

Report

Land at east of Knowsley Lane, Knowsley

Biodiversity Air Quality Modelling Assessment

For Hallam Land Management Ltd

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1 Introduction

- 1.1 This report presents the potential changes to air quality at designated nature conservation sites near to a proposed residential development on land at Home Farm Road, Knowsley. It has been produced to complement the Air Quality assessment within chapter 10 of the Environmental Statement. The proposed development will provide “up to 750 dwellings together with public open space, landscaping, new vehicular access junctions, active travel links, sustainable urban drainage systems and other associated infrastructure”.
- 1.2 The location of the proposed development is shown in Figure 1.

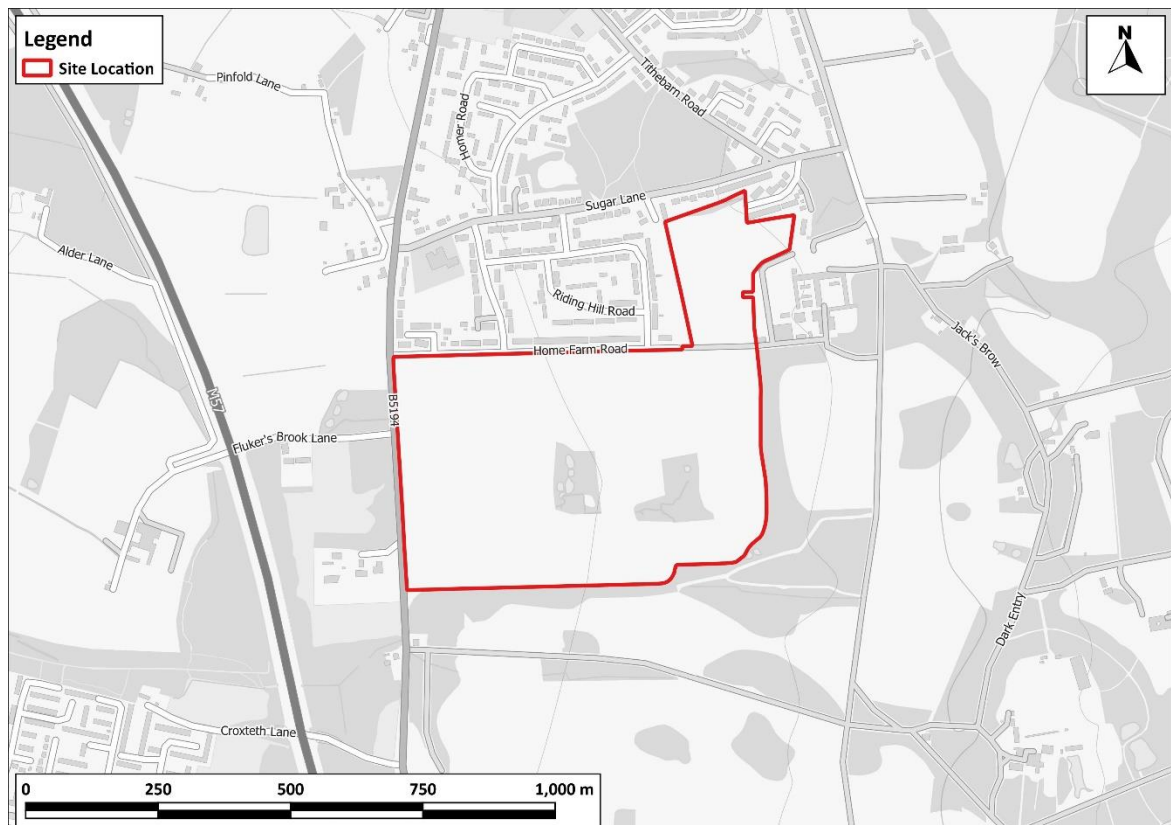


Figure 1: Proposed Development Setting

Additional data sourced from third parties, including public sector information licensed under the Open Government Licence v3.0.

- 1.3 The proposed development will lead to changes in traffic flows on roads which pass within 200 m of a number of designated nature conservation sites. Road traffic can emit nitrogen oxides (NO_x) and ammonia, and some sensitive vegetation may be affected by elevated concentrations of these pollutants. Furthermore, the deposition of both NO_x and ammonia can alter the nutrient and acidity balance of some ecosystems, causing changes to their composition and health. This assessment has quantified the changes to NO_x and ammonia concentrations that would be caused by the proposed development, as well as the changes to nitrogen and acid deposition fluxes.
- 1.4 This report describes the overall scope of the air quality assessment, the dispersion modelling methodology, and the modelled results. The professional experience of the consultants involved in preparing the assessment is summarised in Appendix A1.

2 Critical Levels and Critical Loads

- 2.1 EU Directive 2008/50/EC (The European Parliament and the Council of the European Union, 2008) sets a limit value for annual mean concentrations of nitrogen oxides and for annual and winter mean concentrations of sulphur dioxide. The same values have been set as domestic objectives within the Air Quality (England) Regulations (2000) and the Air Quality (England) (Amendment) Regulations (2002). The limit values and objectives only apply a) more than 20 km from an agglomeration (about 250,000 people), and b) more than 5 km from Part A industrial sources, motorways and built up areas of more than 5,000 people.
- 2.2 The scoping response from Merseyside Environmental Advisory Service (MEAS) stated:
- "Air quality can impact on ancient woodland communities (irreplaceable habitat). Should detailed botanical survey confirm existing woodlands on and adjacent / near to the site to be ancient semi-natural woodland then the air quality chapter should also assess impacts on these woodlands and they should be included as a receptor in air quality assessments. This will need to feed into assessment of impacts to ancient semi-natural woodlands (if confirmed) within the ecology and biodiversity chapter."*
- 2.3 It is understood from discussions with FPCR (the project ecologist) that the following woodlands were flagged as requiring consideration:
- Howards Pits and Knowles's Pits (within the site)
 - Ash Plantation (adjacent to the site within Knowsley Park Local Wildlife Site (LWS))
 - Akers Pits (to the west of the site)
 - Jacks Brow Plantation (within Knowsley Park LWS)
 - Little Wood LWS
 - Meakins Pits LWS
 - The Roughs LWS
- 2.4 FPCR has surveyed the sites shown in Figure 2 . Table 1 further refines the number of sites that require assessment based on traffic impacts from the proposed development (i.e. if no development traffic will pass within 200 m of the site, then an assessment is not judged to be required).

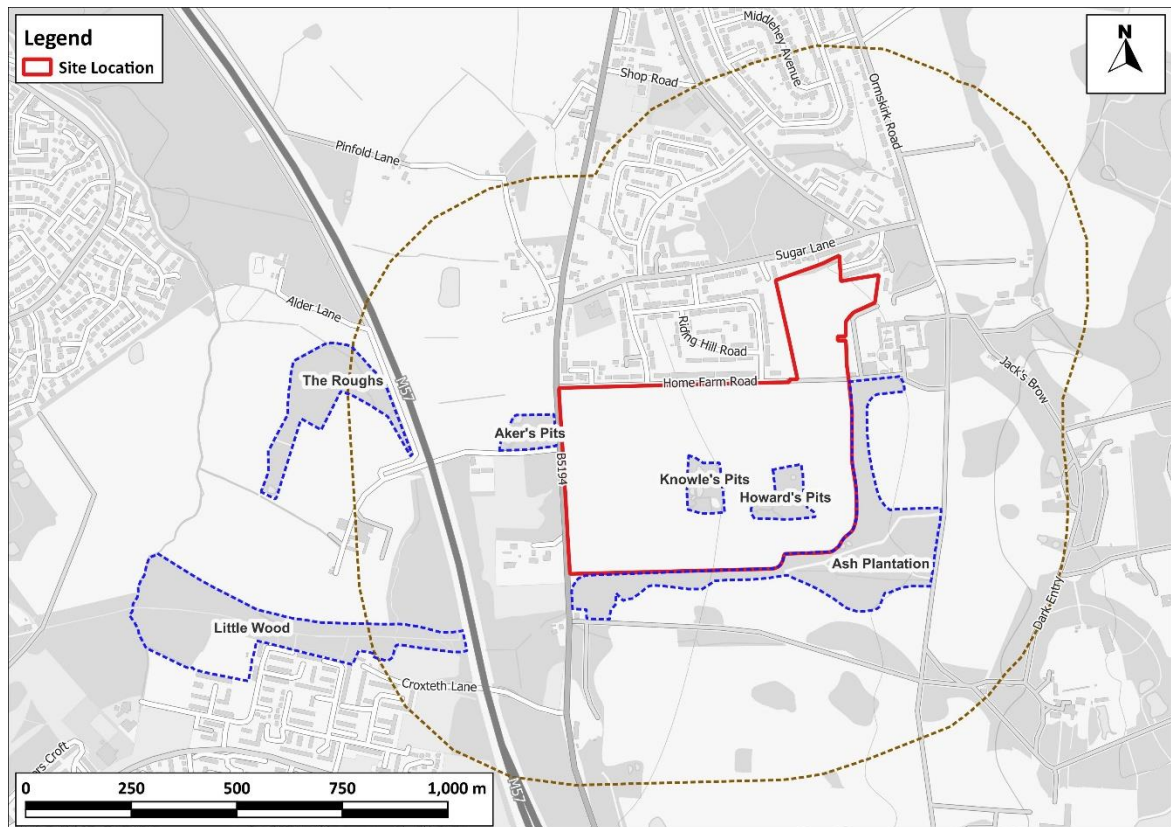


Figure 2: Woodlands Near to the Proposed Development

Additional data sourced from third parties, including public sector information licensed under the Open Government Licence v3.0.

Table 1: Woodlands Site Selection

Ecological Site and Designation	Traffic Impacts from Development	Included in Assessment
Howard's Pits	Traffic from the Proposed Development is predicted to increase on roads near to this site.	Yes
Knowles's Pits	Traffic from the Proposed Development is predicted to increase on roads near to this site.	Yes
Ash Plantation	Traffic from the Proposed Development is predicted to increase on roads near to this site.	Yes
Aker's Pits	Traffic from the Proposed Development is predicted to increase on roads near to this site.	Yes
Jacks Brow Plantation	Not shown in Figure 2; Jacks Brow Plantation was not surveyed by FPCR, as there is no public or traffic access. Traffic from the Proposed Development will not increase near to this site.	No
Little Wood LWS	Traffic from the Proposed Development is not predicted to use the M57 adjacent to this site.	No
Meakin's Pits LWS	Not shown in Figure 2; located adjacent to M57 approximately 500 m from Proposed Development. Traffic	No

Ecological Site and Designation	Traffic Impacts from Development	Included in Assessment
	from the Proposed Development is not predicted to use the M57 adjacent to this site.	
The Roughs LWS	Traffic from the Proposed Development is not predicted to use the M57 adjacent to this site.	No

2.5 Table 1 highlights that four of the nearby woodlands require assessment, as for a number of sites, no development traffic will use a road within 200 m.

2.6 Critical levels (CLEs) and critical loads (CLOs) are the ambient concentrations and deposition fluxes below which significant harmful effects to sensitive ecosystems are unlikely to occur. Exceedances of the CLEs and CLOs are considered in the context of preventing harm to sites which are protected under various designation frameworks. The CLEs relevant to this assessment are set out in Table 2. The CLOs are specific to different habitat types, and those which are most relevant to this assessment are provided in Table 3, as advised by FPCR.

Table 2: Vegetation and Ecosystem CLEs ^a

Pollutant	Time Period	CLE
Nitrogen Oxides (expressed as NO ₂)	Annual Mean ^{a,b}	30 µg/m ³
Ammonia	Annual Mean	3 (1 ^c) µg/m ³

^a The CLEs are defined by the World Health Organisation (WHO, 2000).

^b Away from major sources (see Paragraph 2.1), this CLE is set as an objective (Defra, 2007) and a limit value (The European Parliament and the Council of the European Union, 2008).

^c The more stringent CLE of 1 µg/m³ only applies where lichens or bryophytes are present or form a key part of the ecosystem integrity.

Table 3: Vegetation and Ecosystem CLOs

Habitat Type (and EUNIS code) ^a	Nutrient Nitrogen (kgN/ha/yr) ^b	Acid Deposition 'N _{max} ' (keq/ha/yr) ^b
Broadleaved Deciduous Woodland (G1)	10	1.782

^a The European Nature Information System. (European Environment Agency, 2025).

^b CLOs for nutrient nitrogen and acid deposition have been taken from (APIS, 2025). N_{max} is the value above which additional nitrogen deposition will lead to an exceedance.

3 Assessment Approach

Receptors

- 3.1 Impacts have been predicted within each identified site requiring assessment. To assess an appropriate portion of each designated site, specific receptors have been placed in transects at multiple distances from the road. Multiple transects have been placed at some sites to represent a range of exposure conditions.
- 3.2 All receptors have been modelled at a height of 1.5 m to ensure consistency with the national background deposition modelling carried out on behalf of Defra. The locations of all receptors considered can be viewed in Appendix A2.

Assessment Scenarios

- 3.3 NO_x and ammonia concentrations, and nitrogen and acid deposition fluxes, have been predicted for the following scenarios:
- base year 2023;
 - 2028 without the Proposed Development; and
 - 2028 with the Proposed Development.
- 3.4 The predictions for 2028 include background traffic growth and, as far as possible, expected changes to the vehicle fleet composition and local atmospheric chemistry.

Background Concentrations and Fluxes

- 3.5 Background concentrations of NO_x have been defined using Defra's 2021-based background maps (Defra, 2025). These cover the whole of the UK on a 1x1 km grid. The background annual mean nitrogen oxides maps have been calibrated against concurrent measurements (AQC, 2025a). The calibration factor has also been applied to future year backgrounds.
- 3.6 Background concentrations of ammonia, and nitrogen and acid nitrogen deposition fluxes, have been taken from APIS (2025). The concentrations and deposition fluxes represent 1 km x 1 km averages. APIS currently presents 3-year mean values centred on the calendar year of 2021. These have been adjusted to represent 3-year averages centred on 2023 and 2028 using the rate of change predicted for this area using the Business-as-Usual assumptions of JNCC's Nitrogen Futures project¹.
- 3.7 Estimated background concentrations of NO_x and ammonia are set out in Table 4. The background concentrations of NO_x are predicted to be well below the CLe in both 2023 and 2028. Predicted background concentrations of ammonia are below the CLe of 3 µg/m³ in both years, but above the CLe of 1 µg/m³ for sensitive lichens and bryophytes.

Table 4: Estimated Annual Mean Background Pollutant Concentrations in 2023 and 2028 (µg/m³)

Year	NO _x	Ammonia
2023	18.8	1.4

¹ <https://jncc.gov.uk/our-work/nitrogen-futures/>. A linear rate of change has been assumed between 2017 and the 2030 Business as Usual scenario, with the APIS 2018 data scaled based on the location-specific predicted changes. Acid nitrogen deposition has been scaled proportionally to nutrient nitrogen.

Year	NOx	Ammonia
2028	14.1	1.5
CLe	30	3 (1) ^a

^aThe more stringent CLe of 1 µg/m³ only applies where lichens or bryophytes are present or form a key part of the ecosystem integrity.

- 3.8 Background nitrogen deposition fluxes are presented in Table 5. Predicted background nutrient and acid nitrogen deposition rates exceed the CLo in both years.

Table 5: Estimated Annual Mean Background Deposition Fluxes in 2023 and 2028 (µg/m³)

Year	Nutrient Nitrogen Deposition (kgN/ha/yr)	Acid Nitrogen Deposition (keq/ha/yr)
2023	27.9	1.99
2028	27.6	1.97
CLo	10	1.782

^a Values presented represent the background deposition to woodland habitat.

Modelling Methodology

- 3.9 Concentrations have been predicted using the ADMS-Roads dispersion model, with emissions of NOx derived using Defra's Emission Factor Toolkit (EFT) (v13.1) (Defra, 2025), and emissions of ammonia derived using AQC's Calculator for Road Emissions of Ammonia (CREAM) (v2A) model (AQC, 2025b). Traffic flows have been provided by Astute Transport (the project transport consultants). The model results have been verified against local measurements. Details of the model inputs and the model verification are provided in Appendix A2. Deposition fluxes have been calculated from the predicted concentrations of nitrogen dioxide and ammonia. Details on the method for calculating the deposition are provided in Appendix A2.

Uncertainty

- 3.10 There are many components that contribute to the uncertainty of modelling predictions. The road traffic emissions dispersion model used in this assessment is dependent upon the traffic data that have been input, which will have inherent uncertainties associated with them. There are then additional uncertainties, as models are required to simplify real-world conditions into a series of algorithms.
- 3.11 An important stage in the process of modelling road traffic emissions of is model verification, which involves comparing the model output with measured concentrations (see Appendix A2). Because the model has been verified and adjusted, there can be reasonable confidence in the prediction of base year (2023) concentrations. There are no suitable roadside ammonia monitoring sites in the area which can be used to verify the modelled ammonia concentrations. Development of the CREAM model, which has been used in this assessment, included verifying the emissions model, combined with the ADMS-Roads dispersion model, against measurements from the densest roadside ammonia monitoring network in Europe. The modelling has thus been verified as far as is possible.
- 3.12 Predicting pollutant concentrations in a future year will always be subject to greater uncertainty. For obvious reasons, the model cannot be verified in the future, and it is necessary to rely on a series of projections provided by DfT and Defra as to what will happen to traffic volumes, background

pollutant concentrations and vehicle emissions. Historic versions of Defra's EFT tended to over-state emissions reductions into the future. However, analyses of the more recent versions of Defra's EFT carried out by AQC (2020a; 2020b) suggest that, on balance, these versions are unlikely to over-state the rate at which NOx emissions decline in the future at an 'average' site in the UK. In practice, the balance of evidence suggests that NOx concentrations are most likely to decline more quickly in the future, on average, than predicted by previous versions of the EFT, especially against a base year of 2016 or later. Whilst such an analysis has not been undertaken by AQC for EFT v13.1, it is considered that using EFT v13.1 for future-year forecasts in this report provides a robust assessment, given that the model has been verified against measurements made in 2023.

- 3.13 Historically, less attention has been given to calculating emissions of ammonia from road traffic than to calculating emissions of NOx. Future forecasts of traffic-related ammonia are thus quite uncertain. However, the CREAM model takes a deliberately conservative approach regarding these future uncertainties and can thus be considered robust.
- 3.14 It should also be recognised that the deposition velocities which have been used for ammonia may be particularly conservative. There is strong evidence that where ammonia concentrations are high, the deposition of ammonia can be significantly inhibited (Cape et al, 2008). The deposition velocity for ammonia used in this assessment was developed by the Air Quality Technical Advisory Group (AQTAG) to be precautionary in most settings. Thus, close to emissions sources it is likely to have caused the deposition of ammonia to have been over-predicted.

Assumptions

- 3.15 It is necessary to make a number of assumptions when carrying out an air quality assessment; in order to account for some of the uncertainty in the approach, as described above, assumptions made have generally sought to reflect a realistic worst-case scenario. Key assumptions made in carrying out this assessment include:
- the assumption that the Proposed Development is complete and fully operational in 2028. This will have overestimated the traffic emissions and hence the 2028 "With Scheme" concentrations. In reality the development is unlikely to be fully occupied before 2039, thus it will not be generating its full traffic volumes until this year; and
 - that the Liverpool meteorological monitoring station appropriately represents conditions in the study area (this is discussed further in Appendix A2).

4 Dispersion Model Results

NO_x

- 4.1 Table 6 sets out the total concentrations and changes relative to the CLe for NO_x at the modelled transects. NO_x concentrations show an overall reduction between 2023 and 2028.

Table 6: Model Results for NO_x

Transect	Distance from Road Edge (m)	Total Concentration (µg/m³)			% Change from Proposed Development Relative to CLe (30 µg/m³) ^a
		2023 Baseline	2028 Baseline	2028 With Proposed Development	
Howard's Pits					
Road Link 25 West	56	19.1	14.3	14.5	0.7
	57	19.1	14.3	14.5	0.7
	59	19.1	14.3	14.5	0.7
	63	19.1	14.3	14.5	0.7
	71	19.1	14.3	14.5	0.7
	87	19.1	14.3	14.5	0.7
	119	19.1	14.3	14.5	0.6
	183	19.2	14.3	14.5	0.6
Road Link 25 North	53	19.1	14.3	14.5	0.7
	54	19.1	14.3	14.5	0.7
	56	19.1	14.3	14.5	0.7
	60	19.1	14.3	14.5	0.7
	68	19.1	14.3	14.5	0.6
	84	19.1	14.3	14.5	0.6
	166	19.1	14.3	14.5	0.5
	Knowles's Pits				
Road Link 22 South	34	19.4	14.4	14.7	1.0
	35	19.4	14.4	14.7	1.0
	37	19.4	14.4	14.7	1.0
	41	19.4	14.4	14.7	0.9
	49	19.4	14.4	14.7	0.8

Transect	Distance from Road Edge (m)	Total Concentration ($\mu\text{g}/\text{m}^3$)			% Change from Proposed Development Relative to CLe ($30 \mu\text{g}/\text{m}^3$) ^a
		2023 Baseline	2028 Baseline	2028 With Proposed Development	
	65	19.4	14.4	14.6	0.7
	95	19.4	14.4	14.6	0.6
Road Link 25 North	68	19.3	14.4	14.6	0.7
	69	19.3	14.4	14.6	0.7
	71	19.3	14.4	14.6	0.7
	75	19.3	14.4	14.6	0.7
	83	19.3	14.4	14.6	0.6
	99	19.3	14.4	14.6	0.6
	131	19.3	14.4	14.5	0.6
	187	19.3	14.4	14.6	0.8
Ash Plantation					
Road Link 26 East	2	34.4	23.3	24.1	2.5
	3	32.9	22.4	23.1	2.3
	5	30.7	21.1	21.7	1.9
	9	28.0	19.5	20.0	1.5
	17	25.2	17.9	18.2	1.1
	33	22.7	16.4	16.6	0.7
	65	21.0	15.4	15.5	0.4
	129	20.0	14.8	14.9	0.3
	179	19.7	14.6	14.7	0.3
Aker's Pits					
Road Link 21 West	2	33.6	22.6	24.1	4.8
	3	32.2	21.9	23.2	4.4
	5	30.2	20.7	21.8	3.7
	9	27.7	19.2	20.1	2.9
	17	24.9	17.6	18.2	2.0
	33	22.5	16.3	16.6	1.2
	65	20.9	15.3	15.5	0.7

Transect	Distance from Road Edge (m)	Total Concentration ($\mu\text{g}/\text{m}^3$)			% Change from Proposed Development Relative to CLe ($30 \mu\text{g}/\text{m}^3$) ^a
		2023 Baseline	2028 Baseline	2028 With Proposed Development	
	114	20.0	14.8	14.9	0.4

^a Based on unrounded numbers.

Ammonia

- 4.2 Table 7 sets out the total concentrations and changes relative to both the $1 \mu\text{g}/\text{m}^3$ CLe and $3 \mu\text{g}/\text{m}^3$ CLe for ammonia at the modelled transects.

Table 7: Model Results for Ammonia

Transect	Distance from Road Edge (m)	Total Concentration (µg/m³)			% Change Relative to CLe (1 µg/m³) ^a	% Change Relative to CLe (3 µg/m³) ^a
		2023 Baseline	2028 Baseline	2028 With Proposed Development		
Howard's Pits						
Road Link 25 West	56	1.4	1.5	1.5	0.9	0.3
	57	1.4	1.5	1.5	0.9	0.3
	59	1.4	1.5	1.5	0.9	0.3
	63	1.4	1.5	1.5	0.9	0.3
	71	1.4	1.5	1.5	0.8	0.3
	87	1.4	1.5	1.5	0.8	0.3
	119	1.4	1.5	1.5	0.7	0.2
	183	1.4	1.5	1.5	0.7	0.2
Road Link 25 North	53	1.4	1.5	1.5	0.9	0.3
	54	1.4	1.5	1.5	0.8	0.3
	56	1.4	1.5	1.5	0.8	0.3
	60	1.4	1.5	1.5	0.8	0.3
	68	1.4	1.5	1.5	0.7	0.2
	84	1.4	1.5	1.5	0.6	0.2
	166	1.4	1.5	1.5	0.6	0.2
Knowles's Pits						
	34	1.4	1.5	1.5	1.2	0.4

Transect	Distance from Road Edge (m)	Total Concentration ($\mu\text{g}/\text{m}^3$)			% Change Relative to CLe (1 $\mu\text{g}/\text{m}^3$) ^a	% Change Relative to CLe (3 $\mu\text{g}/\text{m}^3$) ^a
		2023 Baseline	2028 Baseline	2028 With Proposed Development		
Road Link 22 South	35	1.4	1.5	1.5	1.2	0.4
	37	1.4	1.5	1.5	1.2	0.4
	41	1.4	1.5	1.5	1.1	0.4
	49	1.4	1.5	1.5	1.0	0.3
	65	1.4	1.5	1.5	0.8	0.3
	95	1.4	1.5	1.5	0.7	0.2
Road Link 25 North	68	1.4	1.5	1.5	0.8	0.3
	69	1.4	1.5	1.5	0.8	0.3
	71	1.4	1.5	1.5	0.8	0.3
	75	1.4	1.5	1.5	0.8	0.3
	83	1.4	1.5	1.5	0.7	0.2
	99	1.4	1.5	1.5	0.7	0.2
	131	1.4	1.5	1.5	0.6	0.2
	187	1.4	1.5	1.5	0.9	0.3
Ash Plantation						
Road Link 26 East	2	1.9	1.9	1.9	3.7	1.2
	3	1.8	1.9	1.9	3.3	1.1
	5	1.8	1.8	1.8	2.7	0.9
	9	1.7	1.7	1.7	2.0	0.7
	17	1.6	1.6	1.6	1.4	0.5
	33	1.5	1.6	1.6	0.8	0.3
	65	1.5	1.5	1.5	0.5	0.2
	129	1.5	1.5	1.5	0.3	0.1
	179	1.4	1.5	1.5	0.3	0.1
Aker's Pits						
Road Link 21 West	2	1.8	1.8	1.9	7.2	2.4
	3	1.8	1.8	1.9	6.5	2.2
	5	1.7	1.7	1.8	5.4	1.8
	9	1.6	1.7	1.7	4.0	1.3
	17	1.6	1.6	1.6	2.6	0.9

Transect	Distance from Road Edge (m)	Total Concentration ($\mu\text{g}/\text{m}^3$)			% Change Relative to CLe (1 $\mu\text{g}/\text{m}^3$) ^a	% Change Relative to CLe (3 $\mu\text{g}/\text{m}^3$) ^a
		2023 Baseline	2028 Baseline	2028 With Proposed Development		
	33	1.5	1.5	1.6	1.5	0.5
	65	1.5	1.5	1.5	0.8	0.3
	114	1.4	1.5	1.5	0.4	0.1

^a Based on unrounded numbers.

Nitrogen Deposition

4.3 Table 8 sets out the total deposition rates and changes relative to the CLo load for nutrient nitrogen at the modelled transects. Deposition rates show an overall reduction between 2023 and 2028.

Table 8: Model Results for Nitrogen Deposition

Transect	Distance from Road Edge (m)	Total Deposition (kgN/ha/yr)			% Change from Proposed Development Relative to CLo (10 kgN/ha/yr) ^a
		2023 Baseline	2028 Baseline	2028 With Proposed Development	
Howard's Pits					
Road Link 25 West	56	28.0	27.7	27.8	1.0
	57	28.0	27.7	27.8	1.0
	59	28.0	27.7	27.8	1.0
	63	28.0	27.7	27.8	1.0
	71	28.0	27.7	27.7	1.0
	87	28.0	27.7	27.7	0.9
	119	28.0	27.7	27.7	0.8
	183	28.0	27.7	27.7	0.8
Road Link 25 North	53	28.0	27.7	27.8	1.0
	54	28.0	27.7	27.8	0.9
	56	28.0	27.7	27.8	0.9
	60	28.0	27.7	27.8	0.9
	68	28.0	27.7	27.7	0.8
	84	28.0	27.7	27.7	0.7
	166	28.0	27.7	27.7	0.7
Knowles's Pits					

Transect	Distance from Road Edge (m)	Total Deposition (kgN/ha/yr)			% Change from Proposed Development Relative to CLo (10 kgN/ha/yr) ^a
		2023 Baseline	2028 Baseline	2028 With Proposed Development	
Road Link 22 South	34	28.0	27.7	27.9	1.4
	35	28.0	27.7	27.9	1.4
	37	28.0	27.7	27.8	1.3
	41	28.0	27.7	27.8	1.2
	49	28.0	27.7	27.8	1.1
	65	28.1	27.7	27.8	0.9
	95	28.1	27.7	27.8	0.8
Road Link 25 North	68	28.0	27.7	27.8	0.9
	69	28.0	27.7	27.8	0.9
	71	28.0	27.7	27.8	0.9
	75	28.0	27.7	27.8	0.9
	83	28.0	27.7	27.8	0.8
	99	28.0	27.7	27.8	0.8
	131	28.0	27.7	27.8	0.7
	187	28.0	27.7	27.8	1.0
Ash Plantation					
Road Link 26 East	2	33.5	32.3	32.7	3.9
	3	32.9	31.8	32.1	3.5
	5	32.1	31.1	31.4	2.9
	9	31.1	30.2	30.4	2.2
	17	30.0	29.4	29.5	1.5
	33	29.2	28.6	28.7	1.0
	65	28.6	28.1	28.2	0.6
	129	28.2	27.9	27.9	0.4
	179	28.1	27.8	27.8	0.3
Aker's Pits					
Road Link 21 West	2	32.8	31.5	32.3	7.5
	3	32.3	31.1	31.8	6.8
	5	31.6	30.6	31.1	5.7

Transect	Distance from Road Edge (m)	Total Deposition (kgN/ha/yr)			% Change from Proposed Development Relative to CLo (10 kgN/ha/yr) ^a
		2023 Baseline	2028 Baseline	2028 With Proposed Development	
	9	30.7	29.8	30.3	4.3
	17	29.8	29.1	29.4	2.9
	33	29.0	28.5	28.6	1.7
	65	28.5	28.1	28.1	0.9
	114	28.2	27.9	27.9	0.5

^a Based on unrounded numbers.

Acid Deposition

4.4 Table 9 sets out the total deposition rates and changes relative to the CLo for acid nitrogen at the modelled transects.

Table 9: Model Results for Acid Deposition

Transect	Distance from Road Edge (m)	Total Deposition (keq/ha/yr)			% Change from Proposed Development Relative to CLo (1.782 keq/ha/yr) ^a
		2023 Baseline	2028 Baseline	2028 With Proposed Development	
Howard's Pits					
Road Link 25 West	56	2.0	2.0	2.0	0.4
	57	2.0	2.0	2.0	0.4
	59	2.0	2.0	2.0	0.4
	63	2.0	2.0	2.0	0.4
	71	2.0	2.0	2.0	0.4
	87	2.0	2.0	2.0	0.3
	119	2.0	2.0	2.0	0.3
	183	2.0	2.0	2.0	0.3
Road Link 25 North	53	2.0	2.0	2.0	0.4
	54	2.0	2.0	2.0	0.4
	56	2.0	2.0	2.0	0.4
	60	2.0	2.0	2.0	0.3
	68	2.0	2.0	2.0	0.3

Transect	Distance from Road Edge (m)	Total Deposition (keq/ha/yr)			% Change from Proposed Development Relative to CLo (1.782 keq/ha/yr) ^a
		2023 Baseline	2028 Baseline	2028 With Proposed Development	
	84	2.0	2.0	2.0	0.3
	166	2.0	2.0	2.0	0.3
Knowles's Pits					
Road Link 22 South	34	2.0	2.0	2.0	0.6
	35	2.0	2.0	2.0	0.6
	37	2.0	2.0	2.0	0.5
	41	2.0	2.0	2.0	0.5
	49	2.0	2.0	2.0	0.4
	65	2.0	2.0	2.0	0.4
	95	2.0	2.0	2.0	0.3
Road Link 25 North	68	2.0	2.0	2.0	0.4
	69	2.0	2.0	2.0	0.4
	71	2.0	2.0	2.0	0.4
	75	2.0	2.0	2.0	0.4
	83	2.0	2.0	2.0	0.3
	99	2.0	2.0	2.0	0.3
	131	2.0	2.0	2.0	0.3
	187	2.0	2.0	2.0	0.4
Ash Plantation					
Road Link 26 East	2	2.4	2.3	2.3	1.5
	3	2.4	2.3	2.3	1.4
	5	2.3	2.2	2.2	1.2
	9	2.2	2.2	2.2	0.9
	17	2.1	2.1	2.1	0.6
	33	2.1	2.0	2.1	0.4
	65	2.0	2.0	2.0	0.2
	129	2.0	2.0	2.0	0.2
	179	2.0	2.0	2.0	0.1
Aker's Pits					

Transect	Distance from Road Edge (m)	Total Deposition (keq/ha/yr)			% Change from Proposed Development Relative to CLo (1.782 keq/ha/yr) ^a
		2023 Baseline	2028 Baseline	2028 With Proposed Development	
Road Link 21 West	2	2.3	2.3	2.3	3.0
	3	2.3	2.2	2.3	2.7
	5	2.3	2.2	2.2	2.3
	9	2.2	2.1	2.2	1.7
	17	2.1	2.1	2.1	1.1
	33	2.1	2.0	2.0	0.7
	65	2.0	2.0	2.0	0.4
	114	2.0	2.0	2.0	0.2

^a Based on unrounded numbers.

5 References

APIS (2025) *APIS*, Available: <http://www.apis.ac.uk/>.

AQC (2020a) *Performance of Defra's Emission Factor Toolkit 2013-2019*, Available: <https://www.aqconsultants.co.uk/CMSPages/GetFile.aspx?guid=7fba769d-f1df-49c4-a2e7-f3dd6f316ec1>.

AQC (2020b) *Comparison of EFT v10 with EFT v9*, Available: <https://www.aqconsultants.co.uk/CMSPages/GetFile.aspx?guid=9d6b50e1-3897-46cf-90f1-3669c6814f1d>.

AQC (2025a) *Calibrating Defra's 2021-based Background Maps against 2022, 2023 & 2024 Measurements*.

AQC (2025b) 'Development of CREAM Emissions Model Version 2', no. <https://www.aqconsultants.co.uk/resources>.

AQTAG (2011) *AQTAG06 - Technical guidance on detailed modelling approach for an appropriate assessment for emissions to air*.

Cape et al (2008) *Concentration-dependent deposition velocities for ammonia: moving from lab to field*, 631181st edition.

Defra (2007) *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland*, Defra.

Defra (2025) *Local Air Quality Management (LAQM) Support Website*, Available: <http://laqm.defra.gov.uk/>.

DfT (2024) *DfT Road traffic statistics (TRA03)*, Available: <https://www.gov.uk/government/statistical-data-sets/road-traffic-statistics-tra>.

European Environment Agency (2025) *The European Nature Information System*, Available: <http://eunis.eea.europa.eu/habitats-code.jsp>.

The Air Quality (England) (Amendment) Regulations 2002, Statutory Instrument 3043 (2002), HMSO, Available: <https://www.legislation.gov.uk/ukSI/2002/3043/contents/made>.

The Air Quality (England) Regulations 2000 Statutory Instrument 928 (2000), HMSO, Available: <http://www.legislation.gov.uk/ukSI/2000/928/contents/made>.

The European Parliament and the Council of the European Union (2008) *Directive 2008/50/EC of the European Parliament and of the Council*, Available: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0050>.

WHO (2000) *Air Quality Guidelines for Europe; 2nd Edition*. http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf.

6 Glossary

AADT	Annual Average Daily Traffic
ADMS-Roads	Atmospheric Dispersion Modelling System model for Roads
APIS	Air Pollution Information System
AQC	Air Quality Consultants
CLe	Critical Level - "concentrations of pollutants in the atmosphere above which direct adverse effects on receptors, such as human beings, plants, ecosystems or materials, may occur according to present knowledge" (APIS, 2025)
CLo	Critical Load – "a quantitative estimate of exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge" (APIS, 2025)
Defra	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
EFT	Emissions Factors Toolkit
EUNIS	European Nature Information System
Exceedance	A period of time when the concentration of a pollutant is greater than the appropriate air quality objective. This applies to specified locations with relevant exposure
HDV	Heavy Duty Vehicles (> 3.5 tonnes)
IAQM	Institute of Air Quality Management
kph	Kilometres Per hour
LWS	Local Wildlife Site
µg/m ³	Microgrammes per cubic metre
NO	Nitric oxide
NO ₂	Nitrogen dioxide
NO _x	Nitrogen oxides (taken to be NO ₂ + NO)
Objectives	A nationally defined set of health-based concentrations for nine pollutants, seven of which are incorporated in Regulations, setting out the extent to which the standards should be achieved by a defined date. There are also vegetation-based objectives for sulphur dioxide and nitrogen oxides
Standards	A nationally defined set of concentrations for nine pollutants based on assessment of the effects of each pollutant on human health, including the effects on sensitive sub-groups
WHO	World Health Organisation

7 Appendices

A1 Professional Experience

Dr Denise Evans, BSc (Hons) PhD MEnvSc MIAQM

Dr Evans is a Technical Director with AQC, with more than 25 years' relevant experience. She has prepared air quality review and assessment reports for local authorities, and has appraised local authority air quality assessments on behalf of the UK governments, and provided support to the Review and Assessment helpdesk. She has extensive modelling experience, completing air quality and odour assessments to support applications for a variety of development sectors including residential, mixed use, urban regeneration, energy, commercial, industrial, and road schemes, assessing the effects of a range of pollutants against relevant standards for human and ecological receptors. Denise has acted as an Expert Witness and is a Member of the Institute of Air Quality Management.

Dr Imogen Heard, BSc (Hons) MSc PhD

Dr Heard is an Associate of AQC with over 12 years' experience in the field of air quality. She has been involved in numerous development projects including road schemes, energy from waste facilities, urban extensions and energy centres. These have included the use of ADMS-5 and ADMS-Roads dispersion models to study the impacts of a variety of pollutants, including nitrogen dioxide, PM₁₀ and PM_{2.5}, and the preparation of air quality assessment reports and air quality chapters for Environmental Statements. She also has experience in undertaking construction dust risk assessments, Air Quality Neutral assessments and human health risk assessments, as well as in preparing local authority reports. Prior to joining AQC she worked as a scientist in the Atmospheric Dispersion and Air Quality area at the UK Met Office for four years, modelling the dispersion of a range of pollutants over varying spatial and temporal scales.

Isabel Stanley, MSci (Hons)

Miss Stanley is a Senior Consultant with AQC, having joined the company in October 2019. Prior to joining AQC she completed an MSci degree in Geology at the University of Bristol, where her studies included modules focusing on GIS, dispersion modelling and environmental geochemistry. She has undertaken numerous air quality assessments, including road traffic and plant emissions modelling, as well as indoor air quality plans and construction dust risk assessments.

A2 Modelling Methodology

Model Inputs

A2.1 Predictions have been carried out using the ADMS-Roads dispersion model (v5). The model requires the user to provide various input data, including emissions from each section of road and the road characteristics (including road width). Vehicle emissions have been calculated based on vehicle flow, composition and speed data using the EFT (Version 13.1) published by Defra (2025) and the CREAM V2A model published by AQC (2025b). Model input parameters are summarised in Table A2-1 and, where considered necessary, discussed further below.

Table A2-1: Summary of Model Inputs

Model Parameter	Value Used
Terrain Effects Modelled?	No
Variable Surface Roughness File Used?	Yes – 12km x 12km Cartesian grid at 50m resolution
Urban Canopy Flow Used?	No
Advanced Street Canyons Modelled?	No
Noise Barriers Modelled?	No
Meteorological Monitoring Site	Liverpool
Meteorological Data Year	2023
Dispersion Site Surface Roughness Length (m)	n/a (variable surface roughness file used)
Dispersion Site Minimum MO Length (m)	30
Met Site Surface Roughness Length (m)	0.2
Met Site Minimum MO Length (m)	30
Gradients?	No

A2.2 AADT flows the proportions of HDVs have been provided by Astute Transport, who have undertaken the transport assessment work for the Proposed Development. Traffic speeds have been estimated based on professional judgement, taking account of the road layout, speed limits and the proximity to a junction. The traffic data used in this assessment are summarised in Table A2-2. Diurnal and monthly flow profiles for the traffic have been derived from the national profiles published by DfT (2024).

Table A2-2: Summary of Traffic Data used in the Assessment

Road Link	2023		2028 (Without Scheme)		2028 (With Scheme)	
	AADT	%HDV	AADT	%HDV	AADT	%HDV
22	-	-	-	-	1,650	0.6
25	-	-	-	-	1,064	0.6
16	2,922	2.5	3,068	2.5	3,301	2.4

Road Link	2023		2028 (Without Scheme)		2028 (With Scheme)	
	AADT	%HDV	AADT	%HDV	AADT	%HDV
18	11,583	3.6	12,162	3.6	13,804	3.2
19	447	2.3	470	2.3	474	2.3
21	11,838	3.5	12,431	3.5	14,080	3.1
54	11,838	3.5	12,431	3.5	13,788	3.2
26	11,838	3.5	12,431	3.5	13,495	3.3

A2.3 Figure A2-1 shows the road network included within the model, along with the speed at which each link was modelled and the location of modelled transects.

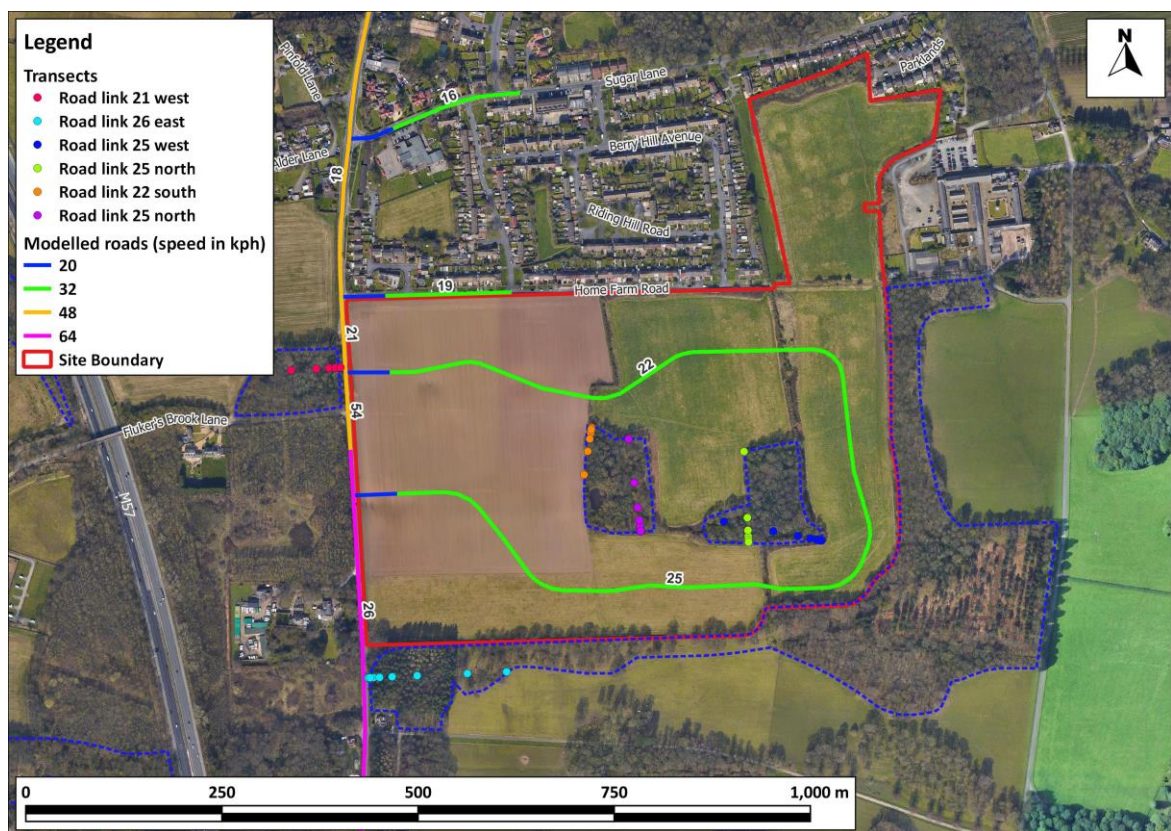


Figure A2-1: Modelled Road Network & Speed & Receptor Transects

Imagery ©2025 Airbus, Bluesky, Infoterra Ltd & COWI A/S, Maxar Technologies. Contains data from Stantec drawing no. 333102382-0116.

A2.4 Hourly sequential meteorological data in sectors of 10 degrees from Liverpool for 2023 have been used in the model. The Liverpool meteorological monitoring station is located at Liverpool John Lennon Airport, approximately 12.5 km to the south of the proposed development. A wind rose for the site for 2023 is provided in Figure A2-2. Measurements from this site are considered to be most representative of the study area, and to provide the most robust basis to predict meteorology within the model domain. Raw data were provided by the Met Office and processed by AQC for use in ADMS.

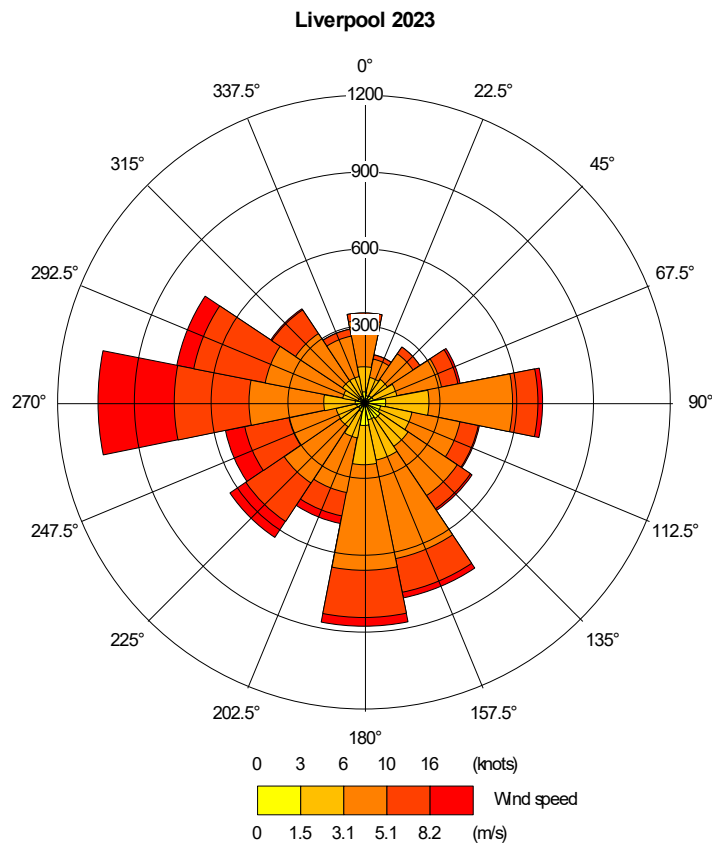


Figure A2-2: Wind Rose

Model Verification

- A2.5 Evidence collected over many years has shown that, in most urban areas, dispersion modelling relying upon Defra's EFT has tended to systematically under-predict roadside nitrogen dioxide concentrations. To account for this, it is necessary to adjust the model against local measurements. The model has been run to predict annual mean nitrogen dioxide concentrations during 2023 at the P1, P2 and P3 diffusion tube monitoring sites located in Prescott.

Background Concentrations

- A2.6 The background annual mean nitrogen dioxide concentrations used in the model verification were $16.8 \mu\text{g}/\text{m}^3$ for site P1 and $15.1 \mu\text{g}/\text{m}^3$ for sites P2 and P3, having been derived from the national maps using the same approach as described in Paragraph 3.5.

Traffic Data

- A2.7 AADT flows, and the proportions of HDVs, for roads within 200 m of the monitoring sites, have been provided by Astute Transport. Traffic speeds have been estimated based on professional judgement, taking account of the road layout, speed limits and the proximity to a junction. Traffic data used in the model verification are summarised in Table A2-1. Diurnal and monthly flow profiles for the traffic have been derived from the national profiles published by DfT (2024).

Table A2-1: 2023 Traffic Data used in the Model Verification

Road Link	AADT	%HDV
49	127	0.0
48	9,412	3.1
55	9,539	3.1
56	18,871	3.2
47	9,331	3.4
50	11,104	3.0
58	5,539	3.1
59	5,565	2.9
57	6,668	2.2
46	6,198	2.0
43	15,037	2.8
45	31	11.3
44	6,642	3.2

A2.8 Figure A2-6 shows the road network included within the model verification, along with the speed at which each link was modelled.

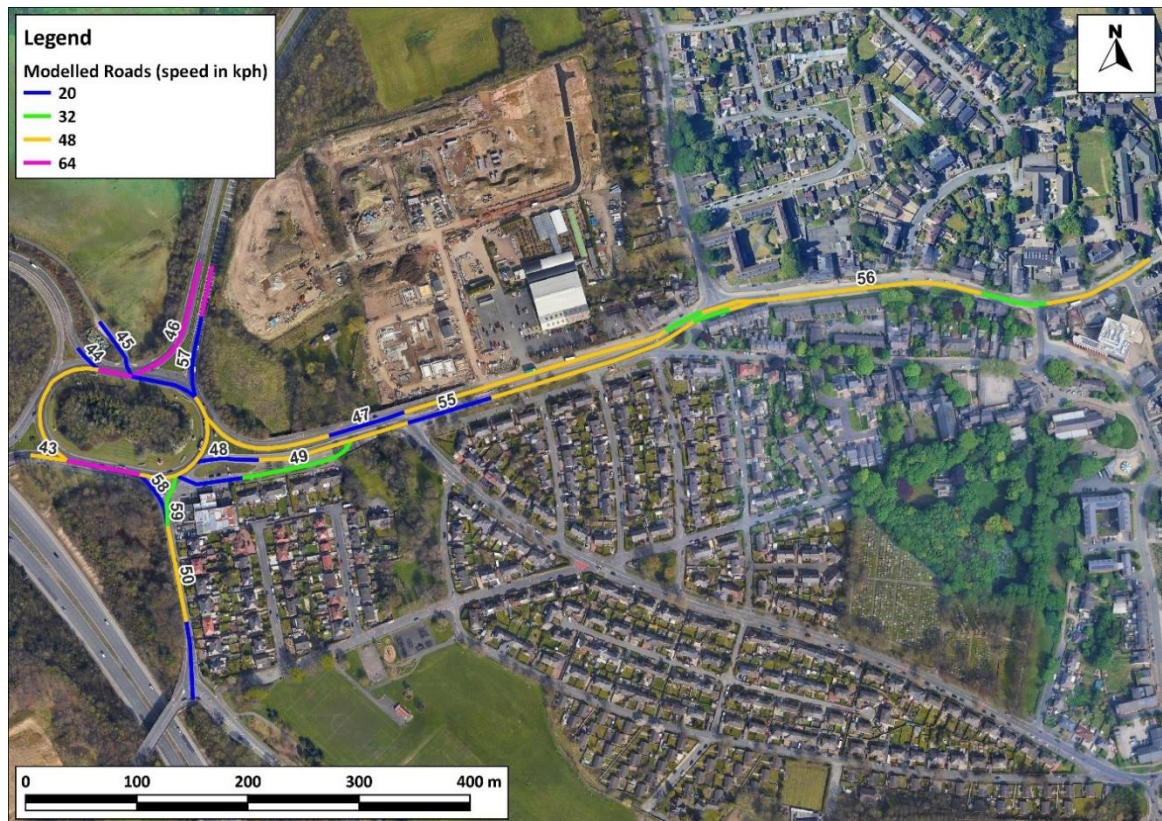


Figure A2-1: Road Network & Speeds used in the Model Verification

Imagery ©2025 Airbus, Bluesky, Infoterra Ltd & COWI A/S, Maxar Technologies.

Nitrogen Dioxide

- A2.9 Most nitrogen dioxide (NO₂) is produced in the atmosphere by reaction of nitric oxide (NO) with ozone. It is therefore most appropriate to verify the model in terms of primary pollutant emissions of nitrogen oxides (NO_x = NO + NO₂).
- A2.10 The model output of road-NO_x (i.e. the component of total NO_x coming from road traffic) has been compared with the 'measured' road-NO_x. Measured road-NO_x has been calculated from the measured NO₂ concentrations and the predicted background NO₂ concentration using the NO_x from NO₂ calculator (Version 9.1) available on the Defra LAQM Support website (Defra, 2025).
- A2.11 The unadjusted model has under predicted the road-NO_x contribution; this is a common experience with this and most other road traffic emissions dispersion models. An adjustment factor has been determined as the slope of the best-fit line between the 'measured' road contribution and the model derived road contribution, forced through zero (Figure A2-2). The calculated adjustment factor of 3.252 has been applied to the modelled road-NO_x concentration for each receptor to provide adjusted modelled road-NO_x concentrations.
- A2.12 The total nitrogen dioxide concentrations have then been determined by combining the adjusted modelled road-NO_x concentrations with the predicted background NO₂ concentration within the NO_x to NO₂ calculator. Figure A2-3 compares final adjusted modelled total NO₂ at each of the monitoring sites to measured total NO₂, and shows a close agreement.

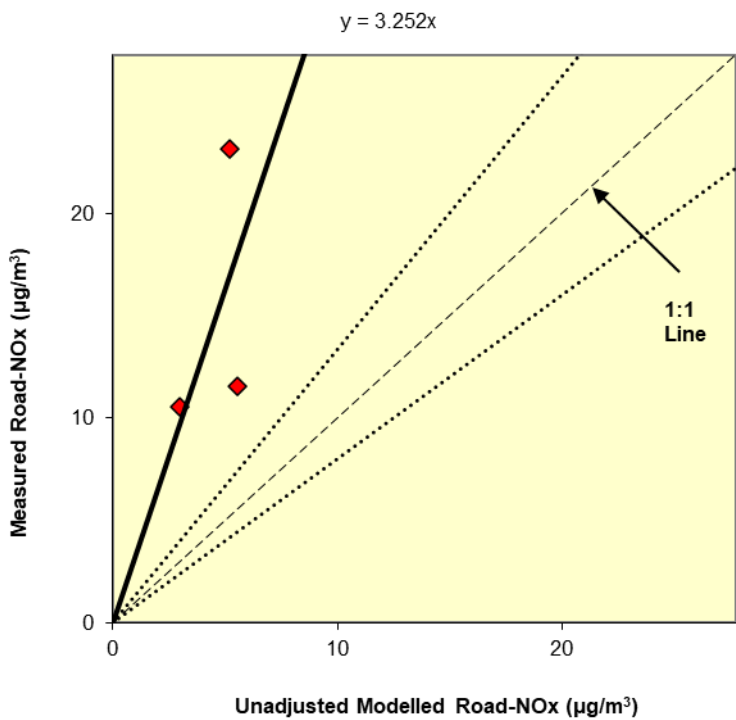


Figure A2-2: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations. The dashed lines show ± 25%.

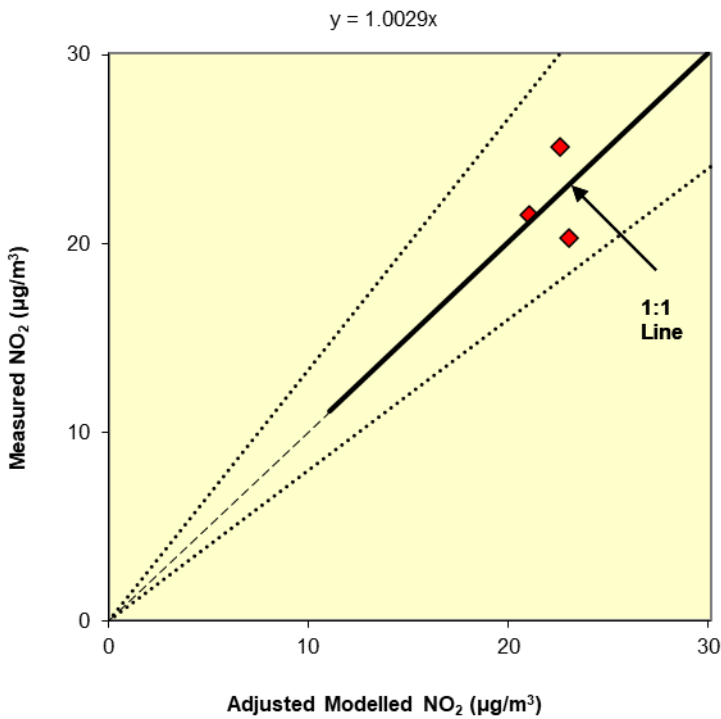


Figure A2-3: Comparison of Measured Total NO2 to Final Adjusted Modelled Total NO2 Concentrations. The dashed lines show ± 25%.

- A2.13 The predicted road-NO_x concentrations at each receptor location within the transect have been adjusted using the adjustment factor set out above, which, along with the background NO₂, has been processed through the NO_x to NO₂ calculator available on the Defra LAQM Support website (Defra, 2025). The traffic mix within the calculator has been set to "All other urban UK traffic", which is considered suitable for the study area. The calculator predicts the component of NO₂ based on the adjusted road-NO_x and the background NO₂.

Ammonia

- A2.14 Emissions of ammonia from road traffic have been predicted using the CREAM model (AQC, 2025b), which has been developed including a comparison against the best roadside ammonia measurements currently available in the UK. No further local verification is possible, and no adjustment is required.

Deposition Rates

- A2.15 Deposition has not been included within the dispersion model because the principal depositing component of concern is nitrogen dioxide and this is calculated from nitrogen oxides outside of the model. Instead, deposition has been calculated from the predicted ambient concentrations using the deposition velocities set out in Table A2-2. Deposition velocities refer to a height above ground, typically 1 or 2 m, although in practice the precise height makes little difference and here they have been applied to concentrations predicted at a height of 1.5 m above ground. The velocities are applied simply by multiplying a concentration ($\mu\text{g}/\text{m}^3$) by the velocity (m/s) to predict a deposition flux ($\mu\text{g}/\text{m}^2/\text{s}$) and then scaling by time and area to represent kg/ha/yr of the nitrogen component of the molecule.

Table A2-2: Deposition Velocities Used in This Assessment

Pollutant	Deposition Velocity (m/s)	Reference
Nitrogen Dioxide	0.003 m/s (Forest)	AQTAG06 (AQTAG, 2011)
Ammonia	0.03 m/s (Forest)	AQTAG06 (AQTAG, 2011)

- A2.16 Wet deposition of the emitted pollutants close to the emission source will be restricted to wash-out, or below cloud scavenging. For this to occur, rain droplets must come into contact with the gas molecules before they hit the ground. Falling raindrops displace the air around them, effectively pushing gasses away. AQTAG06 guidance (AQTAG, 2011) is that the wet deposition of sulphur dioxide, nitrogen dioxide and ammonia is not significant within a short range. It has thus not been included.
- A2.17 Deposition may have an acidifying effect through the release of acid protons during chemical transformation in the soil or biota. Thus, even alkaline gases such as ammonia can have an acidifying effect. The acidity CLoS are expressed as equivalents ('eq'), referring to the molar equivalent of potential acidity. This is calculated from the mass (in g) of the deposited element, taking account of both its atomic mass and its valency. For example, the acidifying potential (in eq) of both ammonium (NH₄⁺) and nitrate (NO₃⁻) is 1/14 times the deposited mass in grammes (with 14 being the atomic mass of nitrogen). The species included in the calculation of acid deposition, and their calculated acidifying potentials, are set out in Table A2-3.

Table A2-3: Species Included in Acid Deposition Calculations

Pollutant	Calculation (kg deposition to keq)
N (from deposited NO ₂ , Ammonia)	0.071



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