The Lake Lothing (Lowestoft) Third Crossing Order 201[*]

Document 6.3: Environmental Statement Volume 3 Appendices

Appendix 8B

Local Air Quality Modelling and Model Verification

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1.1 Atmospheric Dispersion Model

1.1.1 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 the Cambridge Environmental Research Consultants (CERC) atmospheric dispersion modelling system for roads (ADMS-Roads v4.1.1).

1.1.2 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.

1.1.3 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.

1.1.4 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 (see Table 1-1);
- Development of emissions inventories for each pollutant to be assessed, using Defra's emission factor toolkit (EFT 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 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 (2016);
- 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 Scheme on local air quality.

1.1.5 The key model inputs used in the air quality assessment are summarised in Table 1-1.

Table 0-1 Data Inputs to the ADMS Roads Dispersal Model

Input Data Set	Description
One year of meteorological data	Hourly sequential meteorological data set of 12 month period (2016) from the closest representative coastal meteorological station, situated at Weybourne.
Sensitive receptor locations	Ordnance Survey (OS) grid coordinates for each sensitive receptor within 200m of an affected road identified through applying the DMRB local air quality screening criteria. Sensitive receptor locations were identified using the OS Address Plus data set, which specifies each property classification.
Network of road sources	To include all the road sources within the traffic data set provided that may influence pollutant concentrations at identified sensitive receptors, receptors within 200m of each 'affected road' meeting the affected roads criteria detailed in ES Chapter 8 Paragraph 8.4.16 were selected. The coverage of the network of modelled road sources has been determined by selecting all roads with traffic data that fall within or intersect an area of 200m around a sensitive receptor location.
Road traffic emissions	Vehicle emissions inventories for the modelled road network were calculated using the Defra emission factors toolkit (EFT v8.0.1). The road source emissions rates (g/km/s) were entered into the model for each respective road source link.
Minimum Monin-Obukhov length	The Minimum Monin-Obukhov length represents the stability of the atmosphere and the model takes the setting as the minimum height above which vertical turbulent motion is significantly inhibited by stable stratification. A Minimum Monin-Obukhov length of 10m was selected to reflect the low building height in the study area and the spatial characteristics of the town of Lowestoft which is coastal with the open area of Lake Lothing situated centrally.
Surface Roughness	The model was run with the option to take the surface roughness from the dispersal site which was 0.5 (considered relevant to open suburbia).

1.1.6 Model validation undertaken by the software developer Cambridge Environmental Research Consultants (CERC). To evaluate the performance of the model within the context of the Scheme study area a verification procedure is followed according to Defra guidance LAQM TG(16).

Traffic Data

1.1.7 Traffic flow data comprising Period Traffic flows for the AM Peak (3hrs, 7am to 10am), Inter-peak (6hrs 10am to 4pm), PM Peak (3hrs, 4pm to 7pm) and Off-peak (12hrs, 7pm to 7am). Traffic composition (percentage HDVs) and average link speeds (km/h) were used in the modelling as provided for the assessed road network.

1.1.8 Traffic flow data were provided for the following scenarios:

- 2016 Base Year (*model verification year*);
- 2022 Opening Year Do Minimum (*without* Scheme); and
- 2022 Opening Year Do Something (*with* Scheme).

1.1.9 The study area for the modelling assessment focused on the new road layout that would be introduced by the Scheme, in addition to existing roads affected by the Scheme, including:

- The A47 including the existing A47 Bascule Bridge and approach roads;
- Mutford Bridge and approach roads (Bridge Rd and Saltwater Way);
- Peto Way;
- Waveney Drive;
- Victoria Rd;
- Denmark Rd;
- B1375; and
- A12.

1.1.10 The Defra EFT v8.0.1 was used to calculate vehicle emissions of NO_x, PM_{10} and $PM_{2.5}$ for each scenarios, which were used as an input to the dispersion model. Road traffic emissions were calculated from period traffic data covering the AM peak period from 7 to 10 a.m., the inter-peak (IP) period from 10 a.m. to 4 p.m., the PM peak period from 4 to 7p.m. and the off-peak (OP) period from 7p.m. to 7a.m.

Meteorological Data

1.1.11 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.

1.1.12 Meteorological data input to the model were obtained from the closest meteorological station in Weybourne for the year 2016. The 2016 data were used to be consistent with the base/verification traffic year and were applied to the remaining scenarios for the local air quality assessment. The 2016 wind rose is presented in Appendix 8F.

Conversion of NO_x to NO_2

1.1.13 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, November 2017 https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxNO2calc), in accordance with Defra guidance.

Model Validation

1.1.14 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 (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

1.1.15 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 sources of uncertainty in air quality dispersal modelling;

- Estimates of background pollutant concentrations;
- Meteorological data uncertainties;
- Traffic data uncertainties and emission factor uncertainties;
- Model input parameters such as roughness length and minimum Monin-Obukhov length;
- Overall limitations of the dispersion model.

1.1.16 Model verification is a process that facilitates these uncertainties to be investigated and, through appropriate adjustment of the modelled road-NO_x contribution, minimised to improve the consistency of modelling results versus available monitored data. Model adjustment factors for road-NO_x, derived through this process, were applied to all subsequent model scenario outputs.

Model Precision

1.1.17 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, for example how wide the scatter or residual variability of the predicted values compare with the monitored concentration of an air pollutant at a given location, once systematic error has been allowed for. The quantification of model precision provides an estimate of how the final predictions may deviate from monitored pollutant concentrations at the same location over the same period.

1.1.18 A combination of Local Authority air quality monitoring and Scheme specific air quality monitoring was used for the verification process as presented in Table 0-4 and Appendix 8D.

Model Performance

1.1.19 An evaluation of model performance has been undertaken to establish confidence in the model results. Defra guidance LAQM.TG (16) identifies a number of statistical procedures that are appropriate to evaluate model performance and assess the uncertainty, as summarised in Table 1-2.

Table 0-2 Model Performance Statistics

Statistical Parameter	Comments	Ideal Value
Root Mean Square Error (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 for the pollutant 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 40 $\mu g.m^3$, if an RMSE of 10 $\mu g.m^3$ 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 $\mu g.m^3$ for the annual mean NO_2 objective.	0.00
Fractional Bias (FB)	Fractional bias 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.	0.00
Correlation Coefficient (CC)	Correlation coefficient is used to measure the linear relationship between predicted and observed data. A value of zero means no relationship and a value of one means an absolute relationship. This statistic can be particularly useful when comparing a large number of model and observed data points.	1.00

1.2 Assessment Verification Approach

1.2.1 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).

1.2.2 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, but ideally within

+/- 10%). 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.

1.2.3 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.

1.2.4 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-NO_x prior to being used in the NO_x to NO_2 conversion process.

Monitoring Data for Verification

1.2.5 The 2017 NO_2 diffusion tube monitoring results were annualised to the modelled Base Year of 2016 for verification purposes. Annualisation was applied following the method given in Defra LAQM TG(16) guidance and Appendix 8E The monitoring results used in the verification process are presented in Table 0-4.

1.2.6 Considering the location of the monitoring sites, roadside and background site status, traffic data network coverage, and data capture 17 Scheme specific monitoring locations were selected for model verification. Selection of monitoring sites for verification purposes was undertaken by review of each location. There were multiple sites that were not used for verification due to the presence of on street parking which is not resolved in the traffic data, other sites were not used due to the presence of bus stops or construction traffic and roadworks during the monitoring period.

1.3 Verification Adjustment Zones

1.3.1 Two model verification adjustment zones (VAZs) were identified based generally on conditions within the Scheme traffic reliability area (TRA), with one zone covering areas where there are junctions present in proximity to sensitive receptors, and the second zone covering areas that do not have the presence of a junction in proximity. The application of the *junction* or *non-junction* status for verification to a specific location/modelled receptor was conducted using geographical information systems (GIS) spatial analysis and the application of professional judgement. The verification adjustment zones are described in Table 0-3.

Table 0-3 Verification Adjustment Zones

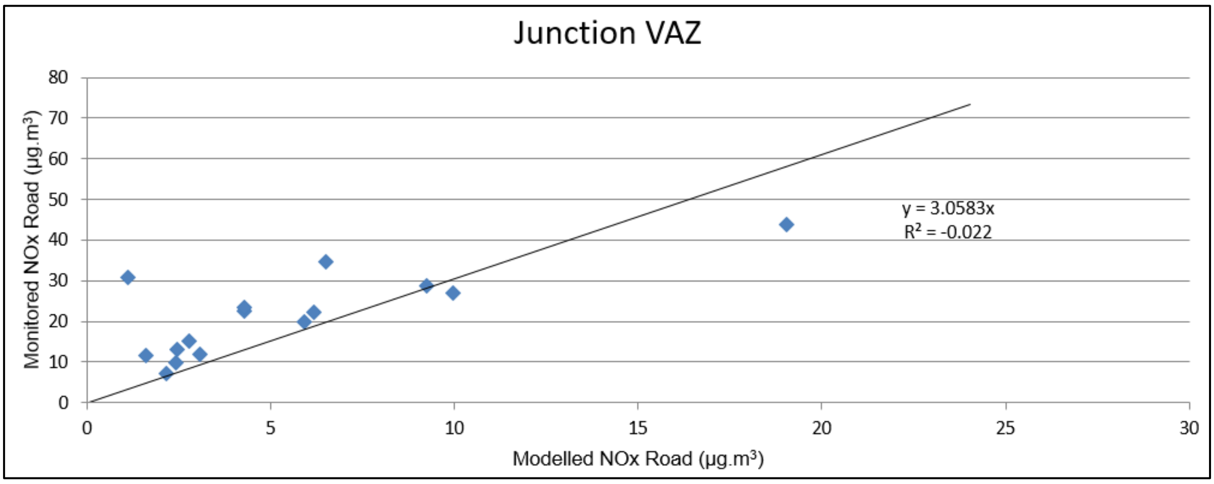
Zone	Description
Zone 1: Junctions	Areas within the urbanised centre of Lowestoft considered to be influenced by a junction within 200 metres, or outside the town where the influence of a junction is present within 200 metres of the modelled receptor to its verification factor will be applied. The majority of the sensitive receptors in the vicinity of the Scheme fall into this category as the urban areas of Lowestoft has many junctions. These conditions

	mean that the air quality modelling accuracy will be strongly dependent on the resolution of the traffic data at this junctions.
Zone 2: Non Junctions	Areas where receptors do not fall into the category given above. There are areas with minor junctions, for example where traffic data are not provided that have been categorised in the non-junction verification zone using professional judgement, reflecting the conditions of the air quality modelling as determined by the traffic data provided for the assessment.

1.4 Zone 1: Junctions

1.4.1 The modelled versus monitored NO_2 concentrations are presented in Table 0-4. The initial comparison between the predicted concentrations and monitoring data illustrates that the model tends to under predict NO_2 concentrations across the modelled area. Data were collected from 15 suitable diffusion monitoring sites in the areas considered to be influenced by junctions.

Figure 1 Modelled versus Monitored Road NO_x Junction VAZ



1.5 Zone 2: Non Junctions

1.5.1 The modelled versus monitored NO_2 concentrations are presented in Table 0-4. The initial comparison between the predicted concentrations and monitoring data illustrates that the model tends to under predict NO_2 concentrations across the modelled area. Data were collected from 8 suitable diffusion monitoring sites in the areas considered to be not influenced by junctions.

Figure 2 Modelled versus Monitored Road NO_x Non Junction VAZ

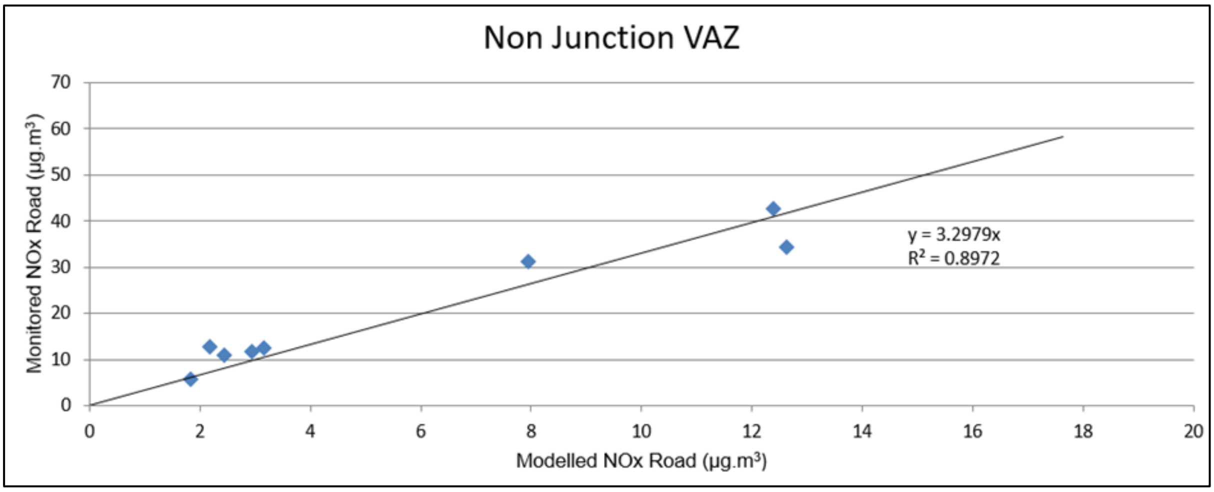


Table 0-4 Verification Summary: Modelled vs Monitored annual mean road-NO_x and total annual mean NO_2

Monitoring Sites	Verification Zone	X (m)	Y (m)	Background NO_2	Monitored NO_2	Monitored NO_x (Roads)	Modelled NO_x (Road)	Modelled Total NO_2 (no adjustment)	Adjusted Modelled NO_x* (Road)	Adjusted Total NO_2	Total NO_2 % Change Adj. vs Mon. NO_2
Waveney DT4	Non Junction	652299	293013	11.0	27.9	34.3	12.6	17.6	41.7	31.7	3.8
WSP7	Non Junction	652990	291235	10.8	17.6	12.8	2.2	11.9	7.2	14.7	-2.9
WSP13	Non Junction	653665	292175	10.8	16.7	11.0	2.4	12.1	8.0	15.1	-1.6
WSP14	Non Junction	653921	292379	10.8	17.5	12.6	3.2	12.5	10.4	16.4	-1.1
WSP18	Non Junction	652230	292922	11.0	32.1	42.5	12.4	17.5	40.9	31.4	-0.7
WSP26	Non Junction	655111	293373	14.0	29.9	31.3	7.9	17.7	26.2	27.4	-2.5
WSP38	Non Junction	653165	294640	10.7	17.0	11.8	2.9	12.3	9.7	15.9	-1.1
WSP20	Non Junction	653310	293434	10.9	14.0	5.78	1.8	11.8	6.0	14.1	0.1
Waveney DT1	Junction	650623	290478	8.8	20.7	22.6	4.3	11.6	13.1	15.9	-23.2
Waveney DT3	Junction	651888	292103	10.3	24.3	27.1	10.0	15.7	30.5	25.9	6.6
Waveney DT5	Junction	652045	292499	11.0	26.7	30.8	1.1	11.5	3.4	12.8	-52.1
Waveney PT4 to 6	Junction	654763	292815	12.6	27.2	28.7	9.2	17.2	28.2	27.0	-0.7

Monitoring Sites	Verification Zone	X (m)	Y (m)	Background NO_2	Monitored NO_2	Monitored NO_x (Roads)	Modelled NO_x (Road)	Modelled Total NO_2 (no adjustment)	Adjusted Modelled NO_x* (Road)	Adjusted Total NO_2	Total NO_2 % Change Adj. vs Mon. NO_2
Waveney PT10 to12	Junction	654687	292622	12.6	34.2	43.9	19.0	22.2	58.2	40.4	18.1
WSP6	Junction	653463	291452	10.6	16.8	11.6	1.6	11.5	4.9	13.3	-20.8
WSP17	Junction	652144	292483	11.0	22.5	22.2	6.2	14.2	18.9	20.9	-7.1
WSP24	Junction	654661	292916	12.6	30.0	34.7	6.5	15.7	19.9	23	-23.3
WSP27	Junction	654909	293431	13.1	21.0	15.2	2.8	14.1	8.5	17.6	-16.2
WSP28	Junction	654164	293603	13.1	19.3	11.8	3.1	14.3	9.5	18.1	-6.2
WSP29	Junction	653600	293805	10.9	16.2	10	2.4	12.1	7.4	14.9	-8
WSP30	Junction	652570	293874	10.5	21.0	20	5.9	13.8	18.1	20.1	-4.3
WSP12	Junction	653291	291968	10.6	17.6	13.1	2.5	12	7.5	14.7	-16.5
WSP23	Junction	654159	292951	12.6	24.7	23.5	4.3	14.6	13.1	19.5	-21.1
WSP16	Junction	652406	292476	11.0	14.8	7.1	2.2	12.1	6.6	14.5	-2

* Adjustment factor applied to modelled road-NO_x, as per $y = mx$ equation given in Figure 1 (Junction VAZ; 3.0583) and Figure 2 (Non-Junction VAZ; 3.2979)

1.6 Summary

1.6.1 The summary results and model performance statistics, as defined LAQM TG(16), are provided in Table 0-5.

1.6.2 A comparison of the performance of the modelled concentrations from the air quality model against the monitoring data was undertaken. The results show that the verification performance for each individual VAZ is satisfactory. The model performance statistics show that the uncertainty in the predictions of adjusted total NO_2 was acceptable for the Non Junction Zone as the RMSE is less than 4µg/m^3. The Junction Zone has an RMSE over 4µg/m^3, however 7 of the 15 locations are within +/- 10% of the monitoring equivalent and only 1 location is outside of the +/- 25% range, therefore the adjusted model is considered to be performing suitably with respect to NO_2 levels in proximity to junctions.

1.6.3 The road-NO_x adjustment factors derived through the model verification process were applied to each subsequent model scenario outputs to calculate the respective road-NO_x at each identified sensitive receptor location.

1.6.4 The road-NO_x model adjustment factors were applied to derive the road-PM_{10} and road-$PM_{2.5}$ concentrations at each receptor in the absence of local and Scheme-specific PM_{10} and $PM_{2.5}$ monitoring data.

Table 0-5 *VAZ Model Performance Statistics*

VAZ	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		
Non Junction	8	8	6	2.09	5.2	0.04	0.97
Junction	15	14	7	4.99	12.5	0.12	0.79

*****LAQM.TG(16) state that "…Ideally and RMSE within 10% of the air quality Objective would be derived, which equates to 4µg/m^3 for the annual average NO_2 objective."*