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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

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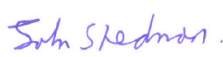| Title	UK air quality modelling for annual reporting 2008 on ambient air quality assessment under Council Directives 96/62/EC, 1999/30/EC and 2004/107/EC
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Executive summary

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 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, PM_{10} particles and lead. Directive 2004/107/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.

This is the first year for which an annual air quality assessment for the fourth Daughter Directive pollutants is required. A questionnaire has been completed for submission to the EU containing the results of this air quality assessment. The assessment takes the form of comparisons of measured and modelled air pollutant concentrations with the limit and target values set out in the Directives. Air quality modelling has been carried out to supplement the information available from the UK national air quality monitoring networks. The annual air quality assessments for the first and second Daughter Directive pollutants are discussed in a separate report (Grice et al., 2009). The annual air quality assessment for ozone required by the third Daughter Directive has been carried out by Kent and Stedman (2009).

A description of the assessment for Pb has been included in this report because the modelling method for this pollutant is very similar to those for the heavy metals covered by AQDD4. Previous assessments (Grice et al., 2009) for Pb were in the basis of objective estimation based on emission inventory results for zones for which measurements were not available. The development of the models for the heavy metals included in AQDD4 enables us now to carry out a more detailed modelling assessment for Pb.

This report summarises the modelling methods used for estimation of As, Cd, Ni and Pb concentrations and provides similar information for BaP. This includes:

- Details of the modelling methods

- Information on the verification of the models used and comparisons with data quality objectives

- Detailed modelling results.

The annual mean background concentrations for the heavy metals are made up of contributions from:

- Area sources

- Point sources

- The heavy metal component of regional PM as a result of long range transport

- Re-suspension of heavy metals from bare soils and associated with vehicles.

Annual mean concentrations of BaP include contributions from area and point sources.

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. The status of zones in relation to the target values for the AQDD4 pollutants and AQDD1 limit value for Pb have been listed and reported to the EU in the questionnaire. The status has been determined from a combination of monitoring data and model results. The results of this assessment are summarised in Table E1.

Table E1. Summary results of air quality assessment for 2008

Pollutant	Averaging time	Number of zones exceeding target value (limit value for pb)
As	Annual	None
Cd	Annual	None
Ni	Annual	2 zones modelled (Swansea, S Wales measured at non-network site, so reported as m)
BaP	Annual	6 zones, (3 zones measured: Yorkshire & Humberside, Teeside, N Ireland + 3 zones modelled: Swansea, S Wales, Belfast)
Pb	Annual	None

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Appendices

1 Introduction

1.1 The Framework and fourth and first Daughter Directive

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 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, PM_{10} particles and lead. Directive 2004/107/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 and AQDD4 have been prepared (Bush 2000, Bush 2007). AQDD1 and AQDD4 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.

Directive 2008/50/EC on ambient air quality and clean air for Europe entered into force in June 2008. This directive will replace the framework and first three daughter directives two years after entering into force (June 2010). Air quality reporting therefore continues as required by the framework and daughter directives until then.

1.2 This report

Annual air quality assessments are required by the ambient air quality directives. This report describes the methods used to carry out the assessments for the pollutants included in AQDD4 (As, Cd, Ni and BaP) and Pb which is included in AQDD1. The assessments for the remaining pollutants covered by AQDD1 (SO_2, NO_x, NO_2 and PM_{10}) and for the pollutants covered by the second Daughter Directive (CO and benzene) are discussed in a separate report (Grice et al., 2009). The assessment for ozone required by the third Daughter Directive is described by Kent and Stedman (2009).

A questionnaire has been completed for submission to the EU containing the results of these air quality assessments. A copy of the completed questionnaire can be found on the Central Data Repository of the European Environment Agency (CDR, 2009). The assessment takes the form of comparisons of measured and modelled air pollutant concentrations with the limit and target values set out in the Directives. This report provides a summary of key results from the questionnaire for As, Cd, Ni, Pb and BaP and additional information on the modelling methods that have been used to assess concentrations throughout the UK.

Section 2 describes the Pollution Climate Mapping (PCM) modelling methods used for estimation of As, Cd, Ni and Pb concentrations and section 3 provides similar information for BaP. This includes:

- Details of the modelling methods

- Information on the verification of the models used and comparisons with data quality objectives

- Detailed modelling results.

The status of zones in relation to the target values for the AQDD4 pollutants and AQDD1 limit value for Pb have been listed and reported to the EU in the questionnaire (CDR, 2009) and copies of these

lists are included in Section 4. The status has been determined from a combination of monitoring data and model results.

A description of the assessment for Pb has been included in this report because the modelling method for this pollutant is very similar to those for the heavy metals covered by AQDD4. Previous assessments (Grice et *al.*, 2009) for Pb were in the basis of objective estimation based on emission inventory results for zones for which measurements were not available. The development of the models for the heavy metals included in AQDD4 enables us now to carry out a more detailed modelling assessment for Pb.

1.3 Preliminary assessments and definition of zones

The preliminary assessment carried out for AQDD1 and AQDD4 (Bush 2000, Bush 2007) defined a set of zones to be used for air quality assessment in the UK. The UK has been divided into 15 zones based on official Government Office boundaries within England and boundaries provided or authorised by the relevant Government offices within Scotland, Wales and Northern Ireland. A further 28 agglomeration zones (areas of urban population > 250,000) have also been agreed. These were based on Government geographical information system (GIS) data on urban areas for England, Scotland, Wales and Northern Ireland (Scottish Executive 2004, ONS 2004 and NISRA 2005). Table 1.1 contains details of area, population (from 2001 census) and urban road length contained in each zone and agglomeration. The zones and agglomerations map for the UK is presented in Figure 1.1.

Figure 1.1. UK zones and agglomerations for 2008

UK Agglomerations (red)
and Non-Agglomeration Zones
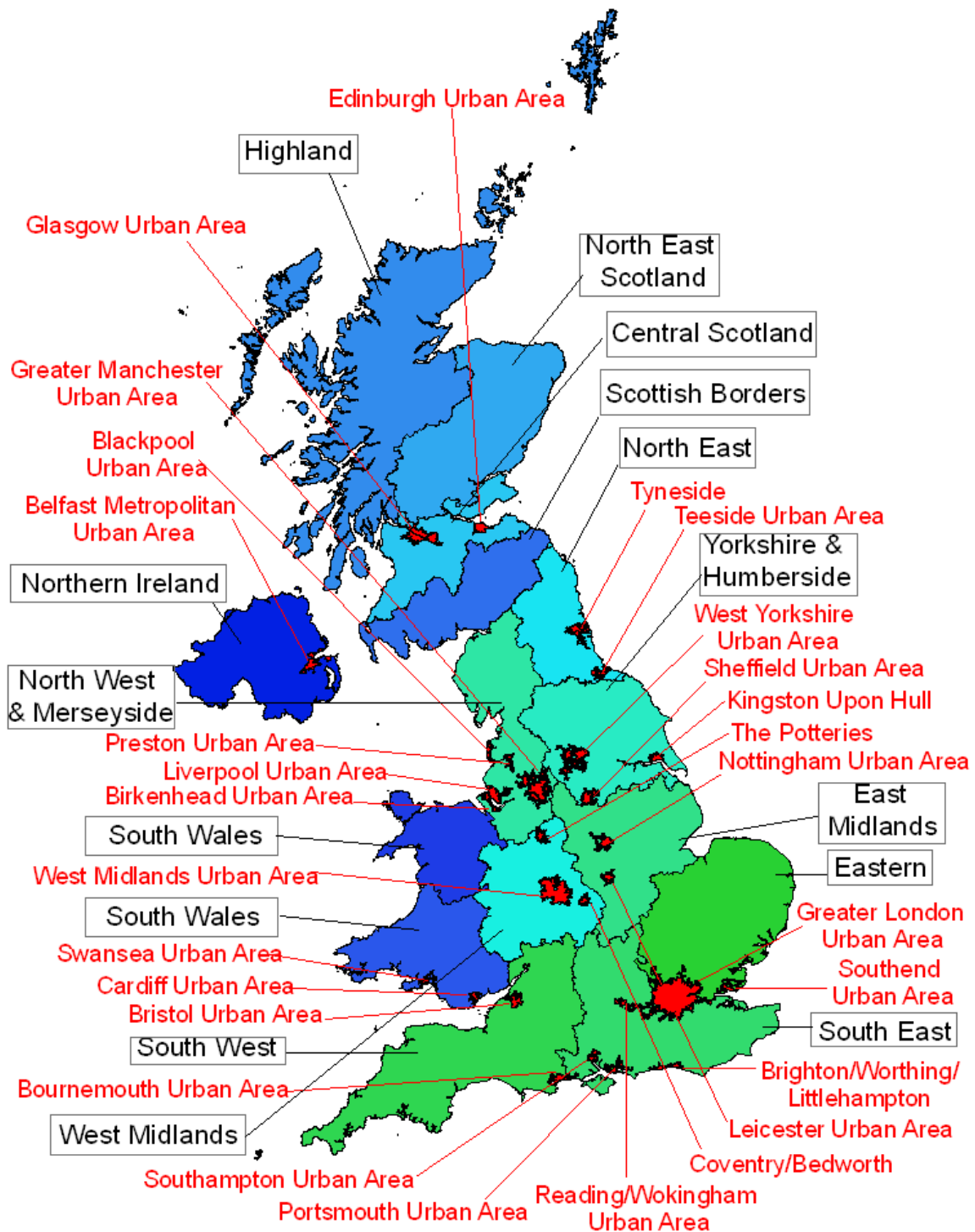
Table 1.1. Zones for AQDD reporting

Zone	Zone code	Ag or nonag*	Population	Area (km²)	Number of urban road links	Length of urban road links (km)
Greater London Urban Area	UK0001	ag	8278251	1629.9	1934	1890.4
West Midlands Urban Area	UK0002	ag	2284093	599.7	393	552.2
Greater Manchester Urban Area	UK0003	ag	2244931	556.5	550	661.0
West Yorkshire Urban Area	UK0004	ag	1499465	370.0	282	423.9
Tyneside	UK0005	ag	879996	210.7	171	206.0
Liverpool Urban Area	UK0006	ag	816216	186.1	254	216.7
Sheffield Urban Area	UK0007	ag	640720	162.2	110	160.3
Nottingham Urban Area	UK0008	ag	666358	158.4	123	134.0
Bristol Urban Area	UK0009	ag	551066	139.8	113	116.2
Brighton/Worthing/Littlehampton	UK0010	ag	461181	94.1	61	88.9
Leicester Urban Area	UK0011	ag	441213	101.6	66	81.3
Portsmouth Urban Area	UK0012	ag	442252	94.4	55	75.3
Teesside Urban Area	UK0013	ag	365323	114.3	63	73.6
The Potteries	UK0014	ag	362403	96.6	112	129.0
Bournemouth Urban Area	UK0015	ag	383713	108.1	48	72.1
Reading/Wokingham Urban Area	UK0016	ag	369804	93.2	65	76.8
Coventry/Bedworth	UK0017	ag	336452	75.5	29	36.0
Kingston upon Hull	UK0018	ag	301416	80.4	40	60.1
Southampton Urban Area	UK0019	ag	304400	72.8	53	63.7
Birkenhead Urban Area	UK0020	ag	319675	89.1	65	73.4
Southend Urban Area	UK0021	ag	269415	66.8	31	50.6
Blackpool Urban Area	UK0022	ag	261088	65.8	48	64.8
Preston Urban Area	UK0023	ag	264601	60.4	35	47.4
Glasgow Urban Area	UK0024	ag	1168270	368.7	201	300.6
Edinburgh Urban Area	UK0025	ag	452194	120.1	60	102.3
Cardiff Urban Area	UK0026	ag	327706	75.6	38	59.1
Swansea Urban Area	UK0027	ag	270506	79.7	29	65.1
Belfast Metropolitan Urban Area	UK0028	ag	515484	198.1	29	158.4
Eastern	UK0029	nonag	4909880	19133.7	603	866.0
South West	UK0030	nonag	4039460	23562.6	439	648.9
South East	UK0031	nonag	6160630	18672.6	808	1303.0
East Midlands	UK0032	nonag	3261330	15495.9	418	696.3
North West & Merseyside	UK0033	nonag	3470620	13722.9	578	970.7
Yorkshire & Humberside	UK0034	nonag	3003870	14796.6	365	754.8
West Midlands	UK0035	nonag	2624020	12186.3	351	544.4
North East	UK0036	nonag	1443910	8291.4	199	289.3
Central Scotland	UK0037	nonag	1883010	9347.6	222	360.9
North East Scotland	UK0038	nonag	976022	18631.4	130	230.4
Highland	UK0039	nonag	341329	39134.5	9	32.4
Scottish Borders	UK0040	nonag	250529	11184.1	35	47.3
South Wales	UK0041	nonag	1698080	12228.4	167	321.1
North Wales	UK0042	nonag	702506	8382.6	86	156.0
Northern Ireland	UK0043	nonag	1149150	13974.1	85	348.9
Total			61392538	244813.3	9553	13609.8

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

1.4 Monitoring sites

The monitoring stations operating during 2008 for the purpose of the ambient air quality directives are listed in Form 3 of the questionnaire which can be found on the CDR (2009). Not all sites had sufficient data capture during 2008. The minimum data capture for the pollutants are 90% as set in the Annex IV of the directives. The minimum time coverage is 100% for Pb, 50% for As, Cd, Ni and 33% for BaP. We have, however, included all measurements for model calibration and verification. In the questionnaire, only the measurements of at least 75% of full year data capture are presented. The monitoring data for these monitoring sites are shown in Table 2.1.

Data capture statistics for all the monitoring sites operational during 2008 are presented in Form 3 of the reporting questionnaire.

1.5 Target values and limit values

The target values (TV) included in AQDD4 and the limit value (LV) for lead in AQDD1 are listed in Tables 1.2 to 1.3. The Directives states that Member States should take all necessary measures not entailing disproportionate costs to ensure that the target values are met by the compliance date. limit values are more stringent and the Member State should take all measures required to ensure compliance.

Table 1.2. Target values for As, Cd and Ni

Pollutant	Averaging period	TV (ng/m^3)	Date by which TV is to be met
As	Calendar year	6	31 December 2012
Cd	Calendar year	5	31 December 2012
Ni	Calendar year	20	31 December 2012
Benzo(a)pyrene	Calendar year	1	31 December 2012

Table 1.3. Limit value for Pb

	Averaging period	LV (μg m^{-3})	Date by which LV is to be met
Annual LV for the protection of human health	Calendar year	0.5	1 January 2005

1.6 Data quality objectives for modelling results and model verification

AQDD1 and AQDD4 set data quality objectives (DQOs) in terms of accuracy, which acts as a guide for quality assurance programmes when identifying an acceptable level of accuracy for assessment methods appropriate for supplementary assessment. Accuracy is defined in the Directives as the maximum deviation of the measured and calculated concentration levels, over the period considered by the limit value, without taking into account the timing of events.

DQOs have been set at 60% for annual averages of As, Cd, Ni and BaP and 50% for the annual averages of Pb.

The models used to calculate the maps of air pollutants presented in this report have been calibrated and verified using the national network monitoring data, for sites listed in Form 3 of the reporting questionnaire. Model verification results are listed in the following sections on each pollutant.

1.7　Air quality in Gibraltar in 2008

Air quality monitoring is undertaken in Gibraltar and these data are submitted to the Commission each year via a separate questionnaire to that compiled for the UK (CDR 2009). The results of the air quality assessment for Gibraltar are presented in Appendix 2, including tables of the relevant forms from the questionnaire and details of the monitoring sites.

2 Heavy metals

2.1 Introduction

Heavy metals are dangerous to health and the environment. Scientific evidence shows that heavy metals are human genotoxic carcinogens and that there is no identifiable threshold below which these substances do not pose a risk to human health. Impacts on human health and on the environment arise from both concentrations of metals in ambient air and their deposition. With a view to cost-effectiveness, ambient air concentrations of heavy metals which would not pose a significant risk to human health cannot be achieved in specific area. TVs were set in 4th Daughter Directive for As, Cd, Ni and Benzo(a)pyrene and LV for Pb in First Daughter Directive with the aim of minimising harmful effects on human health, paying particular attention to sensitive populations, and the environment as a whole, of airborne heavy metals.

An assessment to determine the concentration of each heavy metal in ambient air has been undertaken. It has been considered that annual mean background concentrations for each of the pollutant are made up of contributions from:

- Area sources,
- Point sources,
- Heavy metals component of long range transport of primary PM, and
- Resuspension of heavy metals from bare soils and from vehicles.

Modelling work has been undertaken previously by Vincent and Passant (2008) to predict ambient concentrations of As, Cd and Ni in preparation for implementing the 4th Daughter Directive. Measured concentrations were under-predicted by the model which suggested that the source apportionment of ambient concentration was poorly understood. Only area and point sources were considered as the sources that contributed to the ambient concentrations. The resuspension of heavy metals from bare soils and from vehicles was not included in the previous modelling assessment which used only reported emission inventories.

Abbott (2008) has suggested a method for estimating the contribution to ambient heavy metal concentration from soil and vehicle related re-suspension processes. The methods used to estimate PM mass and the heavy metal concentrations from re-suspension processes are described below.

The preliminary assessment carried out for AQDD4 (Bush, 2007), highlighted the need additional monitoring at 11 locations across in the UK. As National Physical Laboratory (NPL) ran the Heavy Metals Network on behalf of Defra, they were tasked in expanding the Network by 11 sites. The details of these additional monitoring sites are shown in the NPL report (Butterfield et *al.*, 2008) and the results of these additional monitoring sites are included in this report.

2.2   Monitoring sites

The monitoring sites that presented in Table 2.1 contain data capture of at least 75% to ensure we can make maximum use of data from the monitoring sites operational for the full of 2008 for reporting purposes.

Table 2.1. Measured annual mean heavy metal concentrations in 2008 for monitoring sites with > 75% data capture
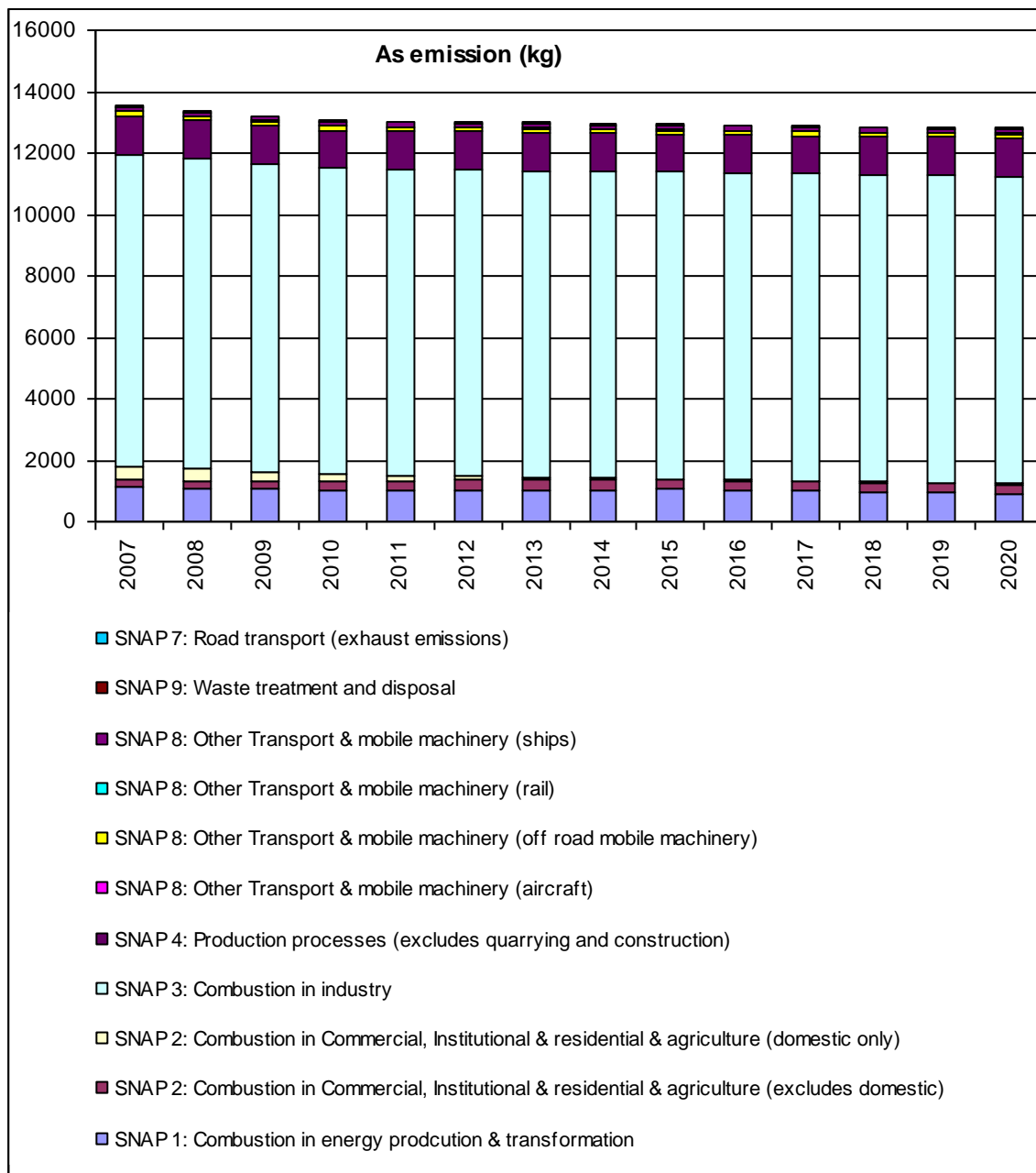
Site name	Site type	As		Cd		Ni		Pb	
		dc %	ng/m3	dc %	ng/m3	dc %	ng/m3	dc %	ng/m3
Auchencorth	Rural	100	0.23	100	0.05	100	0.28	100	1.85
Banchory	Rural	89	0.21	89	0.04	89	1.02	89	1.35
Belfast Centre Metals	Urban background	100	0.39	100	0.09	100	1.08	100	6.00
Bristol Avonmouth	Industrial	100	0.64	100	0.38	100	2.45	100	12.77
Bristol Hallen	Industrial	100	0.58	100	0.33	100	1.17	100	8.20
Central London Metals	Urban background	100	0.76	100	0.20	100	1.84	100	10.37
Cockley Beck	Rural	83	0.25	83	0.04	83	0.40	83	1.84
Cwmystwyth	Rural	87	0.25	87	0.04	87	0.46	87	2.19
Detling	Rural	79	0.75	79	0.17	79	1.74	79	9.09
Eskdalemuir	Rural	100	0.06	100	0.04	100	0.34	100	1.16
London Cromwell Road	Roadside	100	0.69	100	0.20	100	1.65	100	11.61
London Marylebone Road Metals	Urban background	82	0.96	-	-	82	3.13	82	12.59
Manchester Wythenshawe	Roadside	100	0.65	100	0.15	100	0.93	100	7.38
Monks Wood	Rural	84	0.68	84	0.13	84	1.10	84	5.20
Motherwell Centre	Urban background	100	0.33	100	0.12	100	0.35	100	6.57
Pontardawe	Industrial	100	0.94	100	0.62	100	43.00	100	8.70
Port Talbot Margam Metals	Industrial	92	0.62	92	0.31	92	2.03	92	11.90
Runcorn Weston Point	Industrial	100	0.71	100	0.19	100	1.24	100	9.16
Sheffield Brinsworth	Industrial	100	1.01	100	0.46	100	12.31	100	27.17
Sheffield Centre Metals	Urban background	92	0.50	92	0.17	92	1.98	92	11.00
Swansea Coedwilym	Industrial	100	0.49	100	0.17	100	19.61	100	8.01
Swansea Morriston	Urban background	100	0.51	100	0.30	100	7.60	100	20.50
Walsall Centre	Industrial	100	0.98	100	0.48	100	1.47	100	19.30
Walsall Willenhall Metals	Industrial	100	1.15	100	2.24	100	1.66	100	88.10
Yarner Wood	Rural	87	0.38	87	0.08	87	0.87	87	2.13

* This site is operated by the local authority and therefore not included in the Questionnaire but is used for model verification.

2.3   Emissions

Emission estimates for heavy metals are published annually on the NAEI website. The emission estimates derived from the emission inventory for the the UK are provided by NAEI (Murrells et *al.*, 2009) for the latest available year 2007. The projections of the emission estimates to 2008 and to future years 2010, 2015 and 2020 were derived from the Updated Energy Projections (UEP 37) provided by the Department of Energy and Climate Change (DECC). Values for intermediate years have been interpolated. The emission estimates for 2007-2020 split by SNAP code are shown in Figures 2.1-2.4 for the pollutants As, Cd, Ni and Pb.

Figure 2.1. UK total As emissions for 2007 and emissions projections up to 2020 by SNAP code from NAEI 2007

SNAP 7: Road transport (exhaust emissions)

SNAP 9: Waste treatment and disposal

SNAP 8: Other Transport & mobile machinery (ships)

SNAP 8: Other Transport & mobile machinery (rail)

SNAP 8: Other Transport & mobile machinery (off road mobile machinery)

SNAP 8: Other Transport & mobile machinery (aircraft)

SNAP 4: Production processes (excludes quarrying and construction)

SNAP 3: Combustion in industry

SNAP 2: Combustion in Commercial, Institutional & residential & agriculture (domestic only)

SNAP 2: Combustion in Commercial, Institutional & residential & agriculture (excludes domestic)

SNAP 1: Combustion in energy prodcution & transformation

The estimates of As emission for 2007-2020 show that only a small reduction of As emission is expected over the next 13 years. The trend is fairly consistent and constantly showing approximately 70% of the As emission is from the source combustion activity in industry (SNAP code 3). As emission are primarily from the combustion of solid fuel. The bulk of these emissions are estimated to be from

the burning of wood treated with copper chromium arsenate. The estimate for this source is highly uncertain since there are no reliable estimates of the extent of this activity and the emission factor is also very uncertain.

Figure 2.2. UK total Cd emissions for 2007 and emissions projections up to 2020 by SNAP code from NAEI 2007
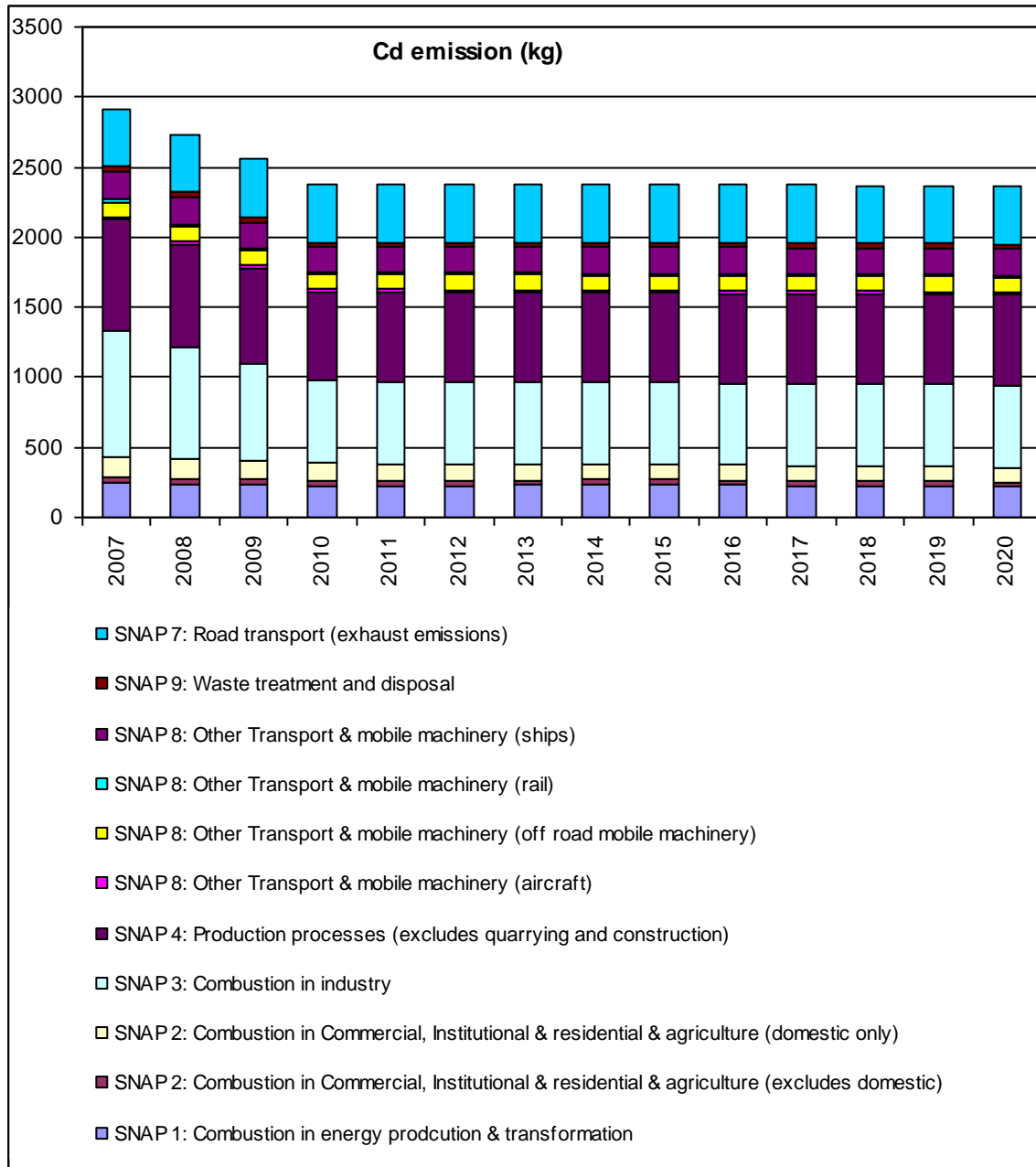

The total emissions for Cd are expected to reduce by approximately 15% from 2007 to 2010 and remain fairly consistent over the next 10 years. From the Figure 2.2, the activities such as production processes (SNAP code 4) and combustion in industry (SNAP code 3) as well as the road transport sources are the largest sources. Cd emissions are primarily from the combustion of liquid fuel and from non-fuel related emissions.

Figure 2.3. UK total Ni emissions for 2007 and emissions projections up to 2020 by SNAP code from NAEI 2007
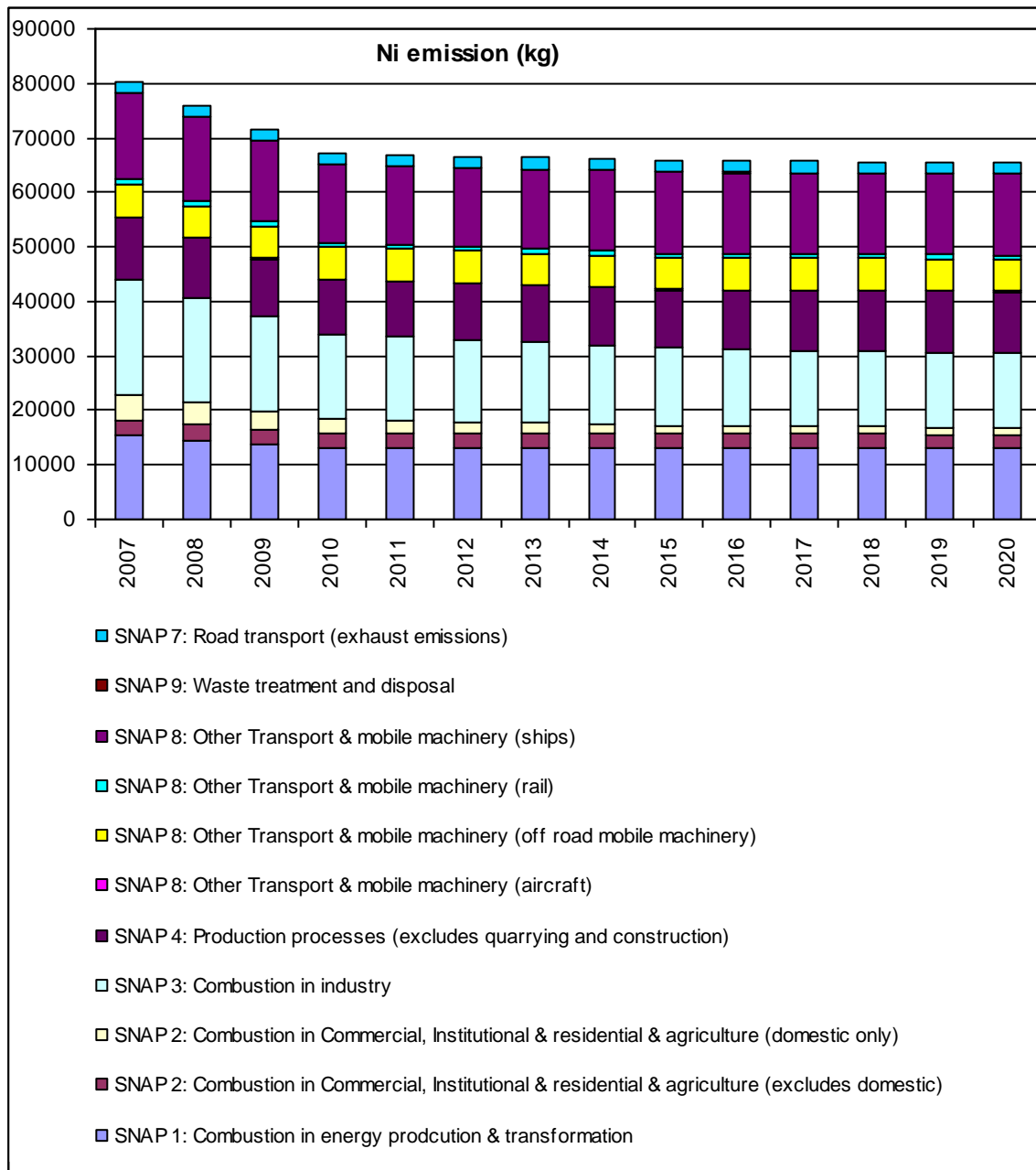
Similar to Cd, Ni emissions are expected to reduce by approximately 15% from 2007 to 2010 and remained fairly consistent over the next 10 years. A large percentage of the Ni contribution is estimated to have generated from ships (SNAP code 8), production processes (SNAP code 4), combustion in industry (SNAP code 3) and combustion in energy production & transformation (SNAP code 1). Ni emissions are primarily from the combustion of liquid fuels.

Figure 2.4. UK total Pb emissions for 2007 and emissions projections up to 2020 by SNAP code from NAEI 2007
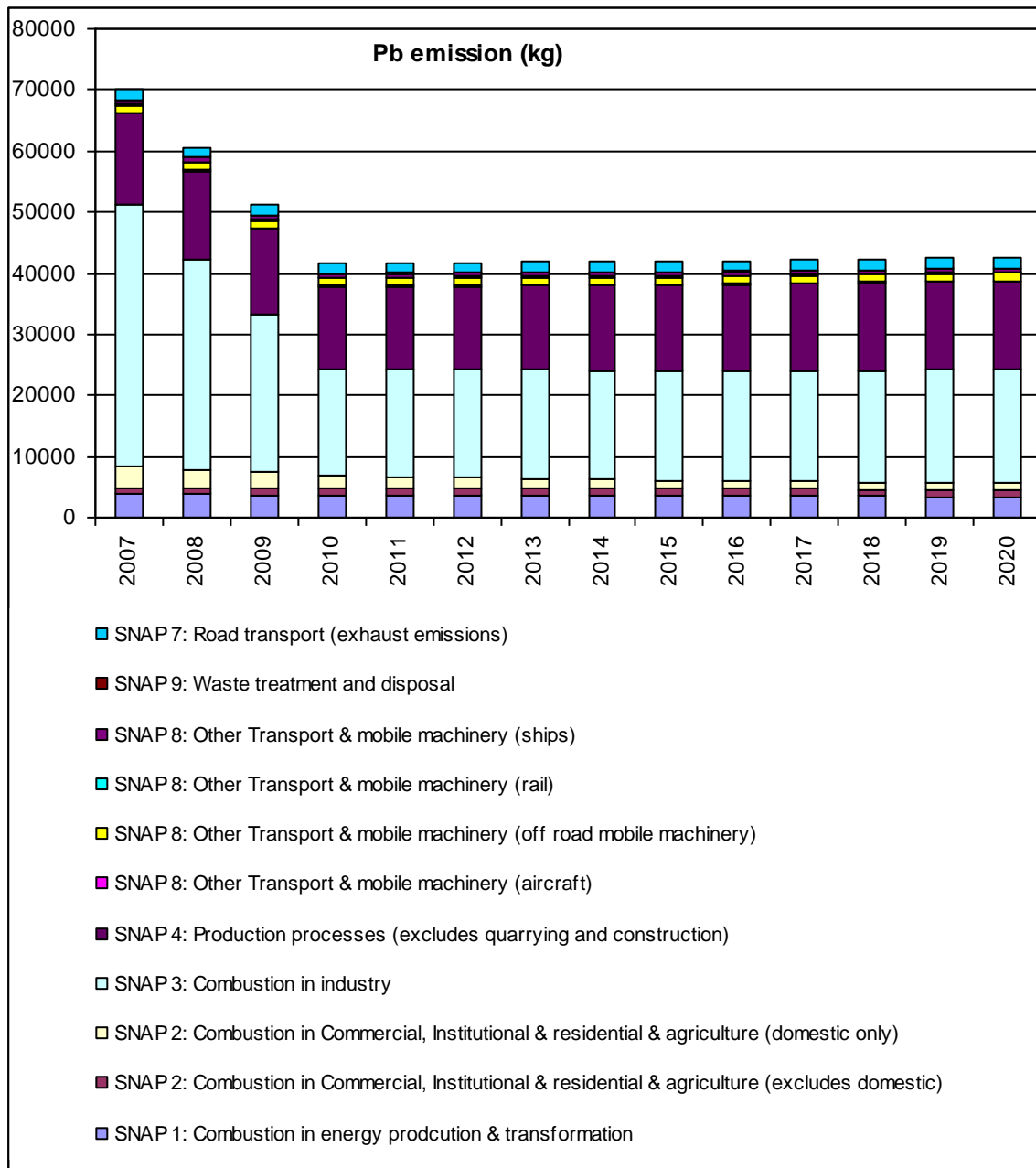
A similar trend has been predicted for Pb but with a steeper decline of about 40% between 2007 and 2010. The major sources for Pb are production processes (SNAP code 4) and combustion in industry (SNAP code 3). Pb emissions are primarily from non-fuel related emissions. The source apportionment of ambient concentrations is discussed in the following section and is often very different from the split for total national emissions.

Ambient concentrations are influenced by the location and release characteristics of the emissions and are also influenced by sources not included in the inventory, such as re-suspension.

Maps of emissions from area sources for 2008 were derived from the 2007 inventory maps using sector specific scaling factors derived from the projections shown above. The emissions from point sources were not scaled and the emissions for 2007 were assumed to apply in 2008.

2.4 The model

2.4.1 Heavy metal contribution from large point sources

Contributions to ground level annual mean heavy metal concentrations from point sources (those with stack parameters datasets) in the 2007 NAEI were estimated by modelling each source explicitly using an atmospheric dispersion model (ADMS 4.0) and sequential meteorological data for 2008 from Waddington. Surface roughness was assumed to be 0.1 metres. Concentrations were calculated for a 99km x 99km square composed of a regularly spaced 1km x 1km resolution receptor grid. Each receptor grid was centred on the point source. For each large point source information was retrieved from our stack parameters database. This database has been developed over a period of time under the PCM contract and is updated annually as required. Data sources for this database include a survey of Part A authorisation notices held by the Environment agency and previously collated datasets on emission release parameters from large SO_2 point sources (Abbott and Vincent, 1999). Parameters used in the modelling from the stack parameters database include:

- Stack height
- Stack diameter
- Discharge velocity
- Discharge temperature

2.4.2 Heavy metal contribution from small point and fugitive sources

The contributions to ambient concentrations from fugitive and point sources (those without stack parameters datasets) in the 2007 NAEI were modelled using the small point model. The model consists of separate 'in-square' and 'out-of-square' components, in which concentrations are estimated using a point source dispersion kernel. The dispersion kernel has been calculated by using dispersion model ADMS 4.0 to model the dispersion of unit emissions from a central source to a grid of receptors at a spatial resolution of 1km x 1km squares with the stack characteristics as presented in Table 2.2. Hourly sequential meteorological data from Waddington in 2008 has been used to construct the dispersion kernels. The centre square of the dispersion kernel has been calculated as the maximum contribution of the surrounding 8 squares to reflect the fact that the dispersion generated from the point source would expect a greatest concentration at the point where the emission was emitted.

Table 2.2. Stack release parameters used to characterise emissions from point sources with no available stack parameters

Variable	Parameters
Stack height	15m
Diameter	1m
Temperature	15˚C
Emission rate as PM_{10}	1g/s
Surface roughness	0.5

Characterising the amount of heavy metal from industrial plant is notoriously difficult. According to Passant (personal communication 2005) approximately three times the reported emission from metal processing industries may be released as a fugitive emission. The emission release parameters are provided in Table 2.3. Once again the centre square of the dispersion kernel has been calculated as the maximum contribution of the surrounding 8 squares to reflect the fact that the dispersion generated from the point source would expect a greatest concentration at the point where the emission was emitted.

We have found that assuming a fugitive emission of 0.3 times the reported emission provides the best agreement with available measurement.

Table 2.3. Stack release parameters used to characterise fugitive emission release

Variable	Parameters
Stack height	10m
Diameter	1m
Temperature	15°C
Emission rate as PM_{10}	1g/s
Surface roughness	0.5

2.4.3　Heavy metal contribution from local area sources

The modelled uncalibrated area source contribution has been calculated by applying an ADMS 4.0 derived dispersion kernel to calculate the contribution to ambient concentrations at a central receptor location from area source emissions within a 33km x 33km square surrounding each receptor. Hourly sequential meteorological data from Waddington in 2008 has been used to construct the dispersion kernels, as described in Appendix 1.

We have chosen to incorporate the area source calibration coefficient of 2.4547 derived within the 2008 PCM model for NO_x (Grice at *al*., 2009). This coefficient has been derived for a pollutant for which both the emissions source apportionment and measurements are well characterised. The source apportionment for heavy metals is subject to greater uncertainty however we found that using the coefficient derived for NO_x provided a reasonable estimates of heavy metal concentrations as demonstrated in the verification plots presented for each pollutant below. In contrast we found that the NOx coefficient did not provide reasonable estimates of BaP concentration and a BaP specific calibration was therefore applied (see section 3).

The modelled area source contribution was multiplied by the empirical coefficient to calculate the calibrated area source contribution for each grid square in the country.

For certain sectors (noted within each pollutant section described below) caps have been applied to emissions based on expert judgement of the model results in order to address known artefacts in the area source emissions grids and to reconcile the model results with the measured data at each monitoring site. The application of these caps is annually reported back to the NAEI as part of the quality checking process to ensure that continual improvements are made in the emissions grids.

2.4.4　Heavy metal contribution from long range transport of primary PM

The contribution to ambient concentrations from long range transport of heavy metals has been derived estimates of regional primary PM used in the 2008 PCM model for PM_{10} mass (Grice et *al*., 2009). Contributions from long range transport of PM particles on a 20km x 20km grid have been estimated using the TRACK receptor oriented, Lagrangian statistical model (Lee *et al*., 2000). Emissions of primary PM were taken from the NAEI for the UK sources and EMEP for sources in the rest of Europe. Primary PM was modelled as an inert tracer. All sources within 10km of the receptor point were excluded from the TRACK model to allow the area source model and the point source model to be nested within this long-range transport model without duplicating source contributions.

The contribution to ambient heavy metal concentration from long range transport sources has been derived by calculating a fraction of the PM mass for each heavy metal. This fraction has been estimated as the ratio of the UK total emissions for each SNAP sector for each metal to the total PM_{10} emission for this sector. These ratios were also assumed to apply to the contribution from non-UK European sources.

2.4.5　Heavy metal contribution from re-suspension

Introduction

The 2008 model for heavy metal concentrations includes a contribution to ambient concentrations from re-suspension. The contributions from two processes have been included:

- Rural PM dusts from re-suspension of soils and

- PM dusts from re-suspension due to vehicle activity.

The heavy metal contribution from re-suspension has been calculated by using the methods suggested by Abbott (2008). The methods used to estimate the total PM mass from these processes have been revised by Grice et *al* (2009) to provide estimates suitable for inclusion in the PCM model.

Re-suspension of soils

The starting point for the estimate of the contribution to PM mass from re-suspension from soils is the proportions of bare soils, root crops and cereal crops in 1 km x 1 km grid squares across the UK within the Land Cover Map 2000 (Land Cover Map 2000, 2009). The concentration of PM mass cannot be calculated using the standard approach of using an estimate of the annual emissions and an air dispersion model. This is because the rate of re-suspension and the atmospheric dispersion of these emissions are both dependant on the meteorological conditions. The emission rate will be higher when the wind is stronger but the dispersion of these emissions will also be more efficient under these conditions.

The method presented by Abbott (2008) makes use of combined emission and dispersion kernels for cereal and root crop fields and for bare soils. Concentrations were calculated for each hour of the year based on hourly sequential meteorological data from twelve sites throughout the UK for 1999. This year was selected because the data were readily available.

We have adapted this method for use within the PCM models by using an inverse distance weighted average of the results from the different kernels for each receptor location. This revised method avoids the discontinuities caused by the use of a simpler nearest met site to the receptor method used in the original work.

Re-suspension due to vehicle activity

Abbott (2008) has also developed a method for estimating the contribution to PM mass from re-suspension due to vehicle activity. This method takes vehicle km statistics for heavy-duty vehicles (heavy good vehicles and buses) as it's starting point. These estimates are likely to be subject to greater uncertainty than the estimates for re-suspension from rural soils because there is little information on the availability of material on road surfaces to be re-suspended.

Abbott (2008) calculated two sets of combined emission and dispersion kernels for each of the 12 meteorological stations for 1999: one to represent rural conditions and one to represent urban conditions. The estimated re-suspension rate was considerably higher for rural conditions due to the higher speeds assumed. These two sets of kernels were then used to calculate the contribution to PM_{10} concentrations according to the proportion of urban and rural land cover in each 1 km x 1 km grid square. A detailed examination of the results from this assessment has shown that the concentrations in urban areas were largely driven by the small proportion of rural land cover in these urban areas. We have therefore chosen to apply the urban kernels for all roads within our PCM model.

Estimating heavy metal concentrations

Abbott (2008) also suggested a method for estimating the contributions to the ambient concentrations of heavy metals from soil and vehicle related re-suspension processes. The maps of PM mass from re-suspension of soils and re-suspension associated with vehicle movements can be used to estimate the contributions to the ambient concentration of heavy metals using a combination of information on the heavy metal content of soils and enhancement factors.

The National Soil Inventory (http://www.landis.org.uk/data/natmap.cfm) provides a data set of arsenic, cadmium, nickel and lead concentrations in topsoil at 5 km resolution throughout England and Wales. Measurement data on heavy metals concentration in topsoil for other areas of the UK is available from the Geochemical Atlas of Europe developed under the auspices of the Forum of European Geological Surveys (FOREGS) [www.gtk.fi/publ/foregsatlas/]. These data were interpolated onto a 1 km x 1 km grid. The predicted annual PM emission rates and the contribution to atmospheric concentrations were multiplied by the topsoil concentrations to estimate the annual metal re-suspension rates and the contributions to atmospheric concentrations of the heavy metals.

There is some evidence that metal concentration in the surface soils are higher than in the underlying topsoil. EMEP have suggested in the report by Abbott (2008) that there may be some enhancement of the metal content of the re-suspended dust because the metals may form complexes with humic matter. Abbott (2008) carried out regression analysis of measured heavy metal concentrations against the combined model predictions for sites in the UK Rural Heavy Metal Network and this analysis suggested that there may be other mechanisms that result in heavy metals being concentrated in the small particle fraction of soils. For example, much of the metal content may be present as the result of historical deposition of small particles or the application of sewage sludge and farmyard slurries and these materials may now be only loosely bonded to the surface of the soil particles. The fine particles released by re-suspension mechanisms would therefore be likely to contain a much higher concentration of metals than the underlying topsoil. The enhancement factors listed in Table 2.4 have been chosen to provide the best agreement of our total model predictions with measured concentrations of heavy metal concentrations and are broadly consistent with the regression coefficients determined by Abbott (2008)

Table 2.4. Heavy metal enhancement factors used in the assessment

Pollutant	Enhancement factor
As	25
Cd	25
Ni	7
Pb	25

2.5 Arsenic

2.5.1 Introduction

The method used to estimate the As ambient concentration across the UK has been described in section 2.4 above.

A cap of 0.1 ng/m^3 has also been applied for the contribution generated from re-suspension of bare soil. This value has been chosen as our estimate of the maximum likely concentration generated from this source.

2.5.2 Maps of annual mean concentrations

Figure 2.5 shows the modelled annual mean As concentrations, There are no modelled exceedances of the target value of 6 ng/m^3 in 2008.

2.5.3 Source apportionment

A source apportionment graph has been plotted in Figure 2.6 to present the As contribution from different sources at monitoring site locations. Concentrations measured at the monitoring sites are also presented. Thus the source apportionment graphs also give an indication level of agreement between the modelled and measured concentrations. This analysis suggests that the main sources of this air pollutant at the monitoring site locations are point and fugitive industrial emissions, non-road area sources and re-suspension processes.

2.5.4 Verification of mapped concentrations

An alternative presentation of the comparisons of modelled and measured annual mean As concentrations in 2008 at different monitoring site locations are shown in Figures 2.7-2.10 with lines representing y = x – 60% and y = x + 60% (this is the AQDD4 data quality objective for modelled annual mean As concentration). This helps to check the reliability of our modelled estimates of As.

Figure 2.5. Annual mean map of As concentrations for comparison with the As target value of 6ng/m^3, 2008 (ng/m^3)
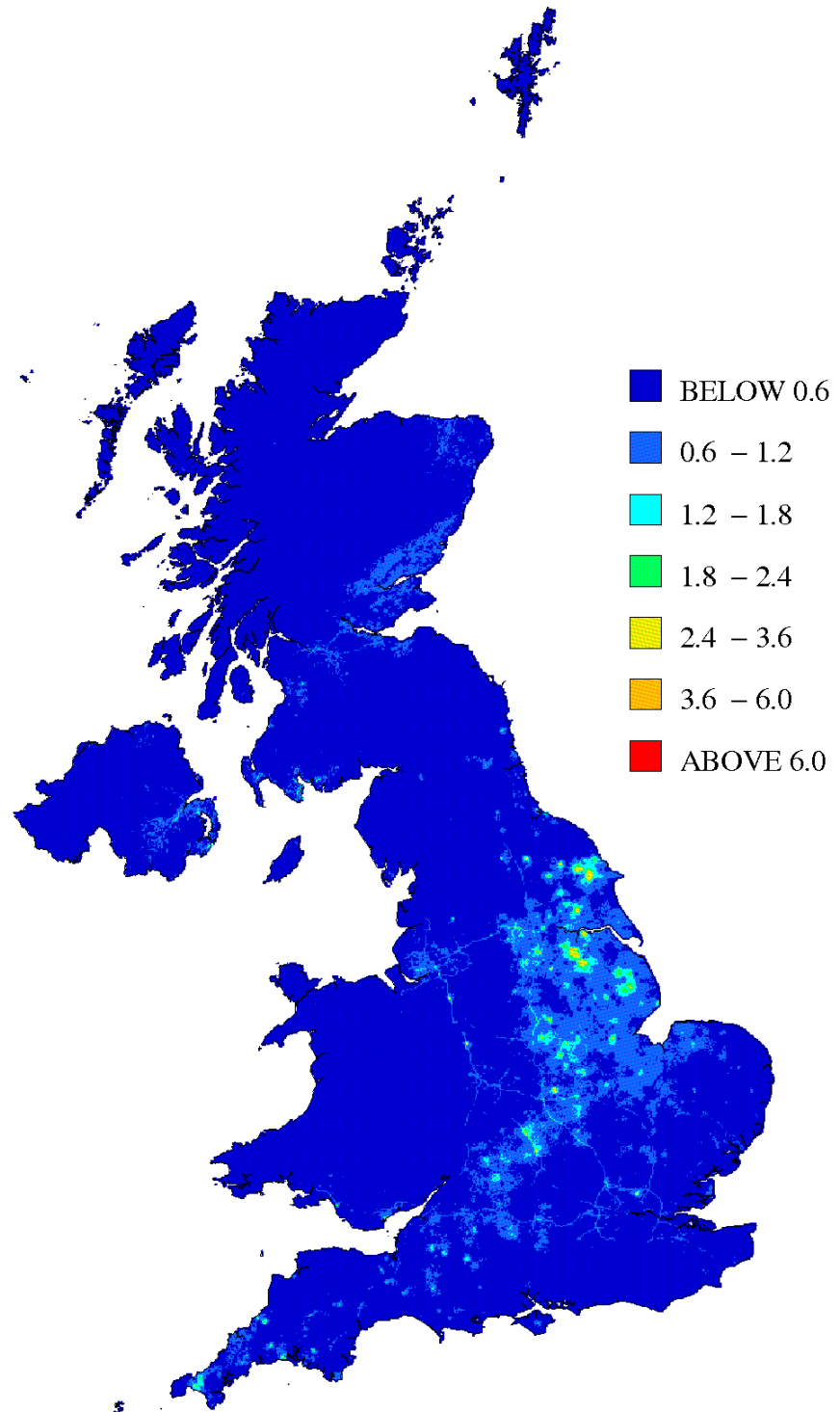
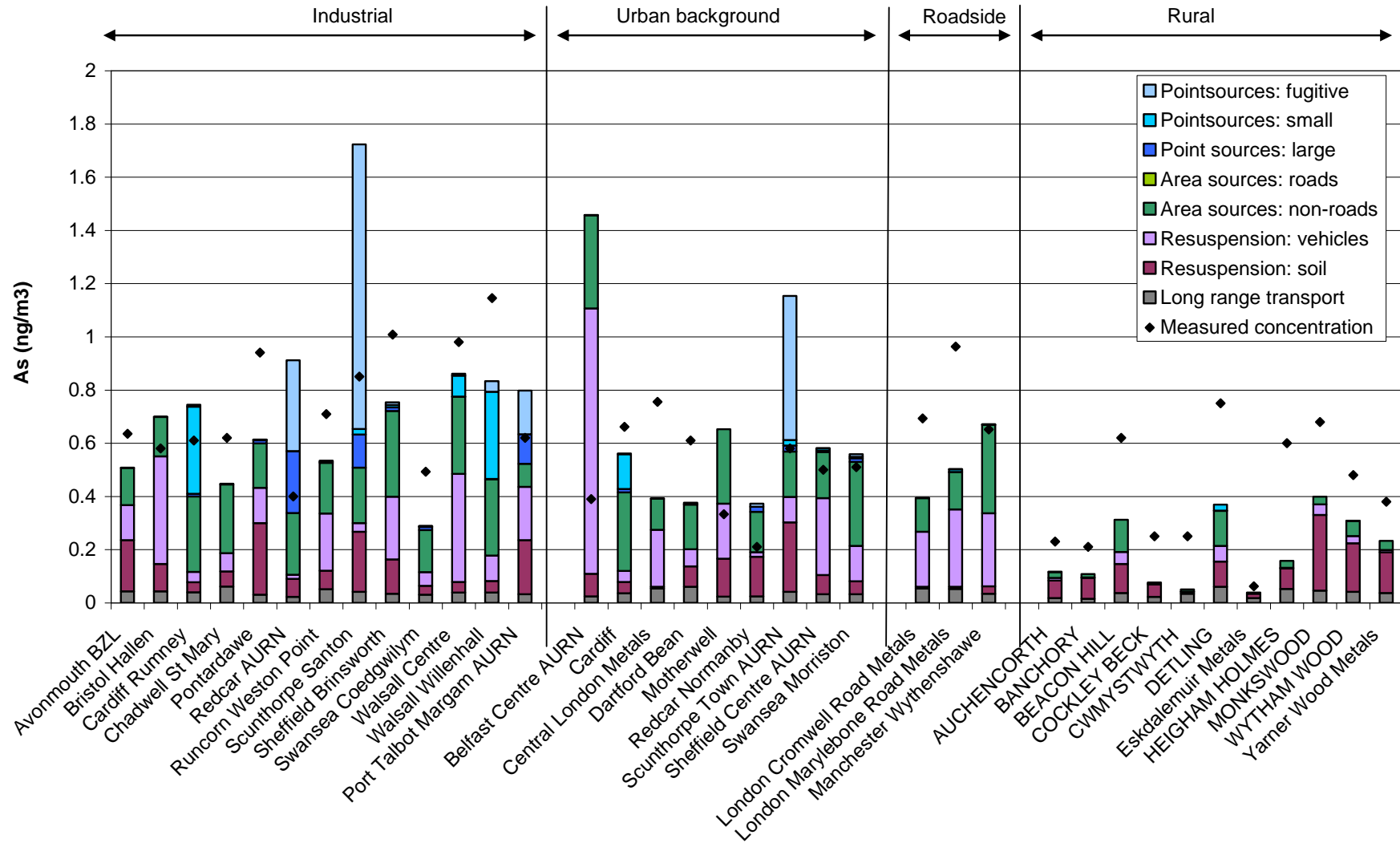**Figure 2.6. Source apportionment for As**

Figure 2.7. Verification of annual mean As at Industrial sites
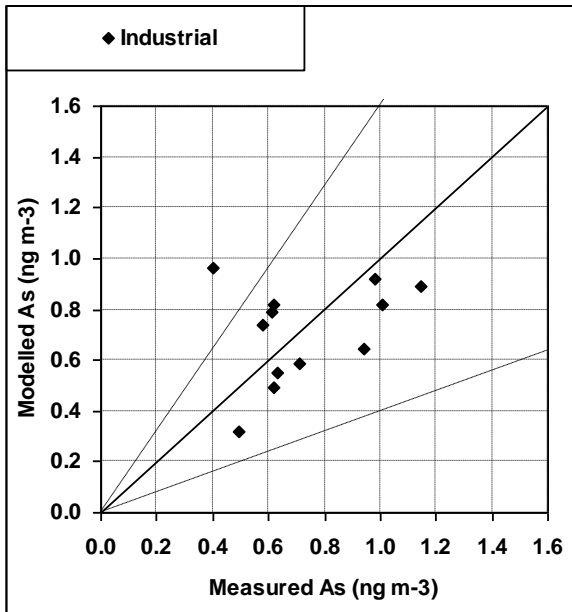

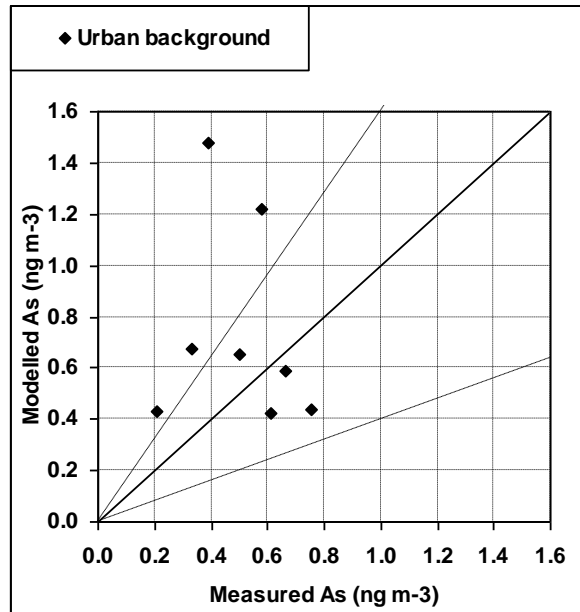**Figure 2.8. Verification of annual mean As at urban background sites**

Figure 2.9. Verification of annual mean As at roadside sites
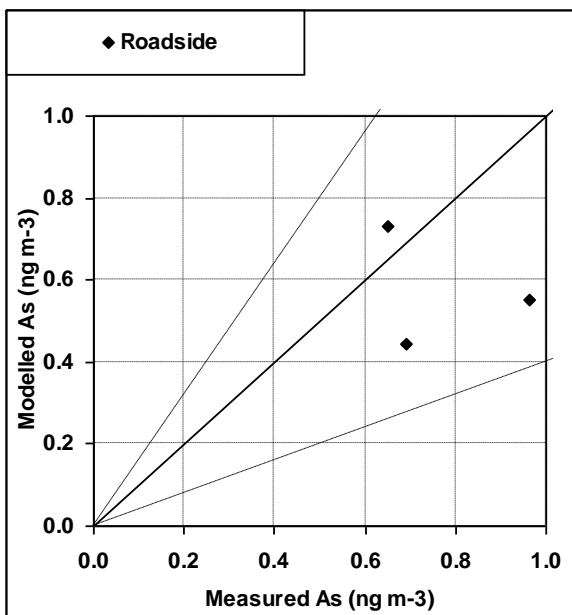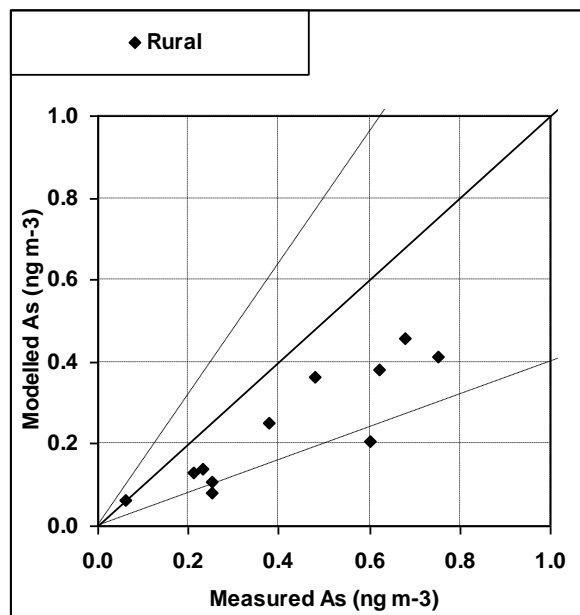

Figure 2.10. Verification of annual mean As at rural sites

Summary statistics for modelled and measured As concentrations and the percentage of sites for which the modelled values are outside the data quality objectives (DQOs) and the total number of sites included in the analysis are listed in Table 2.5.

The mean measured and modelled concentrations agree reasonably well for the industrial, urban background and roadside monitoring sites. The agreement between measured and modelled concentrations on a site-by-site basis (quantified using R^2) is poor for all the monitoring sites, except rural sites. Note that the non-emission inventory sources such as fugitive, re-suspension and long range transport of primary PM result in additional uncertainty in comparison with a pollutant such as NOx, which has a better characterised source apportionment. However, it can be seen that the revised

modelling to account the heavy metal contribution from re-suspension to the ambient As concentration has significantly improved the agreement with the measured concentration to the modelling analysis for emission inventory sources only presented by Vincent and Passant (2008). The agreement is much better at the rural sites in particular, where the previous assessment predicted much lower concentrations.

Table 2.5. Summary statistics for comparison between modelled and measured annual mean concentrations at different monitoring sites

	Mean of measurements (μg/m^3)	Mean of model estimates (μg/m^3)	R^2	% of sites outside DQO of ±60%	Number of sites in assessment
Industrial sites	0.74	0.79	0.09	15.38	13
Urban background sites	0.51	0.72	0.02	44.44	9
Roadside sites	0.77	0.30	0.06	0.00	3
Rural sites	0.41	0.24	0.81	18.18	11

2.5.5 Comparison of modelling results with the target values

There were no modelled exceedances of the target value for As in 2008.

2.6   Cadmium

2.6.1   Introduction

The method used to estimate the Cd ambient concentration across the UK has been described in section 2.4 above.

2.6.2   Maps of annual mean concentrations

Figure 2.11 shows the modelled annual mean Cd concentrations. There are no modelled exceedances of the target value of 5 ng/m^3 in 2008.
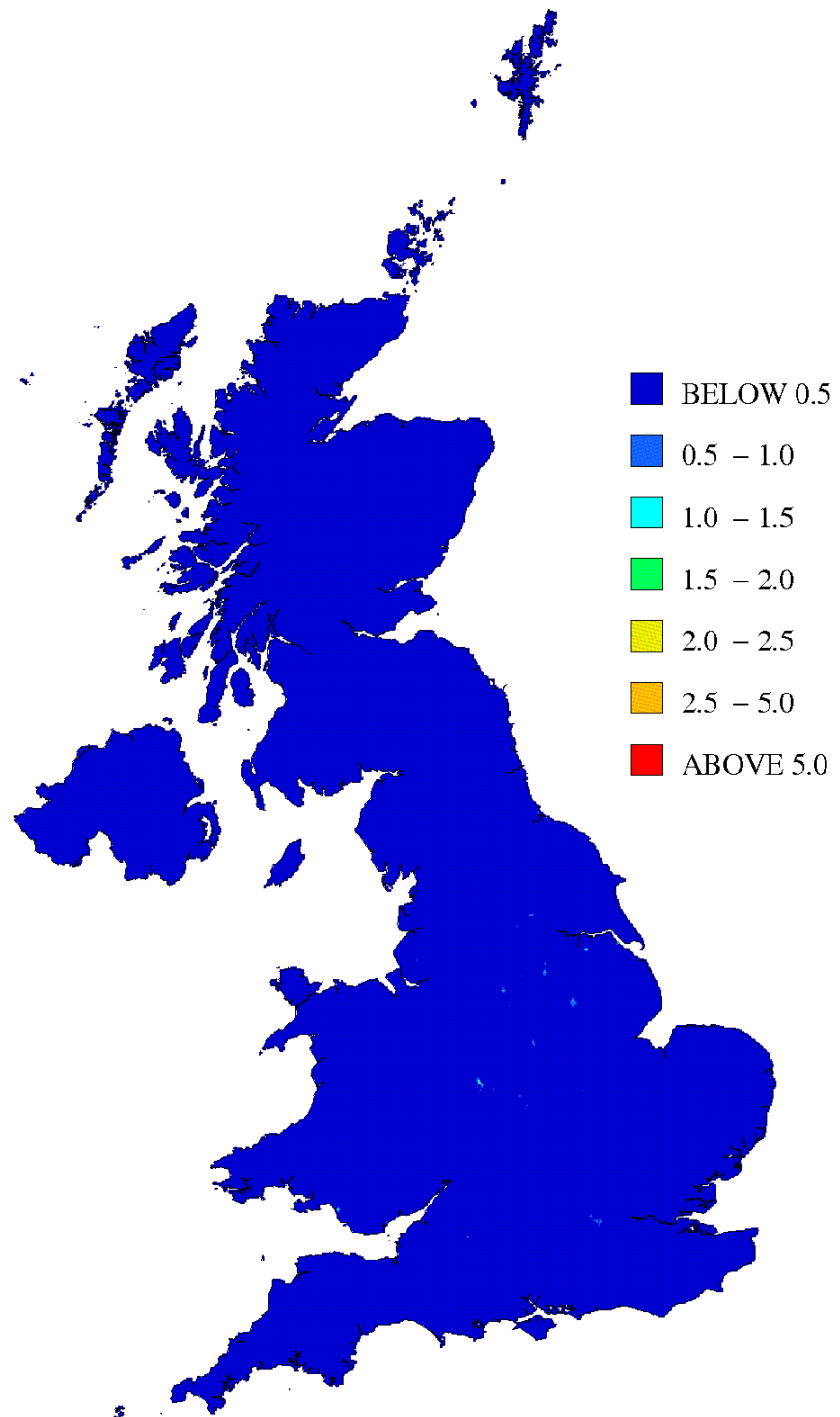
2.6.3   Source apportionment

A source apportionment graph has been plotted in Figure 2.12 to present the Cd contribution from different sources at monitoring site locations. Concentrations measured at the monitoring sites are also presented. Thus the source apportionment graphs also give an indication level of agreement between the modelled and measured concentrations. This analysis suggests that the main sources of this air pollutant at the monitoring sites with the highest concentrations are point and fugitive industrial emissions and re-suspension processes associated with vehicles.

2.6.4   Verification of mapped concentrations

An alternative presentation of the comparisons of modelled and measured annual mean Cd concentrations in 2008 at different monitoring site locations are shown in Figures 2.13-2.16 with lines representing y = x – 60% and y = x + 60% (this is the AQDD4 data quality objective for modelled annual mean Cd concentration). This helps to check the reliability of our modelled estimates of Cd.

Figure 2.11. Annual mean map of Cd concentrations for comparison with the Cd target value of 5ng/m^3, 2008 (ng/m^3)

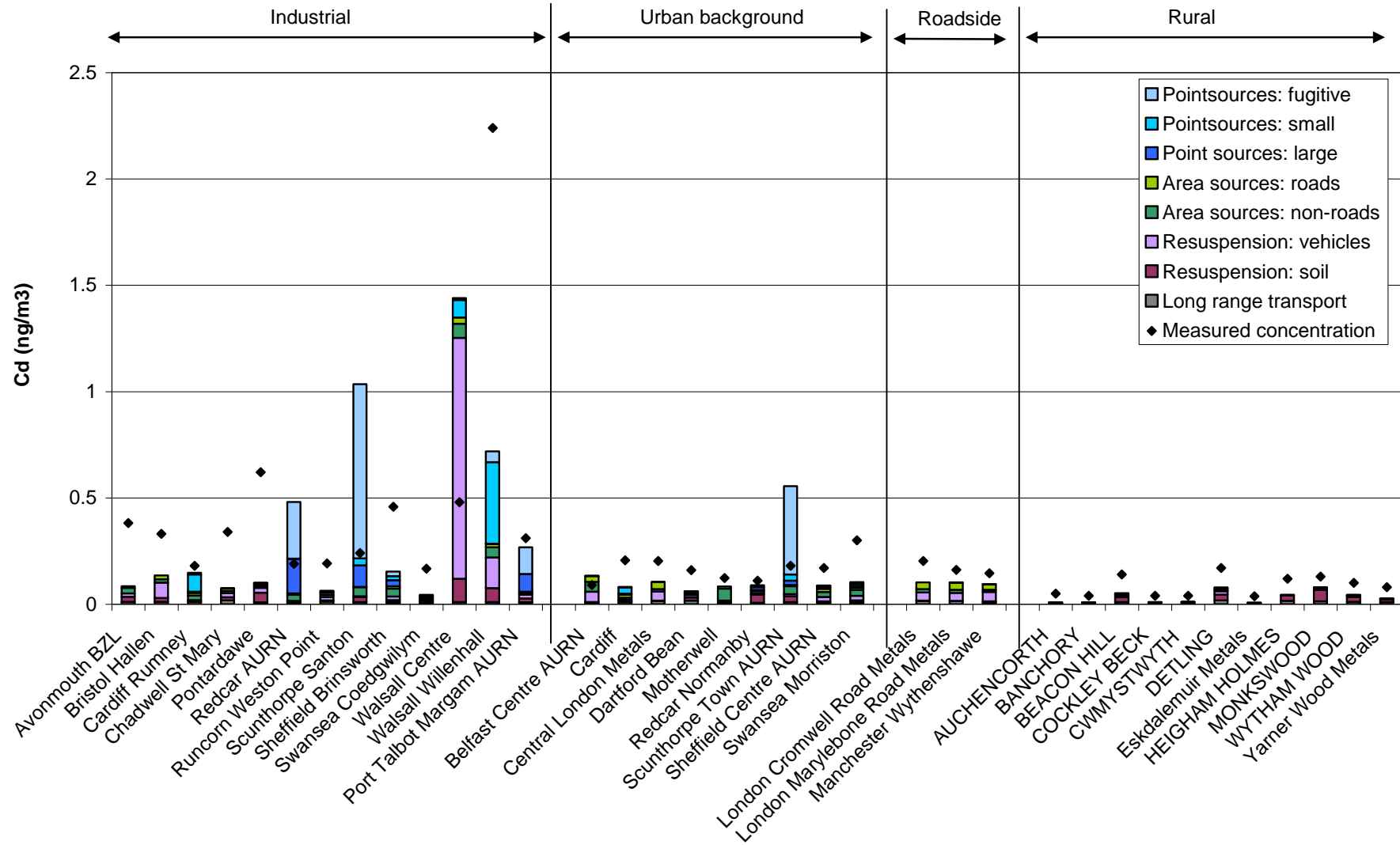**Figures 2.12 Source apportionment for Cd**

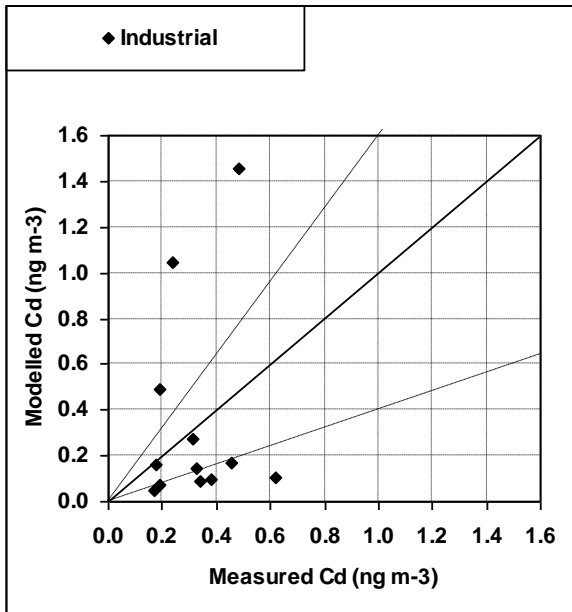**Figure 2.13. Verification of annual mean Cd at Industrial sites**

Figure 2.14. Verification of annual mean Cd at urban background sites
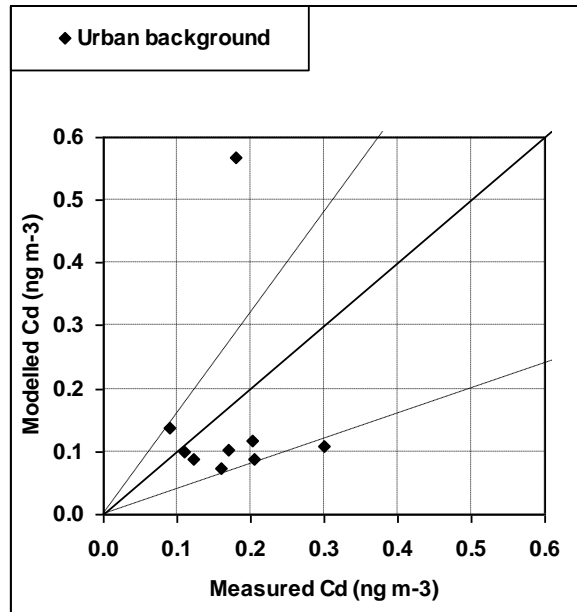

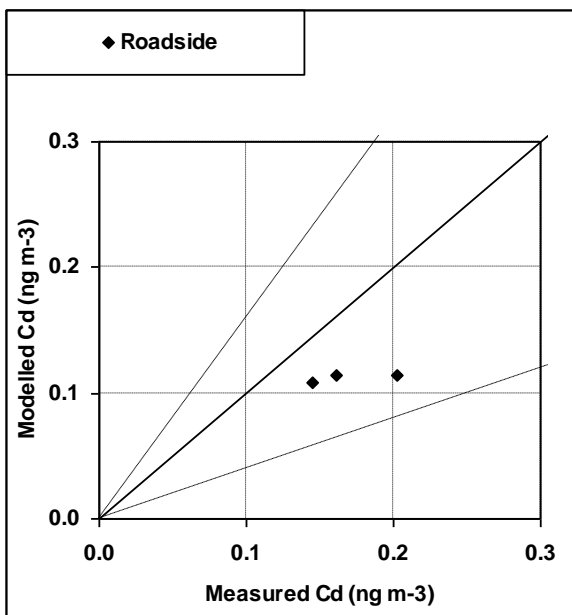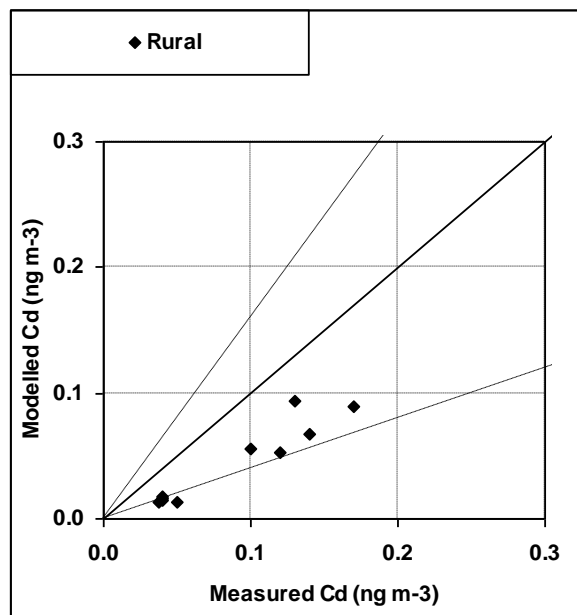**Figure 2.15. Verification of annual mean Cd at roadside sites**

Figure 2.16. Verification of annual mean Cd at rural sites

Summary statistics for modelled and measured Cd concentrations and the percentage of sites for which the modelled values are outside the data quality objectives (DQOs) and the total number of sites included in the analysis are listed in Table 2.6.

The mean measured and modelled concentrations agree reasonably well for the industrial, urban background, roadside and rural monitoring sites. The agreement between measured and modelled concentrations on a site-by-site basis (quantified using R^2) is poor for all the monitoring sites, except rural sites. Note that the non-emission inventory sources such as fugitive, re-suspension and long range transport of primary PM result in additional uncertainty in comparison with a pollutant such as NOx, which has a better characterised source apportionment. However, it can be seen that the revised

modelling to account the heavy metal contribution from re-suspension to the ambient Cd concentration has significantly improved the agreement with the measured concentration to the modelling analysis for emission inventory sources only presented by Vincent and Passant (2008). The agreement is much better at the rural sites in particular, where the previous assessment predicted much lower concentrations.

Table 2.6. Summary statistics for comparison between modelled and measured annual mean concentrations at different monitoring sites

	Mean of measurements (µg/m³)	Mean of model estimates (µg/m³)	R^2	% of sites outside DQO of ±60%	Number of sites in assessment
Industrial sites	0.47	0.37	0.07	76.92	13
Urban background sites	0.17	0.15	0.00	22.22	9
Roadside sites	0.17	0.11	0.52	0.00	3
Rural sites	0.09	0.04	0.90	36.36	11

2.6.5 Comparison of modelling results with the target values

There were no modelled exceedances of the target value for Cd in 2008.

2.7 Nickel

2.7.1 Introduction

The method used to estimate the Ni ambient concentration across the UK has been described in section 2.4 above.

Initial model runs for Ni suggested exceedance of the TV in many areas where there was no evidence from the monitoring data was to suggest that concentrations are elevated to this extent. Additional analysis was therefore carried out to identify the sources responsible for these predicted exceedances and the emissions from these sources were reviewed.

Shipping and industrial combustion sectors within the non-road area sources were the major source for the grid squares with predicted exceedances of the TV. The emissions from these sectors were reviewed in comparison with the emission inventory and available measurements for NOx. This comparison indicated that the maximum expected contributions to ambient concentrations from these sectors are 2.5 ng/m^3 for shipping and 10 ng/m^3 for industrial combustion. The emissions from these two sectors where therefore capped so that the contribution to concentrations from emissions from within the same 1 km x 1 km grid square did not result in concentrations higher than these values.

A cap of 1ng/m^3 has also been applied for the contribution generated from re-suspension of bare soil. This value has been chosen as our estimate of the maximum likely concentration generated from this source.

2.7.2 Maps of annual mean concentrations

Figure 2.17 shows the extent to which the modelled concentrations exceed the target value concentration for Ni. There are no modelled exceedances of the target value of 20 ng/m^3 for 2008, but see below for the full results of the air quality assessment.

2.7.3 Source apportionment

A source apportionment graph has been plotted in Figure 2.18 to present the Ni contribution from different sources at monitoring site locations. The concentrations measured at the monitoring sites are also presented. Thus the source apportionment graphs also give an indication between level of agreement between the modelled and measured concentrations.

Figure 2.18 shows that an annual mean Ni concentration of 43 ng/m^3 was measured at the local authority monitoring site at Pontardawe, which is greater than the TV of 20 ng/m^3. The modelled concentration was however much lower than this at only 2.1 ng/m^3. The model also predicted much lower concentrations than the measured values at the Swansea Coedgwilym and Swansea Morriston National network sites in the surrounding area.

2.7.4 Verification of mapped concentrations

An alternative presentation of the comparisons of modelled and measured annual mean Ni concentrations in 2008 at different monitoring site locations is shown in Figures 2.19-2.22 with lines representing y = x − 60% and y = x + 60% (this is the AQDD4 data quality objective for modelled annual mean Ni concentration). This helps to check the reliability of our modelled estimates of Ni.

Summary statistics for modelled and measured Ni concentrations and the percentage of sites for which the modelled values are outside the data quality objectives (DQOs) and the total number of sites included in the analysis are listed in Table 2.7.

The mean measured and modelled concentrations agree reasonably well for the roadside and rural monitoring sites. The agreements between measured and modelled concentrations on a site-by-site basis (quantified using R^2) are poor for all the urban background and industrial monitoring. Note that the non-emission inventory sources such as fugitive, re-suspension and long range transport of primary PM result in additional uncertainty in comparison with a pollutant such as NOx, which has a

better characterised source apportionment. However, it can be seen that the revised modelling to account the heavy metal contribution from re-suspension to the ambient Ni concentration has significantly improved the agreement with the measured concentration to the modelling analysis for emission inventory sources only presented by Vincent and Passant (2008). The agreement is much better at the rural sites in particular, where the previous assessment predicted lower concentrations.

Table 2.7. Summary statistics for comparison between modelled and measured annual mean concentrations at different monitoring sites

	Mean of measurements ($\mu g/m^3$)	Mean of model estimates ($\mu g/m^3$)	R^2	% of sites outside DQO of ±60%	Number of sites in assessment
Industrial sites	6.94	3.38	0.02	69.23	13
Urban background sites	1.97	2.59	0.02	55.56	9
Roadside sites	1.90	1.78	0.96	33.33	3
Rural sites	0.84	0.76	0.49	9.09	11

2.7.5 Detailed comparison of modelled results with the target value

The tabular results for the supplementary assessment for Ni are presented in Table 2.8. We have reported exceedances of the TV for the Swansea Urban Area and South Wales zones. This exceedance has been reported on the basis of the annual mean concentration of 43 ng/m³ measured at the local authority site at Pontardawe. This monitoring site is within the Swansea Urban Area zone but is very near to the boundary of the South Wales zone. The grid square with the highest modelled concentration is in the South Wales zone and very close to the Swansea Urban Area zone. A concentration very close to the target value (19.6 ng/m³) was measured at the Swansea Coedgwilym national network monitoring site. Further measurement and modelling work is underway in order to gain a better understanding the origins of the Ni concentrations in the vicinity of the industrial sources in this area.

Figure 2.17 Annual mean map of Ni concentrations for comparison with the Ni target value of 20ng/m³, 2008 (ng/m3)
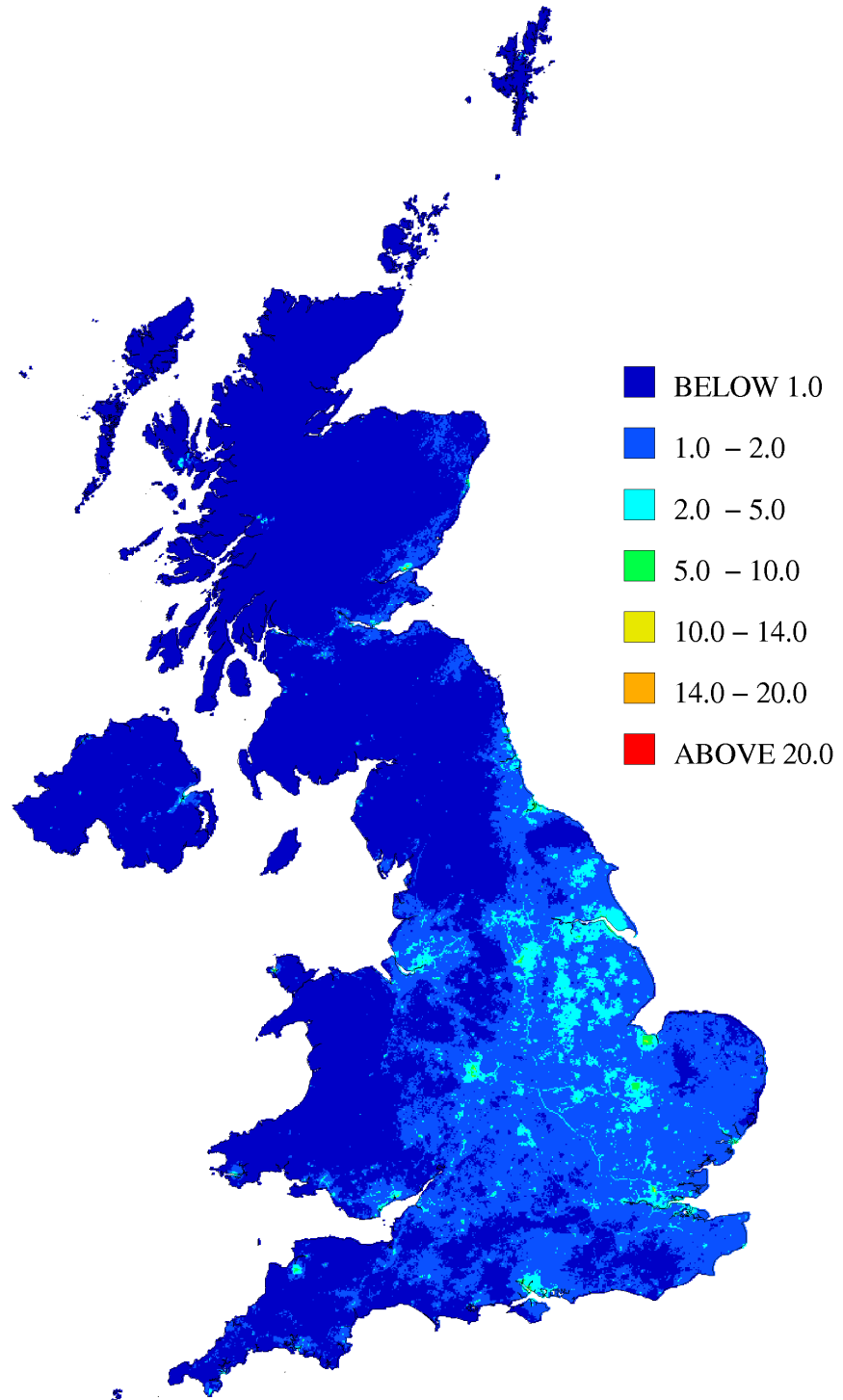
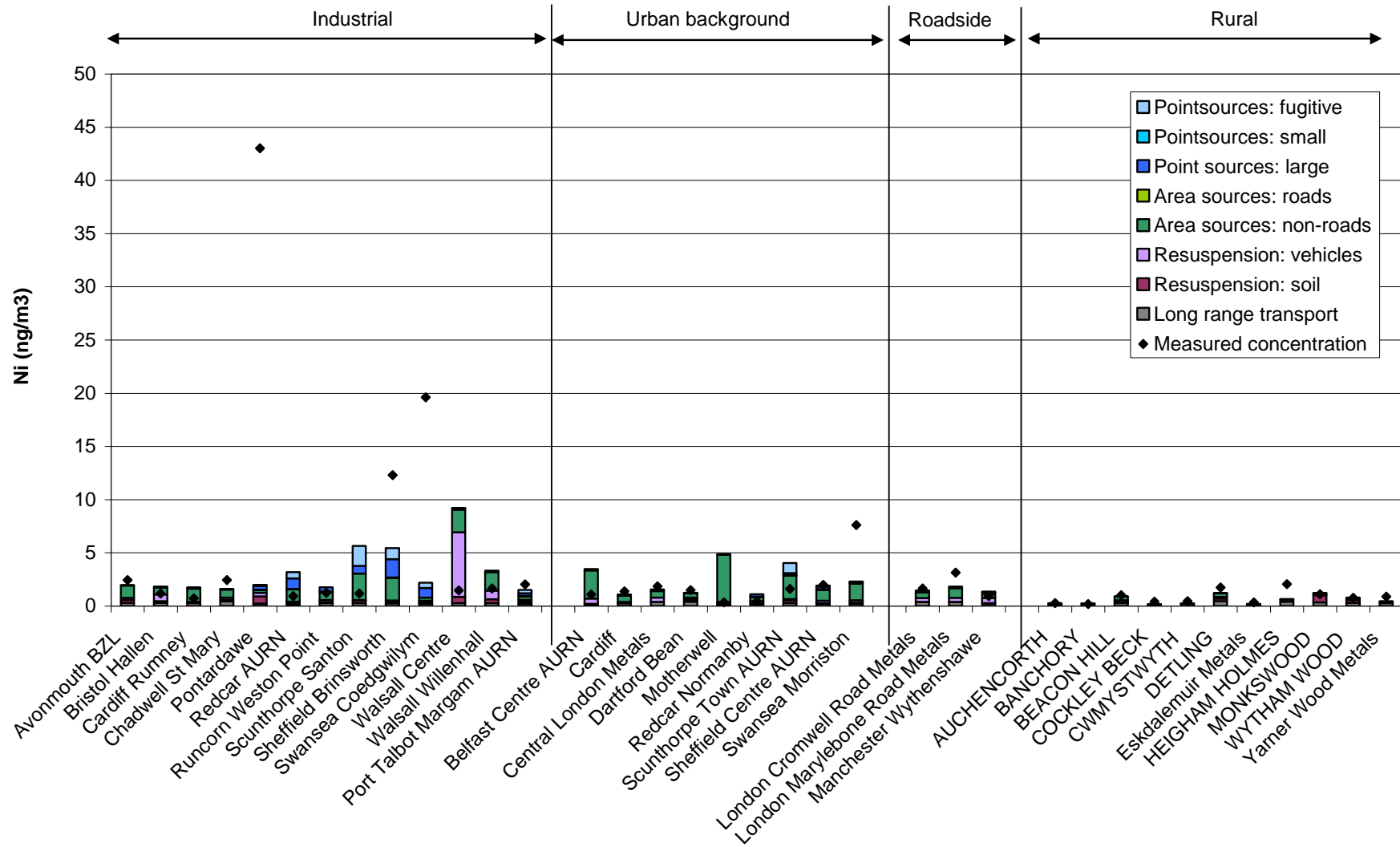**Figure 2.18 Source apportionment for Ni.**

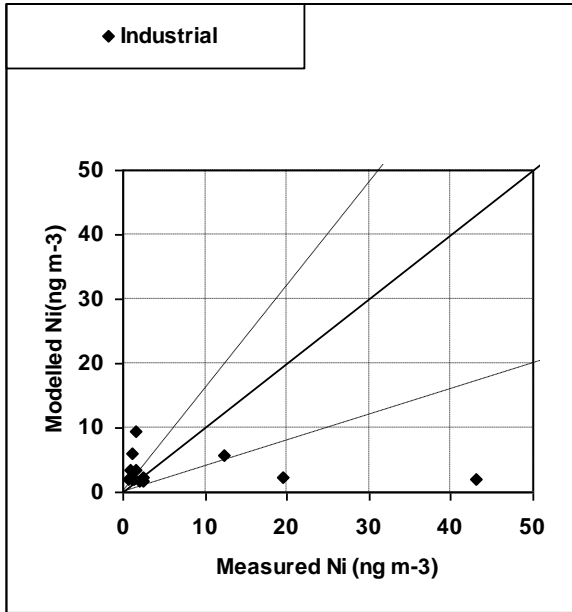**Figure 2.19. Verification of annual mean Ni at Industrial sites**

Figure 2.20. Verification of annual mean Ni at urban background sites
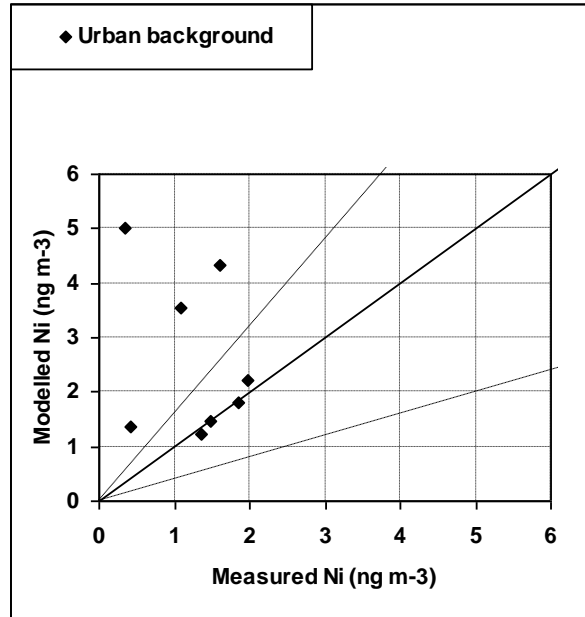

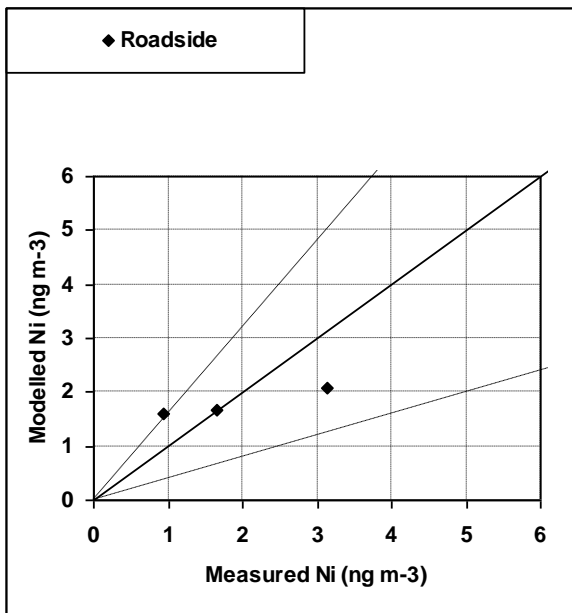**Figure 2.21. Verification of annual mean Ni at roadside sites**
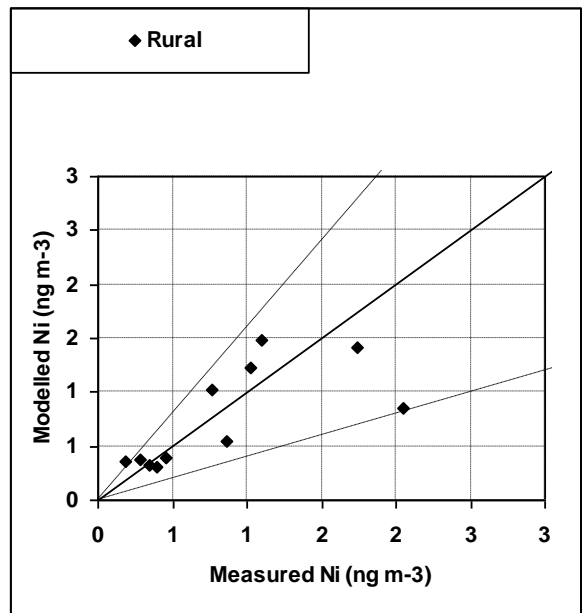

Figure 2.22. Verification of annual mean Ni at rural sites

Table 2.8. Tabular results of and methods used for supplementary assessment for Ni

Zone	Zone code	Above TV for health (annual mean)			
		Area		Population exposed	
		Km^2	Method	Number	Method
Greater London Urban Area	UK0001	0	B	0	B
West Midlands Urban Area	UK0002	0	B	0	B
Greater Manchester Urban Area	UK0003	0	B	0	B
West Yorkshire Urban Area	UK0004	0	B	0	B
Tyneside	UK0005	0	B	0	B
Liverpool Urban Area	UK0006	0	B	0	B
Sheffield Urban Area	UK0007	0	B	0	B
Nottingham Urban Area	UK0008	0	B	0	B
Bristol Urban Area	UK0009	0	B	0	B
Brighton/Worthing/Littlehampton	UK0010	0	B	0	B
Leicester Urban Area	UK0011	0	B	0	B
Portsmouth Urban Area	UK0012	0	B	0	B
Teesside Urban Area	UK0013	0	B	0	B
The Potteries	UK0014	0	B	0	B
Bournemouth Urban Area	UK0015	0	B	0	B
Reading/Wokingham Urban Area	UK0016	0	B	0	B
Coventry/Bedworth	UK0017	0	B	0	B
Kingston upon Hull	UK0018	0	B	0	B
Southampton Urban Area	UK0019	0	B	0	B
Birkenhead Urban Area	UK0020	0	B	0	B
Southend Urban Area	UK0021	0	B	0	B
Blackpool Urban Area	UK0022	0	B	0	B
Preston Urban Area	UK0023	0	B	0	B
Glasgow Urban Area	UK0024	0	B	0	B
Edinburgh Urban Area	UK0025	0	B	0	B
Cardiff Urban Area	UK0026	0	B	0	B
Swansea Urban Area	UK0027	1	B	1900	B
Belfast Urban Area	UK0028	0	B	0	B
Eastern	UK0029	0	B	0	B
South West	UK0030	0	B	0	B
South East	UK0031	0	B	0	B
East Midlands	UK0032	0	B	0	B
North West & Merseyside	UK0033	0	B	0	B
Yorkshire & Humberside	UK0034	0	B	0	B
West Midlands	UK0035	0	B	0	B
North East	UK0036	0	B	0	B
Central Scotland	UK0037	0	B	0	B
North East Scotland	UK0038	0	B	0	B
Highland	UK0039	0	B	0	B
Scottish Borders	UK0040	0	B	0	B
South Wales	UK0041	1	B	215	B
North Wales	UK0042	0	B	0	B
Northern Ireland	UK0043	0	B	0	B
Total		0		0	

2.8 Lead

2.8.1 Introduction

The method used to estimate the Pb ambient concentration across the UK has been described in section 2.4 above.

A cap of 5ng/m^3 has also been applied for the contribution generated from re-suspension of bare soil. This value has been chosen as our estimate of the maximum likely concentration generated from this source.

2.8.2 Maps of annual mean concentrations

Figure 2.23 shows the modelled annual mean Pb concentrations. There are no modelled exceedances of the limit value of 0.5 μg/m^3 (500 ng/m^3) in 2008.

2.8.3 Source apportionment

A source apportionment graph has been plotted in Figure 2.24 to present the Pb contribution from different sources at monitoring site locations. Concentrations measured at the monitoring sites are also presented. Thus the source apportionment graphs also give an indication level of agreement between the modelled and measured concentrations. This analysis suggests that the main sources of this air pollutant at monitoring sites are point and fugitive industrial emissions and re-suspension processes.

2.8.4 Verification of mapped concentrations

An alternative presentation of the comparisons of modelled and measured annual mean As concentrations in 2008 at different monitoring site locations are shown in Figures 2.25-2.28 with lines representing y = x − 50% and y = x + 50% (this is the AQDD4 data quality objective for modelled annual mean Pb concentration). This helps to check the reliability of our modelled estimates of Pb.

Figure 2.23 Annual mean map of Pb concentrations for comparison with the Pb limit value of 500 ng/m^3, 2008 (ng/m^3)
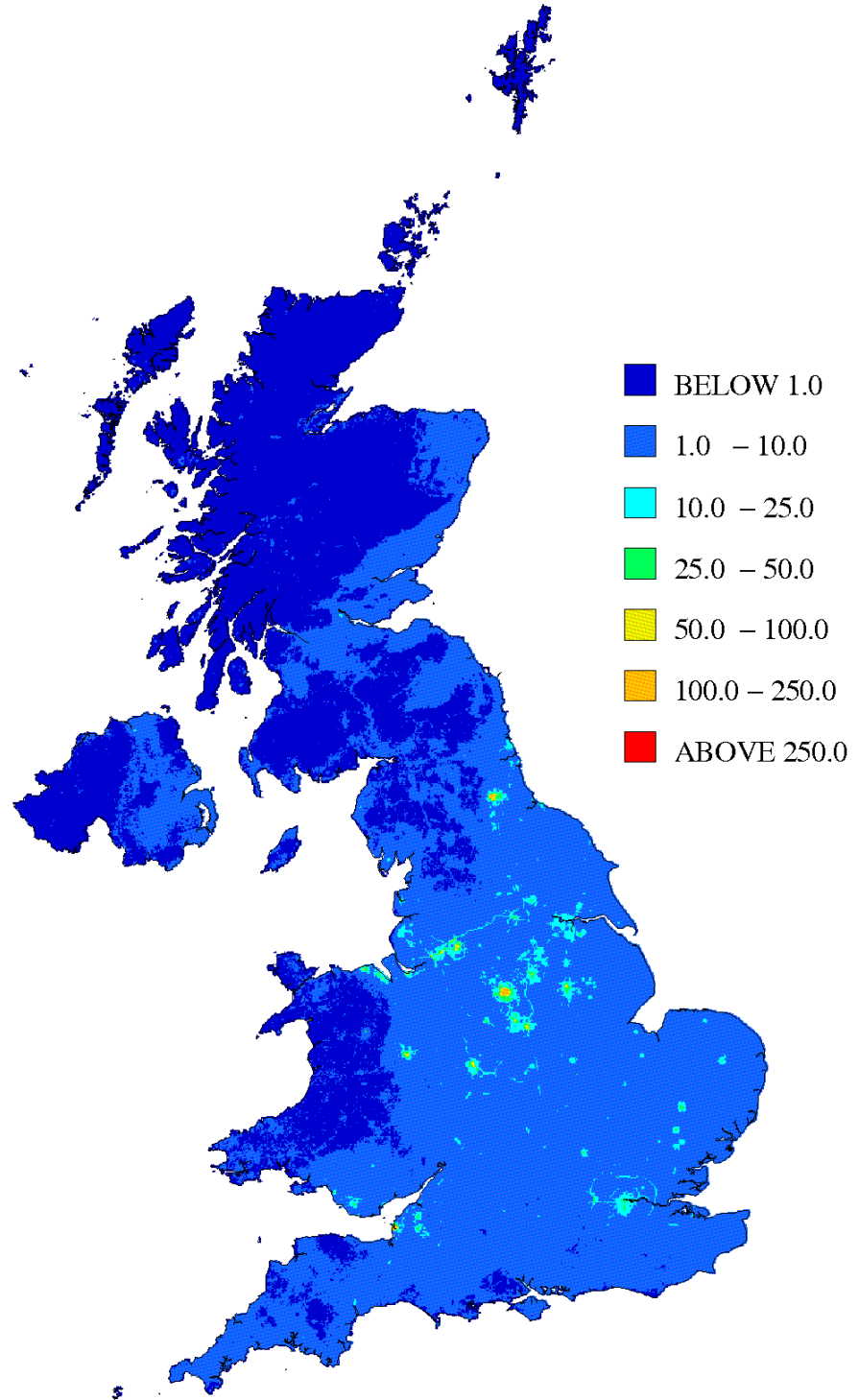
Figure 2.24 Source apportionment for Pb
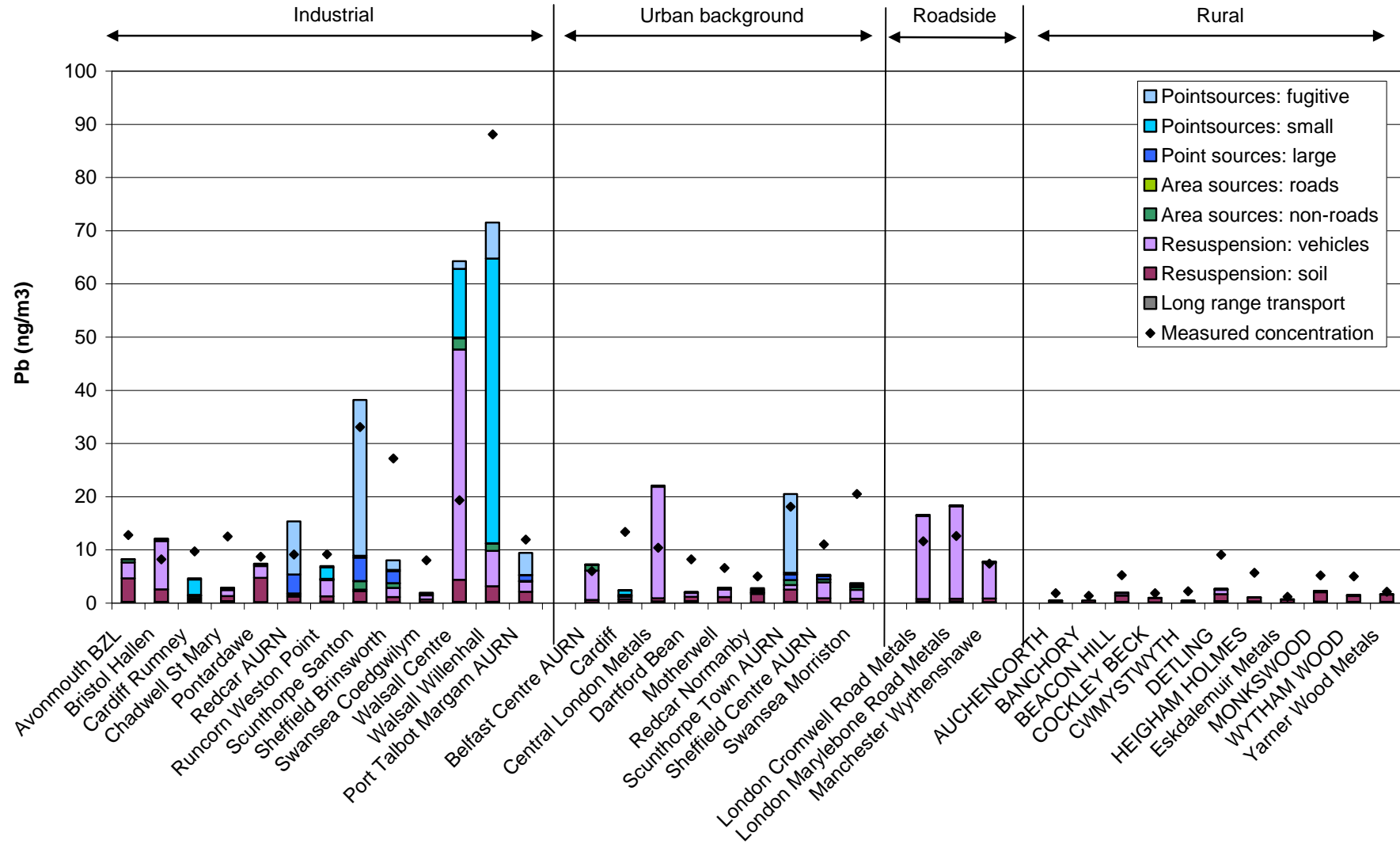
Figure 2.25. Verification of annual mean Pb at Industrial sites
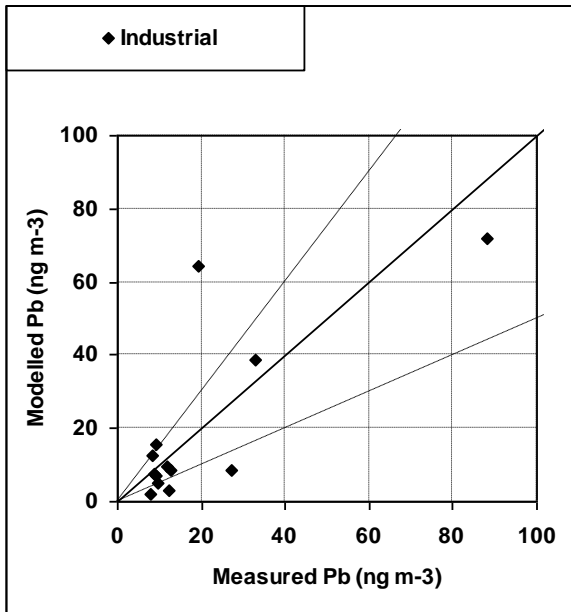
Figure 2.26. Verification of annual mean Pb at urban background sites
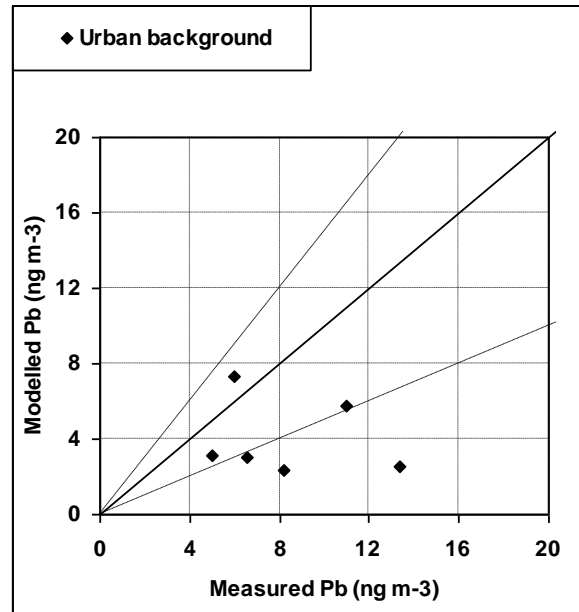
Figure 2.27. Verification of annual mean Pb at roadside sites
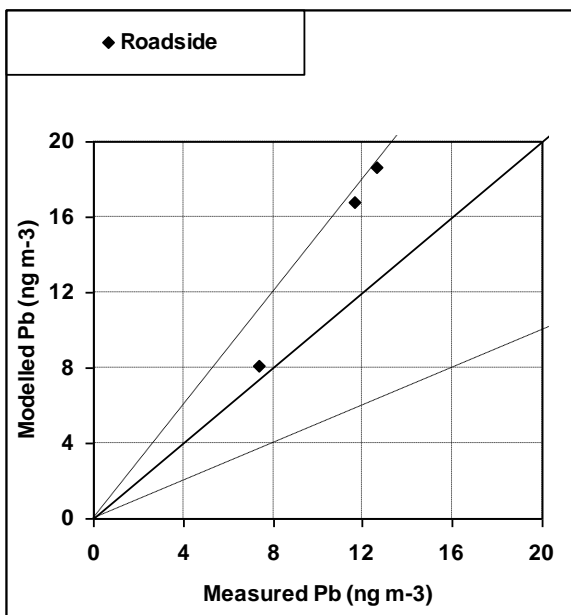
Figure 2.28. Verification of annual mean Pb at rural sites
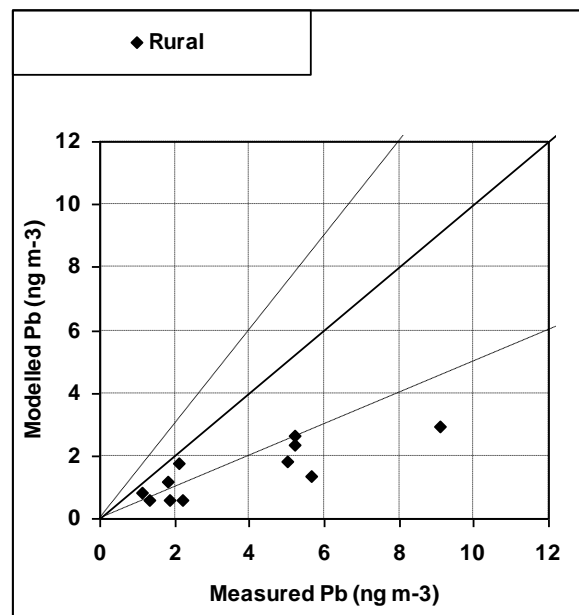
Summary statistics for modelled and measured Pb concentrations and the percentage of sites for which the modelled values are outside the data quality objectives (DQOs) and the total number of sites included in the analysis are listed in Table 2.9.

The mean measured and modelled concentrations agree reasonably well for the industrial, urban background, roadside and rural monitoring sites. The agreement between measured and modelled concentrations on a site-by-site basis (quantified using R^2) is poor for all the monitoring sites, except rural sites. Note that the non-emission inventory sources such as fugitive, re-suspension and long range transport of primary PM result in additional uncertainty in comparison with a pollutant such as NOx, which has a better characterised source apportionment. However, it can be seen that the revised

modelling to account the heavy metal contribution from re-suspension to the ambient Pb concentration has significantly improved the agreement with the measured concentration to the modelling analysis for emission inventory sources only presented by Vincent and Passant (2008). The agreement is much better at the rural sites in particular, where the previous assessment predicted much lower concentrations.

Table 2.9. Summary statistics for comparison between modelled and measured annual mean concentrations at different monitoring sites

	Mean of measurements (µg/m^3)	Mean of model estimates (µg/m^3)	R^2	% of sites outside DQO of ±50%	Number of sites in assessment
Industrial sites	19.82	19.54	0.59	46.15	13
Urban background sites	11.01	7.90	0.09	55.56	9
Roadside sites	10.53	14.52	1.00	0.00	3
Rural sites	3.70	1.51	0.70	63.64	11

2.8.5   Comparison of modelling results with the limit values

There were no modelled exceedances of the limit value for Pb in 2008.

3 Benzo(a)pyrene

3.1 Introduction

Benzo(a)pyrene (BaP) concentrations were modelled for 2005 by Vincent el al (2007) to inform the UK Preliminary Assessment for the fourth daughter Directive (Bush, 2007). 2008 is the first year for which a full air quality assessment is required and national modelling of BaP has therefore been undertaken in order to assess compliance with the target value set out in the Directive.

3.2 Monitoring sites

Connolly (2009) has described the changes made to the UK PAH monitoring network during 2007 in order to satisfy the requirements of the fourth daughter Directive. These changes included the establishment of additional monitoring sites, a change to the use of Digitel sampling instruments at most sites and changes to the chemical analysis method. A summary of the Digitel monitoring data for 2008 is presented Table 3.1 below.

Table 3.1 Summary BaP monitoring data for 2008 (Digitel analysers)

Site name	Site type	Instrument type	BaP (annual mean)	
			dc %	ng/m3
Auchencorth Moss A	Rural	Digitel	78	0.04
Ballymena Ballykeel	Urban background	Digitel	94	2.48
Birmingham Tyburn (PAH)	Urban background	Digitel	99	0.37
Bolsover	Urban background	Digitel	97	0.29
Cardiff Lakeside	Urban background	Digitel	96	0.29
Derry Brandywell	Urban background	Digitel	98	1.34
Edinburgh St Leonards (PAH)	Urban background	Digitel	99	0.12
Glasgow Centre (PAH)	Urban background	Digitel	98	0.31
Harwell A	Rural	Digitel	97	0.00
Hazelrigg (PAH)	Rural	Digitel	84	0.12
High Muffles (PAH)	Rural	Digitel	95	0.10
Hove (PAH)	Urban background	Digitel	95	0.34
Kinlochleven	Urban background	Digitel	92	0.27
Leeds Millshaw	Urban background	Digitel	100	0.48
Lisburn Dunmurry High School	Urban background	Digitel	89	0.75
Liverpool Speke (PAH)	Urban background	Digitel	97	0.32
London Brent (PAH)	Urban background	Digitel	98	0.23
London Crystal Palace Parade	Urban background	Digitel	99	0.29
London Marylebone Road (PAH)	Urban background	Digitel	87	0.33
Lynemouth	Industrial	Digitel	96	0.76
Middlesbrough (PAH)	Industrial	Digitel	95	2.81
Newcastle Centre (PAH)	Urban background	Digitel	100	0.26
Newport	Urban background	Digitel	99	0.34

Site name	Site type	Instrument type	BaP (annual mean)	
			dc %	ng/m3
Port Talbot (PAH)	Industrial	Digitel	99	0.60
Royston	Industrial	Digitel	95	2.65
Salford Eccles	Urban background	Digitel	98	0.31
Scunthorpe Santon	Industrial	Digitel	95	6.10
Scunthorpe Town (PAH)	Industrial	Digitel	99	3.15
South Hiendley	Industrial	Digitel	97	1.33
Stoke Ferry (PAH)	Rural	Digitel	98	0.15
Swansea CWM Level Park	Urban background	Digitel	87	0.32

The network in 2008 included both Andersen and Digitel samplers. Because the Digitel samplers result in higher measured concentrations than the Andersen samplers at the same location, a comparison was done using collocated sites using quarterly data from both instruments from 2007 and 2008 where at least 2 of the 3 months in each quarter was present. This comparison provided a scaling factor used to scale the Andersen concentrations to a 'Digitel equivalent'. This provided a greater volume of comparable data to use in the study. The sites available for inclusion in the comparison were Harwell, Hazelrigg, High Muffles, Scunthorpe Town and Stoke Ferry. The relationship is shown in Figure 3.1, below.

Figure 3.1 Relationship between collocated Andersen and Digitel analysers, 2007 and 2008

Using the relationship defined by Figure 3.1, the Andersen concentrations for 2008 were scaled using a factor of 1.2765 in order to provide a 'Digitel-equivalent' value, presented in Table 3.2.
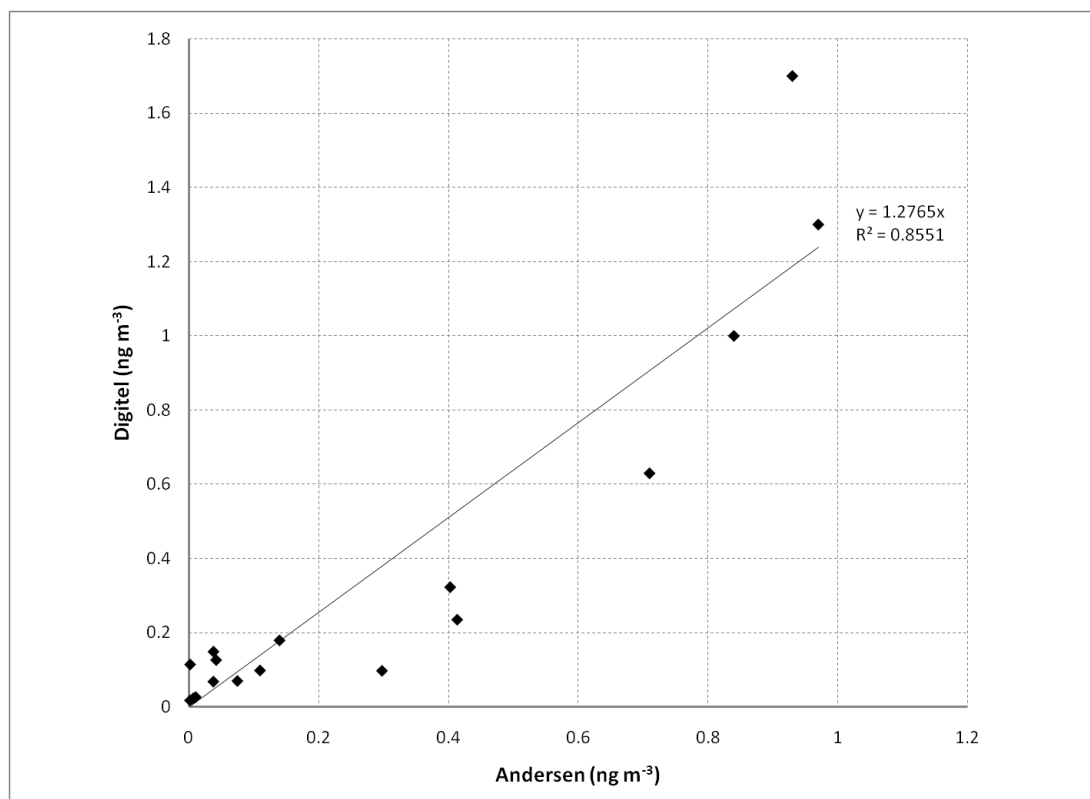
Table 3.2 Summary BaP monitoring data for 2008 (Digitel analysers)

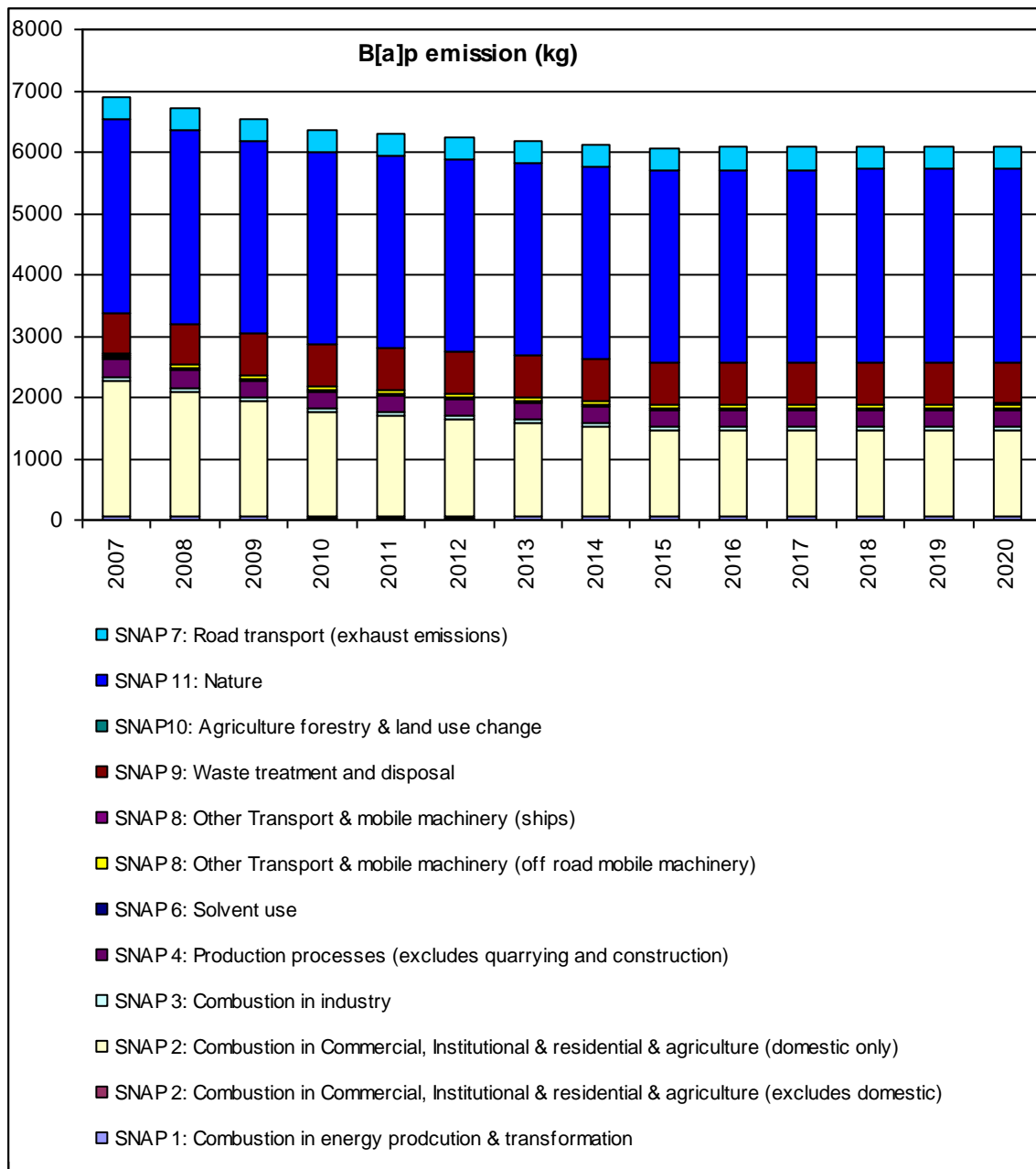| Site name	Site type	Instrument type	BaP (annual mean) Measured concentration (ng m^{-3})	BaP (annual mean) Scaled concentration (ng m^{-3})
Hazelrigg	Rural	Andersen	0.12	0.16
High Muffles	Rural	Andersen	0.10	0.12
London Nobel House	Urban background	Andersen	0.17	0.21
Manchester Law Courts	Urban background	Andersen	0.09	0.11
Middlesbrough Longlands College	Industrial	Andersen	2.81	3.59

3.3 Emissions

BaP emissions for 2007 from the National Atmospheric Emissions Inventory (NAEI) (Murrells et al, 2009) were used in the model. The NAEI values were checked against the Environment Agency's Pollution Inventory (PI) for consistency.

Projections of the emission estimates to 2008 and to future years 2010, 2015 and 2020 were derived from the Updated Energy Projections (UEP 37) provided by the Department of Energy and Climate Change (DECC). Values for intermediate years have been interpolated. The emission estimates for 2007-2020 split by SNAP code are shown in Figure 3.2. This shows that emissions from BaP are expected to decline from 2007 to 2015 with the sharpest decline until 2010. From 2015 onwards, emissions are expected to remain stable. A contributory factor for this lack of decline is that some of the most significant sources of BaP emissions are outside of regulatory controls. For example, the single largest source is SNAP 11: Nature which refers to BaP emissions from combustion in the natural environment such as forest fires. Despite the relatively high emissions contribution from this source sector, the method for distribution of these emissions ensures that natural combustion is spread evenly across the UK and does not unduly affect the modelled ambient concentrations in any particular area.

Another significant source of emission is the combustion of solid fuels for domestic heating – this is represented by the pale yellow bars in Figure 3.2. This is a particularly important source in rural areas (particularly those in Northern Ireland and Scotland) where there may be a heavy dependency on solid fuels instead of natural gas due to limitations of the gas supply infrastructure in more remote locations. The emissions inventory provides maps of emissions in a 1 km x 1 km grid, which is likely to be too coarse to incorporate very local variations in emissions from sources such as domestic heating, where there may be considerable in square variation due to differences in fuel use. Updates to the mapped NAEI emissions inventory for 2008 are expected to include new information on the spatial distribution of domestic gas use, which was last updated for the 2004 inventory.

Maps of emissions from area sources for 2008 were derived from the 2007 inventory maps using sector specific scaling factors derived from the projections shown above. The emissions from point sources were not scaled and the emissions for 2007 were assumed to apply in 2008.

Figure 3.2 UK total BaP emissions for 2007 and emissions projections up to 2020 by SNAP code from NAEI 2007

Legend:
- SNAP 7: Road transport (exhaust emissions)
- SNAP 11: Nature
- SNAP 10: Agriculture forestry & land use change
- SNAP 9: Waste treatment and disposal
- SNAP 8: Other Transport & mobile machinery (ships)
- SNAP 8: Other Transport & mobile machinery (off road mobile machinery)
- SNAP 6: Solvent use
- SNAP 4: Production processes (excludes quarrying and construction)
- SNAP 3: Combustion in industry
- SNAP 2: Combustion in Commercial, Institutional & residential & agriculture (domestic only)
- SNAP 2: Combustion in Commercial, Institutional & residential & agriculture (excludes domestic)
- SNAP 1: Combustion in energy prodcution & transformation

3.4   The model

Ground level annual mean concentrations of BaP are considered to consist of

- Point sources from industrial processes
- Area source emissions

A significant change to the modelling methodology since the 2005 assessment has been the decision to implement a calibration based on monitoring data from the national network. This decision was made to ensure that the model result was realistically consistent with the measurements. To an extent a model calibration hides imperfections in the emissions inventory but given the increased measured concentrations from 2007 and 2008 it was deemed appropriate to use a calibration in order to obtain results consistent with those from the monitoring network. Particular consideration was given to appropriate application of calibration factors to the model and for this reason separate calibration factors were derived for the area and point source components of the model.

3.4.1   Area sources

The modelled uncalibrated area source contribution has been calculated by applying an ADMS 4.0 derived dispersion kernel to calculate the contribution to ambient concentrations at a central receptor location from area source emissions within a 33km x 33km square surrounding each receptor. Hourly sequential meteorological data from Waddington in 2008 has been used to construct the dispersion kernels, as described in Appendix 1.

A calibration has been applied to the modelled BaP area source component (Figure 3.3). This has been achieved by plotting the uncalibrated area source component from the model against measured concentrations that have been adjusted to represent background (non-industrial) concentrations only (i.e. measured concentrations at background sites minus modelled point source contributions at those locations).

The modelled area source contribution was multiplied by the coefficient (13.01) to calculate the calibrated area source contribution for each grid square in the country.

In the process of running the model it became apparent that some of the area source emissions were resulting in unrealistic concentrations. As a result some manually applied emissions caps were used for certain sectors and areas. Due to the initially modelled high concentrations at Grangemouth, process emissions (SNAP code 4) were capped at 0.5 kg /a (the maximum was originally 0.66 kg/a). Similarly emissions from solvents (SNAP code 6) at Prestwick in Scotland were capped to 0.4 kg/a (from the original maximum of 0.5 kg/a). Domestic emissions of BaP from domestic combustion in Scotland were originally higher than in Northern Ireland which was considered unrealistic. Therefore the maximum domestic emission for the UK was capped at 0.46 kg/a (shown to provide a reasonable maximum concentration of 0.6 ng m^{-3} from this sector when emitted and dispersed from a single cell) except for Central Scotland and North East Scotland, which were capped more heavily with a domestic maximum emission of 0.4 kg/a. These caps have been applied based on expert judgement of the model results in order to address known artefacts in the area source emissions grids and to reconcile the model results with the measured data at each monitoring site. The application of these caps is annually reported back to the NAEI as part of the quality checking process to ensure that continual improvements are made in the emissions grids.

Figure 3.3 Calibration of area source model for BaP
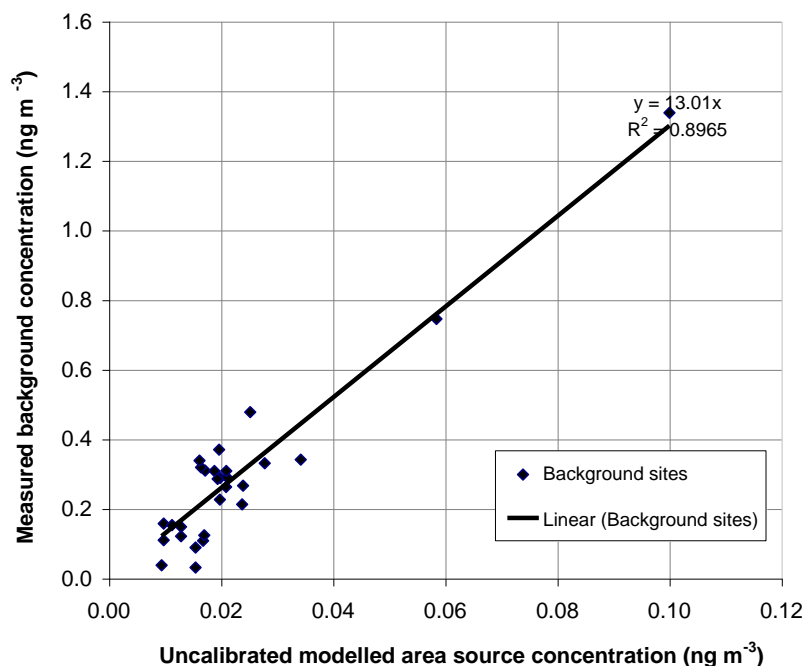
3.4.2 Point sources

Contributions to ground level annual mean BaP concentrations from point sources in 2007 NAEI were estimated by modelling each source explicitly using an atmospheric dispersion model (ADMS4.0) and sequential meteorological data for 2008 from Waddington.

Industrial point sources of BaP are either fugitive (as from coking plants) or from clearly defined stacks for other sources. The emission amount is derived either from direct measurement or by emission factors. Release characteristics were obtained from the NAEI point sources database and included parameters such as

- Stack height
- Stack diameter
- Discharge velocity
- Discharge temperature

Several point sources were modelled using specially tailored modelling parameters to accommodate non-standard stack arrangements. These included:

- Anglesey anode baking processes which uses a dual flue concentric stack arrangement
- Coke works at Barnsley, Teeside, Port Talbot and Scunthorpe which were all modelled as line sources

Specific emission information for coking plants was provided by Peter Coleman (2009) and covered Barnsley (Monkton coke oven), Teeside (Redcar and South Bank coke ovens and sinter plant), Port Talbot (Morfa coke works and sinter plant) and Scunthorpe (Dawes Lane and Appleby coke ovens and sinter plant).

In order to obtain a model result that was consistent with measured concentrations, the model was calibrated using monitoring data from the national network. Industrial sites only were used to calibrate the point source contribution (Figure 3.4). Measured industrial concentrations were adjusted by subtracting the calibrated modelled area source concentration so that the measured value represented

the industrial component only. There is an element of circularity involved in the calibration of both area and point sources because the calibration process for each requires the subtraction of the other in order to isolate the component being calibrated. A decision was made to calibrate the area source component first using the uncalibrated modelled point source component and then to use the calibrated area source component to subtract from the measured industrial concentrations in the calibration of the point sources. A multiple regression analysis for all monitoring sites was considered but was rejected because it would be likely to over fit to the data and not provide realistic coefficients.

Figure 3.4 Calibration of point source model for BaP
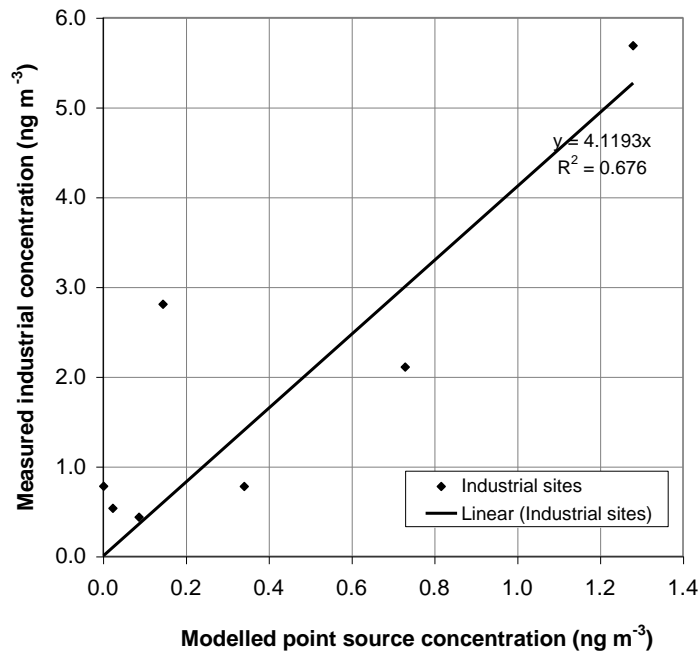
The modelled point source contribution was multiplied by the coefficient (4.1193) to calculate the calibrated point source contribution.

3.5   Results

3.5.1   Map of annual mean concentrations

Figure 3.5 shows the modelled annual mean BaP concentrations.

3.5.2   Source apportionment

A source apportionment graph has been plotted in Figure 3.6 to present the BaP contribution from different sources at monitoring site locations. Concentrations measured at the monitoring sites are also presented as marker so these plots provide an indication of the level of agreement between the modelled and measured concentrations.

3.5.3   Verification of mapped concentrations

An alternative presentation of the comparisons of modelled and measured annual mean BaP concentrations in 2008 at different monitoring site locations are shown in Figures 3.7-3.9. Lines representing y = x − 60% and y = x + 60% (the AQDD4 data quality objective for modelled annual mean BaP concentration) have been added to display the reliability of our modelled estimates of BaP.

Figure 3.5 Annual mean map of BaP concentrations for comparison with the BaP target value of 1 ng/m^3, 2008 (ng/m^3)
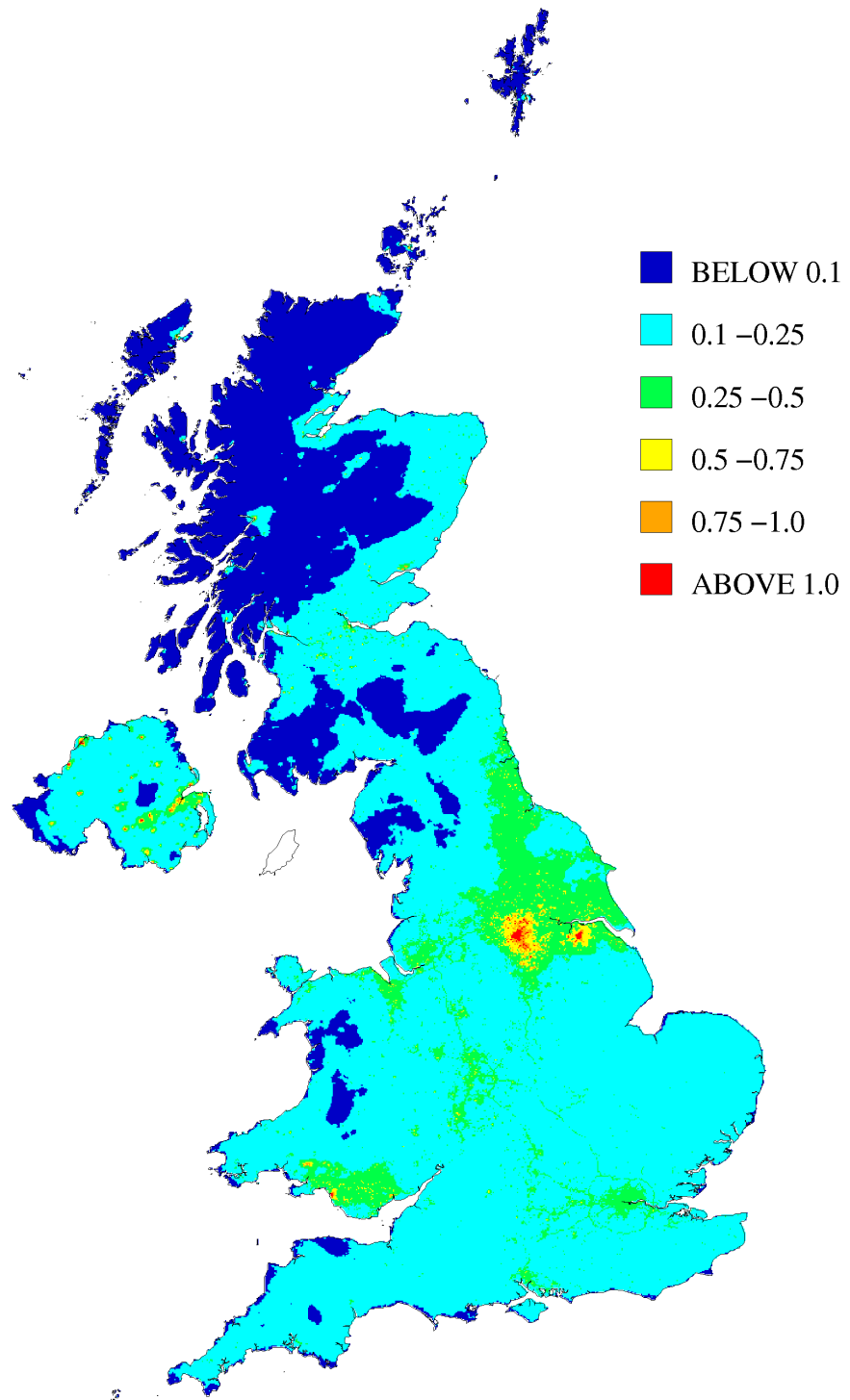
Figure 3.6 Source apportionment for BaP
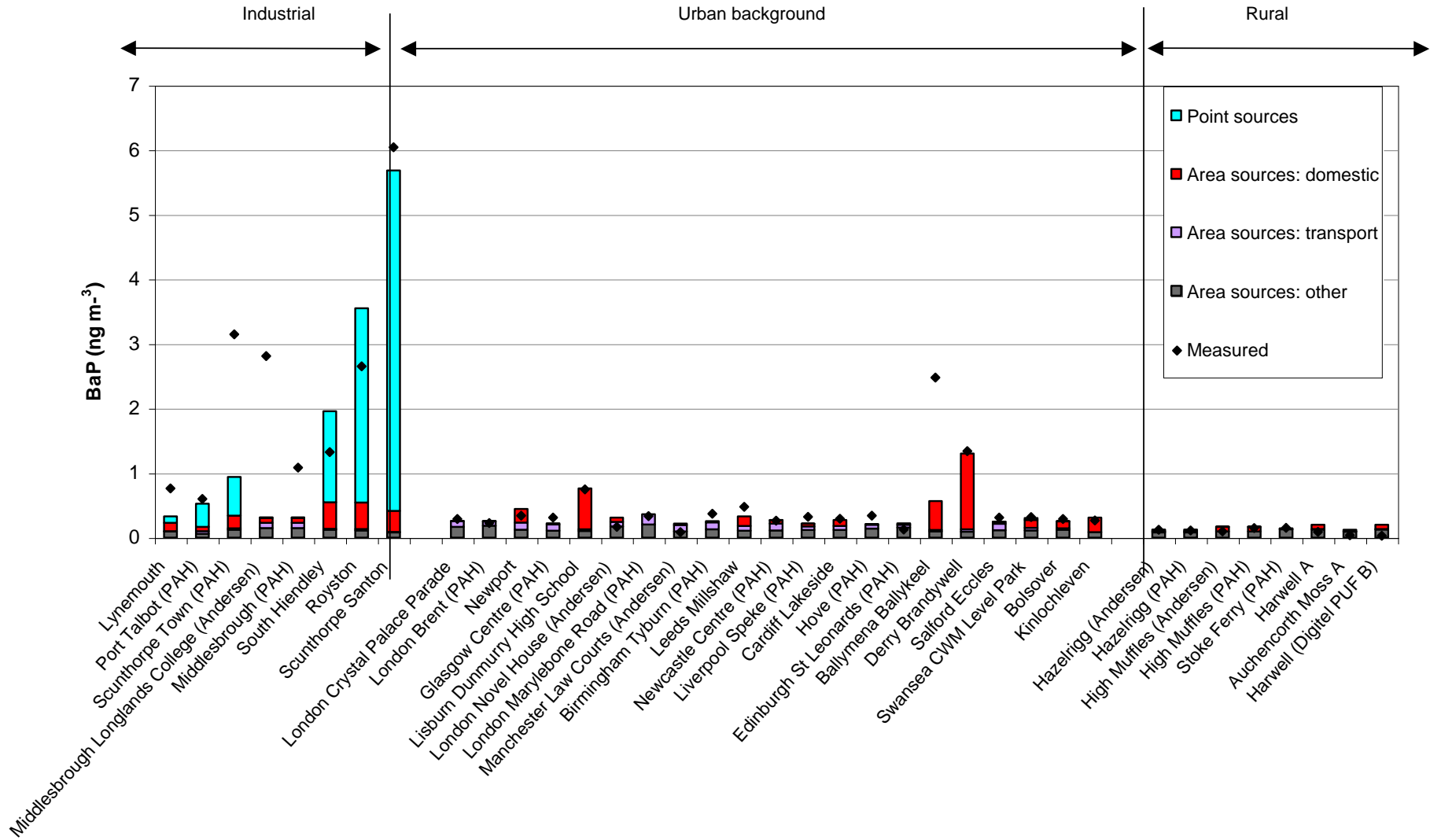
Figure 3.7. Verification of annual mean BaP at Industrial sites
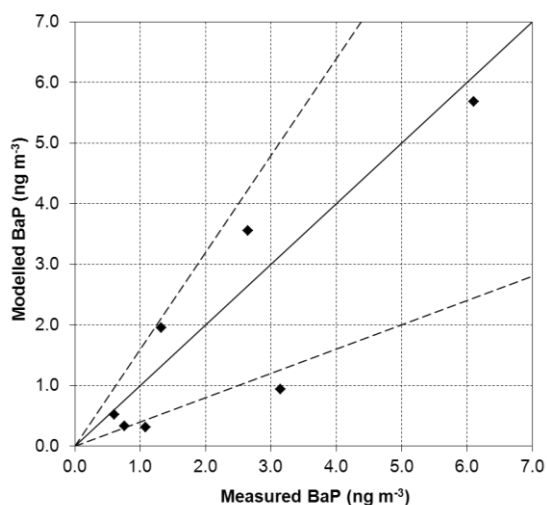
Figure 3.8. Verification of annual mean BaP at urban background sites
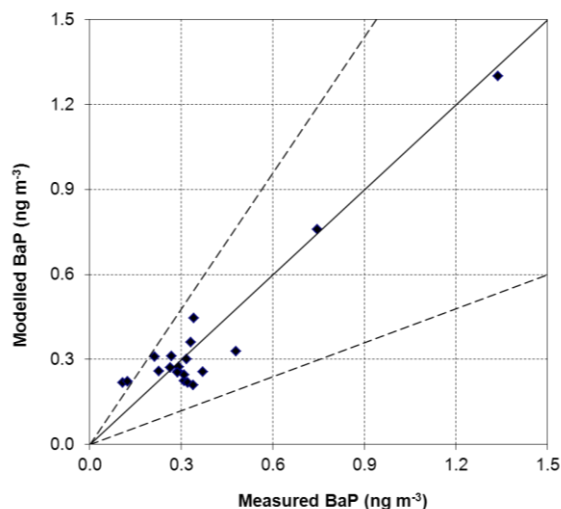
Figure 3.9. Verification of annual mean BaP at rural sites
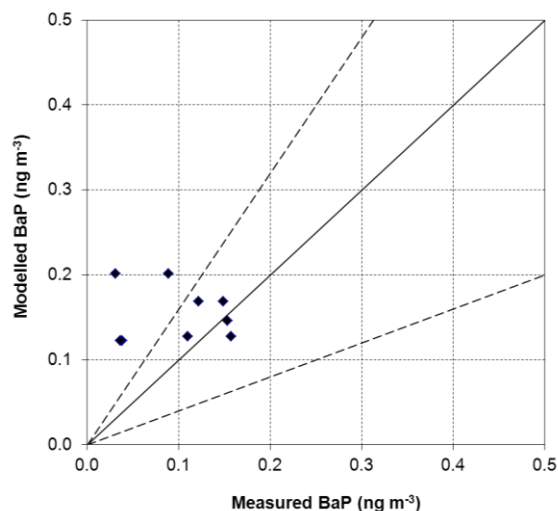
Summary statistics for modelled and measured BaP concentrations, the percentage of sites for which the modelled values are outside the data quality objectives (DQOs) and the total number of sites included in the analysis are listed in Table 3.3.

The calculated means of measured compared with modelled concentrations are in good agreement for urban background and rural sites. The agreement between measured and modelled concentrations at industrial sites is poorer. It is likely that variation of BaP concentrations in close proximity to these major sources is not as well represented in the model. The R^2 values are high for industrial and particularly for urban background sites but poor for rural sites. This is because the model results are principally driven by the calibration process in which industrial and urban background sites are prominent in defining the relationship.

Table 3.3. Summary statistics for comparison between modelled and measured annual mean BaP concentrations at different monitoring sites

	Mean of measurements (ng/m^3)	Mean of model estimates (ng/m^3)	R^2	% of sites outside DQO of ±60%	Number of sites in assessment
Industrial sites	2.24	1.90	0.76	29%	7
Urban background sites	0.36	0.35	0.91	10%	20
Rural sites	0.10	0.16	0.01	38%	8

3.5.4 Comparison of modelling results with the target value

Tabular results for the supplementary assessment for BaP are presented in Table 3.4. Exceedances of the 1 ng m-3 target value have been modelled for five zones. The exceedances in the Swansea Urban Area and South Wales zones were associated with coking operations at Port Talbot. The exceedances in the Yorkshire & Humberside zone were associated with coking operations at Monkton and Scunthorpe and domestic solid fuel use. The exceedances in the Northern Ireland and Belfast Metropolitan Urban Area zones were associated with domestic solid fuel use.

Measured concentrations also exceeded the target value in the Yorkshire & Humberside and Northern Ireland zones and we have therefore reported measured exceedances for these zones in the air quality assessment. A measured exceedance was also reported for the Teeside zone for which there were no modelled exceedances.

Table 3.4. Tabular results of and methods used for supplementary assessment for BaP

Zone	Zone code	Above TV for health (annual mean)			
		Area		Population exposed	
		Km²	Method	Number	Method
Greater London Urban Area	UK0001	0	B	0	B
West Midlands Urban Area	UK0002	0	B	0	B
Greater Manchester Urban Area	UK0003	0	B	0	B
West Yorkshire Urban Area	UK0004	0	B	0	B
Tyneside	UK0005	0	B	0	B
Liverpool Urban Area	UK0006	0	B	0	B
Sheffield Urban Area	UK0007	0	B	0	B
Nottingham Urban Area	UK0008	0	B	0	B
Bristol Urban Area	UK0009	0	B	0	B
Brighton/Worthing/Littlehampton	UK0010	0	B	0	B
Leicester Urban Area	UK0011	0	B	0	B
Portsmouth Urban Area	UK0012	0	B	0	B
Teesside Urban Area	UK0013	0	B	0	B
The Potteries	UK0014	0	B	0	B
Bournemouth Urban Area	UK0015	0	B	0	B
Reading/Wokingham Urban Area	UK0016	0	B	0	B
Coventry/Bedworth	UK0017	0	B	0	B
Kingston upon Hull	UK0018	0	B	0	B
Southampton Urban Area	UK0019	0	B	0	B
Birkenhead Urban Area	UK0020	0	B	0	B
Southend Urban Area	UK0021	0	B	0	B
Blackpool Urban Area	UK0022	0	B	0	B
Preston Urban Area	UK0023	0	B	0	B
Glasgow Urban Area	UK0024	0	B	0	B
Edinburgh Urban Area	UK0025	0	B	0	B
Cardiff Urban Area	UK0026	0	B	0	B
Swansea Urban Area	UK0027	3	B	1991	B
Belfast Urban Area	UK0028	3	B	10654	B
Eastern	UK0029	0	B	0	B
South West	UK0030	0	B	0	B
South East	UK0031	0	B	0	B
East Midlands	UK0032	0	B	0	B
North West & Merseyside	UK0033	0	B	0	B
Yorkshire & Humberside	UK0034	147	B	100456	B
West Midlands	UK0035	0	B	0	B
North East	UK0036	0	B	0	B
Central Scotland	UK0037	0	B	0	B
North East Scotland	UK0038	0	B	0	B
Highland	UK0039	0	B	0	B
Scottish Borders	UK0040	0	B	0	B
South Wales	UK0041	4	B	208	B
North Wales	UK0042	0	B	0	B
Northern Ireland	UK0043	21	B	59581	B
Total		178		172891	

4 Lists of zones in relation to target values

The tables included in this section are from Form 8d and 9b of the questionnaire. Exceedance (or otherwise) of the target value (TV) and limit value (LV) where this exists are indicated by a 'y' for measured exceedances and with an 'm' for modelled exceedances. 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, >LV + MOT or ≤LV + MOT; >LV indicates that modelled concentrations were higher than measured concentrations. Modelled concentration 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 doe not correspond to the location of the highest concentration in the zone. An 'm' in the columns marked ≤TV or ≤LV indicates that measurements were not available for that zone and modelled values were therefore used.

The results of the air quality assessments for As, Cd, Ni, Pb and BaP are listed in Tables 4.1 and 4.2. Exceedances of the target value for Ni have been reported for two zones and exceedances of the target value for BaP have been reported for six zones.

Table 4.1 List of zones and agglomerations where levels exceed or do not exceed target values for arsenic, cadmium, nickel and benze(a)pyrene (2004/1007/EC, Annex I)

Zone	Zone code	Arsenic		Cadmium		Nickel		Benzo(a)pyrene	
		> TV	≤TV	> TV	≤TV	> TV	≤TV	> TV	≤TV
Greater London Urban Area	UK0001		y		y		y		m
West Midlands Urban Area	UK0002		y		y		y		y
Greater Manchester Urban Area	UK0003		y		y		y		y
West Yorkshire Urban Area	UK0004		m		m		m		y
Tyneside	UK0005		m		m		m		y
Liverpool Urban Area	UK0006		m		m		m		y
Sheffield Urban Area	UK0007		y		y		y		m
Nottingham Urban Area	UK0008		m		m		m		m
Bristol Urban Area	UK0009		y		y		y		m
Brighton/Worthing/Littlehampton	UK0010		m		m		m		y
Leicester Urban Area	UK0011		m		m		m		m
Portsmouth Urban Area	UK0012		m		m		m		m
Teesside Urban Area	UK0013		m		m		m	y	
The Potteries	UK0014		m		m		m		m
Bournemouth Urban Area	UK0015		m		m		m		m
Reading/Wokingham Urban Area	UK0016		m		m		m		m
Coventry/Bedworth	UK0017		m		m		m		m
Kingston upon Hull	UK0018		m		m		m		m
Southampton Urban Area	UK0019		m		m		m		m
Birkenhead Urban Area	UK0020		m		m		m		m
Southend Urban Area	UK0021		m		m		m		m
Blackpool Urban Area	UK0022		m		m		m		m
Preston Urban Area	UK0023		m		m		m		m
Glasgow Urban Area	UK0024		y		y		y		y
Edinburgh Urban Area	UK0025		m		m		m		y
Cardiff Urban Area	UK0026		m		m		m		y
Swansea Urban Area	UK0027		y		y	m		m	
Belfast Urban Area	UK0028		y		y		y	m	
Eastern	UK0029		y		y		y		y

Zone	Zone code	Arsenic		Cadmium		Nickel		Benzo(a)pyrene	
		> TV	≤TV	> TV	≤TV	> TV	≤TV	> TV	≤TV
South West	UK0030		y		y		y		m
South East	UK0031		y		y		y		y
East Midlands	UK0032		m		m		m		y
North West & Merseyside	UK0033		y		y		y		y
Yorkshire & Humberside	UK0034		m		m		m	y	
West Midlands	UK0035		m		m		m		m
North East	UK0036		m		m		m		y
Central Scotland	UK0037		y		y		y		y
North East Scotland	UK0038		y		y		y		m
Highland	UK0039		m		m		m		y
Scottish Borders	UK0040		y		y		y		m
South Wales	UK0041		y		y	m		m	
North Wales	UK0042		m		m		m		m
Northern Ireland	UK0043		m		m		m	y	

Table 4.2 List of zones and agglomerations where levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV + MOT) (96/62/EC Articles 8, 9 and 11, 1999/30/EC Annexes I, II, III and IV, 2000/69/EC Annexes I and II)

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

5   Acknowledgements

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Appendices

Appendix 1: Dispersion kernels for area source model

Appendix 2: Air Quality Assessment for Gibraltar in 2008

Appendix 1 Dispersion kernels for area source model

DISPERSION KERNELS FOR AREA SOURCE MODEL

Dispersion kernels for calculating the annual mean contribution of emissions from area sources to ambient annual mean concentrations were calculating using ADMS. Separate kernels were calculated for traffic and other area sources (which were assumed to have a constant temporal profile of emissions). Kernels were generated for 2008 using sequential meteorological data from Waddington. The dispersion parameters used to calculate the kernels are listed in Table A1.1. The emission profile used to represent traffic emissions for the traffic kernels is shown in Figure A1.1. This was obtained from a distribution of all traffic in the United Kingdom by time of day (DETR, 2000).
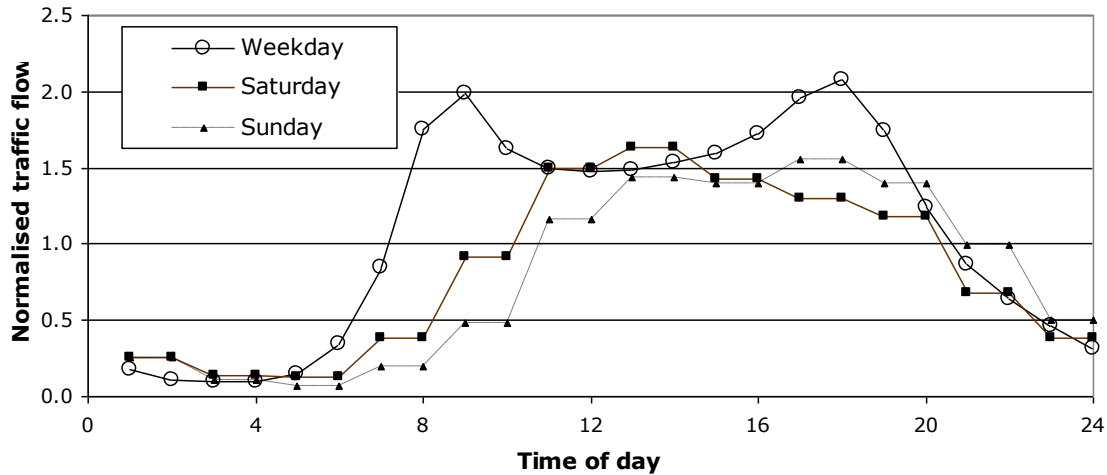

Figure A1.1 Temporal profile of traffic emissions

The kernels are on a 1km x 1km resolution matrix and are made using ADMS 4.0. The centre squares have been scaled to remove the impact of sources within 50m of the receptor location in that square on the basis that background sites are not located very close to specific sources such as major roads. Different kernels have been made for different area types, to take into account different dispersion conditions in urban areas of different sizes. The location of the different area types are shown in Figure A1.2. and surface roughness due to different land use.

Table A1.1: Summary of inverted dispersion kernel parameters

Kernel name	Area types	Type of location	LMO (m)	Surface roughness	Height (m) of volume source	Variable emission profile?	Emission rate $(g/m^3/s)$
Non road transport	1,2,4	Conurbation	75	1	30	N	3.33E-08
Non road transport	3,4,5,6,7,8	Smaller urban	20 [A]	1	30	N	3.33E-08
Non road transport	9,10	Rural	10	1	30	N	3.33E-08
Road transport	1,2,4	Conurbation	75	1	10	Y	1.0E-7

Table A1.1 (cont.): Summary of inverted dispersion kernel parameters

Kernel name	Area types	Type of location	LMO (m)	Surface roughness	Height (m) of volume source	Variable emission profile?	Emission rate (g/m^3/s)
Road transport	3,4,5,6,7,8	Smaller urban	10	1	10	Y	1.0E-7
Road transport	9,10	Rural	20 [A]	1	10	Y	1.0E-7

A. ADMS 4.0 recommends using a minimum Monin Obukhov Length (LMO) of 30m for an urban area. However, sensitivity testing showed 20m works better in ADMS 4.0
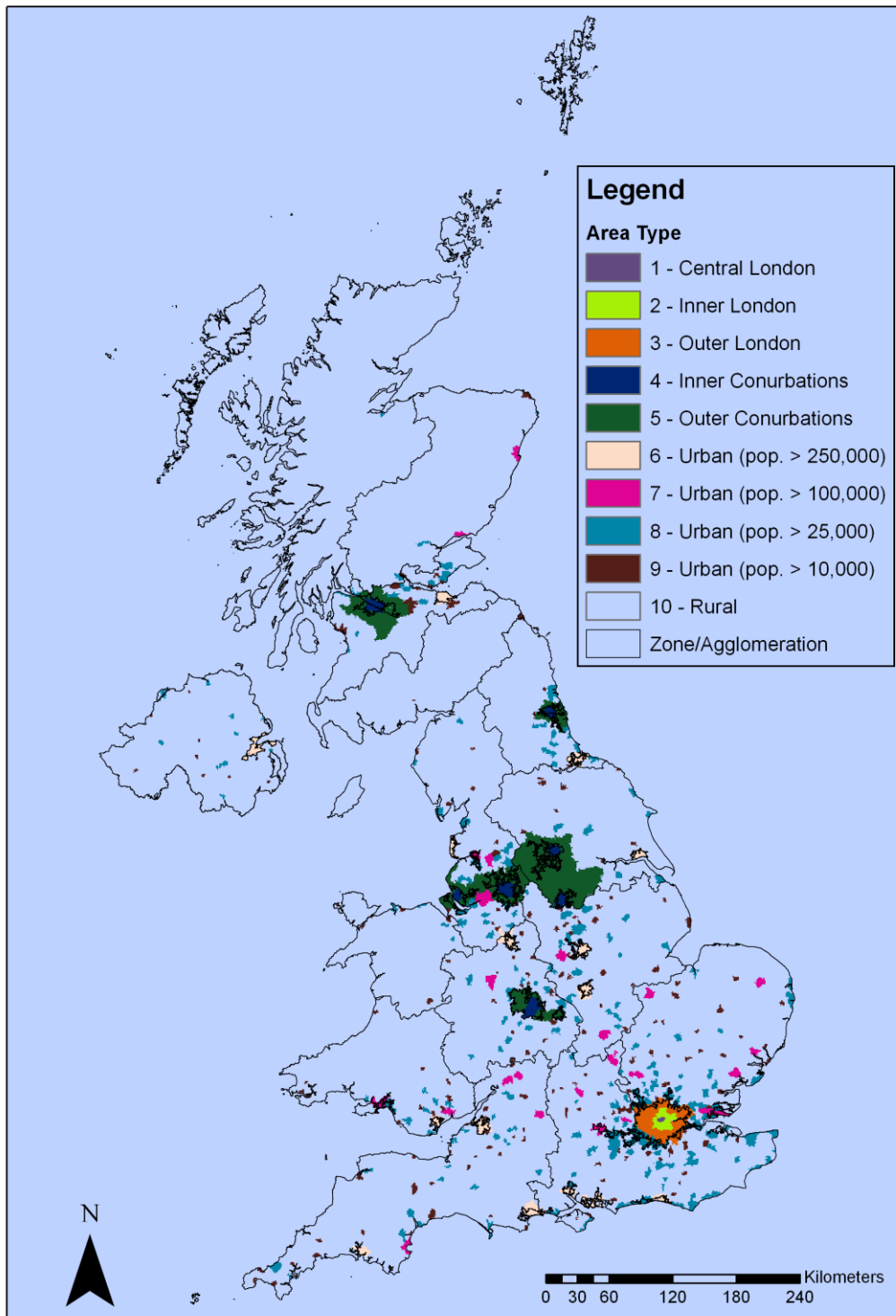
Figure A1.2: Map of UK area types

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Appendix 2 Air Quality Assessment for

Gibraltar in 2008

Introduction

Gibraltar is subject to the same European environmental legislation as the UK. Gibraltar comprises of a single non-agglomeration zone. No modelling assessment has been undertaken. The exceedance status of the Gilbraltar zone has been determined from monitoring data only. This Appendix summarises ambient results of the air quality assessment reported for 2008 for Gibraltar. The results of the air quality assessments for the pollutants covered by the other ambient air quality directives have been reported by Grice, et al, (2009) and Kent and Stedman (2009).

Table A2.1 Gibraltar air quality monitoring network site details

Site	Site type	Latitude	Longitude	Altitude	Pollutants
Rosia Road	ROADSIDE	36 08 00N	05 21 11W	15 m	As, Cd, Ni, Pb, Benzo[a]pyrene

Annual summary

Table A2.2 shows the annual mean concentrations for the pollutants covered in this report.

Table A2.2 Gibraltar Rosia Road monitoring data, 2008

POLLUTANT	As	Cd	Ni	Pb	Benzo[a]pyrene
Annual average (ng/m^3)	1.28	0.20	20.44	10	0.08
Data capture (%)	100	100	100	100	67
target value (ng/m^3)	6	5	20	500 (limit value)	1

Lists of zones in relation to target values and limit value

The tables presented below are from Form 9 and Form 8 for Pb of the questionnaire and are equivalent tables for Gibraltar as those shown for the UK in section 5. Exceedence (or otherwise) of the target value (TV) and limit value (LV) where this exists are indicated by a 'y' for measured exceedences.

The results of the air quality assessments in Gibraltar for As, Cd, Ni, Pb and BaP are listed in Tables A2.3-A2.4.

Table A2.3 Exceedence situation in Gibraltar showing whether levels exceed or do not exceed target value (TV) for arsenic, cadmium, nickel and benzo(a)pyrene (2004/1007/EC Annex I)

Zone	Zone code	Arsenic		Cadmium		Nickel		Benzo(a)pyrene	
		> TV	≤ TV	> TV	≤ TV	> TV	≤ TV	> TV	≤ TV
Gibraltar Zone	UK (GIB)		y		y	y			m*

* reported as 'm' as a results of an objective estimation based on the measured concentration, which a low data capture

Table A2.4 Exceedence situation in Gibraltar showing whether levels exceed or do not exceed limit values (LV) or limit values plus margin of tolerance (LV+MOT) for lead (96/62/EC Articles 8, 9 and 11 and 1999/30/EC Annexes I, II, III and IV)

Zone	Zone code	LV		
		>LV+MOT	≤LV+MOT; >LV	≤LV
Gibraltar Zone	UK(GIB)			y

Measured exceedences of target value

Exceedances of the target value are presented in Form 14 of the questionnaire. Form 14C is presented below in Table A2.5, showing the station which the target value is exceeded. Reason code S14 represents emissions from shipping.

Table A2.5 Exceedence of target value (2002/3/EC, Article 10(2b) and Annex III, 2004/107/EC Article 5 and Annex I)

Zone code	Station code	Nickel					Reason code
		Concentration (ng/m3)	Area		Population exposed		
			km^2	Method	Number	Method	
UK(GIB)	GB0050A	20.44	6.5	n/a	27928	n/a	S14