

UoM Fallowfield Owens Park Residences

Air Quality Exposure Assessment

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Glossary

Term	Definition
AADT	Annual average daily traffic
AQMA	Air Quality Management Area
AQO	Air Quality Objective
ASR	Annual Status Report
EPUK	Environmental Protection UK
HDV	Heavy Duty Vehicles
IAQM	Institute of Air Quality Management
LAQM	Local Air Quality Management
MCC	Manchester City Council
NO ₂	Nitrogen dioxide
NO _x	Nitrogen oxides
PM	Particulate matter

1 Executive summary

This Report has been prepared to support a Reserved Matters Application for consideration of appearance, layout, scale and landscaping, pursuant to the approve Outline Planning Permission Ref. 138126/OO/2023 for the redevelopment of the Site to deliver up to 3,300 Purpose Built Student Accommodation (PBSA) bedrooms alongside associated facilities and ancillary accommodation.

The report has been prepared to address Condition 37a of the outline planning consent, which is as follows:

“Prior to commencement of development within each phase, with the exception of demolition and site clearance, an exposure assessment together with any mitigation measures to safeguard local air quality in relation to that phase shall be submitted to and approved in writing by the City Council as local planning authority.”

The exposure assessment has been carried out using air dispersion modelling. The air dispersion model has been verified against air quality monitoring data carried out by Buro Happold on-site to ensure a good level of model accuracy. The air dispersion model has predicted NO₂, PM₁₀ and PM_{2.5} concentrations at future building facades, for the opening year 2027, when the first blocks will be occupied.

The modelled results show that the UK Air Quality Objectives (AQOs) will not be exceeded at any future receptor location. Furthermore, the PM_{2.5} concentrations are modelled to be in compliance with the annual average PM_{2.5} Target concentration, which is more stringent than the current AQO.

As the AQOs will not be exceeded on-site, no further mitigation is deemed to be required and it is considered that the future users have been safeguard against air pollution, thus Condition 37a can be discharged.

2 Purpose of this report

Buro Happold have been appointed to carry out air quality consultancy services to aid in discharging planning condition 37a of the University of Manchester Fallowfield Campus redevelopment, which was granted outline planning permission in January 2024, subject to conditions.

This is included as part of the Reserved Matters Application for consideration of appearance, layout, scale and landscaping, pursuant to Outline Planning Permission Ref. 138126/OO/2023 for the redevelopment of the Site to deliver up to 3,300 Purpose Built Student Accommodation (PBSA) bedrooms alongside associated facilities and ancillary accommodation.

Condition 37a, is as follows:

"Prior to commencement of development within each phase, with the exception of demolition and site clearance, an exposure assessment together with any mitigation measures to safeguard local air quality in relation to that phase shall be submitted to and approved in writing by the City Council as local planning authority."

This report outlines the on-site exposure assessment that has been carried out to address this condition.

3 Redevelopment context

The Site is in the Fallowfield area, in southern Manchester, within the authoritative jurisdiction of Manchester City Council (MCC).

The Redevelopment comprises of demolition and redevelopment of existing UoM Fallowfield campus to create a new 3,300 bed student residence alongside associated facilities and ancillary accommodation. There will be limited car parking, with 17 blue badge spaces proposed. Air Source Heat Pumps (ASHPs) will provide heating and hot water for the Redevelopment.

An Air Quality Management Area (AQMA) has been declared across Manchester city centre and surrounding arterial roads owing to consistent exceedances of the AQO for annual average NO_2 concentrations¹. The AQMA was first declared in 2001 and has undergone a number of revisions, most recently in 2016. Roads are the predominant source of emissions within the AQMA. The AQMA covers most of the major roads in the area, including the roads that bound the Site to the east and south, namely Winslow Road and Moseley Road (Figure 3-1). The Site is in a primarily residential area. University buildings border the Site to the north and west.

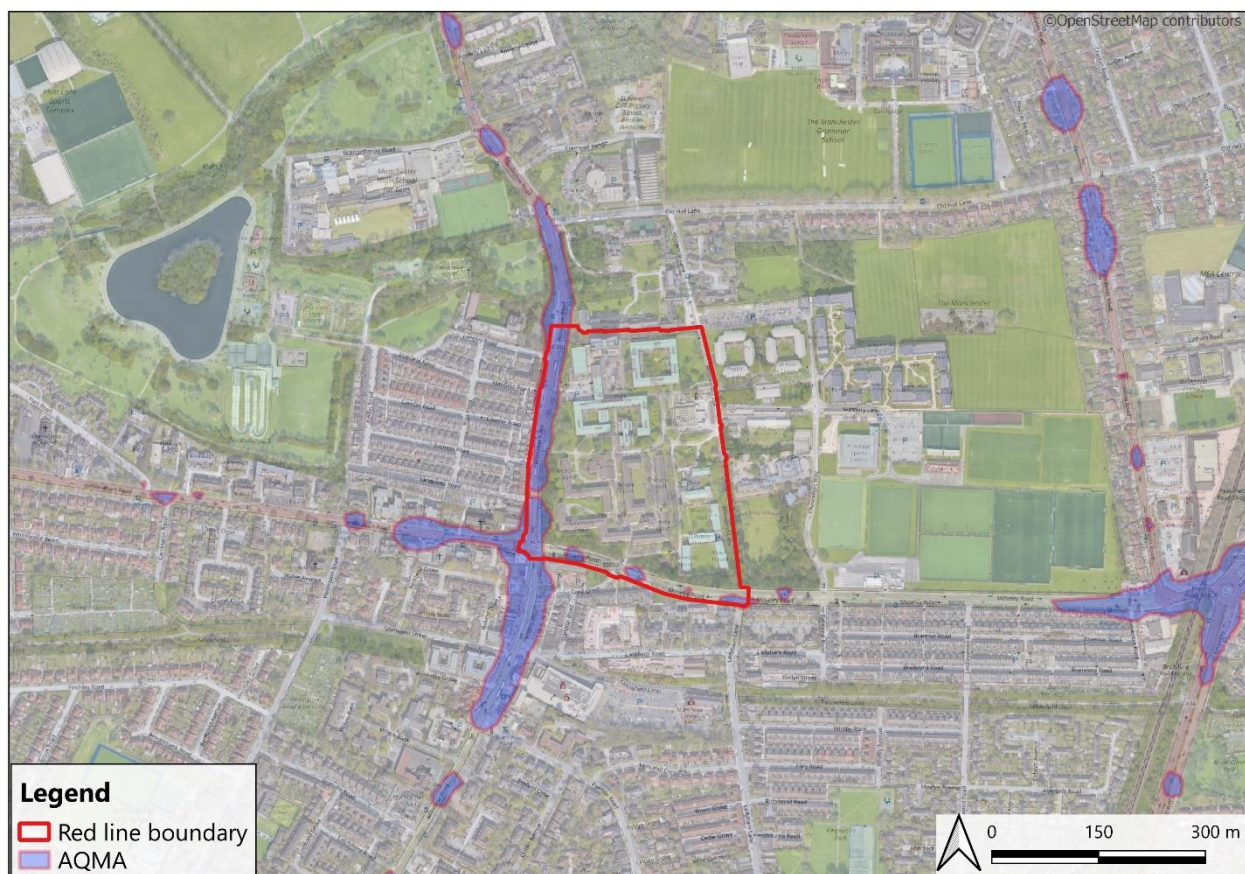


Figure 3-1 Manchester AQMA in the vicinity of the Site

¹ Defra. (2024). AQMA details – Manchester AQMA. https://uk-air.defra.gov.uk/aqma/details?aqma_ref=36

4 Methodology

4.1 Consultation

The Environmental Protection Section of MCC have been consulted on the on-site exposure assessment methodology outlined in this section. The methodology has been reviewed and deemed it acceptable by MCC in an email on 26/09/2024.

4.2 Air Dispersion Modelling overview

The exposure assessment has been carried out using ADMS-Roads (v 5), a air dispersion modelling software developed by Cambridge Environmental Research Consultants (CERC).

The air dispersion model includes major roads in the vicinity of the Site, (see Figure 4-1). It utilises traffic data supplied by the Buro Happold transport team. The traffic data has been compiled using a combination of survey data, undertaken for the ES, and publicly available data from Department for Transport² and Manchester-i³. The future year traffic data includes changes due to future growth in traffic and committed developments, as well as changes due to the full operation of the Redevelopment. The traffic data is presented in full in Appendix A.

The air dispersion model has been run for a future operational scenario for the opening year of the first block (2027). Vehicle emission factors for 2027 have been derived using Defra's Emission Factor Toolkit⁴ (EFT) (v 12.1). The EFT predicts the vehicle emissions will decrease beyond 2027. Therefore, using the earliest opening year rather than the year of full operation (2029) is a worst-case assumption.

The model has been used to predict concentrations of NO₂, PM₁₀ and PM_{2.5} at the building facades of the Redevelopment. The locations of modelled receptors are shown in Figure 4-1, with further details in Appendix B.

A summary of the model input parameters is presented in Appendix C.

² Department for Transport. (2024). Road Traffic Statistics. <https://roadtraffic.dft.gov.uk/#6/51.632/-2.428/basemap-regions-countpoints>

³ Manchester-i. <https://manchester-i.com/projects>

⁴ Defra. (2024). Emissions Factor Toolkit. <https://laqm.defra.gov.uk/air-quality/air-quality-assessment/emissions-factors-toolkit/>



Figure 4-1 Model setup – modelled roads and receptors, overlaid on Redevelopment plans (supplied by Sheppard Robson)

4.3 Background concentrations

Background concentrations have been obtained from Defra background maps⁵. These cover the whole of the UK on a 1x1 km grid and are projected for each year from 2018 until 2040. The Site covers multiple grid squares. Therefore, the background concentration for the grid square at which each modelled receptor is within has been utilised. The 2027 background concentrations are presented in Table 4-1.

Data from nearby automatic urban background sites indicate that background NO₂, PM₁₀ and PM_{2.5} concentrations have decreased in the years following the COVID-19 pandemic and are below the pre-pandemic levels. Therefore, it is deemed robust to assume that background concentrations will continue the decline in the area and therefore to utilise future projected background concentrations.

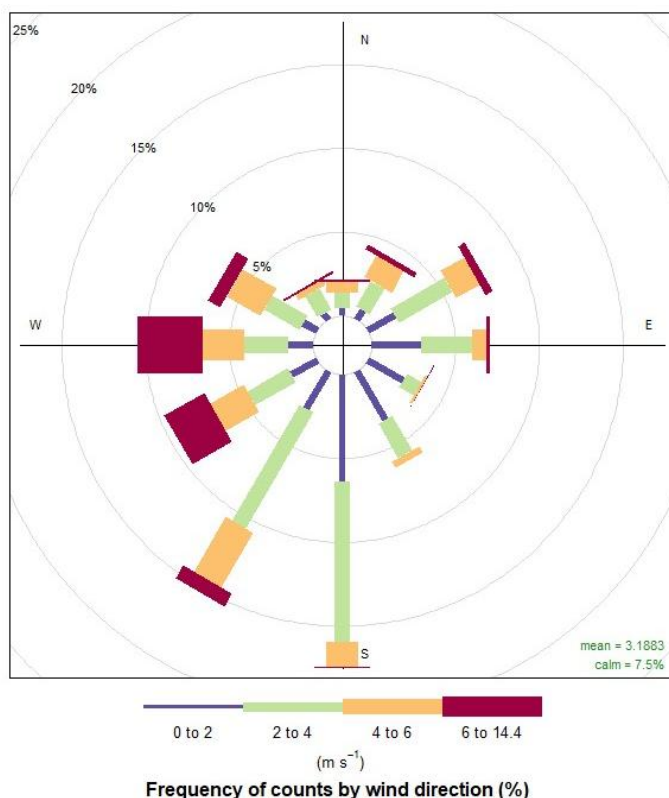
⁵ Defra. (2018). Background Mapping data for local authorities. <https://uk-air.defra.gov.uk/data/laqm-background-home>

Table 4-1 Defra modelled background concentrations that will be utilised in the assessment.

Receptors	2027 modelled annual mean background concentration ($\mu\text{g}/\text{m}^3$)					
	Grid square X	Grid square Y	NO ₂	NO _x	PM ₁₀	PM _{2.5}
Block28.1, Block28.2, Block29.1, Block29.2	385500	393500	17.5	13.0	12.6	7.6
All other receptors	385500	394500	17.2	12.9	12.8	7.5

4.4 Meteorological conditions

Hourly sequential meteorological data from Manchester Airport has been input into the model. The data set provides hourly temperature, wind speed, wind direction and cloud cover. 2023 data has been obtained from the NOAA Integrated Surface Database⁶, via the wormlet R package. This meteorological station is 10 km to the south of the Site, so is deemed to be representative of conditions on-site. Due to there being low cloud cover data availability at Manchester Airport, the cloud cover has been gap filled using data from Rostherne meteorological station, which has ensured that availability is over 92% for all key parameters. A wind rose, displaying the frequency of wind speeds and directions is presented in Figure 4-2.

**Figure 4-2 Wind rose displaying frequency of wind speeds and directions recorded at Manchester Airport in 2023.**

⁶ NOAA. (2024). Global Hourly - Integrated Surface Database (ISD). <https://www.ncei.noaa.gov/products/land-based-station/integrated-surface-database>

4.5 Model verification

The roads within the ADMS model have undergone a detailed adjustment and verification process, following the methodology set out in LAQM TG22⁷ Box 7-17 and 7-18. Each road was appraised and adjusted following a detailed review of the road layout using satellite imagery and geographical information system (GIS) software.

The drawn road layout considers:

- Road width;
- Existing junctions; and
- Road links where queuing is expected.

Speeds have been determined based on the traffic survey data. The speed was reduced on portions of roads close to junctions or where queuing is expected, in line with guidance within TG22.

Verification is an iterative process that follows the following key steps:

- (i) Compare modelled and monitored NO₂ concentrations at verification site locations;
- (ii) Calculate a road NO_x adjustment factor to improve agreement between modelled and monitored concentrations;
- (iii) Ensure difference between modelled NO₂ concentrations is within at least 25%, and ideally within 10%, of the monitored concentration;
- (iv) Where the difference between modelled and monitored is greater than 25%, model assumptions and set-up will be re-visited. Adjustments will be made to improve model performance and the process is repeated from step 1.

The air dispersion model has been verified with three locations included from the air quality monitoring data collected by Buro Happold in 2023 and one MCC monitoring location in the area (MA75NO, on Stockport Road, 1.5 km to the east of the Site). Details of the site specific Buro Happold air quality monitoring is presented in Appendix D.

Due to there being no PM₁₀ or PM_{2.5} monitoring sites within the model domain, the adjustment factor derived for NO₂ was applied to the road contribution of these pollutants in line with TG22.

A verification factor of 3.3186 has been derived. The verification process is detailed in Appendix E.

To derive NO₂ concentrations from modelled NO_x, results have been processed through the NO_x to NO₂ calculator (v9.1) available on the Defra LAQM Support website⁸. This calculator predicts the component of NO₂ based on the adjusted road-NO_x and the background NO_x and NO₂.

4.6 Impact significance

⁷ Defra. (2022). Local Air Quality Management Technical Guidance (TG22). <https://laqm.defra.gov.uk/wp-content/uploads/2022/08/LAQM-TG22-August-22-v1.0.pdf>

⁸ Defra. (2024). NO_x to NO₂ Calculator v9.1. <https://laqm.defra.gov.uk/air-quality/air-quality-assessment/nox-to-no2-calculator/>

The EPUK/IAQM guidance on land use planning and development control⁹ provides guidance on assessment of significance of air quality effects. The guidance states that:

“Where the air quality is such that an air quality objective at the building façade is not met, the effect on residents or occupants will be judged as significant, unless provision is made to reduce their exposure by some means.”

Therefore, the modelled concentrations have been compared to the UK air quality objectives (AQOs), as defined in the Air Quality (Standards) Regulations 2010¹⁰ and subsequent amendment in 2016¹¹ (presented in Table 4-2). It is convention to assess PM_{2.5} compliance against the PM_{2.5} limit value which was set at 20 µg/m³ in 2020¹². Where the modelled concentration does not exceed the relevant AQO, the impact of exposure to air pollution is deemed not significant. To account for model uncertainty, further mitigation is considered when the modelled concentration is within 10% of AQO, consistent with methodology outlined in Defra’s Local Air Quality Management Technical Guidance TG22 (LAQM TG22)¹³.

Table 4-2 Air quality objectives relevant to this assessment.

Pollutant	Objective
Nitrogen dioxide (NO ₂)	200 µg/m ³ measured as a 1-hour mean, not to be exceeded more than 18 times a year
	40 µg/m ³ measured as an annual mean
Particulate Matter (PM ₁₀)	50 µg/m ³ measured as a 24-hour mean, not to be exceeded more than 35 times a year
	40 µg/m ³ measured as an annual mean
Particulate Matter (PM _{2.5})	20 µg/m ³ measured as an annual mean

As the receptor locations modelled are student residential, the annual average, 24 hour and 1 hour mean objectives apply, as per LAQM TG22¹².

Assessing short-term exceedances of NO₂ using dispersion modelling is not straightforward. Analysis of monitoring has shown that the 1-hour NO₂ objective is unlikely to be exceeded at roadside locations where the annual average concentration is below 60 µg/m³¹². Therefore, all receptors determined to comply with this concentration are considered to also comply with the 1-hour NO₂ objective.

The risk of exceeding the PM₁₀ 24-hour mean AQO has been assessed according to the guidance in LAQM TG22. This guidance provides the calculation below to determine compliance:

$$\text{No. 24-hour mean exceedances} = -18.5 + 0.00145 \times \text{annual mean}^3 + (206/\text{annual mean})$$

⁹ Moorcroft and Barrowcliffe. et al. (2017). Land-Use Planning & Development Control: Planning For Air Quality v1.2. Institute of Air Quality Management. <http://www.iaqm.co.uk/text/guidance/air-quality-planning-guidance.pdf>

¹⁰ HM Government. (2010). The Air Quality Standards Regulations 2010
<https://www.legislation.gov.uk/uksi/2010/1001/contents/made>

¹¹ HM Government. (2016). The Air Quality Standards (Amendment) Regulations 2016.
<https://www.legislation.gov.uk/uksi/2016/1184/contents/made>

¹² HM Government. (2020). The Environment (Miscellaneous Amendments) (EU Exit) Regulations 2020.
<https://www.legislation.gov.uk/uksi/2020/1313/regulation/2/made>

¹³ Defra. (2022). Local Air Quality Management Technical Guidance (TG22). <https://laqm.defra.gov.uk/wp-content/uploads/2022/08/LAQM-TG22-August-22-v1.0.pdf>

4.6.1 PM_{2.5} Targets

The Environment Act 2021¹⁴, required the government to set new targets for PM_{2.5}. The subsequent Environmental Targets (Fine Particulate Matter) (England) Regulations 2023¹⁵ set the following targets:

- Annual mean PM_{2.5} concentration of 10 µg/m³ by 2040; and
- At least a 35% reduction in population exposure of PM_{2.5} by the end of 2040.

These targets are not applicable in the same way as the AQOs, nonetheless, comparison to the PM_{2.5} targets is made as these are aspirational targets and provide context for the direction of travel of air quality legislation.

4.7 Assumptions and limitations

The assumptions and limitations of the assessment are as follows:

- There are a number of factors that will contribute to uncertainty in the modelling predictions, including the traffic and emissions data model inputs which will have inherent uncertainty associated with them. There is also additional uncertainty owing to the model simplifying real-world conditions into a series of algorithms. To reduce this uncertainty, model verification was carried out for the assessment of traffic emissions by comparing modelled and monitored concentrations.
- It has been assumed that Defra's NO_x to NO₂ calculator (v9.1) accurately predicts NO_x and NO₂ ratios, and EFT v12.0 accurately calculates emission rates for each pollutant.
- Vehicle emissions factors and background concentrations for 2027, which is the opening year of the first phase of the Redevelopment, have been utilised for the future operational years. Not all phases will be operational in this year, with full build out of the Redevelopment not anticipated until 2029. Therefore, using 2027 as the modelled future baseline year for the operation of the Redevelopment is a conservative assumption and will help to minimise uncertainty arising from future projections in vehicle emissions and background concentrations.
- It is assumed that weather conditions at Manchester Airport meteorological station used in the modelling are similar to those in the vicinity of the site and that the meteorological data for 2023 is representative of the conditions in 2027. The weather station is approximately 10km to the south of the site. No major physical features are likely to significantly impact the weather conditions between the Manchester Airport meteorological station and the Site. Therefore, using data from this meteorological station is considered acceptable. It is not possible to forecast weather conditions in the opening year accurately, and therefore, assuming that weather conditions remain the same as the baseline meteorological conditions is the only reasonable option available.

¹⁴ HM Government. (2021) Environment Act 2021. <https://www.legislation.gov.uk/ukpga/2021/30/contents>

¹⁵ HM Government. (2023). Environmental Targets (Fine Particulate Matter) (England) Regulations 2023. <https://www.legislation.gov.uk/uksi/2023/96/contents/made>

5 Modelled results

The full modelled receptor results are presented in Appendix F.

In the earliest opening year there will be no exceedance of the AQOs at any on-site receptors. The five model receptors with the highest predicted concentrations are presented in Table 5-1. Figure 5-1 presents the predicted annual average NO₂ concentrations at ground level model receptors.

Table 5-1 Five model receptors with the highest predicted concentrations.

Receptor (height)	NO ₂			PM ₁₀			PM _{2.5}		
	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?
Block16.1(1.5)	22.5	56.3%	N	16.3	40.6%	N	9.31	46.5%	N
Block16.2(1.5)	21.7	54.2%	N	15.9	39.8%	N	9.14	45.7%	N
Block17.1(1.5)	20.8	51.9%	N	15.7	39.2%	N	9.01	45.1%	N
Block16.1(4.5)	20.6	51.4%	N	15.5	38.8%	N	8.93	44.6%	N
Block16.2(4.5)	20.1	50.3%	N	15.4	38.4%	N	8.84	44.2%	N

The highest modelled annual average NO₂ concentration is at ground floor receptor at Block16.1. At this model receptor, predicted annual average NO₂ is 22.5 µg/m³, equating to 56% of the AQO (40 µg/m³). The concentration at the majority of model receptors will be less than 50% of the annual average NO₂ AQO. Only five model receptors will experience concentrations greater than 50% of the AQO. Therefore, all modelled receptors are in compliance with the AQO.

An annual mean NO₂ concentration of 60 µg/m³ has been used to determine whether an exceedance of the 1-hour mean NO₂ AQO is likely. As all modelled annual average NO₂ concentrations are below this threshold at all modelled receptors, exceedance of the 1-hour mean NO₂ AQO is deemed unlikely, in accordance with LAQM TG22 guidance¹².

The highest modelled annual average PM₁₀ will also be at ground floor receptor at Block16.1. At this model receptor the predicted annual average PM₁₀ is 16.3 µg/m³, 41% of the AQO (40 µg/m³). All other model receptors will be less than 40% of the annual average PM₁₀ AQO. All model receptors are expected to exceed 50 µg/m³ less than one time per year (when following the equation in section 4.6) and will therefore comply with the 24-hour PM₁₀ AQO.

The highest modelled annual average PM_{2.5} will also be at ground floor receptor at Block16.1. At this model receptor the predicted annual average PM_{2.5} is 9.31 µg/m³, 47% of the AQO (20 µg/m³). Whilst not a planning requirement (see section 4.6.1), this also means that all model receptors will comply with the government's PM_{2.5} target for 2040(10 µg/m³).

As no AQOs will be exceeded at any modelled receptor, no further mitigation is deemed to be required to safeguard future occupants from air pollution.

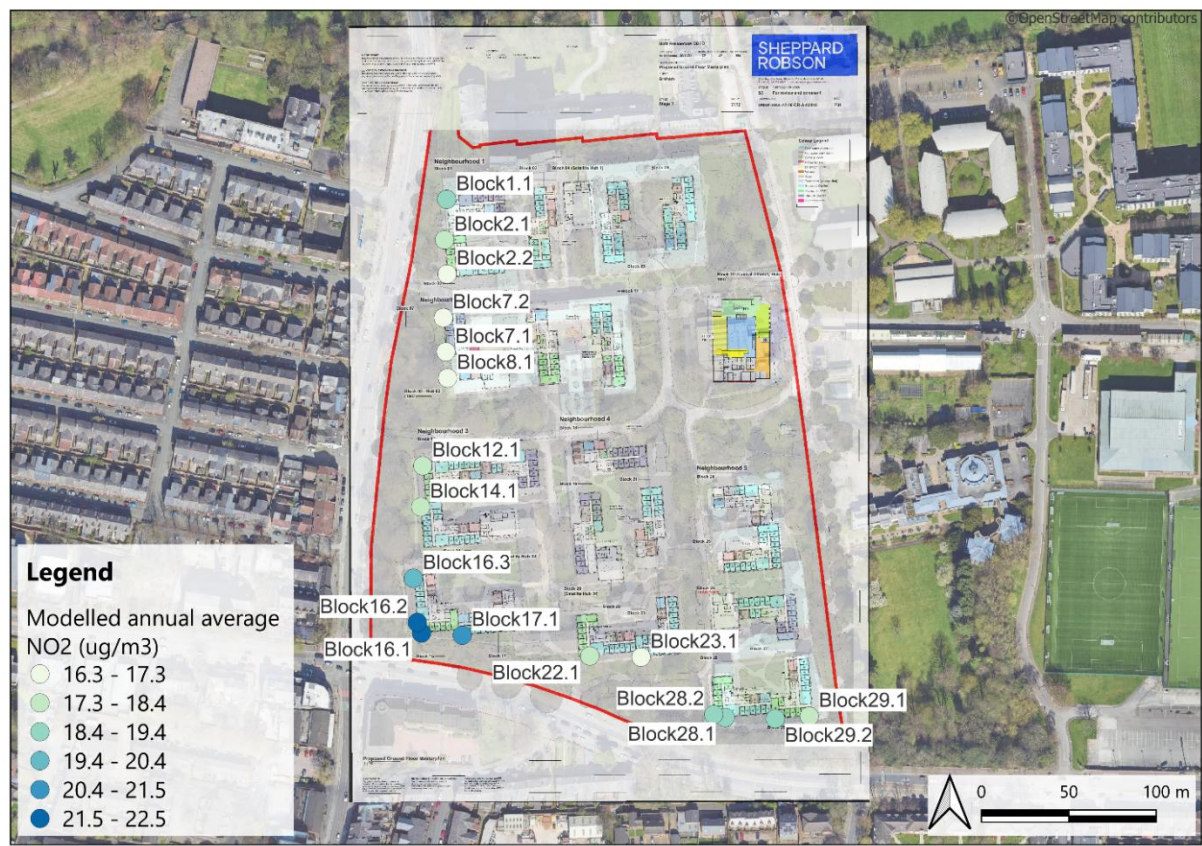


Figure 5-1 Predicted annual average NO₂ concentration at ground level model receptors.

6 Conclusions

This report outlines an assessment of on-site exposure of future site users of the University of Manchester Owens Park Residences redevelopment. NO₂, PM₁₀ and PM_{2.5} concentrations have been predicted at building facades for the earliest opening year of 2027. All modelled concentrations are in compliance with the annual average and short-term UK Air Quality Objectives. Therefore, no further mitigation is deemed to be required to safeguard future occupants from air pollution. Therefore, condition 37a can be discharged.

Appendix A Supplied traffic data

The traffic data used in this assessment was provided by the project transport consultant (Buro Happold transport team) on 09/12/2024. The location of the roads is presented in Figure A-1. The data is presented in Table A-1.

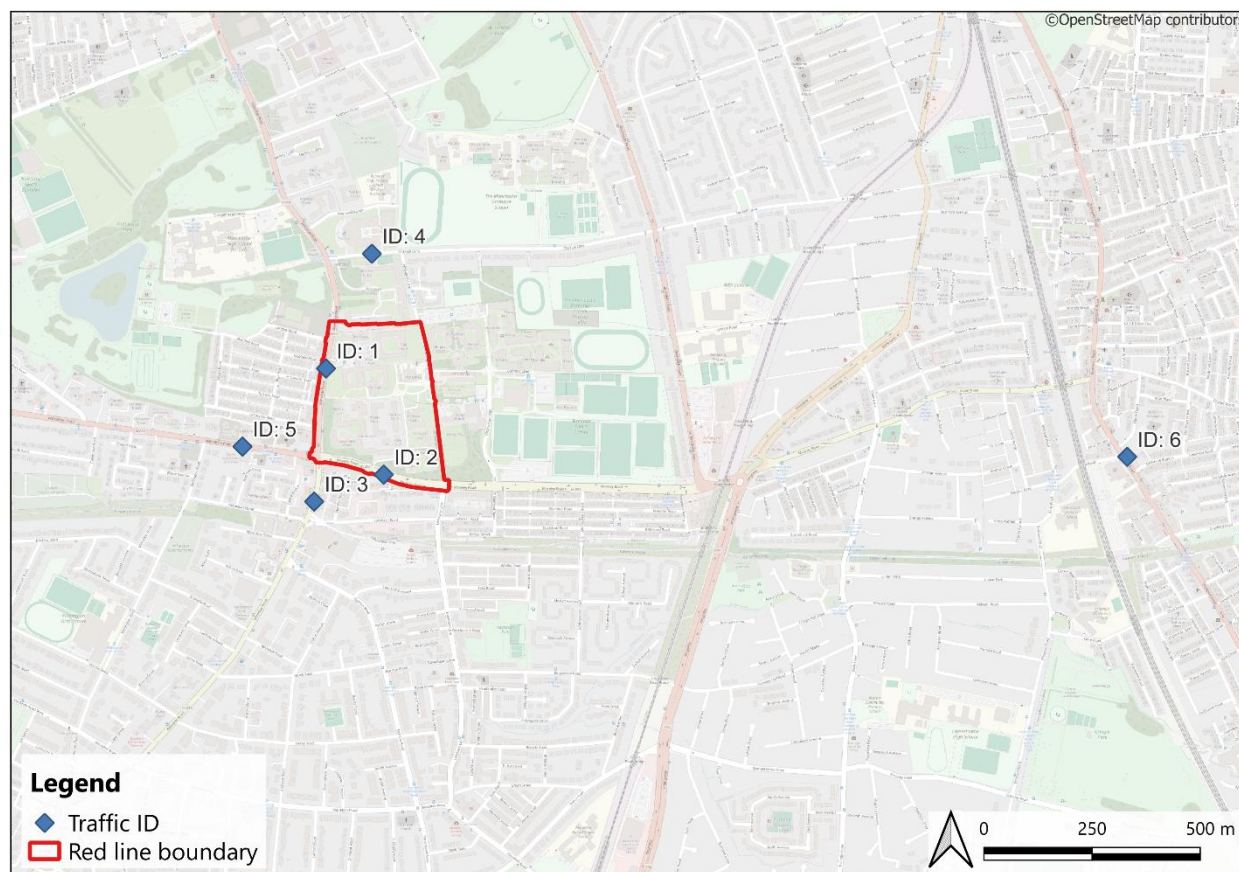


Figure A-1 Traffic data point IDs.

Table A-61 Traffic data used in this assessment.

ID	Location	Baseline (2023)		Future baseline with Redevelopment "Do Something, DS" (2027)	
		AADT	HDV %	AADT	HDV AADT
1	Wilmslow Rd N	13508	9.6	14278	9.7
2	Moseley Rd E	17683	7.0	18701	7.1
3	Wilmslow Rd S	14342	4.1	15170	4.1
4	Old Hall Ln	3660	5.6	3863	5.6
5	Moseley Rd W	14708	5.9	15564	5.9
6	Stockport Road*	27948	3.1	-	-

* This road has been used for verification only and therefore DS traffic flows are not relevant to the assessment.

Appendix B Receptor locations

The Ordinance survey grid references of the modelled on-site receptors are presented in Table B-1. Each receptor was modelled from approximate breathing height (1.5 m) to approximate roof level of the relevant building (as determined from drawings for the Reserved Matters application, prepared by Sheppard Robson), at 3 m intervals.

Table B-1 Modelled receptor locations

Receptor ID	X (m)	Y (m)	Height minimum (m)	Height maximum (m)
Block1.1	385637.7	394273.3	1.5	19.1
Block2.1	385636.5	394250.2	1.5	19.1
Block2.2	385638	394230.6	1.5	19.1
Block7.1	385637.3	394186.2	1.5	19.1
Block7.2	385635.9	394205.7	1.5	19.1
Block8.1	385638.3	394171.2	1.5	19.1
Block12.1	385624.1	394121.1	1.5	19.8
Block14.1	385622.9	394097.6	1.5	19.8
Block16.1	385623.4	394025.5	1.5	18.6
Block16.2	385621	394031.6	1.5	18.6
Block16.3	385618.7	394056.7	1.5	18.6
Block17.1	385646.7	394024.2	1.5	18.6
Block22.1	385719.6	394012.4	1.5	18.9
Block23.1	385748.9	394011.8	1.5	18.9
Block28.1	385797	393977.2	1.5	17.6
Block28.2	385790.5	393978.9	1.5	17.6
Block29.1	385845.1	393978	1.5	17.5
Block29.2	385825.7	393976.5	1.5	17.5

Appendix C Model input parameters

The model input parameters are summarised in Table C-1.

Table C-1 Model input parameters

Parameter	Description	Input Variable
Surface Roughness	Surface roughness of the modelling domain as a function of land use	A surface roughness length (z_0) of 0.85m was used for the dispersion site and 0.1 m at the meteorological site. These values are considered appropriate for the surface roughness of the dispersion modelling assessment.
Road Source Emissions	Source of the emission factors used	EFT v.12.1
Verification Year	Modelling year used to calculate verification factor for the traffic emissions	2023
Verification Factor	Applied modelled road contribution NO_x , PM_{10} and $\text{PM}_{2.5}$ to ensure model accuracy.	3.319, derived following the methodology in Appendix E.
NO_x to NO_2 Conversion	Conversion from NO_x concentrations to NO_2 concentrations	NO_x to NO_2 calculator v9.1. General inputs – Manchester, All other urban UK traffic.
Road Type	Road type within the EFT emission database	Urban (not London)
Elevation of Road	Height of the road link above ground level	All road elevations were set to 0.
Road Width	Width of the road link	Road width measured from satellite imagery.
Road Speed	Road speed in km/h	As provided by Buro Happold transport, speeds reduced at junctions in line with LAQM TG22 guidance.
Meteorology	Representative hourly sequential meteorological data	Manchester Airport 2023. Cloud cover gap filled with data from Rostherne 2023.
Background	Background pollutant concentration considered during the modelling	2027 Defra background maps (base year of 2021) 1km x 1km grid squares as set out in Table 4-1.
Output	Output as gridded or specified points	At specified points as detailed in Appendix B.
Pollutant Output	Pollutants modelled and averaging time	NO_2 , PM_{10} and $\text{PM}_{2.5}$ annual mean

Appendix D Site specific monitoring study

Buro Happold undertook a three-month air quality monitoring survey at six locations in the area surrounding the Site (shown in Figure D-1).

Palmes-type diffusion tubes were used were supplied and analysed by Gradko, a UKAS accredited laboratory, and were prepared using the 50% TEA in acetone method. Diffusion tubes were deployed for a four to five week periods:

- Period 1: 10/05/2023 - 09/06/2023;
- Period 2: 09/06/2023 - 13/07/2023; and
- Period 3: 13/07/2023 - 14/08/2023.

Diffusion tubes were placed in locations representative of roadside concentrations and at background locations but also that were accessible for safe collection and deployment.

All diffusion tubes sites were;

- At least 5cm from any the surface it was placed on;
- Above 2m in height; and
- Away from: boiler flues, overhanging vegetation, air conditioning outlets and extractor vents.

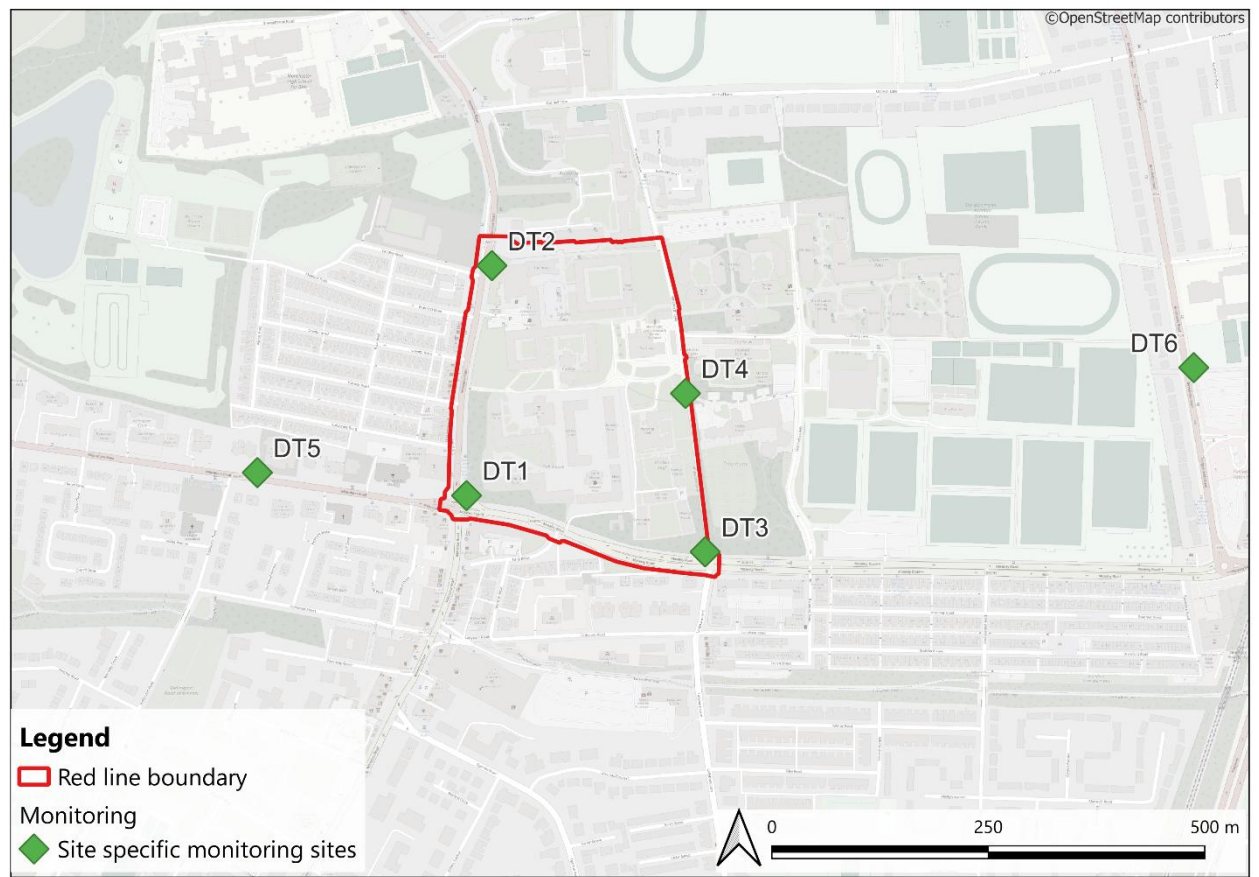


Figure D-1 Project specific monitoring locations.

Table D-1 Details of monitoring sites in project specific study

Site ID	Site description	Type	X OS grid ref (m)	Y OS grid ref (m)	Height (m)	Photo
DT 1	Wilmslow Road – Moseley Road junction	Roadside	385592	394016.6	2	

Site ID	Site description	Type	X OS grid ref (m)	Y OS grid ref (m)	Height (m)	Photo
DT 2	Wilmslow Road	Kerbside	385621.4	394281.9	2	
DT 3	Moseley Road	Roadside	385868.4	393950.1	2	
DT 4	Whitworth Lane	Urban Background	385845.0	394134.4	2	

Site ID	Site description	Type	X OS grid ref (m)	Y OS grid ref (m)	Height (m)	Photo
DT 5	Wilbraham Road	Roadside	385353.8	394042.4	2	
DT 6	Birchfields Road	Roadside	386432.0	394164.3	2	

Annualisation is the process of adjusting short term monitoring to be representative of a full calendar year, accounting for seasonal variations in concentrations, allowing for comparison against long-term annual average air quality objectives. Annualisation has been carried out in line with LAQM TG22 to give the annual mean NO₂ concentration at each of the monitoring sites.

Three background automatic sites have been used to calculate the annualisation factor: Manchester Piccadilly, Blackburn Accrington Road and Trafford Wellacre Academy. An annualisation factor has been derived at each of these automatic monitoring sites by dividing the annual average monitored concentration by the monitored concentration over the time of the diffusion tube survey. The average of the annualisation factors from each of the three sites has been calculated to be 1.535. Table D-2 outlines the annualisation calculations.

Table D-2 Annualisation factors derived from nearby automatic monitoring sites

Period	Blackburn Accrington Road		Manchester Piccadilly		Trafford Wellacre Academy	
	Mean conc (µg/m ³)	Data availability	Mean conc (µg/m ³)	Data availability	Mean conc (µg/m ³)	Data availability
2023-05-10 – 2023-06-09	10.8	100	11.8	99	10.0	99

Period	Blackburn Accrington Road		Manchester Piccadilly		Trafford Wellacre Academy	
	Mean conc (µg/m³)	Data availability	Mean conc (µg/m³)	Data availability	Mean conc (µg/m³)	Data availability
2023-06-09 – 2023-07-13	19.3	100	19.4	100	15.6	100
2023-07-13 – 2023-08-14	6.8	99	6.9	100	5.5	99
Period mean (PM)	10.9		18.1		6.4	
Annual mean (AM)	15.9		26.8		10.7	
Site annualisation factor (AM/PM)	1.45		1.48		1.67	
Average factor	1.535					

The bias adjustment factor used in this assessment is 0.83, derived from the 2023 national bias adjustment factor for Gradko 50% TEA in acetone diffusion tubes. This was obtained from the national diffusion tube bias adjustment factor spreadsheet¹⁶.

In line with Defra technical guidance (TG22), results have been annualised and bias adjusted, to determine the equivalent annual mean value (using the factors presented in Table D-3).

Table D-3 Summary of values used in post processing data from short term diffusion tube monitoring study.

Factor	Value	Derivation
Annualisation factor	1.535	Using monitoring data from three urban background automatic monitoring sites: Manchester Piccadilly, Trafford Wellacre Academy and Salford Eccles. All sites had over 85% data capture over the year and the study period.
Bias adjustment	0.83	National bias adjustment factor for Gradko 50% TEA diffusion tubes in 2023.

These factors are applied to the raw monitoring data following the process outlined below to obtain an annual average concentration at each diffusion tube site. This methodology is in line with LAQM TG22.

- 1) Calculate average concentration of the raw data over the study period (10 May 2023 – 14 August 2023);
- 2) Multiply by the bias adjustment factor to obtain a bias adjusted period average concentration;
- 3) Multiply the 3-month average concentration by the annualisation factor to obtain a 2023 annual average concentration.

¹⁶ Defra. (2023). National Bias Adjustment Factors. <https://laqm.defra.gov.uk/air-quality/air-quality-assessment/national-bias/>

The annual average monitoring results for 2023 are summarised in Table D-4.

Table D-4 Results from 3-month monitoring survey.

ID	Period 1 10/05/2023 -	Period 2 09/06/2023 -	Period 3 13/07/2023 -	Mean	Bias adjusted mean	2023 annual mean (annualised)
	09/06/2023	13/07/2023	14/08/2023			
DT1	35.8	38.2	34.2	36.0	29.9	43.8
DT2	46.0	42.4	28.8	39.0	32.4	47.4
DT3	26.6	25.8	17.0	23.1	19.2	28.1
DT4	10.6	11.2	9.8	10.5	8.7	12.8
DT5	NA	31.6	NA	31.6	26.2	NA
DT6	NA	23.8	22.8	23.3	19.4	NA

Sites DT 5 and DT 6 are not presented as missing data meant that less than 25% of the year is available and therefore are not suitable for annualisation (as per LAQM TG22¹²).

Appendix E Model verification

Modelled results have been verified against monitored concentrations in the vicinity of the Site. Data from both local authority monitoring and from the site-specific monitoring survey carried out by Buro Happold has been used. The verification process follows the methodology set out in LAQM TG22¹².

The verification sites used in the assessment are presented in Figure E-1. This includes DT1, DT2 and DT3 from the site-specific air quality monitoring survey. Other sites were excluded from the verification process due to a lack of data (i.e. less than 25% of the year meaning they are not suitable for annualisation), lack of suitable traffic data or due to the site type (e.g. urban background sites are not suitable for verification).

MCC monitoring site MA75NO was also included in the verification. The micro siting of this monitoring site has been appraised on using street view imagery to ensure the location within the model is as representative of actual conditions as possible.

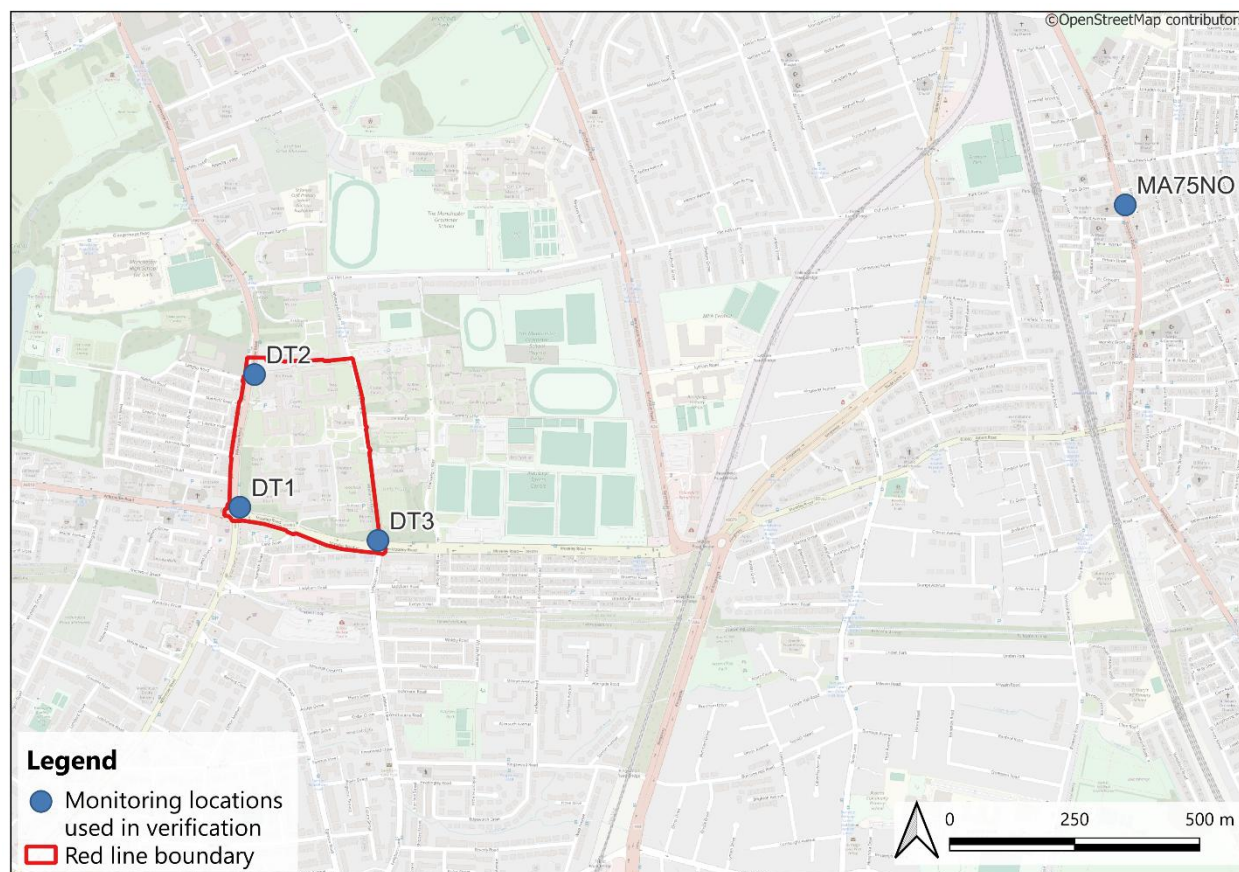


Figure E-1 Monitoring locations used in the verification process.

The verification process follows the methodology set out in LAQM TG22. The monitored road contribution NO_x has been determined from the total monitored NO₂ using Defra's NO_x to NO₂ calculator v9.1¹⁷. Comparison of modelled and monitored total NO₂ concentrations at verification sites are presented Table E-1.

This shows that the model systematically under-predicts the monitored NO₂ concentrations beyond the recommended margin of error (25%). Therefore, it is necessary to apply an adjustment factor. The road contribution NO_x modelled by the dispersion model is plotted against the road contribution NO_x monitored by diffusion tubes in Figure E-2.

Table E-1 Unadjusted modelled and monitored total NO₂ at verification sites.

Monitoring Site ID	Modelled total NO ₂ (µg/m ³)	Monitored total NO ₂ (µg/m ³)	% Difference
MA75NO	23.7	39.6	40.2
DT2	25.6	47.4	46.1
DT1	26.7	43.8	39.1
DT3	21.2	28.1	24.4

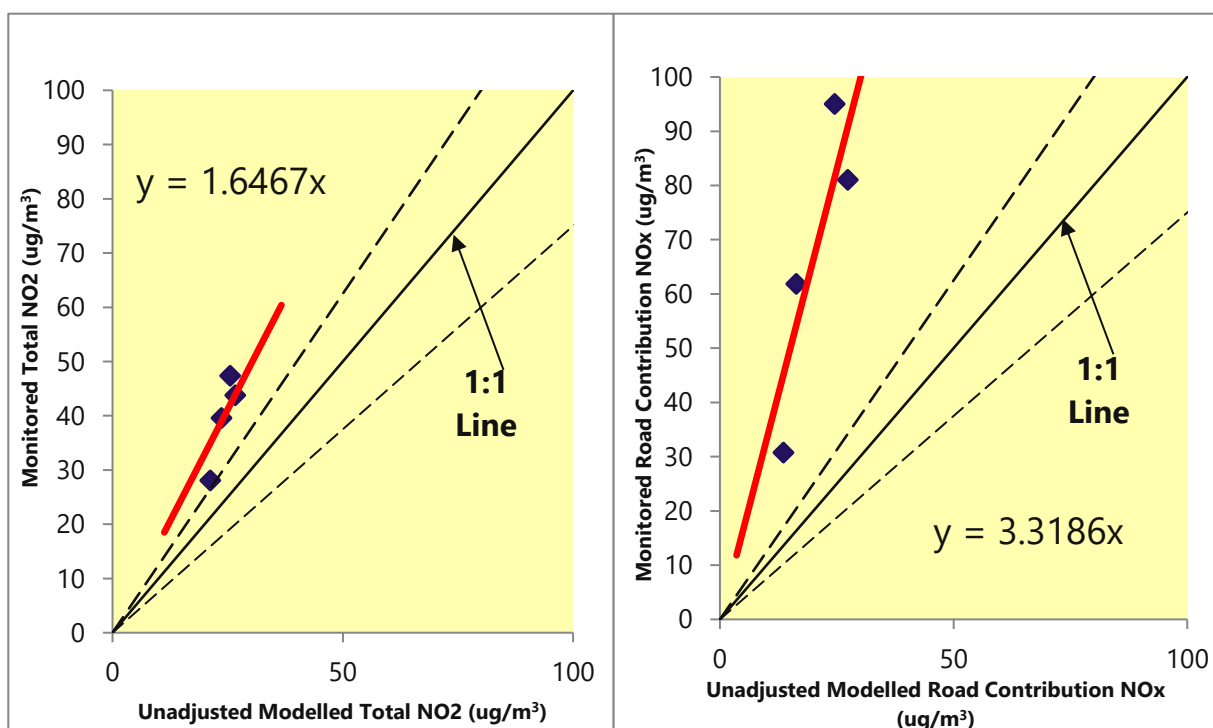


Figure E-2 Monitored road contribution NO_x plotted against unadjusted modelled road contribution NO_x.

This graph shows that a verification factor of 3.3189 (derived from the gradient of the line of best fit of the monitored against modelled road contribution NO_x) should be applied in order to obtain more accurate modelled concentrations. The adjustment factor has subsequently been applied to all modelled road NO_x concentrations (Table E-2). Adjusted NO₂ plotted against monitored NO₂ is presented in Figure E-3. The adjusted modelled total NO₂ is

¹⁷ Defra. (2024). NO_x to NO₂ Calculator v9.1. <https://laqm.defra.gov.uk/air-quality/air-quality-assessment/nox-to-no2-calculator/>

within 25% of the monitored and are therefore within the acceptable bounds of accuracy, as per LAQM TG22. All monitoring sites apart from one are 10%, which is the preferable bound of accuracy.

The root mean square error (RMSE) in the modelled NO₂ is 3.53 µg/m³, which equates to an error percentage of 8.83 % of the annual average NO₂ objective. Defra LAQM TG22 states that the model should be re-assessed if the RMSE is greater than 25% of the AQO and ideally will be within 10% of AQO. Therefore, the level of error complies with this quality check, indicating that the model performs well at these locations when the verification factor is applied.

The fractional bias is -0.1, close to the ideal value of 0. The correlation coefficient is 0.89, close to the ideal value of 1. This indicates that the model performs well with the adjustment applied.

Table E-2 Adjusted modelled road NO_x and total NO₂ concentrations.

Monitoring Site ID	Background (µg/m ³)		Monitored total NO ₂ (µg/m ³)	Monitored Road NO _x (µg/m ³)	Modelled Road NO _x (µg/m ³)	Adjusted Modelled Road NO _x (µg/m ³)	Adjusted modelled total NO ₂ (µg/m ³)	Total NO ₂ % Difference after adjustment	NO ₂ RMSE (µg/m ³)
	NO _x	NO ₂							
MA75NO	22.8	16.5	39.6	61.9	16.3	54.3	37.3	5.86	3.53
DT2	20.5	15.0	47.4	95.1	24.5	81.4	43.9	7.45	
DT1	20.5	15.0	43.8	81.1	27.4	90.9	46.3	-5.80	
DT3	20.7	15.2	28.1	30.8	13.6	45.0	33.2	-18.0	

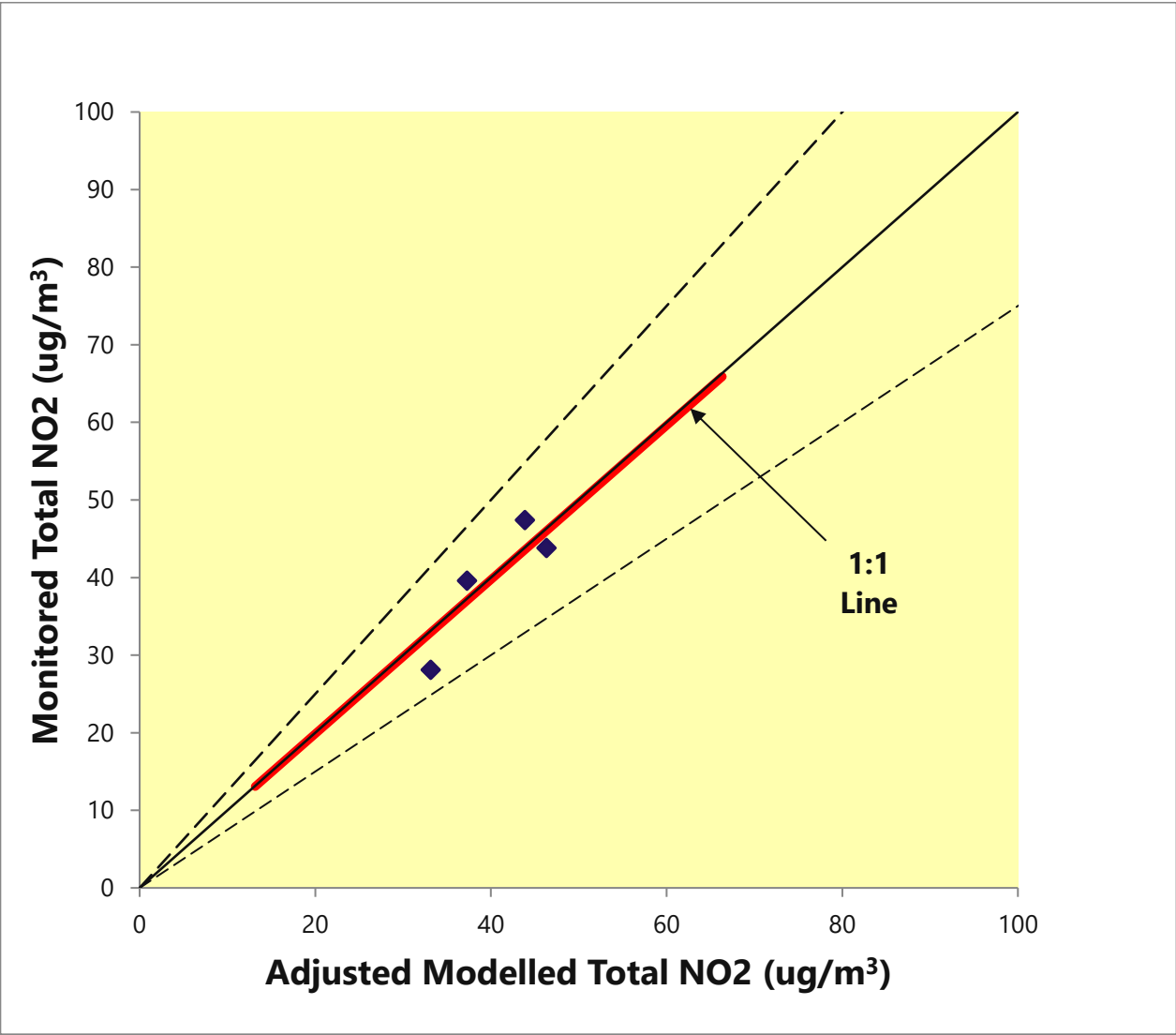


Figure E-3 Adjusted modelled total NO₂ plotted against monitored total NO₂.

Appendix F Modelled receptor results

The full modelled NO₂, PM₁₀ and PM_{2.5} concentrations at each on-site receptor introduced by the Redevelopment for the 2027 scenario are presented in Table F-1.

Table F-1 Modelled receptor results

Receptor (height)	NO ₂			PM ₁₀			PM _{2.5}		
	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?
Block29.1(1.5)	18.0	45.0%	N	14.6	36.6%	N	8.67	43.4%	N
Block29.1(4.5)	17.2	43.1%	N	14.3	35.8%	N	8.50	42.5%	N
Block29.1(7.5)	16.1	40.3%	N	13.8	34.5%	N	8.24	41.2%	N
Block29.1(10.5)	15.1	37.7%	N	13.4	33.5%	N	8.02	40.1%	N
Block29.1(13.5)	14.4	36.0%	N	13.1	32.8%	N	7.87	39.3%	N
Block29.1(16.5)	14.0	34.9%	N	12.9	32.3%	N	7.78	38.9%	N
Block29.2(1.5)	18.4	46.1%	N	14.8	37.1%	N	8.77	43.9%	N
Block29.2(4.5)	17.5	43.8%	N	14.4	36.1%	N	8.56	42.8%	N
Block29.2(7.5)	16.2	40.5%	N	13.9	34.7%	N	8.27	41.3%	N
Block29.2(10.5)	15.1	37.8%	N	13.4	33.5%	N	8.03	40.1%	N
Block29.2(13.5)	14.4	36.0%	N	13.1	32.7%	N	7.87	39.3%	N
Block29.2(16.5)	13.9	34.9%	N	12.9	32.3%	N	7.77	38.9%	N
Block28.1(1.5)	19.0	47.6%	N	15.1	37.7%	N	8.91	44.6%	N
Block28.1(4.5)	17.9	44.7%	N	14.6	36.5%	N	8.64	43.2%	N
Block28.1(7.5)	16.4	40.9%	N	13.9	34.8%	N	8.30	41.5%	N
Block28.1(10.5)	15.1	37.8%	N	13.4	33.5%	N	8.03	40.1%	N
Block28.1(13.5)	14.4	35.9%	N	13.1	32.7%	N	7.87	39.3%	N
Block28.1(16.5)	13.9	34.8%	N	12.9	32.3%	N	7.77	38.9%	N
Block22.1(1.5)	17.9	44.9%	N	14.9	37.1%	N	8.57	42.9%	N
Block22.1(4.5)	17.2	43.1%	N	14.5	36.4%	N	8.41	42.0%	N

Receptor (height)	NO ₂			PM ₁₀			PM _{2.5}		
	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?
Block22.1(7.5)	16.2	40.4%	N	14.1	35.2%	N	8.17	40.9%	N
Block22.1(10.5)	15.2	37.9%	N	13.7	34.2%	N	7.96	39.8%	N
Block22.1(13.5)	14.4	36.1%	N	13.4	33.5%	N	7.80	39.0%	N
Block22.1(16.5)	14.0	34.9%	N	13.2	33.0%	N	7.70	38.5%	N
Block17.1(1.5)	20.8	51.9%	N	15.7	39.2%	N	9.01	45.1%	N
Block17.1(4.5)	19.3	48.2%	N	15.1	37.8%	N	8.72	43.6%	N
Block17.1(7.5)	17.3	43.3%	N	14.4	36.0%	N	8.34	41.7%	N
Block17.1(10.5)	15.7	39.3%	N	13.8	34.6%	N	8.03	40.2%	N
Block17.1(13.5)	14.7	36.7%	N	13.4	33.6%	N	7.84	39.2%	N
Block17.1(16.5)	14.0	35.1%	N	13.2	33.0%	N	7.72	38.6%	N
Block16.1(1.5)	22.5	56.3%	N	16.3	40.6%	N	9.31	46.5%	N
Block16.1(4.5)	20.6	51.4%	N	15.5	38.8%	N	8.93	44.6%	N
Block16.1(7.5)	18.0	45.0%	N	14.6	36.5%	N	8.45	42.2%	N
Block16.1(10.5)	16.0	39.9%	N	13.9	34.8%	N	8.07	40.4%	N
Block16.1(13.5)	14.7	36.8%	N	13.5	33.7%	N	7.85	39.2%	N
Block16.1(16.5)	14.0	35.1%	N	13.2	33.0%	N	7.72	38.6%	N
Block16.2(1.5)	21.7	54.2%	N	15.9	39.8%	N	9.14	45.7%	N
Block16.2(4.5)	20.1	50.3%	N	15.4	38.4%	N	8.84	44.2%	N
Block16.2(7.5)	17.9	44.8%	N	14.6	36.5%	N	8.43	42.2%	N
Block16.2(10.5)	16.1	40.1%	N	13.9	34.8%	N	8.09	40.4%	N
Block16.2(13.5)	14.8	37.0%	N	13.5	33.7%	N	7.86	39.3%	N
Block16.2(16.5)	14.1	35.2%	N	13.2	33.1%	N	7.72	38.6%	N
Block16.3(1.5)	19.5	48.8%	N	15.2	38.0%	N	8.75	43.7%	N
Block16.3(4.5)	18.6	46.6%	N	14.9	37.1%	N	8.58	42.9%	N

Receptor (height)	NO ₂			PM ₁₀			PM _{2.5}		
	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?
Block16.3(7.5)	17.3	43.2%	N	14.4	35.9%	N	8.32	41.6%	N
Block16.3(10.5)	16.0	40.0%	N	13.9	34.8%	N	8.07	40.4%	N
Block16.3(13.5)	15.0	37.4%	N	13.5	33.8%	N	7.88	39.4%	N
Block16.3(16.5)	14.3	35.6%	N	13.3	33.2%	N	7.75	38.8%	N
Block14.1(1.5)	17.8	44.5%	N	14.6	36.6%	N	8.46	42.3%	N
Block14.1(4.5)	17.2	43.1%	N	14.4	36.0%	N	8.35	41.7%	N
Block14.1(7.5)	16.4	41.0%	N	14.1	35.2%	N	8.17	40.9%	N
Block14.1(10.5)	15.6	38.9%	N	13.8	34.4%	N	8.00	40.0%	N
Block14.1(13.5)	14.8	37.1%	N	13.5	33.7%	N	7.86	39.3%	N
Block14.1(16.5)	14.3	35.8%	N	13.3	33.3%	N	7.76	38.8%	N
Block14.1(19.5)	13.9	34.8%	N	13.2	32.9%	N	7.69	38.4%	N
Block12.1(1.5)	17.4	43.6%	N	14.5	36.3%	N	8.40	42.0%	N
Block12.1(4.5)	16.9	42.3%	N	14.3	35.8%	N	8.29	41.5%	N
Block12.1(7.5)	16.1	40.3%	N	14.0	35.0%	N	8.13	40.6%	N
Block12.1(10.5)	15.4	38.4%	N	13.7	34.3%	N	7.97	39.9%	N
Block12.1(13.5)	14.7	36.9%	N	13.5	33.7%	N	7.85	39.2%	N
Block12.1(16.5)	14.3	35.7%	N	13.3	33.2%	N	7.76	38.8%	N
Block12.1(19.5)	13.9	34.8%	N	13.2	32.9%	N	7.69	38.4%	N
Block8.1(1.5)	16.3	40.8%	N	14.1	35.3%	N	8.19	40.9%	N
Block8.1(4.5)	16.0	40.0%	N	14.0	35.0%	N	8.12	40.6%	N
Block8.1(7.5)	15.5	38.8%	N	13.8	34.5%	N	8.01	40.1%	N
Block8.1(10.5)	15.0	37.4%	N	13.6	33.9%	N	7.90	39.5%	N
Block8.1(13.5)	14.5	36.3%	N	13.4	33.5%	N	7.81	39.0%	N
Block8.1(16.5)	14.1	35.4%	N	13.3	33.1%	N	7.74	38.7%	N

Receptor (height)	NO ₂			PM ₁₀			PM _{2.5}		
	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?
Block7.1(1.5)	16.4	41.1%	N	14.2	35.4%	N	8.21	41.1%	N
Block7.1(4.5)	16.1	40.2%	N	14.0	35.0%	N	8.13	40.7%	N
Block7.1(7.5)	15.5	38.8%	N	13.8	34.5%	N	8.02	40.1%	N
Block7.1(10.5)	14.9	37.4%	N	13.6	33.9%	N	7.90	39.5%	N
Block7.1(13.5)	14.5	36.2%	N	13.4	33.5%	N	7.80	39.0%	N
Block7.1(16.5)	14.1	35.3%	N	13.2	33.1%	N	7.73	38.7%	N
Block2.1(1.5)	17.4	43.6%	N	14.5	36.3%	N	8.40	42.0%	N
Block2.1(4.5)	16.7	41.7%	N	14.2	35.6%	N	8.25	41.2%	N
Block2.1(7.5)	15.7	39.2%	N	13.8	34.6%	N	8.05	40.2%	N
Block2.1(10.5)	14.9	37.3%	N	13.5	33.9%	N	7.89	39.4%	N
Block2.1(13.5)	14.4	35.9%	N	13.3	33.4%	N	7.78	38.9%	N
Block2.1(16.5)	14.0	35.1%	N	13.2	33.0%	N	7.71	38.6%	N
Block1.1(1.5)	18.4	46.0%	N	14.7	36.8%	N	8.50	42.5%	N
Block1.1(4.5)	17.2	43.0%	N	14.3	35.8%	N	8.30	41.5%	N
Block1.1(7.5)	15.8	39.6%	N	13.9	34.7%	N	8.06	40.3%	N
Block1.1(10.5)	14.9	37.2%	N	13.5	33.8%	N	7.88	39.4%	N
Block1.1(13.5)	14.3	35.8%	N	13.3	33.3%	N	7.78	38.9%	N
Block1.1(16.5)	14.0	35.0%	N	13.2	33.0%	N	7.71	38.5%	N
Block23.1(1.5)	17.0	42.5%	N	14.5	36.1%	N	8.36	41.8%	N
Block23.1(4.5)	16.5	41.3%	N	14.3	35.6%	N	8.26	41.3%	N
Block23.1(7.5)	15.8	39.5%	N	13.9	34.9%	N	8.10	40.5%	N
Block23.1(10.5)	15.0	37.6%	N	13.6	34.1%	N	7.93	39.7%	N
Block23.1(13.5)	14.4	36.0%	N	13.4	33.4%	N	7.80	39.0%	N
Block23.1(16.5)	14.0	34.9%	N	13.2	33.0%	N	7.71	38.5%	N

Receptor (height)	NO ₂			PM ₁₀			PM _{2.5}		
	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?	Modelled Annual mean concentration (µg/m ³)	% of AQO	Within 10% of AQO?
Block7.2(1.5)	16.7	41.7%	N	14.3	35.7%	N	8.27	41.3%	N
Block7.2(3.5)	16.4	41.0%	N	14.2	35.4%	N	8.21	41.1%	N
Block7.2(5.5)	16.0	40.0%	N	14.0	35.0%	N	8.12	40.6%	N
Block7.2(7.5)	15.6	38.9%	N	13.8	34.5%	N	8.03	40.1%	N
Block7.2(9.5)	15.1	37.8%	N	13.6	34.1%	N	7.94	39.7%	N
Block7.2(11.5)	14.8	36.9%	N	13.5	33.7%	N	7.86	39.3%	N
Block7.2(13.5)	14.4	36.1%	N	13.4	33.4%	N	7.80	39.0%	N
Block7.2(15.5)	14.2	35.5%	N	13.3	33.2%	N	7.75	38.7%	N
Block7.2(17.5)	14.0	35.0%	N	13.2	33.0%	N	7.71	38.5%	N
Block2.2(1.5)	16.8	42.1%	N	14.3	35.8%	N	8.29	41.5%	N
Block2.2(4.5)	16.3	40.8%	N	14.1	35.3%	N	8.18	40.9%	N
Block2.2(7.5)	15.6	38.9%	N	13.8	34.5%	N	8.03	40.1%	N
Block2.2(10.5)	14.9	37.2%	N	13.5	33.9%	N	7.89	39.4%	N
Block2.2(13.5)	14.4	36.0%	N	13.4	33.4%	N	7.79	38.9%	N
Block2.2(16.5)	14.1	35.1%	N	13.2	33.1%	N	7.72	38.6%	N
Block28.2(1.5)	19.0	47.5%	N	15.1	37.7%	N	8.90	44.5%	N
Block28.2(4.5)	17.9	44.7%	N	14.6	36.4%	N	8.64	43.2%	N
Block28.2(7.5)	16.4	40.9%	N	13.9	34.8%	N	8.30	41.5%	N
Block28.2(10.5)	15.1	37.9%	N	13.4	33.5%	N	8.03	40.2%	N
Block28.2(13.5)	14.4	36.0%	N	13.1	32.7%	N	7.87	39.3%	N
Block28.2(16.5)	13.9	34.9%	N	12.9	32.3%	N	7.77	38.9%	N

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