APPENDIX 14.10 – MODEL VERIFICTION

Model verification studies are undertaken in order to check the performance of dispersion models and, where modelled concentrations are significantly different to monitored concentrations, a factor can be established by which the modelled results can be adjusted in order to improve their reliability. The model verification process is detailed in LAQM.TG(22).

According to TG(22), no adjustment factor is necessary where the results of the model all lie within 25% of the monitored concentrations, but ideally within 10%.

Model verification can only be undertaken where there is sufficient roadside monitoring data in the vicinity of the subject scheme being assessed. TG(22) recommends that a combination of automatic and diffusion tube monitoring data is used; although this may be limited by data availability. For this assessment, NO_2 diffusion tube sites were used to verify against due to the lack of automatic monitoring close to the site.

It is noted that one NO_2 diffusion tube is located to the south of Goldthorpe (DT 45), however, due to an error with the monitor in the 2023 Air Quality Annual Status Report, and the uncertainty of whether this tube is located in an Urban Background setting or a Roadside setting, it has been discounted from the verification process.

NO_2 Adjustment

Eight monitoring sites within Barnsley, located along the A633 and Sheffield Road have been used for the verification process, due to the lack of availability of suitable monitoring data within Goldthorpe. To note, monitors 40, 47 and 48 were discounted from the verification process due to the lack of traffic data available at these locations to accurately model NO_2 concentrations. Concentrations recorded at these diffusion tubes have been compared to modelled concentrations in order to derive an adjustment factor for NO_2. Table 14.10.1 compares the monitored and modelled NO_2 concentrations at these monitoring locations.

Table 14.10.1:Comparison of Monitored and Modelled NO_2 Concentrations

Site ID	Type	Concentrations (µg/m^3)		% Difference
		Monitored	Modelled	
57	Diffusion Tube	31.7	17.5	-44.8
58	Diffusion Tube	27.3	16.7	-38.8
61	Diffusion Tube	36.7	23.8	-35.2
53	Diffusion Tube	43.6	23.7	-45.7
65	Diffusion Tube	34.6	18.4	-46.8
62	Diffusion Tube	39.1	19.0	-51.5
63	Diffusion Tube	25.4	16.8	-33.9
64	Diffusion Tube	26.4	16.7	-36.9

The data in Table 14.10.1 shows that the model is under-predicting NO_2 concentrations. This is not unusual and is likely to be the result of local dispersion conditions.

As the difference for all of the sites is greater than +/- 25% of the monitored concentration, an adjustment factor has been derived to ensure a conservative assessment is undertaken.

As it is primary NO_x rather than secondary NO_2 emissions that are modelled, an adjustment factor must be derived for the road contribution of NO_x. A ratio of the modelled versus monitored NO_x concentrations using the least squares statistical method has been undertaken to derive an adjustment factor, as set out in Table 14.10.2.

Table 14.10.2:Comparison of Monitored and Modelled NO_2 Concentrations

Site ID	Concentrations (µg/m^3)		Ratio
	Monitored Road NO_x	Modelled Road NO_x	
57	34.7	6.4	5.852
58	25.6	4.9	
61	33.7	7.3	
53	49.1	7.1	
65	39.3	6.6	
62	49.3	7.7	
63	20.2	3.6	
64	22.2	3.3	

Table 14.10.3 compares monitored and modelled NO_2 concentrations at the monitoring location after the adjustment factor has been applied to both modelled road-NO_x concentrations.

Table 14.10.3:Comparison of Monitored and Adjusted Modelled NO_2 Concentrations

Site ID	Type	Concentrations (µg/m^3)		% Difference
		Monitored	Modelled	
57	Diffusion Tube	31.7	32.9	3.8
58	Diffusion Tube	27.3	28.9	5.9
61	Diffusion Tube	36.7	40.9	11.3
53	Diffusion Tube	43.6	40.3	-7.6
65	Diffusion Tube	34.6	34.2	-1.2
62	Diffusion Tube	39.1	37.1	-5.1
63	Diffusion Tube	25.4	25.8	1.7
64	Diffusion Tube	26.4	25.1	-4.9

The data in Table 14.10.3 shows that all modelled NO_2 concentrations are now within =/- 25% of monitored concentrations, and the majority within the ideal 10% of the monitored concentration as set out in TG(22), indicating that the model is performing acceptably.

Root Mean Square Error

A Root Mean Square Error (RMSE) has been calculated in Table 14.10.4 to determine the error within the calculations before Road-NOx adjustment, based upon the following calculation:

$$RMSE = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (obs_i - Pred_i)^2}$$

Table 14.10.4:Root Mean Squared Error

Site ID	Concentrations (µg/m³)		
	Monitored	**Modelled**	**Difference**
57	31.7	32.9	1.2
58	27.3	28.9	1.6
61	36.7	40.9	4.2
53	43.6	40.3	-3.3
65	34.6	34.2	-0.4
62	39.1	37.1	-2.0
63	25.4	25.8	0.4
64	26.4	25.1	-1.3
RMSE			**2.2**

The calculated RMSE is 2.2 µg/m^3, which correlates to an 5.5% error ratio. The RMSE means that modelled results could be under or over predicting pollution concentrations between +/- 2.2 µg/m^3. The RMSE means that modelled results are acceptable, as they are within a 10% margin of error (as advised in TG(22)), and therefore no further adjustment factor is required.

Fractional Bias

The fractional bias, as set out in Table 14.10.5, has been calculated to identify if the model shows a systematic tendency to over or under-predict. The following formula has been used to calculate the fractional bias:

$$FB = \frac{(Avg.Obs - Avg.Pred)}{0.5\,(Avg.Obs + Avg.Pred)}$$

Table 14.10.5: Fractional Bias

Average Observed Values ($\mu g/m^3$)	Average Predicted Values ($\mu g/m^3$)	Fractional Bias
33.1	33.1	-0.001

The calculated fractional bias is -0.001 which indicates that the model is slightly overpredicting. However, the fractional bias is close to the ideal value of 0, which suggests that the model is performing acceptably.

Correlation Coefficient

A correlation coefficient has been calculated to measure the linear relationship between predicted and observed data. A value of zero means no relationship and a value of 1 means absolute relationship.

The correlation coefficient for the monitored and modelled values set out in Table 14.10.3 is 0.934, which suggests that the monitored and modelled values post adjustment are close to an absolute relationship.

Particulate Matter Adjustment

An adjustment factor has also been calculated at one automatic monitoring site for PM_{10}. Monitor BAR9, located along the A635 Doncaster Road, monitored concentrations of PM_{10} in 2022. Concentrations recorded at this monitor has been compared to modelled concentrations in order to derive an adjustment factor for PM_{10}. Table 14.10.6 compares the monitored and modelled PM_{10} concentration at this monitoring location.

Table 14.10.6:Comparison of Monitored and Modelled PM_{10} Concentrations

Site ID	Type	Concentrations ($\mu g/m^3$)		% Difference
		Monitored	Modelled	
BAR9	Automatic Monitor	21.0	14.9	-29.1

The data in Table 14.10.6 shows that the model is under-predicting PM_{10} concentrations. This is not unusual and is likely to be the result of local dispersion conditions.

As the difference for all of the sites is greater than +/- 25% of the monitored concentration, an adjustment factor has been derived to ensure a conservative assessment is undertaken. A ratio of the modelled versus monitored PM_{10} concentrations using the least squares statistical method has been undertaken to derive an adjustment factor, as set out in Table 14.10.7.

Table 14.10.7:Comparison of Monitored and Modelled PM_{10} Concentrations

Site ID	Concentrations ($\mu g/m^3$)		Ratio
	Monitored Road PM_{10}	Modelled Road PM_{10}	
BAR9	6.8	0.7	**10.051**

The data in Table 14.10.7 shows that the modelled PM_{10} concentration is now within the ideal =/-10% of the monitored concentration as set out in TG(22), indicating that the model is performing acceptably.

As there are no appropriate $PM_{2.5}$ monitoring locations within the study area, the predicted road-$PM_{2.5}$ components have been adjusted using the road-PM_{10} factor above before adding the appropriate background concentration.