoking an AQMA based on measured pollutant concentrations, the authority needs to be reasonably certain that any future exceedances (that might occur in more adverse meteorological conditions) are unlikely.

To assess the risk of variable weather conditions potentially leading to exceedances of the air quality objectives in future years, a sensitivity analysis of meteorological conditions measured at Glasgow Airport from 2009 to 2019 has been included in the dispersion modelling assessment. 2019 baseline traffic activity data was used to calculate emissions. The sensitivity analysis was used to determine the annual dataset that produced the maximum ambient pollutant concentrations, and to quantify the inter-year variability in predicted concentrations attributable to differences in the various annual meteorological datasets.

The results have been presented in accordance with the guidelines for presenting the variability of dispersion modelling results published by the UK Atmospheric Dispersion Modelling Liaison Committee[8] as mean of all met years modelled ± twice the standard deviation. This represents a variability range within which 97.5% of the values are expected to be found over the likely range of annual weather conditions that could occur.

[8] ADMLC (2004) Guidelines for the Preparation of Dispersion Modelling Assessments for Compliance with Regulatory Requirements – an Update to the 1995 Royal Meteorological Society Guidance

The results of the sensitivity test for NO_2 and $PM_{2.5}$ are presented in Table 9 and Table 10 respectively. More detailed tables containing model results at receptors for all years modelled are presented in Appendix 4.

The sensitivity analysis conducted using meteorological dataset from 2009 through to 2019 indicates that is unlikely that exceedances of the NO_2 or $PM_{2.5}$ annual mean objective will occur at these receptor locations due to inter-annual variability in weather conditions.

Table 9: Meteorological sensitivity analysis for receptors (2009 to 2019) – NO_2 annual mean ($\mu g.m^{-3}$)

Receptor	Minimum	Maximum	Mean	Standard Deviation x 2	Mean + Standard Deviation x 2
Lanark Automatic Site	15.8	18.8	17.5	1.9	19.4
10_Park_Place	12.9	15.8	14.0	1.7	15.8
2_High_St	31.4	38.7	35.0	4.2	39.2
1_Wellgate	12.2	13.7	12.9	1.0	13.8
18_Bloomgate	28.2	35.0	31.1	4.0	35.1
15_Bannatyne	22.8	27.8	25.0	3.0	28.0
123_High_St	15.2	18.1	16.7	1.7	18.3
9_Broomgate	6.8	7.5	7.1	0.4	7.5

Table 10: Meteorological sensitivity analysis for receptors (2009 to 2019) – $PM_{2.5}$ annual mean ($\mu g.m^{-3}$)

Receptor	Minimum	Maximum	Mean	Standard Deviation x 2	Mean + Standard Deviation x 2
Lanark Automatic Site	6.1	6.3	6.2	0.1	6.3
10_Park_Place	6.1	6.4	6.2	0.2	6.4
2_High_St	7.3	7.9	7.6	0.3	7.9
1_Wellgate	5.9	6.1	6.0	0.1	6.1
18_Bloomgate	7.2	7.8	7.5	0.4	7.8
15_Bannatyne	6.7	7.1	6.9	0.2	7.1
123_High_St	6.2	6.4	6.3	0.1	6.4
9_Broomgate	5.5	5.6	5.6	0.0	5.6

4.4.3 Future Year Development Scenarios

An important consideration when investigating revocation of an AQMA is to consider future housing allocations in the AQMA and the surrounding local area. The aim being to assess if there is a risk of the AQMA being required again in future years when the proposed development sites become operational.

South Lanarkshire Council Roads and Transports services identified three small residential developments that are due to be developed, or are currently in development, within or near to Lanark AQMA, detailed in Table 11. Trip generation figures were provided for Bellefield Road development only.

To represent a worst-case projected trip generation, the two smaller developments (Cleghorn and Gallowhill) were included in the future scenario assessment. Although no projected trip generation factors were provided for these dwellings, based on the known 90 dwellings creating 65 vehicle trips during peak hours in Bellefield Road, we have assumed that one dwelling would generate **0.72** vehicle trips for all developments.

Table 11: Lanark future local developments

Development	Dwellings	Peak hour trip generation within Lanark (outbound + inbound)
Bellefield Road	90	65
Cleghorn Lea	13	9 *
Gallowhill	26	19 *

*Based on the assumption of Bellefield Road trip generation of one dwelling = 0.72 trips

Additionally, South Lanarkshire Council's National Low Emission Framework (NLEF[9]) Stage 1 Screening Appraisal was submitted in June 2020 and documents that:

- there are no major planned developments which could impact air quality within or surrounding the AQMA; and
- By considering the trends in vehicle movements over the past 10 years and the likely impact of nearby development; the traffic flows in and around the Lanark AQMA are likely to remain stable i.e., they are likely to increase in line with national growth projections only.

An overview of the NLEF Stage 1 Screening Appraisal for South Lanarkshire Council is available in South Lanarkshire Council 2020 Annual Progress Report[10]. A more detailed report has been submitted separately[11].

Future year (2025) baseline traffic flows were calculated created by applying a National Road Traffic Forecast (NRTF) 1997 for Central annual growth factor of 1.0153 applied to the 2019 AADT value. Future development AADT was calculated by applying an AADT to peak ratio factor of 6.26 to the known peak hour vehicle trips, creating an overall additional 584 vehicles. To assess a worst-case scenario we modelled the additional 584 vehicles on all road links; in reality these vehicle trips will be distributed in lower numbers around the road network.

Modelled NO_2 annual mean results for the 2025 future baseline and hypothetical with development scenario are presented in Table 12.

Table 12. Future year baseline and development scenarios – NO_2 annual mean ($\mu g.m^{-3}$)

Receptor	2019 baseline	2025 baseline	2025 with development
Lanark Auto Site	17.5	12.2	13.0
Diffusion Tube - Bannatyne	17.5	11.5	12.0
Diffusion Tube - Bloomgate	32.8	11.4	12.1
Diffusion Tube - St Leonards	18.8	20.4	20.9
10_Park_Place	14.2	9.4	9.5
2_High_St	36.0	21.9	22.6
1_Wellgate	12.9	8.4	8.7
18_Bloomgate	31.6	20.0	20.5
15_Bannatyne	25.4	16.2	16.9
123_High_St	16.5	11.4	11.9
9_Broomgate	7.1	5.2	5.3

[9] https://www.gov.scot/publications/national-low-emission-framework/pages/2/

[10] http://www.scottishairquality.scot/assets/documents//AQ_South_Lanarkshire_APR_2020_Issue_1.pdf

[11] Ricardo Energy & Environment, "Scottish National Low Emission Framework (NLEF) Screening Determination", Report for South Lanarkshire Council, Issue 1, June 2020

When considered in context with the 2 x standard deviation value from the meteorological sensitivity analysis for receptors (Table 9) the 2025 baseline and 2025 with development annual mean values indicate that the Scottish 40 µg.m^{-3} annual mean NO_2 objective is very unlikely to be exceeded at any of these receptor locations within Lanark in future years due to inter-year variability in weather conditions.

Modelled $PM_{2.5}$ annual mean results for the 2025 future baseline and future 'with development' scenario are presented in Table 13.

Table 13. Future year baseline and development scenarios – $PM_{2.5}$ annual mean (µg.m^{-3})

Receptor	2019 baseline	2025 baseline	2025 with development
Lanark Auto Site	6.2	5.7	5.8
Diffusion Tube - Bannatyne	6.4	5.9	6.0
Diffusion Tube - Bloomgate	7.5	6.9	7.0
Diffusion Tube - St Leonards	6.3	5.8	5.9
10_Park_Place	6.2	5.7	5.8
2_High_St	7.7	7.1	7.1
1_Wellgate	6.0	5.5	5.6
18_Bloomgate	7.5	6.9	7.0
15_Bannatyne	6.9	6.4	6.5
123_High_St	6.3	5.8	5.9
9_Broomgate	5.6	5.1	5.1

The meteorological sensitivity analysis (Table 10) and numerical results indicate that the 10 µg.m^{-3} Scottish $PM_{2.5}$ annual mean objective is very unlikely to be exceeded at any of these receptor locations within Lanark in future years.

5 Conclusion

This report describes a Detailed Assessment of air quality in Lanark, South Lanarkshire. The assessment is primarily concerned with NO_2 and $PM_{2.5}$ concentrations within the Lanark air quality management area (AQMA).

The Detailed Assessment aims to provide evidence that will aid the Council in deciding if revocation of the AQMA is appropriate at this time, or if the AQMA is still required, or may be required in the future when planned nearby developments become operational.

The review of pollutant measurements over the last ten years has concluded:

- An annual mean in excess of the NO_2 40 µg.m^{-3} objective was measured once at the Bloomgate diffusion tube in 2013. Since then, measured concentrations have in general declined at all measurement sites. In 2019 all measured concentrations were significantly less than the 40µg.m^{-3} objective.
- For $PM_{2.5}$, annual mean concentrations have been consistently below the Scottish objective of 10 µg.m^{-3} since monitoring began in 2015.

The dispersion modelling study of current and future road traffic NO_2 and $PM_{2.5}$ emissions indicated that:

- In 2019, the NO_2 and $PM_{2.5}$ annual mean objectives were not exceeded at any locations where relevant human exposure is present within the study area.

- The sensitivity analysis conducted using meteorological dataset from 2009 through to 2019 indicates that is unlikely that exceedances of the NO_2 or $PM_{2.5}$ annual mean objective will occur at these receptor locations due to inter-annual variability in weather conditions.
- In 2025, when likely traffic growth and inter-annual variability in weather conditions are considered, the NO_2 and $PM_{2.5}$ annual mean are not predicted to exceed the Scottish objectives at any locations where relevant human exposure is present within the study area.
- In 2025 with future developments, the NO_2 and $PM_{2.5}$ annual means are not predicted to exceed the Scottish objectives at any locations where relevant human exposure is present within the study area

In light of the conclusions of this Detailed Assessment of Air Quality, South Lanarkshire Council may wish to consider revocation of the Lanark Air Quality Management Area at this time.

Although we have attempted to minimise uncertainty in the modelling aspects of this assessment as much as possible, the results should be considered in context with the uncertainties regarding model input data discussed in the report.

6 Acknowledgements

Ricardo Energy & Environment gratefully acknowledges the support received from South Lanarkshire Council when completing this assessment.

Appendices

Appendix 1: Traffic data

Appendix 2: Meteorological dataset

Appendix 3: Model verification

Appendix 4: Meteorological Analysis

Appendix 1 – Traffic Data

Table A1.1, A1.2 and A1.3 summarise the Annual Average Daily Traffic flows (AADT) and fleet compositions used to model each road link.

Table A1.1: South Lanarkshire 2019 – Annual Average Daily Flows

Street name	AADT	% Car	% LGV	% Rigid HGV	% Artic HGV	% Bus	% Motorcycle
Park Place	14843	77.69298	13.43509	3.64642	0.68641	4.08917	0.44992
Bloomgate	14845	78.82346	13.63115	2.95090	0.81843	3.30851	0.46754
Bannatyne Street	8984	86.16091	9.58755	0.53335	0.31013	3.21282	0.19524
St Leonard Street	5029	66.22332	27.93174	3.35396	0.64056	1.61091	0.23951
High Street EB	7251	82.34726	13.28093	1.40670	0.59302	1.97214	0.39994
High Street WB	9275	83.27763	13.09973	1.38005	0.39892	1.54178	0.30189
Hyndford Road EB	3010	75.68106	14.38538	6.21262	2.12625	1.09635	0.49834
Hyndford Road WB	3025	78.71074	13.12397	4.76033	1.55372	1.25620	0.59504
Westport	14845	78.82346	13.63115	2.95090	0.81843	3.30851	0.46754

Table A1. 2: South Lanarkshire 2025 – Annual Average Daily Flows

Street name	AADT	% Car	% LGV	% Rigid HGV	% Artic HGV	% Bus	% Motorcycle
Park Place	16259	77.69298	13.43509	3.64642	0.68641	4.08917	0.44992
Bloomgate	16261	78.82346	13.63115	2.95090	0.81843	3.30851	0.46754
Bannatyne Street	9841	86.16091	9.58755	0.53335	0.31013	3.21282	0.19524
St Leonard Street	5509	66.22332	27.93174	3.35396	0.64056	1.61091	0.23951
High Street EB	7943	82.34726	13.28093	1.40670	0.59302	1.97214	0.39994
High Street WB	10160	83.27763	13.09973	1.38005	0.39892	1.54178	0.30189
Hyndford Road EB	3297	75.68106	14.38538	6.21262	2.12625	1.09635	0.49834
Hyndford Road WB	3314	78.71074	13.12397	4.76033	1.55372	1.25620	0.59504
Westport	16261	78.82346	13.63115	2.95090	0.81843	3.30851	0.46754

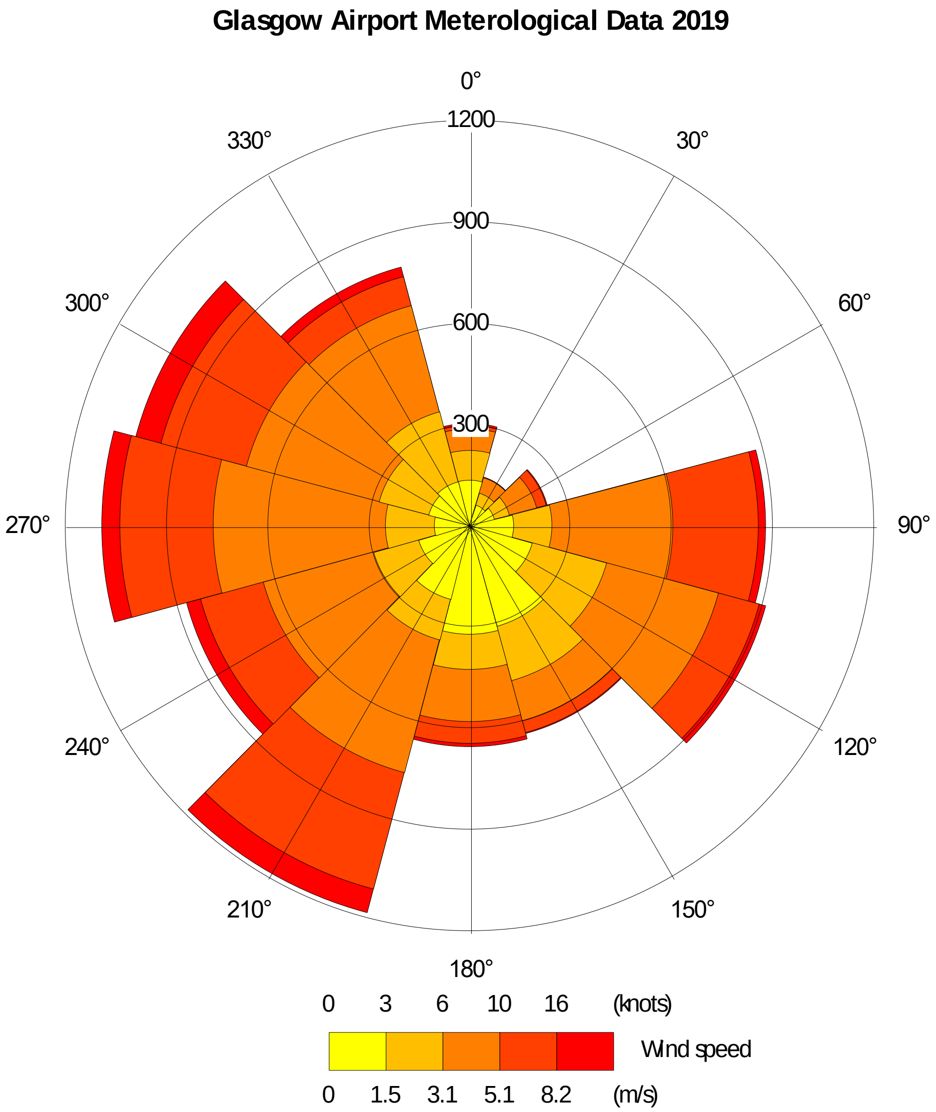
Table A1. 3: South Lanarkshire 2025 with development – Annual Average Daily Flows

Street name	AADT	% Car	% LGV	% Rigid HGV	% Artic HGV	% Bus	% Motorcycle
Park Place	16843	77.69298	13.43509	3.64642	0.68641	4.08917	0.44992
Bloomgate	16845	78.82346	13.63115	2.95090	0.81843	3.30851	0.46754
Bannatyne Street	10425	86.16091	9.58755	0.53335	0.31013	3.21282	0.19524
St Leonard Street	6093	66.22332	27.93174	3.35396	0.64056	1.61091	0.23951
High Street EB	8527	82.34726	13.28093	1.40670	0.59302	1.97214	0.39994
High Street WB	10744	83.27763	13.09973	1.38005	0.39892	1.54178	0.30189
Hyndford Road EB	3881	75.68106	14.38538	6.21262	2.12625	1.09635	0.49834
Hyndford Road WB	3898	78.71074	13.12397	4.76033	1.55372	1.25620	0.59504
Westport	16845	78.82346	13.63115	2.95090	0.81843	3.30851	0.46754

Appendix 2 – Meteorological Dataset

The wind rose for Glasgow Airport 2019 meteorological measurement site is presented below.

Figure A2.1: Meteorological dataset wind rose for Glasgow Airport, 2019



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. LAQM.TG(16) 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 Box 7.15 of LAQM.TG(16) has been used in this case.

The modelled NO_x concentrations in this study were verified using the automatic site and two available roadside diffusion tube measurement. The third available diffusion tube (St Leonards) was excluded from verification as it is a kerbside site. As stated in LAQM.TG(16) 'Annex 3 – Modelling', kerbside sites are not recommended for the adjustment of road traffic modelling results as the inclusion of these sites may lead to an over-adjustment of modelling at roadside sites.

The following Road NO_x adjustment factor was derived**: 1.0532**.

The adjustment factor was applied to the modelled road NO_x concentrations, and the adjusted total NO_2 concentrations were then calculated using the Defra NO_x/NO_2 calculator.

After the NO_x/NO_2 model was run no further adjustments were made to the data. Model agreement for modelled vs measured NOx and NO_2 monitoring data after adjustment are presented below.

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

Model uncertainty was evaluated by calculating the root mean square error (RMSE) of the modelled vs measured annual mean NO_2 concentrations. The LAQM.TG(16) guidance suggests that an RMSE value of less than 10% of the objective being assessed indicates acceptable model performance. In this case multiple measurement were available for NO_2 only; the RMSE for NO_2 was 2.17 µg.m^{-3}, the model has therefore performed sufficiently well for this type of assessment.

For $PM_{2.5}$ – No adjustment was applied to Road $PM_{2.5}$, background concentrations were added to the modelled contribution to calculate annual mean results. The $PM_{2.5}$ results may therefore represent an overestimation and should be considered in context with this uncertainty.

Table A3.1: Measured vs modelled NO_2 annual mean – Lanark 2019

Measurement site	Measured NO_2 (µg.m^{-3})	Modelled NO_2 (µg.m^{-3})
Lanark Auto Site	19	18.7
D-tube - Bloomgate	31.2	35.2
D-Tube - Bannatyne	20.3	18.7
	RMSE	**2.17**

Figure A3.1: Linear regression measured vs modelled Road NOx before and after adjustment – 2019

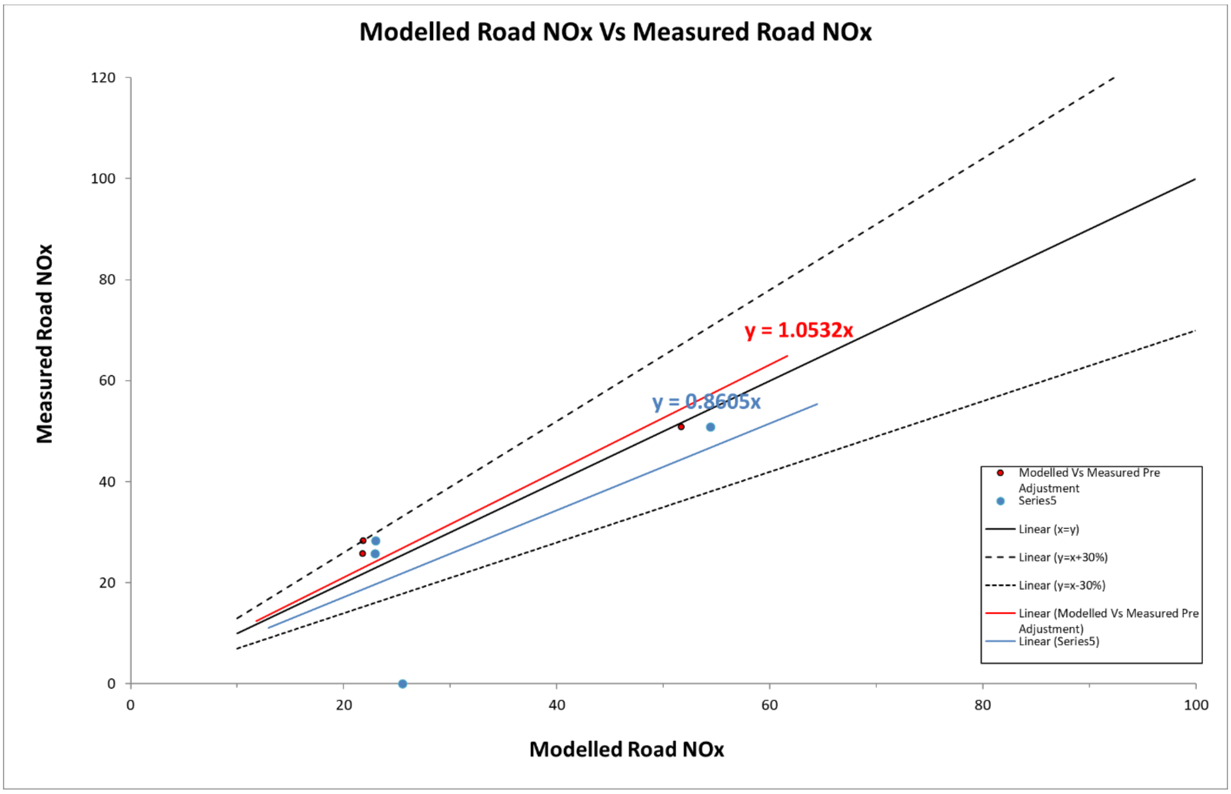
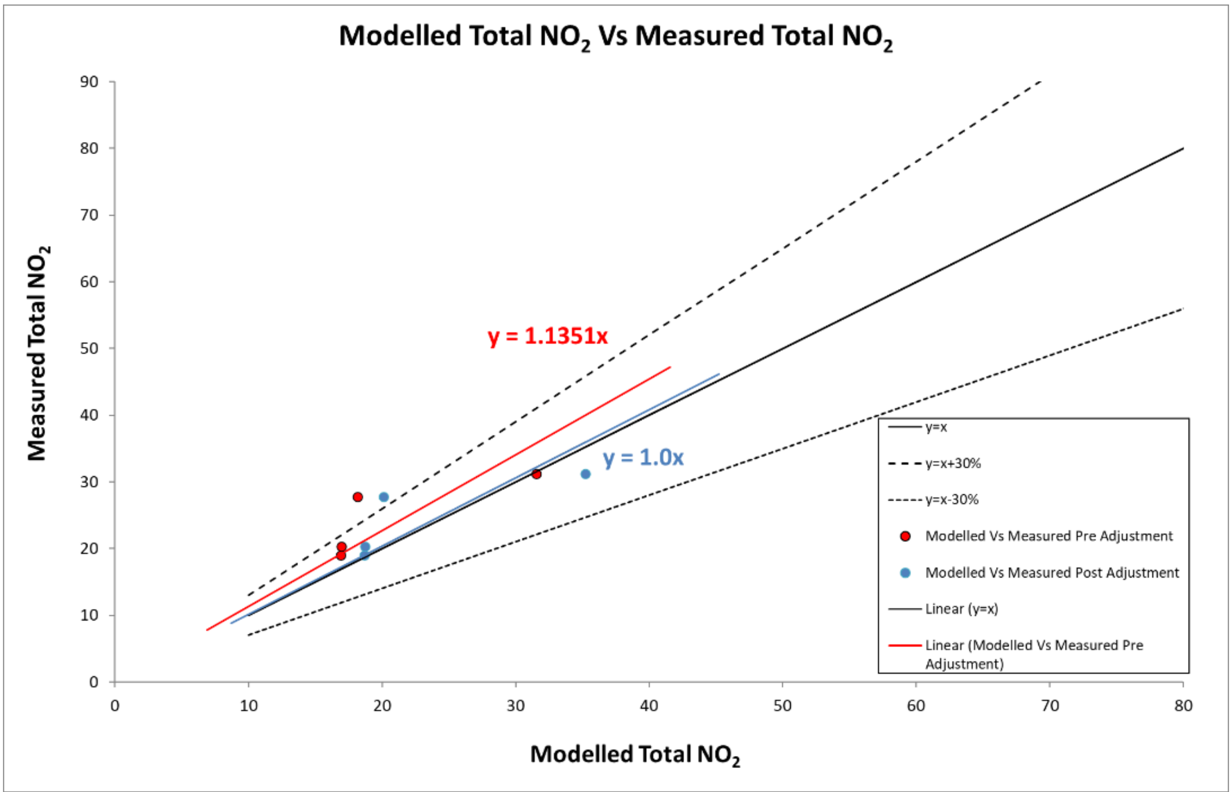


Figure A3.2 Modelled vs. measured annual mean NO_2 concentrations 2019



Appendix 4 – Meteorological Sensitivity Analysis

Table A4.4: NO_2 meteorological sensitivity analysis results (µg.m^{-3})

Site ID/Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Diffusion Tube – St Leonards	20.7	18.4	17.9	18.2	18.1	19.1	18.7	20.2	19.2	18.9	18.8
Diffusion Tube - Bannatyne	17.5	17.6	15.7	15.8	15.6	17.9	17.0	19.8	18.0	18.1	17.5
Lanark Automatic Site	18.6	17.1	15.8	17.0	16.6	17.1	17.6	18.8	18.7	17.3	17.5
Diffusion Tube - Bloomgate	33.9	32.6	29.2	30.5	29.7	32.3	31.6	35.6	33.7	32.1	32.8
10_Park_Place	14.3	14.2	12.9	13.1	12.9	14.4	13.7	15.8	14.5	14.4	14.2
2_High_St	37.3	34.7	31.4	33.2	32.5	35.1	34.5	38.7	36.5	35.2	36.0
1_Wellgate	13.4	12.8	12.2	12.3	12.2	12.9	12.7	13.7	13.2	12.9	12.9
18_Bloomgate	31.8	32.1	28.2	29.2	28.2	31.8	30.4	35.0	32.3	31.4	31.6
15_Bannatyne	25.9	25.5	22.8	23.6	23.0	25.2	24.6	27.8	26.3	25.1	25.4
123_High_St	18.1	16.3	15.2	16.5	16.0	16.4	16.6	17.8	17.5	16.3	16.5
9_Broomgate	7.0	7.2	6.8	7.1	6.9	7.3	7.0	7.5	7.1	7.1	7.1

Table A4. 1: $PM_{2.5}$ met analysis results (µg.m^{-3})

Site ID/Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Diffusion Tube – St Leonards	6.4	6.3	6.2	6.3	6.2	6.3	6.3	6.4	6.3	6.3	6.3
Diffusion Tube - Bannatyne	6.4	6.4	6.3	6.3	6.3	6.5	6.4	6.6	6.5	6.5	6.4
Lanark Automatic Site	6.3	6.2	6.1	6.2	6.1	6.2	6.2	6.3	6.3	6.2	6.2
Diffusion Tube - Bloomgate	7.6	7.5	7.2	7.3	7.3	7.5	7.4	7.8	7.6	7.5	7.5
10_Park_Place	6.2	6.2	6.1	6.1	6.1	6.2	6.2	6.4	6.2	6.2	6.2
2_High_St	7.8	7.6	7.3	7.4	7.4	7.6	7.5	7.9	7.7	7.6	7.7
1_Wellgate	6.0	6.0	5.9	5.9	5.9	6.0	6.0	6.1	6.0	6.0	6.0
18_Bloomgate	7.5	7.6	7.2	7.3	7.2	7.5	7.4	7.8	7.6	7.5	7.5
15_Bannatyne	6.9	6.9	6.7	6.8	6.7	6.9	6.8	7.1	7.0	6.9	6.9
123_High_St	6.4	6.3	6.2	6.3	6.2	6.3	6.3	6.4	6.4	6.3	6.3
9_Broomgate	5.6	5.6	5.5	5.6	5.5	5.6	5.6	5.6	5.6	5.6	5.6

Ricardo
Energy & Environment

The Gemini Building
Fermi Avenue
Harwell
Didcot
Oxfordshire
OX11 0QR
United Kingdom

t: +44 (0)1235 753000
e: enquiry@ricardo.com

ee.ricardo.com