Deriving Background Concentrations of NOx and NO_2

January 2016

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1 Calibration of DEFRA Background Maps

1.1 Background concentrations of nitrogen dioxide (NO_2), nitrogen oxides (NOx), and fine particulate matter (PM_{10} and $PM_{2.5}$) may be derived either from monitoring[1] or using Defra's national background maps[2]. These maps cover the whole country on a 1x1 km grid and are published for each year from 2011 until 2030. The maps include the influence of emissions from a range of different sources; one of which is road traffic. The maps currently in use were verified by Defra against measurements made at its Automatic Urban and Rural Network (AURN) sites during 2011 and so there can be reasonable confidence that the maps are representative of conditions during 2011. Historically, it has proved difficult for Defra to accurately predict the rate at which concentrations of NOx and NO_2 will reduce into the future. For this reason, it is necessary to re-calibrate the maps against more recent data. Where suitable local monitoring data are not available, it is appropriate to apply one of the following calibration factors.

2013 Base Year

1.2 For 2013, the mapped NO_2 values have been calibrated against concurrent (2013) measurements made at suitable background AURN sites (Defra, 2016d). Based on the 52 sites with more than 75% data capture, the maps under-predicted the background concentrations by 6% on average (Figure 1). It is thus appropriate to multiply mapped background NO_2 concentrations by 1.060 for all studies with a 2013 base year[3,4].

1.3 Figure 2 shows the same comparison for NOx. In studies with a 2013 base year in which NOx (rather than NO_2) is the pollutant of concern, it is appropriate to multiply mapped background NOx concentrations by 1.132.

2014 Base Year

1.4 For 2014, the mapped NO_2 values have been calibrated against the 40 background AURN sites with more than 75% data capture (Figure 3). This shows that the maps under-predicted the background concentrations by 2.6% on average. It is thus appropriate to multiply mapped background NO_2 concentrations by 1.026 for all studies with a 2014 base year[3,4].

1.5 Figure 4 shows the same comparison for NOx. In studies with a 2014 base year in which NOx (rather than NO_2) is the pollutant of concern, it is appropriate to multiply mapped background NOx concentrations by 1.108.

1 if there is an appropriately-sited monitor sufficiently close to the study area. Many sites which are described as 'background' are influenced by local emission sources.

2 http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html

3 The adjustment should be made to both base-year and future-year background concentrations.

4 Were local suitable background measurements are available, these might be used in preference.

2015 Base Year

1.6 For 2015, the mapped NO_2 values have been calibrated against the 44 background AURN sites with more than 75% data capture (Figure 5). This shows that the maps under-predict the background concentrations by 3.1%, on average. It is thus appropriate to multiply mapped background NO_2 concentrations by 1.031 for all studies with a 2015 base year [3,4,5].

1.7 Figure 6 shows the same comparison for NOx. In studies with a 2015 base year in which NOx (rather than NO_2) is the pollutant of concern, it is appropriate to multiply mapped background NOx concentrations by 1.104[5].

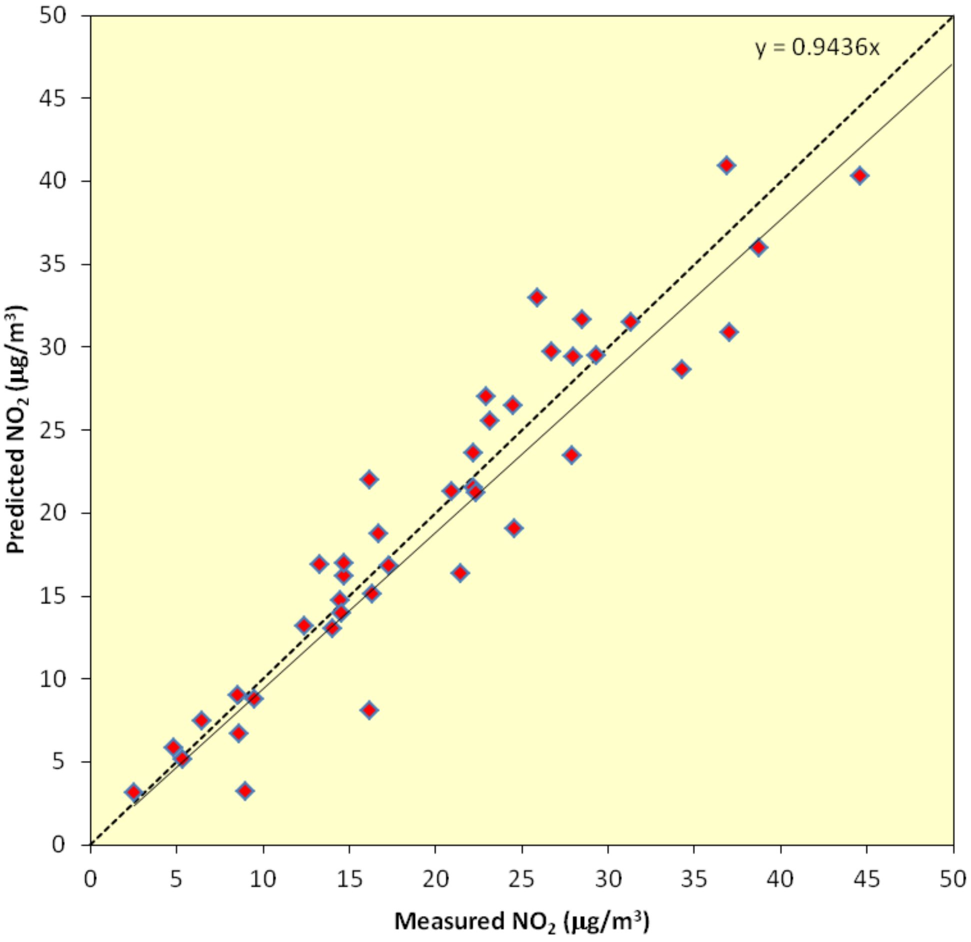

Figure 1: Predicted Mapped versus Measured NO_2 Concentrations at AURN Background Sites in 2013

5 The 2015 data are currently unratified

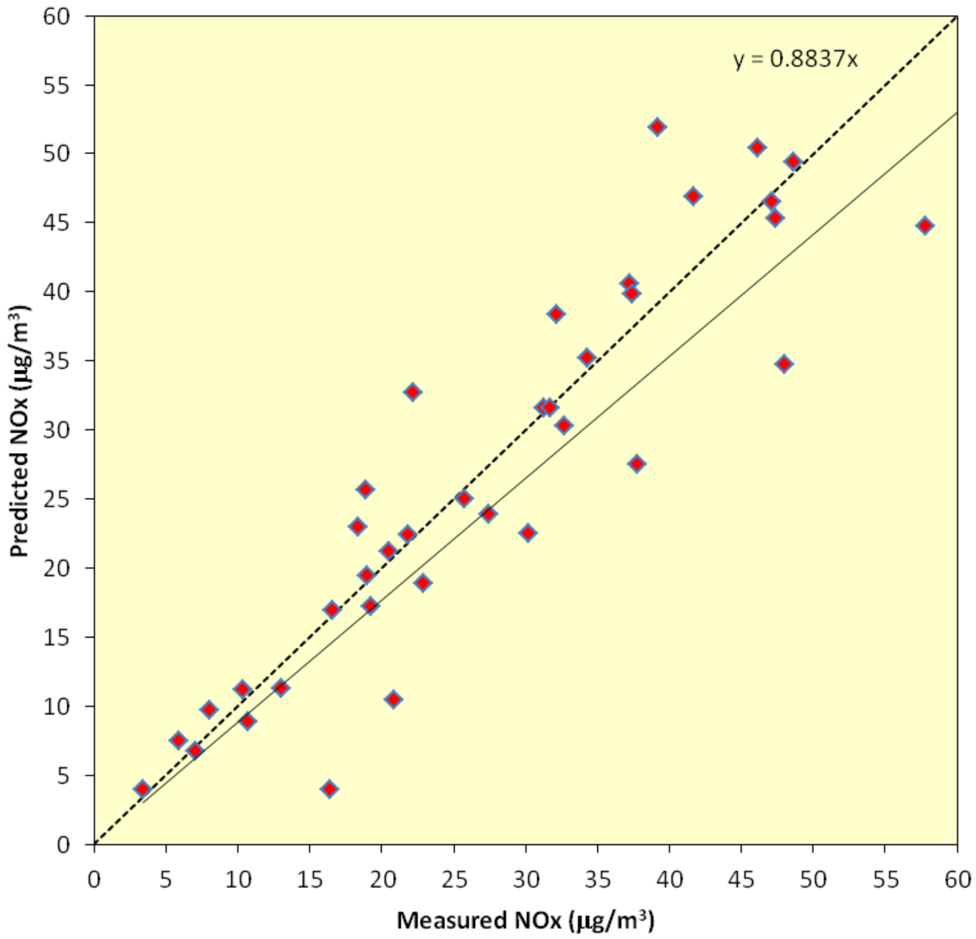

Figure 2: Predicted Mapped versus Measured NOx Concentrations at AURN Background Sites in 2013

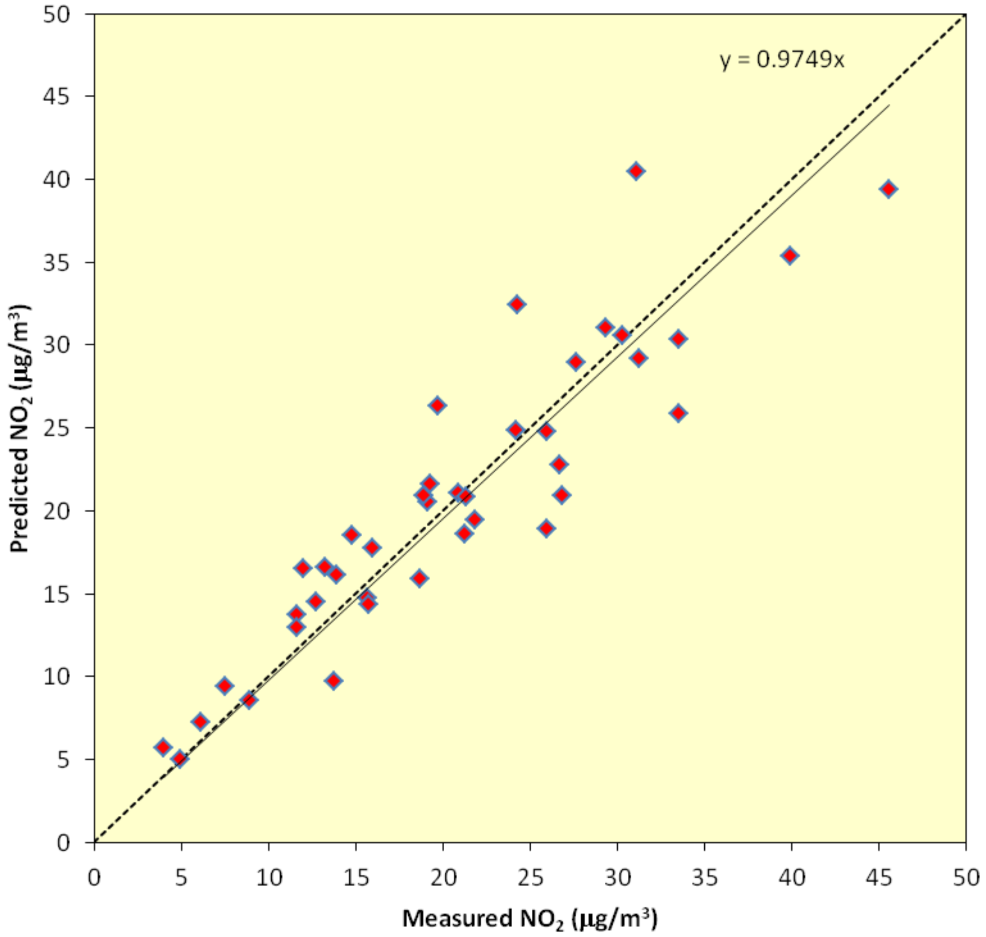

Figure 3: Predicted Mapped versus Measured NO_2 Concentrations at AURN Background Sites in 2014

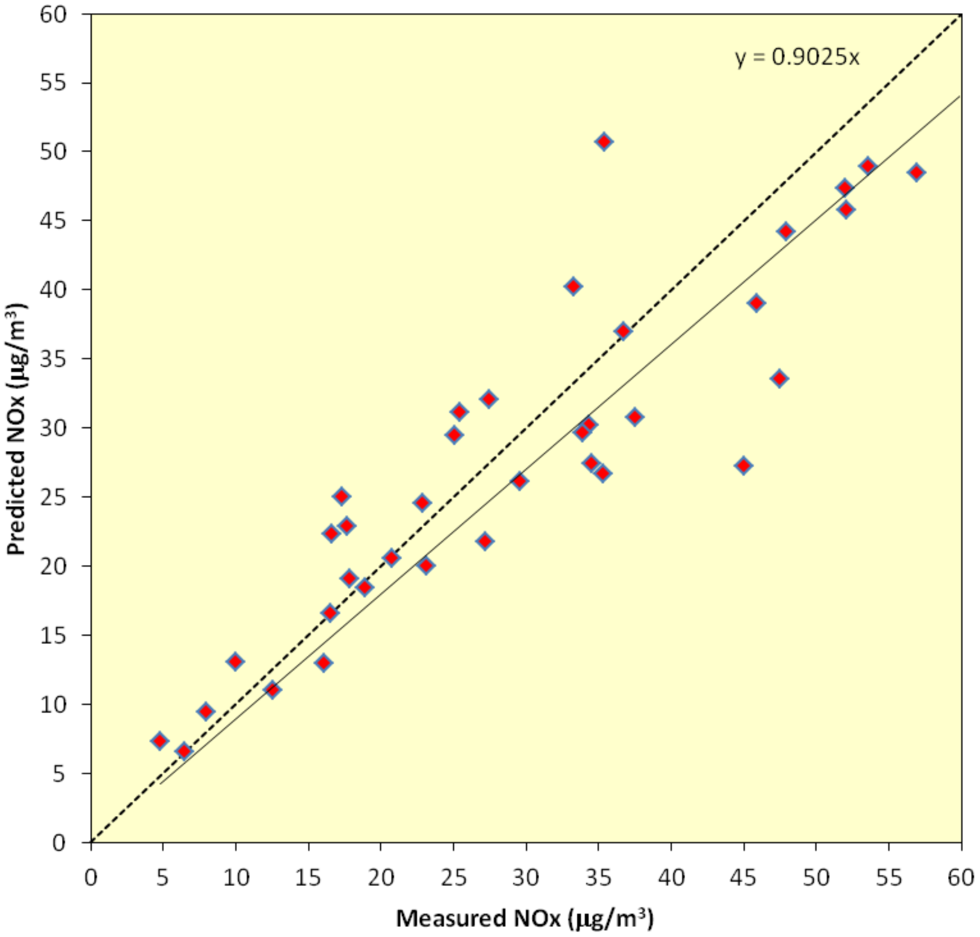

Figure 4: Predicted Mapped versus Measured NOx Concentrations at AURN Background Sites in 2014

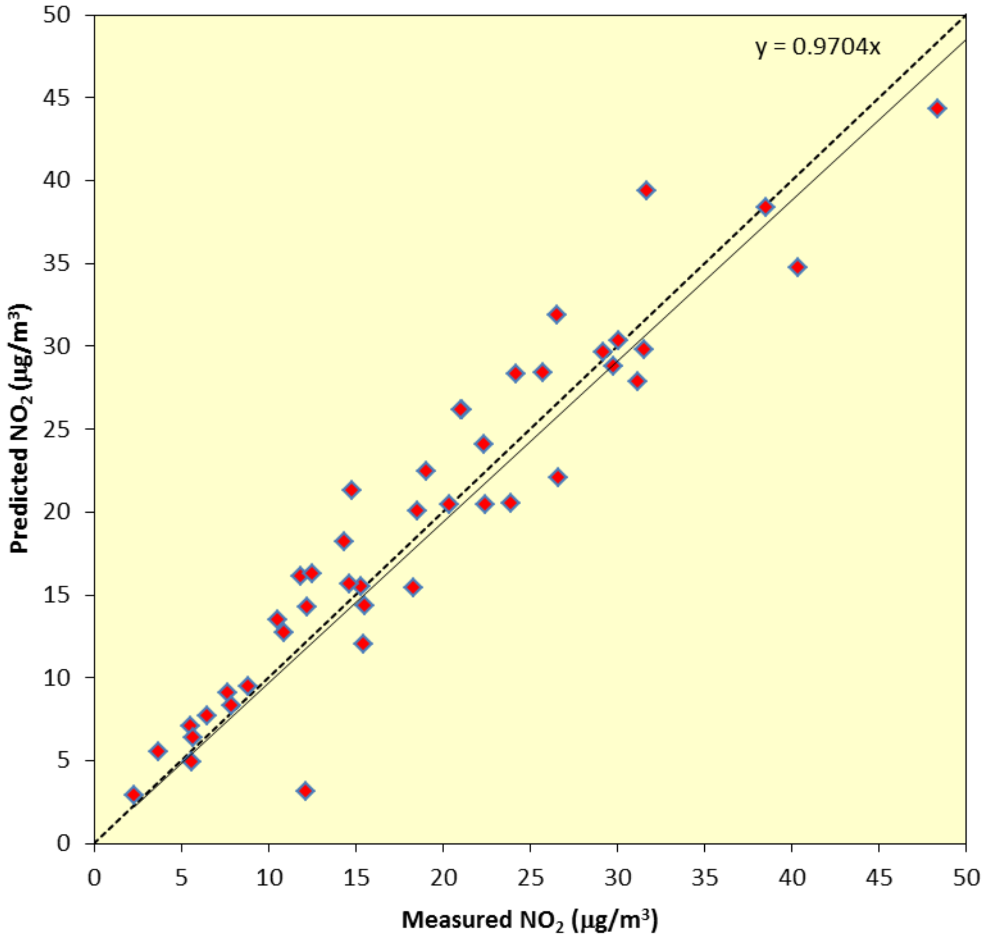

Figure 5: Predicted Mapped versus Measured NO_2 Concentrations at AURN Background Sites in 2015[5]

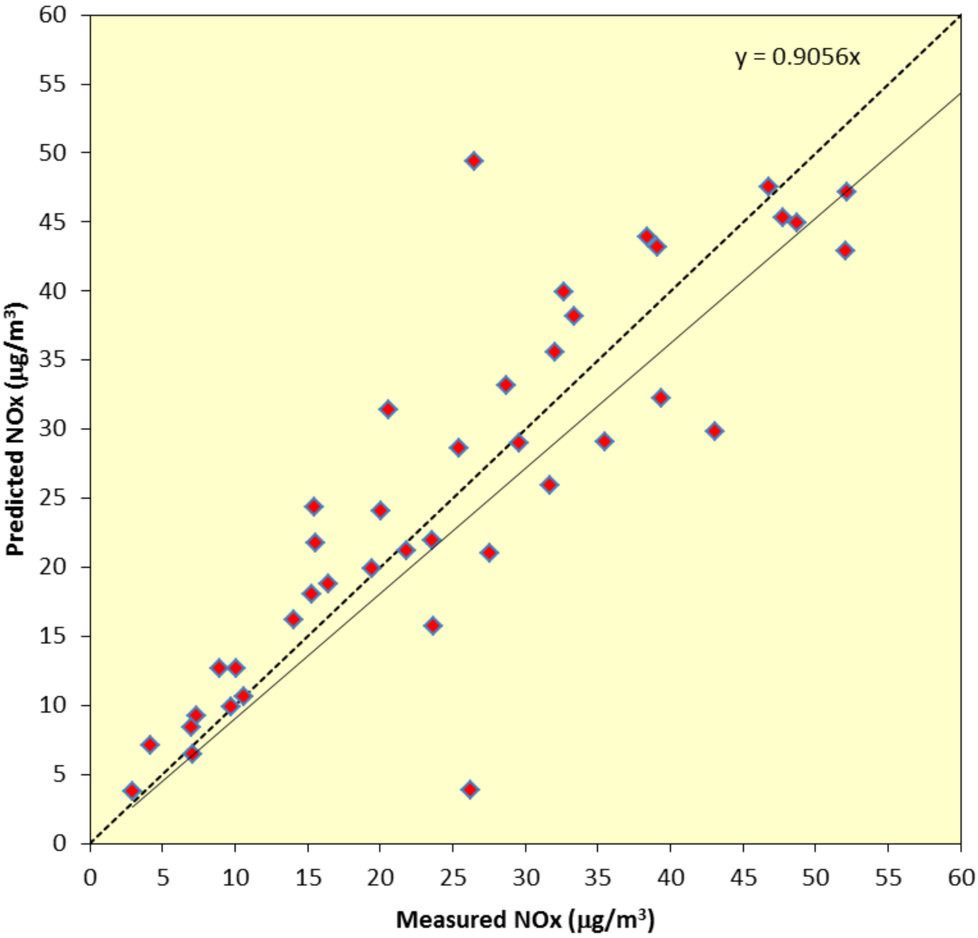

Figure 6: Predicted Mapped versus Measured NOx Concentrations at AURN Background Sites in 2015[5]

2 Sensitivity Test for NOx and NO_2

2.1 A report has been produced, separately, which outlines an approach to dealing with uncertainty over nitrogen oxides (NOx) emissions from modern diesel vehicles[6]. This approach has been used to adjust Defra's Emissions Factor Toolkit (EFT) so as to provide a sensitivity test in dispersion modelling studies[6]. Defra's national background maps are based upon the same assumptions for road traffic as Defra's EFT (v6.02) and thus also require adjusting for the sensitivity test. The approach set out below provides consistency between the adjusted EFT and the adjusted background concentrations.

2.2 The Department for Transport has published traffic data for 34,000 traffic counters across the UK. These data are used by Defra to produce its background maps. The flows reported for 2014 from the 33,000 count points which recorded more than 1,000 vehicles per day[7] have been input to the EFT. Each road has been entered into the EFT several times to cover a range of years (from 2011 until 2030[8]), a range of road types[9,10], and a range of speeds (20 kph, 50 kph, and 110kph). The same procedure was then carried out using the 'AQC-adjusted EFT', which applies the uplifts for the sensitivity test[6]. The two sets of results were then compared to see how much higher, for the fleets which populate the national background maps, the emissions predicted by the AQC-adjusted EFT were from those predicted by Defra's EFT.

2.3 Figure 7 to Figure 9 show the results. The whiskers show the range for each year (i.e. the minima and maxima) and show quite a large spread. In those instances where the percentage additional emissions (from the AQC-adjusted EFT when compared with Defra's EFT) are zero, the roads in question carried no heavy duty vehicles. The roads with the highest percentage additional emissions were those which carried no light duty vehicles. Despite the large range shown by the whiskers in Figure 7 to Figure 9, the quartile ranges are very narrow, showing that the majority of roads had relatively uniform fleet compositions and thus uniform divergence in emissions between the two EFTs.

2.4 Figure 10 compares the mean additional emissions across the three modelled speeds and shows a fairly consistent pattern for each speed. It is considered that the mean values at 50 kph provide a reasonable basis for adjusting the background maps. These are shown in Table 1.

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6 Emissions of Nitrogen Oxides from Modern Diesel Vehicles. Air Quality Consultants Ltd. January 2016. http://www.aqconsultants.co.uk/Resources/Download-Reports.aspx

7 as an Annual Average Daily Flow

8 i.e. the 2014 flows were assumed each year. Not factoring in traffic growth will have only a minor effect on this analysis since the key traffic feature of interest is the vehicle fleet composition.

9 The road types used in the EFT were: Inner London; urban in England outside London, rural in England outside London, and rural in Scotland.

10 All roads were assumed to represent all geographical locations, regardless of the actual location of the traffic count point.

2.5 It is considered that in the base year for an assessment, the total background concentration should be the same in both the Defra-EFT-based modelling and the AQC sensitivity test. This is because: a) measurements are available to allow calibration of total background concentrations (see Section 1), and b) having a higher base-year background in the sensitivity test would reduce the required model calibration factor; thus making the sensitivity test less worst-case. Furthermore, Defra calibrated its background maps against measurements in 2011 and so uplifting the 2011 values would be inappropriate in any event.

2.6 The approach should thus be to use either locally-measured background NO_2 (and/or NOx) concentrations or the calibrated Defra-mapped background NO_2 (and/or NOx) concentrations for the base year in both the Defra-EFT-based modelling and the AQC sensitivity test.

2.7 In order to derive future-year background concentrations for the sensitivity test, the year-specific background values should be multiplied by the year-specific value from Table 1, divided by the base-year value from Table 1; i.e.:

A = B x C/D

Where 'A' is the year-specific background NOx concentration to use in the sensitivity test, B is the future-year Defra-mapped background NOx concentration, C is the future-year value from Table 1, and D is the base-year value from Table 1.

2.8 Background nitrogen dioxide concentrations should then be calculated using Defra's background map sector removal tool[11].

2.9 Figure 11 shows a worked example of how this method adjustment alters the total predicted background annual mean nitrogen dioxide concentrations at a nominal location in London based on a 2015 base-year. By way of comparison, the results are also presented assuming no change in the road component of background nitrogen dioxide from 2011. The rate of reductions under the sensitivity test is slower than assumed by Defra's maps, but quicker than derived by holding traffic emissions constant.

[11] http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxsector

Table 1: Percentage Additional Emissions from Sensitivity Test

Year	% Additional Emissions
2011	14.5
2012	17.7
2013	19.1
2014	18.9
2015	19.8
2016	22.3
2017	25.3
2018	28.4
2019	31.5
2020	35.0
2021	38.4
2022	41.8
2023	45.4
2024	48.8
2025	52.1
2026	55.3
2027	58.0
2028	60.1
2029	61.6
2030	62.7

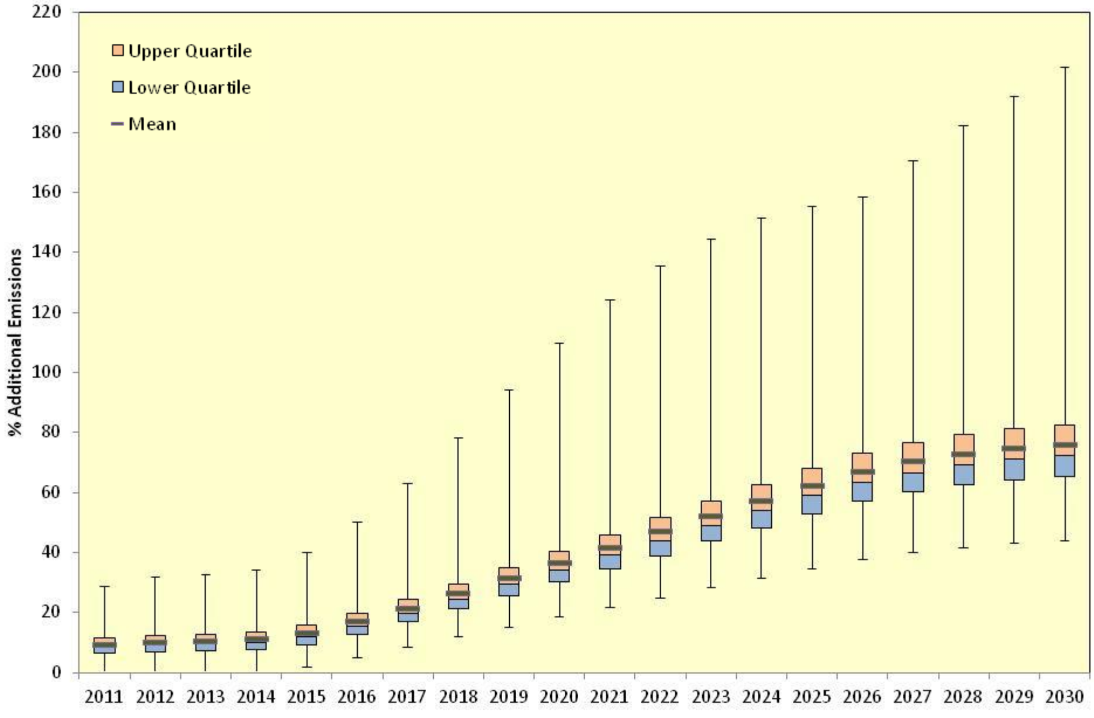

Figure 7: Additional Emissions using Sensitivity Test Compared with Standard EFT (20 kph)

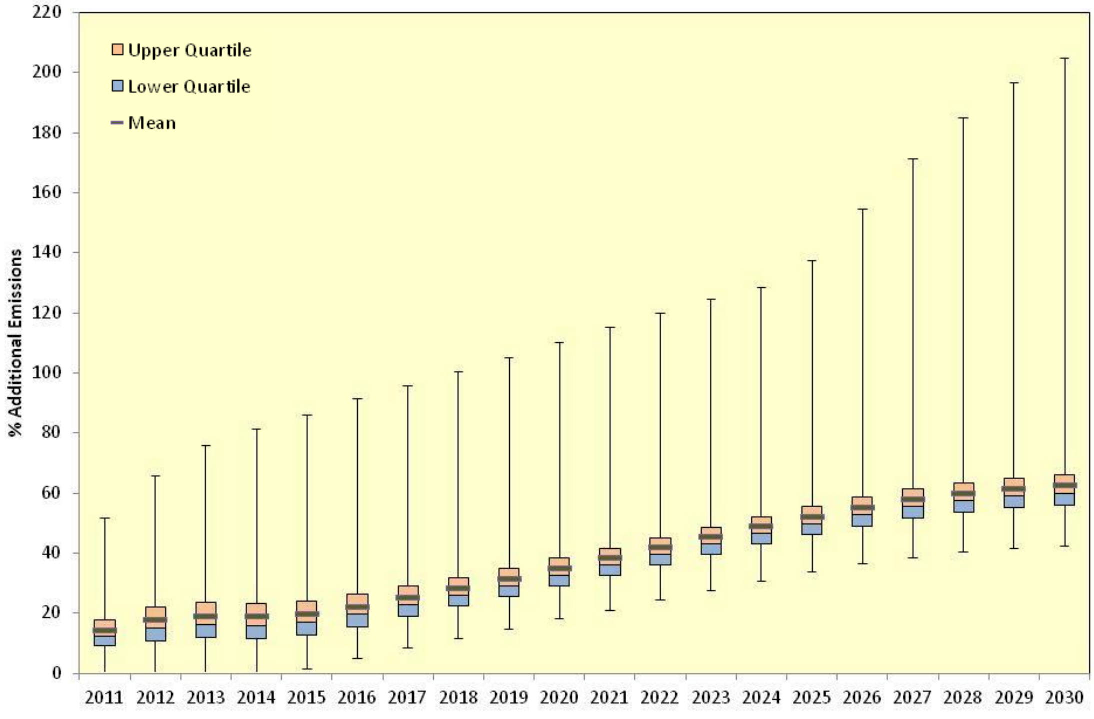

Figure 8: Additional Emissions using Sensitivity Test Compared with Standard EFT (50 kph)

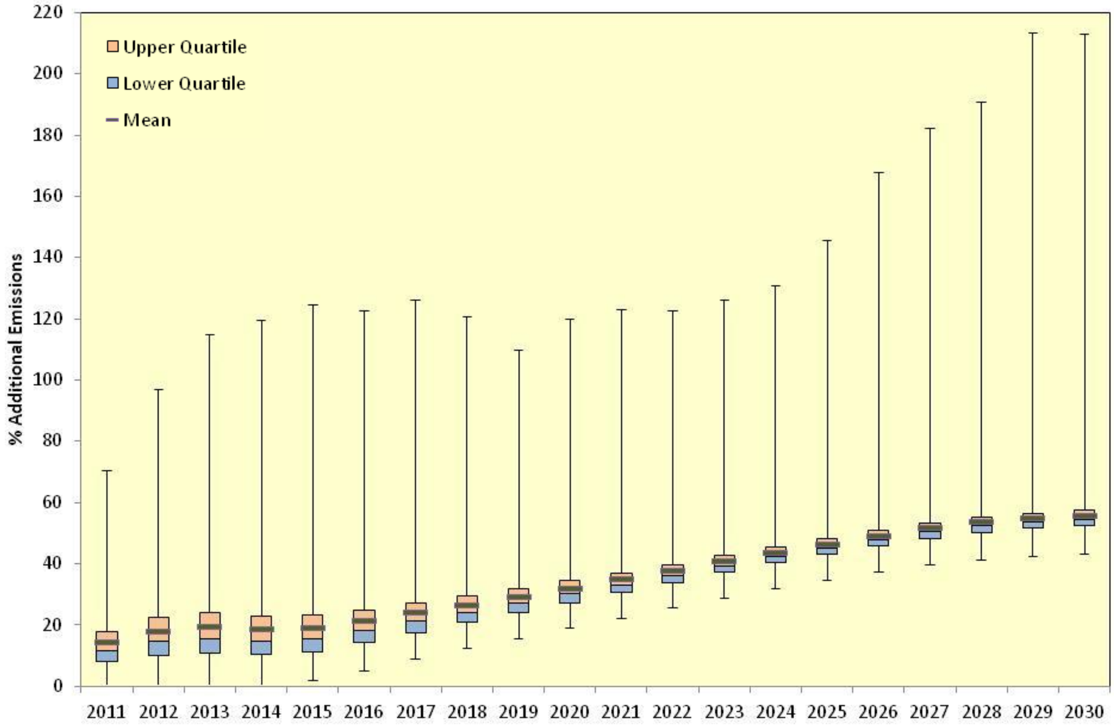

Figure 9: Additional Emissions using Sensitivity Test Compared with Standard EFT (110 kph)

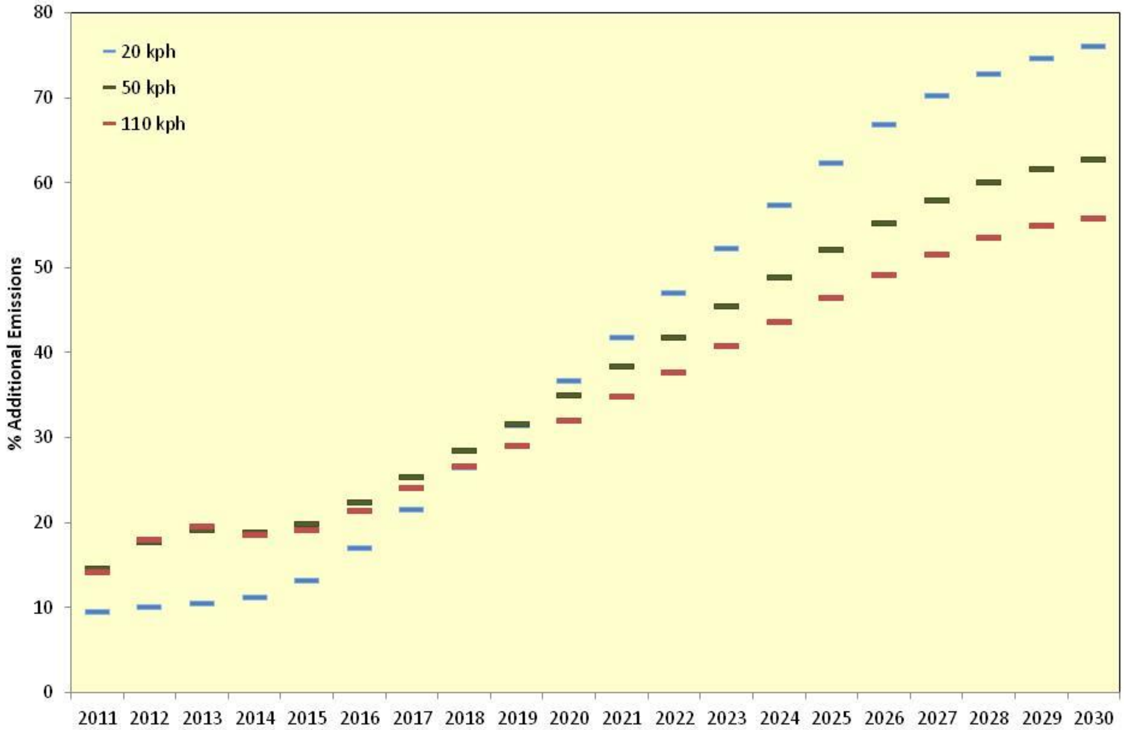

Figure 10: Mean Additional Emissions using Sensitivity Test Compared with Standard EFT at Three Speeds

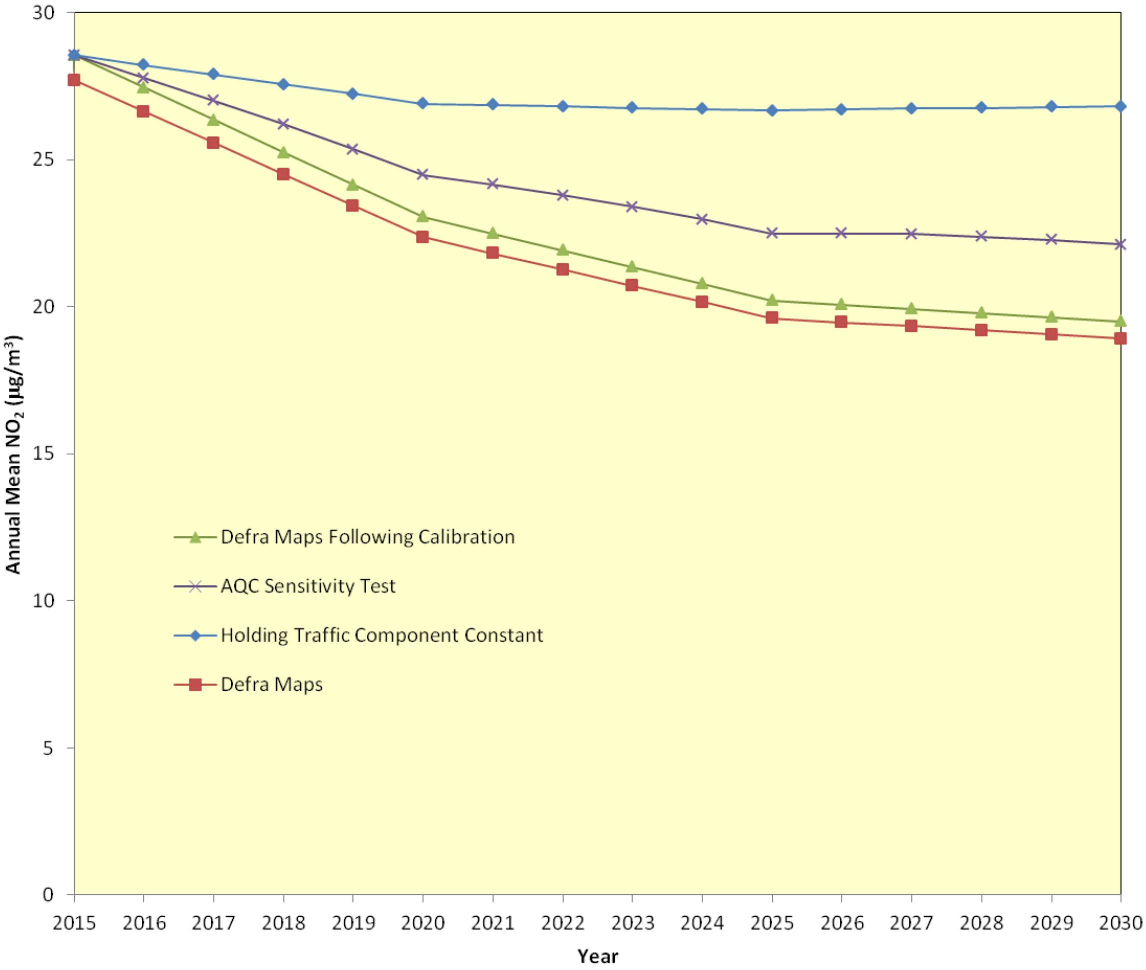

Figure 11: Worked Example of Adjusted Mapped Background Concentrations (for a nominal location in Chiswick, London (grid square 520500,177500))