M20 Junction 10a

TR010006

Appendix 5.1 Model Verification

APFP Regulation 5(2)(q)

Revision A

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

Volume 6.3

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Content

1. Model Verification

1.1 Methodology

1.1.1 The Defra (2016) definition of model verification is

'the comparison of modelled results versus monitoring results at relevant locations to enable the adjustment of model outputs, minimising inherent uncertainties associated with dispersion modelling.'

1.1.2 Verification of modelled 2014 annual mean NO_2 concentrations has been carried out using monitoring results from a number of relevant diffusion tubes sites within the study area.

1.1.3 Data from local authority monitoring and the scheme monitoring were reviewed and only sites that are within the Affected Road Network (ARN) or roads within 200 metres of the ARN have been included in the verification process.

1.1.4 Two of the local authority monitoring sites were coincident with the affected road network; 1 site at Hythe Road (AS06) and a triplicate exposure site at Lees Road (AS15).

1.1.5 A number of scheme monitoring sites have been included within the model verification. Scheme monitored concentrations are available from September 2013 to August 2014 (12 months of data).

1.1.6 There are 2 approaches that can be undertaken with a data set that incorporates 12 months of monitoring over 2 separate years. The first approach is to treat the 12 months of data from 2013-2014 as representative of a 2014 annual mean. The second approach is to annualise the 8 months of 2014 data following Defra guidance (TG(16)).

1.1.7 This assessment has undertaken both approaches and the annualisation approach has been applied as this presents the most conservative adjustment factor for assessing deteriorations in air quality. The annualisation process is described in Appendix 5.2, Volume 6.3.

1.1.8 Table 1.8 presents the reasons for inclusion or exclusion of diffusion tubes from the verification process.

1.1.9 No data are available within the study area to verify modelled PM_{10}, and as such the verification has been carried out for NO_2 only. Given the low PM_{10} concentrations within the study area, and relatively low potential for impact in comparison with NO_2, verification of PM_{10} is not considered necessary.

1.1.10 Table 1.1 presents the monitoring data used within the model verification.

Table 1.1 Monitoring Date used within the Model Verification

Site ID	Type	Annual Mean (µg/m^3)	
		NO_x[(a)]	NO_2
M20J10A_001_0813	Diffusion Tube	30.5	19.8
M20J10A_003_0813	Diffusion Tube	78.4	40.5
M20J10A_004_0813	Diffusion Tube	42.3	25.4
M20J10A_005_0813	Diffusion Tube	45.9	27.2
M20J10A_006_0813	Diffusion Tube	82.5	42.2
M20J10A_007_0813	Diffusion Tube	51.2	29.6
M20J10A_008_0813	Diffusion Tube	46.0	27.3
M20J10A_009_0813	Diffusion Tube	44.2	26.5
M20J10A_010_0813	Diffusion Tube	42.8	25.8
M20J10A_011_0813	Diffusion Tube	45.4	27.0
M20J10A_012_0813	Diffusion Tube	63.1	34.6
M20J10A_013_0813	Diffusion Tube	39.3	24.1
M20J10A_014_0813	Diffusion Tube	35.5	22.8
M20J10A_015_0813	Diffusion Tube	37.6	23.3
M20J10A_018_0813	Diffusion Tube	74.9	39.1
AS06	Diffusion Tube	50.6	29.3
AS15	Diffusion Tube	69.3	37.1

Notes: [(a)] Derived from NO_2 to NO_x calculator

1.2 Results

1.2.1 Table 1.2 and Figure 1.1 present the results of the model verification. The negative percentage differences presented in Table 1.2 show that the modelled NO_2 concentrations at all locations are below the monitored value meaning the model under-predicts annual mean NO_2 concentrations at all the monitoring sites. An adjustment factor of 2.4 has been derived for all receptor locations. The suitability of the adjustment factor has been discussed below.

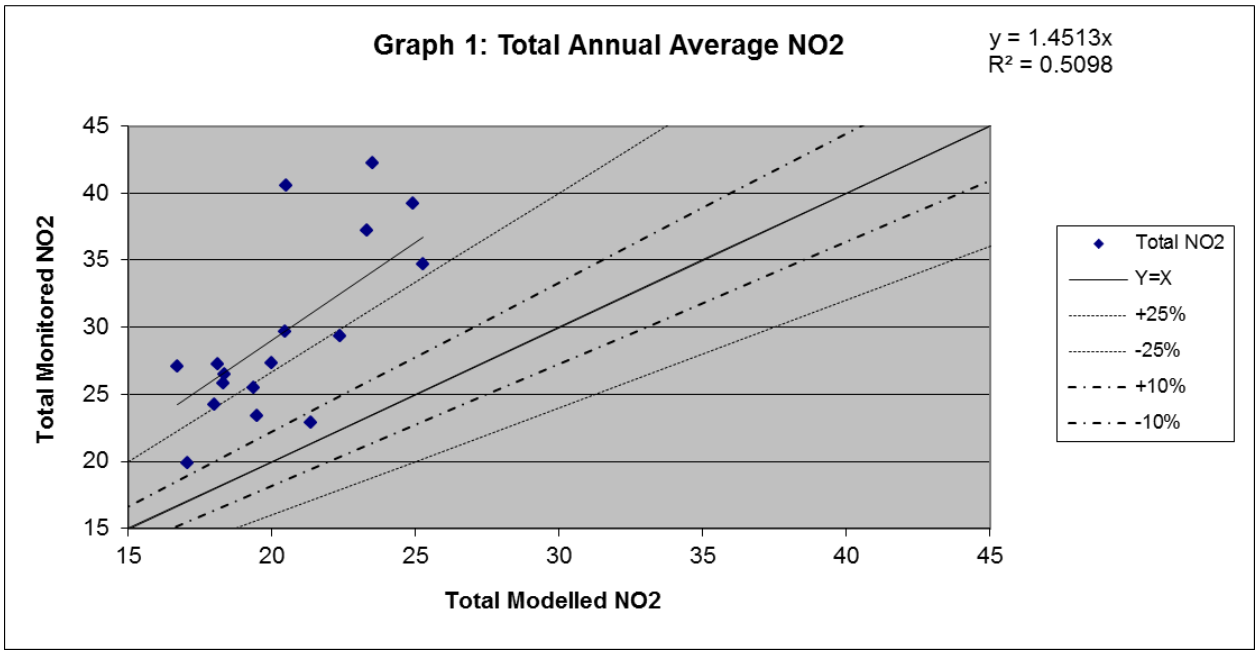
1.2.2 Before adjustment, the modelled NO_2 concentrations are within 10% of the monitored concentration at one monitoring site, between 10% and 25% at four monitoring sites and greater than 25% at 12 monitoring sites.

1.2.3 Following the application of the adjustment factor to the NO_x model outputs, the NO_2 concentrations are within 10% of the monitored concentration at 8 monitoring sites, between 10% and 25% at 8 monitoring sites and greater than 25% at 1 monitoring site.

Table 1.2 Unadjusted Model Verification Results

Site ID	Monitored Road NO_x ($\mu g/m^3$)	Modelled Road NO_x ($\mu g/m^3$)	Monitored Total NO_2 ($\mu g/m^3$)	Modelled Total NO_2 ($\mu g/m^3$)	Total NO_2 % Difference
M20J10A_001_0813	30.5	8.5	19.8	17.1	-13.8
M20J10A_003_0813	78.4	15.4	40.5	20.5	-49.3
M20J10A_004_0813	42.3	13.1	25.4	19.4	-23.8
M20J10A_005_0813	45.9	9.4	27.2	18.1	-33.4
M20J10A_006_0813	82.5	20.5	42.2	23.5	-44.3
M20J10A_007_0813	51.2	14.1	29.6	20.5	-30.8
M20J10A_008_0813	46.0	13.2	27.3	20.0	-26.6
M20J10A_009_0813	44.2	9.8	26.5	18.3	-30.7
M20J10A_010_0813	42.8	9.8	25.8	18.3	-29.0
M20J10A_011_0813	45.4	6.6	27.0	16.7	-38.2
M20J10A_012_0813	63.1	24.6	34.6	25.3	-26.9
M20J10A_013_0813	39.3	9.5	24.1	18.0	-25.5
M20J10A_014_0813	35.5	12.7	22.8	21.4	-6.4
M20J10A_015_0813	37.6	12.5	23.3	19.5	-16.5
M20J10A_018_0813	74.9	24.7	39.1	24.9	-36.3
AS06	50.6	18.0	29.3	22.4	-23.7
AS15	69.3	20.4	37.1	23.3	-37.1

Figure 1.1 Unadjusted Model Verification Results



1.2.4 Table 1.1 and Figure 1.2 present the adjusted modelled NO_2 concentrations and the 2014 annualised NO_2 monitoring data at each of the verification sites. The adjustment factor is applied to the modelled road NO_x contributions and added to the background NO_x concentrations to give total corrected NO_x at the verification site. The NO_x to NO_2 conversion has been applied to these values to provide total adjusted modelled NO_2.

1.2.5 Exceedances of the annual NO_2 objective were measured at sites M20J10A_003_0813 and M20J10A_006_0813, where a respective concentration of 40.5 and 42.2 µg/m^3 was monitored. At these sites the adjusted model results are under-predicting annual mean NO_2 concentrations by 25% and 14.9% respectively. There could therefore be exceedances of the annual objective at nearby receptors which are not being represented in the model, and so this has been reviewed as described in the paragraph below.

1.2.6 Site M20J10A_003_0813 is the only roadside site within 5m of the curb on the A20 (Hythe Road), and the modelled versus monitored results suggest that concentrations are likely to be under predicted along this road. The closest receptors to the A20 (within the Affected Road Network, ARN) are located approximately 12m from the road, and so taking into account the monitoring data, it is likely that there would be no exceedances of the annual objective at worst-case receptors adjacent to the A20. Furthermore, traffic flows on the A20 decrease as a result of the Scheme, and so no adverse effects are predicted at receptors on this road.

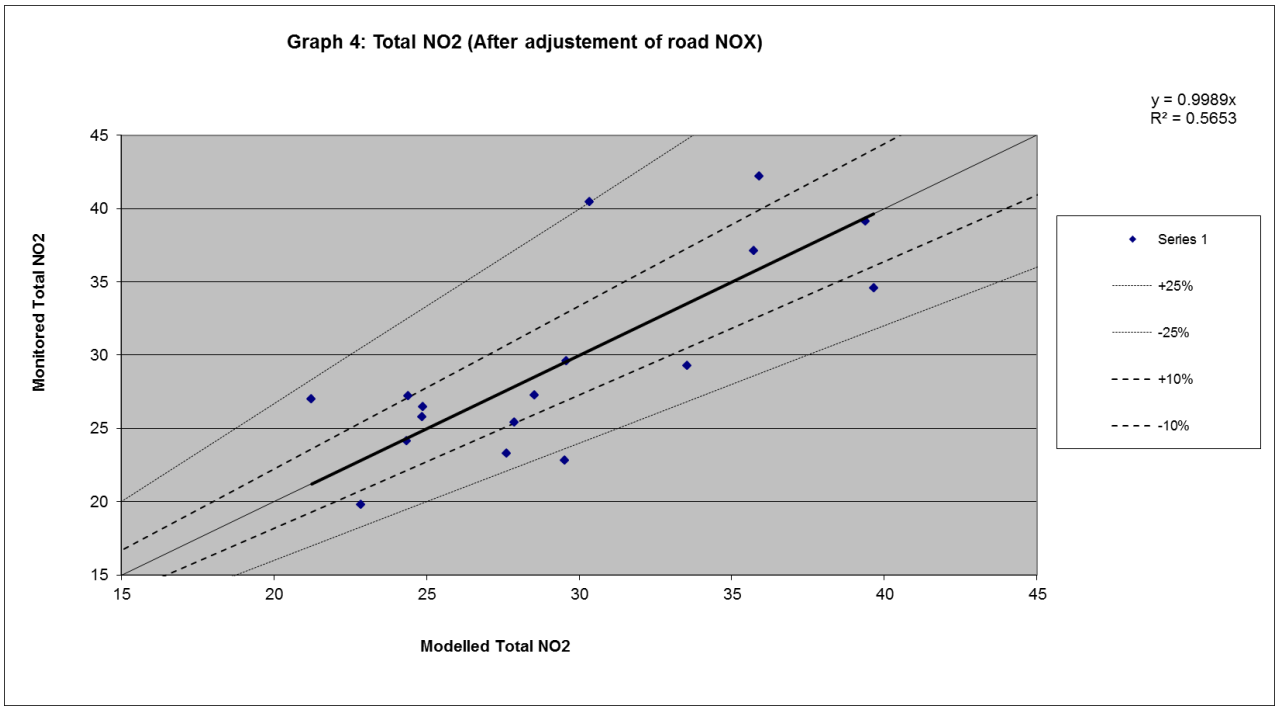
1.2.7 Site M20J10A_006_0813 is the only roadside site adjacent to the A2070 (Kennington Road), and it is likely that concentrations could also be under predicted along this road. This road has been included in the model in order to represent a background contribution at receptors as it is within 200 metres of the ARN. A small portion of receptors along the A2070 (Kennington Road) are included in the assessment as they are within 200m of the ARN, however these receptors are not predicted to have any adverse effects as a result of the Scheme.

Table 1.3 Adjusted Model Verification Results

Site ID	Monitored Total NO_2 (µg/m^3)	Modelled Total NO_2 (µg/m^3)	% Difference
M20J10A_001_0813	19.8	22.9	15.4
M20J10A_003_0813	40.5	30.3	-25.0
M20J10A_004_0813	25.4	27.9	9.8
M20J10A_005_0813	27.2	24.4	-10.3
M20J10A_006_0813	42.2	35.9	-14.9
M20J10A_007_0813	29.6	29.6	0.0
M20J10A_008_0813	27.3	28.5	4.7
M20J10A_009_0813	26.5	24.9	-5.9
M20J10A_010_0813	25.8	24.9	-3.6
M20J10A_011_0813	27.0	21.2	-21.4
M20J10A_012_0813	34.6	39.7	14.7

Site ID	Monitored Total NO_2 (µg/m^3)	Modelled Total NO_2 (µg/m^3)	% Difference
M20J10A_013_0813	24.1	24.4	0.9
M20J10A_014_0813	22.8	29.5	29.4
M20J10A_015_0813	23.3	27.6	18.5
M20J10A_018_0813	39.1	39.4	0.6
AS06	29.3	33.5	14.5
AS15	37.1	35.7	-3.7

Figure 1.2 Adjusted Model Verification Results



1.2.8 Table 1.4 presents 2 statistical parameters for describing model uncertainty.

1.2.9 The Root Mean Square Error (RMSE) is used to define the average error or uncertainty of the model. The results of the RMSE calculation in this case are concentrations of NO_2 measured in units of micrograms per metre cubed. Table 1.4 shows that before adjustment the model uncertainty was as high as ±37.5µg/m^3 or 93.8% of the annual mean NO_2 objective. After adjustment the model uncertainty is reduced to ±0.3µg/m^3 or 0.75% of the annual mean NO_2 objective. Therefore, after adjustment the model uncertainty is well within the desired 10% of the relevant objective.

1.2.10 Fractional Bias (FB) is used to identify if the model shows a tendency to over or under predict and values can vary between +2 and -2 and have an ideal value of 0. Negative values suggest a model over-prediction and positive values suggest a model under-prediction. Table 1.4 shows that before adjustment the model is under-predicting annual mean NO_2 concentrations. Following adjustment the model is very close to the desired FB value of 0 with a slight tendency to under-predict.

Table 1.4 Description of Model Uncertainty

Statistical Parameter	Before Adjustment	After Adjustment	Ideal Value
Root Mean Square Error	37.5	0.3	0
Fractional Bias[(a)]	0.364	0.002	0

Note: [(a)] Fractional bias shown to three decimal places to show after adjustment value is not 0, as a value of 0 means the model outputs are perfectly representing monitored concentrations.

1.3 Additional Adjustment Factor

1.3.1 Following the application of the 2.4 adjustment factor to the whole study area the predicted modelled concentrations at the area of receptors located adjacent to the M20, Silver Hill Road and Lees Road was investigated further.

1.3.2 A review of the diffusion tubes closest tubes to this area, M20J10A_012_0813 and AS15 indicates that (after adjustment) the model is performing well at location AS15 but is over predicting by approximately 15% at M20J10A_012_0813. It should be noted that tube AS15 is a triplicate site and therefore considered to provide more accurate results than a diffusion tube in isolation.

1.3.3 The modelled contributions of NO_x from the M20 at both monitoring locations (M20J10A_012_0813 and AS15) are similar. A review of individual road contributions at both sites showed that the 15% over prediction was not solely as a result of additional NO_x contributions from Silver Hill Road as contributions from this road link are small, as demonstrated in the Table 1.5.

Table 1.5 Modelled NO_x Contributions at Diffusion Tubes ($\mu g/m^3$)

Diffusion tube	M20 unadjusted NO_x contribution	Silver Hill Road unadjusted NO_x contribution
M20J10A_012_0813	21.9	2.7
AS15	20.2	0.2

1.3.4 The model over prediction at tube M20J10A_012_0813, compared is AS15, is considered to be likely to be due to the difference in elevation between the two respective monitoring locations, relative to the M20.

1.3.5 The two diffusion tubes are similar distances from the M20. However, diffusion tube AS15 was located on the façade of a property on Lees Road that is approximately the same height as the M20 carriageway and M20J10A_012_0813 was located on a lamp post approximately 5 metres below the carriageway.

1.3.6 Because of this, a separated adjustment factor has been derived for this area. This has been based on the tube M20J10A_012_0813 and has been derived in the same way as describe above. Table 1.6 and Table 1.7 present the

unadjusted and adjusted modelled results at tube 12. An adjustment factor of 1.9 has been derived based on the results for tube 12 only.

Table 1.6 Unadjusted Model Verification Results

Site ID	Monitored Road NO_x ($\mu g/m^3$)	Modelled Road NO_x ($\mu g/m^3$)	Monitored Total NO_2 ($\mu g/m^3$)	Modelled Total NO_2 ($\mu g/m^3$)	Total NO_2 % Difference
M20J10A_012_0813	63.1	24.6	34.6	25.3	-26.9

Table 1.7 Adjusted Model Verification Results

Site ID	Monitored Total NO_2 ($\mu g/m^3$)	Modelled Total NO_2 ($\mu g/m^3$)	% Difference
M20J10A_012_0813	34.6	34.6	0

1.3.7 The adjustment factor of 1.9 has been applied to 14 receptors in total in the area in question. These are:

- 451 – Wynarcki
- 624 - 7 Winslade Terrace
- 155 – ‘Stepping Stones’, Lees Road
- 198 – 2 Winslade Terrace
- 460 – ‘Sunningdale’ Silver Hill Road
- 607 – 3 Winslade Terrace
- 608 – 5 Winslade Terrace
- 609 – 4 Winslade Terrace
- 610 - 3 Winslade Way
- 611 – 5 Winslade Way
- 619 - 1 Winslade Terrace
- 627 – 6 Winslade Terrace
- 818 – 2 Windslade Way
- 1373 – 1 Windslade Way

1.3.8 The results presented in Chapter 5 Air Quality, Volume 6.1 indicate the closest receptors to the carriageway are predicted to experience an exceedence of the air quality objective in both the Do-Minimum and Do-Something scenarios after applying the adjustment factor of 1.9.

1.3.9 The choice of adjustment factor at these locations does not affect the conclusions of this assessment. When applying either adjustment factor (2.4 or 1.9) to these receptors the changes in annual mean concentrations between the Do-Minimum and Do-Something scenarios are less than 0.4µg/m^3 and therefore considered imperceptible.

1.3.10 The need for a separate adjustment factor for other parts of the study area where there are receptors located at heights below the M20 was reviewed and not considered necessary. The application of the more conservative adjustment of 2.4 at all other locations factor does result in an exceedance of the air quality objectives and is consistent with the monitoring data available. When applying the adjustment factor of 2.4 to the rest of the study area the scheme is not considered to have significant impacts.

1.4 Diffusion Tube Notes

Table 1.8 Diffusion Tube Notes

Tube ID	X	Y	Included?	Reason[(a)]
AS03	600976	142547	No	Outside study area
AS04	601021	142754	No	Background site
AS06	603153	141990	Yes	-
AS07	587945	133079	No	Outside study area
AS14	601460	143509	No	Outside study area
AS15	603401	142081	Yes	-
AS18	601309	143569	No	Outside study area
AS21	600734	142717	No	Outside study area
AS22	601218	143491	No	Outside study area
AS23	601431	142735	No	Background site
AS24	600778	142915	No	Outside study area
AS26	601249	142975	No	Outside study area
AS27	600794	142320	No	Outside study area
AS30	599433	142371	No	Background site
AS31	601828	141461	No	Outside study area
AS32	600973	143027	No	Kerbside Site and outside study area
M20J10A_001_0813	604514	141023	Yes	-
M20J10A_002_0813	604821	140402	No	No traffic flows on adjacent link in Base SATURN model outputs
M20J10A_003_0813	604186	141441	Yes	-
M20J10A_004_0813	604060	141639	Yes	-
M20J10A_005_0813	603996	141702	Yes	-
M20J10A_006_0813	603767	141807	Yes	-
M20J10A_007_0813	603616	141885	Yes	-
M20J10A_008_0813	603482	141791	Yes	-
M20J10A_009_0813	603599	141530	Yes	-
M20J10A_010_0813	603587	141305	Yes	-
M20J10A_011_0813	603547	141113	Yes	-
M20J10A_012_0813	603331	142141	Yes	-

Tube ID	X	Y	Included?	Reason[a]
M20J10A_013_0813	603138	142211	Yes	-
M20J10A_014_0813	602948	142452	Yes	-
M20J10A_015_0813	603046	142537	Yes	-
M20J10A_016_0813	598856	140312	No	Outside study area
M20J10A_017_0813	602105	144824	No	Outside study area
M20J10A_018_0813	604693	141027	Yes	-
M20J10A_019_0813	603673	141872	No	Low data capture
M20J10A_020_0813	603655	141886	No	Low data capture
M20J10A_021_0813	603384	142092	No	Low data capture
M20J10A_022_0813	603328	142178	No	Low data capture
M20J10A_023_0813	603282	142040	No	Low data capture