M3 Junction 9 Improvement

Scheme Number: TR010055

6.3 Environmental Statement Appendix 5.1 - Air Quality Modelling Methodology and Verification

APFP Regulation 5(2)(a)

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6.3 ENVIRONMENTAL STATEMENT - APPENDIX 5.1: AIR QUALITY MODELLING METHODOLOGY AND VERIFICATION

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1.1 Defra background maps adjustment

1.1.1 Background pollutant concentrations vary spatially and temporally across the UK and have been obtained from the Defra UK-AIR website (Defra, 2020) for oxides of nitrogen (NO_x), nitrogen dioxide (NO_2), and particulate matter with an aerodynamic dimeter <10µm (PM_{10}).

1.1.2 The latest Defra predictions are forecast from a 2018 base year, whereas the traffic model base year is 2015. Therefore, the 2018 background maps were 'back-casted' to represent 2015 by deriving an adjustment factor based on the change in measured annual mean concentrations from background Automatic Urban Rural Network (ARUN) monitoring stations.

1.1.3 The Environment Agency operate four AURN sites within 50km of the Scheme that have both 2015 and 2018 data suitable for comparison. The derived adjustment factor for NOx of 1.06 is summarised in **Table 1**.

Table 1.1: AURN comparison sites

AURN Site	2015 Measured NOx Concentration	2018 Measured NOx Concentration	2015-2018 Factor
Southampton	52.2	47.8	1.09
Bournemouth	16.3	14.8	1.10
Reading	35.7	35.4	1.01
Portsmouth	27.4	26.5	1.03
Average			**1.06**

1.1.4 This analysis was also undertaken in relation to PM_{10} concentrations, however there was no significant variation in measured background concentrations at AURN monitors between 2015 and 2018, therefore no adjustment factor was directly applied.

1.1.5 These concentrations comprise a background and local component. The background component is determined by regional, national and international emissions, and often represents a significant proportion of the total pollutant concentration. The local component comprises emissions from sources such as traffic and industry which and add to the background concentration.

1.1.6 In order to prevent double-counting of contributions from roads included within the Strategic Transport Model, background concentrations of NOx and PM_{10}

(and $PM_{2.5}$) were adjusted to remove the local contributions from motorways, trunk roads and primary roads (both within and outside the 1km grid square due to the large contribution of the M3 and A34 beyond 1km).

1.1.7 Adjusted background NO_2 concentrations were then calculated using the NO_2 Adjustment for NOx Sector Removal Tool (Defra, 2020).

1.2 Model verification

1.2.1 The comparison of modelled concentrations with local monitored concentrations is a process termed 'verification'.

1.2.2 Model verification aims to account for discrepancies between modelled and measured concentrations. The following are examples of potential causes of such discrepancies:

- Background pollutant concentration uncertainties
- Meteorological data uncertainties
- Traffic data uncertainties
- Emission factor uncertainties
- Overall limitations of the ability of the dispersion model to model dispersion in a complex urban environment

1.2.3 The verification process initially 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.

1.2.4 Alternatively, the model may perform poorly against the monitoring data (acceptable limits of model verification performance are set out in Defra's LAQM TG.16 (Defra, 2021), as a result there is a need to check all the input data to ensure that it is reasonable and accurately represented in the air quality modelling process.

1.2.5 Where all input data, such as traffic data, emissions rates and background concentrations have been checked and considered to be reasonable, then the modelled results may require adjustment to best align them with the monitoring data. This may be 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 situations within the study area.

1.3 NOx

1.3.1 Most NO_2 is produced in the atmosphere by the reaction of nitric oxide (NO) with ozone. It is therefore most appropriate to verify the model in terms of primary pollutant emission of nitrogen oxides (NO_x = NO + NO_2).

1.3.2 The model has been run to predict the 2015 annual mean road-NOx contribution at a range of appropriate monitoring locations in proximity to the Affected Road Network (ARN).

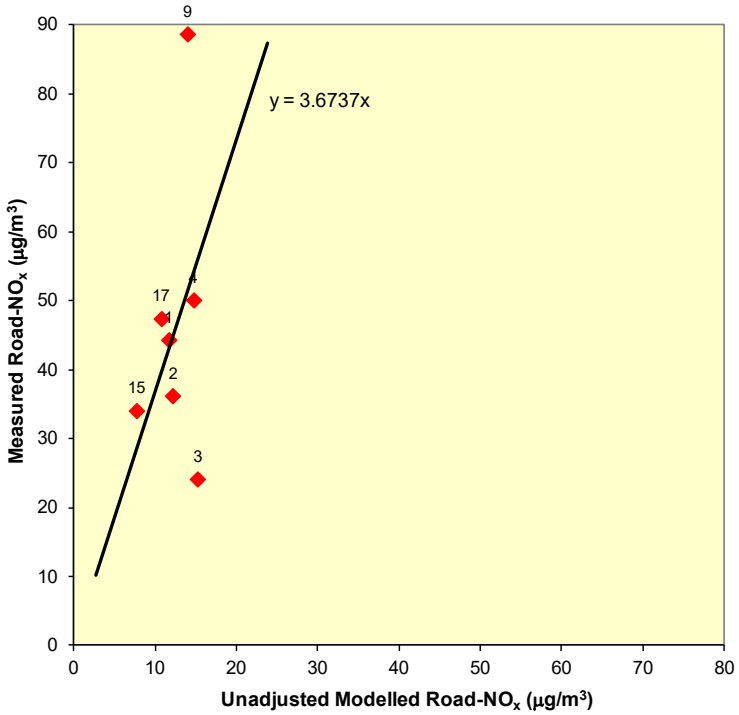
1.3.3 Two verification zones have been identified based on the environment in which monitoring locations are situated. Firstly an 'urban' zone which applies Winchester City Council monitoring data and is considered appropriate for receptors within Winchester City, and has also been applied to rural locations outside the influence of the motorway network. A second zone has been defined for locations where conditions are dominated by free flow traffic on motorway and trunk roads and the verification for this zone primarily applies National Highways monitoring data.

1.4 Urban verification zone

1.4.1 A primary adjustment factor of **3.674** has been determined as the slope of the best fit line between the modelled road NO_x contribution and the 'measured' road-NO_x (which is calculated from the measured and background NO_2 concentrations within DEFRA's NO_x from NO_2 calculator (DEFRA, 2019e)), forced through zero (**Insert 1.1**). The calculated adjustment factors imply that overall, the model has marginally under-predicted the road-NO_x contribution. This is a common experience with this and most other models.

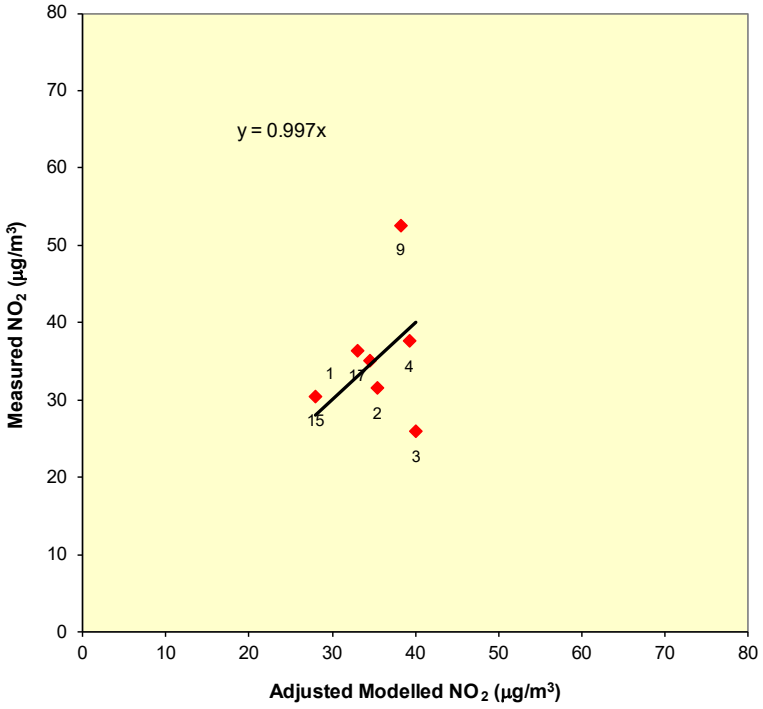
1.4.2 This factor has then been applied to the raw modelled road-NO_x concentration to provide adjusted modelled road-NO_x concentrations.

Insert 1.1: Measured and Unadjusted Road-NO_x Comparison for the 'Urban' Zone



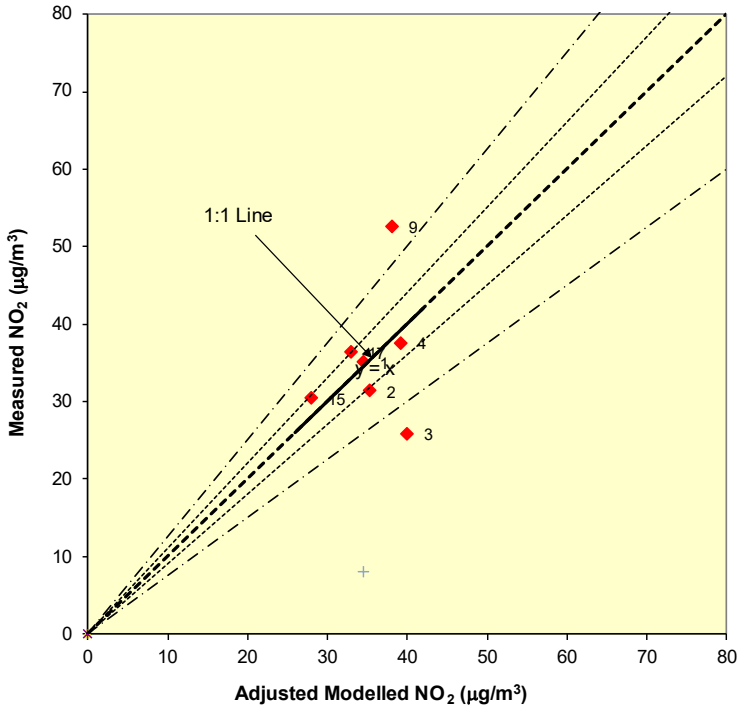
1.4.3 The total NO_2 concentrations have then been determined by combining the adjusted modelled road-NO_x concentrations with the background NO_2 concentration within Defra's NO_x from NO_2 calculator (Defra, 2020c). A secondary adjustment factor of **0.997** has then been calculated as the slope of the best fit line applied to the adjusted data and forced through zero (**Insert 1.2**).

Insert 1.2: Measured and Primary Adjusted Modelled NO_2 Comparison for the 'Urban' Zone



1.4.4 **Insert 1.3** compares final adjusted modelled total NO_2 at each of the monitoring sites, to measured total NOx and shows the 1:1 relationship, as well as ±10% and ±25% of the 1:1 line.

Insert 1.3: Measured and Final Adjusted Modelled NO_2 Comparison for the 'Urban Zone'

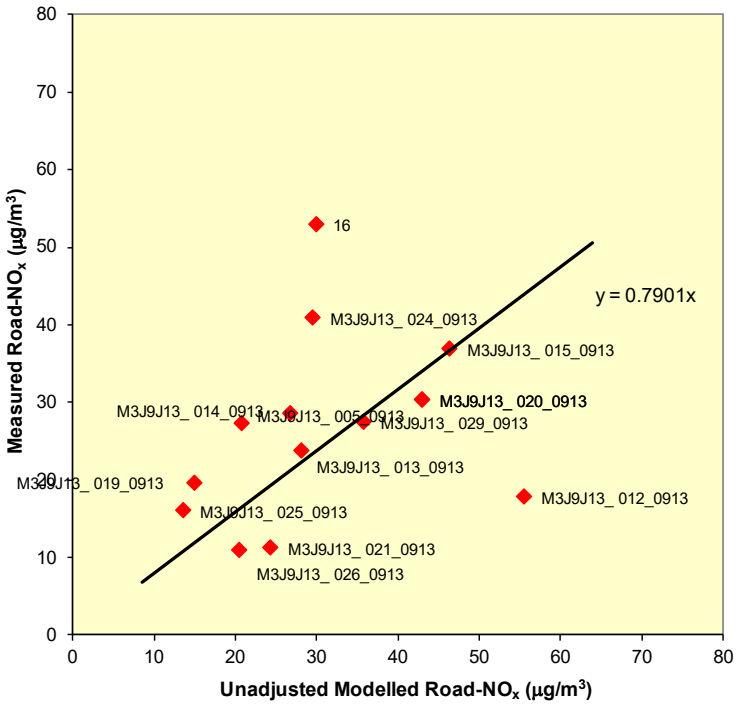


1.5 Motorway verification zone

1.5.1 A primary adjustment factor of **0.7900** has been determined as the slope of the best fit line between the modelled road NO_x contribution and the 'measured' road-NO_x (which is calculated from the measured and background NO_2 concentrations within DEFRA's NO_x from NO_2 calculator (DEFRA, 2019e)), forced through zero for the 'non-urban' zone (I**nsert 1.4**). The calculated adjustment factors imply that overall, the model has marginally over-predicted the road-NO_x contribution.

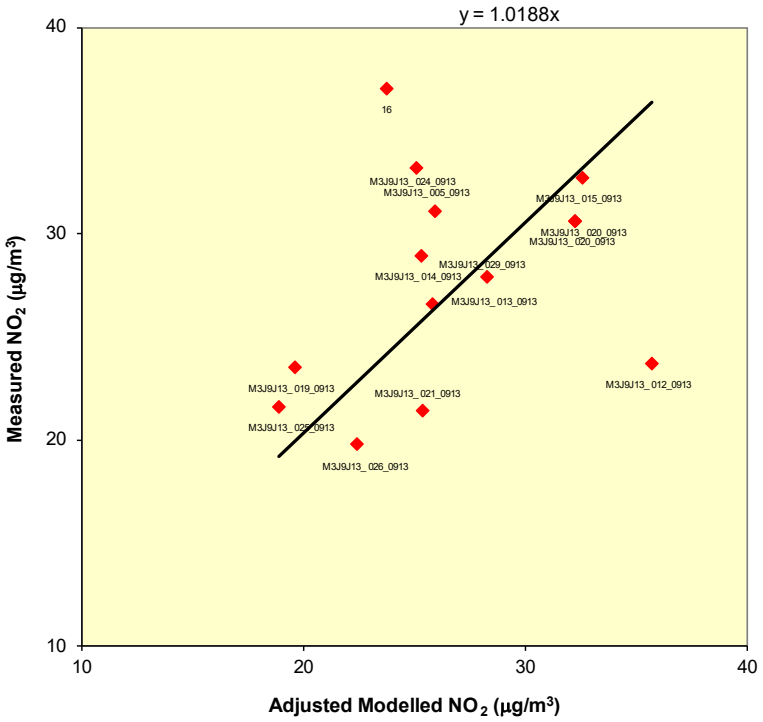
1.5.2 No factor has therefore been applied to the raw modelled road-NO_x concentration to provide adjusted modelled road-NO_x concentrations.

Insert 1.4: Measured and Unadjusted Road-NO_x Comparison for the 'Motorway' Zone



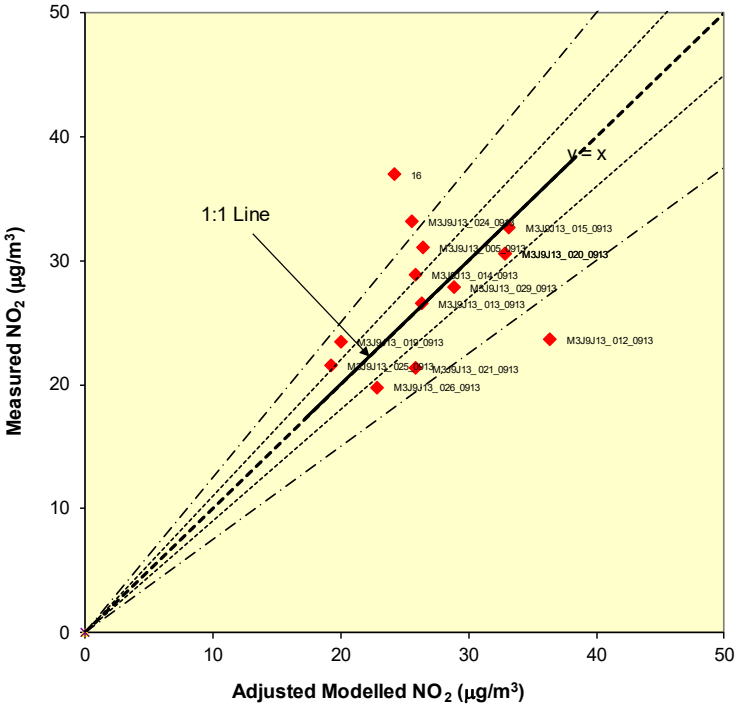
1.5.3 The total NO_2 concentrations have then been determined by combining the adjusted modelled road-NO_x concentrations with the background NO_2 concentration within Defra's NO_x from NO_2 calculator (Defra, 2020c) (**Insert 1.5**).

Insert 1.5: Measured and Primary Adjusted Modelled NO_2 Comparison for the 'Non-Urban' Zone



1.5.4 **Insert 1.6** compares final adjusted modelled total NO_2 at each of the monitoring sites, to measured total NO_x and shows the 1:1 relationship, as well as ±10% and ±25% of the 1:1 line.

Insert 1.6: Measured and Final Adjusted Modelled NO_2 Comparison for the 'Motorway' Zone



1.6 Model performance

1.6.1 A degree of residual uncertainty will remain after systematic error or 'overall model accuracy' has been accounted for in the final predictions. The quantification of final model accuracy provides an estimate of how the final predictions may deviate from the 'true' (monitored) values at the same location over the same period. Whilst this is expressed in terms of model uncertainty, it should be recognised that some of the residual uncertainty will be down to uncertainties in the monitored values; this uncertainty is greater for monitoring using diffusion tubes than for automatic monitors.

LAQM.TG (16) (Defra, 2021) identifies a number of statistical procedures that are appropriate to evaluate model performance and assess the uncertainty. The calculated statistical parameters are set out in Table 1.2 Model Verification Statistics.Table 1.2: Model Verification Statistics

Statistical Measure	Urban	Motorway
Primary Adjustment Factor	3.6737	None applied
Secondary Adjustment Factor	0.9969	None applied
Root Mean Square Error (µg/m^3)	7.9	5.84
Fractional Bias	0.006	0.02
Correlation Coefficient	0.21	0.31

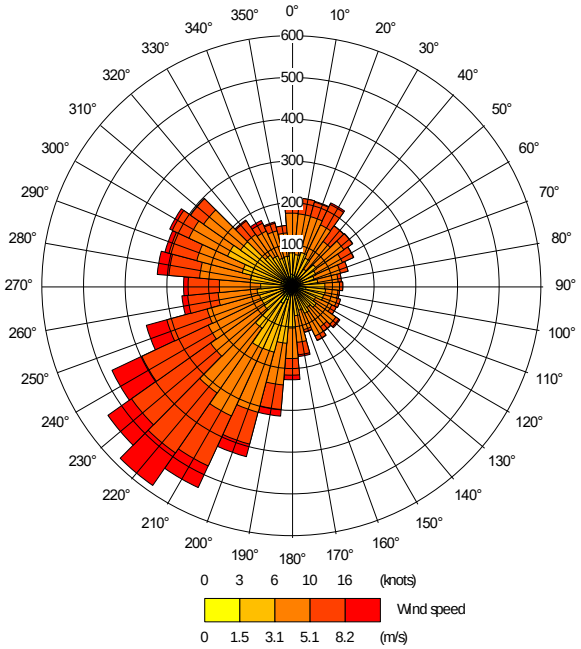
1.6.2 The calculated Root Mean Square Error (RMSE) for the urban verification zone (7.9µg/m^3) lies within the range considered to be acceptable by DEFRA (Defra, 2021) (4 – 10 µg/m^3) and within this area there are generally improvements due to decreases in traffic flows as a result of the Scheme. The Fraction Bias indicates a very minor underprediction. The verification for the non-urban zone indicates improved model performance.

1.6.3 The model is therefore considered to provide an appropriate tool for prediction of future concentrations at receptor locations for Environmental Impact Assessment (EIA) purposes.

1.7 PM_{10}

1.7.1 There are no automatic monitoring stations measuring PM_{10} within proximity to the ARN that are considered to be representative of the Scheme, and the adjustment factor calculated for NO_2 has been applied to the modelled road-PM_{10} concentrations.

1.8 Model inputs

Model Input	Details
Meteorological Data	2015 Hourly meteorological data from Southampton Airport has been used in the model. The wind rose is shown below: 
ADMS	Version 5.0.1.3
Time Varying Emission Factors	Traffic Model AM/IP/PM/OP time varying flows applied
Latitude	50.9°
Minimum Monin-Obukhov length	A value of 30 for ‘cities and large towns’ was used to represent the modelled area. A value of 26 was used to represent the meteorological station site
Emissions Factor Toolkit	IAN185-13 Speed Band Emissions Factors V3.1
NO_x to NO_2 Conversion	NOx to NO_2 Calculator version 8.1, August 2020 (Defra, 2020) For model verification (2015), a f-NO_2 factor of 0.268 was applied
Background Maps	2018 reference year background maps adjusted for 2015 as detailed in this appendix.