Northamptonshire County Council

APPENDIX 6-4

Dispersion Model Approach and Verification

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QUALITY CONTROL

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6. DISPERSION MODEL APPROACH AND VERIFICATION

INTRODUCTION

6.1.1. Air pollution in urban areas is dominated by emissions from road vehicles. The main pollutants of concern from road traffic are oxides of nitrogen (NO_x/NO_2) and fine particulate matter (PM_{10} and $PM_{2.5}$), since these pollutants are most likely to approach their relevant air quality limit values in proximity to major road links.

6.1.2. The introduction of the Proposed Scheme has the potential to change the total flow, distribution and characteristics of traffic movements on the affected road links, which would result in changes to emissions of the aforementioned pollutants. The local air quality assessment was completed to predict the potential impacts of these changes on ambient pollutant concentrations at identified sensitive receptors within proximity to affected roads.

6.1.3. The air quality conditions were described for the base year (2018) and Assessment Years (2021 and 2031). In 2021 and 2031, the dispersion modelling assessment considered both the Do-Minimum ('without' Proposed Scheme) and Do-Something ('with' Proposed Scheme) scenarios.

6.1.4. The changes in local traffic related pollution levels predicted at the receptor locations were assessed by comparing the predicted concentrations of NO_2, PM_{10} and $PM_{2.5}$ with the current air quality Objectives and considering the change (improvement or worsening) between the Do-Minimum and both Do-Something scenarios.

MODELLING METHODOLOGY

ATMOSPHERIC DISPERSION MODEL SELECTION

6.1.5. The predicted impacts on local air quality associated with changes to vehicle emissions as a result of the operation of the scheme were assessed using Cambridge Environmental Research Consultants (CERC) atmospheric dispersion modelling system for roads (ADMS-Roads v4.1.1).

6.1.6. ADMS-Roads applies advanced algorithms for the height-dependence of wind speed, turbulence and stability to produce improved predictions of air pollutant concentrations within the given model domain. It can predict long-term and short-term concentrations, as well as calculations of percentile concentrations.

6.1.7. ADMS-Roads is a validated model, developed in the UK by CERC. The model validation process includes comparisons with data from the UK's Automatic Urban Rural Network (AURN) and specific verification exercises using standard field, laboratory and numerical data sets. CERC is also involved in European programmes on model harmonisation, and their models were compared favourably against other EU and U.S. EPA systems. Further information in relation to this is available from the CERC web site at http://www.cerc.co.uk/environmental-software/model-validation.html.

ATMOSPHERIC DISPERSION MODELLING PROCESS

6.1.8. The procedures involved in undertaking the dispersion modelling assessment are outlined below:

- Collation of input data – traffic data (flows, speeds, percentage of Heavy Duty Vehicles (HDVs)), road network mapping, sensitive receptor coordinates and meteorological data;

- Input of data in to the ADMS-Roads model for the scenarios to be modelled;
- Development of emissions inventories for each pollutant to be assessed, using Defra's emission factor toolkit (v8.0.1);
- Running the ADMS-Roads model for each considered scenario;
- Conversion of modelled NO_X concentrations to NO_2 concentrations using Defra's NO_x-NO_2 calculator v6.1;
- Addition of Defra background concentrations to the modelled concentrations with the background road sector contribution removed (Motorways, Trunk Roads and Primary Roads) to avoid double counting of the road source component;
- Verification and adjustment of modelled road-NO_x contributions from the assessed road network through analysing the ADMS-Roads modelled road-NO_x outputs versus scheme specific monitored road-NO_x for the base year scenario (2018);
- Comparison of predicted NO_2, PM_{10} and $PM_{2.5}$ concentrations at all receptors to the relevant air quality Objectives in each scenario; and
- Analysis of changes in pollutant concentrations between the Do Minimum and Do Something scenarios to assess the significance of impacts associated with the Proposed Scheme on local air quality.

TRAFFIC DATA

6.1.9. Traffic flow data comprising period breakdown, traffic composition (percentage HDVs) and average link speeds (km/h) were used in the modelling as provided for the assessed road network.

6.1.10. Traffic flow data were provided by the project transport planning consultants (WSP). Data were provided for the following scenarios:

- Base/Verification Year of 2018;
- Do-minimum 2021 (Including Dallington Grange Development);
- Do-something 2021 (Including Dallington Grange Development and Proposed Scheme);
- Do-minimum 2031 (Including Dallington Grange Development); and
- Do-something 2031 (Including Dallington Grange Development and Proposed Scheme).

6.1.11. Traffic data was screened in accordance with the DMRB Guidance as stated below:

- A change in alignment of 5m or more; or
- A change in daily traffic flows of 1,000 Annual Average Daily Traffic (AADT) or more; or
- A change in heavy duty vehicle Heavy Duty Vehicles (HDVs) flows of 200 AADT or more; or
- A change in daily average speed by 10 km/hr or more; or
- A change in peak hour speed of 20 km/hr or more.

TIME VARYING EMISSIONS

6.1.12. The ADMS-Roads model uses an hourly traffic flow based on the daily (AADT) flows. Traffic flows follow a diurnal variation throughout the day, thus emissions throughout a 24-hour period will be weighted according to the profile of traffic during peak, inter-peak and off-peak periods.

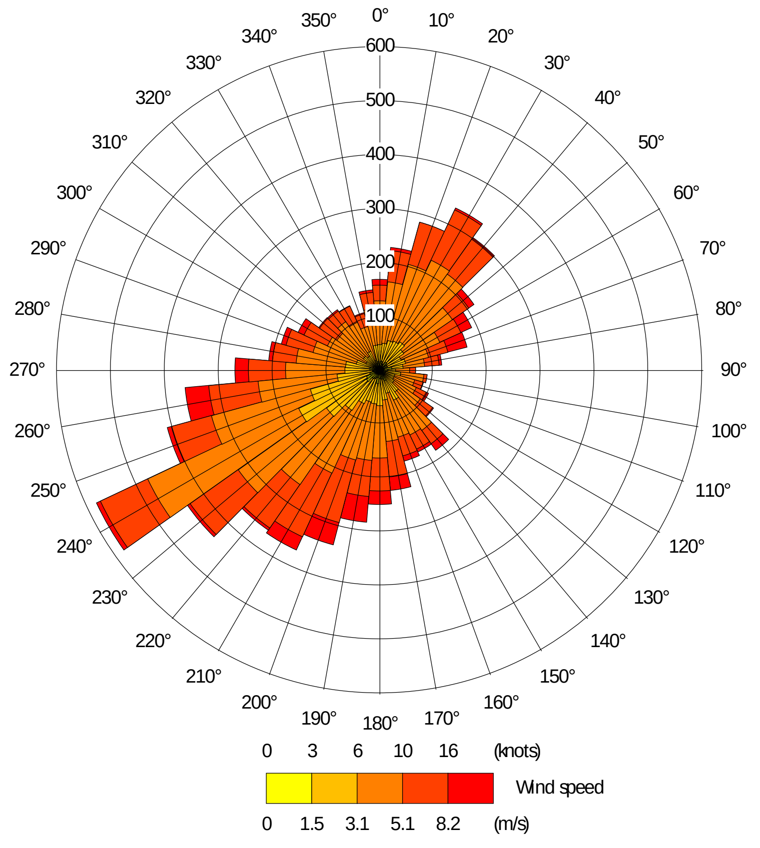
6.1.13. To account for this, traffic data were provided as hourly averages representative of the aforementioned periods (AM peak, PM peak, inter peak and off peak). Therefore vehicle emission sources relative to each period of the day were assigned to the appropriate hours within ADMS-Roads, thus allowing the respective time-varying nature of emissions to be simulated within dispersion modelling. A diurnal profile was used in the model to replicate how the average hourly traffic flow varies throughout weekdays and on Saturday and Sunday. Various Automatic Traffic Counts (ATC) were conducted in association with the Proposed Scheme. A diurnal profile was created by taking an average of the closest ATC locations to the Proposed Scheme based on surveys completed in September

METEOROLOGICAL DATA

6.1.14. ADMS-Roads utilises hourly sequential meteorological data; including wind direction, wind speed, temperature, precipitation and cloud cover, to facilitate the prediction of pollution dispersion between source and receptor.

6.1.15. Meteorological data input to the model were obtained from the closest meteorological station, Bedford, for the year 2018. The 2018 data was used to be consistent with the base/verification traffic year and were applied to the remaining scenarios for the local air quality assessment. The 2018 wind rose is presented as **Figure 6-4-1**.

Figure 6-4-1- Bedford 2018 Wind Rose based on hourly data



CONVERSION OF NO_X TO NO_2

6.1.16. Oxides of nitrogen (NO_x) concentrations were predicted using the ADMS-Roads model. The modelled road contribution of NO_x at the modelled receptor locations was then converted to NO_2 using the NO_x to NO_2 calculator (v6.1, October 2017 https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxNO2calc), in accordance with Defra guidance.

MODEL VERIFICATION METHODOLOGY

MODEL VALIDATION

6.1.17. The ADMS-Roads dispersion model has been validated for road traffic assessments and is considered to be fit for purpose. Model validation undertaken by the software developer Cambridge Environmental Research Consultants (CERC) is unlikely to have included validation in the vicinity of the scheme considered in this assessment. It is therefore necessary to perform a comparison of model results with local monitoring data at relevant locations.

MODEL VERIFICATION

6.1.18. The comparison of modelled concentrations with local monitored concentrations is a process termed 'verification'. Model verification investigates the discrepancies between modelled and measured concentrations, which can arise due to the presence of inaccuracies and/or uncertainties in model input data, modelling and monitoring data assumptions. The following are examples of potential causes of such discrepancy:

- Estimates of background pollutant concentrations;
- Meteorological data uncertainties;
- Traffic data uncertainties;
- Model input parameters, such as 'roughness length; and
- Overall limitations of the dispersion model.

6.1.19. Full details of the model verification process specific to the Proposed Scheme modelling assessment are provided in the 'Assessment Verification Methodology' section below.

MODEL PRECISION

6.1.20. Residual uncertainty may remain after systematic error or 'model accuracy' has been accounted for in the final predictions. Residual uncertainty may be considered synonymous with the 'precision' of the model predictions, i.e. how wide the scatter or residual variability of the predicted values compare with the monitored true value, once systematic error has been allowed for. The quantification of model precision provides an estimate of how the final predictions may deviate from true (monitored) values at the same location over the same period. Suitable local monitoring data for the purpose of verification is used for model verification.

6.1.21. An evaluation of model performance has been undertaken to establish confidence in model results. LAQM.TG16 identifies a number of statistical procedures that are appropriate to evaluate model performance and assess the uncertainty. The statistical parameters used in this assessment are:

- Root mean square error (RMSE);
- Fractional bias (FB); and
- Correlation coefficient (CC)

6.1.22. A brief explanation of each statistic is provided in

Table 6-4-1 and further details can be found in Defra's LAQM.TG16 document.

Table 6-4-1 – Model Performance Statistics

Statistical Parameter	Comments	Ideal Value
RMSE	RMSE is used to define the average error or uncertainty of the model. The units of RMSE are the same as the quantities compared. If the RMSE values are higher than 25% of the Objective being assessed, it is recommended that the model inputs and verification should be revisited in order to make improvements. For example, if the model predictions are for the annual mean NO_2 Objective of 40µg/m^3, if an RMSE of 10 µg/m^3 or above is determined for a model it is advised to revisit the model parameters and model verification. Ideally an RMSE within 10% of the air quality Objective would be derived, which equates to 4 µg/m3 for the annual mean NO_2 Objective.	0.0
FB	It is used to identify if the model shows a systematic tendency to over or under predict. FB values vary between +2 and -2 and has an ideal value of zero. Negative values suggest a model over-prediction and positive values suggest a model under-prediction.	0.0
CC	It is used 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. This statistic can be particularly useful when comparing a large number of model and observed data points.	1.00

6.1.23. The calculations were carried out after model adjustment to provide information on the improvement of the model predictions as a result of the application of the verification adjustment factors.

ASSESSMENT VERIFICATION METHODOLOGY

6.1.24. The verification process involves a review of the modelled pollutant concentrations against corresponding monitoring data to determine how well the air quality model has performed. Depending on the outcome it may be considered that the model has performed adequately and that there is no need to adjust any of the modelled results LAQM.TG (16).

6.1.25. Alternatively, the model may perform outside of the ideal performance limits as stated by LAQM.TG16 (i.e. model agrees within +/-25% of monitored equivalent). There is then a need to check all the input data to ensure that it is reasonable and accurately represented in the air quality modelling process.

6.1.26. Where all input data, such as traffic data, emissions rates, and background concentrations have been checked and considered as reasonable, then the modelled results require adjustment to best align with the monitoring data. This may either be a single verification adjustment factor to be applied to the modelled concentrations across the study area, or a range of different adjustment factors to account for different zones in the study area e.g. major roads, local roads.

6.1.27. The adjustment was applied to the NO_x road source contribution (road-NO_x) and not total NO_2, given that ADMS-Roads was used to predict road-NO_x only. This ensured that any adjustment was applied to road-NOx prior to being used in the NO_x to NO_2 conversion process.

6.1.28. The modelled and monitored NO_2 concentrations for the monitoring locations used for the verification process are presented in **Table 6-4-2**. The initial comparison between the total modelled and monitored annual mean NO_2 concentration values illustrates that the model tends to over predict NO_2 concentrations within the study area.

Table 6-4-2 – Data Used in Model Verification Before Adjustment

Monitoring Site ID	2018 Measured Data (µg/m^3)	Measured Road-NO_x (µg/m^3) from NO_x:NO_2 Calculator	Modelled road-NO_x (µg/m^3)- Before adjustment	Modelled Annual Mean NO_2 Concentration (µg/m^3)- Before adjustment	% Difference (Measured vs Monitored NO_2)
NLR2	16.9	13.4	5.0	12.3	-27%
NLR3*	19.4	19.8	3.3	10.7	-45%
NLR7	17.9	10.4	5.8	15.5	-14%
NLR10	21.5	20.6	5.8	13.8	-36%
50	35.4	50.3	7.8	14.9	-58%
52	42.3	66.6	10.1	16.1	-62%
53	42.0	65.9	9.3	15.7	-63%
55	40.5	62.1	13.0	17.6	-57%
59	39.3	57.9	12.2	17.9	-55%
60	43.0	66.6	9.3	16.4	-62%
62	30.8	38.5	7.8	15.6	-49%

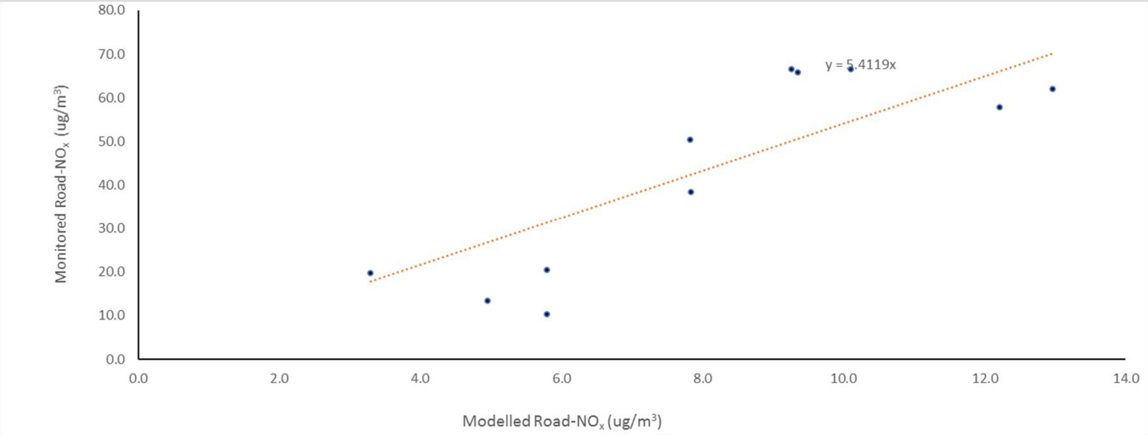
* Annualised mean concentration (2018). See Appendix 7.3

6.1.29. Therefore, verification and adjustment of modelled road-NO_x was undertaken in accordance with LAQM.TG(16) for the monitoring locations included in the verification. The calculation steps taken to adjust modelled road-NO_x are summarised in **Table 6-4-3**, with the relationship between monitored and modelled road-NO_x concentrations at the respective monitoring locations presented in **Figure 6-4-2**.

Table 6-4-3 – Model Results After Adjustment

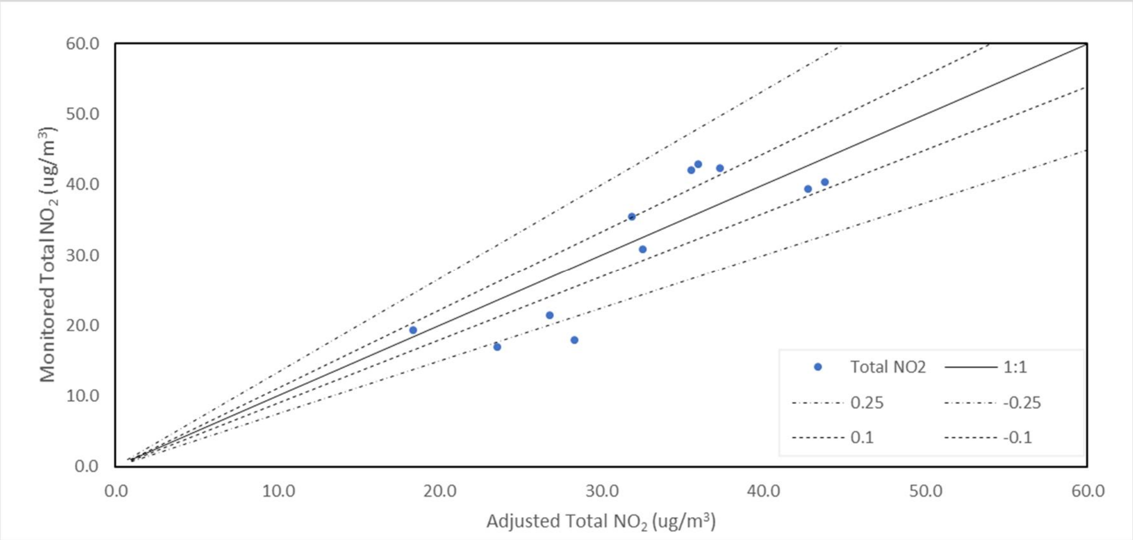
Monitoring Site ID	2018 Measured Data (µg/m^3)	Modelled Annual Mean NO_2 Concentration (µg/m^3)- After adjustment	% Difference (Measured vs Monitored NO_2)
47	15.2	13.2	-13%
NLR2	16.9	23.5	39%
NLR3	19.4	18.4	-5%
NLR7	17.9	28.3	58%
NLR10	21.5	26.8	25%
50	35.4	31.9	-10%
52	42.3	37.3	-12%
53	42.0	35.5	-15%
54	44.4	62.5	41%
55	40.5	43.8	8%
56	37.1	35.9	-3%
57	55.4	39.0	-30%
59	39.3	42.8	9%
60	43.0	36.0	-16%
61	36.2	27.3	-25%
62	30.8	32.5	6%

Figure 6-4-2- Comparison of Unadjusted Modelled Road-NO_x Versus Measured Road-NO_x



6.1.30. With the road-NO_x adjustment factor applied to the modelled values, the total annual mean NO_2 concentrations derived at each location are all within +/-20% of the monitored equivalents are presented in **Figure 6-4-3**.

Figure 6-4-3- Comparison of Unadjusted Modelled Road-NO_x Versus Measured Road-NO_x



6.1.31. Consequently, the modelled road-NO_x concentrations predicted at identified sensitive receptors within the area were adjusted by a factor of 5.4 in the base and future year scenarios.

6.1.32. In the absence of scheme-specific PM_{10} and $PM_{2.5}$ monitoring, the derived model adjustment factors for road-NO_x were applied to modelled road contributions for these pollutants also.

Summary

6.1.33. The summary of the verification outcome and model performance statistics, as defined in LAQM.TG(16), are provided in **Table 6-4-4**.

Table 6-4-4 - Summary of verified model performance and uncertainty statistics (Adjusted Modelled NO_2 versus Monitored NO_2)

No. of monitoring sites	No. sites within +/- 25%	No. sites within +/- 10%	Root Mean Square Error*		Fractional Bias	Correl Coeff
			µg/m^3	% of Objective		
11	7	4	5.5	14	-0.02	0.86

Note: LAQM.TG (16) states "…Ideally an RMSE within 10% of the air quality Objective would be derived, which equates to 4 µg.m^{-3} for the annual average NO_2 limit value."

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