

Verification

The annual mean NO₂ concentrations for the base year have been verified by means of comparison against available ratified monitoring data. The modelled road NO_x concentrations were adjusted where appropriate, with reference to the methodology set out in Defra's LAQM.TG(16). Once adjusted, the total NO₂ concentrations have been considered to have acceptable model performance in accordance with Defra's LAQM.TG(16).

It was not possible to derive an adjustment factor for NH₃, PM₁₀ or PM_{2.5} as there is no suitable PM₁₀ monitoring in the air quality study area for the Scheme. The modelled road NH₃, PM₁₀ and PM_{2.5} concentrations were adjusted using the same factor delivered for NO₂ where appropriate, with reference to the methodology set out in Defra's LAQM.TG(16).

Air Quality Model Verification

Verification for NO₂

It is good practice to compare modelled estimates of pollutant concentrations with real-world monitoring to assess the model's performance for a base year and to inform the interpretation of model results for future years. Verification of the 2019 base year scenario has been undertaken by comparison of the modelled concentration against that measured at the closest monitoring site to the study area.

Model verification was undertaken considering monitoring sites within 200 metres of the roads located at suitable locations. A total of five monitoring sites were taken forward in the model verification.

The annual mean NO₂ concentrations for the 2019 base year were verified by means of comparison against available ratified monitoring data. The modelled road NO_x concentrations were adjusted where appropriate, with reference to the methodology set out in DEFRA's LAQM.TG(16). 2019 annual mean NO₂ monitored concentrations were not available, they were estimated from the 2021 values obtained from the Site specific diffusion tube survey using the roadside adjustment factor derived from the comparison between 2019 and 2021 as detailed in LAQM.TG(16).

Uncertainty in modelled estimates has been considered by calculating root mean square error (RMSE) and fractional bias statistics. An air quality model can be considered to perform reasonably well where 95% of modelled concentrations are within 25% of monitored concentrations in accordance with Defra's Technical Guidance LAQM.TG(16). The RMSE should ideally be within 10% of the relevant air quality criterion but is acceptable where it is within 25% of the relevant air quality criterion. The Fractional Bias (FB) has an ideal value of 0 but is acceptable in the range between +2 and -2.

Step1

Firstly, unadjusted modelled estimates of total annual mean NO₂ concentrations have been compared against monitored annual means. None of the modelled estimates are within +/- 25% of monitored concentrations without adjustment, as given in Table 0.1. The Fractional Bias (FB) is above the ideal value of 0, indicating that the model tends to underestimate.

Table 0.1 - Comparison of Unadjusted Modelled and Measured NO₂ Concentrations

Site	X, Y coordinates	Background Annual Mean NO ₂ (µg/m ³)	Modelled NO ₂ (µg/m ³)	Monitored NO ₂ (µg/m ³)	Modelled - Monitored	% Difference ([Modelled - Monitored] / Monitored)
1	271830.0, 195870.0	8.8	10.1	17.1	-7.0	-41%
2	271994.0, 195942.0	8.8	12.7	22.3	-9.7	-43%
3	272013.0, 196156.0	14.7	18.9	29.1	-10.2	-35%
4	272168.0, 196352.0	14.7	19.2	29.1	-9.9	-34%
5	271245.5, 194060.5	8.1	9.8	15.9	-6.0	-38%

Table 0.2 - Model Statistics Pre-Adjustment

RMSE [i]	FB [ii]	R [iii]
8.72	0.46	0.988

[i] Root Mean Square Error: RMSE is used to define the average error or uncertainty of the model (units = µg/m³). In the case of modelled annual mean NO₂ a value of less than 10 is acceptable and less than 4 is the ideal

[ii] Fractional Bias: FB is used to identify if the model shows a systematic tendency to over or under estimate. Ideal value is 0

[iii] Correlation coefficient: r is used to measure the linear relationship between modelled and observed data. Ideal value is 1

For unadjusted modelled estimates of NO₂ compared to monitored concentrations, the RMSE is 8.71 µg/m³, which is above the target value according to DEFRA's LAQM.TG(16) i.e. ideally less than 4 µg/m³ in relation to the 40 µg/m³ AQS objective for annual mean NO₂ concentrations, but as a minimum not more than 25% of the objective i.e. 10 µg/m³. Overall, the unadjusted model tends to underestimate total concentrations of NO₂, as indicated by a high fractional bias value of 0.46.

Step 2

The second comparison of modelled estimates of road contributed annual mean NO_x with the road NO_x component derived from monitoring data is presented in Table 0.3. This analysis requires the estimation of the monitored road NO_x component. This has been undertaken using DEFRA's NO₂ to NO_x calculator (version 8.1).

Modelled road NO_x concentrations can be adjusted by taking the slope of the linear regression line that has been forced through zero.

The results have been used to derive an adjustment factor of 3.63.

Table 0.3 - Comparison of Unadjusted Modelled and Measured NO_x Concentrations

Site	Modelled Road-NO _x (unadjusted)	Monitored Road-NO _x (from NO ₂ to NO _x converter)	Modelled - Monitored	Monitored / Modelled	% Difference ([Modelled - Monitored] / Monitored)
1	2.3	15.1	-12.9	6.7	-85%
2	7.0	25.4	-18.4	3.6	-72%
3	7.7	27.8	-20.0	3.6	-72%
4	8.4	27.7	-19.4	3.3	-70%
5	3.1	14.2	-11.1	4.5	-78%

Step 3

The third comparison of the adjusted modelled estimates of total annual mean NO₂ with monitored concentrations is presented in Table 0.4. Out of 5 comparisons, all modelled estimates are within +/- 25% of monitored concentrations with adjustment.

The model statistics post-adjustment are presented in Table 0.5. The overall RMSE calculated for both verification zones is below the threshold value of 25% of the AQS objective (i.e. 10 µg/m³) in both verification zones and is, therefore, considered acceptable. The FB is improved and is closer to the ideal value (0).

Table 0.4 - Comparison of Modelled and Measured NO₂ Concentrations after Adjustment

Site	Background Annual Mean NO ₂ (µg/m ³)	Adjusted Modelled Total NO ₂ (From NO _x to NO ₂ converter)	Monitored Total NO ₂	Difference Modelled - Monitored (ug/m ³)	%age Difference (Modelled-Monitored / Monitored)
1	8.8	13.4	17.1	-3.7	-22%
2	8.8	22.3	22.3	0.0	0%
3	14.7	29.2	29.1	0.1	0%
4	14.7	30.3	29.1	1.3	4%
5	8.1	14.4	15.9	-1.5	-9%

Table 0.5 - Model Statistics Post-Adjustment

RMSE [i]	FB [ii]	R [iii]
1.88	0.03	0.991

[i] Root Mean Square Error: RMSE is used to define the average error or uncertainty of the model (units = $\mu\text{g}/\text{m}^3$). In the case of modelled annual mean NO₂ a value of less than 10 is acceptable and less than 4 is the ideal

[ii] Fractional Bias: FB is used to identify if the model shows a systematic tendency to over or under estimate. Ideal value is 0

[iii] Correlation coefficient: r is used to measure the linear relationship between modelled and observed data. Ideal value is 1