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Modelling Air Quality for London using ADMS-Urban

TOPIC REPORT

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EXECUTIVE SUMMARY

The 'map report' is the third in a series of topic reports prepared as part of a CERC's contract[1] to model air pollutants in urban areas in the UK. The scenario anticipated in Greater London without further measures was investigated, i.e. business as usual, using the Air Dispersion Modelling System ADMS-Urban to model several important pollutants: Nitrogen Dioxide (NO_2); Oxides of Nitrogen (NO_x); particles smaller than 10 microns diameter (PM_{10}); and Ozone (O_3). This is the basis for further modelling of alternative scenarios that may be employed to achieve the air quality objectives laid out in the UK air quality strategy.

Objectives to be achieved by 2004 and 2005

The following conclusions were drawn for 2004 and 2005, assuming there are no additional emissions reductions:

- **Annual average NO_2** is likely to exceed the 40µg/m^3 UK air quality objective for:
  - Around 32% of the total area of London in the target year (2005), despite a reduction of approximately half of the area exceeding between 1999 and 2005.
  - Between 22% and 43% of the total area of London if the margin of error is applied to the modelled concentrations for the base year meteorological conditions.
  - 17 of the 23 automatic urban and rural network (AURN) monitoring locations for both base and worst case meteorological conditions.

- **99.8 percentile of 1-hour average NO_2** (equivalent to 18 exceedences) is likely to exceed the UK air quality objective (200µg/m^3) for:
  - Approximately 3% of the modelled area when modelled with the base year meteorological conditions.
  - Only Marylebone road from the 23 AURN monitoring locations, for both base and worst case meteorological conditions.

- All **PM_{10}** objectives are likely to be achieved by 2004 for base and worst case meteorological conditions, with the following exceptions at Marylebone Road only:
  - The worst case year Annual Average exceeds the 40µg/m^3 AQS limit.
  - 90.4 percentile for base and worst case years (representing 35 exceedences) exceeds the limit of 50µg/m^3.

Air quality targets to be achieved by 2010

The following conclusions were drawn for 2010, assuming there are no additional emissions reductions:

[1] This contract is funded by DEFRA and the devolved administrations.

- **Annual average NO_2** is likely to exceed the 40μg/m^3 EU air quality limit value for:
  - Approximately 13% of the total area of London in the target year.
  - Between 8% and 20% of the total area of London if the margin of error is applied to the modelled concentrations for the base year meteorological conditions.
  - 15 of the 23 AURN monitoring locations for base case and 17 AURN locations for worst case meteorological conditions.

- **99.8 percentile of 1-hour average NO_2** (equivalent to 18 exceedences) concentrations is unlikely to exceed the EU air quality limit value (200μg/m^3).

- The **annual average PM_{10}** concentrations are likely to exceed the London 23μg/m^3 objective for:
  - Less than 1% of the area of London if the base case meteorological conditions are used in the modelling.
  - Up to 2% of London if the margin of error for the modelled concentration is taken into account.
  - The whole of London in a worst case year, because the worst case annual average background concentration alone is 23 μg/m^3.
  - 2 AURN monitoring locations for base case and all 11 AURN locations for worst case meteorological conditions.

- The **annual average PM_{10}** concentrations are likely to exceed the EU 20μg/m^3 indicative limit value for:
  - 75% of the area of London if the base case meteorological conditions are used in the modelling.
  - As low as 8% or as much as 100% of London if the margin of error for the modelled concentration is taken into account. Small changes in predicted concentration have a great impact on areas exceeding a threshold because the concentrations of PM_{10} are relatively uniform.
  - The whole of the modelled area if the worst case meteorological conditions are used in the modelling.
  - All of the 11 AURN monitoring locations for both base and worst case meteorological conditions.

- The **PM_{10} 97.2 percentile of 24-hour average** is likely to exceed the London objective of 50 μg/m^3 (equivalent to 10 exceedences):
  - Nowhere if base case meteorological conditions are assumed.
  - Over approximately 36% of the area modelled, if worst case meteorological conditions are assumed.
  - At all 11 of the AURN monitoring locations if worst case meteorological conditions are modelled.

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1. Introduction

This 'map report' is the third in a series of topic reports prepared as part of a CERC's contract[2] to model air pollutants in urban areas in the UK. The scenario anticipated in Greater London without further measures was investigated, i.e. business as usual, using the Air Dispersion Modelling System ADMS-Urban to model several important pollutants: Nitrogen Dioxide (NO_2); Oxides of Nitrogen (NO_x); particles smaller than 10 microns diameter (PM_{10}); and Ozone (O_3). This is the basis for further modelling of alternative scenarios that may be employed to achieve the air quality objectives laid out in the UK air quality strategy.

The other two topic reports record a validation and sensitivity study (Carruthers et al., 2003a) and a comparison with the results of two other pollution prediction methodologies (Carruthers et al., 2003b). The validation study demonstrated the generally good agreement of ADMS-Urban calculated concentrations with measured data. The sensitivity study demonstrated that the predicted concentrations show the most sensitivity to the year for which the meteorological data are recorded, the location of the meteorological site and the emissions database. Sensitivity to the model set-up parameters, minimum Monin Obukhov length, height of grid sources and surface roughness, where they vary within reasonable ranges, is smaller.

This report presents maps of modelled NO_x, NO_2, PM_{10} and O_3 concentrations for London for 1999 and the AQS objective years of 2004 (PM_{10} only), 2005 (NO_x, NO_2, O_3 only) and 2010. There are also maps of the modelled PM_{10} concentration for 2010 assuming the worst case meteorological conditions and maps of the annual average NO_2/NO_x ratio for all relevant years. For each air quality standard, the precise modelled concentration at each AURN location is presented in a series of tables that cover all relevant years. The tables also include results modelled using the appropriate worst case meteorological data.

PM_{10} concentrations have been presented as gravimetric values whilst all NO_x concentrations are presented as "NO_x as NO_2".

[2] Funded by DEFRA and the devolved administrations

2. Air Quality Targets

Limit values are set at a European level, and take into account the effects of each pollutant on the health of those who are most sensitive to air quality. The UK Air Quality Strategy (AQS) sets objectives that take the European standards into account (DETR, 2000). These objectives are the subject of Statutory Instrument 2000 No. 928, *The Air Quality (England) Regulations 2000*, which came into force on 6th April 2000. The applicable objectives and target years for NO_2 and PM_{10} are summarised in Table 2.1. Most recently additional objectives specific to London have been introduced for PM_{10} to be achieved by 2010.

Table 2.1 Air Quality Objectives

	Concentration (µg/m^3)	Measured as	Target Date
National Air Quality Strategy			
NO_2	40 (21ppb)	Annual average	31-12-2005
	200 (105ppb)	1-hour mean not to be exceeded more than 18 times a year (modelled as 99.8 percentile)	31-12-2005
PM_{10}	40	Annual average	31-12-2004
	50	24-hour mean not to be exceeded more than 35 times a year (modelled as 90.4 percentile)	31-12-2004
PM_{10}	23	Annual average for London	31-12-2010
	50	24-hour mean not to be exceeded more than 10 times a year in London (modelled as 97.2 percentile)	31-12-2010
European Daughter Directive			
NO_2	40 (21ppb)	Annual average	1-1-2010
	200 (105ppb)	1-hour mean not to be exceeded more than 18 times a year (modelled as 99.8 percentile)	1-1-2010
PM_{10}	40	Annual average	1-1-2005
	50	24-hour mean not to be exceeded more than 35 times a year (modelled as 90.4 percentile)	1-1-2005
PM_{10}	20	Annual average	1-1-2010
	50	24-hour mean not to be exceeded more than 7 times a year (modelled as 98.1 percentile)	1-1-2010

3. London Emissions Inventory

The Greater London Authority (GLA) has prepared an emissions inventory which covers the area inside the M25. The London Atmospheric Emissions Inventory (LAEI) includes emissions from air pollutant sources of Air Quality Strategy (AQS) pollutants. In this report only emissions of NO_x, PM_{10} and VOC are considered. Emissions of VOC are important in chemical reactions that affect the levels of NO_2.

Two versions of the LAEI have been used in the preparation of the pollutant maps presented in this report. The current version of the emissions inventory was issued in February 2002, this version has been used in most of the calculations. An earlier version, issued in December 2001, which used slightly different traffic emission factors, was used in the preparation of some of the maps of PM_{10} concentrations, namely the maps for 1999 and 2004 emissions using 1999 meteorology. The maps for 1999 will show an overestimate in calculated concentrations, as the February inventory had slightly lower emission rates of PM_{10} (3% lower in total). The 2004 maps will show a slight underestimate, as the February inventory had slightly higher emission rates (5% higher in total). Table 3.1 compares the total PM_{10} emission rates in the two inventories.

Table 3.1 PM_{10} emission totals from two versions of the LAEI (Tonnes/year)

	December 2001 inventory		February 2002 inventory	
Source Type	1999	2004	1999	2004
Road	3,199 (77%)	1,898 (66%)	3,073 (76%)	2,029 (68%)
Non-road	968 (23%)	967 (34%)	968 (24%)	967 (32%)
Total	**4,167**	**2,866**	**4,041**	**2,996**

The remaining discussion on the emission rates will concentrate on the most recent inventory, from February 2002.

3.1 Future Changes in Emission Rates

Maps of calculated concentrations of pollutants have been prepared for a base year, which for the current version of the LAEI is 1999. In order to see if it is likely that AQS objectives will be met in future years, the 1999 emissions inventory has been projected forward to the years 2004, 2005 and 2010 by the GLA. AQS objectives for NO_2 relate to the years 2005 and 2010, whereas for PM_{10} the objectives are to be reached by the years 2004 and 2010. Maps of NO_2 and PM_{10} concentrations have therefore been prepared for their relevant AQS objective years.

In this section the LAEI total emission rates are compared for the years 1999, 2004/05 and 2010. Table 3.2 shows the emission rates of NO_x, PM_{10} and VOC from traffic sources, other sources and as a total. The percentage of the total emission due to each source type is given in brackets beside each emission rate in the table. Table 3.3 summarises the percentage reduction in emissions from the year 1999.

Table 3.2 Future LAEI emission totals (Tonnes/year)

	Source Type	1999	2004/05	2010
NO_x	Road	65,308 (67%)	43,155 (50%)	30,699 (48%)
	Non-road	31,462 (33%)	42,422 (50%)	32,714 (52%)
	Total	**96,770**	**85,577**	**63,413**
VOC	Road	42,144 (42%)	18,933 (24%)	10,454 (15%)
	Non-road	58,999 (58%)	59,045 (76%)	57,499 (85%)
	Total	**101,143**	**77,978**	**67,953**
PM_{10}	Road	3,073 (76%)	2,029 (68%)	1,084 (51%)
	Non-road	968 (24%)	968 (32%)	1,051 (49%)
	Total	**4,041**	**2,996**	**2,135**

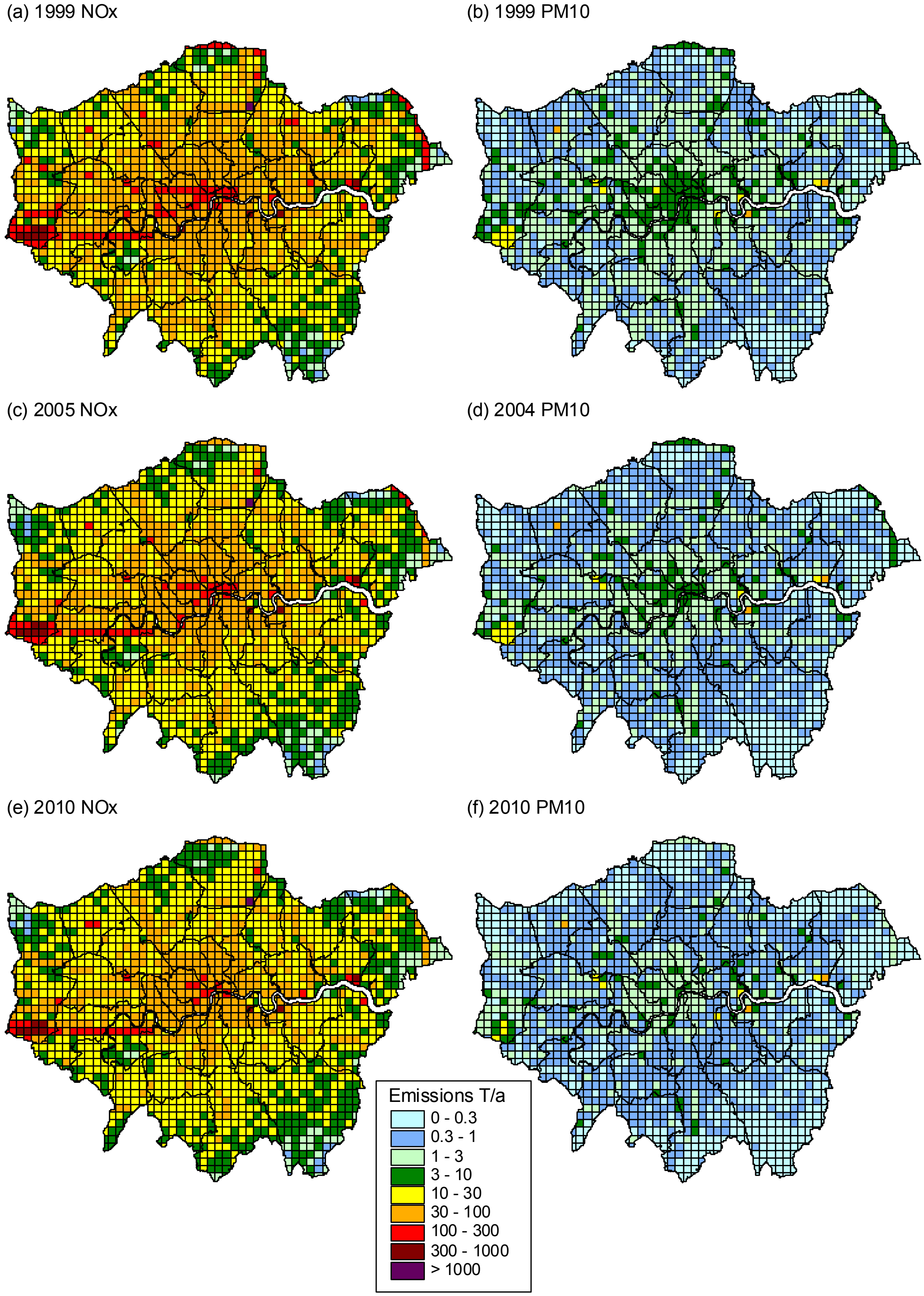
Table 3.3 Percentage reduction in emission totals from 1999 values

	Source Type	% decrease from 1999 to 2004/05	% decrease from 1999 to 2010
NO_x	Road	34	53
	Non-road	-35	-4
	Total	**12**	**34**
VOC	Road	61	75
	Non-road	0	3
	Total	**23**	**33**
PM_{10}	Road	34	65
	Non-road	0	-9
	Total	**26**	**47**

A large decrease in traffic emissions has been projected for the period 1999 to 2004/05, followed by a smaller decrease between 2005 to 2010. The non-road NO_x emission rates show an to increase between 1999 and 2005, then decrease again between 2005 and 2010. Whereas the VOC and PM_{10} emission rates due to non-road sources stay the same between 1999 and 2004/05, then the VOC levels slightly decrease by 2010 and PM_{10} levels increase.

The total emission rates of NO_x and PM_{10} are shown in Figures 3.1 and 3.2. In the Figures all emissions have been aggregated onto grid cells of 1x1km over the area bounded by the M25. The location of major roads and Heathrow airport can clearly be seen in the maps, isolated areas of high emissions indicate the position of industrial sources. The reduction in calculated emission rates from the year 1999 through 2004/05 to 2010 is highlighted by the Figures.

Figure 3.1 Total Emissions from the February Emissions Inventory



4. Model set-up

The modelling carried out in this report used the atmospheric dispersion model ADMS-Urban, version 1.7. A summary of this model and the methodology used for the base case scenario is provided in the validation and sensitivity report (Carruthers et al., 2003a). The following sections contain a summary of these data and details of input data where they have not previously been described in the validation report.

4.1 Methodology

Various parameters need to be set when using ADMS-Urban. The parameters are used to describe the modelled area, for example, the surface roughness characterises the surrounding area in terms of the effects it will have on wind speed and turbulence, which are key components of the modelling. The parameter values assumed in the modelling were chosen following a sensitivity analysis, which is described in full in the first topic report, Validation and Sensitivity. The analysis looked at the effect of varying surface roughness, area source grid depth, meteorological station and minimum Monin-Obukhov length. The values chosen as those most representative for the modelling area are given in Table 4.1.

It is not possible to model the whole of the Greater London area in one calculation at the highest spatial resolution using ADMS Urban. In order to achieve suitable resolution on the output maps, the modelled area needs to be split up into several calculation areas. To produce the maps presented in this report the Greater London area was split up into 23 sections of varying size. The central London areas were modelled with higher output resolution than the outer areas, as the number of explicitly defined roads in central London is higher and more detail can be modelled. Features in outer London have been modelled more crudely, for example, Heathrow airport has been modelled as an aggregated grid source, rather than modelling individual runways.

Additional calculations have been made at the 24 AURN locations within London. The Bromley AURN site is believed to be unrepresentative due to poor siting of the monitor and has therefore been omitted from this study

Table 4.1 Model parameter values

Parameter	Value
Surface roughness (m)	1
Roughness at meteorological site (m)	0.2
Minimum Monin-Obukhov length (m)	75
Meteorological data	Heathrow 1999
Initial mixing height of traffic pollution (m)	2
Area source grid depth (m)	75

4.2 Meteorology

Meteorological data representative of the study area is used to model air dispersion. In this report data from Heathrow Airport has been used from a typical meteorological year, which was chosen as 1999. This is located at (507700, 176700) at a height of 10m and has a roughness length of 0.2m.

Worst case meteorological years have also been modelled. The year 1996 was a year that experienced high concentrations of PM_{10}, therefore PM_{10} concentrations have also been modelled using Heathrow data from 1996 as a worst case scenario. Similarly 1997 experienced high NO_2 concentrations, so NO_2 concentrations have also been modelled using Heathrow data from 1997 as a worst case scenario. A comparison of the three meteorological data sets is given below. A summary of the three years of meteorological data is given in Table 4.2 and wind roses are shown in Figure 4.1.

Overall 1996 was the year with the highest wind speeds and also the coolest year. The wind rose for 1996 shows a large number of winds from the north-east, this is not typical of sites within the UK, which usually show a prevailing wind from the south-west, such as the wind rose for 1997 shows. 1999 had fewer than usual winds from the north-east, with more winds than usual from the south-west.

4.3 Background Concentrations

Hourly sequential background concentration data were included in the modelling to represent pollutants transported into the modelled area. Concentrations were derived from measured data adjusted to be appropriate to the meteorological year used in the calculation. Summaries of the different background values calculated are given in Table 4.3.

1999 Base Case Background Data

The method used to calculate 1999 background data for 1999 meteorology using measured data from Rochester, Harwell, Lullington Heath and Wicken Fen is described in the Validation and Sensitivity report (Carruthers et al., 2002a).

1999 Worst Case Background Data

Some of the modelling was carried out using meteorological data from worst case years. These are accepted to be 1996 for PM_{10} and 1997 for NO_x. Background data were calculated for PM_{10} in 1996 and NO_x in 1997 using the same method as for 1999 base case data referred to above. These background values were then projected forward to 1999 as described next.

Figure 4.1 Heathrow wind roses

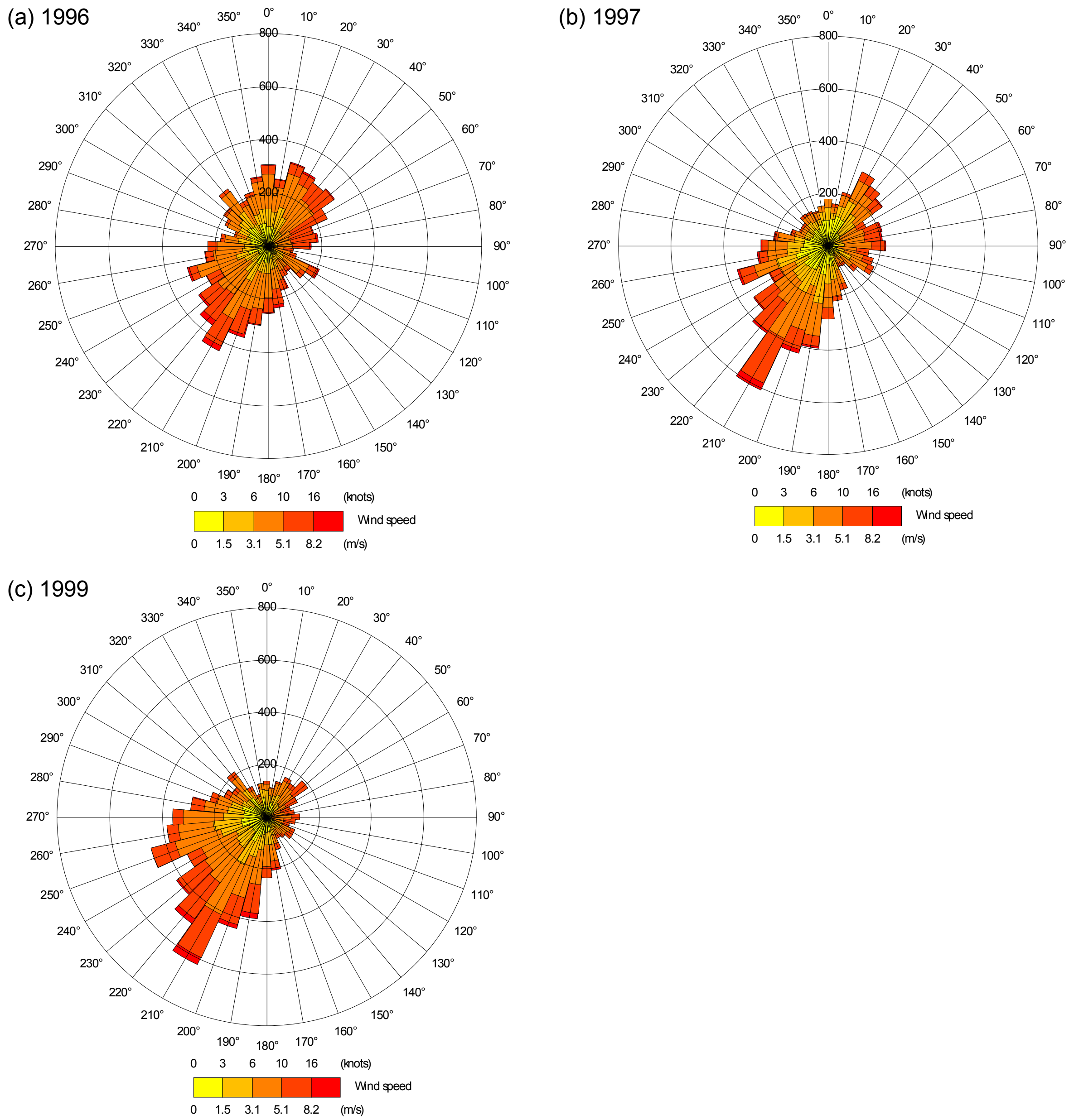


Table 4.2 Meteorological statistics

	1996			1997			1999		
Data Capture	99.2%			98.2%			99.8%		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Temperature (°C)	-5.0	10.5	31.1	-5.2	11.9	31.4	-4.6	11.8	32.7
Wind speed (m/s)	0	3.6	13.4	0	3.0	12.9	0	3.1	12.9
Cloud cover (oktas)	0	6	8	0	5	8	0	6	8

Table 4.3 1999 Background Concentrations for NO_x, NO_2, O_3 and PM_{10}

		1999 meteorology						Worst case meteorology					
		1999 emissions		2004/5 emissions		2010 emissions		1999 emissions		2004/5 emissions		2010 emissions	
		μg/m³	ppb	μg/m³	ppb	μg/m³	ppb	μg/m³	ppb	μg/m³	ppb	μg/m³	ppb
NO_x	Annual Average	19	10	15	8	13	7	23	12	19	10	15	8
	Maximum 1-hour average	342	179	287	150	241	126	306	160	256	134	216	113
	99.8 percentile	174	91	147	147	124	124	216	113	181	95	153	80
NO_2	Annual Average	13	7	11	6	10	5	17	9	15	8	13	7
	Maximum 1-hour average	94	49	53	28	50	26	82	43	76	40	71	37
	99.8 percentile	67	35	50	26	48	25	71	37	67	35	63	33
O_3	Annual Average	58	29	60	30	62	31	54	27	56	28	58	29
	Maximum 1-hour average	222	111	230	115	232	116	230	115	234	117	238	119
	99.8 percentile	174	87	174	87	176	88	172	86	176	88	180	90
PM_{10}	Annual Average	23.4	-	21.9	-	19.1	-	25.2	-	27.5	-	23.3	-
	Maximum 1-hour average	125.9	-	112.7	-	88.4	-	209.3	-	239.4	-	184.9	-
	90.4 percentile of 24-hour mean	35.1	-	32.2	-	26.9	-	39.1	-	43.6	-	35.6	-
	98.1 percentile of 24-hour mean	46.9	-	42.7	-	35.0	-	55.0	-	61.8	-	49.5	-

Table 4.4 Factors for projecting background data to future years

	1996 → 1999	1996 → 2004	1996 → 2010	1997 → 1999	1997 → 2005	1997 → 2010	1999 → 2004/5	1999 → 2010
NO_x	-	-	-	0.921	0.773	0.652	0.839	0.708
PM_{10}	0.644	0.741	0.565	-	-	-	0.886	0.677

Projection of Background Data to Future Years

Background NO_x and PM_{10} data for future years were estimated by multiplying measured data with factors obtained from NETCEN (John Stedman, Personal Communication). Relevant factors are given in Table 4.4. No factors were supplied for NO_2 or ozone.

NO_x-NO_2 correlations were derived to calculate background NO_2 data for future years. For both 1999 (base case) and 1997 (worst case) best fit curves were derived to relate NO_2 to NO_x. Assuming that the relationship between NO_x and NO_2 background concentrations remains constant for future years, base case and worst case background NO_2 values for 2005 and 2010 were determined from the calculated hourly base case and worst case NO_x values corresponding to each year.

Projected ozone concentrations were calculated by conserving total oxidant. That is, if the NO_2 concentration decreased by *x* ppb between the measured data year and the projected year, the ozone concentration for that hour was assumed to increase by *x* ppb.

5. Receptor Points Concentration for 1999 and Future Projection

The calculated concentrations for each modelled emission year with each meteorological set at the 23 automatic urban and rural network (AURN) receptor locations in London are given in Table 5.1 to 5.7. The concentration values that exceed the first objective are highlighted in bold text.

The majority of the AURN sites show a calculated exceedence of the annual average NO_2 objective (40µg/m^3) for all modelled emission years, with both the base and the worst case meteorology. The calculated 99.8th percentiles of hourly average NO_2 concentration do not exceed the AQS standard (200µg/m^3) by the objective year of 2005, except at Marylebone Road. By 2010, the EU target year, there are no exceedences predicted.

Marylebone Road is the only AURN site with a modelled annual average PM_{10} value that exceeds both AQS 2004 objectives in 1999 and 2004, with base case meteorology and worst case meteorology. However, for the base case scenario, all sites show exceedences of the 2010 London annual average 23µg/m^3 objective for the years 1999 and 2004, reducing to just two sites by 2010. No sites exceed the London percentile objective by 2010. With worst case meteorology all of the sites are modelled to exceed both London objectives by 2010. All sites breach the EU 20µg/m^3 annual average objective in all years with base case and worst case meteorology.

Higher worst case PM_{10} concentrations are partly due to the background contribution, which is higher when using the worst case meteorological year compared to using base meteorology. This is due to the NETCEN factors used to project 1996 background data forward (Section 4.3).

Table 5.1 Annual Average NO_x concentration ($\mu g/m^3$)

		1999 Monitored	1999 meteorology: 1999 emissions	1999 meteorology: 2005 emissions	1999 meteorology: 2010 emissions	1997 worst case meteorology: 1999 emissions	1997 worst case meteorology: 2005 emissions	1997 worst case meteorology: 2010 emissions
Roadside Monitoring Sites	A3	256	227	138	105	237	143	113
	Camden	210	204	143	117	210	151	122
	Cromwell Road	256	260	193	141	277	202	155
	Haringey	136	115	84	71	120	88	78
	Hounslow	191	132	88	69	138	94	76
	Marylebone Road	390	386	290	220	390	288	227
	Southwark Roadside	227	183	132	107	206	151	122
	Sutton Roadside	117	76	57	46	88	65	53
	Tower Hamlets	241	193	138	113	195	139	115
Background Monitoring Sites	Bexley	69	78	61	52	73	55	50
	Bloomsbury	136	120	96	78	124	109	84
	Brent	67	76	57	50	84	63	55
	Bridge Place	105	111	90	71	111	88	74
	Eltham	65	86	67	55	80	61	53
	Hackney	134	113	84	71	118	88	76
	Hillingdon	166	206	132	101	193	126	99
	Lewisham	139	117	86	71	120	88	74
	North Kensington	82	99	76	65	107	84	73
	Southwark Urban Centre	118	99	80	67	99	78	69
	Sutton Suburban	65	67	52	42	73	55	48
	Teddington	52	59	48	40	65	52	44
	Wandsworth	141	128	94	76	136	101	82
	West London	99	92	71	61	97	76	67

Table 5.2 Annual Average NO_2 concentration ($\mu g/m^3$), exceeding values are in bold

			1999 meteorology			1997 worst case meteorology		
		1999 Monitored	1999 emissions	2005 emissions	2010 emissions	1999 emissions	2005 emissions	2010 emissions
Roadside Monitoring Sites	A3	**58**	**67**	**55**	**48**	**69**	**57**	**52**
	Camden	**66**	**71**	**61**	**55**	**71**	**61**	**55**
	Cromwell Road	**93**	**76**	**69**	**59**	**78**	**69**	**61**
	Haringey	**51**	**55**	**48**	**42**	**57**	**48**	**46**
	Hounslow	**60**	**53**	**44**	**40**	**55**	**46**	**42**
	Marylebone Road	**91**	**88**	**78**	**71**	**86**	**78**	**71**
	Southwark roadside	**75**	**67**	**59**	**52**	**71**	**61**	**57**
	Sutton roadside	**44**	**42**	34	29	**44**	38	32
	Tower Hamlets	**70**	**71**	**61**	**55**	**71**	**61**	**55**
	Roadside sites ≥ 40$\mu g/m^3$	***9***	***9***	***8***	***8***	***9***	***8***	***8***
Background Monitoring Sites	Bexley	37	**40**	34	31	38	32	31
	Bloomsbury	**67**	**57**	**52**	**46**	**57**	**53**	**48**
	Brent	37	**44**	38	32	46	38	34
	Bridge Place	**63**	**53**	**48**	**42**	**53**	**46**	**42**
	Eltham suburban	36	**44**	36	32	**42**	36	32
	Hackney	**60**	**55**	**48**	**42**	**55**	**48**	**44**
	Hillingdon	**50**	**63**	**55**	**48**	**63**	**53**	**48**
	Lewisham	**54**	**55**	**46**	**42**	**55**	**48**	**44**
	North Kensington	**46**	**52**	**44**	**40**	**53**	**46**	**42**
	Southwark urban centre	**56**	**50**	**44**	38	**50**	**44**	**40**
	Sutton suburban	35	38	32	27	**40**	34	31
	Teddington	32	34	29	25	36	32	29
	Wandsworth	**52**	**59**	**50**	**44**	**59**	**52**	**46**
	West London	**55**	**50**	**42**	38	**50**	**44**	**40**
	Backg. sites ≥ 40$\mu g/m3$	***9***	***12***	***9***	***7***	***11***	***9***	***9***
	Total sites ≥ 40$\mu g/m3$	***18***	***21***	***17***	***15***	***20***	***17***	***17***

Table 5.3 99.8 percentile NO_2 concentration ($\mu g/m^3$), equivalent to 18 1-hour exceedences, exceeding values are in bold

			1999 meteorology			1997 worst case meteorology		
		1999 Monitored	1999 emissions	2005 emissions	2010 emissions	1999 emissions	2005 emissions	2010 emissions
Roadside Monitoring Sites	A3	178	197	160	143	199	164	149
	Camden	180	**239**	195	178	**241**	189	172
	Cromwell Road	**197**	**233**	185	174	**235**	189	168
	Haringey	147	**204**	166	157	**216**	178	160
	Hounslow	147	180	153	141	178	151	136
	Marylebone Road	**229**	**250**	**204**	191	**254**	**210**	189
	Southwark roadside	176	**212**	180	157	**204**	170	159
	Sutton roadside	122	170	141	128	174	149	134
	Tower Hamlets	181	**233**	195	178	**233**	193	176
	Roadside sites ≥ 200μg/m³	***2***	***6***	***1***	***0***	***6***	***1***	***0***
Background Monitoring Sites	Bexley	117	**229**	193	172	191	162	151
	Bloomsbury	189	**218**	185	172	**208**	178	160
	Brent	130	185	157	143	178	151	139
	Bridge Place	151	**206**	172	157	183	160	151
	Eltham suburban	124	**231**	191	176	181	155	141
	Hackney	189	197	168	155	**216**	181	162
	Hillingdon	136	**220**	180	168	195	168	153
	Lewisham	132	**210**	172	159	174	149	138
	North Kensington	139	185	159	151	178	159	147
	Southwark urban centre	147	**218**	183	168	189	164	151
	Sutton suburban	111	166	139	130	162	139	126
	Teddington	111	157	141	132	155	134	122
	Wandsworth	147	191	162	147	181	159	143
	West London	143	183	155	143	174	151	138
	Backg. sites ≥ 200μg/m³	***0***	***7***	***0***	***0***	***2***	***0***	***0***
	Total sites ≥ 200μg/m³	***2***	***13***	***1***	***0***	***8***	***1***	***0***

Table 5.4 Annual average O_3 concentration ($\mu g/m^3$)

			1999 meteorology			1997 worst NO_2 case meteorology		
		1999 Monitored	1999 emissions	2005 emissions	2010 emissions	1999 emissions	2005 emissions	2010 emissions
Roadside Monitoring Sites	A3	-	14	22	26	12	20	24
	Camden	-	12	16	20	12	16	20
	Cromwell Road	-	10	12	18	8	12	16
	Haringey	-	22	28	32	20	26	28
	Hounslow	-	24	30	34	22	28	32
	Marylebone Road	14	6	8	10	6	8	10
	Southwark roadside	-	12	16	20	12	16	20
	Sutton roadside	-	34	40	44	30	36	40
	Tower Hamlets	-	12	18	22	12	18	22
Background Monitoring Sites	Bexley	40	36	40	42	36	40	42
	Bloomsbury	24	22	26	30	20	24	28
	Brent	40	32	36	40	30	34	38
	Bridge Place	34	26	30	34	24	28	32
	Eltham suburban	40	34	40	42	32	38	40
	Hackney	30	24	30	32	22	28	30
	Hillingdon	26	16	22	28	16	22	26
	Lewisham	20	22	28	32	20	26	30
	North Kensington	36	26	30	34	24	28	32
	Southwark urban centre	30	28	34	36	28	32	34
	Sutton suburban	36	36	42	44	34	40	42
	Teddington	44	40	44	48	36	40	44
	Wandsworth	28	20	26	30	18	24	28
	West London	-	28	32	36	26	30	34

Table 5.5 Annual Average PM_{10} concentration (μg/m³), exceeding values are in bold

			1999 meteorology			1996 worst case meteorology		
		1999 Monitored	**1999 emissions**	**2004 emissions**	**2010 emissions**	**1999 emissions**	**2004 emissions**	**2010 emissions**
Roadside Monitoring	A3	30	31	27	22	31	31	26
	Camden	34	33	28	23	33	32	26
	Haringey	28	29	25	21	29	30	25
	Marylebone Road	**44**	**49**	37	28	**46**	**40**	30
	Sutton roadside	26	26	24	20	28	29	24
	Roadside sites ≥ 40μg/m³	***1***	***1***	***0***	***0***	***1***	***1***	***0***
Background Monitoring Sites	Bexley	25	26	24	20	27	29	24
	Bloomsbury	28	29	25	21	29	30	25
	Brent	23	26	24	20	27	29	24
	Eltham	23	27	24	21	27	29	24
	Hillingdon	27	29	26	21	29	30	25
	North Kensington	27	27	24	21	28	29	25
	Backg. sites ≥ 40μg/m³	***0***	***0***	***0***	***0***	***0***	***0***	***0***
	2004 AQS Objective Total sites ≥ 40μg/m³	***1***	***1***	***0***	***0***	***1***	***1***	***0***
	2010 AQS Objective Total sites ≥ 23μg/m³	***10***	***11***	***11***	***2***	***11***	***11***	***11***
	2010 EU Objective Total sites ≥ 20μg/m³	***11***	***11***	***11***	***11***	***11***	***11***	***11***

Table 5.6 90.4 percentile PM_{10} concentration ($\mu g/m^3$), equivalent to 35 24-hour exceedences, exceeding values are in bold

			1999 meteorology			1996 worst case meteorology		
		1999 Monitored	**1999 emissions**	**2004 emissions**	**2010 emissions**	**1999 emissions**	**2004 emissions**	**2010 emissions**
Roadside Monitoring	A3	46	43	37	30	46	48	39
	Camden	49	47	38	31	47	48	39
	Haringey	42	40	36	30	44	47	38
	Marylebone Road	**65**	**67**	**50**	37	**66**	**58**	43
	Sutton roadside	40	38	34	28	42	46	37
	Roadside sites ≥ 50µg/m³	***1***	***1***	***1***	***0***	***1***	***1***	***0***
Background Monitoring Sites	Bexley	41	37	34	28	41	45	37
	Bloomsbury	42	40	35	29	44	47	38
	Brent	37	38	34	28	42	46	37
	Eltham suburban	35	38	34	28	41	45	37
	Hillingdon	41	41	36	29	45	47	38
	North Kensington	41	39	35	29	43	46	38
	Backg. sites ≥ 50µg/m³	***0***	***0***	***0***	***0***	***0***	***0***	***0***
	Total sites ≥ 50µg/m³	***1***	***1***	***1***	***0***	***1***	***1***	***0***

Table 5.7 97.2 percentile PM_{10} concentration ($\mu g/m^3$), equivalent to 10 24-hour exceedences, exceeding values are in bold

			1999 meteorology			1996 worst case meteorology		
		1999 Monitored	**1999 emissions**	**2004 emissions**	**2010 emissions**	**1999 emissions**	**2004 emissions**	**2010 emissions**
Roadside Monitoring	A3	**54**	**55**	48	38	**62**	**66**	**52**
	Camden	**64**	**60**	48	38	**64**	**65**	**52**
	Haringey	**58**	**51**	45	37	**58**	**64**	**51**
	Marylebone Road	**105**	**80**	**60**	43	**83**	**75**	**57**
	Sutton roadside	47	48	42	34	**59**	**64**	**51**
	Roadside sites ≥ 50μg/m³	***4***	***4***	***1***	***0***	***5***	***5***	***5***
Background Monitoring Sites	Bexley	**59**	46	42	34	**57**	**63**	**50**
	Bloomsbury	**55**	**52**	45	37	**60**	**65**	**51**
	Brent	45	49	44	36	**56**	**62**	**50**
	Eltham suburban	47	47	42	34	**57**	**63**	**51**
	Hillingdon	**54**	**53**	47	38	**58**	**64**	**51**
	North Kensington	**55**	**51**	45	37	**58**	**64**	**51**
	Backg. sites ≥ 50μg/m³	***4***	***3***	***0***	***0***	***6***	***6***	***6***
	Total sites ≥ 50μg/m³	***8***	***7***	***1***	***0***	***11***	***11***	***11***

6. Contour Maps

6.1 Discussion of Contour Maps

The contour maps of NO_2 and PM_{10} concentration modelled using ADMS-Urban over the Greater London area are presented in this section. The contour colour varies from blues and greens through yellow to reds and purples indicating increasing pollutant concentration. For NO_2 and PM_{10} maps, which have associated air quality objectives, the yellow contour has been designated to indicate concentrations exceeding the standard.

The area where concentrations of NO_2 and PM_{10} exceed a range of threshold values has been calculated. These are summarised in Table 6.1 as percentages of the total 1,573km^2 within the boundaries. Where the percentage differs from the base case, the value for the worst case meteorological conditions is given in brackets for PM_{10}.

Table 6.1 The percentage area exceeding concentration thresholds for the modelled concentration (C_m). For PM_{10} predictions using worst case meteorological conditions are given in brackets.

		Threshold (µg/m^3)	1999	2004/5	2010
NO_2	Annual average	$NO_2 > 30$	99	90	71
		$NO_2 > 40$	68	32	13
		$NO_2 > 50$	17	4	1
	99.8 percentile 1-hour average	$NO_2 > 200$	37	3	0
PM_{10}	Annual average	$PM_{10} > 20$	100	100	75 (100)
		$PM_{10} > 23$	100	91	0.4 (100)
		$PM_{10} > 25$	100	0	0 (93)
		$PM_{10} > 40$	0	0	0
	98.1 percentile of 24-hour average	$PM_{10} > 50$	51	0.6	0 (100)
	90.4 percentile 24-hour average	$PM_{10} > 50$	0.6	0	0

Annual Average NO_x

Fig 6.1 London 1999, annual average NO_x (1999 meteorology)
Fig 6.2 London 2005, annual average NO_x (1999 meteorology)
Fig 6.3 London 2010, annual average NO_x (1999 meteorology)

The 1999 annual average NO_x map shows how the concentration of NO_x varies across the modelled area. The highest contours are clearly associated with central London, the busiest roads and Heathrow airport. In the centre of London, approximately the area of the congestion charging zone, the concentration is above 100µg/m^3 everywhere. There are no air quality standards for this pollutant, however, so the map cannot show areas of exceedence. The maps modelled for 2005 and 2010 show that the areas of high concentration are predicted to reduce in area with time.

Annual Average NO_2

Fig 6.4 London 1999, annual average NO_2 (1999 meteorology)
Fig 6.5 London 2005, annual average NO_2 (1999 meteorology)
Fig 6.6 London 2010, annual average NO_2 (1999 meteorology)

The 1999 annual average NO_2 map shows how the concentration of NO_2 varies across the modelled area. Again, the highest contours are clearly associated with the busiest roads and Heathrow airport. In addition to the major roads, the central and inner part of London, approximately 5km around the inner ring road, plus the Heathrow Airport area, exceed the air quality threshold of 40µg/m^3 (68% of the total area, from Table 6.1). In the central region, approximately the area of the congestion charging zone, the concentration is above 52µg/m^3. The area of exceedence approximately halves between 1999 and 2005, the objective year, (32%) and again by 2010 (13%). As well as the remaining area of exceedence predicted for 2010, there are a few areas of high concentration associated with the busiest central roads and Heathrow airport.

99.8 Percentile NO_2 (equivalent to 18 exceedences)

Fig 6.7 London 1999, 99.8 percentile of 1-hour average NO_2 (1999 meteorology)
Fig 6.8 London 2005, 99.8 percentile of 1-hour average NO_2 (1999 meteorology)
Fig 6.9 London 2010, 99.8 percentile of 1-hour average NO_2 (1999 meteorology)

The 99.8 percentile NO_2 maps show contours of the concentration value that is exceeded 18 times by 1-hour values (0.2% of the hours in the year). It is assumed that if this value is over the threshold, 200µg/m^3, then the air quality objective will be exceeded at that location. The 1999 map shows a strong bias of exceedence in the Northeast to Southeast segment. It is possible that these high peak concentrations are associated with the hours for which the wind direction determines the Rochester background data are used. Rochester has the highest percentile values of the four background sites and would be exacerbated by various large industrial emissions sources in the East Thames corridor which are outside the modelled area but included as sources in the model. This area of exceedence greatly reduces from 37% in 1999 to 3% in 2005 and to negligible amounts in 2010.

Annual Average O_3

Fig 6.10 London 1999, annual average O_3 (1999 meteorology)
Fig 6.11 London 2005, annual average O_3 (1999 meteorology)
Fig 6.12 London 2010, annual average O_3 (1999 meteorology)

The ozone maps clearly show a reduction of the available ozone in the high NO_x emissions areas. This is due to the uptake of ozone by NO to produce NO_2. As the NO_x emissions reduce with distance and time the ozone levels increase.

NO_2/NO_x Ratio

Fig 6.13 London 1999, annual average NO_2/NO_x (1999 meteorology)
Fig 6.14 London 2005, annual average NO_2/NO_x (1999 meteorology)
Fig 6.15 London 2010, annual average NO_2/NO_x (1999 meteorology)

This series of maps shows how the annual average NO_2/NO_x ratio varies across London. The ratio tends to be low in areas of high NO_x emissions such as busy roads, i.e. a high proportion of the NO_x is NO. These areas are also associated with high NO_2 concentrations. The NO_x emissions contain a high proportion of NO, some of which reacts with the available ozone to form high levels of NO_2, however the amount of NO that can react is limited by the ozone availability. Where the NO_x emission is lower there is also less NO emitted. A higher proportion of the emitted NO can react with available ozone to produce NO_2, although the result is still less NO_2 than at the areas of high emissions. This effect is also seen in the maps for future years where the NO_x emissions reduce with time. The ratio increases with time, from 1999 to 2005 and then further to 2010.

Annual Average PM_{10}

Fig 6.16 London 1999, annual average PM_{10} (1999 meteorology)
Fig 6.17 London 2004, annual average PM_{10} (1999 meteorology)
Fig 6.18 London 2010, annual average PM_{10} (1999 meteorology)
Fig 6.19 London 2010 worst case, annual average PM_{10} (1996 meteorology)

The yellow contour has been assigned to the more stringent 23μg/m^3 threshold for the annual average PM_{10} maps. The whole modelled area for 1999 exceeds this value. The less stringent 40μg/m^3 threshold is only exceeded over a negligible area in 1999 and not at all in future years. By 2005 there are some of the outer London areas, 9% of the total area, that do not exceed the more stringent threshold and by 2010 less than 1% of the total area exceeds the threshold. 75% of the area in Greater London is over 20μg/m^3, the standard for the rest of the UK outside Scotland.

If the 2010 scenario is modelled using worst met case conditions the whole of the area exceeds the 23μg/m^3 threshold.

90.4 Percentile PM_{10} (equivalent to 35 exceedences)

Fig 6.20 London 1999, 90.4 percentile of 24-hour average PM_{10} (1999 meteorology)
Fig 6.21 London 2004, 90.4 percentile of 24-hour average PM_{10} (1999 meteorology)
Fig 6.22 London 2010, 90.4 percentile of 24-hour average PM_{10} (1999 meteorology)

In the 1999 90.4 percentile PM_{10} map there is a small area, less than 1% of the total, that exceeds the 50μg/m^3 standard. This reduces to no exceedence in future years.

98.1 Percentile PM_{10} (equivalent to 7 exceedences)

Fig 6.23 London 1999, 98.1 percentile of 24-hour average PM_{10} (1999 meteorology)
Fig 6.24 London 2004, 98.1 percentile of 24-hour average PM_{10} (1999 meteorology)
Fig 6.25 London 2010, 98.1 percentile of 24-hour average PM_{10} (1999 meteorology)
Fig 6.26 London 2010 worst case, 98.1 percentile of 24-hour average PM_{10} (1996 meteorology)

The 98.1 percentile PM_{10} maps show contours of the concentration value that is exceeded 7 times by 24-hour values (1.9% of the days in the year). The 1999 map shows approximately half of the total area exceeding the 50μg/m^3 standard. These high peak concentrations appears to be caused mainly by wind directions ranging from easterly to southerly. The exceedences are almost negligible by 2005 and there are none by 2010.

The 2010 map modelled with worst case meteorological conditions does exceed over 93% of the complete modelled area.

97.2 Percentile PM_{10} (equivalent to 10 exceedences)

Fig 6.27 London 2010, 97.2 percentile of 24-hour average PM_{10} (1999 meteorology)
Fig 6.28 London 2010 worst case, 97.2 percentile of 24-hour average PM_{10} (1996 meteorology)

For 2010 a PM_{10} map was produced for the 97.2 percentile which shows contours of the concentration value that is exceeded 10 times by 24-hour values (2.8% of the days in the year). This is the standard that will apply to London in 2010. There are no exceedences of the 50μg/m^3 standard threshold. However, in worst case meteorological conditions there is significant exceedence of the same threshold (36%).

6.2 Uncertainty

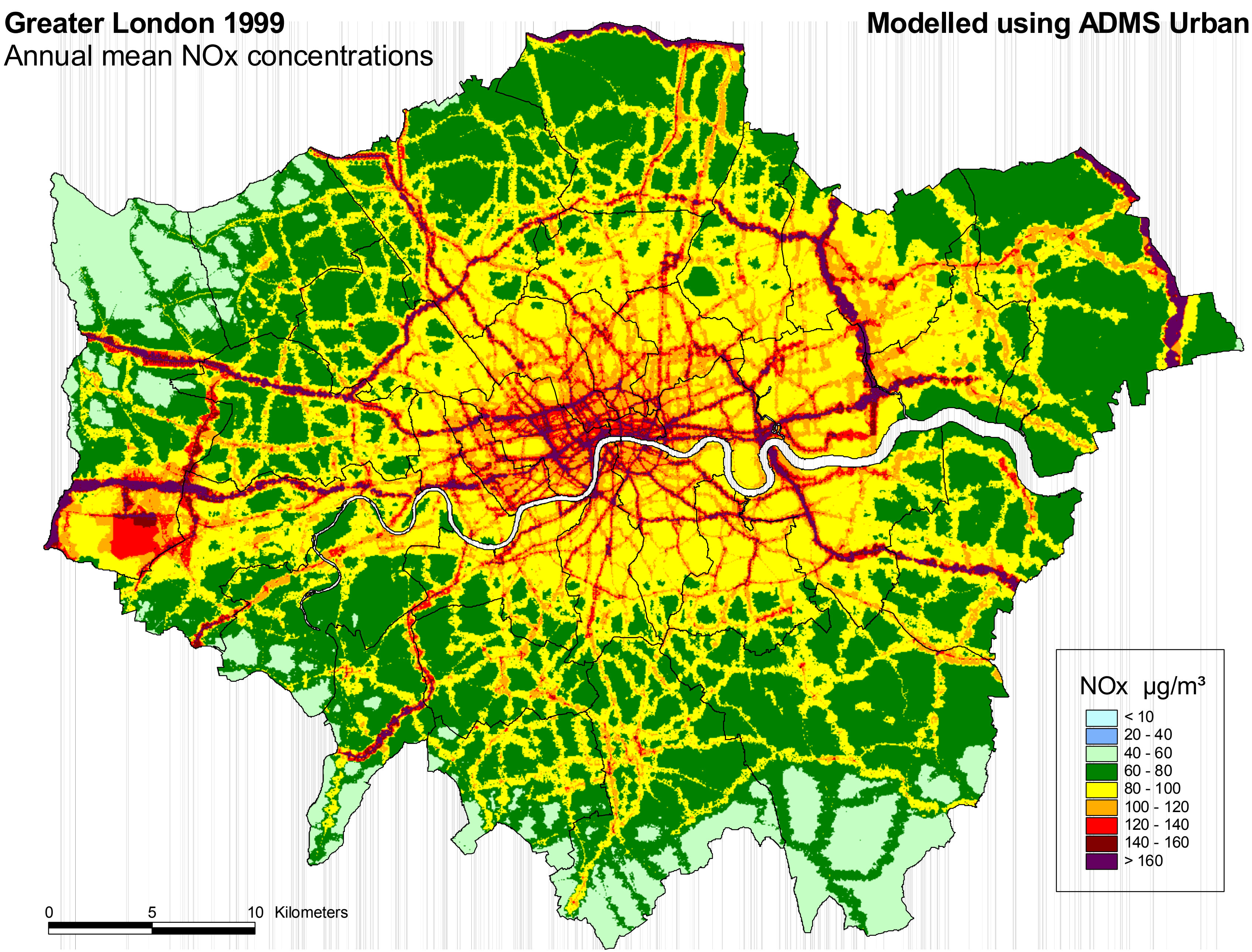
Uncertainty in the modelled calculation leads to uncertainty in the area exceeding annual mean standards for NO_2 and PM_{10} maps. In order to give an indication of the extent of this uncertainty, the annual average maps were analysed to determine the area predicted to exceed certain threshold values for the predicted value ± 5%.

The results are presented in Table 6.2 in terms of percentage of area exceeding a range of threshold values, which in the case of NO_2 and PM_{10}, include the 2004, 2005 and 2010 annual average air quality objectives. Where they differ from the base case, the values for the worst case meteorological conditions given in brackets for PM_{10}.

It can be seen that the estimated 5% uncertainty in concentration has limited impact on the area exceeding the NO_2 annual mean standard (40 μg/m^3). For PM_{10} in some cases, notably the 23 μg/m^3 standard in 2004 and the 20 μg/m^3 standard in 2010, the uncertainty greatly impacts on the area exceeding the standard.

Table 6.2 The percentage area exceeding concentration thresholds for the modelled concentration (C_m) and for C_m±5% (estimated overall uncertainty in annual average NO_2 and PM_{10} concentrations = 5%), the range of percentages represents the uncertainty. Predictions using worst case meteorological conditions given in brackets.

	1999			2004/5			2010		
Threshold (μg/m^3)	C_m -5%	C_m	C_m +5%	C_m -5%	C_m	C_m +5%	C_m -5%	C_m	C_m +5%
NO_2 > 30	97	99	99	84	90	94	59	71	82
NO_2 > 40	**56**	**68**	**79**	**22**	**32**	**43**	**8**	**13**	**20**
NO_2 > 50	10	17	25	2	4	7	0	1	2
PM_{10} > 20	**100**	**100**	**100**	**100**	**100**	**100**	**8 (100)**	**75 (100)**	**100 (100)**
PM_{10} > 23	**100**	**100**	**100**	**18**	**91**	**100**	**0 (64)**	**0.4 (100)**	**1.6 (100)**
PM_{10} > 25	38	100	100	0	0	0	0 (5)	0 (93)	0 (100)
PM_{10} > 40	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**



Greater London 1999
Annual mean NOx concentrations
Modelled using ADMS Urban
NOx µg/m³
< 10
20 - 40
40 - 60
60 - 80
80 - 100
100 - 120
120 - 140
140 - 160
> 160
0
5
10 Kilometers

FIGURE 6.1

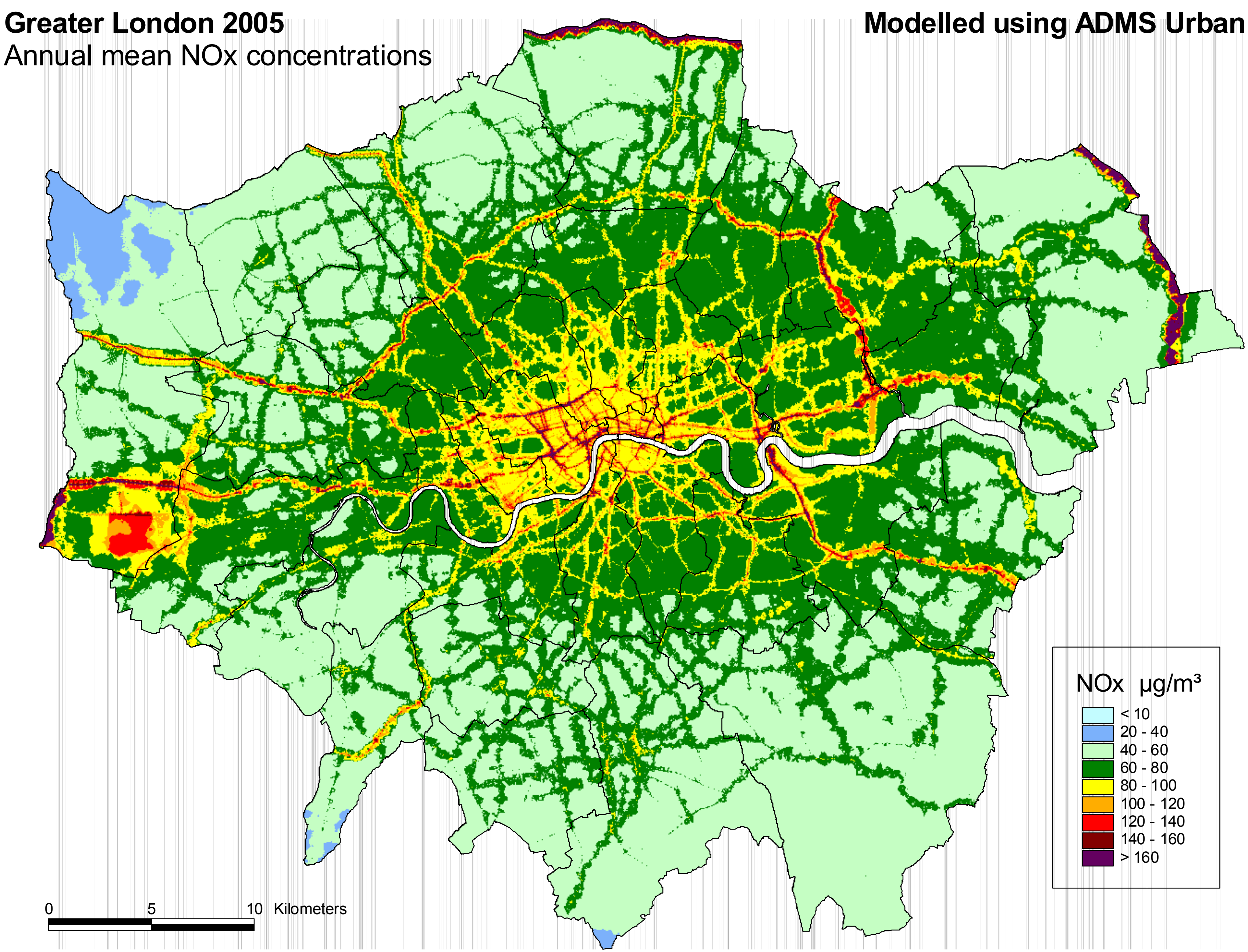

Greater London 2005
Annual mean NOx concentrations
Modelled using ADMS Urban
NOx µg/m³
< 10
20 - 40
40 - 60
60 - 80
80 - 100
100 - 120
120 - 140
140 - 160
> 160
0
5
10 Kilometers

FIGURE 6.2

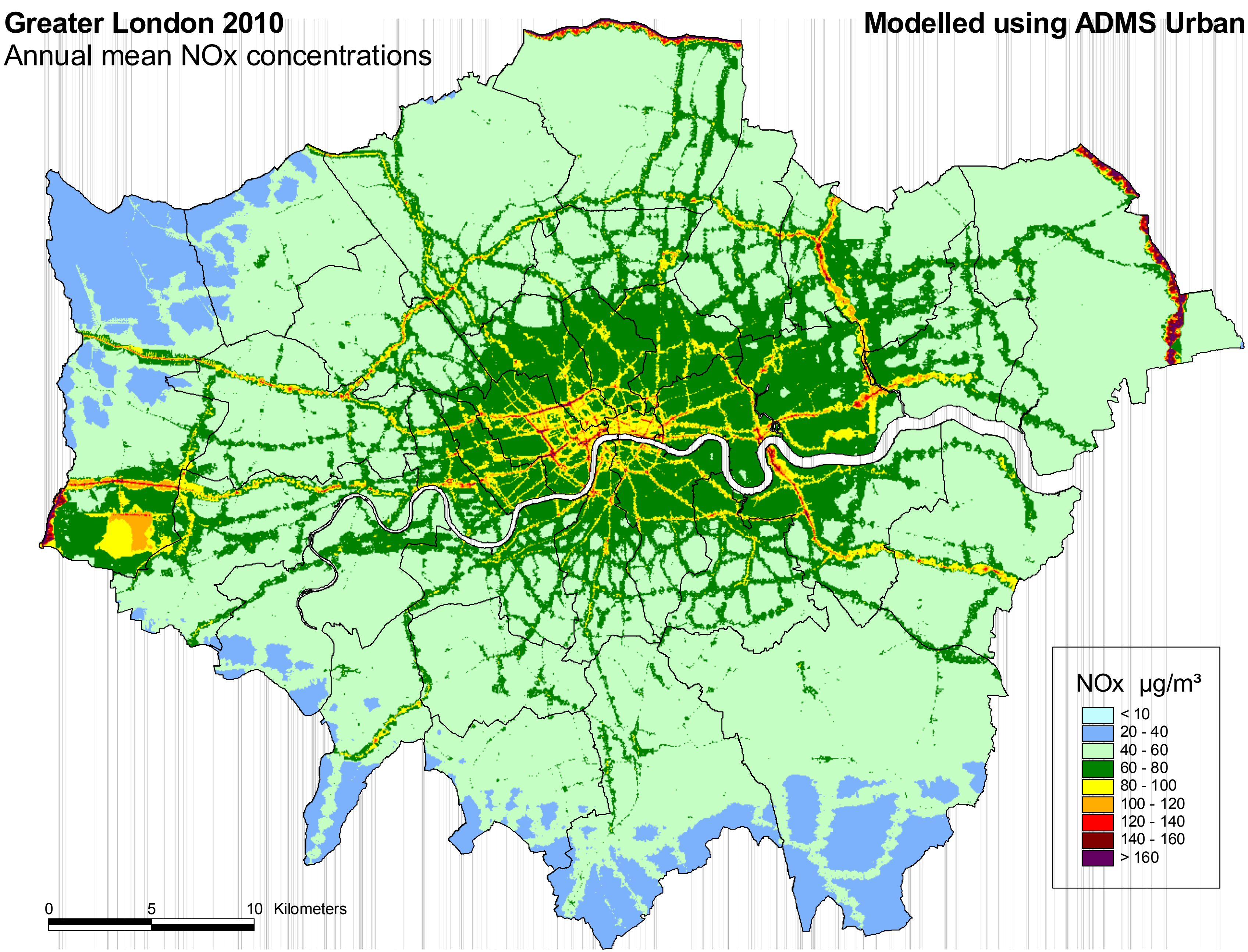

Greater London 2010
Annual mean NOx concentrations
Modelled using ADMS Urban
NOx µg/m³
< 10
20 - 40
40 - 60
60 - 80
80 - 100
100 - 120
120 - 140
140 - 160
> 160
0
5
10 Kilometers

FIGURE 6.3

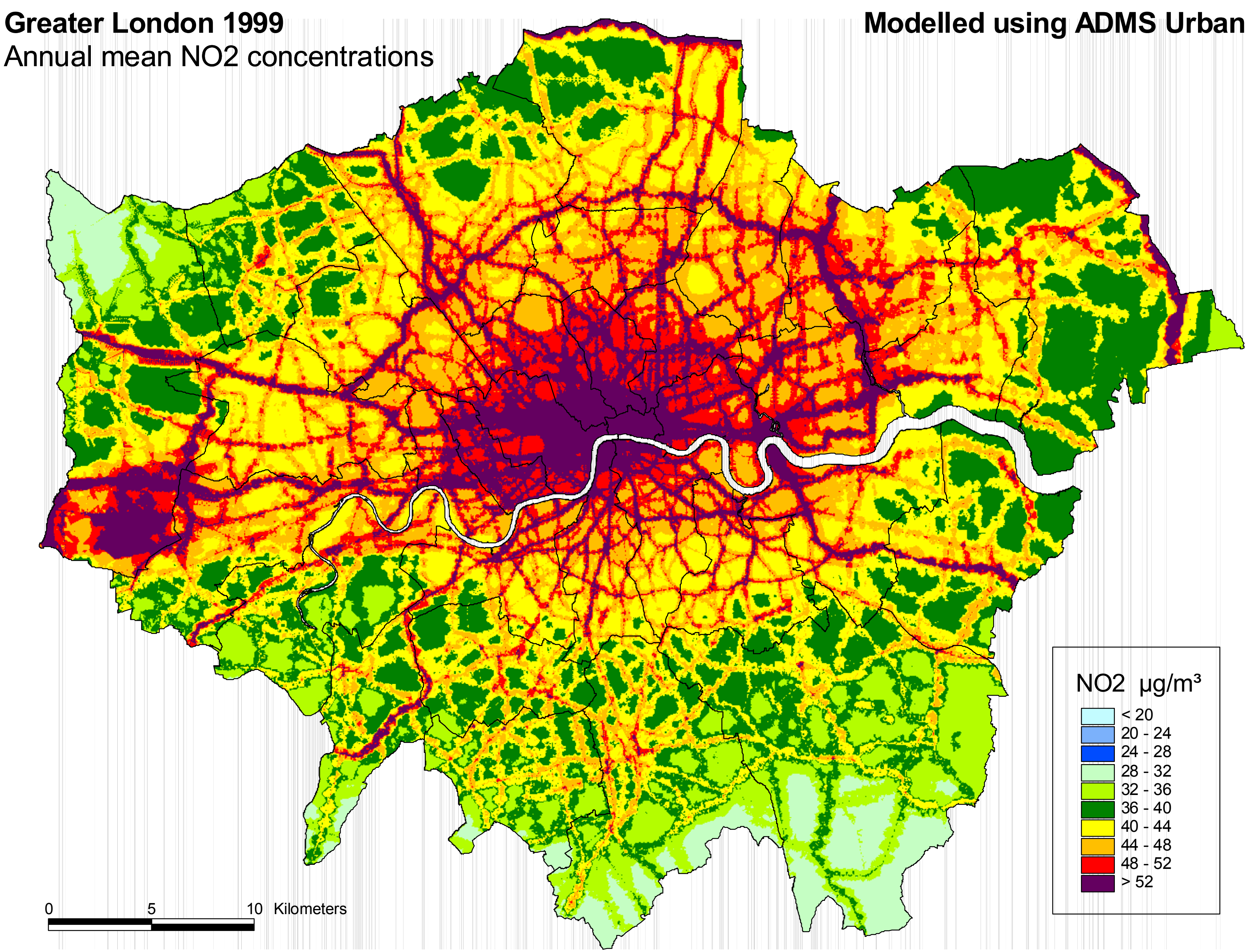

Greater London 1999
Annual mean NO2 concentrations
Modelled using ADMS Urban
NO2 µg/m³
< 20
20 - 24
24 - 28
28 - 32
32 - 36
36 - 40
40 - 44
44 - 48
48 - 52
> 52
0
5
10 Kilometers

FIGURE 6.4

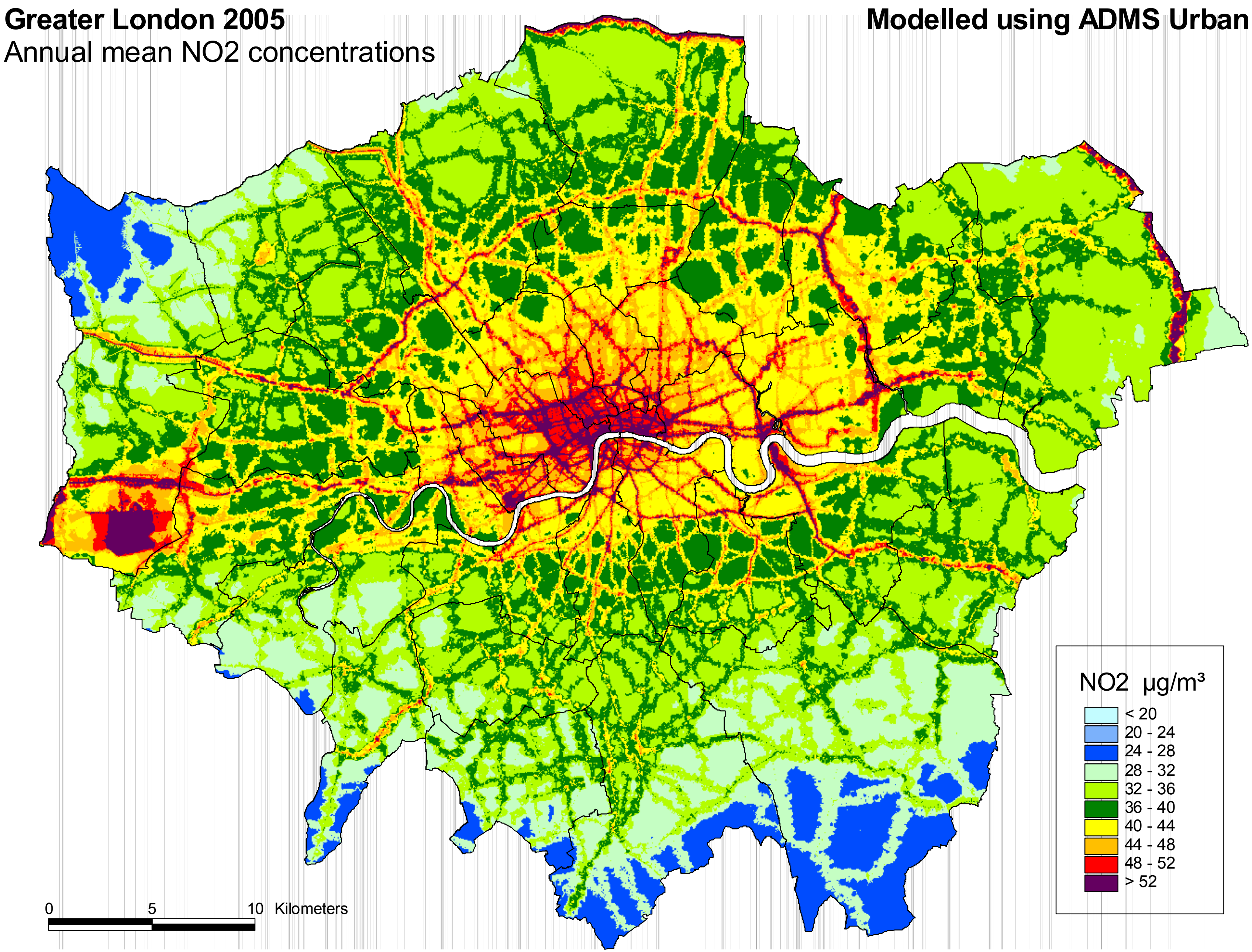
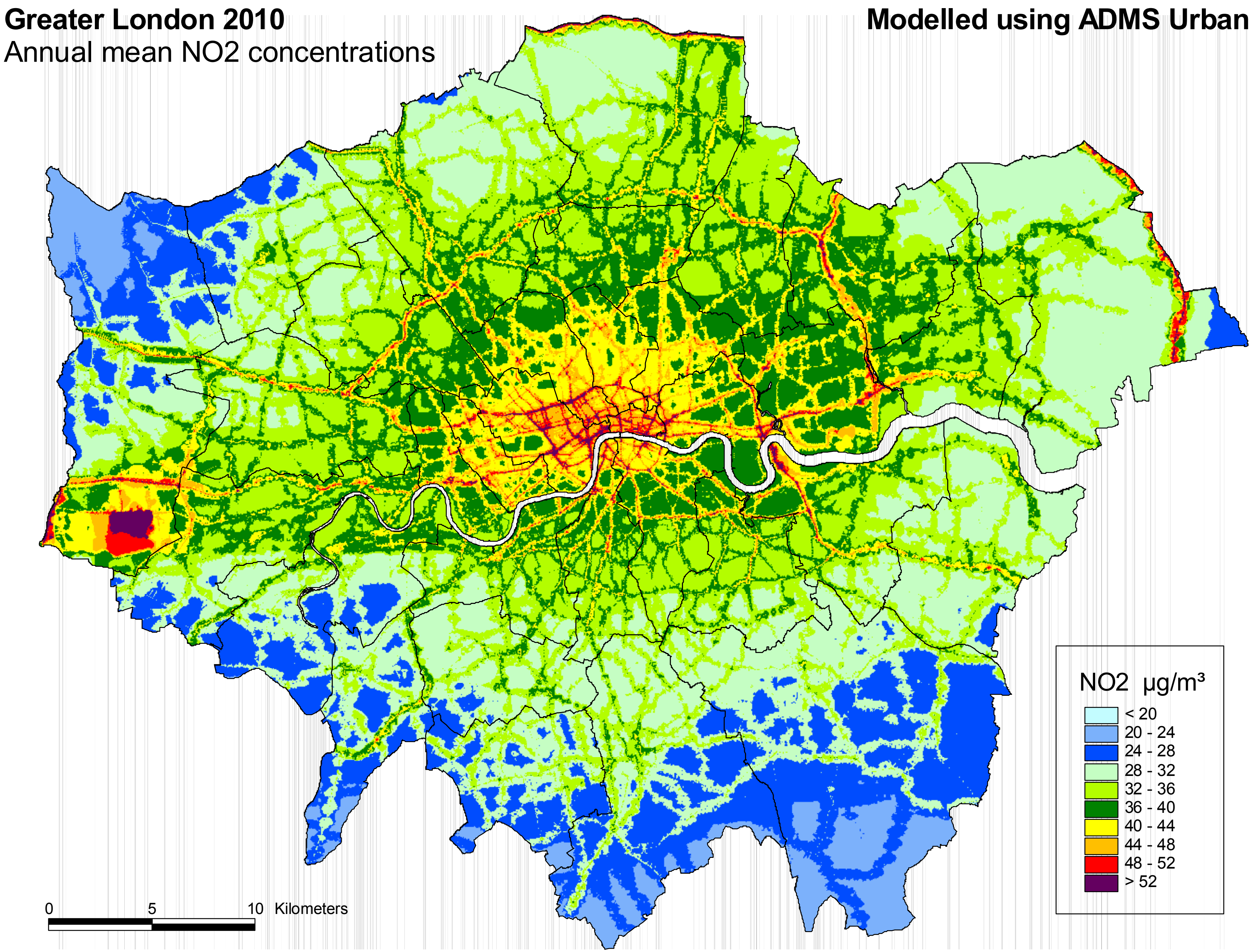
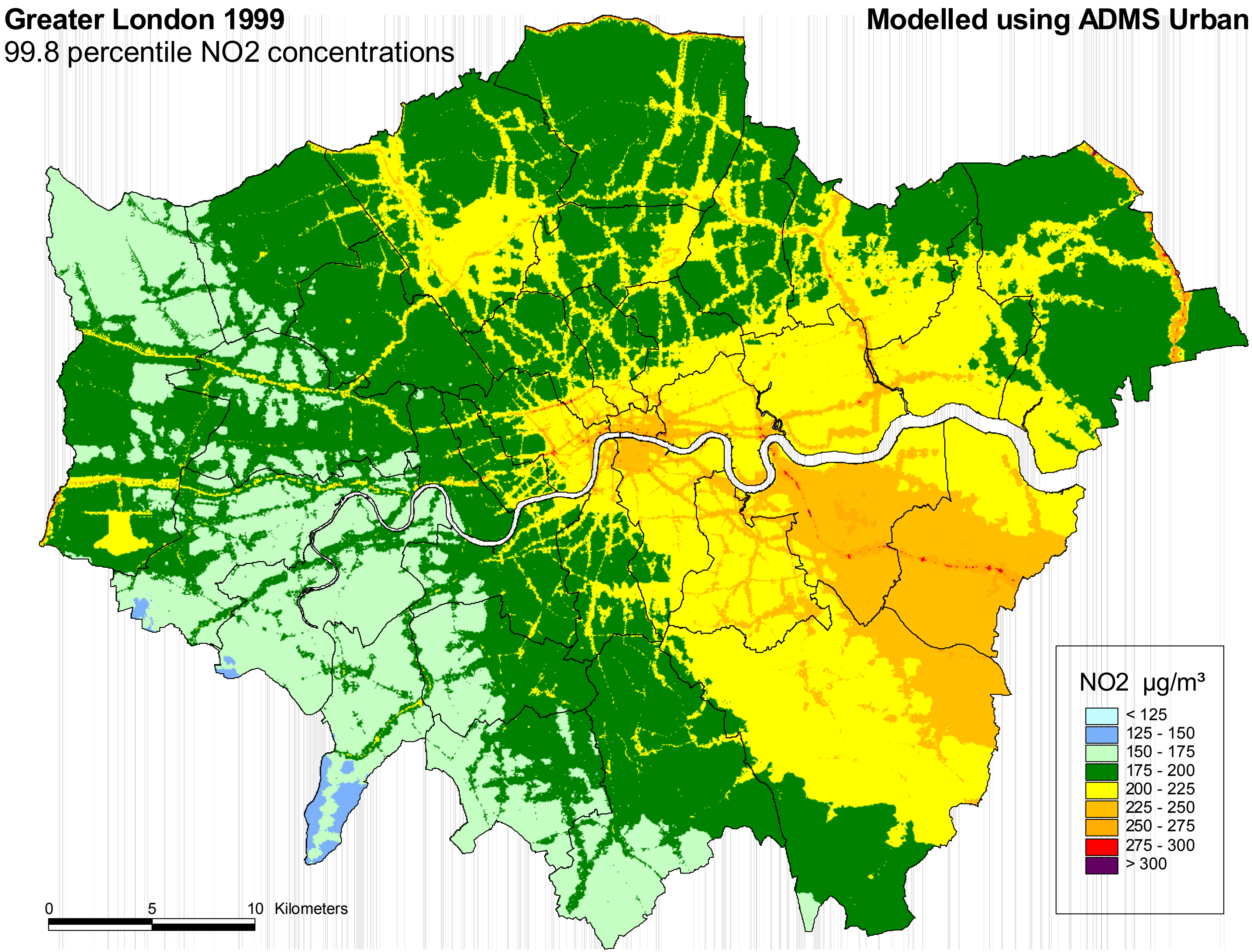

Greater London 2005
Annual mean NO2 concentrations
Modelled using ADMS Urban
NO2 µg/m³
< 20
20 - 24
24 - 28
28 - 32
32 - 36
36 - 40
40 - 44
44 - 48
48 - 52
> 52
0
5
10 Kilometers

FIGURE 6.5



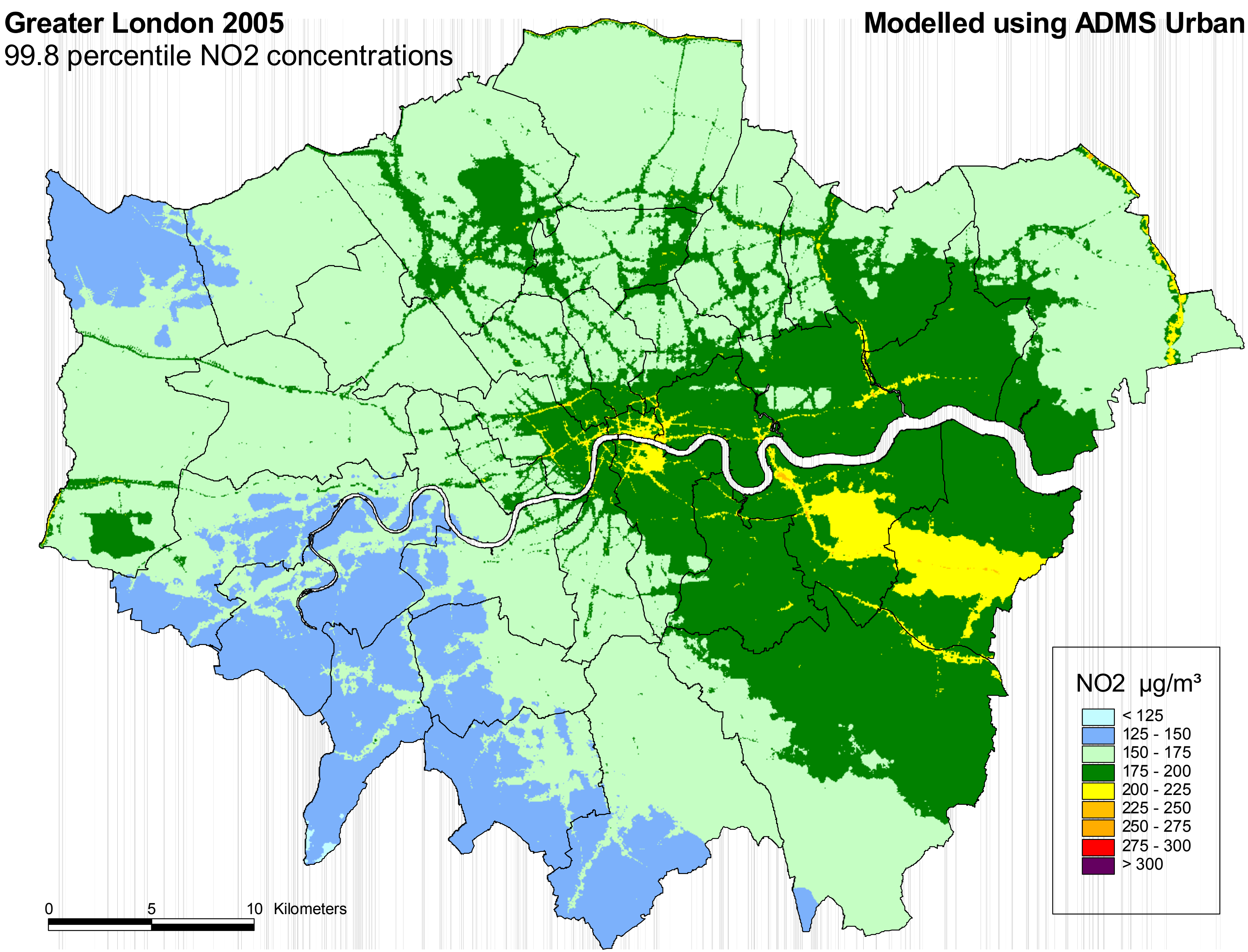
Greater London 2010
Annual mean NO2 concentrations
Modelled using ADMS Urban
NO2 µg/m³
< 20
20 - 24
24 - 28
28 - 32
32 - 36
36 - 40
40 - 44
44 - 48
48 - 52
> 52
0
5
10 Kilometers

FIGURE 6.6



Greater London 1999
99.8 percentile NO2 concentrations
Modelled using ADMS Urban
NO2 µg/m³
< 125
125 - 150
150 - 175
175 - 200
200 - 225
225 - 250
250 - 275
275 - 300
> 300
0
5
10 Kilometers

FIGURE 6.7



Greater London 2005
99.8 percentile NO2 concentrations
Modelled using ADMS Urban
NO2 µg/m³
< 125
125 - 150
150 - 175
175 - 200
200 - 225
225 - 250
250 - 275
275 - 300
> 300
0
5
10 Kilometers

FIGURE 6.8

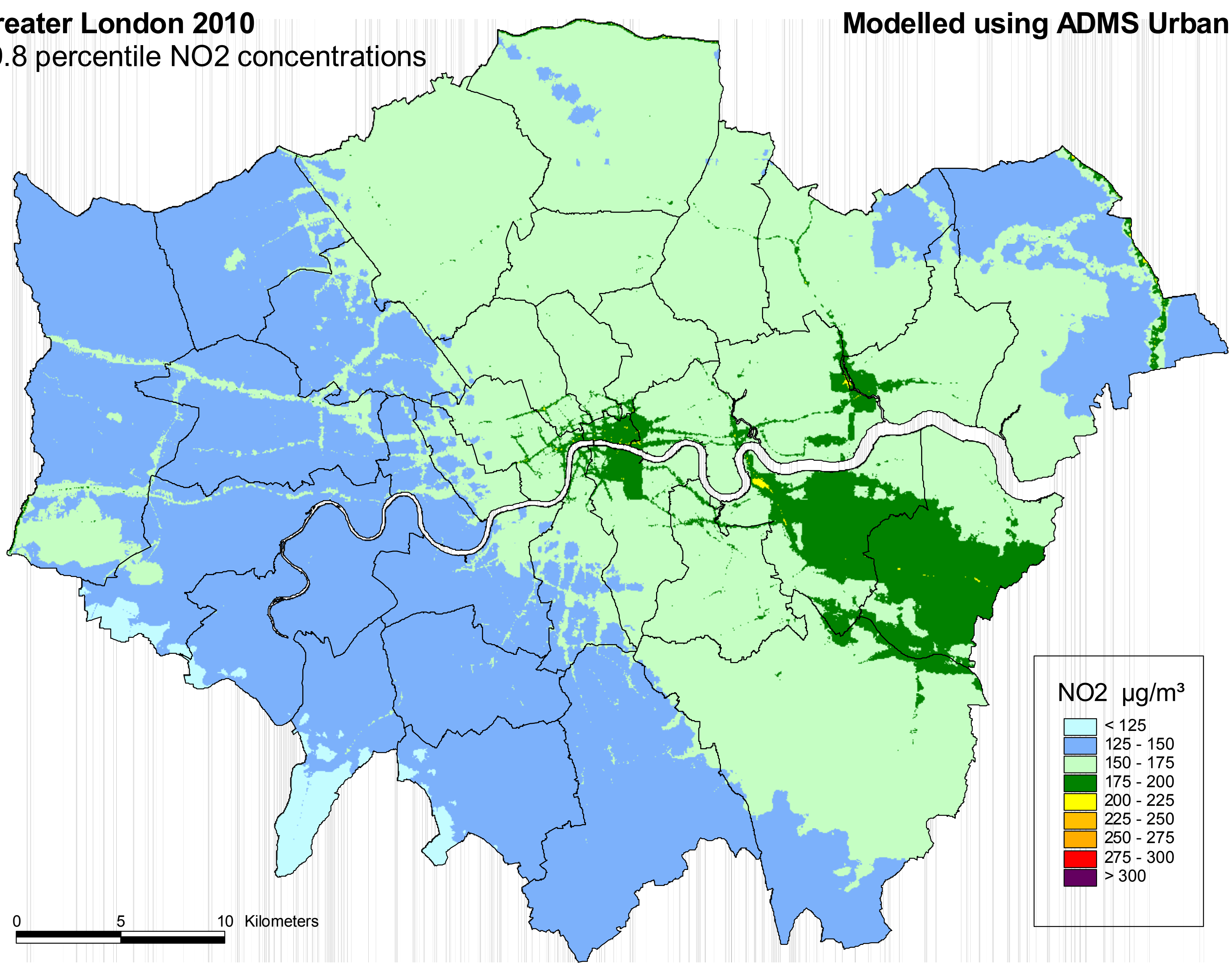
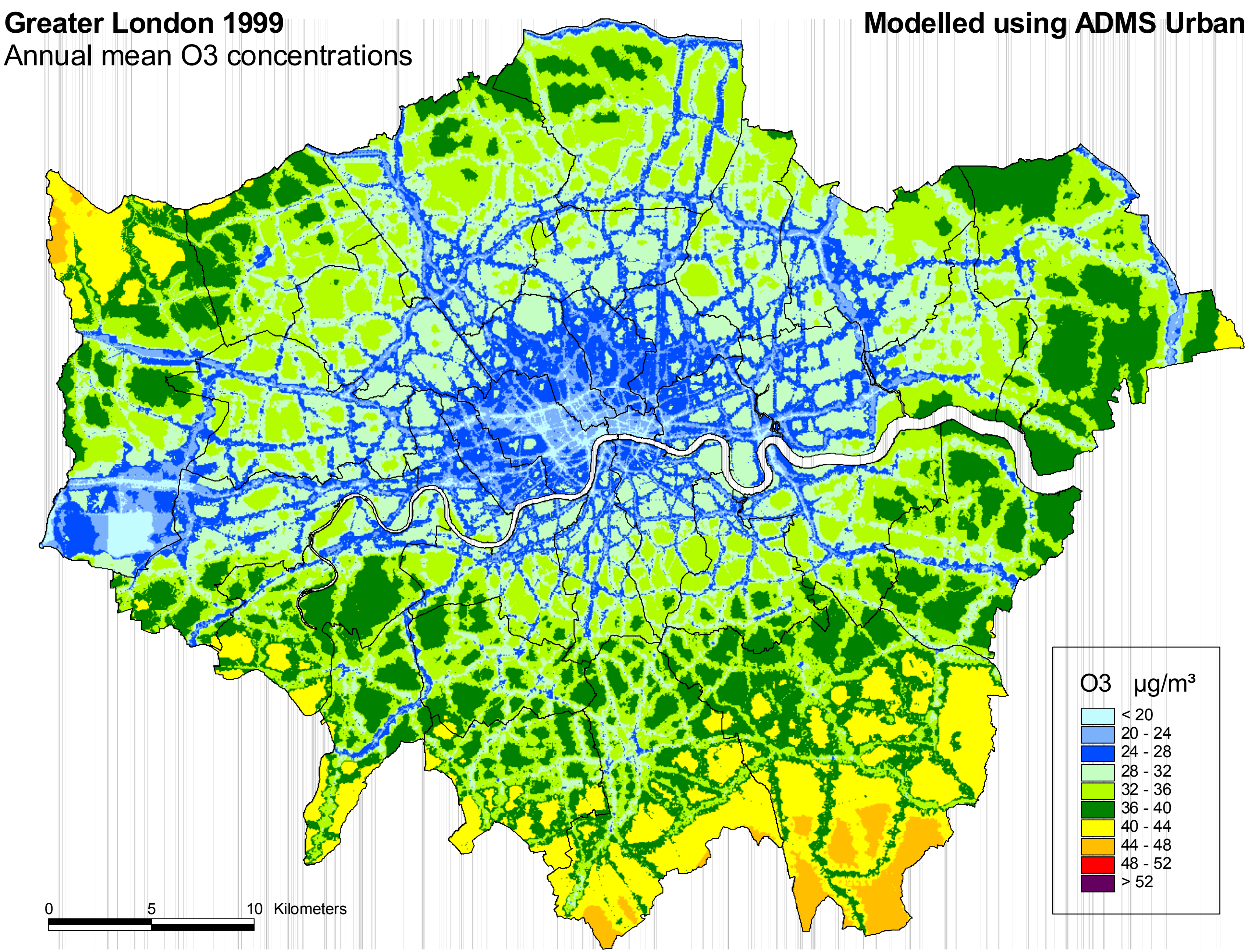
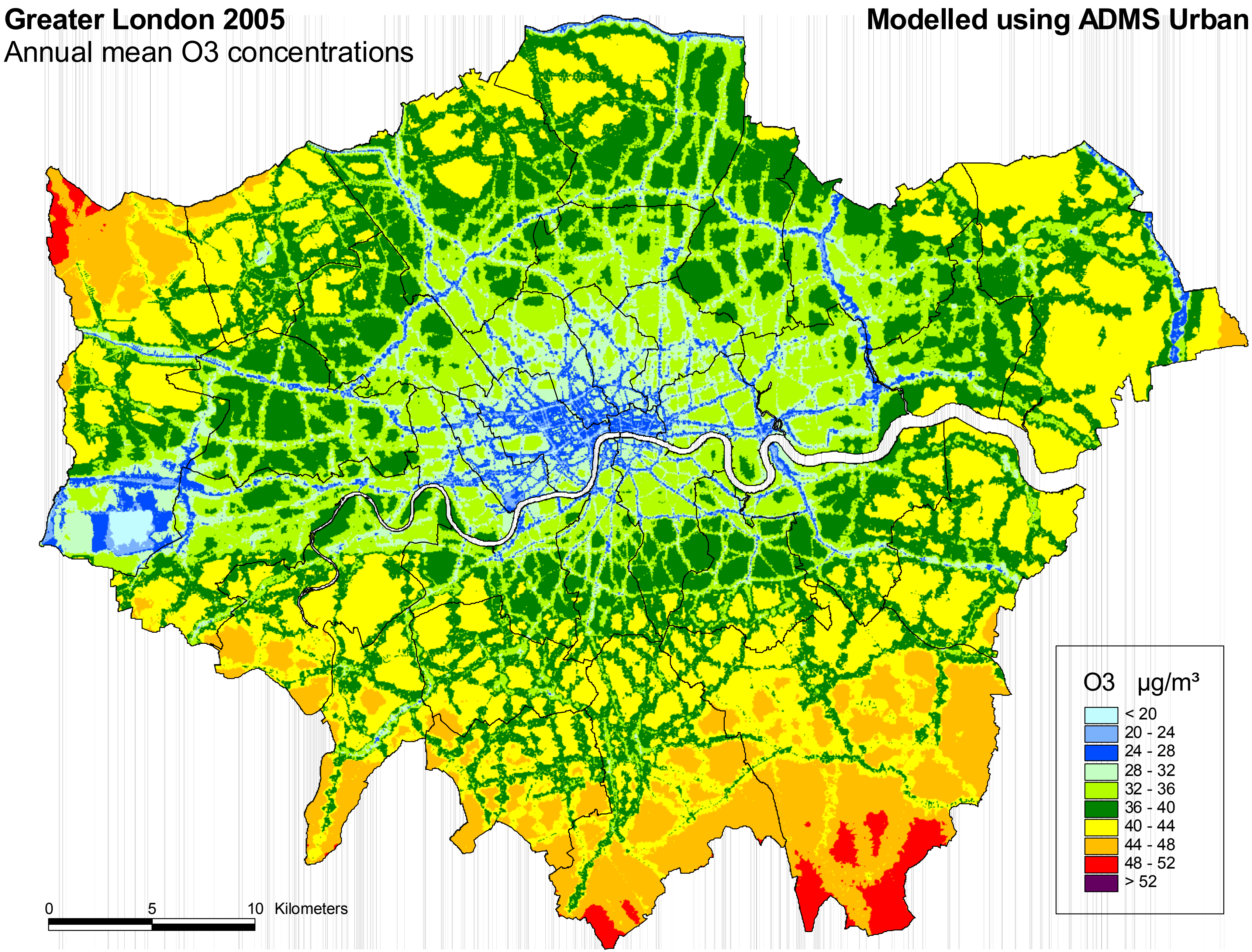

Greater London 2010
99.8 percentile NO2 concentrations
Modelled using ADMS Urban
NO2 µg/m³
< 125
125 - 150
150 - 175
175 - 200
200 - 225
225 - 250
250 - 275
275 - 300
> 300
0
5
10 Kilometers

FIGURE 6.9



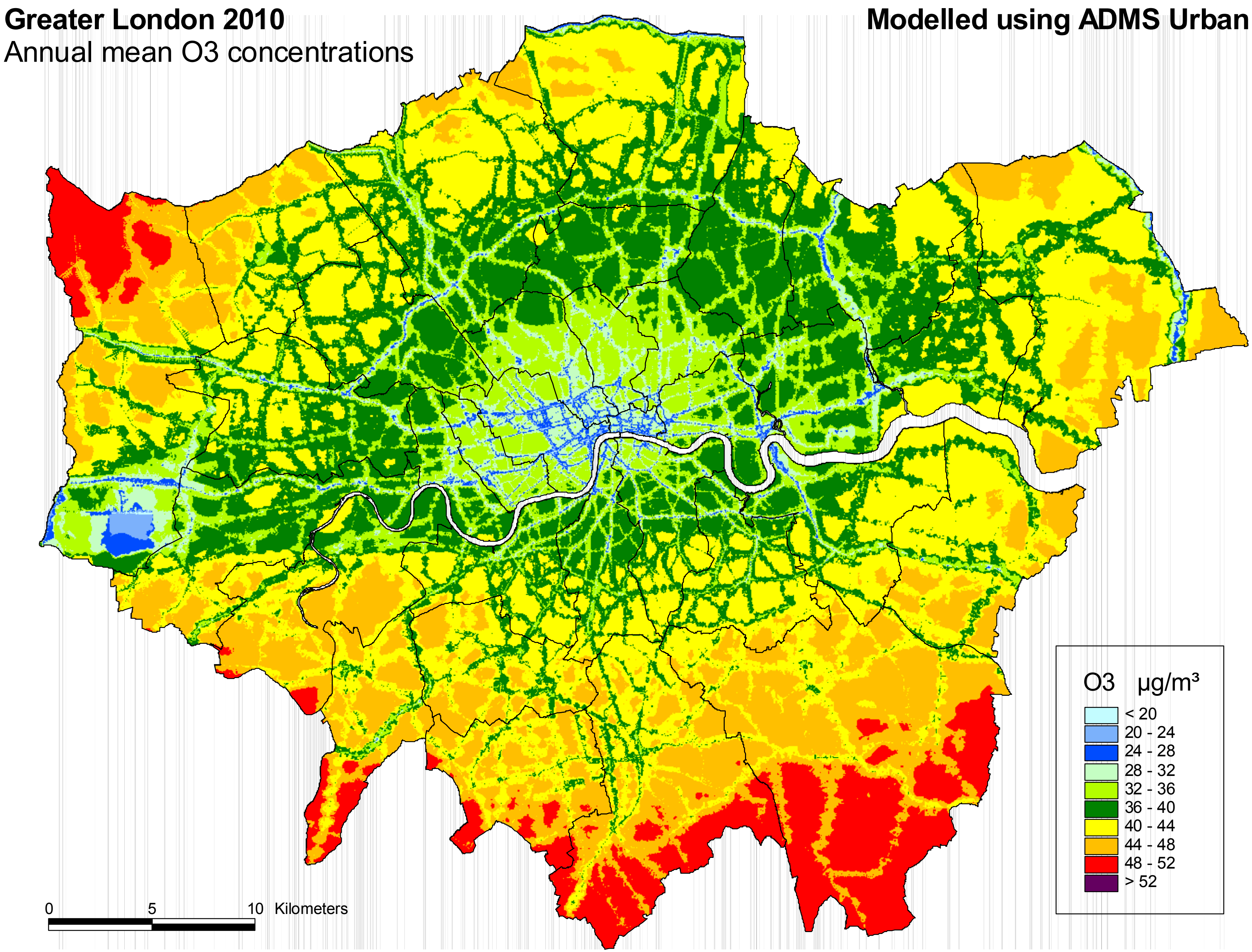
Greater London 1999
Annual mean O3 concentrations
Modelled using ADMS Urban
O3 µg/m³
< 20
20 - 24
24 - 28
28 - 32
32 - 36
36 - 40
40 - 44
44 - 48
48 - 52
> 52
0
5
10 Kilometers

FIGURE 6.10



Greater London 2005
Annual mean O3 concentrations
Modelled using ADMS Urban
O3 µg/m³
< 20
20 - 24
24 - 28
28 - 32
32 - 36
36 - 40
40 - 44
44 - 48
48 - 52
> 52
0
5
10 Kilometers

FIGURE 6.11



Greater London 2010
Annual mean O3 concentrations
Modelled using ADMS Urban
O3 µg/m³
< 20
20 - 24
24 - 28
28 - 32
32 - 36
36 - 40
40 - 44
44 - 48
48 - 52
> 52
0
5
10 Kilometers

FIGURE 6.12

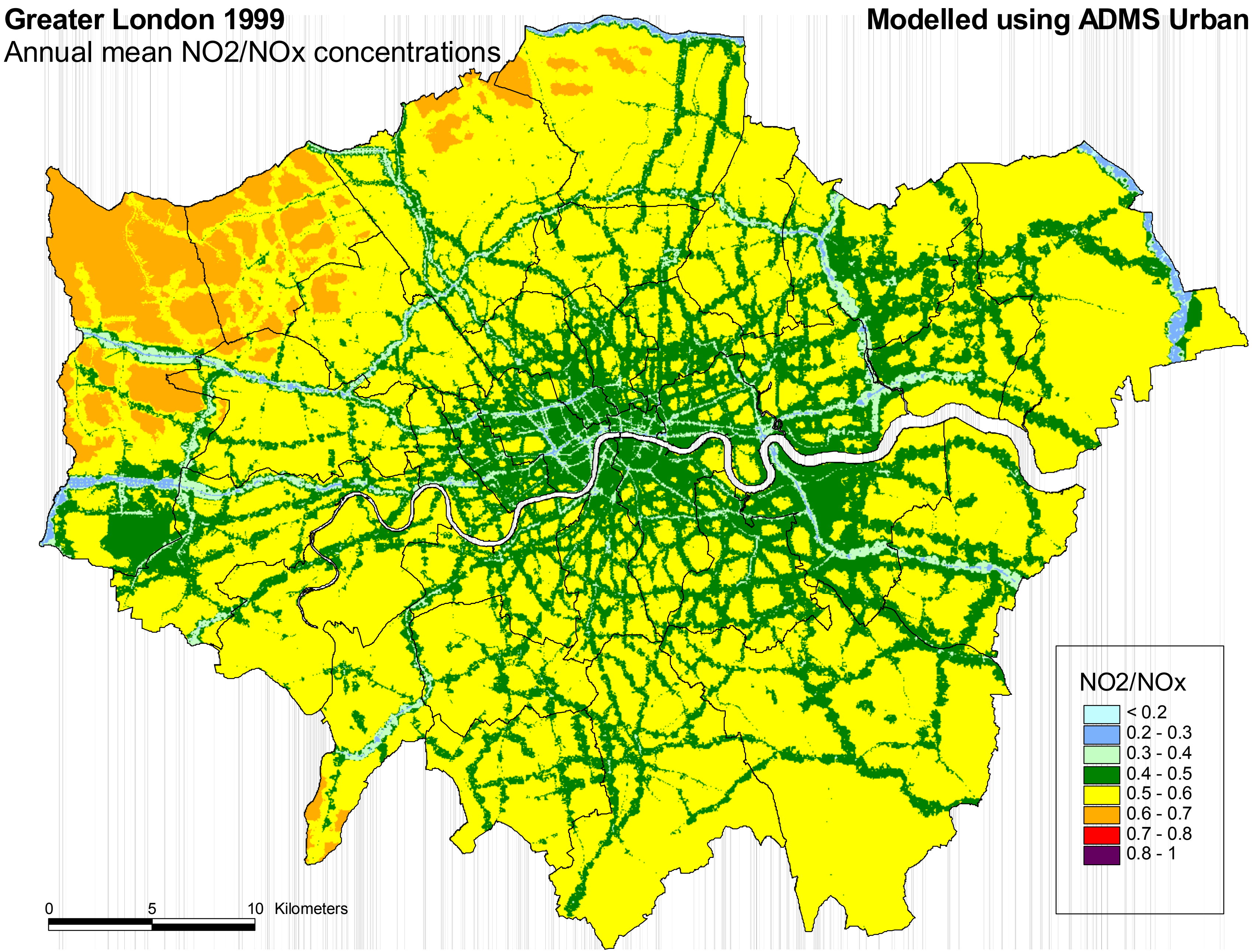

Greater London 1999
Annual mean NO2/NOx concentrations
Modelled using ADMS Urban
NO2/NOx
< 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 1
0
5
10 Kilometers

FIGURE 6.13

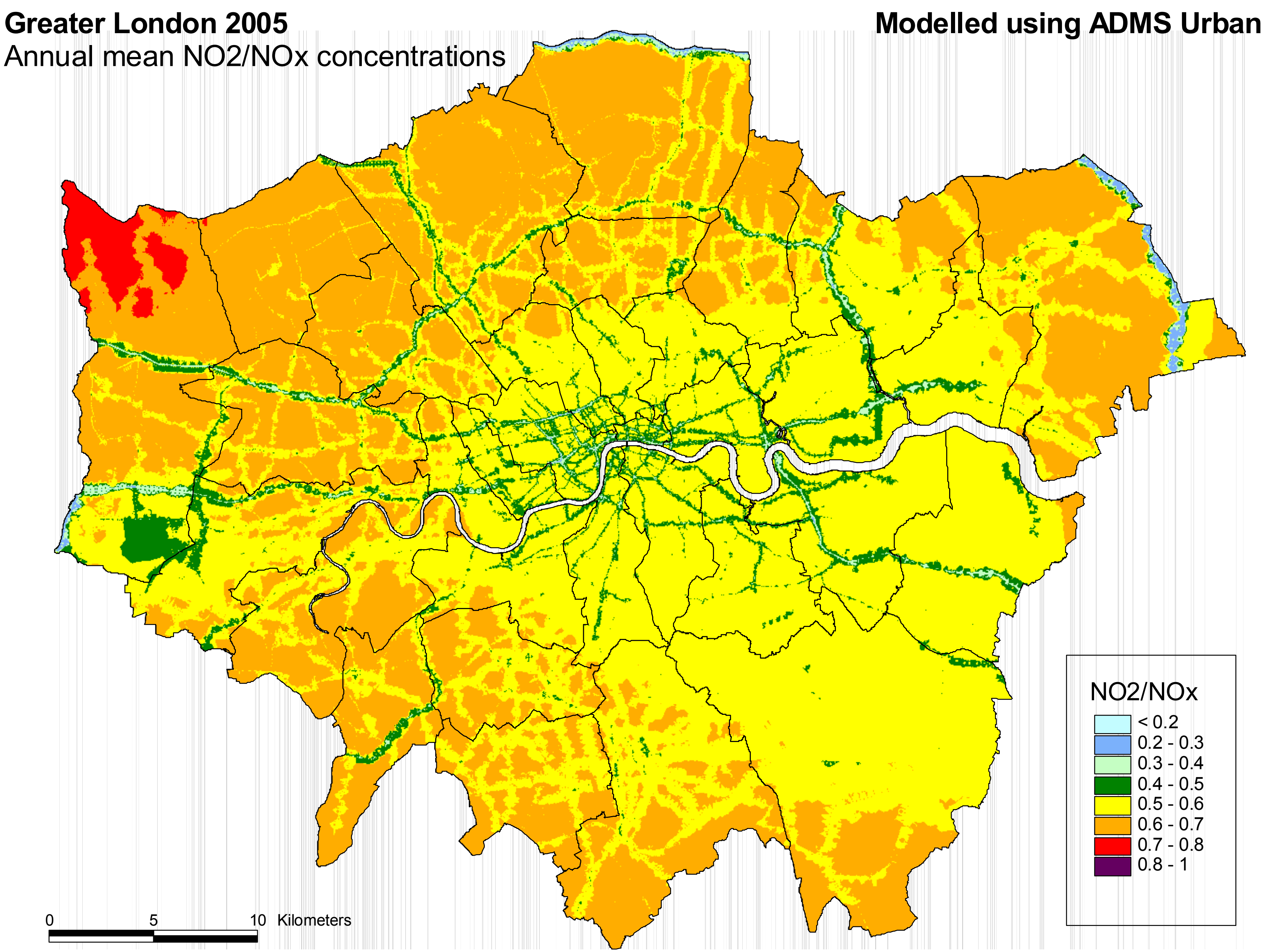
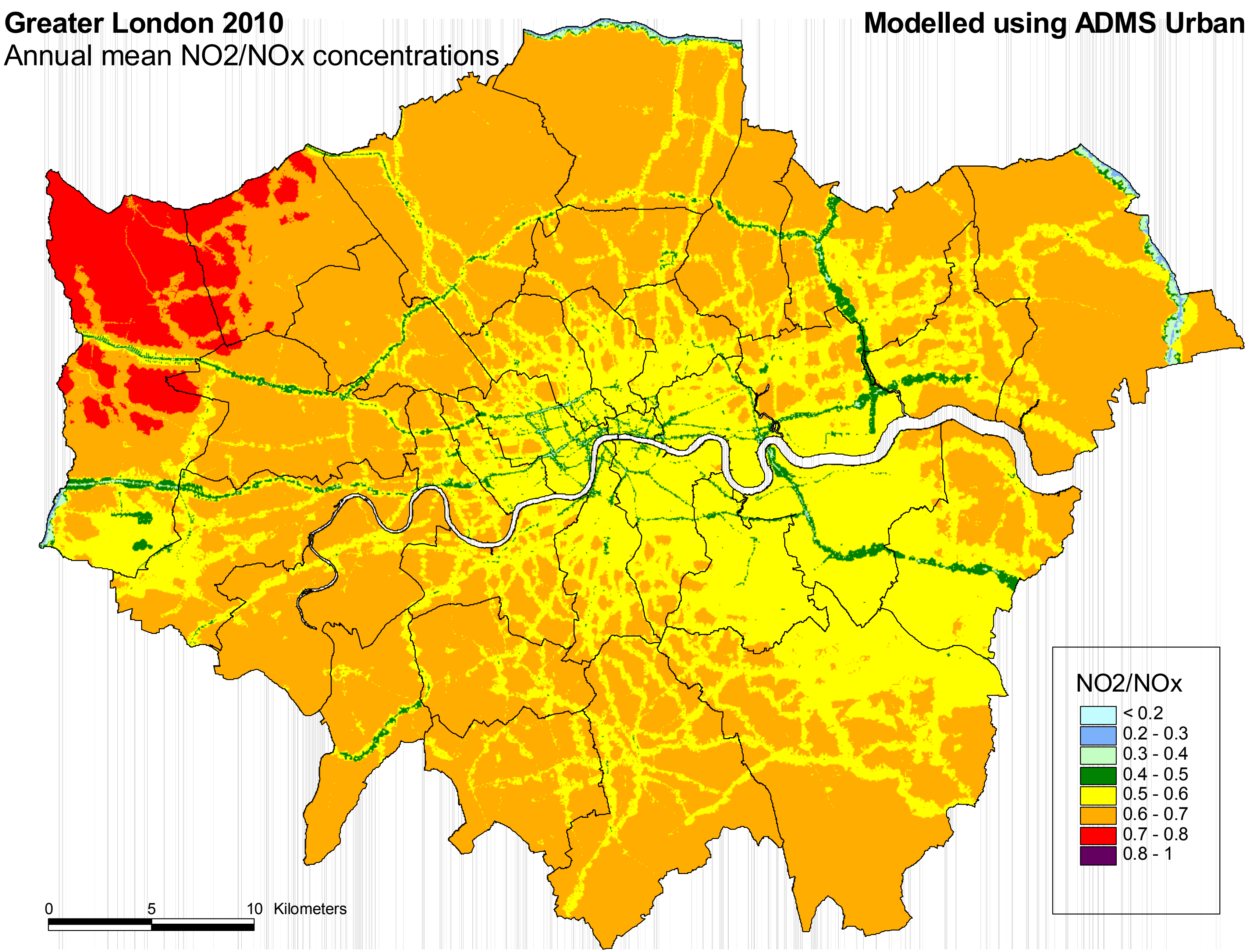

Greater London 2005
Annual mean NO2/NOx concentrations
Modelled using ADMS Urban
NO2/NOx
< 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 1
0
5
10 Kilometers

FIGURE 6.14



Greater London 2010
Annual mean NO2/NOx concentrations
Modelled using ADMS Urban
NO2/NOx
< 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 1
0
5
10 Kilometers

FIGURE 6.15

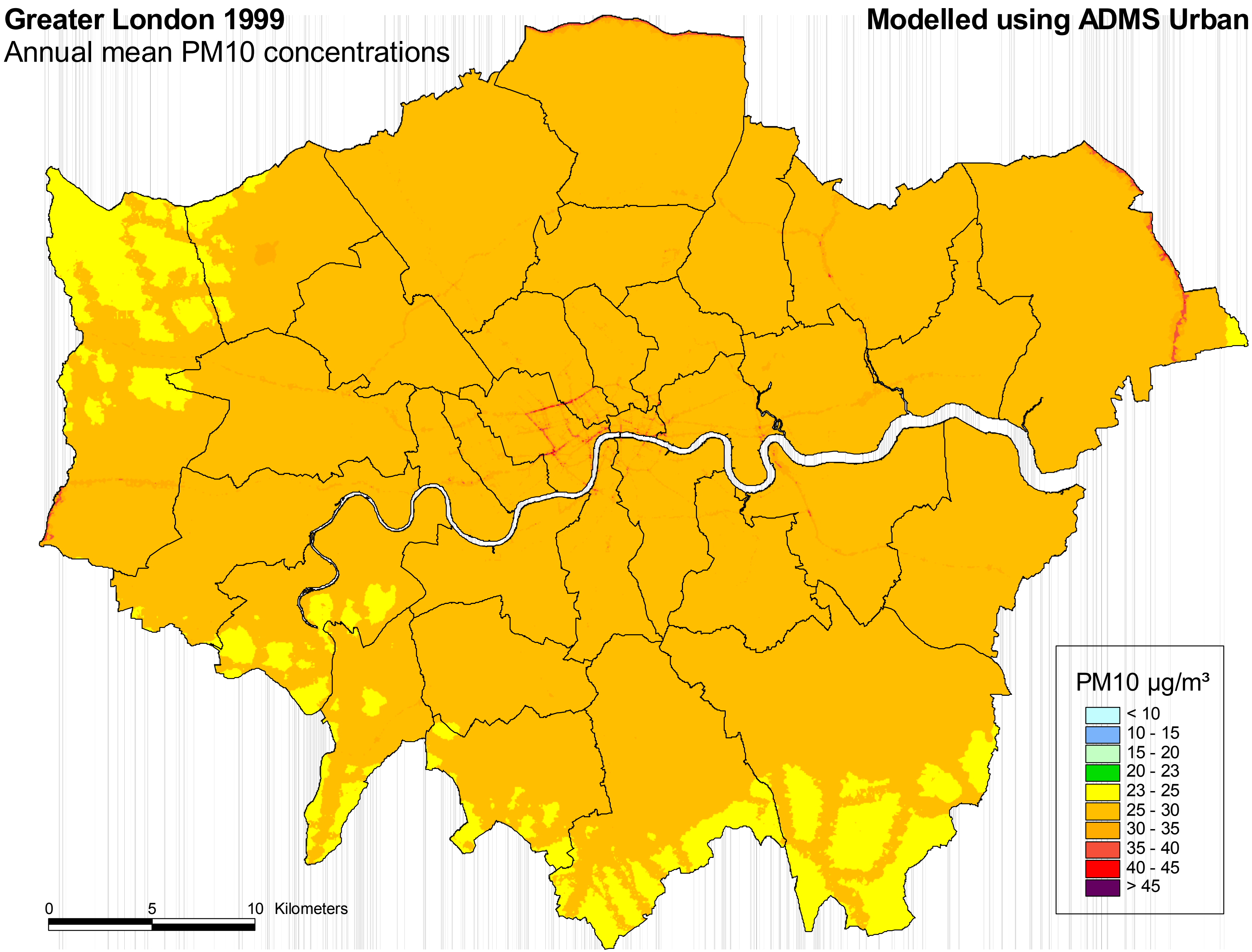
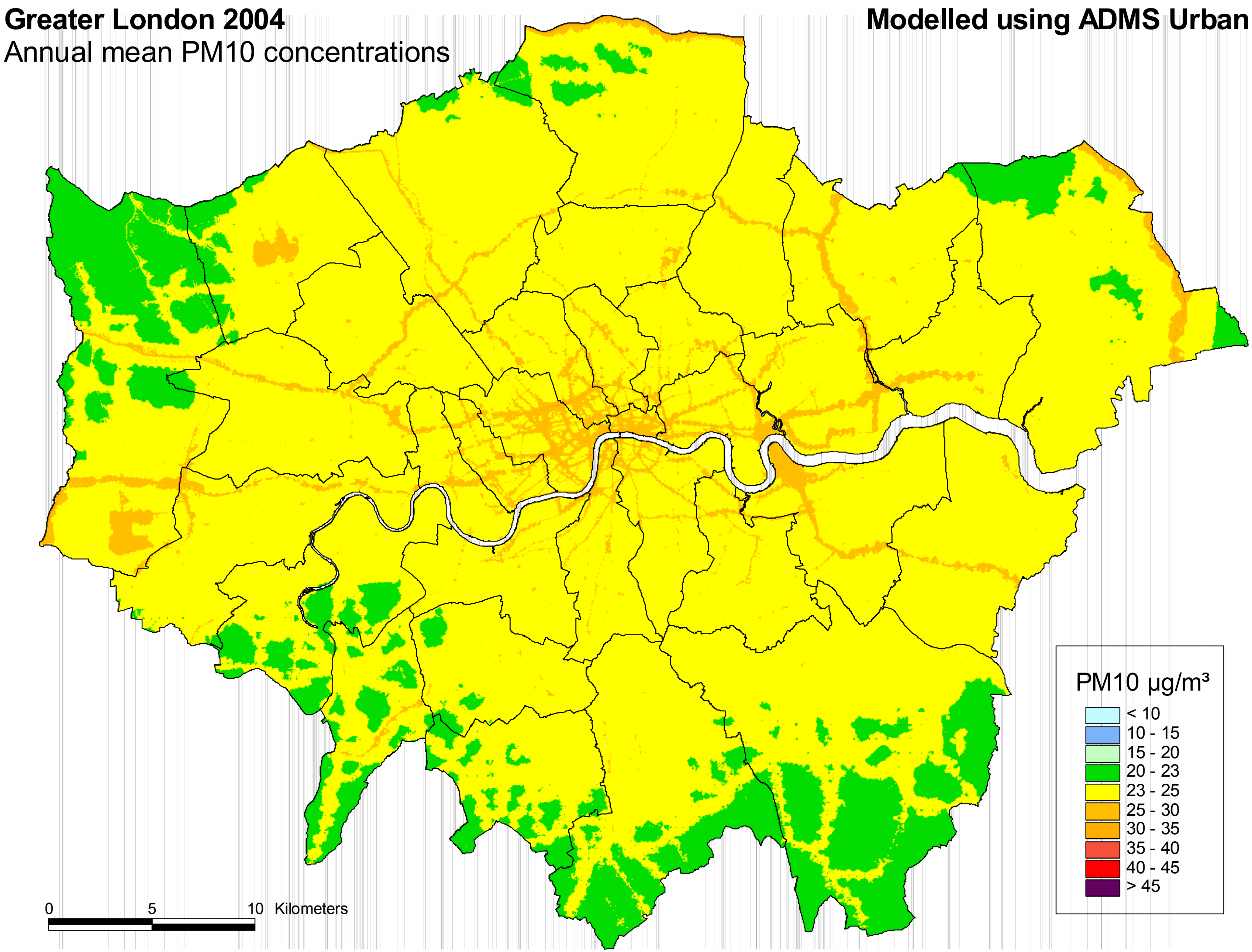
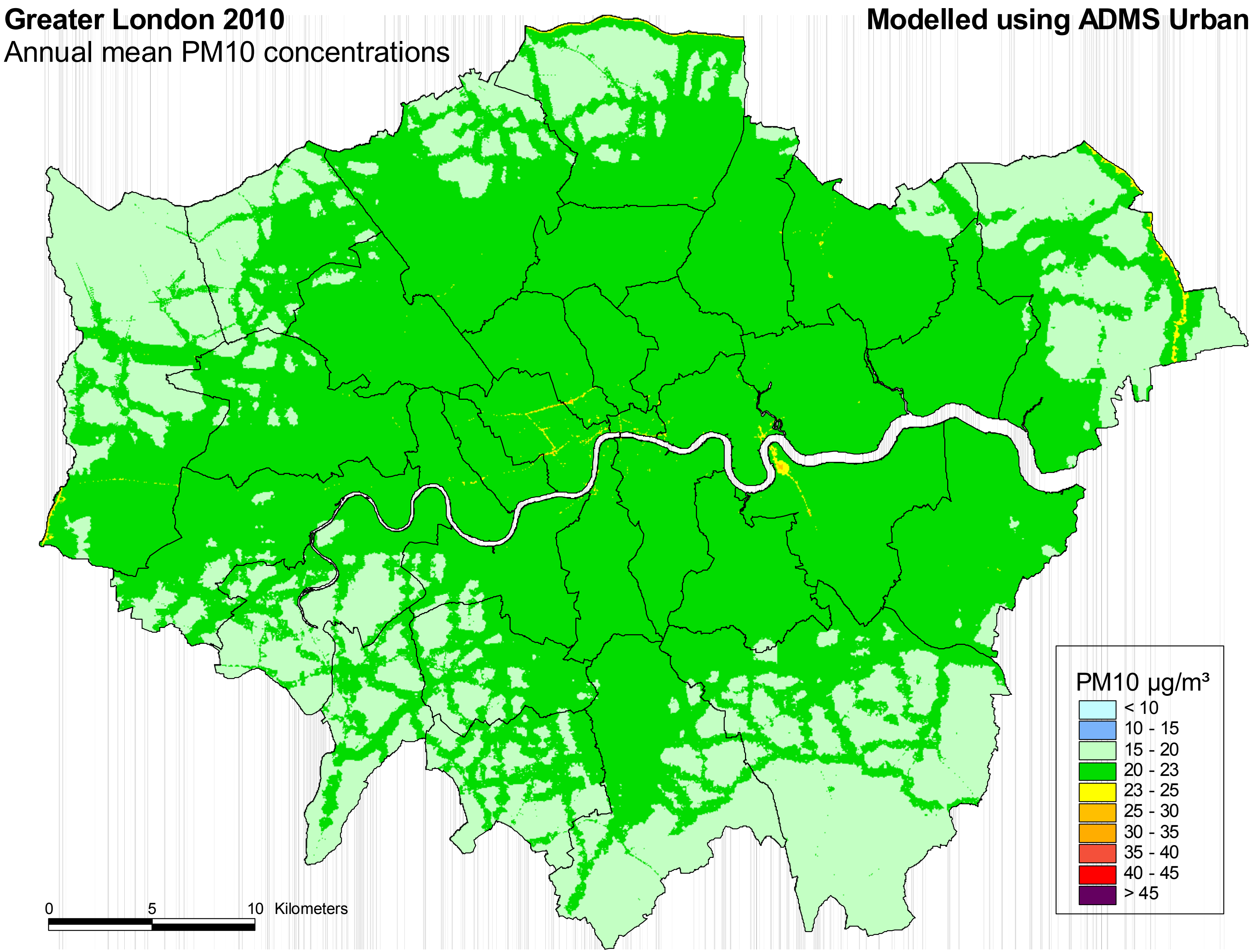

Greater London 1999
Annual mean PM10 concentrations
Modelled using ADMS Urban
PM10 µg/m³
< 10
10 - 15
15 - 20
20 - 23
23 - 25
25 - 30
30 - 35
35 - 40
40 - 45
> 45
0
5
10 Kilometers

FIGURE 6.16



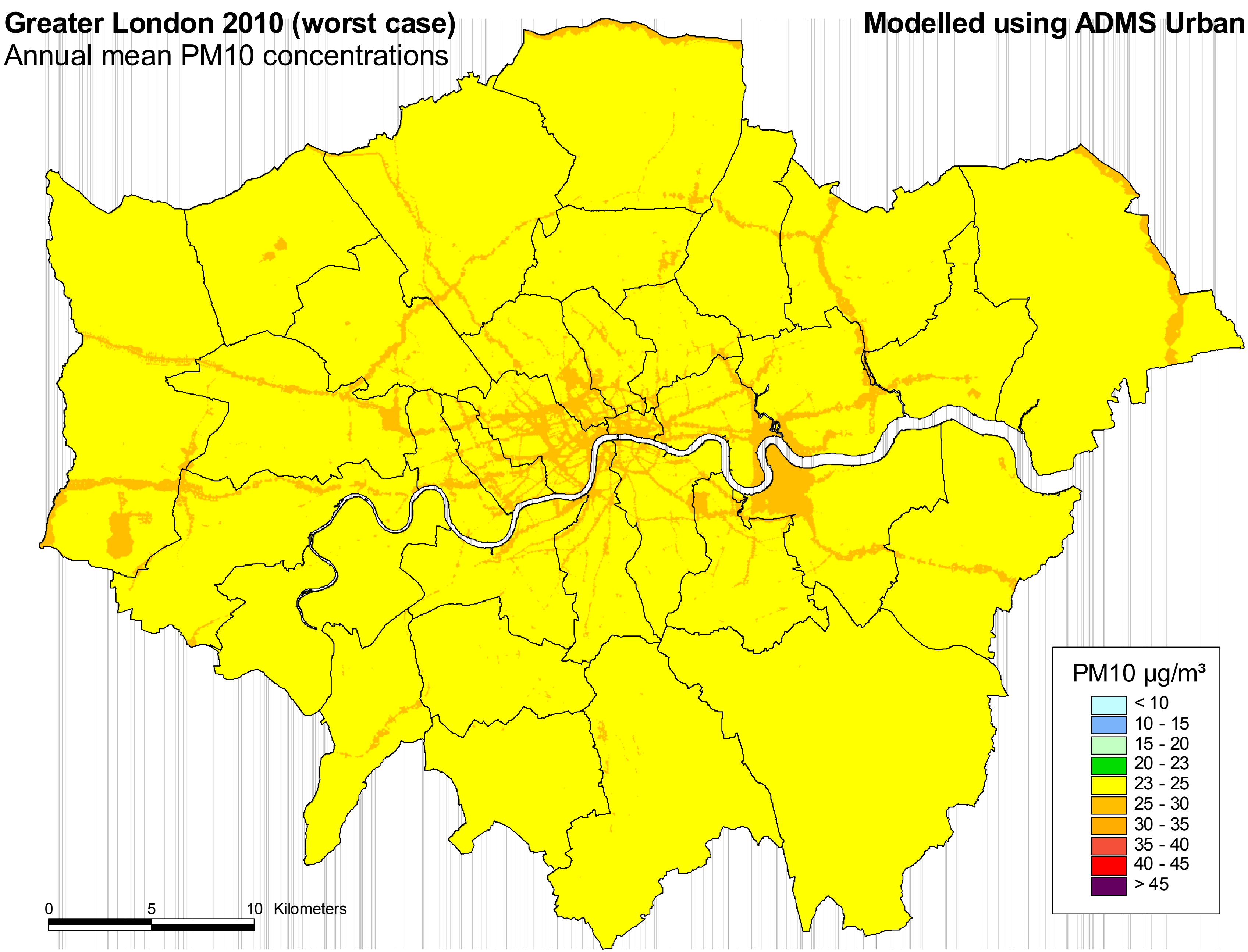
Greater London 2004
Annual mean PM10 concentrations
Modelled using ADMS Urban
PM10 µg/m³
< 10
10 - 15
15 - 20
20 - 23
23 - 25
25 - 30
30 - 35
35 - 40
40 - 45
> 45
0
5
10 Kilometers

FIGURE 6.17



Greater London 2010
Annual mean PM10 concentrations
Modelled using ADMS Urban
PM10 µg/m³
< 10
10 - 15
15 - 20
20 - 23
23 - 25
25 - 30
30 - 35
35 - 40
40 - 45
> 45
0
5
10 Kilometers

FIGURE 6.18



Greater London 2010 (worst case)
Annual mean PM10 concentrations
Modelled using ADMS Urban
PM10 µg/m³
< 10
10 - 15
15 - 20
20 - 23
23 - 25
25 - 30
30 - 35
35 - 40
40 - 45
> 45
0
5
10 Kilometers

FIGURE 6.19

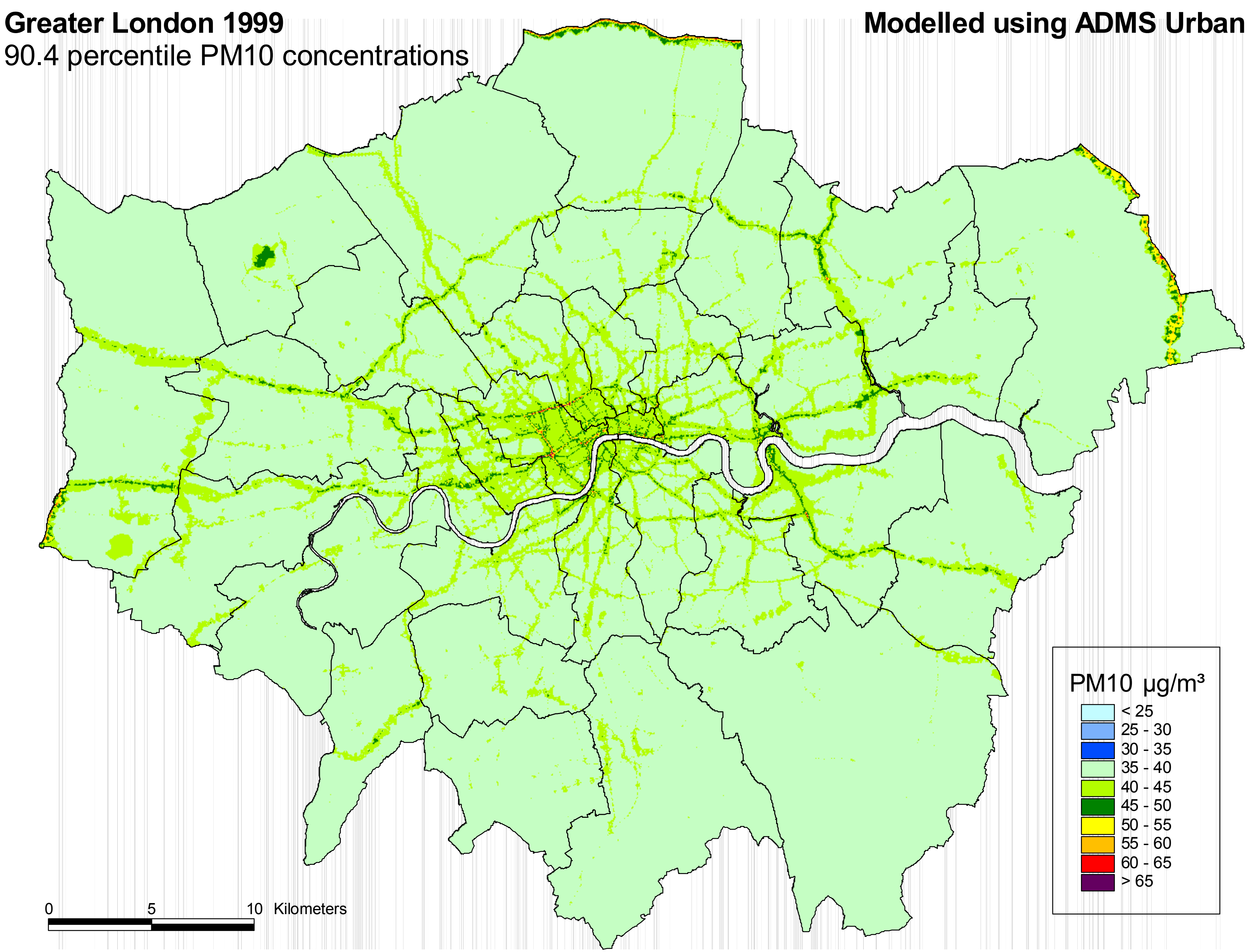
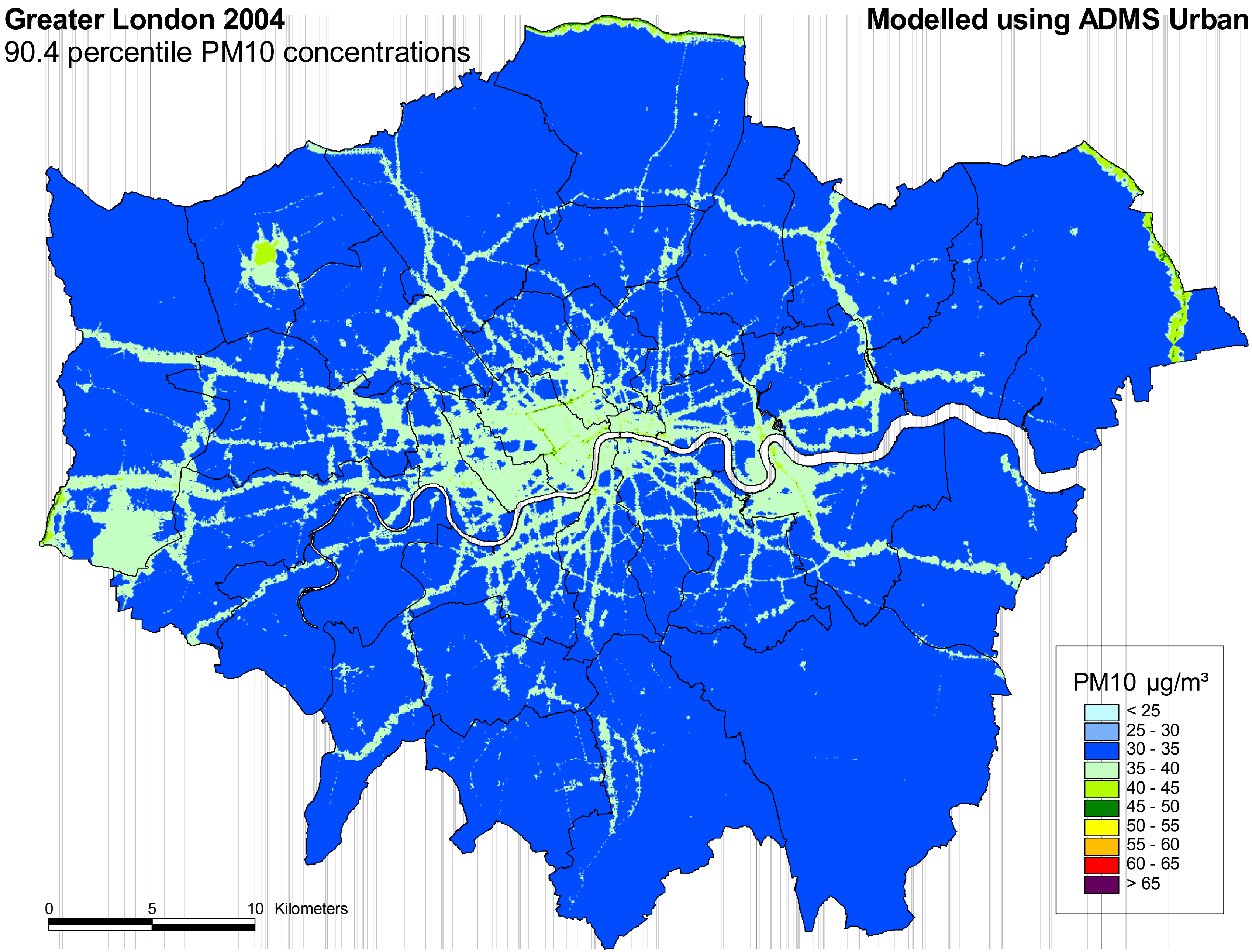
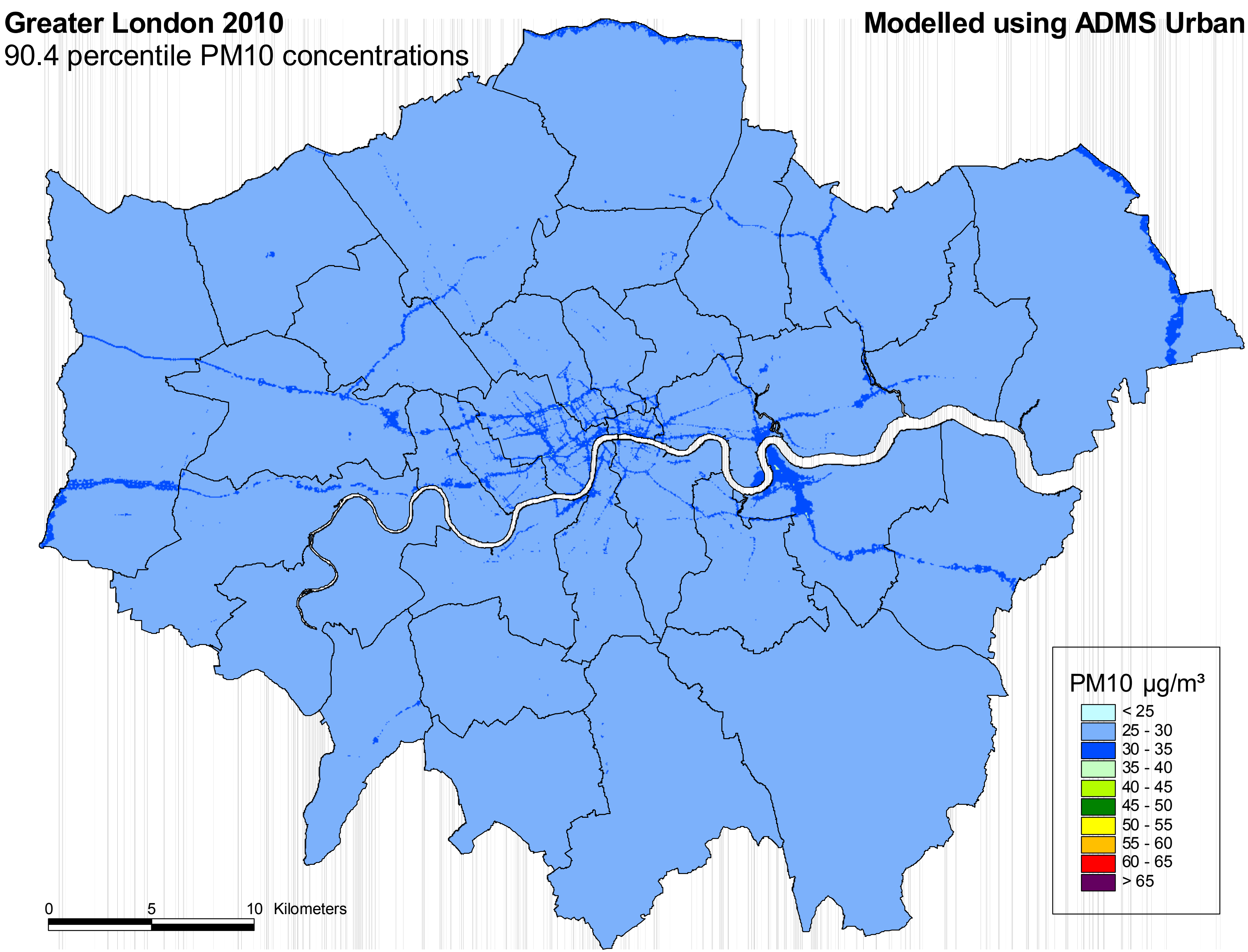

Greater London 1999
90.4 percentile PM10 concentrations
Modelled using ADMS Urban
PM10 µg/m³
< 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
> 65
0
5
10 Kilometers

FIGURE 6.20



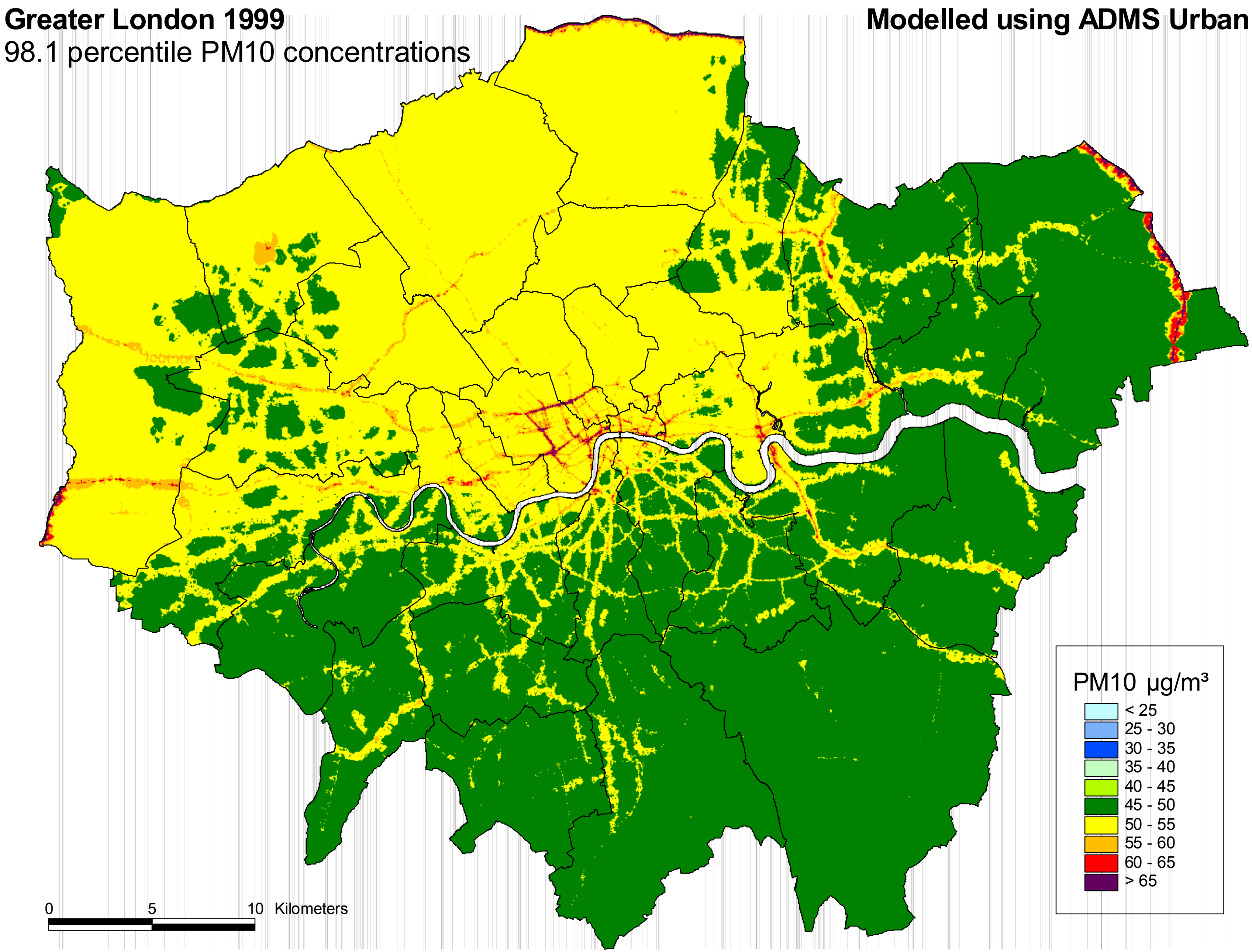
Greater London 2004
90.4 percentile PM10 concentrations
Modelled using ADMS Urban
PM10 µg/m³
< 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
> 65
0
5
10 Kilometers

FIGURE 6.21



Greater London 2010
90.4 percentile PM10 concentrations
Modelled using ADMS Urban
PM10 µg/m³
< 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
> 65
0
5
10 Kilometers

FIGURE 6.22



Greater London 1999
98.1 percentile PM10 concentrations
Modelled using ADMS Urban
PM10 µg/m³
< 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
> 65
0
5
10 Kilometers

FIGURE 6.23

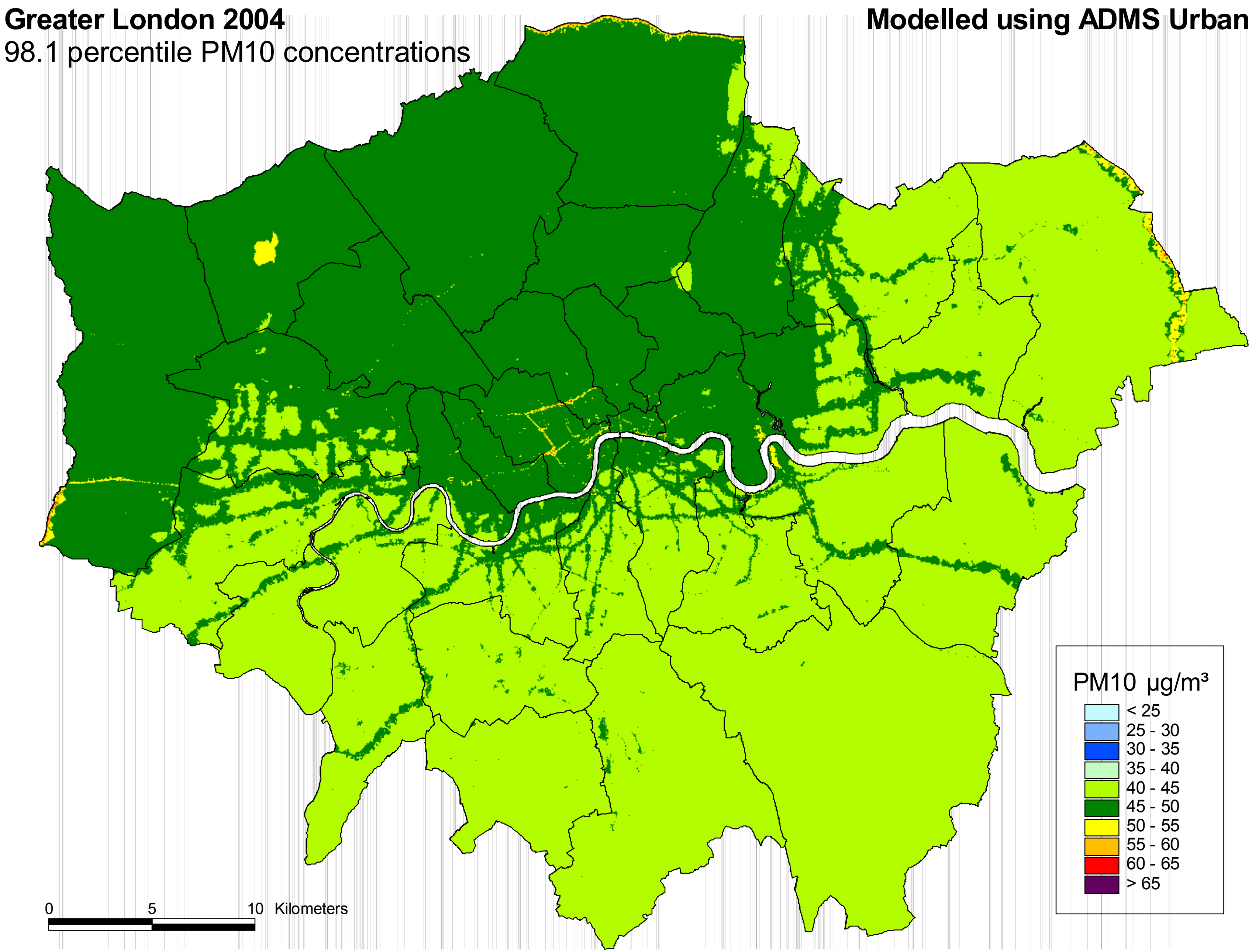

Greater London 2004
98.1 percentile PM10 concentrations
Modelled using ADMS Urban
PM10 µg/m³
< 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
> 65
0
5
10 Kilometers

FIGURE 6.24

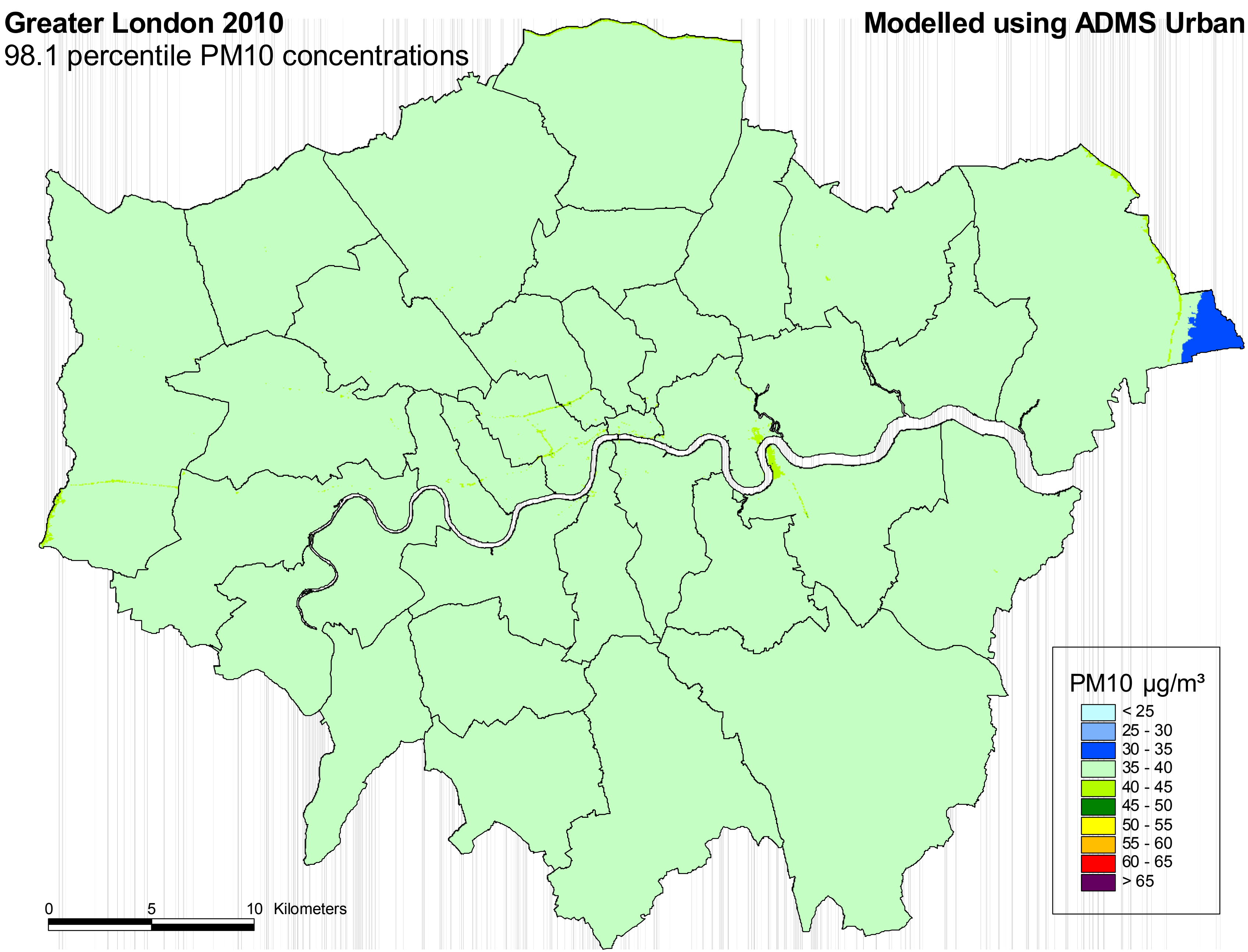
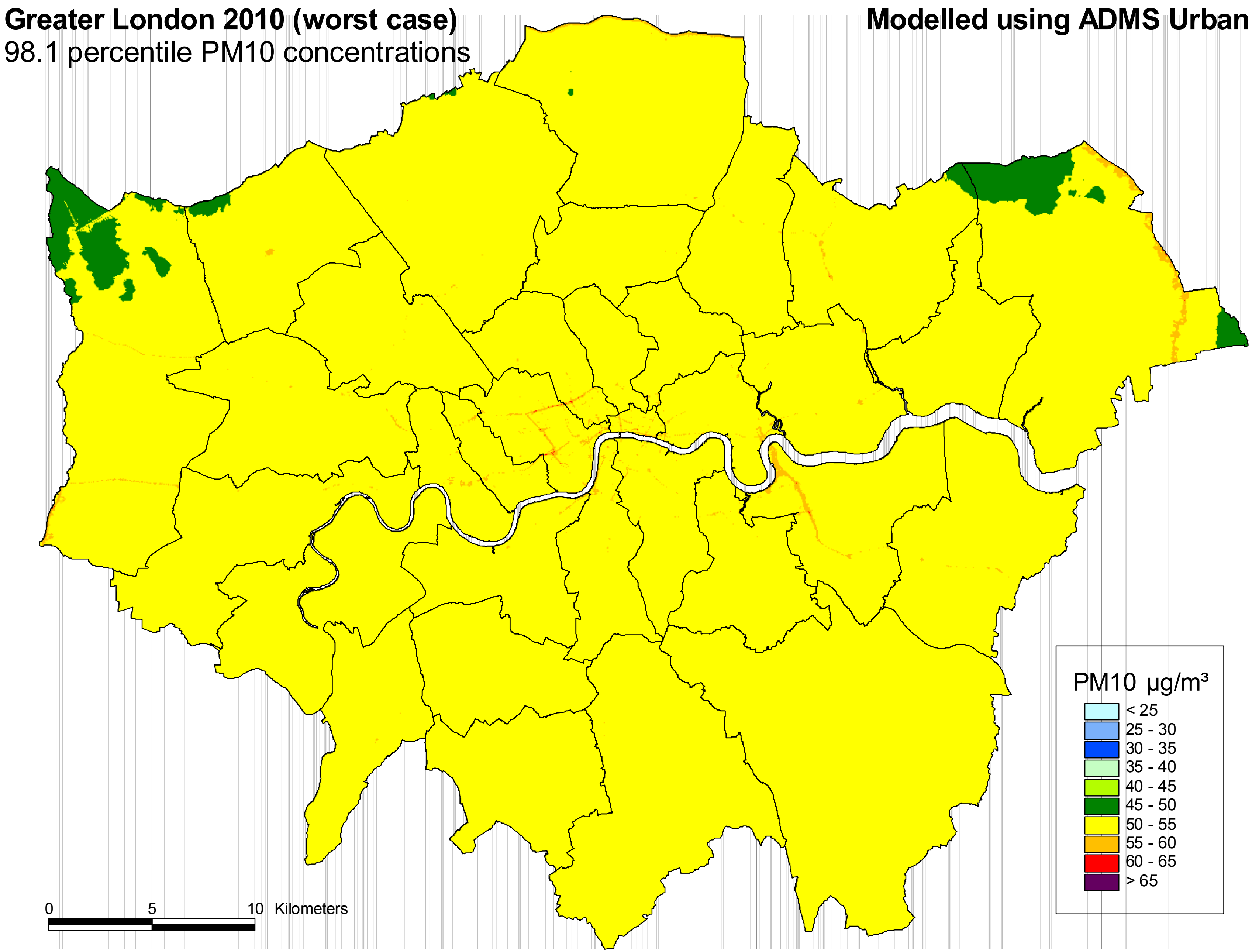
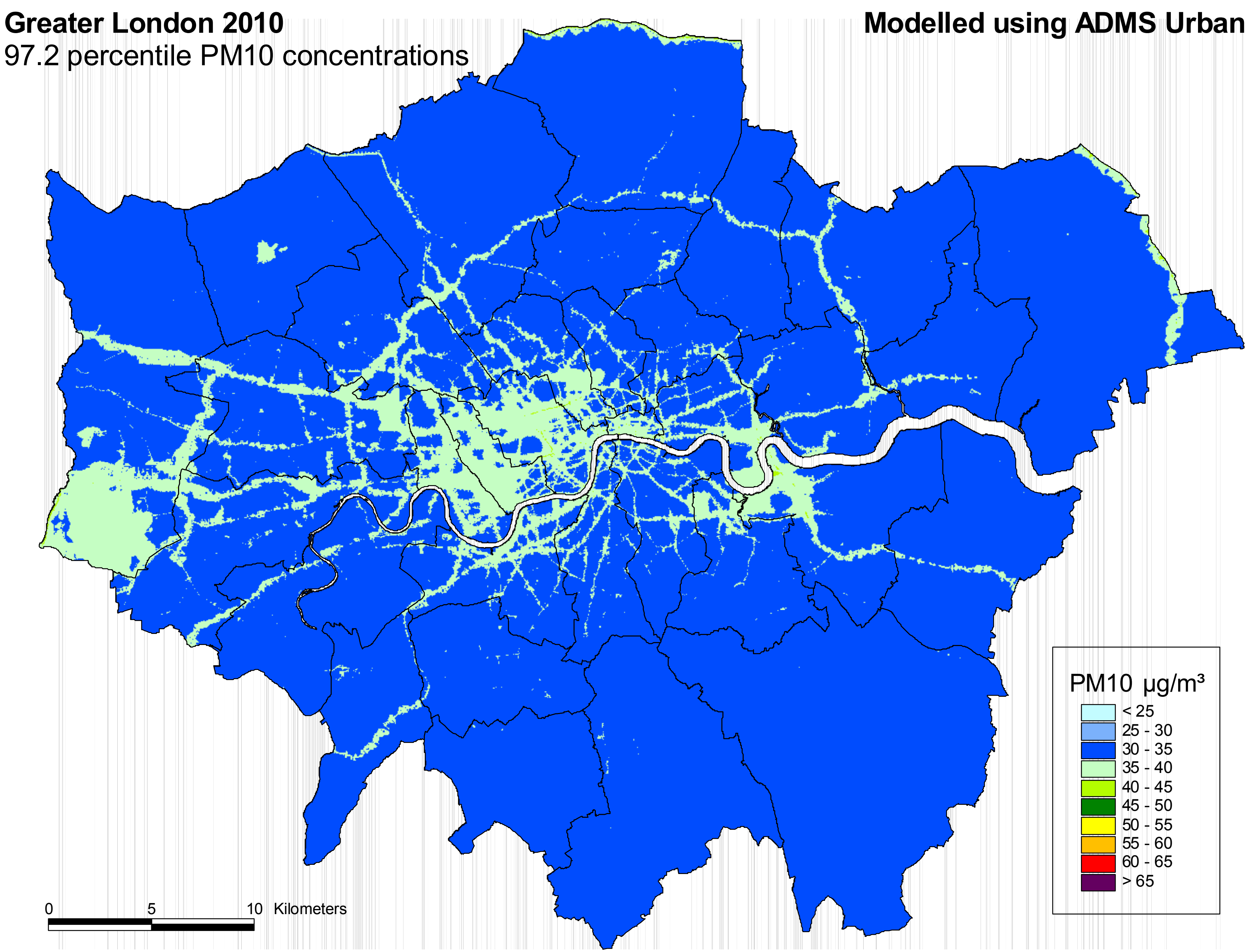

Greater London 2010
98.1 percentile PM10 concentrations
Modelled using ADMS Urban
PM10 µg/m³
< 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
> 65
0
5
10 Kilometers

FIGURE 6.25



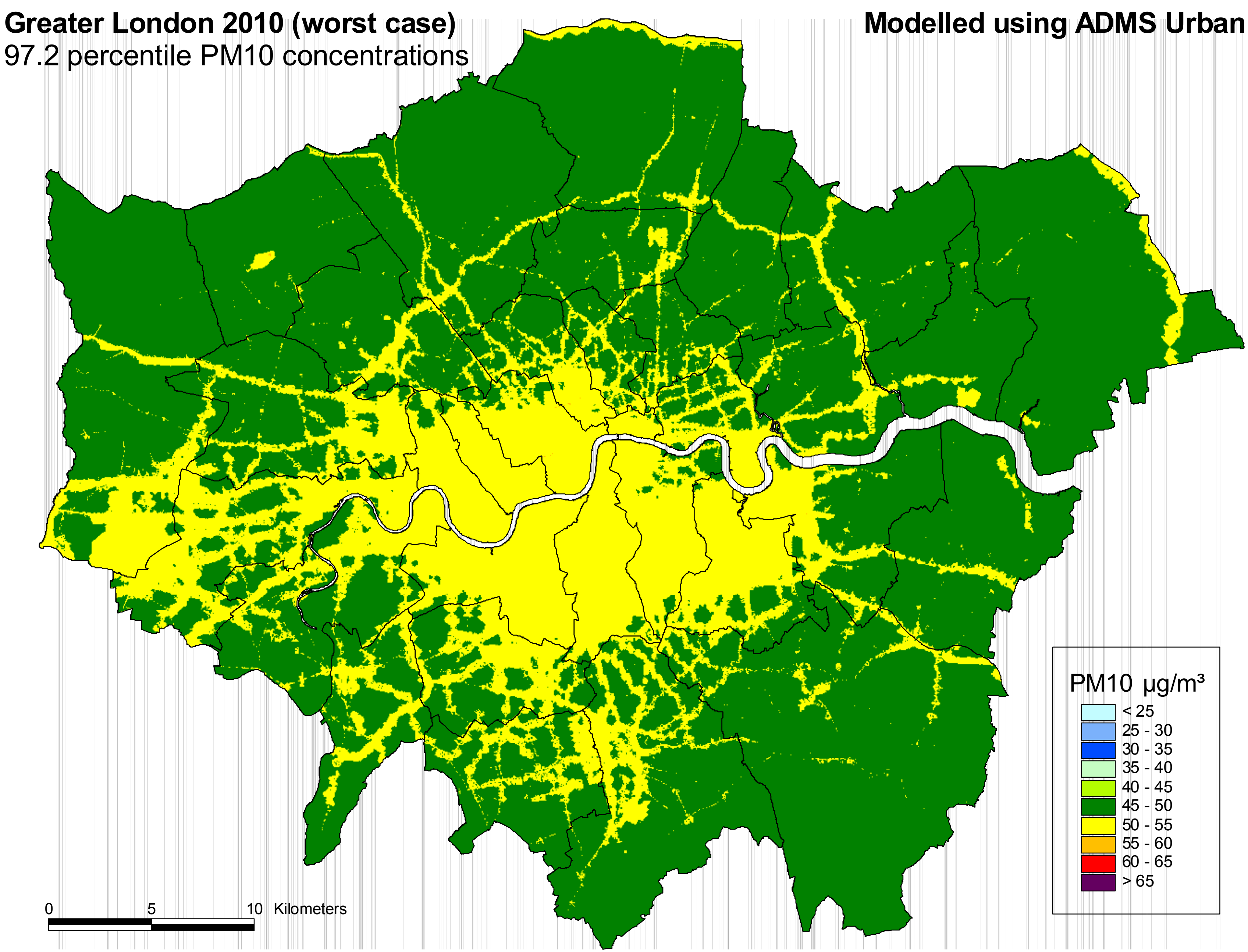
Greater London 2010 (worst case)
98.1 percentile PM10 concentrations
Modelled using ADMS Urban
PM10 µg/m³
< 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
> 65
0
5
10 Kilometers

FIGURE 6.26



Greater London 2010
97.2 percentile PM10 concentrations
Modelled using ADMS Urban
PM10 µg/m³
< 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
> 65
0
5
10 Kilometers

FIGURE 6.27



Greater London 2010 (worst case)
97.2 percentile PM10 concentrations
Modelled using ADMS Urban
PM10 µg/m³
< 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
> 65
0
5
10 Kilometers

FIGURE 6.28

7. Conclusions

Emissions of NO_x and PM_{10} over the Greater London area have been modelled for the years 1999, 2004/05 and 2010 using meteorology from 1999 and worst case meteorology from 1996 (PM_{10}) and 1997 (NO_2). Maps of calculated pollutant concentration have been presented in this report together with spot calculations at the AURN site locations in London.

Air Quality Targets to be achieved by 2004 and 2005

The following conclusions were drawn for 2004 and 2005, assuming there are no additional emissions reductions:

- **Annual average NO_2** is likely to exceed the 40µg/m^3 UK air quality objective for:
  - Around 32% of the total area of London in the target year (2005), despite a reduction of approximately half of the area exceeding between 1999 and 2005.
  - Between 22% and 43% of the total area of London if the margin of error is applied to the modelled concentrations for the base year meteorological conditions.
  - 17 of the 23 automatic urban and rural network (AURN) monitoring locations for both base and worst case meteorological conditions.

- **99.8 percentile of 1-hour average NO_2** (equivalent to 18 exceedences) is likely to exceed the UK air quality objective (200µg/m^3) for:
  - Approximately 3% of the modelled area when modelled with the base year meteorological conditions.
  - Only Marylebone road from the 23 AURN monitoring locations, for both base and worst case meteorological conditions.

- All **PM_{10}** objectives are likely to be achieved by 2004 for base and worst case meteorological conditions, with the following exceptions at Marylebone Road only:
  - The worst case year Annual Average exceeds the 40µg/m^3 AQS limit.
  - 90.4 percentile for base and worst case years (representing 35 exceedences) exceeds the limit of 50µg/m^3.

Air Quality targets to be achieved by 2010

The following conclusions were drawn for 2010, assuming there are no additional emissions reductions:

- **Annual average NO_2** is likely to exceed the 40µg/m^3 EU air quality limit value for:
  - Approximately 13% of the total area of London in the target year.
  - Between 8% and 20% of the total area of London if the margin of error is applied to the modelled concentrations for the base year meteorological conditions.

– 15 of the 23 AURN monitoring locations for base case and 17 AURN locations for worst case meteorological conditions.

- **99.8 percentile of 1-hour average NO_2** (equivalent to 18 exceedences) concentrations is unlikely to exceed the EU air quality limit value (200µg/m^3).

- The **annual average PM_{10}** concentrations are likely to exceed the London 23µg/m^3 objective for:
  – Less than 1% of the area of London if the base case meteorological conditions are used in the modelling.
  – Up to 2% of London if the margin of error for the modelled concentration is taken into account.
  – The whole of London in a worst case year, because the worst case annual average background concentration alone is 23 µg/m^3.
  – 2 AURN monitoring locations for base case and all 11 AURN locations for worst case meteorological conditions.

- The **annual average PM_{10}** concentrations are likely to exceed the EU 20µg/m^3 indicative limit value for:
  – 75% of the area of London if the base case meteorological conditions are used in the modelling.
  – As low as 8% or as much as 100% of London if the margin of error for the modelled concentration is taken into account. Small changes in predicted concentration have a great impact on areas exceeding a threshold because the concentrations of PM_{10} are relatively uniform.
  – The whole of the modelled area if the worst case meteorological conditions are used in the modelling.
  – All of the 11 AURN monitoring locations for both base and worst case meteorological conditions.

- The **PM_{10} 97.2 percentile of 24-hour average** is likely to exceed the London objective of 50 µg/m^3 (equivalent to 10 exceedences):
  – Nowhere if base case meteorological conditions are assumed.
  – Over approximately 36% of the area modelled, if worst case meteorological conditions are assumed.
  – At all 11 of the AURN monitoring locations if worst case meteorological conditions are modelled.

8. Acknowledgements

This report was prepared under contract Number EPG 1/3/176 for DEFRA, the National Assembly for Wales (NAW), the Northern Ireland Executive, represented by the Department of the Environment in Northern Ireland (DoENI), and the Scottish Executive, represented by the Scottish Executive Environment and Rural Affairs Department (SEERAD).

9. References

TOPIC REPORTS

Carruthers, D.J., Blair, J.W., Johnson, K.L. (2002a) Validation and Sensitivity Study of ADMS-Urban for London, Cambridge Environmental Research Consultants **TR-0191**

Carruthers, D.J., Blair, J.W., Johnson, K.L. (2002b) Comparison of ADMS-Urban, NETCEN and ERG Air Quality Predictions for London, Cambridge Environmental Research Consultants **TR-0232**

AIR QUALITY OBJECTIVES

DETR, *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland - Working Together for Clean Air,* January 2000