A47 Wansford to Sutton Dualling

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6.3 Environmental Statement Appendices

Appendix 5.2 – Air quality verification and model adjustment

APFP Regulation 5(2)(a)

Planning Act 2008

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

July 2021

Infrastructure Planning

Planning Act 2008

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

A47 Wansford to Sutton Development Consent Order 202[x]

ENVIRONMENTAL STATEMENT APPENDICES
Appendix 5.2 - Air quality verification and model adjustment

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Appendix 5.2 – Air quality verification and model adjustment

5.1. Introduction

5.1.1. Model verification is the comparison of modelled concentrations with available local monitoring data. Verification identifies how accurate the modelled results are in comparison to monitored results and provides an indication on how well the model is preforming. Discrepancies in results can arise as a result of the following:

- Uncertainties and limitations with meteorological data
- Inaccuracies in the traffic data
- Estimates of background pollutant concentrations and any backcasting required
- Variables in the model input parameters such as roughness length, minimum Monin-Obukhov
- The overall limitations with the dispersion model
- Inaccuracies associated with monitoring data and monitored locations

5.2. Model performance

5.2.1. The model performance was scrutinised to establish how robust the modelled results were when compared to monitoring data. Guidance outlined in Local Air Quality Management Technical Guidance 2016 (LAQM.TG(16)) was used to evaluate the model's performance and identify any uncertainties. The guidance states modelled results must be adjusted to ensure final concentrations are representative of the monitoring information in the study area.

5.2.2. A number of statistical procedures outlined in LAQM.TG(16) were used to evaluate model performance and assess uncertainties. The statistical parameters used to describe the uncertainties within the model are as follows:

- The correlation coefficient
- Fractional bias
- Root Mean Square Error (RMSE)

5.2.3. The statistical parameters estimate whether the modelled results agree or deviate from observations. These parameters provide valuable information on how well the model is preforming. A more detailed description on these statistical parameters can be found in Table 1 below, taken from LAQM.TG(16) Box A7.17.

Table 1: Model performance statistics

Statistical Parameter	Description	Ideal Value
Correlation Coefficient	Measures the linear relationship between the predicted and observed data. A value of zero means there is no relationship and a value of 1 means an absolute relationship exists. This statistic is useful when a large number of model and observed data points are being compared.	1.00
Fractional Bias	Identifies if the model shows a systematic tendency to over or under predict. Fractional bias values vary between +2 and -2, with an ideal value of zero. Negative values suggest the model is over-predicting and positive values suggest the model is under-predicting.	0.0
Root Mean Square Error (RMSE)	Defines the average error or uncertainty of the model. The units of RMSE are the same as the quantities being compared.	0.0

5.2.4. These statistical parameters are used to draw the following comparison:

- To draw a comparison between the observations against the predictions from a given model in order for performance and uncertainty to be evaluated.
- To compare the observations with the predictions from a number of set ups of a given model, called model sensitivity. This identifies which model set up performs better.
- Compare observations with predictions from different models.

5.2.5. These calculations have been carried out prior to and after adjustment and help provide useful information on model improvement as a result of the application of the verification adjustment factors.

5.2.6. If the model does not perform well against the monitoring data, then a review of the input data must be done to ensure it is reasonable and accurately represents the air quality modelling process. If all input data, such as background concentrations and traffic data, has been reviewed and deemed suitable, then the modelled results may need to be adjusted to better align with monitored results.

5.3. Air quality monitoring data

5.3.1. Two sets of air quality monitoring data were available for this air quality assessment:

- Local authority monitoring sites with concentrations ranging from 2015-2018
- Scheme specific Highways England monitoring data producing a 2019 annual mean NO_2

5.3.2. LAQM.TG(16) recommends model verification to be performed on roadside and background sites only. Therefore, in accordance with the guidance, only roadside local authority monitoring locations within the study area were chosen for model verification. This equated to two local authority monitoring tubes in 2015 from Peterborough City Council and Huntingdonshire District Council:

- Site Id = 1 (Wittering)
- Site Id = Stibbington 1 (7 Great North Road)

5.3.3. Due to a baseline traffic dataset for the year 2015 being provided, this had the potential to limit the monitoring data which could be used for verification.

5.3.4. The scheme specific monitoring data once bias adjusted and annualised, was factored back to 2015 to review annual mean concentration around the Proposed Scheme in 2015, and to be used for verification purposes.

5.3.5. The scheme specific monitoring data was factored back from 2019 to 2015 using local measurement data from the Peterborough City Council's monitoring network. The Castle Meadow automatic monitoring site, located within Norwich city centre, was used produce the back-casting factor.

5.3.6. This introduced a level of uncertainty to the monitored results. Full details on the bias adjustment, annualisation and projection of annual mean to 2015 is discussed in the bias adjustment and annualisation section within this appendix.

5.4. Bias adjustment and annualisation

Scheme specific monitoring

5.4.1. Highways England undertook a six-month monitoring survey around the study area using NO_2 diffusion tubes for the purpose of this assessment. The survey ran from September 2019 to March 2020, with the monitoring being reported at three locations within the study area.

5.4.2. The concentrations measured at these locations required bias adjustment and annualisation to produce annual mean concentrations representative of 2019. Bias adjustment was derived using the national bias adjustment spreadsheet (version 03/20). The national bias adjustment factor for SOCOTEC Didcot, using 20% triethanolamine (TEA) in water was 0.76.

5.4.3. A local bias adjustment factor was calculated using the co-location at Norwich Castle Meadow automatic monitoring site; however, this produced a bias adjustment factor of 0.67. This is significantly lower than the national bias adjustment factor and could result in an underprediction of annual mean concentrations. In line with South Norfolk Council's most recent annual status report (ASR), our study has used the national adjustment factor of 0.76.

5.4.4. The bias adjusted diffusion tube data were then annualised to calculate a 2019 equivalent annual mean. The six months of monitoring data used an annualisation factor derived from the local automatic monitoring network. The results on how the factor was derived are presented in Table 2.

Table 2: Derivation of the annualisation factor

Site ID	Site type	2019 annual mean (µg/m³)	2019 period mean (µg/m³)	2019 ratio (annual mean or period Mean)	Annualisation factor (average ratio across all three sites)
Norwich Lakenfields	Urban Background	12.7	15.9	0.80	0.83
Wicken Fen	Rural Background	8.5	11.0	0.77	
Castle Meadow	Roadside	41.2	44.3	0.93	

5.4.5. The bias adjustment and annualisation factors were then applied to the monitored results to produce a final 2019 annual mean. Full results are presented in Table 3 below.

Table 3: Derivation of the 2019 annualised bias adjusted annual mean

Site ID	Raw 6 month period mean	National bias adjustment factor	National bias adjusted 6 month period mean	Annualisation factor	Annualised bias adjusted annual mean
Wansford 4	40.5	0.76	30.8	0.83	25.6
Wansford 5	23.0		17.5		14.6
Wansford 6	17.6		13.4		11.2

Monitoring year adjustment

5.4.6. The baseline year considered within the assessment is 2015, therefore 2019 annual mean data were projected back to produce an indicative 2015 annual mean concentration.

5.4.7. At the time of the assessment 2019 data had not been published by the Local Authorities within the study area. Therefore, 2019 measurement data from the automatic monitoring station at Castle Meadow in Norwich city centre was used to adjust the 2019 data to 2015, to be used for model verification purposes. This was completed by producing a factor by diving the 2019 annual mean by the

2015 annual mean (41/55 = 1.34). The 2019 scheme specific monitoring results were then factored back to 2015 using this value. The full results of the back projection of monitoring concentrations are presented in Table 4.

Table 4: Back projection of 2019 monitored results

Site ID	Annualised bias adjusted annual mean 2019	Factored to 2015 (1.34)
Wansford 4	25.6	34.4
Wansford 5	14.6	19.6
Wansford 6	11.2	15.0

Verification methodology

NO_x and NO_2

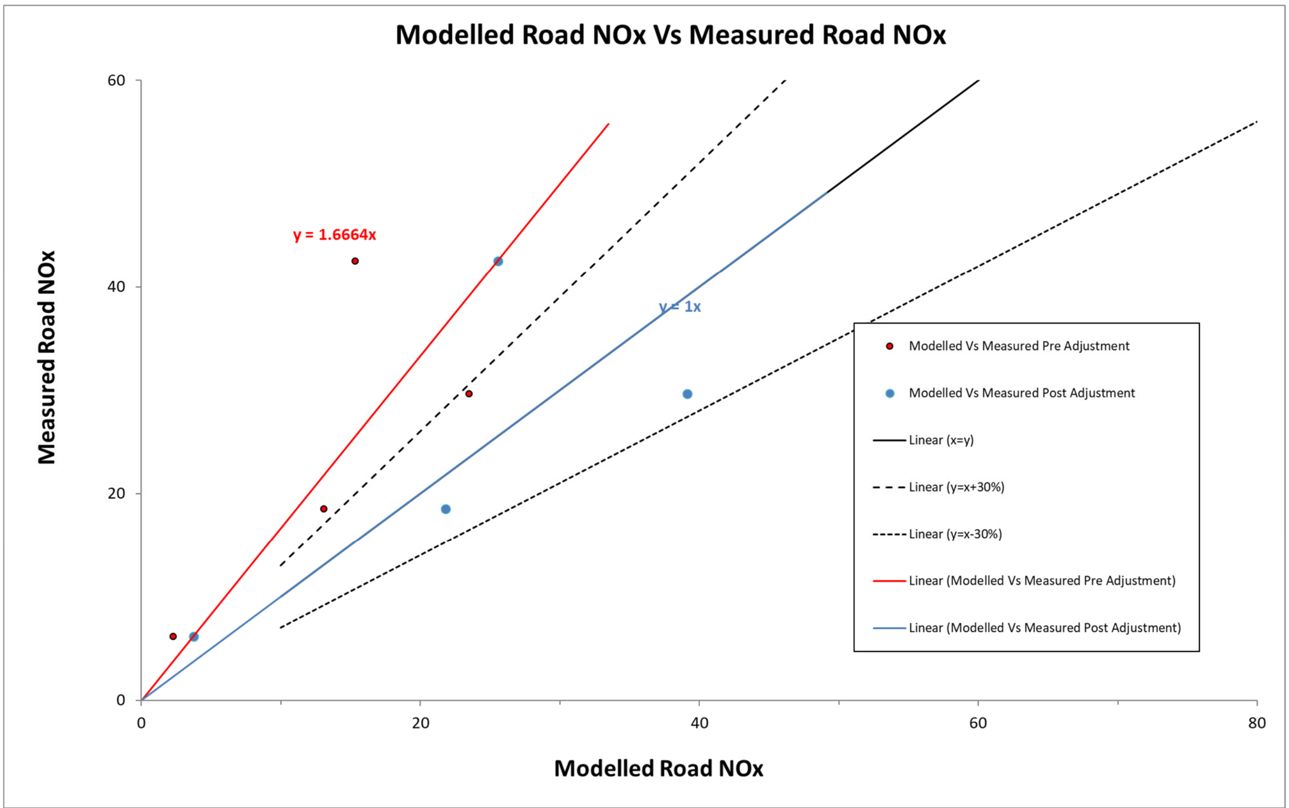
5.4.8. The verification methodology followed the guidance outlined in LAQM TG.(16). The first step in the verification process was to compare the modelled road NO_x against the monitored road NO_x. Since diffusion tubes measure NO_2, the Defra NO_x to NO_2 calculator was used to calculate the road NO_x from the local authority diffusion tubes. This comparison allowed for the modelled road NO_x to be adjusted.

5.4.9. Linear regression determines the best line of fit for the modelled NO_x against the monitored NO_x. The gradient of the best line of fit is then used as the adjustment factor.

5.4.10. The second step in the verification process was to calculate the road NO_2. Using the adjusted road NO_x from step 1. The NO_x to NO_2 calculator was used to convert the adjusted road NO_x into road NO_2. A comparison was then drawn between the road NO_2 against the monitored NO_2, and the road NO_2 was adjusted accordingly.

5.4.11. The linear regression plots comparing modelled and monitored road NO_x concentrations before and after adjustment for both the local authority monitoring can be found in Figure 1.

Figure 1: Linear regression plot of modelled vs monitored NO_x 2015 – local authority and scheme specific monitoring.



5.4.12. Prior to adjusting the modelling results all input data were reviewed, and no further improvements were identified.

5.4.13. Following modelling adjustment of the road NO_x as described above. The calculated annual mean NO_2 concentrations, modelled vs monitored concentrations before and after adjustment can be found in Table 5.

Table 5: Calculated annual mean NO2 concentrations, modelled vs monitored concentrations before and after adjustment

Tube ID	Monitoring	Monitored NO_2 ($\mu g/m^3$)	Unadjusted Total NO_2 ($\mu g/m^3$)	Percentage difference (%)	Adjusted Total NO_2 ($\mu g/m^3$)
5 – Wittering	Local authority	21.9	19.2	12	23.6
Stibbington 1 – Great North Rd	Local authority	29.6	26.8	9	34.0
Wansford 4	Scheme specific	34.4	21.9	36	26.9
Wansford 6	Scheme specific	15.0	12.9	14	13.8

5.4.14. A summary of the adjustment factors and model performance statistics can be found in Table 6 below.

Table 6: summary of adjustment factors and model performance statistics

Monitoring Sites	Number of monitoring sites	Adjustment factor	RMSE
Local authority and scheme specific	4	1.6664	4.47

PM_{10}

5.4.15. In accordance with LAQM TG (16), in the absence of any PM_{10} monitoring data for verification, the NO_x adjustment factor may be applied to the modelled PM_{10} results. Due to the absence of monitoring sites measuring PM_{10} around the study area, the NO_x verification factor was used to adjust the PM_{10} baseline modelled results.