UK and Gibraltar air quality modelling for annual reporting 2008 on ambient air quality assessment under Council Directives 96/62/EC and 2002/3/EC relating to ozone in ambient air

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Executive Summary

Directive 96/62/EC on Ambient Air Quality Assessment and Management (the Framework Directive) establishes a framework under which the EU sets limit values or target values for the concentrations of specified air pollutants. Directive 2002/3/EC (the third Daughter Directive) sets Target Values (TVs) and Long-term Objectives (LTOs) to be achieved for ozone.

2008 is the fifth year for which an annual air quality assessment for the third Daughter Directive pollutants is required. A questionnaire has been completed for submission to the EU containing the results of this air quality assessment along with those required for the first, second and fourth Daughter Directives. The assessment takes the form of comparisons of measured and modelled air pollutant concentrations with the Target Values and Long-term Objectives set out in the Directive. Air quality modelling has been carried out to supplement the information available from the UK national air quality monitoring networks.

This report provides a summary of key results from the questionnaire and additional technical information on the modelling methods that have been used to assess the levels of ozone throughout the UK. This includes:

- Details of modelling methods
- Information on the verification of the models used and comparisons with data quality objectives (DQOs)
- Detailed modelling results and comparison with Target Values and Long-term Objectives.

Maps of background ozone concentrations in 2008 on a 1 km x 1 km grid have been prepared for the UK. The following metrics set out by the third Daughter Directive have been modelled:

- Number of days above 120 μgm^{-3} in 2008
- Number of days above 120 μgm^{-3} per year averaged over three years 2006-2008
- AOT40 wheat crops in 2008
- AOT40 wheat crops averaged over five years 2004-2008

The models used in this assessment have been selected based on a critical appraisal of the techniques available within the UK.

The UK has been divided into 43 zones for air quality assessment. There are 28 agglomeration zones (large urban areas) and 15 non-agglomeration zones. An assessment of measured levels of ozone in Gibraltar is also presented in this report. Gibraltar is comprised of a single non-agglomeration zone for which no modelling assessment has been undertaken but data from automatic monitoring is presented in this report. The exceedence status of the zones in the UK has been determined from a combination of monitoring data and model results. The exceedence status of the Gibraltar zone has been determined from monitoring data only. The results of the UK assessment are summarised in Tables E1 and E2 in terms of exceedences of Target Values (TV) and Long-term Objectives (LTO). Corresponding results for Gibraltar based on monitoring data only are presented in Tables E3 and E4.

Table E1 UK summary results of air quality assessment relative to the Target Values for ozone for 2010

Target Value	*Number of zones exceeding*
Max Daily 8-hour mean Target Value	1 zone measured (Eastern)
AOT40 Target Value	none

Table E2 UK summary results of air quality assessment relative to the Long-term Objectives for ozone

Long-term Objective	*Number of zones exceeding*
Max Daily 8-hour mean Long-term Objective	43 zones (35 measured + 8 modelled)
AOT40 Long-term Objective	41 zones (25 measured + 16 modelled)

Table E3 Gibraltar summary results of air quality assessment relative to the Target Values for ozone for 2010

Target Value	*Number of zones exceeding*
Max Daily 8-hour mean Target Value	none
AOT40 Target Value	none

Table E4 Gibraltar summary results of air quality assessment relative to the Long-term Objectives for ozone

Long-term Objective	*Number of zones exceeding*
Max Daily 8-hour mean Long-term Objective	1 zone (measured)
AOT40 Long-term Objective	1 zone (measured)

Contents

Appendices

1 Introduction

1.1 The Framework and Daughter Directives

Directive 96/62/EC on Ambient Air Quality Assessment and Management (the Framework Directive (Council Directive 96/62/EC)) establishes a framework under which the EU sets limit values or target values for the concentrations of specified air pollutants in ambient air. Directive 1999/30/EC (the first Daughter Directive, AQDD1) sets the limit values to be achieved for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particles and lead. Directive 2000/69/EC (the second Daughter Directive, AQDD2) sets limit values to be achieved for benzene and carbon monoxide. Directive 2002/3/EC (the third Daughter Directive, AQDD3) sets Target Values (TVs) and Long-term Objectives (LTOs) to be achieved for ozone. Directive 2004/10/EC (the fourth Daughter Directive, AQDD4) sets target values to be achieved for arsenic, cadmium, nickel and polycyclic aromatic hydrocarbons with benzo(a)pyrene (BaP) as an indicator species.

The Framework Directive includes a requirement for Member States to undertake preliminary assessments of ambient air quality, prior to the implementation of the Daughter Directives under Article 5 this Directive. The objectives of these assessments are to establish estimates for the overall distribution and levels of pollutants, and to identify additional monitoring required to fulfil obligations within the Framework Directive. Reports describing the preliminary assessment for the UK for AQDD1, AQDD2, AQDD3 and AQDD4 have been prepared[1,2,3,4]. The Daughter Directives define the number of air quality monitoring sites required on the basis of the concentrations of pollutants and population statistics. The number of monitoring sites required is significantly reduced if other means of assessment, in addition to fixed monitoring sites, are also available. Air quality modelling has therefore been carried out to supplement the information available from the UK national air quality monitoring networks and contribute to the assessments required by the Framework and subsequent Daughter Directives. Obligations for assessments in Gibraltar are entirely fulfilled by measurements.

1.2 This report

The first and second Daughter Directives make provision for an annual air quality assessment for NO_2, PM_{10}, SO_2, CO and benzene. 2008 is the fifth year for which an annual air quality assessment is required for ozone as specified in the third Daughter Directive. A questionnaire has been completed for submission to the EU containing the results of this air quality assessment. A copy of the completed questionnaire for the UK and Gibraltar can be found on the Central Data Repository of the European Environment Agency[5]. The assessment takes the form of comparisons of measured and modelled air pollutant concentrations with the limit values set out in the Directives. This report details the results of annual air quality assessments undertaken to satisfy the UK and Gibraltar's obligation under the third Daughter Directive (AQDD3) and focuses on the modelling methodology for ozone. The air quality assessments for NO_2, PM_{10}, SO_2, CO and benzene are covered in a separate report[6] that can be

[1] Bush T (2000). Article 5 Assessment of Nitrogen Dioxide, PM10, sulphur dioxide and lead in the UK. Report to the Department for Environment, Food and Rural Affairs, the Scottish Executive, Welsh Assembly Government and the Department of the Environment in Northern Ireland. AEA Technology, Netcen report AEAT/R/ENV/0165.
http://www.airquality.co.uk/archive/reports/cat09/0502100920_Art5_v9commission2(final_draft).pdf
[2] Bush T (2002) Preliminary Assessment of benzene and carbon monoxide levels in the UK. Report to the Department for Environment, Food and Rural Affairs, the Scottish Executive, Welsh Assembly Government and the Department of the Environment in Northern Ireland. AEA Technology, Netcen report AEAT/ENV/R/1333/Issue 1
http://www.airquality.co.uk/archive/reports/cat09/art5_dd2_v3aeat.pdf
[3] Bush T and Kent A (2003). Preliminary Assessment of ozone levels in the UK . Report to the Department for Environment, Food and Rural Affairs, the Scottish Executive, Welsh Assembly Government and the Department of the Environment in Northern Ireland. AEA Technology, Netcen report AEAT/ENV/R/1528/Issue 1.
http://www.airquality.co.uk/archive/reports/cat09/0506130933_o3dd1_art5_rep2.pdf
[4] Bush T and Kent A J (2003) Preliminary assessment of air quality in Gibraltar. Report to the Gibraltar Environmental Agency. AEA Technology, Netcen report AEAT/ENV/R/1512/Issue1
[5] CDR, 2008, http://cdr.eionet.europa.eu/gb/eu/annualair

found on the National Air Quality Archive. The air quality assessments for heavy metals and polycyclic aromatic hydrocarbons included in AQDD4 are presented in a third report[7].

Section 2 describes the modelling procedures used for estimation of ozone in the UK. These include:

- Information on the calibration and verification of the models
- Background ambient concentration maps
- Detailed model results and identification of modelled exceedences of TV and LTO

The following metrics relevant to the annual reporting of data to the Commission have been investigated:

- Number of days above 120 $\mu g\ m^{-3}$ in 2008
- Number of days above 120 $\mu g\ m^{-3}$ per year averaged over three years 2006-2008
- AOT40 wheat crops in 2008
- AOT40 wheat crops averaged over five years 2004-2008

The definitions of the metrics presented above and the Target Values and Long-term Objectives are given in Annex I of the Directive. In addition, Annex II of the Directive presents Alert and Information Thresholds designed to inform the public and organisations representing sensitive population groups on occasions when there is increased a risk to human health from exposure to elevated levels of ozone. Annex I and II are presented below.

Section 3 presents the exceedence status of zones in the UK in relation to the TV and LTO in 2008. These results are distinct from the modelled results presented in Section 2, as they also incorporate monitoring data from the national networks to determine the zone status.

Section 4 presents the exceedence information for Gibraltar in 2008. Information for the Gibraltar zone is limited to measured data from continuous automatic monitoring and no model output is available for Gibraltar at this time.

[6] Grice et al. (2009). UK air quality modelling for annual reporting 2008 on ambient air quality assessment under Council Directives 96/62/EC, 1999/30/EC and 2000/69/EC. Report to the Department for Environment, Food and Rural Affairs, the Scottish Executive, Welsh Assembly Government and the Department of the Environment in Northern Ireland. AEA report. AEAT/ENV/R/2656 Issue 1.

[7] Yap, F.W., Kent, A.J., Stedman, J.R., Grice, S.E. and Vincent, K.J. (2009). UK air quality modelling for annual reporting 2008 on ambient air quality assessment under Council Directives 96/62/EC, 1999/30/EC and 2004/107/EC. Report to The Department for Environment, Food and Rural Affairs, Welsh Assembly Government, the Scottish Government and the Department of the Environment for Northern Ireland. AEA Report. AEAT/ENV/R/2860 Issue 1.

ANNEX I

DEFINITIONS, TARGET VALUES AND LONG-TERM OBJECTIVES FOR OZONE

I. Definitions

All values are to be expressed in µg/m³. The volume must be standardised at the following conditions of temperature and pressure: 293 K and 101,3 kPa. The time is to be specified in Central European Time.

AOT40 (expressed in (µg/m³)·hours) means the sum of the difference between hourly concentrations greater than 80 µg/m³ (= 40 parts per billion) and 80 µg/m³ over a given period using only the 1 hour values measured between 8:00 and 20:00. Central European Time each day (1).

In order to be valid, the annual data on exceedances used to check compliance with the target values and long-term objectives below must meet the criteria laid down in Section II of Annex III.

II. Target values for ozone

	Parameter	Target value for 2010 (a) (1)
1. Target value for the protection of human health	Maximum daily 8-hour mean (b)	120 µg/m³ not to be exceeded on more than 25 days per calender year averaged over three years (c)
2. Target value for the protection of vegetation	AOT40, calculated from 1 h values from May to July	18 000 µg/m³·h averaged over five years (c)

(a) Compliance with target values will be assessed as of this value. That is, 2010 will be the first year the data for which is used in calculating compliance over the following three or five years, as appropriate.

(b) The maximum daily 8-hour mean concentration shall be selected by examining 8-hour running averages, calculated from hourly data and updated each hour. Each 8-hour average so calculated shall be assigned to the day on which it ends. i.e. the first calculation period for any one day will be the period from 17:00 on the previous day to 01:00 on that day; the last calculation period for any one day will be the period from 16:00 to 24:00 on the day.

(c) If the three or five year averages cannot be determined on the basis of a full and consecutive set of annual data, the minimum annual data required for checking compliance with the target values will be as follows:
— for the target value for the protection of human health: valid data for one year,
— for the target value for the protection of vegetation: valid data for three years.

(1) These target values and permitted exceedance are set without prejudice to the results of the studies and of the review, provided for in Article 11, which will take account of the different geographical and climatic situations in the European Community.

III. Long-term objectives for ozone

	Parameter	Long-term objective (a)
1. Long-term objective for the protection of human health	Maximum daily 8-hour mean within a calender year	120 µg/m³
2. Long-term objective for the protection of vegetation	AOT40, calculated from 1 h values from May to July	6 000 µg/m³·h

(a) Community progress towards attaining the long-term objective using the year 2020 as a benchmark shall be reviewed as part of the process set out in Article 11.

Source; Directive 2002/3/EC

ANNEX II

INFORMATION AND ALERT THRESHOLDS

I. **Information and alert thresholds for ozone**

	Parameter	Threshold
Information threshold	1 hour average	180 $\mu g/m^3$
Alert threshold	1 hour average (a)	240 $\mu g/m^3$

(a) For the implementation of Article 7, the exceedance of the threshold is to be measured or predicted for three consecutive hours.

II. **Minimum details to be supplied to the public when the information or alert threshold is exceeded or exceedance is predicted**

Details to be supplied to the public on a sufficiently large scale as soon as possible should include:

1. information on observed exceedance(s):
   - location or area of the exceedance,
   - type of threshold exceeded (information or alert),
   - start time and duration of the exceedance,
   - highest 1-hour and 8-hour mean concentration;
2. forecast for the following afternoon/day(s):
   - geographical area of expected exceedances of information and/or alert threshold,
   - expected change in pollution (improvement, stabilisation or deterioration);
3. information on type of population concerned, possible health effects and recommended conduct:
   - information on population groups at risk,
   - description of likely symptoms,
   - recommended precautions to be taken by the population concerned,
   - where to find further information;
4. information on preventive action to reduce pollution and/or exposure to it:

   indication of main source sectors; recommendations for action to reduce emissions.

Source; Directive 2002/3/EC

1.3 Preliminary assessments and definition of zones

The preliminary assessment carried out for AQDD1 defined a set of zones to be used for air quality assessments in the UK based on population and urban areas data from the 1991 UK Census. These data have now been updated using information on populations from the 2001 Census and land-use data from the Devolved Administrations. Updated zones are listed in Table 1.1 and illustrated in Figure 1.1. Information on the definition of zones is included in Form 2 of the questionnaire. The zone codes listed in Table 1.1 are used throughout the questionnaire. The population and area of each zone is also shown. The zones are of two types: agglomeration zones (continuous urban areas with a population in excess of 250,000) and non-agglomeration zones. There are 28 agglomeration zones and 15 non-agglomeration zones, giving a total of 43 zones in the UK. The non-agglomeration zones

in England correspond to the Government Office Regions, while those in Scotland, Wales and Northern Ireland were defined in conjunction with the Devolved Administrations.

The preliminary assessment for ozone also defined the monitoring and modelling requirements for each zone based on an assessment of concentrations in relation to TVs and LTOs specified by AQDD3. The minimum monitoring requirement for ozone and NOx in the majority of zones was found to be at least one monitoring site per zone, with the monitoring results to be supplemented with information from modelling studies.

Figure 1.1 UK zones and agglomerations for 2008
(UK agglomerations zones in red text, non-agglomeration zones in black text)

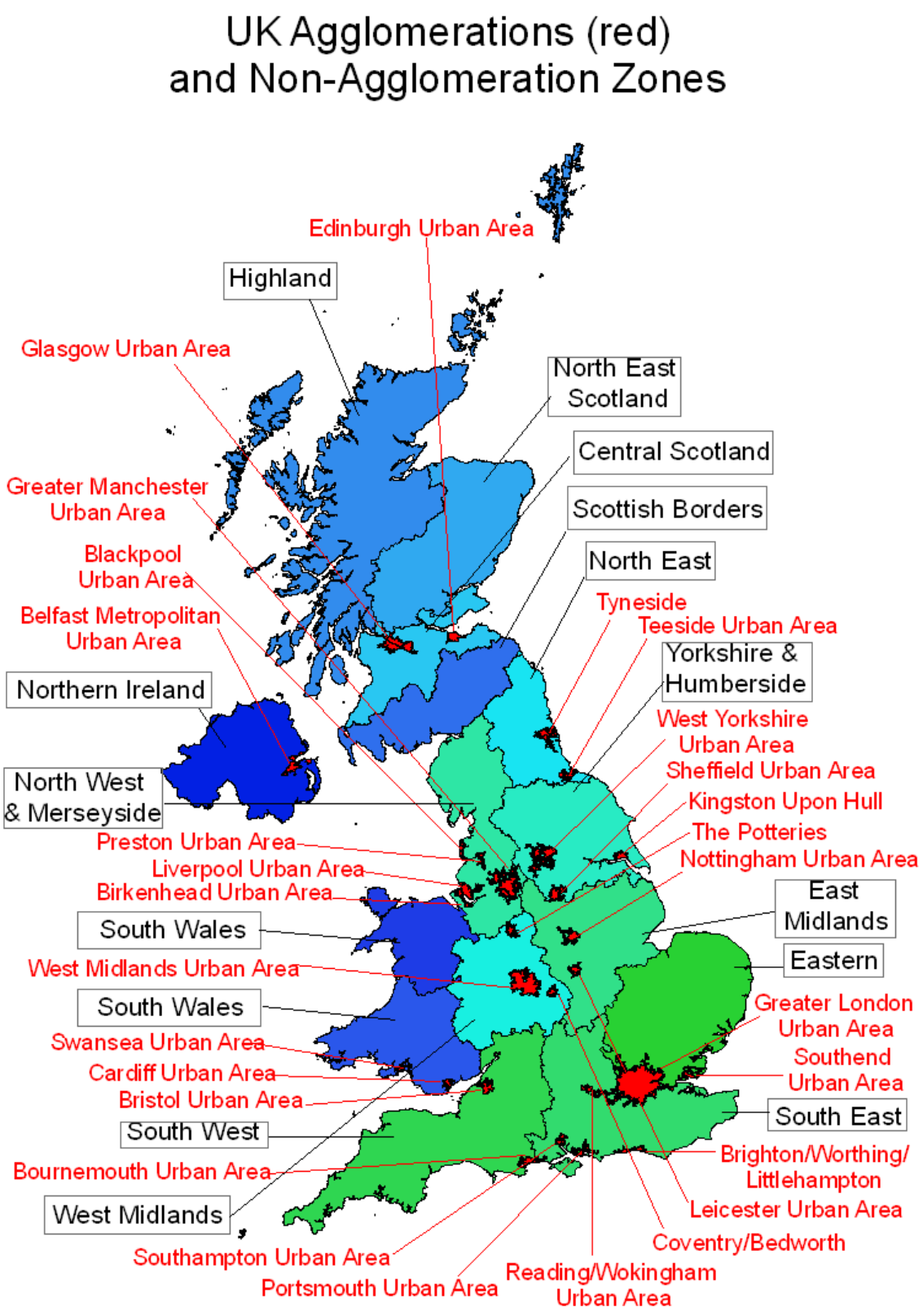


Table 1.1 Zones for AQDD3 reporting

Zone	Zone code	Ag or nonag*	Area (km^2)	Population
Greater London Urban Area	UK0001	ag	1629.9	8278251
West Midlands Urban Area	UK0002	ag	599.7	2284093
Greater Manchester Urban Area	UK0003	ag	556.5	2244931
West Yorkshire Urban Area	UK0004	ag	370.0	1499465
Tyneside	UK0005	ag	210.7	879996
Liverpool Urban Area	UK0006	ag	186.1	816216
Sheffield Urban Area	UK0007	ag	162.2	640720
Nottingham Urban Area	UK0008	ag	158.4	666358
Bristol Urban Area	UK0009	ag	139.8	551066
Brighton/Worthing/Littlehampton	UK0010	ag	94.1	461181
Leicester Urban Area	UK0011	ag	101.6	441213
Portsmouth Urban Area	UK0012	ag	94.4	442252
Teesside Urban Area	UK0013	ag	114.3	365323
The Potteries	UK0014	ag	96.6	362403
Bournemouth Urban Area	UK0015	ag	108.1	383713
Reading/Wokingham Urban Area	UK0016	ag	93.2	369804
Coventry/Bedworth	UK0017	ag	75.5	336452
Kingston upon Hull	UK0018	ag	80.4	301416
Southampton Urban Area	UK0019	ag	72.8	304400
Birkenhead Urban Area	UK0020	ag	89.1	319675
Southend Urban Area	UK0021	ag	66.8	269415
Blackpool Urban Area	UK0022	ag	65.8	261088
Preston Urban Area	UK0023	ag	60.4	264601
Glasgow Urban Area	UK0024	ag	368.7	1168270
Edinburgh Urban Area	UK0025	ag	120.1	452194
Cardiff Urban Area	UK0026	ag	75.6	327706
Swansea Urban Area	UK0027	ag	79.7	270506
Belfast Metropolitan Urban Area	UK0028	ag	198.1	515484
Eastern	UK0029	nonag	19133.7	4909880
South West	UK0030	nonag	23562.6	4039460
South East	UK0031	nonag	18672.6	6160630
East Midlands	UK0032	nonag	15495.9	3261330
North West & Merseyside	UK0033	nonag	13722.9	3470620
Yorkshire & Humberside	UK0034	nonag	14796.6	3003870
West Midlands	UK0035	nonag	12186.3	2624020
North East	UK0036	nonag	8291.4	1443910
Central Scotland	UK0037	nonag	9347.6	1883010
North East Scotland	UK0038	nonag	18631.4	976022
Highland	UK0039	nonag	39134.5	341329
Scottish Borders	UK0040	nonag	11184.1	250529
South Wales	UK0041	nonag	12228.4	1698080
North Wales	UK0042	nonag	8382.6	702506
Northern Ireland	UK0043	nonag	13974.1	1149150
Total			244813.3	61392538

* ag = agglomeration zone, nonag = non-agglomeration zone

1.4 Monitoring sites

The monitoring stations operating during 2008 in the UK and Gibraltar for the purpose of AQDD3 are listed in Table A1.1 and A1.2 in Appendix 1. This information is included in Form 3 of the questionnaire. Not all sites had sufficient data capture during 2008 for data to be reported in the questionnaire. The data quality objective (DQO) for AQDD measurements is 90% data capture. We have included all measurements with at least 75% data capture in the UK modelling analysis in order to ensure that we can make maximum use of data from the monitoring sites operational during 2008 for reporting purposes. Table A1.3 in Appendix 1 lists the data capture rates for all monitoring stations used in the calibration of models for reporting under AQDD1-3.

Measurement data from monitoring stations not in the UK's Automatic Urban and Rural Network have been used as an independent check on the performance of model outputs. These verification data have been sourced from AEA's Calibration Club customers and ad-hoc monitoring campaigns. These data are ratified to the same standard as data from the UK national networks and are widely regarded as high quality and reliable. Monitoring stations used in this verification process are presented in Table A2.1 of Appendix 2.

2 Mapping Methods

This section of the report presents the methods used to map ozone throughout the UK. Following recommendations made by a study comparing the relative performance of the available techniques for modelling ozone within the UK[8], an empirical mapping approach has been used for predicting ozone concentrations in 2008.

The empirical approaches draw upon measurements from the 80 monitoring stations in the AURN during 2008 to produce functions describing ground-level ozone based upon wind velocity, topography and local emissions of NO_X. These functions are capable of predicting ozone levels at a resolution of 1 x 1 km^2 and the methods are briefly described in the following sections; full details can be sourced from the cited references. The methods used here are based upon those presented by Coyle *et al.*[9], NEGTAP[10] and PORG[11].

2.1 Modelling the number of days exceeding 120 μG M^{-3} metric

2.1.1 Days greater than 120 μg m^{-3} methodology

At rural locations in the UK exceedences of 120 μg m^{-3} as a maximum daily 8-hour mean are broadly consistent over wide spatial scales. As a result, measured exceedences from rural monitoring stations have been interpolated throughout the whole UK to represent the likely exceedences of this metric in the absence of NO_X titration effect arising from emissions of NO_X from combustion sources.

The resultant interpolated maps, however, will overestimate exceedences in urban areas, where nitric oxide emissions from combustion sources deplete ozone concentrations. This effect has been accounted for by adding an empirically derived urban ozone decrement expressed as a percentage. The percentage decrement is defined as follows:

> % decrement = 100 * ((measured concentrations - rural interpolated concentration) / rural interpolated concentration)

The derivation of a coefficient relating the percentage decrement to the modelled local NO_X concentration[12] is shown in Figure 2.1 and Figure 2.2.

[8] T Bush and J Targa, 2005. Ozone Mapping Techniques for the 3rd Daughter Directive; OSRM vs Empirical modelling Comparison Report. A report to The Department for Environment, Food and Rural Affairs, Welsh Assembly Government, The Scottish Executive and the Department of the Environment for Northern Ireland. AEA Technology plc, Netcen, Harwell. Report AEAT/ENV/R/2053

[9] Coyle M, Smith R, Stedman J, Weston K and Fowler D, 2002. Quantifying the spatial distribution of surface ozone concentration in the UK. Atmospheric Environment, 36 (2002) 1013-1024.

[10] NEGTAP 2001, Transboundary Air Pollution: Acidification, Eutrophication and Ground-level ozone in the UK. Prepared by the National Expert Group on Transboundary Air Pollution (NEGTAP) on behalf of the Department for Environment, Food and Rural Affairs, the Scottish Executive, Welsh Assembly Government and the Department of the Environment in Northern Ireland. ISBN 1 870393 61 9.

[11] PORG (UK Photochemical Oxidants Review Group), 1998. Ozone in the UK. 4th report of the UK Photochemical Oxidants Review Group, 1st Edition. The Department of the Environment Transport and the Regions.

[12] Grice et al. (2009). UK air quality modelling for annual reporting 2007 on ambient air quality assessment under Council Directives 96/62/EC, 1999/30/EC and 2000/69/EC. Report to the Department for Environment, Food and Rural Affairs, the Scottish Executive, Welsh Assembly Government and the Department of the Environment in Northern Ireland. AEA report. AEAT/ENV/R/2656 Issue 1.

This local NO_X component is calculated as follows:

Local NO_X = modelled background NO_X concentration – modelled rural NO_X concentration

Thus the local NO_X concentration is the sum of contributions from local point and area NO_X emissions calculated using an air dispersion model. Figure 2.1 shows the decrement plot for days greater than 120 μg m^{-3} in 2008 μg m^{-3} (the LTO for human health metric) and Figure 2.2 shows the decrement plot for days greater than 120 μg m^{-3} between 2006 and 2008 (the TV for human health metric).

Figure 2.1 Days greater than 120 μg m^{-3} percentage decrement in ozone concentrations, 2008

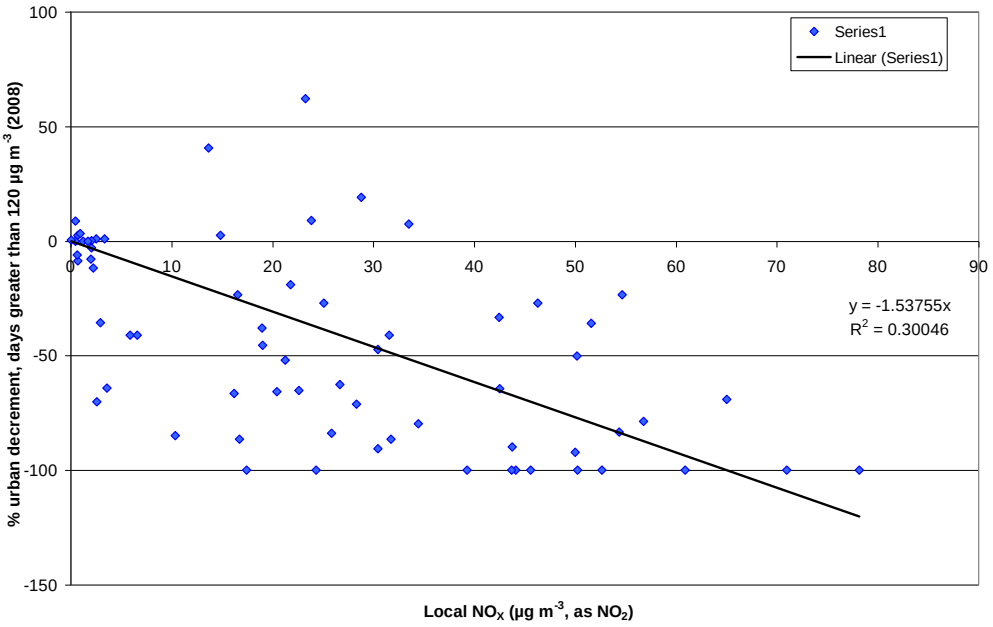
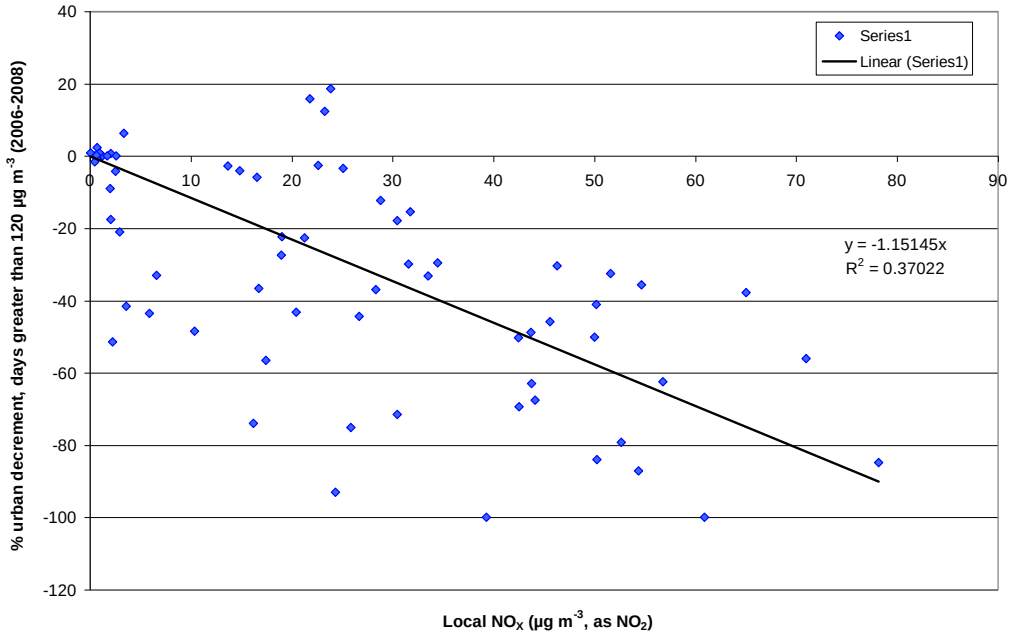


Figure 2.2 Days greater than 120 μg m^{-3} percentage decrement in ozone concentrations, 2006-2008



The calculated decrement is then used to correct the interpolated rural days above 120 μg m^{-3} maps:

Corrected days above 120 μg m^{-3} map = interpolated rural map + decrement

The decrement is a negative value and so reduces the concentration presented in the interpolated rural map to account for titration of ozone due to NO_X concentrations. Where the results of the expression above is a predicted number of days exceeding less than 1, the predicted value is rounded to the nearest integer.

Maps of modelled number of days with maximum daily 8-hour mean ozone concentrations greater than 120 μg m^{-3} for comparison with the Long Term Objective (2008) and Target Value (averaged 2006 to 2008) are presented in Figures 2.3 and 2.4 respectively.

Figures 2.1 and 2.2 show that the relationship between the percentage urban decrement and local NO_X concentration. For some monitoring stations the decrement is positive, indicating that the measured number of days exceeding 120 μg m^{-3} is higher than the corresponding estimated rural value i.e. that the urban influence for these sites is not being properly represented in the model. The cluster of low values close to the origin of these plots largely consists of the rural and remote sites at which there will be little difference between the rural estimated number of days exceeding 120 μg m^{-3} and the measured value. This helps to anchor the relationship to the origin. Percentage urban increments of -100% indicate that there were no measured exceedences of 120 μg m^{-3} that monitoring site.

Figure 2.3 Estimated number of days above 120 μgm^{-3}, 2008

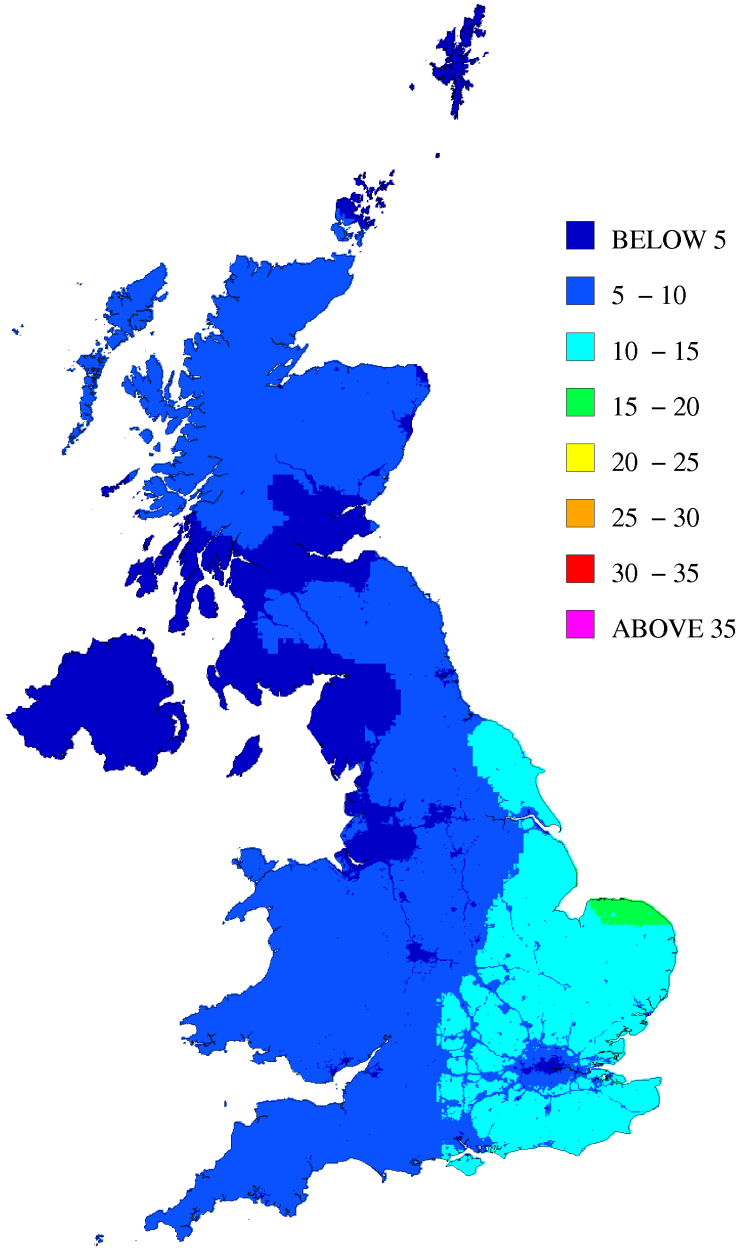
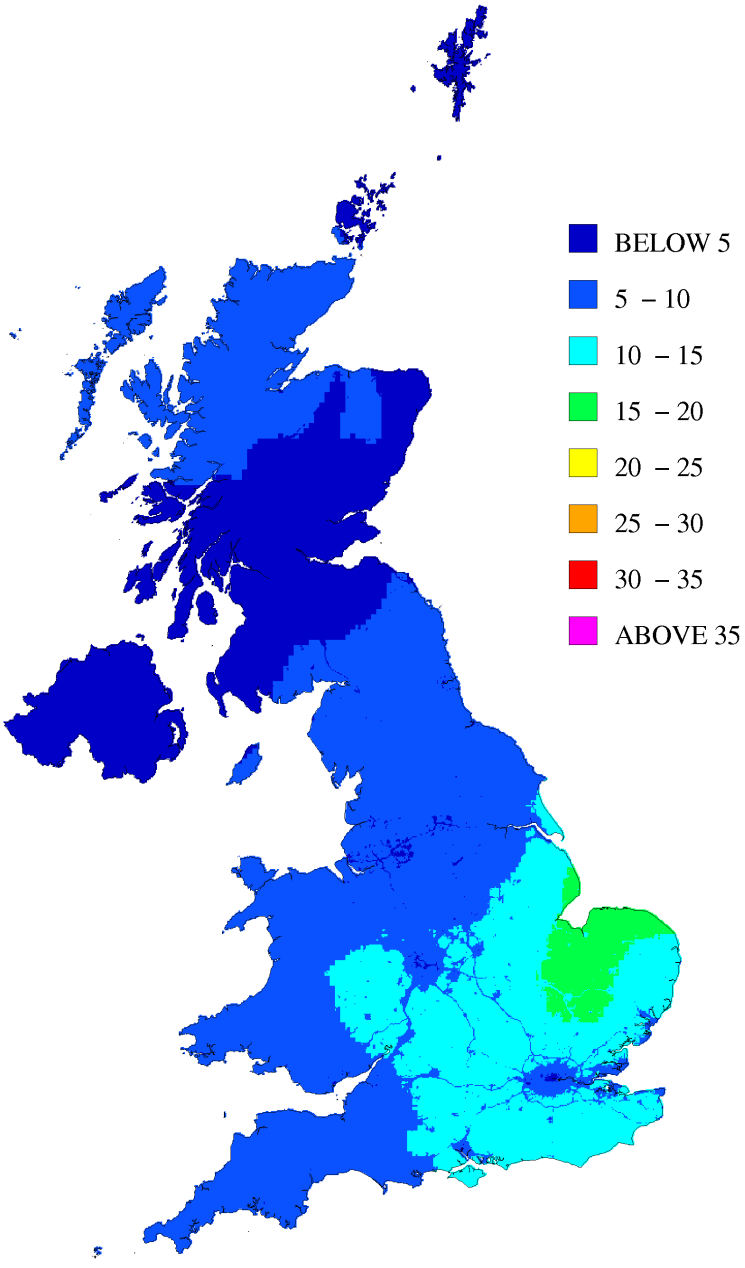


Figure 2.4 Estimated average number of days above 120 μgm^{-3}, 2006 to 2008



2.1.2 Verification of mapped number of days > 120 μg m^{-3} values

Figures 2.5 and 2.6 show comparisons of modelled and measured number of days with maximum daily 8-hour mean ozone concentrations greater than 120 μg m^{-3} in 2008 and averaged 2006-2008 at background locations. Both the national network sites used to calibrate the models and the verification sites are shown. Lines representing y = x – 50 % and y = x + 50% are also shown (this is the AQDD3 data quality objective for modelled ozone concentrations).

Figure 2.5 Verification of background number of days > 120 μg m^{-3} model 2008

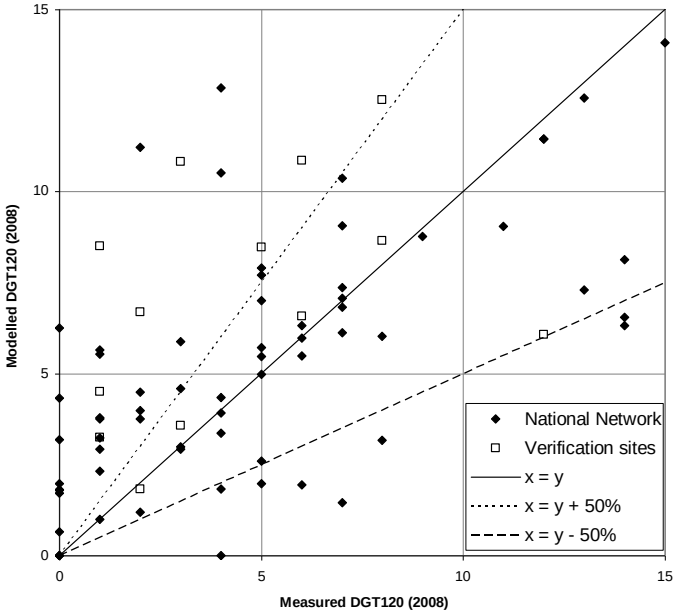


Figure 2.6 Verification of background number of days > 120 μg m^{-3} model 2006 – 2008

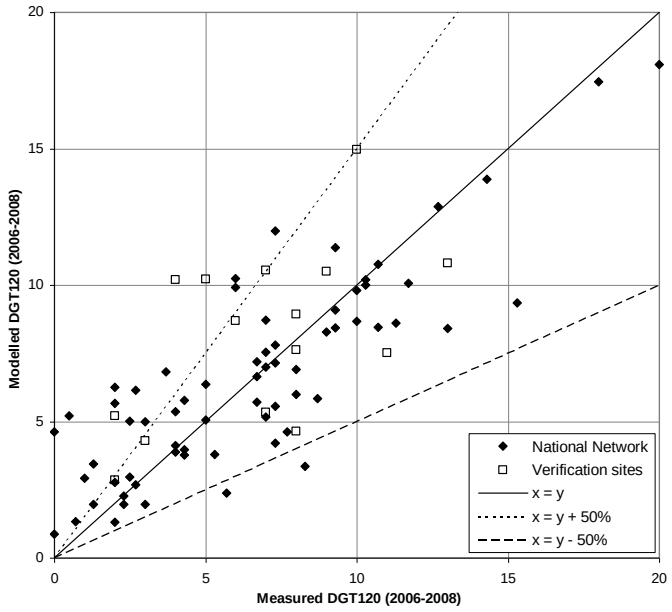


Figure 2.5 indicates that for 2008 none of the verification sites were under estimated, lying outside the +50% DQO and eight were over estimated, lying outside the –50% DQO. The r^2 presented is as low at 0.16. More than half of the verification sites in 2008 were outside the +50% DQO range. The National network sites display much better agreement between measured and modelled figures because these sites were used to generate the relationships used in the model.

Figure 2.6 shows the model performance for the years 2006-2008. This demonstrates an improvement of the multi-year (TV) model over the 2008 (LTO) model. This is because the model performs best in years where ozone concentrations are higher. In 2008 ozone concentrations were particularly low whereas the multi-year model still contains data from the high ozone year of 2006. Again, the model results for the National network sites are shown to closely match the corresponding measured value which is because these sites were used to generate the relationships used in the model. The verification sites in Table 2.1 illustrate an over estimation.

Table 2.1 Summary statistics for comparison between modelled and measured number of days exceeding 120 μg m^{-3} as a maximum daily 8-hour mean

		Mean of measurements (days)	Mean of model estimates (days)	r^2	% outside data quality objectives	No. sites
National Network	2008	4.9	5.4	0.47	49	67
Verification Sites	2008	4.5	7.1	0.16	58	12
National Network	2006-8	6.5	6.6	0.71	27	67
Verification Sites	2006-8	6.9	8.2	0.30	41	17

2.1.3 Detailed comparison of model results with Target Values and Long-term Objectives

The modelling results, in terms of a comparison of modelled concentrations with the Target Value and Long-term Objective, by zone, are summarised in Table 2.2. These data have also been presented in Form 19g of the questionnaire. Method C in this table refers to the modelling method described in this report.

Estimates of area and population exposed have been derived from the background maps only.

Table 2.2 Tabular results of and methods used for supplementary assessment (1999/30/EC Article 7(3) and Annex VIII(II), 2000/69/EC Article 5(3) and Annex VI(II) and 2002/3/EC Article 9(1) and Annex VII(II))

		Above TV for health				*Above LTO for health*			
		Area		*Population exposed*		*Area*		*Population exposed*	
Zone	*Zone code*	*km²*	*Method*	*Number*	*Method*	*km²*	*Method*	*Number*	*Method*
Greater London Urban Area	UK0001	0	C	0	C	1591	C	7469549	C
West Midlands Urban Area	UK0002	0	C	0	C	568	C	2029303	C
Greater Manchester Urban Area	UK0003	0	C	0	C	557	C	1846479	C
West Yorkshire Urban Area	UK0004	0	C	0	C	362	C	1149052	C
Tyneside	UK0005	0	C	0	C	223	C	721105	C
Liverpool Urban Area	UK0006	0	C	0	C	189	C	697951	C
Sheffield Urban Area	UK0007	0	C	0	C	163	C	520456	C
Nottingham Urban Area	UK0008	0	C	0	C	169	C	558935	C
Bristol Urban Area	UK0009	0	C	0	C	142	C	488798	C
Brighton/Worthing/Littlehampton	UK0010	0	C	0	C	103	C	388893	C
Leicester Urban Area	UK0011	0	C	0	C	102	C	374314	C
Portsmouth Urban Area	UK0012	0	C	0	C	102	C	358696	C
Teesside Urban Area	UK0013	0	C	0	C	114	C	302559	C
The Potteries	UK0014	0	C	0	C	91	C	266188	C
Bournemouth Urban Area	UK0015	0	C	0	C	123	C	340957	C
Reading/Wokingham Urban Area	UK0016	0	C	0	C	97	C	305786	C
Coventry/Bedworth	UK0017	0	C	0	C	76	C	277475	C
Kingston upon Hull	UK0018	0	C	0	C	82	C	260479	C
Southampton Urban Area	UK0019	0	C	0	C	79	C	264551	C
Birkenhead Urban Area	UK0020	0	C	0	C	92	C	266360	C
Southend Urban Area	UK0021	0	C	0	C	69	C	220761	C
Blackpool Urban Area	UK0022	0	C	0	C	70	C	218162	C
Preston Urban Area	UK0023	0	C	0	C	58	C	180687	C
Glasgow Urban Area	UK0024	0	C	0	C	365	C	1081776	C
Edinburgh Urban Area	UK0025	0	C	0	C	128	C	432414	C
Cardiff Urban Area	UK0026	0	C	0	C	76	C	264395	C
Swansea Urban Area	UK0027	0	C	0	C	88	C	191717	C
Belfast Urban Area	UK0028	0	C	0	C	208	C	517811	C
Eastern	UK0029	0	C	0	C	19512	C	4965853	C
South West	UK0030	0	C	0	C	24329	C	4105371	C
South East	UK0031	0	C	0	C	19082	C	6230655	C
East Midlands	UK0032	0	C	0	C	15563	C	3260247	C
North West & Merseyside	UK0033	0	C	0	C	14136	C	3503023	C
Yorkshire & Humberside	UK0034	0	C	0	C	14997	C	3022575	C
West Midlands	UK0035	0	C	0	C	12190	C	2622847	C
North East	UK0036	0	C	0	C	8439	C	1489985	C
Central Scotland	UK0037	0	C	0	C	9615	C	1916281	C
North East Scotland	UK0038	0	C	0	C	18837	C	1001550	C
Highland	UK0039	0	C	0	C	43603	C	372608	C
Scottish Borders	UK0040	0	C	0	C	11391	C	254141	C
South Wales	UK0041	0	C	0	C	12624	C	1717133	C
North Wales	UK0042	0	C	0	C	8710	C	716839	C
Northern Ireland	UK0043	0	C	0	C	14547	C	1167417	C

2.2 Modelling the AOT40 vegetation metric

2.2.1 AOT40 methodology

Annex I of the Directive describes AOT40 (expressed in (µg m^{-3})·hours) as the sum of the difference between hourly concentrations greater than 80 µg m^{-3} (= 40 parts per billion) and 80 µg m^{-3} over a given period using only the 1 hour values measured between 8:00 and 20:00 Central European Time each day May to July.

The AOT40 vegetation metrics for 2008 and the averaged metric 2004-2008 were calculated from measured data at rural monitoring stations in the AURN during the "well-mixed" period of the day (hours 1200 UTC to 1800 UTC). These data were interpolated to produce a rural well-mixed map at 5x5 km^2 resolution. Topographic effects are important for some ozone metrics, such as the AOT40 because of the disconnection of a shallow boundary layer from air aloft at times other than during the middle of the day at lowland locations. Surface ozone concentrations are lower at times other than during the middle of the day in these locations due to a combination of dry deposition and titration with NO emissions. This effect is much less marked at higher altitudes and at coastal locations, where wind is generally stronger and a shallow boundary layer does not form. As a result of the influence of altitude on this metric, it is necessary to calculate the metric between these well-mixed hours to allow an appropriate correction to the interpolated well-mixed rural map. This correction accounts for the diurnal variation in ozone, thereby converting the mapped well-mixed AOT40 to an 8.00 to 20.00 AOT40 for comparison against the Directive. The correction uses a variable ΔO_3, where ΔO_3 describes the difference between the AOT40 "well-mixed" and that between 0800 UTC and 2000 UTC[13]. For the purposes of this study the components of ΔO_3 are described as follows and were derived from measured values at rural sites in 2008 for the single year metric and years 2004-2008 for the multi-year metric:

$$\Delta O_{3\ 2007} = 0.0002.\text{altitude} + 1.3688$$

$$\Delta O_{3\ 2003\text{-}7} = 0.0002.\text{altitude} + 1.3667$$

An urban decrement term was subsequently defined for monitoring stations in the AURN and the rural map to correct for the depletion of ozone in areas close to sources of NO. As for the days above 120 µg m^{-3} metric, the decrement is closely related to annual mean NO_X concentration, and has been defined in a similar fashion, using a percentage decrement in ozone concentrations associated with NO_X concentrations. The relationships between the decrement and modelled NO_X concentrations for 2008 and 2004-2008 averaged metrics are presented in Figures 2.7 and 2.8 below.

Using the same methodology discussed in Section 2.1 for the days greater than 120 µg m^{-3} maps, the decrement was then used to correct the final AOT40 maps:

Corrected AOT40 map = interpolated rural map + decrement

Maps of modelled AOT40 for comparison with the Long-term Objective (2008) and Target Value (averaged 2004 to 2008) are presented in Figures 2.9 and 2.10.

[13] Coyle M, Smith R, Stedman J, Weston K and Fowler D, 2002. Quantifying the spatial distribution of surface ozone concentration in the UK. Atmospheric Environment, 36 (2002) 1013-1024.

Figure 2.7 AOT40 percentage decrement in ozone concentrations, 2008

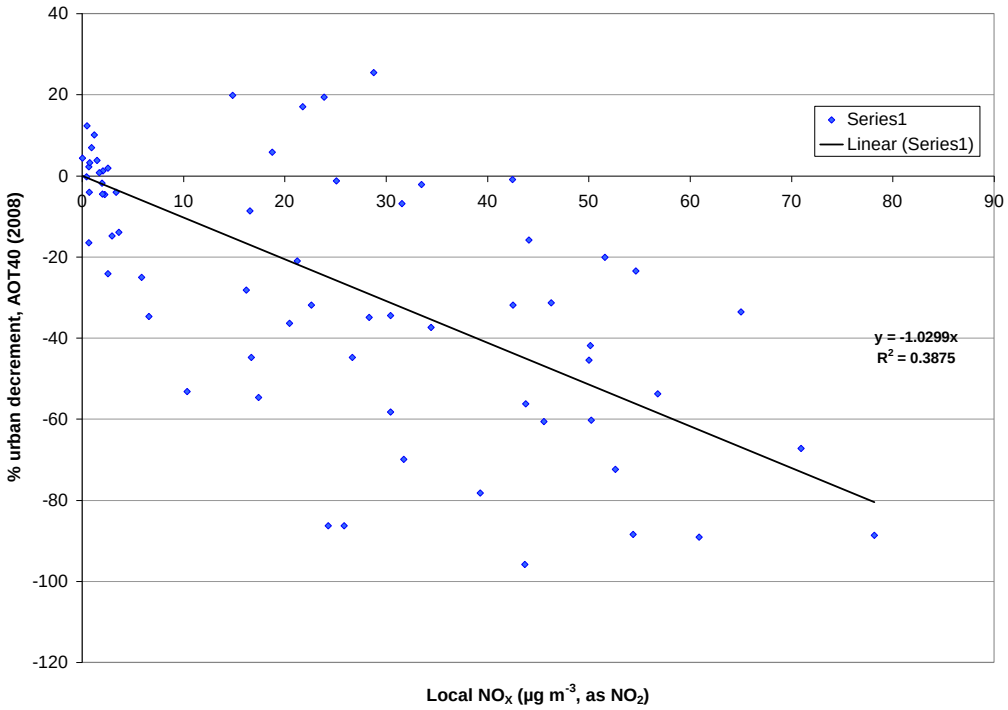


Figure 2.8 AOT40 percentage decrement in ozone concentrations, 2004-2008

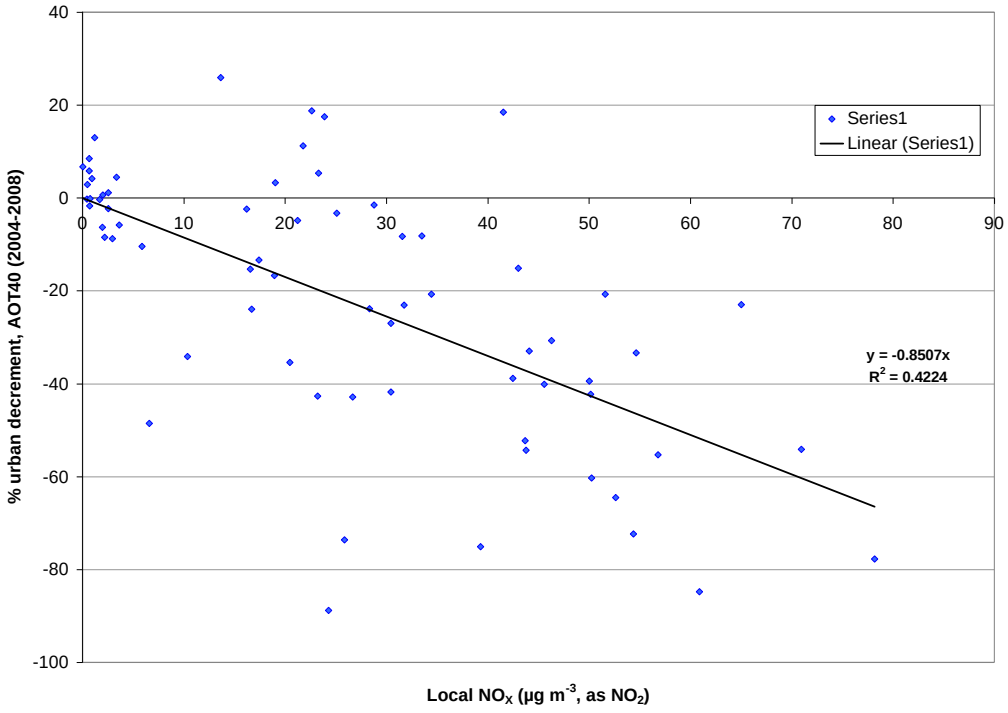


Figure 2.9 Estimated AOT40 vegetation metric, 2008 (μg m^{-3}.hours)

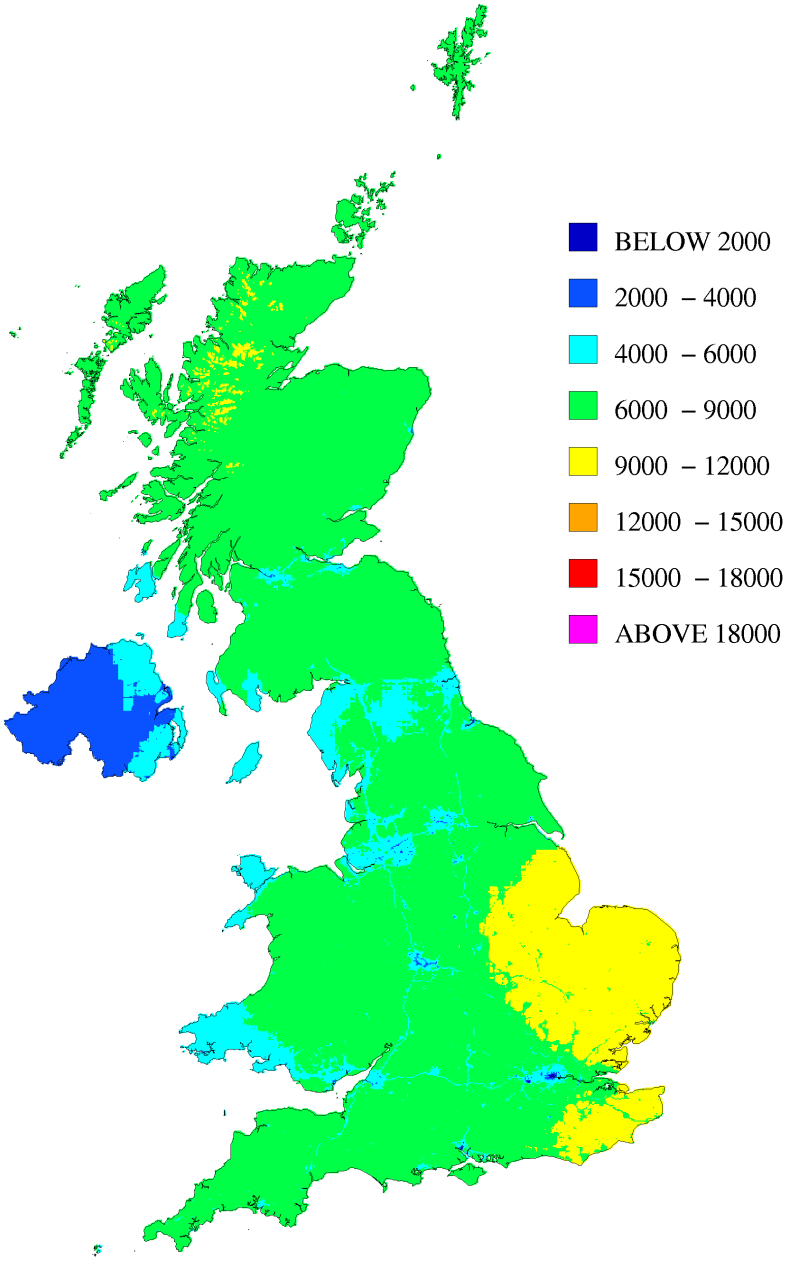
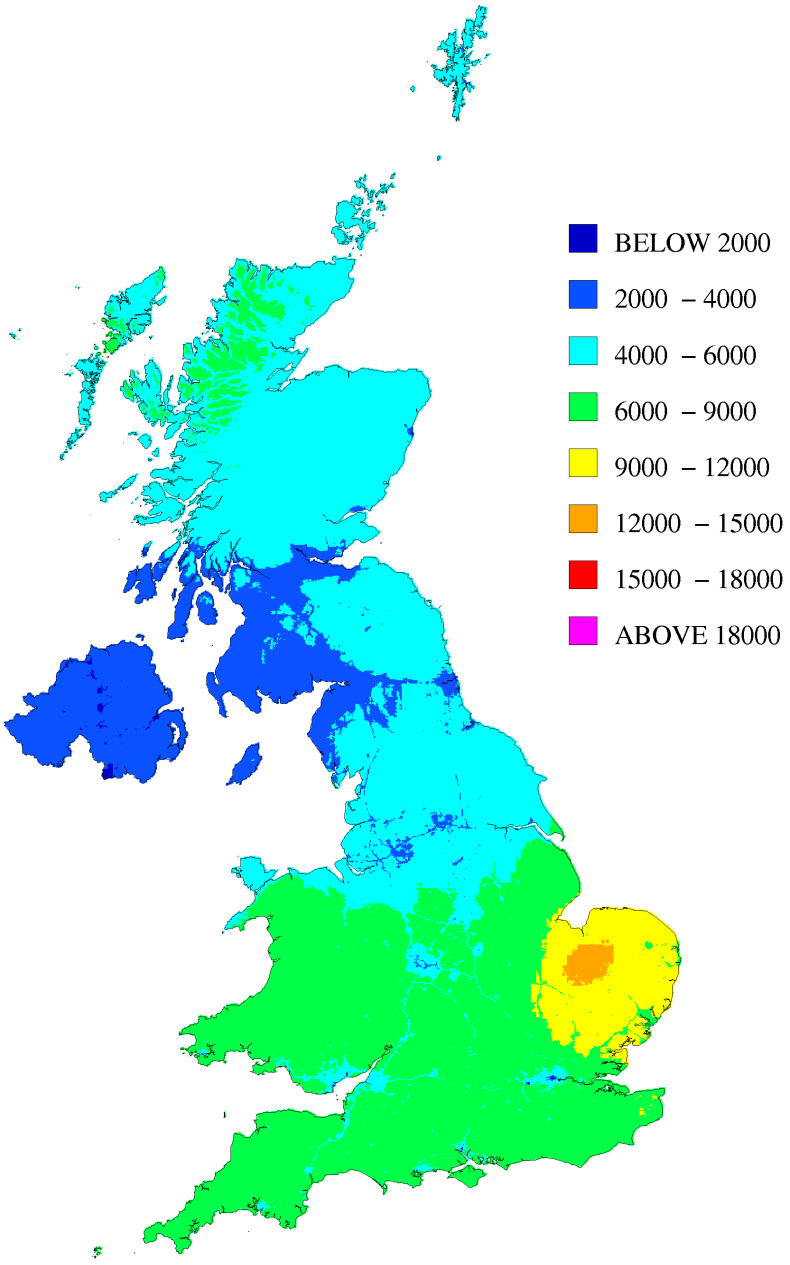


Figure 2.10 Estimated AOT40 vegetation metric, averaged 2004 – 2008 (μg m^{-3}.hours)



2.2.2 Verification of mapped AOT40 values

Figures 2.11 and 2.12 show comparisons of modelled and measured AOT40 metrics in 2008 and averaged 2004-8 at background locations. Both the national network sites used to calibrate the models and the verification sites are shown. Lines representing y = x – 50 % and y = x + 50% are also shown (this is the AQDD3 data quality objective for modelled ozone concentrations).

Figure 2.11 Verification of background AOT40 vegetation model, 2008

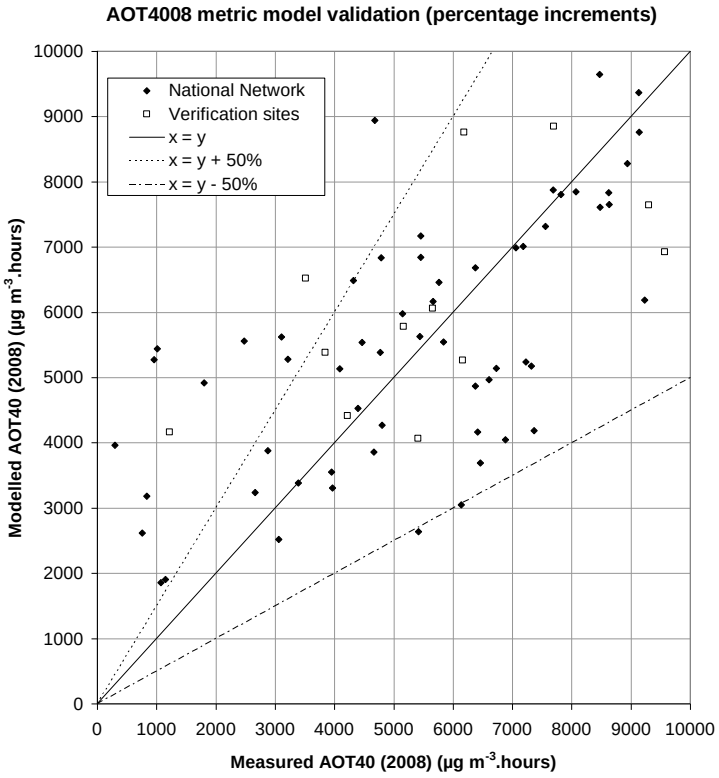
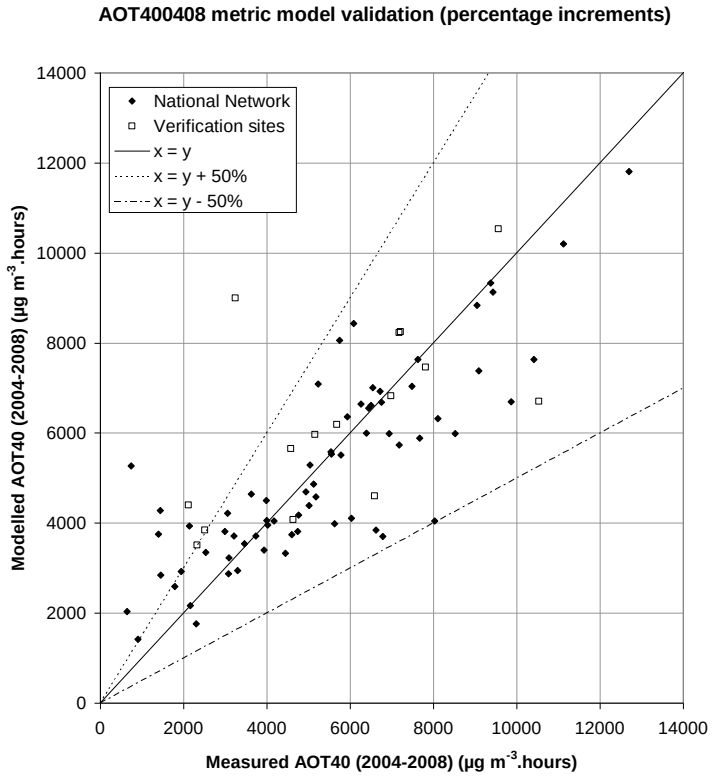


Figure 2.12 Verification of background AOT40 vegetation model, 2004-2008



With the exception of the Thanet rural site, the verification sites generally suggested a slight over estimation by the model for 2008. This is also reflected in the Table 2.3 which presents the summary statistics for the comparison between modelled and measured ozone concentrations. However, the results for the AOT40 metric are more encouraging that those for the number of days greater than 120 µg m^{-3} and all but two of the verification sites was located within the +/- 50% DQO range.

There was not much variation in the multi-year metric (TV) but over estimation was more notable in this metric than in the single year model (LTO), as shown in Table 2.3 below. More verification sites were available for comparison of this metric given the several years across which the metric is calculated. This explains the difference between the 13 sites used for 2008 and the 15 used for 2004-2008.

Table 2.3 Summary statistics for comparison between modelled and measured AOT40 vegetation metric

		Mean of measurements (µg.hours)	Mean of model estimates (µg.hours)	r^2	% outside data quality objectives	No. sites
National Network	2008	6160	5985	0.36	25.3	75
Verification Sites	2008	5787	6475	0.38	15.4	13
National Network	2004-8	5308	5175	0.70	18.7	75
Verification Sites	2004-8	5743	6346	0.39	41.4	15

2.2.3 Detailed comparison of modelling results with Target Values and Long-term Objectives

The modelling results, in terms of a comparison of modelled concentrations with the Long-term Objective and the Target Value by zone, are summarised in Table 2.4. These data have also been presented in Form 19g of the questionnaire. Method C in this table refers to the modelling method described in this report. There are no ecosystems areas in the agglomeration zones (marked with n).

Estimates of area and population exposed have been derived from the background maps only.

Table 2.4 Tabular results of and methods used for supplementary assessment (1999/30/EC Article 7(3) and Annex VIII(II), 2000/69/EC Article 5(3) and Annex VI(II) and 2002/3/EC Article 9(1) and Annex VII(II))

		Above TV for ecosystems				*Above LTO for ecosystems*			
		Area		*Ecosystem area exposed*		*Area*		*Ecosystem area exposed*	
Zone	*Zone code*	*km²*	*Method*	*km²*	*Method*	*km²*	*Method*	*km²*	*Method*
Greater London Urban Area	UK0001	0	C	n	C	1037	C	n	C
West Midlands Urban Area	UK0002	0	C	n	C	240	C	n	C
Greater Manchester Urban Area	UK0003	0	C	n	C	28	C	n	C
West Yorkshire Urban Area	UK0004	0	C	n	C	72	C	n	C
Tyneside	UK0005	0	C	n	C	5	C	n	C
Liverpool Urban Area	UK0006	0	C	n	C	3	C	n	C
Sheffield Urban Area	UK0007	0	C	n	C	109	C	n	C
Nottingham Urban Area	UK0008	0	C	n	C	142	C	n	C
Bristol Urban Area	UK0009	0	C	n	C	10	C	n	C
Brighton/Worthing/Littlehampton	UK0010	0	C	n	C	103	C	n	C
Leicester Urban Area	UK0011	0	C	n	C	78	C	n	C
Portsmouth Urban Area	UK0012	0	C	n	C	74	C	n	C
Teesside Urban Area	UK0013	0	C	n	C	49	C	n	C
The Potteries	UK0014	0	C	n	C	65	C	n	C
Bournemouth Urban Area	UK0015	0	C	n	C	77	C	n	C
Reading/Wokingham Urban Area	UK0016	0	C	n	C	80	C	n	C
Coventry/Bedworth	UK0017	0	C	n	C	61	C	n	C
Kingston upon Hull	UK0018	0	C	n	C	55	C	n	C
Southampton Urban Area	UK0019	0	C	n	C	24	C	n	C
Birkenhead Urban Area	UK0020	0	C	n	C	12	C	n	C
Southend Urban Area	UK0021	0	C	n	C	69	C	n	C
Blackpool Urban Area	UK0022	0	C	n	C	3	C	n	C
Preston Urban Area	UK0023	0	C	n	C	1	C	n	C
Glasgow Urban Area	UK0024	0	C	n	C	93	C	n	C
Edinburgh Urban Area	UK0025	0	C	n	C	19	C	n	C
Cardiff Urban Area	UK0026	0	C	n	C	3	C	n	C
Swansea Urban Area	UK0027	0	C	n	C	0	C	n	C
Belfast Urban Area	UK0028	0	C	n	C	0	C	n	C
Eastern	UK0029	0	C	0	C	19450	C	5180	C
South West	UK0030	0	C	0	C	23611	C	9879	C
South East	UK0031	0	C	0	C	18691	C	2192	C
East Midlands	UK0032	0	C	0	C	15467	C	3627	C
North West & Merseyside	UK0033	0	C	0	C	8314	C	2882	C
Yorkshire & Humberside	UK0034	0	C	0	C	14551	C	4282	C
West Midlands	UK0035	0	C	0	C	11971	C	3501	C
North East	UK0036	0	C	0	C	6898	C	3779	C
Central Scotland	UK0037	0	C	0	C	9181	C	2402	C
North East Scotland	UK0038	0	C	0	C	18739	C	12489	C
Highland	UK0039	0	C	0	C	42452	C	35375	C
Scottish Borders	UK0040	0	C	0	C	10434	C	8337	C
South Wales	UK0041	0	C	0	C	8240	C	5403	C
North Wales	UK0042	0	C	0	C	7354	C	5113	C
Northern Ireland	UK0043	0	C	0	C	0	C	0	C

3 Exceedence of the Target Value and Long-term Objective

3.1 Results for UK in 2008

Table 3.1 presented in this section is derived from Form 9a of the questionnaire. Exceedence (or otherwise) of the Target Value (TV) and Long-term Objective (LTO) where this exists are indicated by a 'y' for measured exceedences and with an 'm' for modelled exceedences. If both measurements and model estimates show that a threshold has been exceeded then the measurements are regarded as the primary basis for compliance status and 'y' is therefore used. An 'm' in the columns marked >TV, ≤TV; >LTO indicates that modelled concentrations were higher than measured concentrations or on rare occasions that measurements were not available for that zone and modelled values were therefore used. Modelled concentrations may be higher than measured concentrations because the modelling studies provide estimates of concentrations over the entire zone. It is possible that the locations of the monitoring sites do not correspond to the location of the highest concentration in the zone. An 'm' in the columns marked ≤LTO indicates that measurements were not available for that zone and modelled values were therefore used.

The results are summarised in Tables 3.2 and 3.3 in terms of exceedences of Target Values (TV) and Long-term Objectives (LTO).

A measured exceedance of the TV for human health has been reported for the Eastern zone as a result of measurements at the Wicken Fen monitoring site. The number of days with running 8-hour mean concentration in the year 2006 to 2008 are listed in Table 3.4. Years with data capture of less than 75% have been excluded from the calculation of the three year average. The number of exceedances during 2007 was much lower than in 2006 or 2008 but the low data capture for this year results is a measured exceedance calculated as the average over the two higher years.

Table 3.1 - Form 9a List of zones and agglomerations in the UK where levels exceed or do not exceed Target Values or Long-term Objective

		Thresholds for health			*Thresholds for vegetation*		
Zone	*Zone code*	*>TV*	*≤TV; >LTO*	*≤LTO*	*>TV*	*≤TV; >LTO*	*≤LTO*
Greater London Urban Area	UK0001		y			y	
West Midlands Urban Area	UK0002		y			y	
Greater Manchester Urban Area	UK0003		y			m	
West Yorkshire Urban Area	UK0004		y			y	
Tyneside	UK0005		m			m	
Liverpool Urban Area	UK0006		m			m	
Sheffield Urban Area	UK0007		m			m	
Nottingham Urban Area	UK0008		y			m	
Bristol Urban Area	UK0009		y			m	
Brighton/Worthing/Littlehampton	UK0010		y			y	
Leicester Urban Area	UK0011		y			y	
Portsmouth Urban Area	UK0012		y			y	
Teesside Urban Area	UK0013		y			m	
The Potteries	UK0014		y			m	
Bournemouth Urban Area	UK0015		y			y	
Reading/Wokingham Urban Area	UK0016		y			y	
Coventry/Bedworth	UK0017		y			y	
Kingston upon Hull	UK0018		y			y	
Southampton Urban Area	UK0019		m			m	
Birkenhead Urban Area	UK0020		y			m	
Southend Urban Area	UK0021		y			y	
Blackpool Urban Area	UK0022		y			y	
Preston Urban Area	UK0023		y			y	
Glasgow Urban Area	UK0024		m			m	
Edinburgh Urban Area	UK0025		y			m	
Cardiff Urban Area	UK0026		y			m	
Swansea Urban Area	UK0027		y			y	
Belfast Urban Area	UK0028		m				y
Eastern	UK0029	y				y	
South West	UK0030		y			y	
South East	UK0031		y			y	
East Midlands	UK0032		y			y	
North West & Merseyside	UK0033		y			m	
Yorkshire & Humberside	UK0034		y			y	
West Midlands	UK0035		y			m	
North East	UK0036		m			m	
Central Scotland	UK0037		y			y	
North East Scotland	UK0038		m			y	
Highland	UK0039		y			y	
Scottish Borders	UK0040		y			y	
South Wales	UK0041		y			y	
North Wales	UK0042		y			y	
Northern Ireland	UK0043		y				y

Table 3.2 - Summary results of air quality assessment relative to the Target Values for ozone for 2010

Target Value	*Number of zones exceeding*
Max Daily 8-hour mean Target Value	1 measured zone (Eastern)
AOT40 Target Value	none

Table 3.3 - Summary results of air quality assessment relative to the Long-term Objectives for ozone

Long-term Objective	*Number of zones exceeding*
Max Daily 8-hour mean Long-term Objective	43 zones (35 measured + 8 modelled)
AOT40 Long-term Objective	41 zones (25 measured + 16 modelled)

Table 3.4 - The number of days with running 8 hour mean concentration for 2006-2008

	Number of days	*Data capture (%)*
2006	39	90
2007	6	74
2008	15	86
3 year average	27	2006 and 2008 only

Individual measured exceedances of ozone thresholds are listed in forms 13a-13c of the EU reporting questionnaire[14]. There were measured exceedances of the ozone information threshold at the Hull Freetown monitoring sites (form 13a). There were no exceedances of the ozone alert threshold (form 13b). Exceedances of the long-term objective for health protection were recorded at a number of monitoring sites (form 13c). There was one exceedance of the target value for human health (form 14a) as described above. There were no exceedances of the target value for vegetation. Summary statistics are presented in form 15a of the questionnaire.

[14] CDR, 2008, http://cdr.eionet.europa.eu/gb/eu/annualair

3.2 Results for Gibraltar in 2008

A comparable air quality assessment for ozone is carried out for Gibraltar just as for the rest of the UK and is submitted to the European Commission in a separate questionnaire. The results of this assessment for 2008 are presented in this section. The results for Gibraltar have been based on measured data from automatic monitoring, no model outputs are available for Gibraltar.

Table 3.6 presented below is from Form 9a of the questionnaire. Exceedence (or otherwise) of the Target Value (TV) and Long-term Objective (LTO) where this exists are indicated by a 'y' for measured exceedences and with an 'm' for modelled exceedences.

The results for Gibraltar are summarised in Tables 3.7 and 3.8 in terms of exceedences of Target Values (TV) and Long-term Objectives (LTO).

Table 3.6 - Form 9a List of zones and agglomerations in Gibraltar where levels exceed or do not exceed Target Values or Long-term Objective

		Thresholds for health			*Thresholds for vegetation*		
Zone	*Zone code*	*>TV*	*≤TV; >LTO*	*≤LTO*	*>TV*	*≤TV; >LTO*	*≤LTO*
Gibraltar	UK(GIB)		y			y	

Table 3.7 - Summary results of air quality assessment relative to the Target Values for ozone for 2010

Target Value	*Number of zones exceeding*
Max Daily 8-hour mean Target Value	none
AOT40 Target Value	none

Table 3.8 - Summary results of air quality assessment relative to the Long-term Objectives for ozone

Long-term Objective	*Number of zones exceeding*
Max Daily 8-hour mean Long-term Objective	1 zone (measured)
AOT40 Long-term Objective	1 zone (measured)

3.3 Measured exceedences in Gibraltar in 2008

Forms 13a-c of the EU reporting questionnaire require reasons associated with the measured exceedences of the LTO, Alert Threshold and Information Threshold to be documented. Available monitoring data shows that neither the Alert Threshold nor the Information Threshold were exceeded in Gibraltar in 2008. There were measured exceedences of the LTO for health in Gibraltar in 2008, the details of which are presented in Form 13c of the EU reporting questionnaire[15]. Measured annual statistics for ozone are presented in Form 15a of the questionnaire. Forms 14a-b relate to measured exceedence of the TVs of which there are none.

[15] CDR, 2008, http://cdr.eionet.europa.eu/gb/eu/annualair

3.4 Acknowledgements

This work was funded by the UK Department for Environment, Food and Rural Affairs, Welsh Assembly Government, the Scottish Executive, the Department of the Environment in Northern Ireland and the Government of Gibraltar. Permission to include monitoring data and detailed information on site locations for the verification sites were kindly provided by the Local Authorities and companies listed in Table A2.1 in Appendix 2. The authors would also like to thank CEH Edinburgh for providing information upon mapping days exceeding and AOT40 metrics.

APPENDIX 1. NATIONAL NETWORK MONITORING SITES

Table A1.1. UK monitoring sites operating during 2008 for AQDD3 reporting.

EoI station code	*Local station code*	*Zone code*	*Type of station**	*Use in relation to Directive 2002/3/EC*		
				O_3	NO_2	NO_x
GB0729A	Aberdeen	UK0038	U	y	y	y
GB0031R	Aston Hill	UK0042	R	y	y	y
GB0895A	Auchencorth Moss	UK0037	R	y		
GB0681A	Barnsley Gawber	UK0034	U	y	y	y
GB0567A	Belfast Centre	UK0028	U	y	y	y
GB0569A	Birmingham Centre	UK0002	U	y	y	y
GB0851A	Birmingham Tyburn	UK0002	U	y	y	y
GB0882A	Blackpool Marton	UK0022	U	y	y	y
GB0654A	Bolton	UK0003	U	y	y	y
GB0032R	Bottesford	UK0032	S	y		
GB0741A	Bournemouth	UK0015	U	y	y	y
GB0860A	Brighton Preston Park	UK0010	U	y	y	y
GB0884A	Bristol St Paul's	UK0009	U	y	y	y
GB0033R	Bush Estate	UK0037	R	y	y	y
GB0580A	Cardiff Centre	UK0026	U	y	y	y
GB0957A	Charlton Mackrell	UK0030	R	y	y	y
GB0739A	Coventry Memorial Park	UK0017	U	y	y	y
GB0744A	Cwmbran	UK0041	U	y	y	y
GB0673A	Derry	UK0043	U	y	y	y
GB0839A	Edinburgh St Leonards	UK0025	U	y	y	y
GB0002R	Eskdalemuir	UK0040	R	y	y	y
GB0640A	Exeter Roadside	UK0030	U	y	y	y
GB0885A	Fort William	UK0039	S	y	y	y
GB0641A	Glasgow Centre	UK0024	U	y	y	y
GB0034R	Glazebury	UK0033	S	y	y	y
GB0035R	Great Dun Fell	UK0033	RB	y		
GB0036R	Harwell	UK0031	R	y	y	y
GB0014R	High Muffles	UK0034	R	y	y	y
GB0776A	Hull Freetown	UK0018	U	y	y	y
GB0037R	Ladybower	UK0032	R	y	y	y
GB0643A	Leamington Spa	UK0035	U	y	y	y
GB0584A	Leeds Centre	UK0004	U	y	y	y
GB0597A	Leicester Centre	UK0011	U	y	y	y
GB0861A	Leominster	UK0035	S	y	y	y
GB0881A	Lerwick	UK0039	R	y		
GB0777A	Liverpool Speke	UK0006	U	y	y	y
GB0566A	London Bloomsbury	UK0001	U	y	y	y
GB0586A	London Eltham	UK0001	S	y	y	y
GB0638A	London Haringey	UK0001	U	y	y	y
GB0837A	London Harlington	UK0001	U	y	y	y
GB0642A	London Hillingdon	UK0001	S	y	y	y
GB0682A	London Marylebone Road	UK0001	U	y	y	y
GB0620A	London N. Kensington	UK0001	U	y	y	y

EoI station code	*Local station code*	*Zone code*	*Type of station**	*Use in relation to Directive 2002/3/EC*		
				O_3	NO_2	NO_x
GB0644A	London Teddington	UK0001	U	y	y	y
GB0743A	London Westminster	UK0001	U	y	y	y
GB0006R	Lough Navar	UK0043	RB	y		
GB0038R	Lullington Heath	UK0031	R	y	y	y
GB0613A	Manchester Piccadilly	UK0003	U	y	y	y
GB0649A	Manchester South	UK0003	S	y	y	y
GB0838A	Market Harborough	UK0032	R	y	y	y
GB0583A	Middlesbrough	UK0013	U	y	y	y
GB0043R	Narberth	UK0041	RB	y	y	y
GB0568A	Newcastle Centre	UK0005	U	y	y	y
GB0738A	Northampton	UK0032	U	y	y	y
GB0684A	Norwich Centre	UK0029	U	y	y	y
GB0646A	Nottingham Centre	UK0008	U	y	y	y
GB0687A	Plymouth Centre	UK0030	U	y	y	y
GB0906A	Port Talbot Margam	UK0027	U	y	y	y
GB0733A	Portsmouth	UK0012	U	y	y	y
GB0731A	Preston	UK0023	U	y	y	y
GB0840A	Reading New Town	UK0016	U	y	y	y
GB0617A	Rochester Stoke	UK0031	R	y	y	y
GB0660A	Salford Eccles	UK0003	U	y	y	y
GB0698A	Sandwell West Bromwich	UK0002	U	y	y	y
GB0615A	Sheffield Centre	UK0007	U	y	y	y
GB0039R	Sibton	UK0029	RB	y		
GB0044R	Somerton	UK0030	R	y	y	y
GB0598A	Southampton Centre	UK0019	U	y	y	y
GB0728A	Southend-on-Sea	UK0021	U	y	y	y
GB0754A	St Osyth	UK0029	R	y	y	y
GB0658A	Stoke-on-Trent Centre	UK0014	U	y	y	y
GB0015R	Strath Vaich	UK0039	RB	y		
GB0863A	Sunderland Silksworth	UK0036	U	y	y	y
GB0645A	Thurrock	UK0029	U	y	y	y
GB0745A	Weybourne	UK0029	R	y		
GB0045R	Wicken Fen	UK0029	R	y	y	y
GB0864A	Wigan Centre	UK0033	U	y	y	y
GB0730A	Wirral Tranmere	UK0020	U	y	y	y
GB0013R	Yarner Wood	UK0030	R	y	y	y

Table A1.2. Gibraltar monitoring sites operating during 2008 for AQDD3 reporting.

EoI station code	*Local station code*	*Zone code*	*Type of station**	*Use in relation to Directive 2002/3/EC*		
				O_3	NO_2	NO_x
GB00051A	Gibraltar Bleak House	UK(GIB)	U	y	y	y

* Station types defined in Annex IV of third Daughter Directive (2002/3/EC):
U = urban
S = suburban
R = rural
RB = rural background

Table A1.3 Data capture rates for sites used in model calibrations for AQDD3, 2008

Site	*Data Capture (%)*	
	O3	*NO2 and NOX*
Aberdeen	99.0	98.0
Aston Hill	84.2	85.4
Auchencorth Moss	97.7	nm
Barnsley Gawber	98.8	90.9
Belfast Centre	85.3	92.2
Birmingham Centre	98.0	96.5
Birmingham Tyburn	98.4	98.4
Blackpool Marton	98.5	98.1
Bolton	35.0	28.1
Bottesford	98.8	nm
Bournemouth	99.0	96.2
Brighton Preston Park	90.0	98.6
Bristol St Paul's	95.5	- nm
Bush Estate	97.5	90.0
Cardiff Centre	98.7	98.6
Charlton Mackrell	32.4	28.8
Coventry Memorial Park	99.5	99.2
Cwmbran	86.6	88.2
Derry	97.7	96.1
Edinburgh St Leonards	96.0	95.6
Eskdalemuir	88.9	93.4
Exeter Roadside	87.5	87.3
Fort William	99.2	88.0
Glasgow Centre	97.7	76.9
Glazebury	90.0	48.7
Great Dun Fell	94.8	nm
Harwell	97.6	97.9
High Muffles	88.3	97.9
Hull Freetown	97.5	92.6
Ladybower	98.2	94.3
Leamington Spa	96.1	85.7
Leeds Centre	99.6	99.5
Leicester Centre	99.3	99.2
Leominster	99.1	94.6
Lerwick	96.1	-nm
Liverpool Speke	98.2	94.6
London Bloomsbury	98.3	99.2
London Eltham	96.7	95.7
London Haringey	98.0	98.2
London Harlington	99.0	97.7
London Hillingdon	99.1	83.1
London Marylebone Road	97.2	99.0
London N. Kensington	99.0	89.8
London Teddington	98.2	97.0
London Westminster	97.9	98.1

Site	*Data Capture (%)*	
	O3	*NO2 and NOX*
Lough Navar	96.0	nm
Lullington Heath	98.0	97.1
Manchester Piccadilly	97.0	78.1
Manchester South	97.4	91.7
Market Harborough	98.6	99.0
Middlesbrough	98.5	98.6
Narberth	71.9	94.1
Newcastle Centre	96.6	92.5
Northampton	95.4	92.4
Norwich Centre	36.2	36.3
Nottingham Centre	97.2	97.8
Plymouth Centre	81.4	81.4
Port Talbot Margam	95.3	95.2
Portsmouth	99.3	97.0
Preston	98.4	88.2
Reading New Town	97.2	98.2
Rochester Stoke	99.2	96.8
Salford Eccles	91.7	92.3
Sandwell West Bromwich	95.4	94.3
Sheffield Centre	98.4	97.6
Sibton	68.8	nm
Somerton	16.3	16.4
Southampton Centre	95.8	94.3
Southend-on-Sea	99.5	99.3
St Osyth	89.7	87.1
Stoke-on-Trent Centre	96.4	96.5
Strath Vaich	84.4	nm
Sunderland Silksworth	98.0	96.3
Thurrock	96.4	96.8
Weybourne	97.0	nm
Wicken Fen	89.6	93.8
Wigan Centre	97.3	98.9
Wirral Tranmere	98.6	98.2
Yarner Wood	87.9	81.7

nm = not measured

Table A1.4 Data capture rates for Gibraltar monitoring sites used for AQDD3,2008

Site	*Data Capture (%)*	
	O3	*NO2 and NOX*
Gibraltar Bleak House	98.6	89.1

APPENDIX 2. MONITORING SITES USED TO VERIFY THE MAPPED ESTIMATES

Table A2.1. Monitoring sites used to verify the mapped estimates

Site	Site Type	Authority
Abingdon	URBAN BACKGROUND	Vale of White Horse DC
Chatham Luton Background	URBAN BACKGROUND	Kent & Medway Air Quality Monitoring Network
Folkestone Suburban	SUBURBAN	Kent & Medway Air Quality Monitoring Network
Glasgow Waulkmillglen Reservoir	RURAL	Glasgow City Council
Maidstone Rural	RURAL	Kent & Medway Air Quality Monitoring Network
Marchlyn Mawr	REMOTE	Gwyneth Council
Newham Wren Close	URBAN BACKGROUND	London Borough of Newham
Newport Malpas Depot	URBAN BACKGROUND	Newport County BC
Oldham West End House	URBAN BACKGROUND	Oldham MBC
Oxford St Ebbes (Cal Club)	URBAN BACKGROUND	Oxford City Council
South Holland	RURAL	South Holland DC
Tameside Two Trees School	URBAN BACKGROUND	Tameside MBC
Thanet Rural	RURAL	Kent & Medway Air Quality Monitoring Network
V Glamorgan Fonmon	RURAL	Vale of Glamorgan Council
Wycombe Abbey	URBAN BACKGROUND	Wycombe District Council