Slough Emissions Inventory

2008 Update

Report for Slough Borough Council

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Acronyms and definitions used in this report

C	Carbon
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DEFRA	Department for Environment, Food and Rural Affairs
DETR	Department for Environment, Transport and the Regions
LAQM	Local Air Quality Management
IPCC	Intergovernmental Panel on Climate Change
NAEI	National Atmospheric Emissions Inventory
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides ($NO+NO_2$)
NMVOC	Non-methane volatile organic compounds
PAH	Polycyclic aromatic hydrocarbons
PM_{10}	Particulate Matter with aerodynamic diameter less than 10µm[1]
$PM_{2.5}$	Particulate Matter with aerodynamic diameter less than 2.5µm
AADT	Annual Average Daily Traffic
SNAP	Selected Nomenclature for reporting of Air Pollutants
SATURN	Simulation and Assignment of Traffic to Urban Road Networks
SO_2	Sulphur Dioxide
UKEFD	UK Emission Factor Database

[1] To be precise, particles that pass through the selective size inlet of a specified measuring instrument with 50% efficiency at 10µm aerodynamic diameter, where the 'aerodynamic diameter' of a particle is the diameter of a spherical particle of unit relative density that would have the same gravitational settling velocity as the particle of interest.

Executive summary

Air quality and climate change issues require national, regional and local governments to take action to curb emissions. Co-ordinated actions are required to be taken at all levels of government in order for the UK to achieve national and international air quality standards and emissions reduction targets to reduce local and global impacts. The development of an emissions inventory is an important mechanism for quantitatively judging the effectiveness of emission reduction initiatives at local, regional and national levels and is a key input into dispersion modelling, used for assessing air quality.

At the local level, there are a number of statutory requirements on Local Authorities that would require access to local atmospheric emissions data particularly for their local council area, as well as for their region. Local emissions data are particularly required:

- To support the Local Air Quality Management (LAQM) review and assessment process, both as an input to dispersion modelling to ascertain the likelihood of achievement of the national air quality objectives and in quantifying the impact of the implementation of options within the air quality action plan.

- As an input to dispersion modelling, to allow Local Authorities to assess the impact of proposed planning applications on air quality.

- In the development of Local Transport Plans, so that transport planners can have an understanding of baseline emissions from road transport to quantify the likely emission reduction as a result of the implementation of options within the Local Transport Plan.

- Additionally, an inventory can also be used to assess action to reduce greenhouse gases such as carbon dioxide.

Slough Borough Council has updated its emissions inventory on a regular basis since 1999 (1997 base year). Each update has updated core elements such as roads and industrial point sources, though other less substantial sources have also been updated in some years.

This report presents the results of the updated 2008 emissions inventory for Slough. The inventory includes the following pollutants:

- Oxides of nitrogen (NO_x)
- Particulate matter, PM_{10}
- Particulate matter, $PM_{2.5}$
- Carbon monoxide (CO)
- Carbon dioxide (CO_2)
- Sulphur dioxide (SO_2)
- Benzene
- 1,3-Butadiene
- Non-methane volatile organic compounds (NMVOC)
- Benzo(a)pyrene as an indicator for polycyclic aromatic hydrocarbons

This 2008 inventory includes revised estimates of the emissions from Part A and Part B point sources, road transport, rail transport and petrol stations based on local information. The inventory also includes estimates of the emissions from boilers operated at schools, libraries, care homes, council offices and other council property. The inventory includes emission estimates provided by the National Atmospheric Emission Inventory for other source sectors.
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The calculated emissions from point sources for 2008 are generally smaller than for 2005. Emissions of carbon dioxide, in particular are substantially smaller because emissions for Slough Heat and Power reported to the Pollution Release and Transfer register are smaller than previous estimates. The calculated emissions from point sources are similar to those calculated by the NAEI for 2008, although the emissions for carbon dioxide are substantially larger.

The calculated emissions from road transport are smaller for 2008 than for 2005 for most pollutants. The calculated road transport emissions are similar to the NAEI estimates.

The calculated emissions from rail transport for 2008 are similar to the 2005 estimate, with emissions of some pollutants increasing while others have decreased, mostly as the result of revised emission factors. The emissions from rail transport amount to approximately 30% of the NAEI estimates of emissions from the "other transport" sector. The other transport sector includes off-road transport, mobile machinery and aircraft emissions, which have not been estimated in detail in this update.

Comparison of the relative contributions made by each source sector to the total emissions shows NO_x, PM_{10}, $PM_{2.5,}$ CO, benzene and 1,3 butadiene are dominated by emissions made from the transport source sectors. Transport accounts for over 50% of total emissions of NO_x, $PM_{2.5,}$ CO, and 1,3 butadiene. Point sources such as Part A and B processes and other combustion sectors are a significant source of CO_2, SO_2, PM_{10} and $PM_{2.5}$. Agriculture and nature makes a significant contribution to benzo(a)pyrene emissions. Solvent use and production processes accounts for two thirds of NMVOC emissions.

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1 Introduction

1.1 Background

Slough Borough Council has had its emissions inventory updated on a regular basis since 1999 (1997 base year). Each update has revised core elements such as roads and industrial point sources, though other less substantial sources have also been updated in some years. The last update was for 2005[2].

Air quality and climate change issues require national, regional and local governments to take action to curb emissions. Co-ordinated actions are required to be taken at all levels of government in order for the UK to achieve national and international air quality standards and emissions reduction targets to reduce local and global impacts. The development of an emissions inventory is an important mechanism for quantitatively judging the effectiveness of emission reduction initiatives at local, regional and national levels and is a key input into dispersion modelling, used for assessing air quality.

At the local level, there are a number of statutory requirements on Local Authorities that would require access to local atmospheric emissions data particularly for their local council area, as well as for their region. Local emissions data are particularly required:

- To support the Local Air Quality Management (LAQM) review and assessment process, both as an input to dispersion modelling to ascertain the likelihood of achievement of the national air quality objectives and in quantifying the impact of the implementation of options within the air quality action plan.

- As an input to dispersion modelling, to allow Local Authorities to assess the impact of proposed planning applications on air quality.

- In the development of Local Transport Plans, so that transport planners can have an understanding of baseline emissions from road transport to quantify the likely emission reduction as a result of the implementation of options within the Local Transport Plan.

- Additionally, an inventory can also be used to assess action to reduce greenhouse gases such as carbon dioxide.

This report presents the updated Slough emissions inventory for 2008. Data related to road traffic, rail and industrial point sources have been updated for this inventory.

1.2 Pollutants covered by the Emissions Inventory

The 2008 emissions inventory for Slough details emissions of the following pollutants, for identifiable sources in the area where data are available.

- Nitrogen dioxide (NO_x);
- Particulate matter (PM_{10});
- Particulate matter ($PM_{2.5}$);
- Sulphur dioxide (SO_2);
- Carbon monoxide (CO);

[2] Slough Emissions Inventory for 2005. AEAT/ENV/R/48579/Issue 1. March 2007.
http://www.slough.gov.uk/documents/SloughEmissionsInventory2005.pdf

- Carbon dioxide (CO_2)
- Benzene;
- 1,3 butadiene;
- Non-methane volatile organic compounds (NMVOCS); and
- Polycyclic aromatic hydrocarbons (PAH) using benzo(a)pyrene as an indicator

1.3 Emissions Sources covered by the Inventory

The emission sources are presented, via a geographical information system, in three broad categories:

- Stationary point sources – for industrial regulated plant, boilers and petrol stations;
- Mobile line sources – related to road, rail and air transportation;
- Area sources – other influential sources, often related to population, which are not specifically resolved as point or line representations.

1.4 Update of Inventory for 2008

The Slough emission inventory update for 2008 includes:

- A revision of industrial emission sources using data provided by Slough Borough Council and the Environment Agency
- Revise all boilers greater than 2 MW
- Update emissions resulting from petrol stations
- Revised road transport emissions estimates, particularly considering changes in traffic flows and minor road estimates
- Update rail emissions

Emission estimates for other sectors are based on the estimates made for the National Atmospheric Emission Inventory.

2 Methodology for the 2008 update

2.1 Introduction

This section describes the methods used in this update to estimate the emissions from point sources, road transport and rail transport. It then describes how these estimates were combined with mapped estimates for other emission sources from the National Atmospheric Emission Inventory to calculate total emissions for Slough.

2.2 Point Source Emissions

Emission estimates have been made for Part A and Part B industrial processes, and for boilers and petrol stations, in Slough for 2008. Each industrial process has been treated as a point source in the Slough emission inventory. In order to produce a total of all the 2008 emission estimates for individual source categories, it was also necessary to convert individual point source maps into a 1 x 1 km area version. It should be noted that in general, industrial sources contribute less to ground level air pollution compared to road transport for many of the pollutants covered by the Air Quality Strategy.

2.2.1 Part A processes

There are 8 Part A industrial processes operational within the study area. These are:

- Slough Heat and Power Ltd
- S. Grundon (Waste) Ltd
- ICI Paints Ltd
- Metal Colours Ltd.
- Colnbrook Landfill
- Lonza Biologics
- Mars UK Ltd
- Lakeside Energy from Waste Ltd

Emissions from the Colnbrook Landfill site are incorporated within SNAP code 09 of the NAEI (Waste Treatment & Disposal category) and are thus not included here. The Lakeside Energy from Waste Ltd plant became operational in 2010 and is not included in this 2008 inventory.

Emissions from Metal Colours Ltd, Mars UK Ltd and Lonza Biologics reported to the Environment Agency [3] were all below reporting thresholds. This inventory does not include emissions from these sources, in the absence of any data.

Emissions from Slough Heat and Power Ltd for carbon dioxide and oxides of nitrogen were obtained from the United Kingdom Pollutant Release and Transfer Register[4]. Emissions of particulate matter (PM_{10} and $PM_{2.5}$) and sulphur dioxide for this site were obtained from the NAEI point source database[5]. Emissions of carbon monoxide and non-methane VOCs and carbon monoxide for this source were carried forward from the 2005 inventory.

[3] http://www.environment-agency.gov.uk

[4] http://prtr.defra.gov.uk/

[5] http://naei.defra.gov.uk/mapping/mapping_2008.php

Emissions from S. Grundon (Waste) Ltd were below the Environment Agency reporting thresholds. Estimates of emissions of were obtained from the NAEI point source database. However, the NAEI estimate of carbon dioxide emissions for this source was greater than the reporting threshold and so the emission value was set to the reporting threshold (10,000 tonnes per annum of carbon dioxide).

The emissions from ICI Paints were less than the Environment Agency thresholds. The NAEI point source database provided operator-reported emissions of non-methane VOCs. Emissions of other pollutants from this source were carried forward from the 2005 inventory: the 2005 inventory emission estimate for carbon dioxide was at the reporting threshold.

Each of the Part A sources was allocated to a 1 km x 1 km square within Slough and total emissions were calculated for each square.

2.2.2 Part B Processes

Slough Borough Council identified 19 Part B processes excluding petrol stations (discussed in Section 2.2.4). Table 1 lists the operator names and provides a summary of the approach used to estimate the emissions. The table identifies the most important pollutants for each source. Measured data was used where possible, although in many cases the measurements were made some time ago. We used emission factors from the National Atmospheric Emission Inventory database or from the US Environmental Protection Agency Compilation of Air Pollutant Emission Factors[6] to estimate emissions from other processes. The table entry "N/A" indicates that the pollutant emission is not considered significant for the particular source and has not been estimated. The table entry "No data" indicates that there was no data available that could be used to estimate the emissions.

Particulate matter, PM_{10} emissions were estimated to be 50% of total suspended particulate emissions, where no size-specific data was available. Similarly, PM_{10} emissions were estimated to be 17.5% of total suspended particulate emissions.

Each of the Part B sources was allocated to a 1 km x 1 km square within Slough and total emissions were calculated for each square.

[6] http://www.epa.gov/ttnchie1/ap42/

Table 1: Approach used to estimate emissions from Part B processes

Operator Name	Process	Potential Pollutants	VOCs	PM	CO	NOx	SO2
DUCO International	Textile and fabric coating and finishing process	VOCs, PM	Measured data collected for 2002 inventory				N/A
Autodex Holdings Ltd	Respraying Vehicles	VOCs, PM	0.24 tonnes NMVOC per tonne solvent	Measured data collected for 2002 inventory	N/A	N/A	N/A
Rainbow Bodyshop	Respraying of road vehicles	VOCs, PM			N/A	N/A	N/A
R & C Motor Company Ltd	Respraying of road vehicles	VOCs, PM		0.05 tonnes total suspended particulate per tonne of solvent based on Autodex and Rainbow data	N/A	N/A	N/A
ICI Paints	Coating manufacture	VOCs, PM	No data	Measured data collected for 2002 inventory	N/A	N/A	N/A
WR Grace Ltd	Bituminous	VOCs, PM	No data	No data	N/A	N/A	N/A
BPV Servicing & SAAB Spares	Waste oil burner	Products of combustion	N/A	US EPA emission factors, kg m^{-3}			
				6.1	0.6	2.3	17.6
Emanuel Brothers Ltd	Respraying of road vehicles	VOCs, PM	0.24 tonnes NMVOC per tonne solvent	Measured data collected for 2002 inventory	N/A	N/A	N/A
Federal Mogul Sealing Systems	Surface cleaning treatment	VOCs, PM	0.59 tonnes NMVOC per tonne solvent	Measured data collected for 2002 inventory	N/A	N/A	N/A
Tigwell & William	Respraying of vehicles	VOCs, PM	0.24 tonnes NMVOC per tonne solvent	0.05 tonnes total suspended particulate per tonne of solvent based on Autodex and Rainbow data	N/A	N/A	N/A
Wiggins Transport Ltd	Crushing and grinding concrete	PM		US EPA 0.0012 kg PM_{10}/ tonne material	N/A	N/A	N/A
Wagstaff Foundries Ltd	Iron sand-casting production process	PM, VOCs	No data	0.626 kg/tonne NAEI database	N/A	N/A	N/A
Slough Cemetery & Crematorium	Crematorium	Products of combustion	NAEI Emission factors, tonnes per 1000 cremations, 1500 cremations per year				
			0.013	0.00003	0.141	0.309	0.054
Bodytechnics Ltd	Respraying of road vehicles	VOC, PM	No data	No data	N/A	N/A	N/A
London Concrete (Heathrow Plant)	Mixing concrete	PM	N/A	Emission factor recommended by Slough Environmental Health 0.164 kg per tonne	N/A	N/A	N/A
	Unloading cement	PM	N/A		N/A	N/A	N/A
Autotech ARC	Respraying of Road Vehicles	VOCs, PM	0.24 tonnes NMVOC per tonne solvent	0.05 tonnes total suspended particulate per tonne of solvent based on Autodex and Rainbow data	N/A	N/A	N/A

Operator Name	Process	Potential Pollutants	VOCs	PM	CO	NOx	SO2
Autotech Slough Ltd	Respraying of Road Vehicles	VOCs, PM	No data	No data	N/A	N/A	N/A
Wartsil Propulsion			No data	No data	N/A	N/A	N/A

2.2.3 Boiler Processes

Local authorities are now required to collate energy data for their sites. Slough Borough Council provided energy consumption and fuel type data for 135 boilers operated at schools, libraries, community centres, care homes and other council-run properties. All of these boilers were rated with less than 2 MW thermal input. Emissions were estimated from this data using emission factors for miscellaneous industrial/commercial combustion from the National Atmospheric Emission Inventory database[7]. Each of the boilers was allocated to a 1 km x 1 km square within Slough and total emissions were calculated for each square.

2.2.4 Petrol Stations

Slough Borough Council provided updated fuel throughput data for the 15 operational petrol stations within the local area. The emissions of NMVOC, benzene and 1,3-butadiene were then estimated using emission factors from the National Atmospheric Emission Inventory database.

Each of the Petrol station sources was allocated to a 1 km x 1 km square within Slough and total emissions were calculated for each square.

2.3 Road Transport Sources

Road traffic estimates in the Slough emissions inventory have been divided into 3 separate categories as follows:

- Major and minor road emissions (including brake and tyre wear),
- Cold start, and
- Evaporative losses.

The following sections describe the methodologies and data used in more detail.

2.3.1 Major and Minor road emissions

'Major roads' in this inventory are defined as either motorways or A roads and all other roads are classified as 'minor roads'. Emissions from both road categories were determined using NAEI speed related emission factors.

Slough Borough Council reported that there had been that no major updates to the road network since the 2005 inventory update. The SATURN modelled data provided by Slough Borough Council for the 2005 update was therefore used for the 2008 update. Slough Borough Council also provided 24–hour classified traffic counts for 21 sites throughout the Borough for 2009. The Highways Agency provided annual average daily traffic flows and fraction of vehicles greater than 6.6 m for 12 motorway sites for 2008. These data were used to update the SATURN modelled flows as described below.

The SATURN modelled data provided the Ordnance Survey coordinates of the end points of each of the links included in the road traffic model. In general, this road network provides an adequate spatial description when compared with more detailed maps. However, the SATURN network does not correspond to more detailed mapping of the M4 motorway between Junctions 5 and 6. This road link was reshaped to correspond to the route of the motorway between Junctions 5 and 6.

We identified the SATURN road links corresponding to the Slough Borough Council and Highways Agency traffic counts. The SATURN data provides modelled traffic flows in

[7] http://naei.defra.gov.uk/emissions/

Passenger Car Units (PCU). The ratio of PCU flows to total traffic flows was estimated for each of these links using the following vehicle weightings:

Motorcycle	0.5 PCU
Car	1.0 PCU
Light Goods Vehicle	1.0 PCU
Rigid Heavy Goods Vehicle	1.9 PCU
Articulated Heavy Goods Vehicle	2.9 PCU
Buses	2.5 PCU

The fractions of each vehicle category were taken from the classified counts. The long vehicle fraction on the motorways was split between LGV, rigid HGV, artic HGV and buses according to the national split for motorways[8]. The short vehicle fraction was similarly split between cars and motorcycles. Where data did not contain a value for long vehicle fraction, the traffic was split according to national split. The average PCU/total traffic ratios were calculated for motorway, major and minor road sites separately.

The SATURN modelled data gives am, pm and daily interpeak hourly flows. We assumed that these correspond to 08:00-09:00, 17:00-18:00 and the average of 10:00-16:00 hrs. The non-motorway counts provide average weekly 2-way flows for each hour of the day and the average total flows. A scaling factor was derived for each count site as the ratio AADT: sum of flows for the modelled hours. For the motorways, the scaling factor was similarly derived from National Road Traffic Statistics (roadtraffdata08). Average scaling factors were calculated for motorway, major and minor sites separately.

The SATURN modelled traffic flows are for 2005. These were scaled to 2008 according to National Road Traffic Forecasts[9] for the SE region adjusted using Tempro factors for Slough. (1.039715).

Annual average daily traffic flows for 2008 were then estimated from the SATURN data using the appropriate average PCU: total traffic ratio, the AADT: sum of the am, pm and six interpeak hour flows ratio and the year factor. The measured traffic counts were then plotted against the flows estimated from the SATURN model. Fig.1 shows the measured and modelled counts for motorways. Fig. 2 similarly shows the counts for the other major roads and minor roads. The trend lines through the points have slopes 1.000 and 0.775 respectively. These factors were used to adjust the estimated flows throughout the whole network. The estimated flows were used for all links where actual count data was not available: actual counts were used where they were available.

[8] http://webarchive.nationalarchives.gov.uk/+/http://www.dft.gov.uk/pgr/statistics/datatablespublications/roadstraffic/speedscongestion/roadstatstsc/roadstats08tsc

[9] http://webarchive.nationalarchives.gov.uk/+/http://www.dft.gov.uk/pgr/economics/ntm/AF07_Annex_Baseline_summary.xls

Fig. 1: Comparison of modelled traffic estimates with actual counts for motorways

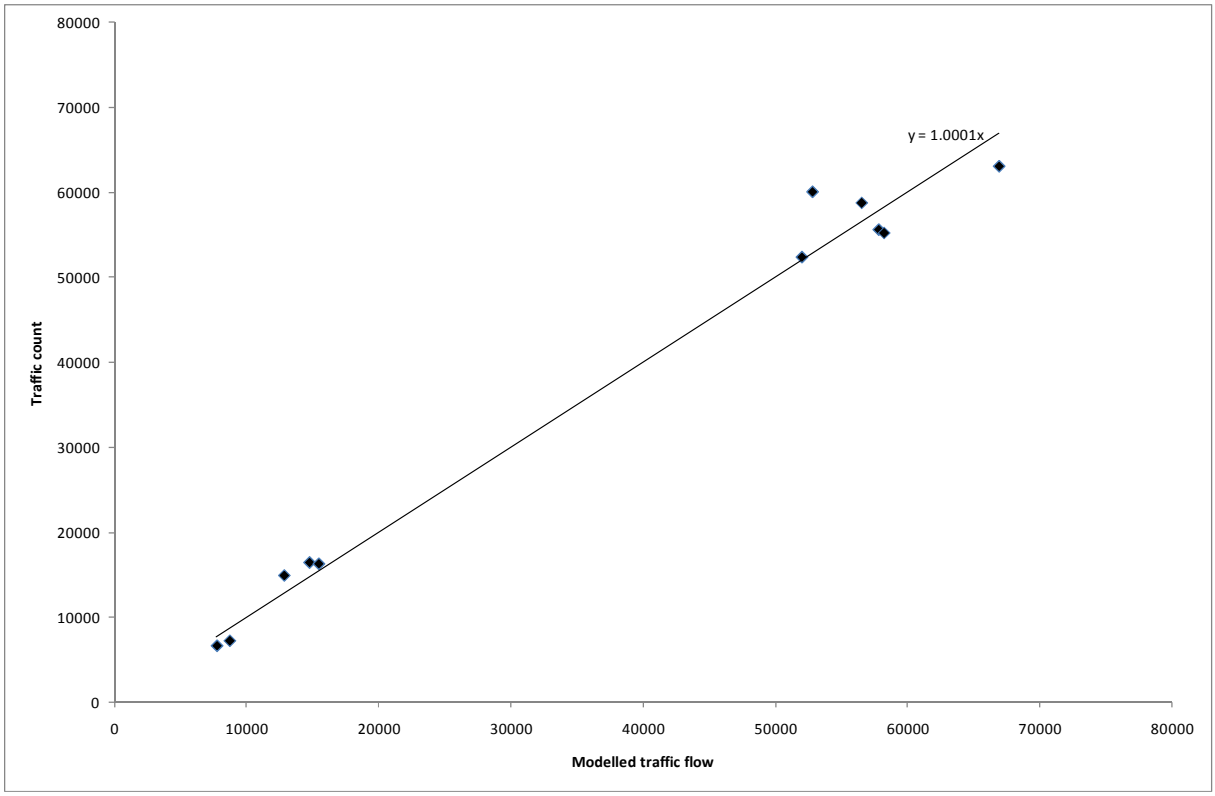
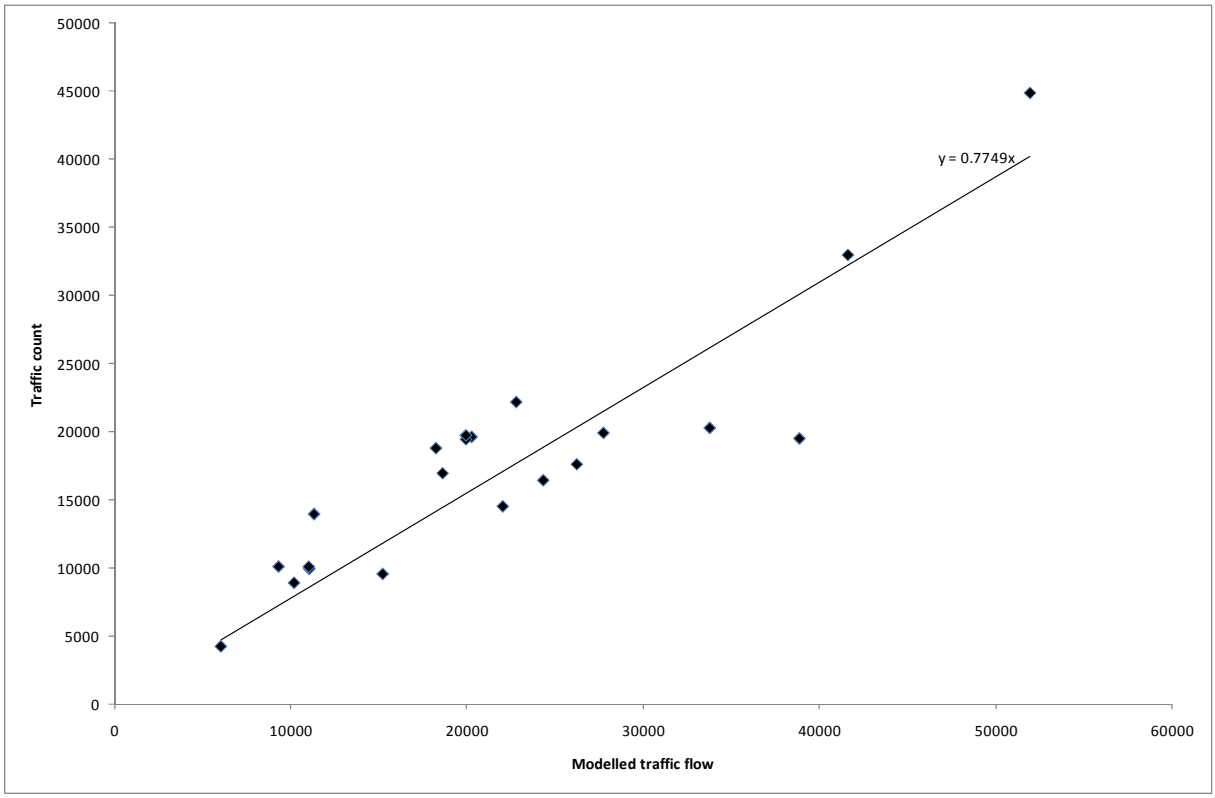


Fig. 2: Comparison of modelled traffic estimates with actual counts for other major roads and minor roads.



We used AEA's LADSUrban model to calculate the emissions from motorway, other major road and minor road links in each 1 km x 1 km grid square of the Slough outer grid shown in

Fig. 3. The Slough outer grid includes the whole of the Borough. We calculated total emissions for the outer grid. We also calculated total traffic emissions for the area allocated to Slough Borough Council in the NAEI maps, also shown in Fig. 3 to allow comparison with emissions from other sectors included in the NAEI maps.

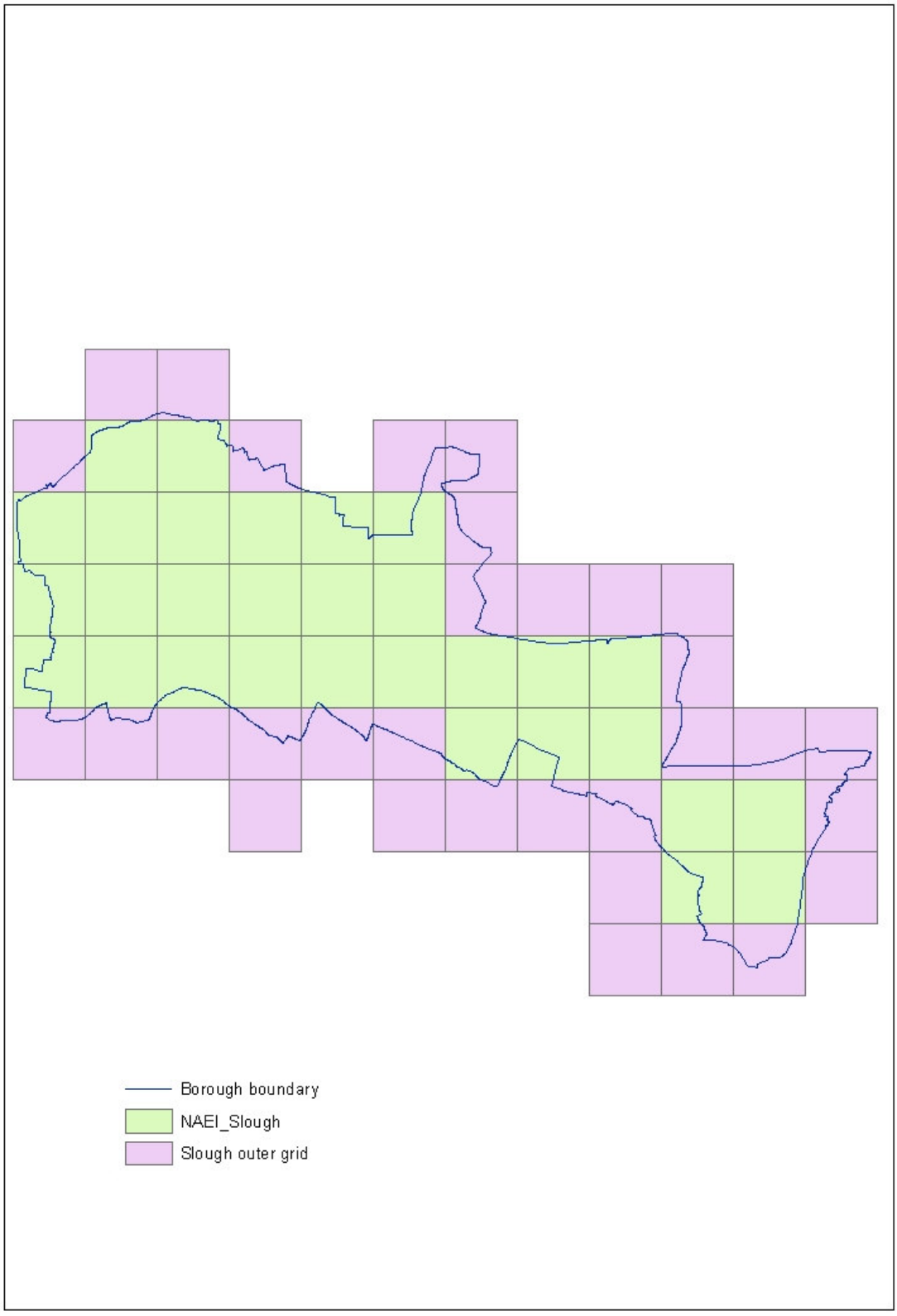
The model calculated the emissions of the following pollutants:

- Benzene
- 1,3-Butadiene
- Carbon monoxide
- Carbon dioxide
- Hydrocarbons
- Non-methane Volatile Organic Compounds (NMVOC)
- Oxides of nitrogen
- Particulate matter, PM_{10}
- Particulate matter, $PM_{2.5}$
- Sulphur dioxide

The particulate matter emission includes the contribution from brake and tyre wear.

The LADSUrban model has been updated since the 2005 update to take account of new emission factors released in 2009. The model requires annual average daily traffic flows, average vehicle speeds and the fractions of cars, light goods, rigid heavy goods, articulated heavy goods, buses and motorcycles for each road link. We used the SATURN modelled speed for the interpeak period for each road link. The Slough Borough Council traffic counts provide information on the traffic mix for specific road links. The Highways Agency counts provide some information on the fraction of Heavy Duty Vehicles on the motorway links. We used this data for the appropriate road links. For other motorway links, we used the national traffic split for motorways (roadtraffdata08). For other major road links, we used the average fractions from the Slough Borough Council counts for A-class roads. For other minor road links, we used the average fractions from the Slough Borough Council counts for minor roads.

Fig.3:1 km x 1 km emission grids used to calculate emission totals for Slough



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2.3.2 Cold starts and evaporative emissions

When vehicles are operating under cold start conditions, i.e. at temperatures below their performance optimum, the rates of emission are higher for a number of pollutants. It is therefore important to make an assessment of emissions for cold starts in order to provide a representative picture of emissions in an area.

The excess emissions of carbon monoxide, oxides of nitrogen, non-methane VOCs, particulate matter, sulphur dioxide and carbon dioxide from cars and light goods vehicles were estimated from the hot emissions using the following formula:

$$E_{cold}/E_{hot} = \beta.\left({}^{e_{cold}}/_{e_{hot}} - 1\right)$$

where:

E_{hot} is the hot exhaust emission
β is the fraction of kilometres driven with cold engines
e_{cold}/e_{hot} is the ratio of cold to hot emissions for the particular pollutant and vehicle type

The parameters β and e_{cold}/e_{hot} are dependent on ambient temperature, length of trip, vehicle type and emissions control technology. Values of these parameters were calculated using the methods set out in the EMEP/EEA air pollutant emission inventory guidebook[10]. We used monthly average temperature data for Heathrow Airport for 2008 and assumed an average trip length of 10 km and an average vehicle speed on urban roads of 25 kph. We calculated average values of

$$\beta.\left({}^{e_{cold}}/_{e_{hot}} - 1\right)$$

for cars and light goods vehicles based on NAEI Fleet composition projections for 2008. Table 2 shows the values of the combined parameter used. The fuel factors were applied to emissions of carbon dioxide, sulphur dioxide, benzene and 1, 3-butadiene.

Table 2: Cold start emission adjustment factor

Vehicle type	E_{cold}/E_{hot} for each pollutant				
	CO	NOx	VOC	PM	fuel
Cars	0.502	0.100	0.653	0.077	0.115
LGV	0.239	0.069	0.485	0.408	0.095

We assumed that cold start emissions are negligible for motorway traffic and for heavy duty vehicles because the trip length for these vehicles is longer.

Evaporative emissions of petrol vapour from the tank and fuel delivery systems in vehicles constitute a significant fraction of NMVOC emissions from road transport. There are three different mechanisms by which petrol evaporates from vehicles:

Diurnal loss
This arises from the increase in the volatility of the fuel and evaporation due to the diurnal rise in ambient temperature. Evaporation through tank breathing occurs each day for all petrol vehicles, even when stationary.

[10] http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009

Hot soak loss
This represents evaporation from the fuel delivery system when a hot engine is turned off and the vehicle is stationary. It arises from the transfer of heat from the engine and hot exhaust to the fuel system.

Running loss
These are the evaporative losses that occur while the vehicle is in motion.

We calculated the evaporative emissions of VOCs for diurnal, hot soak and running losses using equations from the Greenhouse Gas Inventory Annual report, 2009. We used monthly average temperature data for Heathrow Airport for 2008 and assumed a Reid Vapour pressure of 68 kPa. We calculated average emission factors for cars and light goods vehicles based on NAEI Fleet composition projections for 2008. Table 3 shows the values of the emission factors used.

Table 3: Evaporative emission factors for NMVOCs

	Diurnal loss, g/veh.day	Hot soak, g/veh.trip	Running loss, g/veh.km
Cars	0.699	0.113	0.00135
LGV	0.0665	0.006	0.00013

We estimated the number of cars and light goods vehicles in Slough from the national totals (27,021,000 cars and 3,303,000 light good vehicles) on the basis of 2001 population statistics. We then allocated the number of cars and light goods vehicles in each 1 km x 1 km square in Slough for the calculation of diurnal emissions on the basis of the 2001 population.

We assumed that hot soak emissions occur on A roads and minor roads but not on motorways. The number of trips was estimated from the number of car and light goods vehicle kilometres (flow x length of link) assuming an average trip length of 10 km. The emissions from each road link were then allocated to 1 km x 1 km squares throughout Slough.

Running losses were assumed to occur on all roads. The running loss on each road link was calculated from the number of car and light goods vehicle kilometres (flow x length of link). The emissions from each road link were then allocated to 1 km x 1 km squares throughout Slough.

2.4 Rail

There are 2 railways lines operational within the Slough local authority region. No train data was available for the shorter Poyle line however it has been assumed that emissions along this link will be minimal. As with the previous update of the inventory the Poyle line is thus not included quantitatively within this inventory.

Slough is located on the Great Western Line linking Reading with London. Both freight and passenger trains use the line on a daily basis. Estimates of the train movements on this line were taken from the (DATE) Environmental Statement undertaken for Slough Trading Estate, which is situated on the railway line. The ES recorded 488 daily movements, of which 46 were freight, 194 intercity and 248 regional. Emissions for each train type were calculated using these railway movements and emission factors from the NAEI database.

2.5 Total emissions

The UK National Atmospheric Emissions Inventory (NAEI) is the standard reference air emissions inventory for the United Kingdom, and includes emission estimates for a wide range of important pollutants. The NAEI calculates these emissions by applying an emission factor, derived from measurements considered to be representative of a particular source and sector, to an appropriate activity statistic.

Data are made publicly available via an annual report, queriable datasets and emissions maps via http://www.naei.org.uk.

Emissions of pollutants are given by the National Atmospheric Emissions Inventory in the form of UK maps, which spatially illustrate emissions of various pollutants at a 1 km by 1 km resolution using a published methodology (http://www.naei.org.uk/reports.php). These maps are frequently used as a starting point for many local emission inventories.

The NAEI mapped emissions are aggregated to twelve source sectors shown below. This uses the SNAP (Selected Nomenclature for reporting of Air Pollutants) nomenclature developed as part of the EU CORINAIR emission inventory programme and harmonised with nomenclature used by the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Economic Commission for Europe (UNECE).

01	Combustion in energy production and transformation
02	Combustion in commercial, institutional and residential and agriculture
03	Combustion in industry
04	Production processes
05	Extraction and distribution of fossil fuels
06	Solvent use
07	Road transport
08	Other transport and mobile machinery
09	Waste treatment and disposal
10	Agriculture, forestry and land use change
11	Nature
Point sources	Large point source emissions

The NAEI emission totals for sectors 01-11 exclude the emissions from point sources. The NAEI estimates the total emissions from Slough as the sum of these emissions.

The 2008 inventory update for Part A and Part B processes provides information corresponding to the NAEI Point source inventory. Similarly, the 2008 update provides information corresponding to Sector 07: Road transport. The main facilities in Slough associated with the extraction and distribution of fossil fuels (SNAP sector 5) are petrol stations. We have therefore substituted the emissions calculated for this update for the Point source and SNAP sectors 5 and 7 in the emissions totals.

The 2008 update provides estimates of the emissions from rail transport, based on local information on train movements. Rail transport is one component of the SNAP sector 08 emissions: other transport. Emissions from off-road vehicles, mobile machinery and aircraft also contribute to this sector, but have not been quantified separately as part of this update. We compare the emissions for rail transport with the NAEI totals for this sector: however, the NAEI sector total is used in the calculation of the emission totals.

The emissions from boilers operated at schools, libraries, care homes and other council-run premises contribute to SNAP sector 02. Emissions from other sources in this sector have not been quantified as part of this update. We compare the emissions for these boilers with the NAEI totals for this sector: however, the NAEI sector total is used in the calculation of the emission totals.

Part B processes (other than petrol stations) may contribute to the SNAP sector 03: combustion in industry, SNAP sector 04 Production processes and SNAP sector 06: Solvent use. The NAEI totals have been used in the calculation of emission totals. This may result in some double counting: however, the contribution from the identified Part B processes is small compared with the NAEI sector totals.

3 Results of the 2008 update

3.1 Point source emissions

Emissions from Part A processes, Part B processes, Boilers and Petrol Stations were estimated for Slough in 2008. Table 4 shows point source emissions in 2008, and Table 5 shows point source emissions for 2005 from the previous emissions inventory report (AEA, 2007).

Table 4: Emissions from point sources for all pollutants in 2008 in tonnes/year.

Pollutant	Part A	Part B	Part A +Part B	Boilers	Petrol Stations	Total
NO_x	340.3	0.5	340.8	6.5	0	347.3
PM_{10}	5.3	36.6	41.9	0.17	0	42.1
$PM_{2.5}$	3.9	12.9	16.8	0.24	0	17.1
SO_2	82.3	0.1	82.4	5.16	0	87.6
CO	57.7	0.3	60.0	1.2	0	59.2
CO_2 (as C)	65181.8		65181.8	2236.64	0	67418.4
Benzene	0.69		0.69	0.02	0.25	1.0
1,3 Butadiene				0	0.03	0.03
PAH				0	0	0.0
NMVOC	3.5	34.5	38.0	0.3	108.8	147.1

Table 5: Emissions from point sources for all pollutants in 2005 in tonnes/year (AEA, 2007).

Pollutant	Part A	Part B	Boilers	Petrol Stations	Total
NO_x	332.46	70.38	8.91	0	411.74
PM_{10}	18.65	41.73	0.85	0	61.23
$PM_{2.5}$	16.06	16.03	0.57	0	32.66
SO_2	195.06	11.78	11.86	0	218.69
CO	66.61	5.39	0.53	0	72.53
CO_2 (as C)	260194.00	1901.08	2145.08	0	264240.16
Benzene	0	0	0.04	0.76	0.80
1,3 Butadiene	0	0	0	0.04	0.04
PAH	0	0	0	0	0.00
NMVOC	4.53	37.46	0.50	182.55	225.04

The total estimated emissions from point sources are smaller for 2008 than for 2005 for each pollutant (except benzene).

Estimated emissions from Part A processes in 2008 are broadly similar to those in 2005. The emissions of carbon dioxide for Slough Heat and Power reported to the Pollutant Release and Transfer Register are smaller than those included in the 2005 inventory.

Total Part B emissions are smaller in 2008 than in 2005. Emissions of oxides of nitrogen, in particular are considerably smaller because more realistic estimates of the number of cremations per year were available.[11]

There was generally a reduction in boiler emissions apart from CO_2 and CO. There was an increase in available data for the 2008 inventory compared to the previous update and more sources were included in the inventory. Nevertheless, the total emission from boilers was smaller in 2008 for many pollutants because the emission factors were smaller.

Petrol stations have seen a slight reduction in estimated emissions. There was no change in the throughput data provided by Slough Borough Council: the reduction is a result of an update in the NAEI emissions factors which take account of improved emission controls at petrol stations.

3.2 Road transport

Table 6 shows the calculated emissions totals for the outer Slough grid area for motorways, other major roads, minor roads and cold start ad evaporative emissions. Table 7 shows the emission estimates presented in the 2005 inventory report.

Table 6: Emissions from road transport for all pollutants in 2008 in tonnes/year for the Slough outer grid.

Pollutant	Motorways	Major Roads	Minor Roads	Cold Starts and evaporative emissions	Totals
NO_x	1100.5	119.4	140.3	14.8	1375
PM_{10}	44.9	7.4	10.3	1.8	64.4
$PM_{2.5}$	37.9	5.2	7.3	1.3	51.7
SO_2	4.6	0.7	1.1	0.2	6.6
CO	1431.0	347.7	654.2	454.8	2887.7
CO_2 (as C)	65694	10517	14696	2593	93500
Benzene	3.1	1.1	2.0	0.3	6.5
1,3 Butadiene	1.4	0.8	1.1	0.2	3.5
PAH*					0
NMVOC	154.7	37.9	72.2	81.6	346.4

*Emissions not calculated

[11] http://www.slough.gov.uk/services/810.aspx

Table 7 Emissions from road transport for all pollutants in 2005 in tonnes/year for the Slough outer grid

Pollutant	Major Roads	Minor Roads	Hot & Cold Starts	Total
NO_x	1837.83	292.58	63.70	2194.1
PM_{10}	75.94	20.60	3.02	99.6
$PM_{2.5}$	61.36	15.01	2.71	79.1
SO_2	8.84	2.10	0	10.9
CO	1436.02	678.48	939.38	3053.9
CO_2 (as C)	94591.26	25160.07	0	119751.3
Benzene	2.72	1.55	3.44	7.7
1,3 Butadiene	4.81	1.25	0.44	6.5
PAH*	-*	-*	-*	
NMVOC	211.94	74.95	273.35	560.2

* Emissions not calculated

Table 6 indicates that motorways (M4) provide the largest contribution to traffic emissions. The motorway accounts for approximately 70% of NO_x, PM_{10}, $PM_{2.5,}$ SO_2 and CO_2 emissions and more than 40% of CO and NMVOC emissions.

The emissions calculated for 2008 are smaller than those calculated for 2005 for most pollutants. The emissions for motorways and major roads are lower in 2008 for oxides of nitrogen, particulate matter and sulphur dioxide and slightly higher for carbon monoxide, benzene and 1,3-butadiene. The emissions on minor roads are generally smaller in 2008. Cold start and evaporative emissions are also smaller. Several factors contribute to the changes in emissions: these include differences in emission factors and inventory methodology, improved emissions control systems and changes in traffic flows.

Emissions of PAHs are difficult to calculate using the bottom-up methodology deployed by this inventory and therefore only the NAEI estimate is included in this report. The NAEI uses the emissions of benzo(a)pyrene as an indicator for PAH emissions.

Table 8 lists the emission totals from road transport for the area covered by the NAEI grid for Slough. The emissions are smaller than for the Slough outer grid, because the grid is smaller. The totals are similar to those reported by the NAEI but differences arise because of differences in traffic flows, vehicle speeds and emission factors.

Appendix 1 shows the emissions of pollutants from road transport mapped onto a 1 km x 1 km grid covering the outer Slough grid area. The highest emissions of each pollutant are located along the route of the M4 motorway.

Table 8: Emissions from road transport for all pollutants in 2008 in tonnes/year for the NAEI Slough grid.

Pollutant	Motorways	Major Roads	Minor Roads	Cold Starts and evaporative emissions	Totals	NAEI total
NO_x	395.3	86.3	87.0	9.6	578.2	545.9
PM_{10}	17.2	5.4	6.5	1.2	30.3	31.9
$PM_{2.5}$	14.5	3.8	4.6	0.9	23.8	
SO_2	1.86	0.55	0.71	0.12	3.24	1.98
CO	836.1	270.4	437.2	322.9	1866.6	2701.4
CO_2 (as C)	26550.5	7771.9	10153.6	1745.6	46221.6	40676.9
Benzene	1.52	0.86	1.34	0.24	3.96	10.30
1,3 Butadiene	0.40	0.57	0.65	0.12	1.75	3.33
PAH*						0.0005 (Benzo(a) pyrene)
NMVOC	98.4	29.8	49.0	58.7	235.9	214.6

*Emissions not calculated

3.3 Other transport sources

Table 9 lists the emissions from rail transport for 2008 calculated both for the Slough outer grid and for the NAEI Slough grid. The emissions for the NAEI Slough grid are slightly smaller because the grid area is smaller.

Rail emissions contribute part of the emissions from the SNAP category “other transport”. Other emission sources in this category include the emissions from off-road transport and mobile machinery and aircraft. Table 9 also shows the total emissions allocated by the NAEI to “other transport” for the NAEI Slough grid area. The rail emissions calculated for Slough make up approximately 30% of the emissions allocated by the NAEI to “other transport”.

Table 10 shows the emissions calculated for the Slough outer grid area for the 2005 inventory. The 2005 inventory included 619 train movements, of which 36 were freight. The Slough Trading Estate Environmental Statement provided the local data for this inventory which recorded 488 movements, of which 46 were freight. The rail emissions calculated for 2008 are broadly similar to those for 2005, with emissions for some pollutants increasing while others decrease, largely as the result of changes in the emission factors used.

Table 9 Emissions from other transport for all pollutants in 2008, in tonnes/year.

Pollutant	Rail (Slough outer grid)	Rail (NAEI grid for Slough)	Other Transport , NAEI
NO_x	307.55	277.4	775.1
PM_{10}	6.48	5.85	28.4
$PM_{2.5}$			
SO_2	10.36	9.35	30.9
CO	91.86	82.9	854.4
CO_2 (as C)	5634.17	5081.9	22188
Benzene	2.41	2.17	4.91
1,3 Butadiene	0.94	0.84	1.82
Benzo(a)pyrene			0.0001
NMVOC	35.99	32.5	108.6

Table 10 Emissions from rail transport for all pollutants in 2005, in tonnes/year.

Pollutant	Rail (Slough outer grid)
NO_x	153.67
PM_{10}	9.91
$PM_{2.5}$	9.31
SO_2	15.15
CO	43.11
CO_2 (as C)	4916.50
Benzene	0.02
1,3 Butadiene	1.01
Benzo(a)pyrene	
NMVOC	19.08

3.4 Total emissions

Table 11 shows the NAEI emission totals for 2008 for the Slough area for each sector:

01	Combustion in energy production and transformation
02	Combustion in commercial, institutional and residential and agriculture
03	Combustion in industry
04	Production processes
05	Extraction and distribution of fossil fuels
06	Solvent use
07	Road transport
08	Other transport and mobile machinery
09	Waste treatment and disposal
10	Agriculture, forestry and land use change
11	Nature
Point sources	Large point source emissions

The NAEI emission totals for sectors 01-11 exclude the emissions from point sources.

Table 12 shows the emission totals where the emission estimates for Sectors 05 and 07 and Point sources have been substituted by emissions estimates from this update.

Comparison of the emissions from boilers at schools, libraries and other council-run property (Table 4) with the sector 02 in Table 11 total indicates that these emissions only represent a small part of the emissions. Comparison of the NMVOC emissions from Part B processes (Table 4) with the Sector 06 emissions indicates that these processes only contribute a small part of the solvent emissions. In section 3.3, we estimated that rail emissions contributed approximately 30% of Sector 08: other transport emissions. Consequently, Table 12 includes the NAEI sector totals for Sectors 2, 6 and 8.

This update does not provide estimates for sectors 1, 3, 4, 9, 10 and 11. The NAEI estimates for these sectors are included in Table 12.

Appendix 1 shows the total emissions of pollutants from all sources mapped onto a 1 km x 1 km grid covering the NAEI Slough grid area. The highest emissions of each pollutant are generally associated with large point sources, principally Slough Heat and Power for combustion emissions and ICI paints for NMVOCs.

Table 11: NAEI Emission totals (tonnes/annum) for the NAEI Slough grid area

Pollutant	SNAP category												
	1	2	3	4	5	6	7	8	9	10	11	Points	Total
NOx	27.6	202.4	309.2	0.0	0.0	0.0	545.9	775.1	0.8	0.0	0.5	345.0	2206.5
PM10	1.0	4.8	10.5	14.8	0.0	11.3	31.9	28.4	5.3	0.1	4.6	7.6	120.3
PM2.5													0
SO2	0.4	22.5	164.4	0.0	0.0	0.0	2.0	30.9	1.2	0.0	0.0	82.2	303.6
CO	10.2	95.6	207.4	0.0	0.0	0.0	2701.4	854.4	26.1	0.0	21.9	2.4	3919.4
CO2 as C	3694.0	42890.4	21072.0	0	3.7	754.7	40676.9	22188.7	64.2	0.3	0	37365.6	168710.5
Benzene	0.04	1.15	0.79	0.00	0.69	0.00	10.30	4.91	0.31	0.00	0.00	0.73	18.92
1,3-butadiene	0.00	0.00	0.00	0.00	0.01	0.00	3.33	1.82	0.02	0.00	0.00	0.00	5.18
Benzo(a)pyrene	0.00000	0.00015	0.00003	0.00002	0.00000	0.00000	0.00053	0.00012	0.00005	0.00000	0.00061	0.00025	0.00176
NMVOC	0.4	9.8	4.3	56.2	95.7	952.5	214.6	108.6	20.2	0.0	5.7	77.8	1545.8

Table 12: Emission totals (tonnes/annum) for the NAEI Slough grid area with estimates for road transport (SNAP category 7), extraction and distribution of fossil fuels and point source (SNAP category 5) and point source emissions taken from this update

Pollutant	SNAP category												
	1	2	3	4	5	6	7	8	9	10	11	Points	Total
NOx	27.6	202.4	309.2	0.0	0	0.0	578.2	775.1	0.8	0.0	0.5	340.8	2234.6
PM10	1.0	4.8	10.5	14.8	0	11.3	30.3	28.4	5.3	0.1	4.6	41.9	153
PM2.5					0		23.8					16.8	40.6
SO2	0.4	22.5	164.4	0.0	0	0.0	3.24	30.9	1.2	0.0	0.0	82.4	305.04
CO	10.2	95.6	207.4	0.0	0	0.0	1866.6	854.4	26.1	0.0	21.9	60.0	3142.2
CO2 as C	3694.0	42890.4	21072.0	0	0	754.7	46221.6	22188.7	64.2	0.3	0	65181.8	202067.7
Benzene	0.04	1.15	0.79	0.00	0.25	0.00	3.96	4.91	0.31	0.00	0.00	0.69	12.1
1,3-butadiene	0.00	0.00	0.00	0.00	0.03	0.00	1.75	1.82	0.02	0.00	0.00		3.62
Benzo(a)pyrene	0.00000	0.00015	0.00003	0.00002	0	0.00000	0.00053	0.00012	0.00005	0.00000	0.00061	0.00025	0.00176
NMVOC	0.4	9.8	4.3	56.2	108.8	952.5	235.9	108.6	20.2	0.0	5.7	38.0	1540.4

3.5 Source Contributions

Figure 4 shows the estimated relative contribution made by each source sector to total emissions. The emission sources have been grouped into 7 categories based on SNAP codes used by the NAEI.

Sector	SNAP sectors
Road transport	7
Other transport	8
Point sources	Point sources
Combustion	1, 2 and 3
Agriculture and nature	10 and 11
Waste treatment	9
Solvent use and production processes	4 and 6

These source sectors were chosen to complement previous studies in Slough and reflect those source sectors typically understood by the general public.

Comparison of the relative contributions made by each source sector shows NO_x, PM_{10}, $PM_{2.5,}$ CO, benzene and 1,3 butadiene are dominated by emissions made from the transport source sectors. Transport accounts for over 50% of total emissions of NO_x, $PM_{2.5,}$ CO, and 1,3 butadiene. Point sources such as Part A and B processes and other combustion sectors are a significant source of CO_2, SO_2, PM_{10} and $PM_{2.5}$. Agriculture and nature makes a significant contribution to benzo(a)pyrene emissions.. Solvent use and production processes account for two thirds of NMVOC emissions.

Fig. 4: Relative contributions from source sectors to total emissions of each pollutant

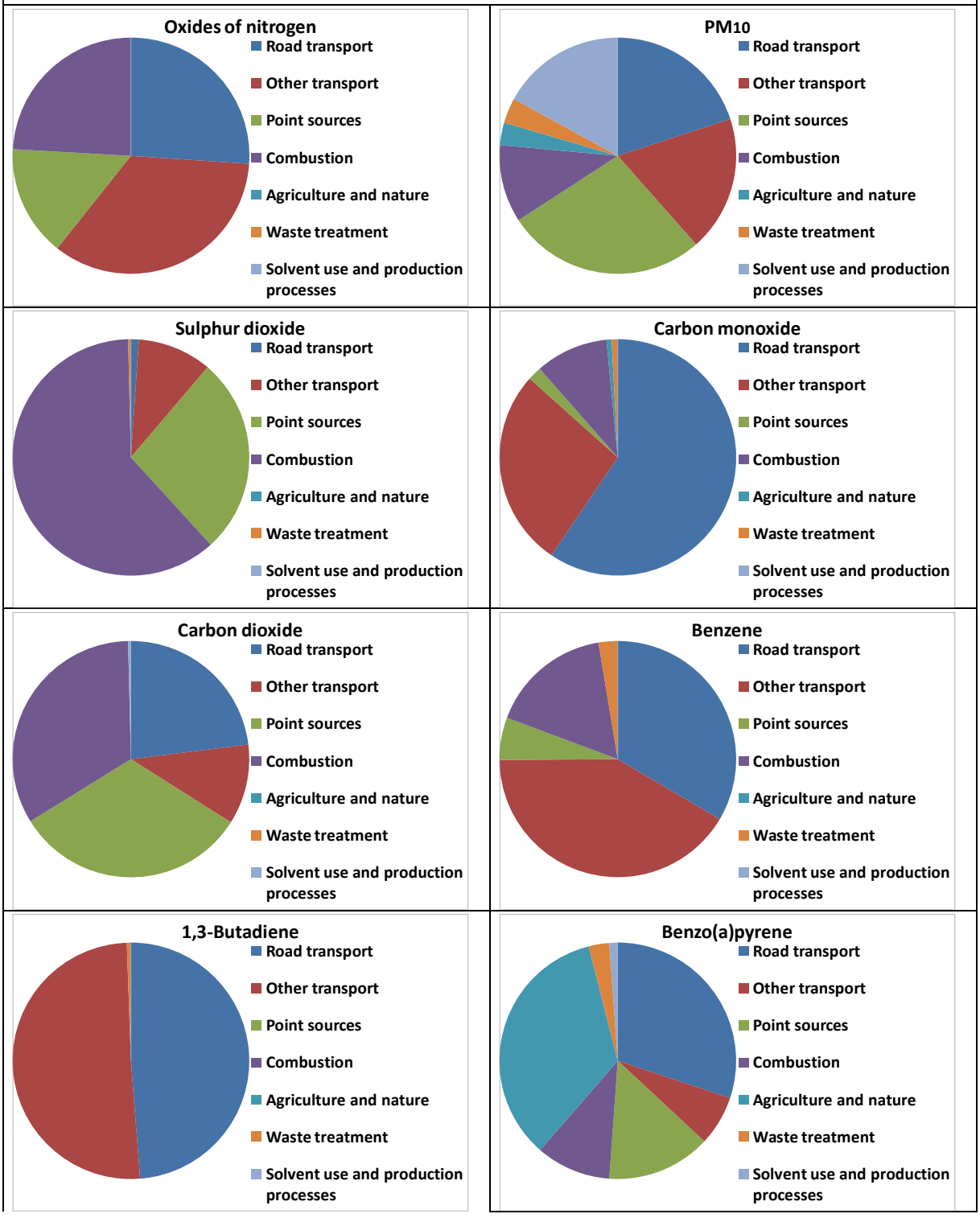
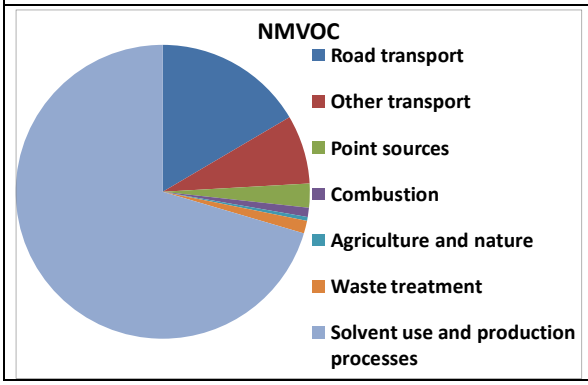


Fig. 4: Relative contributions from source sectors to total emissions of each pollutant



4 Conclusions

This report presents the results of the updated 2008 emissions inventory for Slough. It presents detailed estimates of the emissions from road transport; Part A and Part B point sources; boilers at schools, libraries, care homes and other council properties; and railways. Total emissions for Slough were calculated using NAEI estimates for other sectors as appropriate.

The report presents emissions for 10 different pollutants (NO_x, PM_{10}, $PM_{2.5,}$ CO, CO_2, $SO_{2,}$ benzene, 1,3 butadiene, NMVOCs and benzo(a)pyrene).

The calculated emissions from point sources for 2008 are generally smaller than for 2005. Emissions of carbon dioxide, in particular are substantially smaller because emissions for Slough Heat and Power reported to the Pollution Release and Transfer register are smaller than previous estimates. The calculated emissions from point sources are similar to those calculated by the NAEI for 2008, although the emissions for carbon dioxide are substantially larger.

The calculated emissions from road transport are generally smaller for 2008 than for 2005. The calculated road transport emissions are similar to the NAEI estimates.

The calculated emissions from rail transport for 2008 are similar to the 2005 estimate, with emissions of some pollutants increasing while others have decreased, mostly as the result of revised emission factors. The emissions from rail transport amount to approximately 30% of the NAEI estimates of emissions from the “other transport” sector. The other transport sector includes off-road transport, mobile machinery and aircraft emissions, which have not been estimated in detail in this update.

Comparison of the relative contributions made by each source sector to the total emissions shows NO_x, PM_{10}, $PM_{2.5,}$ CO, benzene and 1,3 butadiene are dominated by emissions made from the transport source sectors. Transport accounts for over 50% of total emissions of NO_x, $PM_{2.5,}$ CO, and 1,3 butadiene. Point sources such as Part A and B processes and other combustion sectors are a significant source of CO_2, SO_2, PM_{10} and $PM_{2.5}$. Agriculture and nature makes a significant contribution to benzo(a)pyrene emissions. Solvent use and production processes accounts for two thirds of NMVOC emissions.

Appendices

Appendix 1: Emissions Maps

Appendix 1 – Emissions Maps

Contents

Road transport emissions maps:

- Oxides of nitrogen and particulate matter, PM_{10}
- Particulate matter, $PM_{2.5}$ and sulphur dioxide
- Carbon monoxide
- Benzene and 1,3-butadiene
- Non-methane VOCs and carbon dioxide

Total emissions maps:

- Oxides of nitrogen and particulate matter, PM_{10}
- Sulphur dioxide and carbon monoxide
- Benzene and 1,3-butadiene
- Non-methane VOCs and carbon dioxide
- Benzo(a)pyrene

Fig. A1: Road transport emissions: oxides of nitrogen and particulate matter, PM_{10}

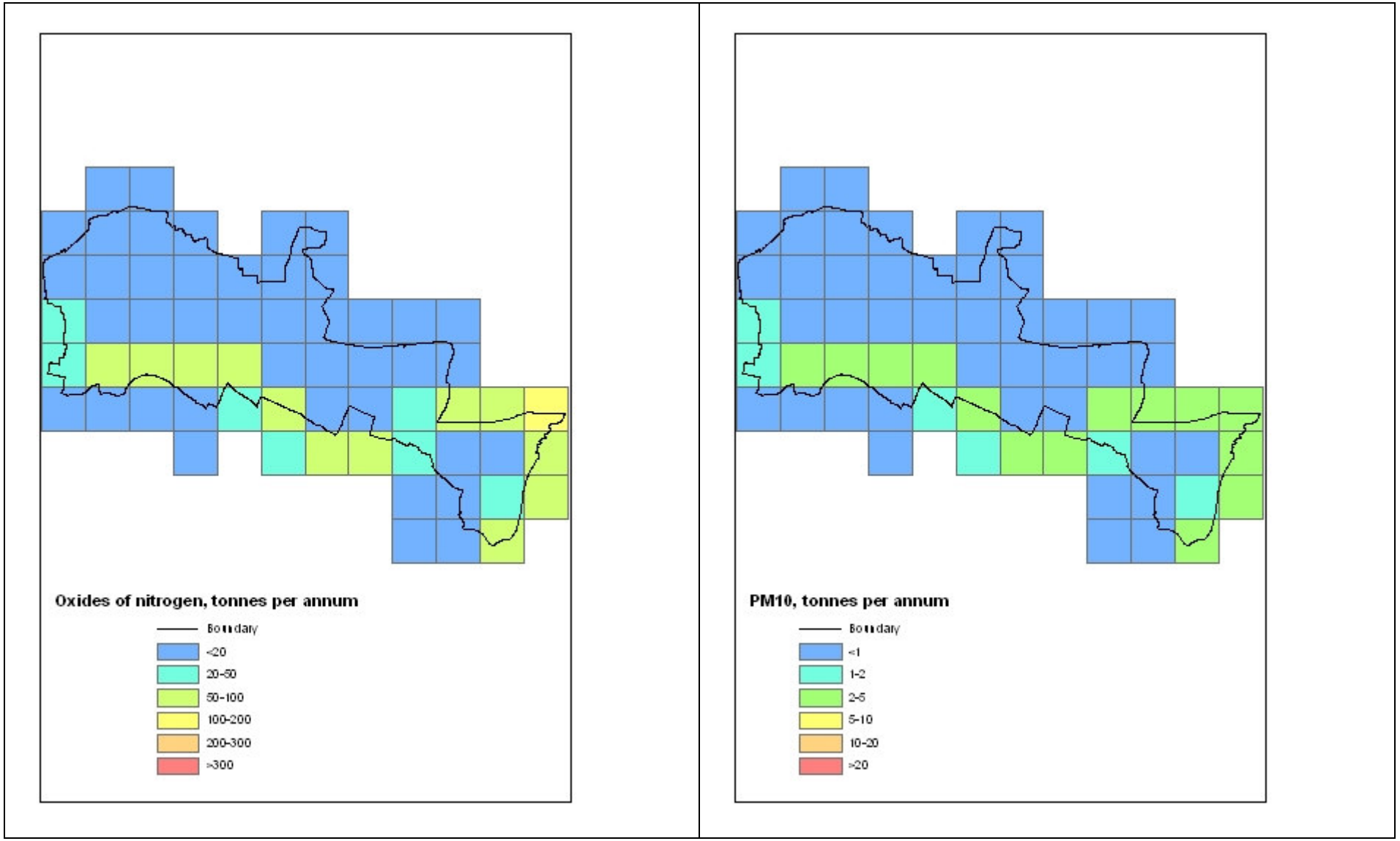


Fig. A2: Road transport emissions: particulate matter, $PM_{2.5}$ and sulphur dioxide

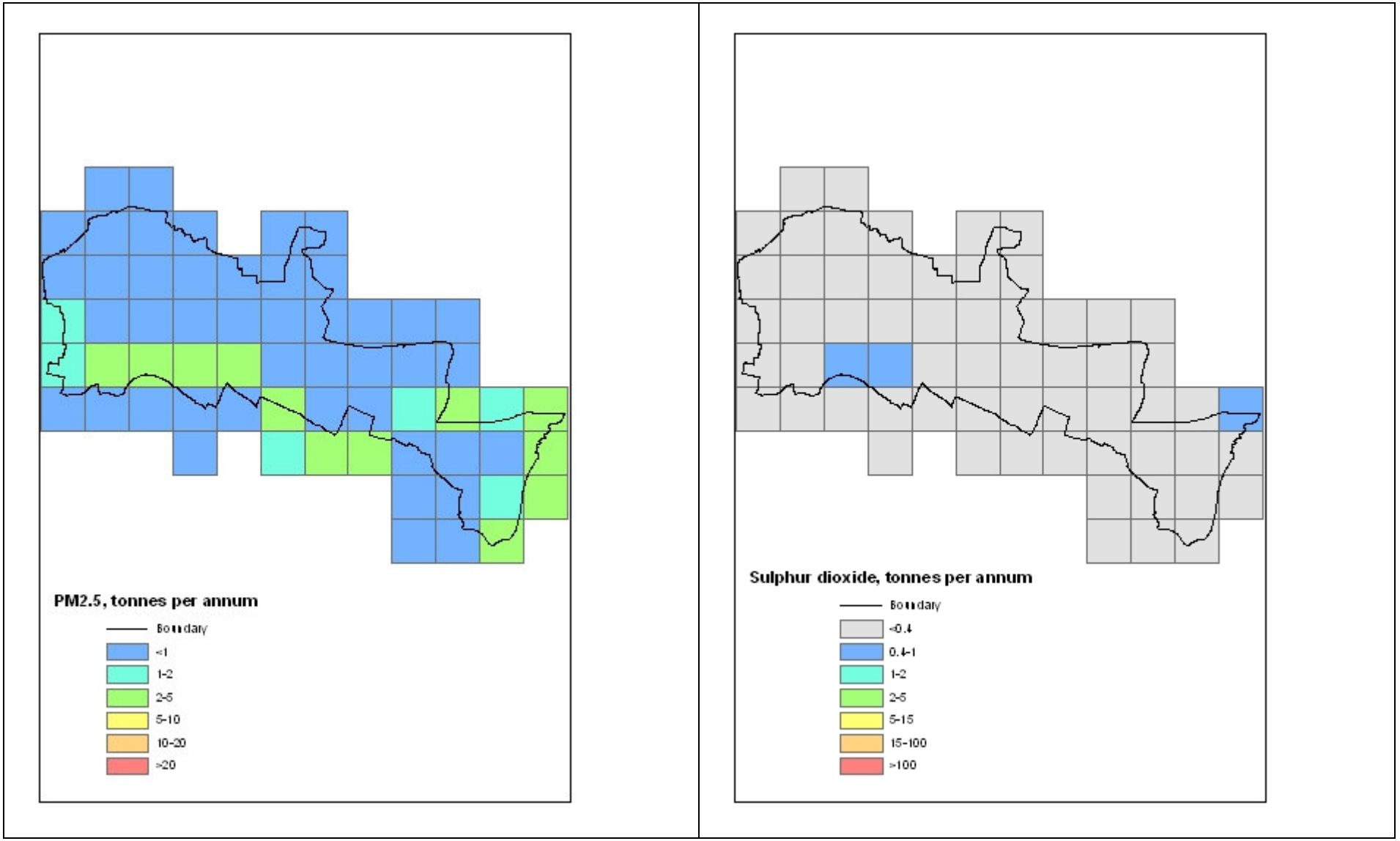


Fig. A3: Road transport emissions: carbon monoxide

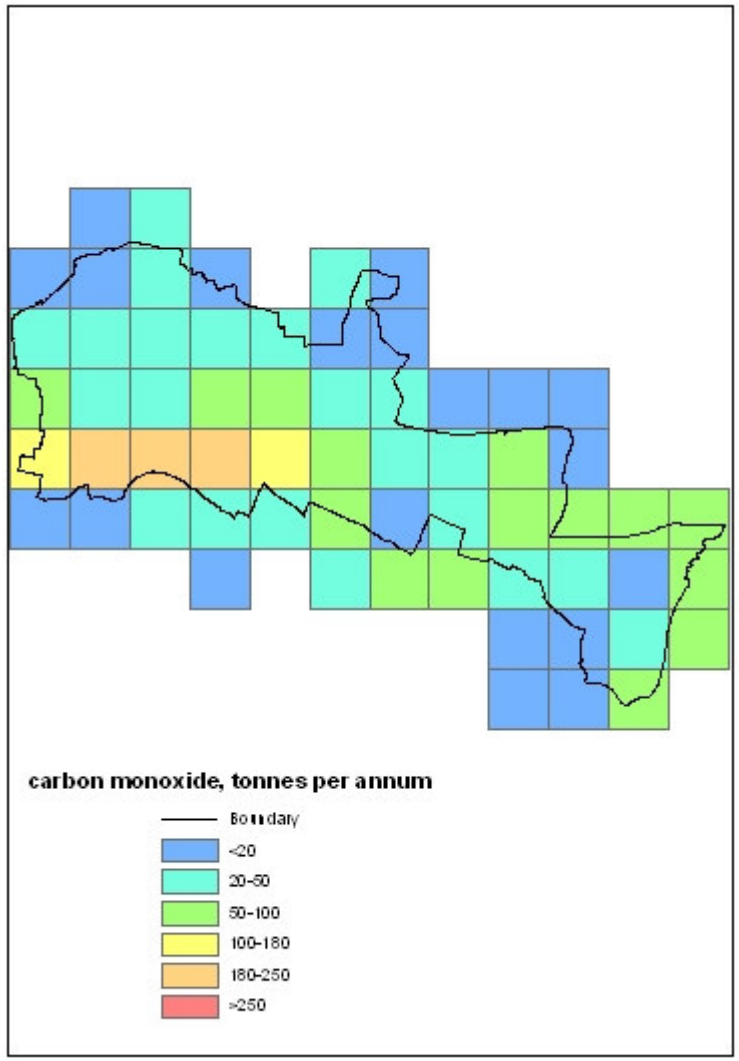
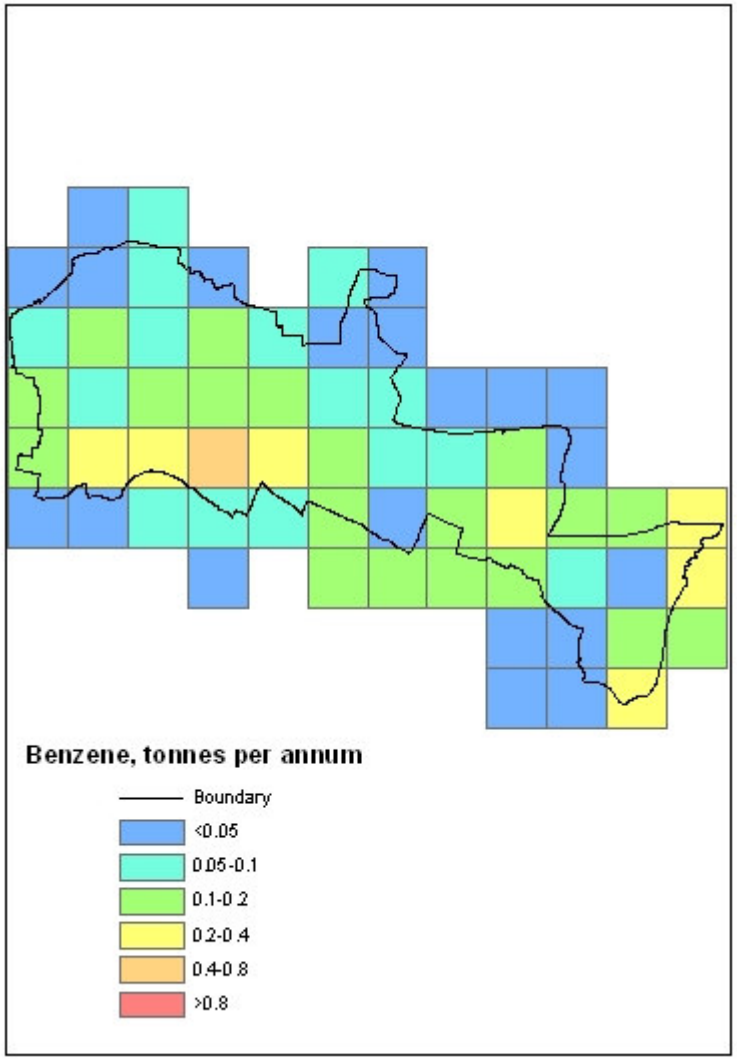


Fig. A4: Road transport emissions benzene and 1,3-butadiene



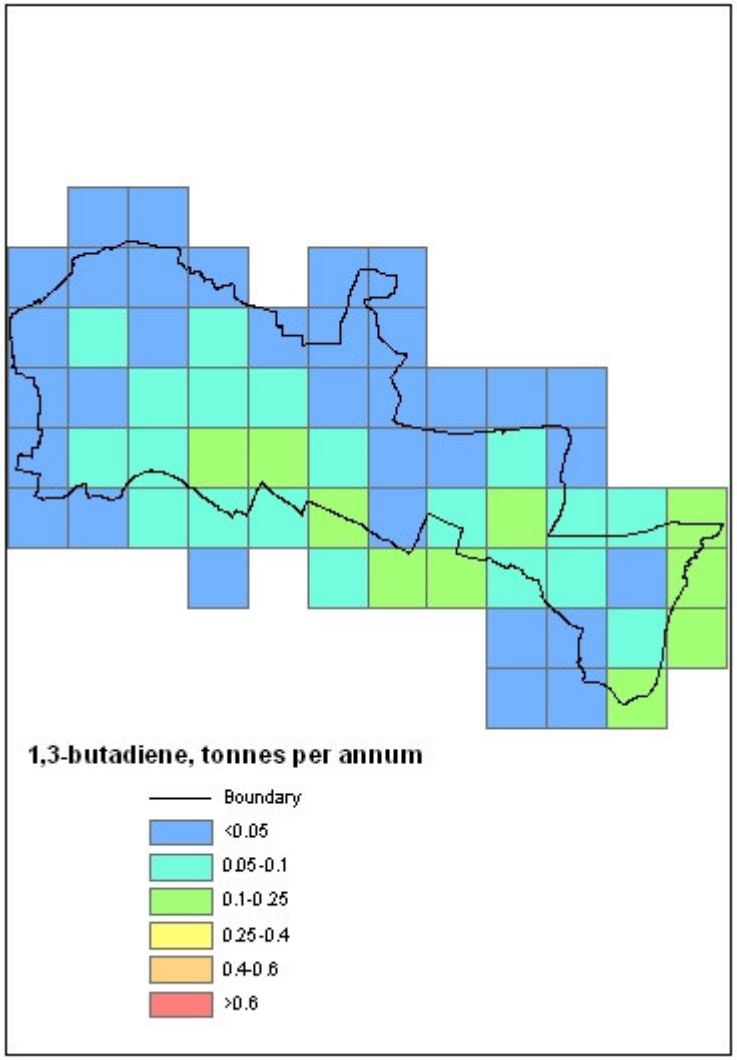


Fig. A5: Road transport emissions: non-methane VOCs and carbon dioxide

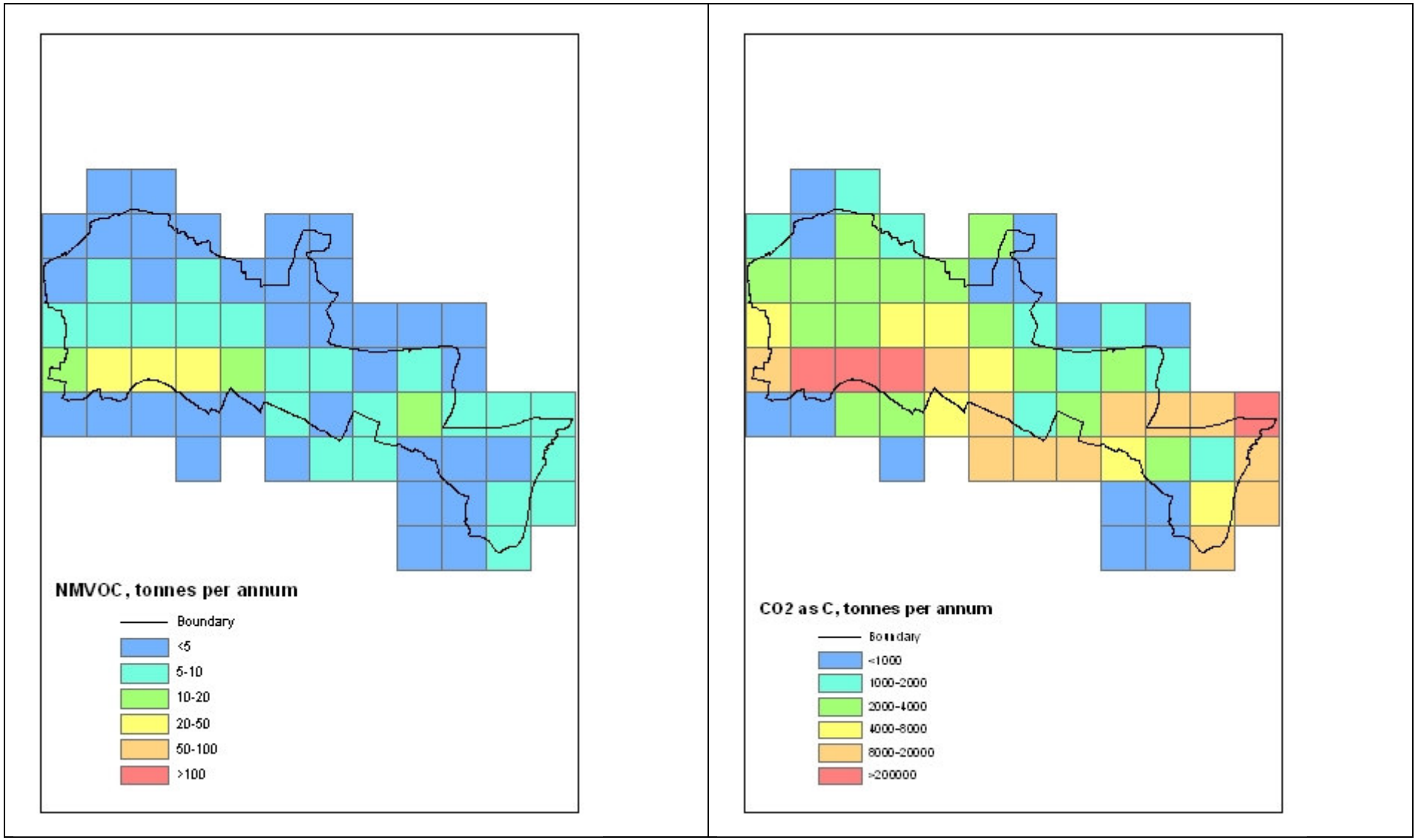


Fig. A6: Total emissions: oxides of nitrogen and particulate matter, PM_{10}

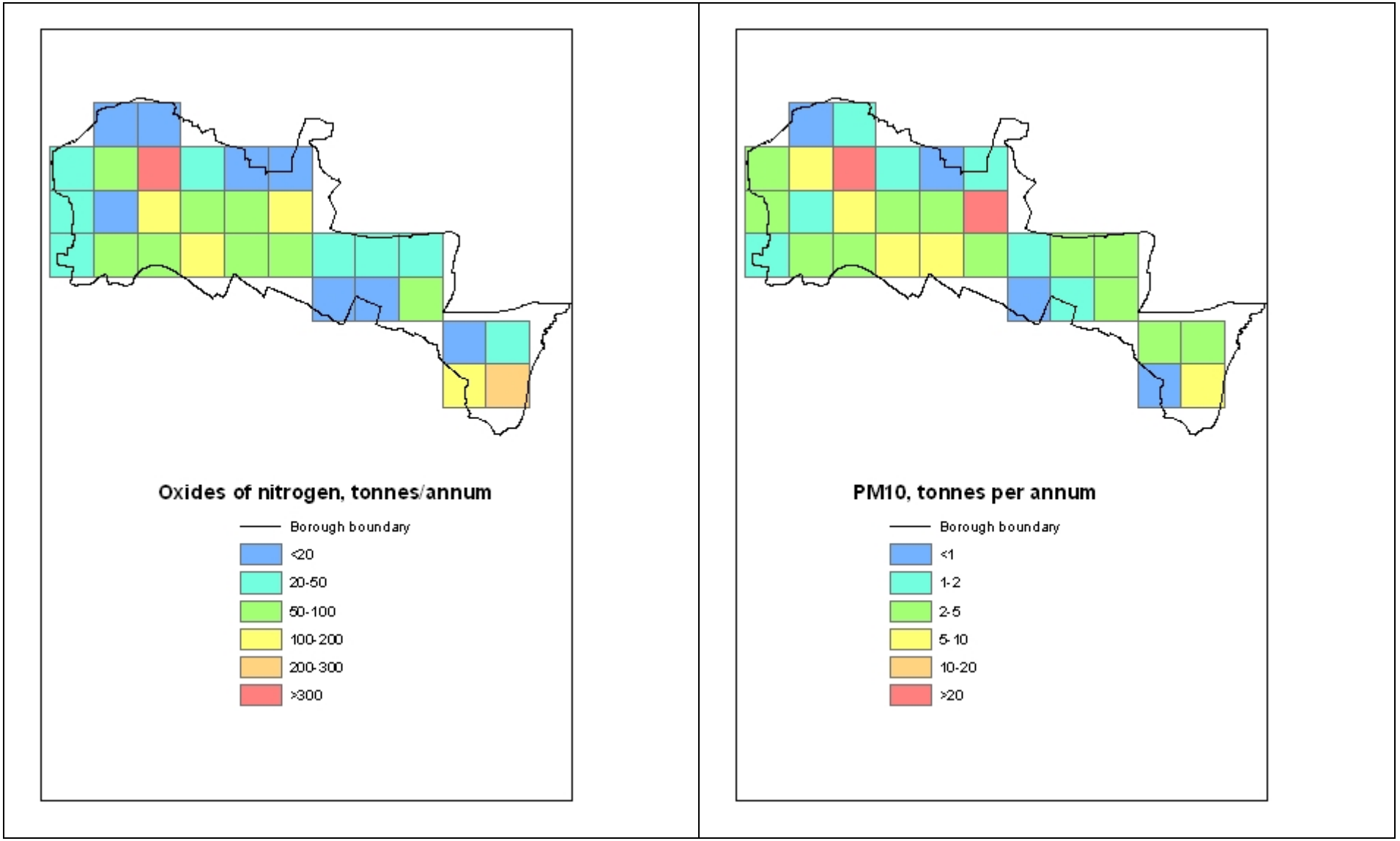


Fig. A6: Total emissions: sulphur dioxide and carbon monoxide

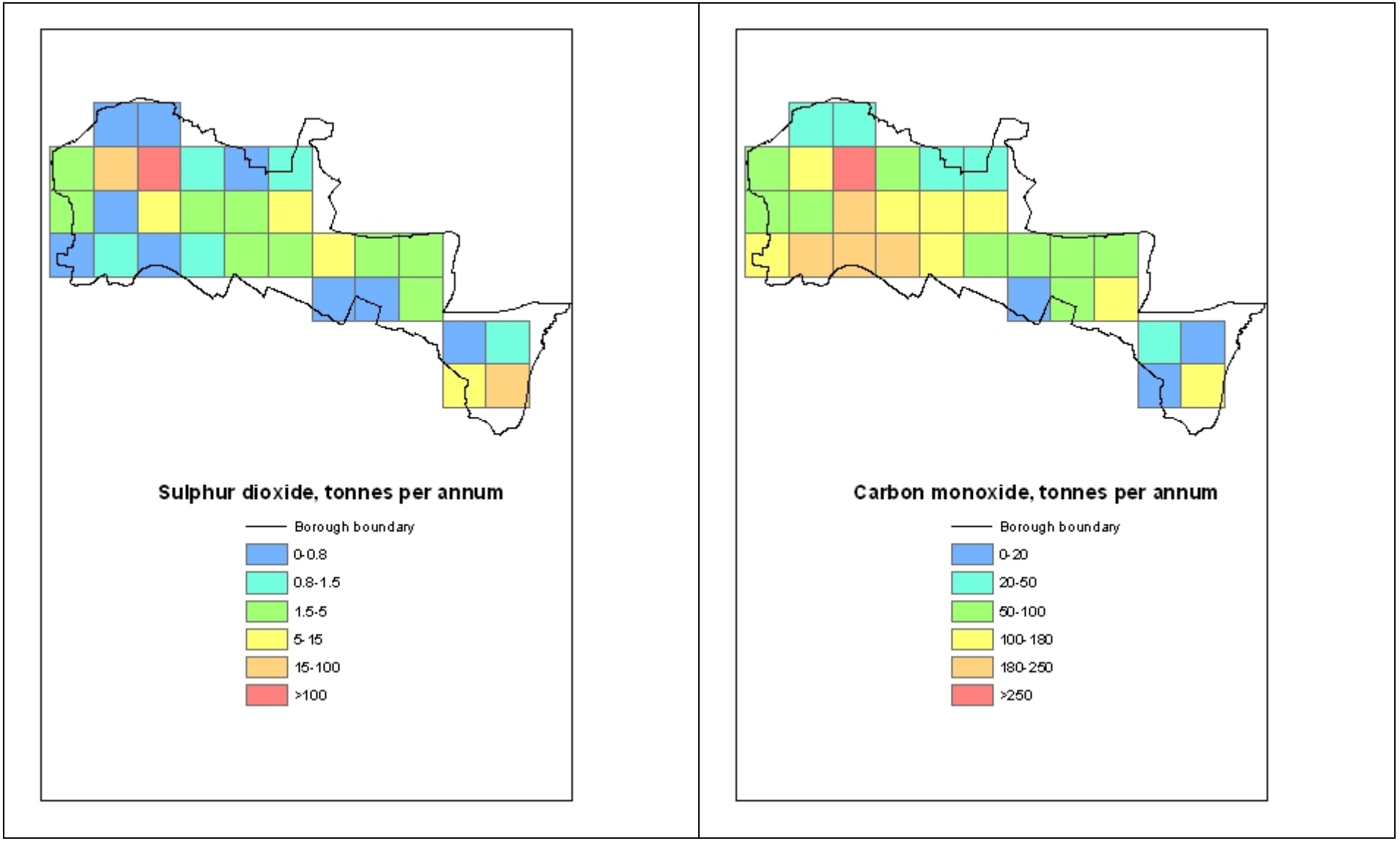


Fig. A7: Total emissions: benzene and 1,3-butadiene

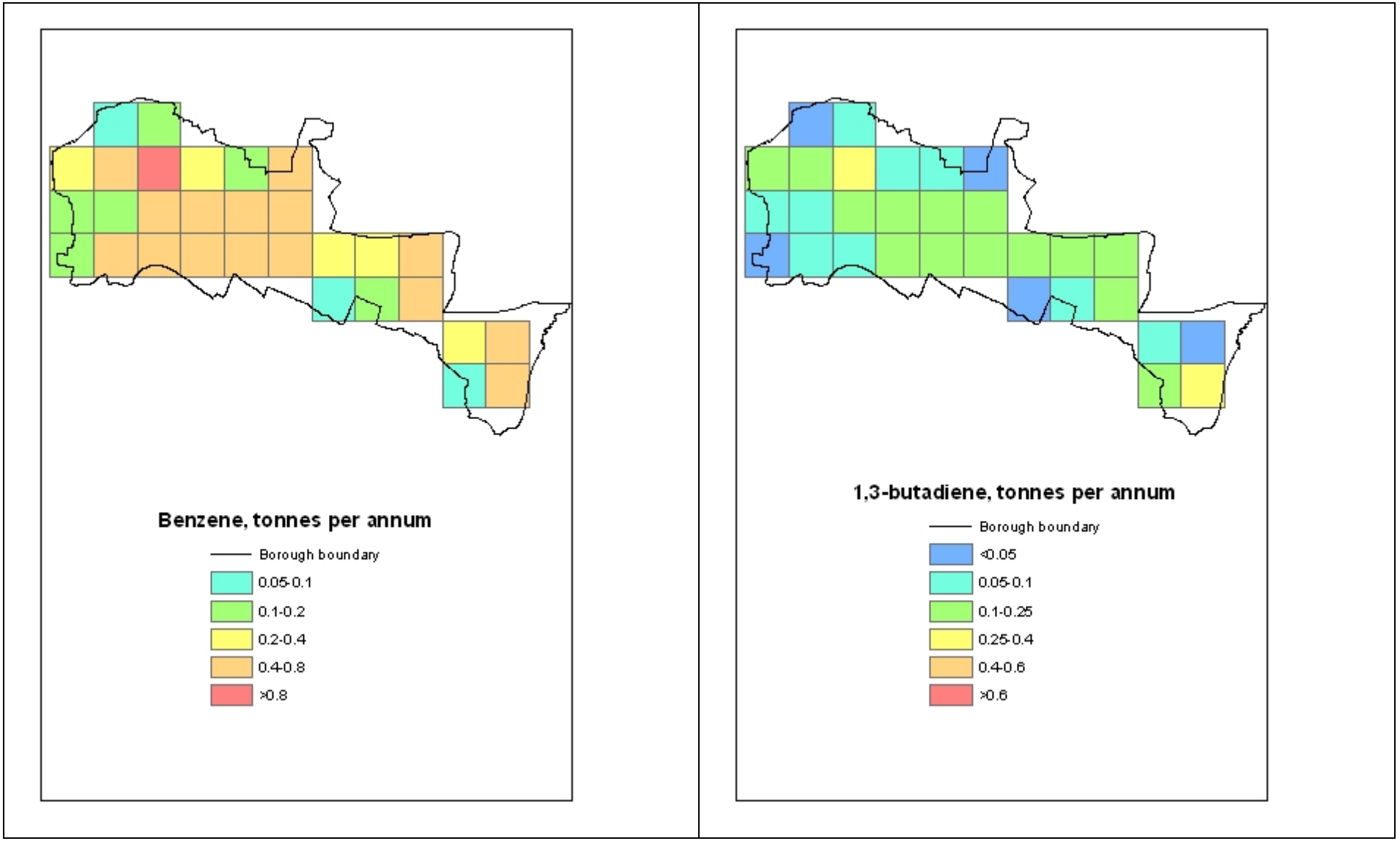


Fig. A8: Total emissions: non-methane VOCs and carbon dioxide

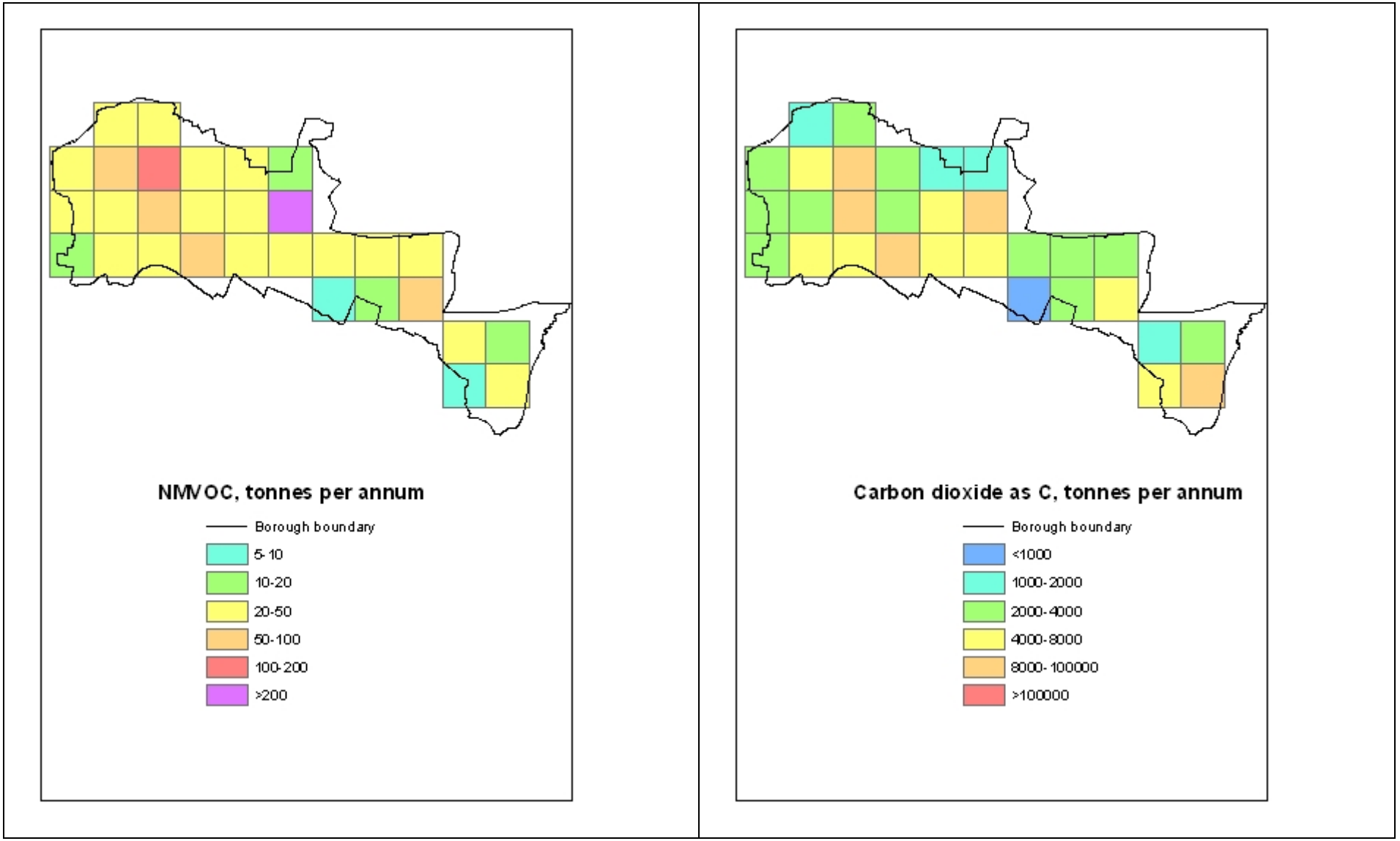
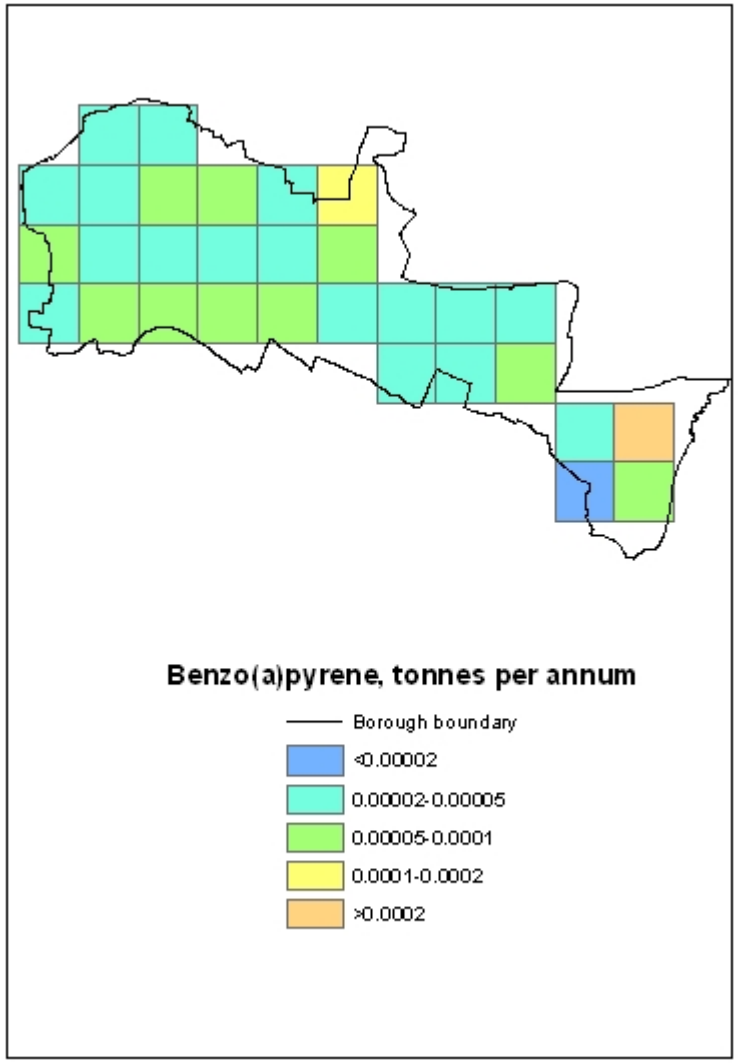


Fig. A6: Total emissions: benzo(a)pyrene



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