A2.1. Emissions Interface and Assumptions Used in Air Quality Modelling by SEIPH-ERG

A2.1.1 The purpose of this chapter is to set out the vehicle stock and emissions assumptions, Part A process emissions and the other area source emissions used in the prediction of air quality made by SEIPH-ERG.

A2.1.2 The traffic and other emissions input data used were the best data available at the time of the modelling.

A2.2. Traffic data

A2.2.1 Data from more than one source was used and thus a hybrid approach was adopted. This approach uses high quality data, either from the rotating census or from local authorities. In those instances of road links where this was not possible, LTS predictions were used. This was mainly undertaken for small and minor roads. It should be noted that a number of previous SEIPH-ERG reports [1,2] highlighted the poor road-by-road vehicle flow prediction of the LTS model. Furthermore it has become increasingly clear that the predicted exceedences of the AQS objectives are close to roads and therefore the use of the most reliable traffic data remains one of the most crucial aspects of the review and assessment process.

A2.3. Rotating Census and Local Authority Traffic Data

A2.3.1 The rotating census data almost cover the entire A road and motorway networks in London, with the most notable exception being the M25. This information was supplemented by the addition of a further 332 local authority counts, the majority of which do not coincide with those in the rotating census. In this way an enhancement of the predictive capability of the traffic flow data has been achieved, using measurements rather than model results.

A2.4. The LTS 91 Model (vB1.10)

A2.4.1 There are clearly considerable data management issues associated with the LTS model: there are over 31,000 road links which have flow information relating to three periods of the day; for each LTS run. Two database tables are formed which contain the following information:

Link Details	**Flows**
Link id	link id
A node id	vehicle code (Bus, HGV or Car + LGV)
B node id	AM flow
Link length	IP flow
Link type (motorway etc.)	PM flow
AM speed	
IP speed	
PM speed	
OS a node easting	
OS a node northing	
OS b node easting	
OS b node northing	
A node description	
B node description	
Location (central, inner, outer or external)	

A2.4.2 The emissions are calculated by time of day for each link individually over the 12 hour period considered in the LTS model. The emissions are then factored to provide estimates over 24 hours using appropriate factors.

A2.5. Stock Model and Vehicle Emissions

A2.5.1 The London vehicle stock model was compiled by SEIPH-ERG using vehicle registration data statistics for Greater London. In more recent work for GOL and the DETR, national statistics compiled in a very similar way have been used. Following the “Air Quality

Modelling in London" Meeting on 6 May 1999 hosted by the DETR and attended by GOL, it was clear that there was a desire to harmonise base data and methods where possible for air quality predictions in London. Therefore, within this report SEIPH-ERG have continued to use national statistics so that the modelling assumptions and base data are consistent with other work being undertaken in London.

A2.5.2 A comparison of the SEIPH-ERG predicted vehicle stock in 2005 and the national prediction shows that the two are very similar. The breakdown of vehicle types to be used is outlined in Table 2.1. It shows the proportions of different vehicle types for 1996 and 2005.

Table A2.1 : Proportions of Different Vehicle Types for 1996 and 2005 (%)

Vehicle type	1996	2005
petrol car	90.1	80.9
diesel car	9.9	19.1
petrol LGV	38.0	12.0
diesel LGV	62.0	88.0
Rigid	62.4	58.4
Articulated	37.6	41.6

A2.5.3 The high level of disaggregation shown in Table 2.2 has been retained in the SEIPH-ERG model to allow detailed scenarios to be tested. For example, the effect of pre-Euro I cars can be assessed.

A2.5.4 There is a mismatch between some of the categories for vehicle stock and those for the emissions, as in general there are more disaggregated data on vehicle emissions than vehicle stock. These statistics derive from vehicle registration data in London for 1996. The vehicle stock for petrol cars provides no information about the size breakdown. Further assumptions are therefore used in order that best use of two data sources can be made based on vehicle licensing statistics for London. These are as follows:

- The vehicle stock for petrol cars is split down into small, medium and large; defined as < 1.4 l, 1.4 to 2.0 l and > 2.0 l engine sizes. It is assumed the split is 38, 54 and 8 % respectively, regardless of year being considered.
- Diesel cars are split into two categories, defined as < 2.0 l and > 2.0 l. 83 % are assumed to be in the < 2.0 l category.
- LGVs, defined as non-car vehicles below 3.5 tonnes, make up about 10 % of the car and LGV group. These vehicles include car-derived vans such as Ford Escort vans. These are split into petrol and diesel types as described in
- Table A2.1. An equal split is assumed between small, medium and large types for pre Euro 1 vehicles. No size split is assumed for newer LGVs.
- HGVs are split up into rigid and articulated types. Rigid HGVs are split into small, medium and large types defined as between 3.5 and 7.5 tonnes, 7.5-16 tonnes and > 16 tonnes. The split for these vehicles is 55, 11 and 34 % respectively. All articulated vehicles are assumed to be large.
- All buses are assumed to be "urban" type, as defined by the emission factors. A better representation of these vehicle types may be possible through the use of London Transport's Bus data.

A2.6 Vehicle Emissions

A2.6.1 In the model speed-dependent vehicle emission factors are available for the vehicle types listed below. These data have been compiled by TRL and AEAT and are the basis of the National Atmospheric Emissions Inventory (NAEI). The speed-emissions curves take the form of a polynomial equation as shown in paragraph 08.1. An important issue is that some extrapolation of emissions is required since no measurements exist for Euro II and Euro III vehicles. The approach adopted is to assume that the speed-emissions curve is reduced in line with the reductions proposed for each pollutant in the emissions legislation. The factors used to reduce the emissions were recommended by the DETR.

A2.6.2 The catalyst failure rate assumed in the NAEI is 5 %. In the SEIPH implementation of this information the catalyst failure is a user input, which can be varied.

A2.6.3 Table 2.2 shows the assumptions used for the split between petrol and diesel cars between 1996 and 2005, petrol and diesel LGVs and rigid and articulated HGVs. The table shows for example that the proportion of diesel cars is assumed to increase from 9.9 % in 1996 to 19.1 % in 2005. These data were derived from the NAEI.

A2.7. Composition of UK Vehicle Fleet km by Emission Standards in Place When Vehicle First Registered

A2.7.1 The Table below summarises the vehicle stock in the UK for 1996, which is used by AEA Technology in their compilation of the National Atmospheric Emissions Inventory. It gives the fraction of each emission technology type for each vehicle type between 1996 and 2020. The Table below only shows data for 1996 and 2005.

Table A2.2: Vehicle Stock Assumed in London for 1996 and 2005

Vehicle type	Size	Emissions class	Fraction in each category[1]	
			1996	2005
Petrol cars	All	ECE 15.01	0.00	0.00
		ECE 15.02	0.00	0.00
		ECE 15.03	0.06	0.00
		ECE 15.04 (+failed TWC)	0.57	0.10
		Euro I (91/441/EEC)	0.25	0.10
		Euro II	0.11	0.31
		Euro III (~2000)	0.00	0.48
		Euro IV (~2005)	0.00	0.00
Diesel cars		83/351/EEC	0.28	0.02
		Euro I (91/441/EEC)	0.53	0.11
		Euro II	0.19	0.33
		Euro III (~2000)	0.00	0.54
		Euro IV (~2005)	0.00	0.00
Petrol LGV	Small	Pre-Euro I	0.92	0.17
		Euro I (93/59/EEC)	0.08	0.11
		Euro II	0.00	0.22
		Euro III (~2000)	0.00	0.50
		Euro IV (~2005)	0.00	0.00
	Medium	Pre-Euro I	0.92	0.17
		Euro I (93/59/EEC)	0.08	0.11
		Euro II	0.00	0.30
		Euro III (~2000)	0.00	0.42
		Euro IV (~2005)	0.00	0.00
	Large	Pre-Euro I	0.92	0.17
		Euro I (93/59/EEC)	0.08	0.11
		Euro II	0.00	0.30
		Euro III (~2000)	0.00	0.42

[1] Fraction of vehicle km:- takes account of decreasing annual mileage with increasing age of vehicle, rounded to 2 decimal places

		Euro IV (~2005)	0.00	0.00
Diesel LGV	Small	Pre-Euro I	0.57	0.06
		Euro I (93/59/EEC)	0.43	0.13
		Euro II	0.00	0.25
		Euro III (~2000)	0.00	0.57
		Euro IV (~2005)	0.00	0.00
	Medium	Pre-Euro I	0.57	0.06
		Euro I (93/59/EEC)	0.43	0.13
		Euro II	0.00	0.34
		Euro III (~2000)	0.00	0.48
		Euro IV (~2005)	0.00	0.00
	Large	Pre-Euro I	0.57	0.06
		Euro I (93/59/EEC)	0.43	0.13
		Euro II	0.00	0.34
		Euro III (~2000)	0.00	0.48
		Euro IV (~2005)	0.00	0.00
HGV	Rigid	Old	0.32	0.00
		Pre-Euro I (88/77EEC)	0.32	0.02
		Euro I (91/542/EEC)	0.33	0.09
		Euro II	0.03	0.39
		Euro III (~2000)	0.00	0.50
		Euro IV (~2005)	0.00	0.00
HGV	Articulated	Old	0.19	0.00
		Pre-Euro I (88/77EEC)	0.30	0.01
		Euro I (91/542/EEC)	0.47	0.05
		Euro II	0.04	0.36
		Euro III (~2000)	0.00	0.58
		Euro IV (~2005)	0.00	0.00
Buses		Old	0.41	0.05
		Pre-Euro I (88/77EEC)	0.26	0.07
		Euro I (91/542/EEC)	0.30	0.10
		Euro II	0.03	0.38
		Euro III (~2000)	0.00	0.41
		Euro IV (~2005)	0.00	0.00

A2.8. Emission factors

A2.8.1 The emission factors for all pollutants take the form:

$$Emission(g/km) = x\left[a + bv + cv^2 + dv^e + f\ln(v) + gv^3 + \frac{h}{v} + \frac{i}{v^2} + \frac{j}{v^3}\right]$$

where: x is a factor applied to ratio between technology classes

v is the mean vehicle speed (km/h)

a, b, c, d, e, f, g, h. I, j are constants

A2.8.2 These data were complied by AEAT. It is based on a compilation of factors from TRL and the COPERT II - *Computer Programme to Calculate Emissions from Road Transport: Methodology and Emission factors.* Data are only presented for NO_X, although similar factors exist for CO, non-methane hydrocarbons and PM10.

A2.9 Other Road Traffic Source Categories

A2.9.1 **Minor Roads**

A2.9.2 The LTS network accounts for most of the vehicle km driven in London. There is however a small but significant number of vehicle km driven on minor roads. It is difficult to estimate the proportion of vehicle km driven on minor roads as these roads are rarely considered in traffic models or surveys of traffic flows. The approach used here is identical to that used by the LRC in their London inventory (ref. LRC), i.e. the total vehicle km in the LTS model is subtracted from the total estimated vehicle km for London (which is derived from rotating census information).

A2.9.3 The difference between these two estimates is assumed to equal the vehicle km on minor roads. These vehicle km are apportioned to minor roads on a 1 km^2 basis according to estimates of minor road density on the same grid square basis.

A2.9.4 SEIPH-ERG has assumed that the average speed of vehicle driving on minor roads in 30 km/h and the traffic composition is identical to that used for LTS.

A2.9.5 The new version of LTS (LTS91, 1996 scenario) has significantly less vehicle km than that originally used (i.e. LTS version 3.3) in the Stage 1 and 2 reports. For example in central London the amount of km driven is reduced by 27 %, for inner London by 22 % and outer London 13 % (MVA, Technical Note 25). As LTS91 is thought to provide more accurate estimates of total flows on the network, it is assumed that previous estimates of vehicle km were overestimated. (It has also been assumed that the minor road vehicle km has remained the same). The alternative would be to increase the vehicle km on the minor roads so that the total London estimate of vehicle km remained the same.

A2.9.6 **Cold Start and Evaporative Emission Sources**

A2.9.7 Cold start emissions, expressed in grammes per trip, have been calculated using the formula (Tim Murrells, personal communication):

Emission = a.(1-y) +y.b

Where a, b and y are constants.

The LRC inventory has been used which gives the estimated number of trips starts in each 1 km^2 grid square. Cold start emissions are therefore treated as an area source.

Table A2.3 Factors Used to Calculate Cold Start Emissions for NO_X and PM10

Vehicle type	Pollutant	Year	a	b	y
Car	NO_X	1996	1.078	0.381	0.099
LGV	NO_X	1996	1.339	0.402	0.617
Car	NO_X	2005	0.396	0.264	0.195
LGV	NO_X	2005	0.474	0.269	0.885
Car	PM10	1996	0	0.0832	0.099
LGV	PM10	1996	0	0.1664	0.617
Car	PM10	2005	0	0.0484	0.195
LGV	PM10	2005	0	0.1125	0.885

A2.10 Other Emissions Sources

A2.10.1 **Part A Processes**

A2.10.2 The Part A process emissions information was collected from the London Atmospheric Emissions Inventory (LRC-Release 2a), through personal communication with the

Environment Agency and through use of the Environment Agency web page. The information in Table A2.2 gives details on the sources and emissions of NO_2 and PM10. Additional information was obtained from the Environment Agency for detailed modelling of SO_2 and is summarised in Table A2.3. This is in addition to process specific information which has also been included and is summarised in Table A2.4 below:

Table A2.2 : Part A Processes Modelled for NO_2 and PM10

Operator Name	Operator Name
Blagden Packaging Ltd	Croda Resins Ltd
Clinical Energy Ltd	Dussek Campbell Ltd
The Drum Group Ltd	HPG
Londonwaste Ltd	Merck, Sharp & Dohme
Northwick Park Hospital Trust	Mitchanol International
SE London Combined Heat & Power Ltd	Wolstenholme International Ltd
AHS Emstar	Philips Printed Circuits (UK)
Citigen (London) Ltd	Pigments Ltd
Ford Motor Co.	Rhone Poulenc Rorer Ltd
Guiness Brewing Ltd	Associated Metal Traders
Heathrow Airport Ltd	Astor Stag Ltd
Kodak Ltd	Brent Smelting Works Ltd
London Underground G	Cohen & Co
Nestle (UK) Ltd	European Colours Ltd
Powergen PLC	Frys Metal Ltd
Tate and Lyle PLC	Inco
Barking Power Ltd	Peter Tilling Plastics Ltd
Enfield Energy	Tunnel Refineries
London Underground Ltd	Wilkinson Sword Ltd
Didcot A	North London Waste Authority
Didcot B	Co-Steel Sheerness
Letchworth GT Power	Powergen Plc - Grain PS
Littlebrook Power Station	Powergen Plc
British Airways	Kimberly Clark Ltd
Colar Fine Art & Graphics Ltd	Powergen Plc - Kingsnorth PS
Engelhard Clar UK Ltd	Rugby Group Plc
Gemala Battery Co Ltd	Wellcome Foundation Ltd
GE Lighting Ltd	Blue Circle Industries Ltd
Hornett Bros Co Ltd	Medway Power Ltd
Johnson Matthey plc	Britannia Refined Metals Ltd
Jotun Polymer	BPB Paper And Packaging Ltd
Union Miniere Oxyde (UK) Ltd	Cargill Plc
UOP Ltd	Lafarge Aluminous Cement Co Ltd
Walterisation UK Ltd	Mobil Oil Company Ltd
Courtaulds	National Power Plc (Tilbury)
Shell UK Ltd	

Table A2.3 Specific Emission Factors used for Power Generators (% of Stated Emission Rate)

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Process																								
National Power Tilbury	19.6	20.0	19.7	17.5	16.1	16.7	24.7	37.3	45.6	49.9	51.6	52.2	51.7	50.3	50.5	51.3	56.5	59.1	56.2	49.9	43.4	36.3	27.5	20.7
Powergen Kingsnorth	27.87	28.91	28.19	25.93	23.68	23.64	29.84	39.14	45.04	48.18	48.77	49.04	48.39	47.23	47.69	47.71	50.67	52.12	49.96	46.05	41.54	37.51	32.92	28.23
Powergen Grain	0.00	0.00	0.00	0.00	0.01	0.08	0.33	0.82	1.26	1.57	1.73	1.90	1.49	1.11	1.06	1.25	1.71	1.56	1.16	1.05	0.82	0.20	0.01	0.00

Table A2.4 Specific Stack and Emissions Details of Modelled Part A SO_2 Emission Sources

Location	Operator	X coord	y coord	Stack ID	Stack Height	Stack Diameter	Exit Vel.	Vol. Flow	Gas Temp.	SO_2 g/s
					(m)	(m)	(m/s)	(m3/s) STP	(K)	
Thurrock	National Power Tilbury	566050	175550	A1	171	6.3	26.8	837.0	417	3611.00
Medway	Powergen Kingsnorth	581150	172030	1	198	12.2	26.0	3039.0	423	3166.00
Medway	Powergen Grain	588500	175500	1	244	13.4	25.0	3525.0	408	9600.00
Dartford	National Power Littlebrook	555700	176500	1	215	5.0	23.0	165.3	814	2311.00
Medway Towns	Rugby Group Plc	569100	164400	1	114	3.0	21.9	154.8	403	9.51
Thurrock	Mobil Oil Company	574350	182050	1	117	2.6	24.6	130.3	463	167.36
Thurrock	Mobil Oil Company	574440	182040	2	92	1.2	18.9	22.0	811	266.68
Thurrock	Mobil Oil Company	574327	182458	A1	117	2.9	11.0	72.4	475	1.26
Thurrock	Mobil Oil Company	574599	182579	A3	80	4.1	3.2	41.7	433	0.37
Thurrock	Mobil Oil Company	574630	182415	A4	91	4.1	7.4	97.5	527	6.79
Thurrock	Mobil Oil Company	574510	182369	A5	37	1.1	3.1	3.7	572	0.38
Thurrock	Mobil Oil Company	574516	182512	A6	23	0.9	1.9	1.2	593	0.02
Thurrock	Mobil Oil Company	574760	182333	A7	46	2.4	3.7	17.2	455	16.58
Thurrock	Mobil Oil Company	574762	182320	A8	46	2.4	3.7	17.2	455	23.40
Thurrock	Mobil Oil Company	574766	182293	A9	107	2.4	9.4	43.7	433	93.93
Thurrock	Mobil Oil Company	574770	182272	A10	107	2.2	7.5	28.2	422	54.49
Thurrock	Mobil Oil Company	574958	182148	A11	31	1.1	1.4	1.5	800	0.13
Thurrock	Mobil Oil Company	575063	182165	A12	52	1.7	1.2	2.7	550	0.20
Thurrock	Mobil Oil Company	575079	182168	A13	46	0.9	12.2	7.9	700	0.14
Thurrock	Mobil Oil Company	575299	182247	A16	50	3.4	6.5	57.3	433	1.88
Thurrock	Mobil Oil Company	575286	182253	A17	16	1.1	11.2	3.1	593	0.10
Barking and Dagenham	Ford Motor Company	549900	181900	1	80	1.5	8.2	19.3	414	0.00
Brent	Guinness Brewing Worldwide	519390	181900	1	92	1.1	12.0	20.7	466	6.93

Brent	Guinness Brewing Worldwide	519390	181900	2	92	1.1	12.0	20.7	466	8.22
Brent	Guinness Brewing Worldwide	519390	181900	3	92	1.0	13.3	20.9	426	3.89
Brent	Guinness Brewing Worldwide	519390	181900	4	92	1.0	13.3	20.9	426	3.83
Harrow	Kodak Ltd	514640	189680	1	64	1.4	13.3	28.2	379	0.02
Newham	Tate and Lyle Sugars Plc	542250	179500	1	94	1.2	9.8	17.7	430	1.06
Newham	Tate and Lyle Sugars Plc	542250	179500	2	94	1.2	9.3	16.8	430	1.02
Newham	Tate and Lyle Sugars Plc	542250	179500	3	94	1.2	9.3	16.8	430	1.34
Newham	Tate and Lyle Sugars Plc	542250	179500	4	70	1.4	2.8	6.0	430	1.42
Enfield	LondonWaste	535710	192610	1	100	2.7	17.0	73.2	503	3.86
Lewisham	SELCHP	535700	178100	1	100	2.1	20.0	66.0	303	3.66
Lewisham	SELCHP	535700	178100	2	100	2.1	20.0	66.0	303	3.28

A2.11. Other Emission Source Categories Included in the London Inventory

A2.11.1 A number of other sources of pollution are included in the model runs within London and these are listed in the following sections. All emissions are from the LRC London emissions inventory, developed as part of the EU life project, co-ordinated by the SEIPH. All the categories are expressed as area source emissions over 1 km^2.

A2.11.2 **Mobile Sources**

- Rail Traffic;
- River Traffic;
- Aircraft.

A2.11.3 **Point Sources**

- Small Industrial Processes (Part B);
- Large Boiler Plant.

A2.11.4 **Stationary Sources**

- Gas Combustion (domestic and commercial);
- Oil Fuel Combustion (domestic and commercial);
- Coal Combustion (domestic and commercial);
- Agriculture and Nature;
- Other.

A2.12. Projected Future Emissions in 2005

A2.12.1 **Assumptions**

A2.12.2 There is a clear and detailed treatment of the future vehicle stock and emissions reductions expected towards 2005 described in the preceding chapters above. Whilst it is recognised that there are limitations to this approach, this represents the best available information at the time of writing and provides consistency with other work being undertaken in London.

A2.12.3 Assumptions regarding all 'other' source categories, included within the LRC inventory are assumed to remain constant to 2005. An assessment of the validity of this assumption would require a considerable effort, which is impractical within the time scale set for the review and assessment process. The effect of such an assumption on the predictions of NO_2 and PM10 are considered to be small however.

A2.12.4 For example, emissions of NO_x from sources, other than gas combustion and vehicles, are small (approx 15 % of the total) and it is not expected that other fuels such as oil or coal will increase in use. Therefore any conversion to gas that is undertaken between now and 2005 is expected to have an insignificant effect on emissions of NO_x. Localised sources of NOx such as Heathrow are also considered to remain constant, which is likely to be an underestimate. Of the other minor sources, rail traffic is not considered to change significantly although there may be a switch from diesel to electric locomotives. By far the most significant emission source in relation to population exposure is the motor vehicle.

A2.12.5 The primary emissions of PM10 also contribute a small proportion of the overall ambient concentration and vehicles dominate these. The majority of emissions of primary particles are therefore dealt with through vehicle stock and emissions changes. The assumptions for 'other' primary emissions are likely therefore to have a small effect. Localised generation of particles from building processes have the effect of raising PM10 concentrations significantly, however most of these are temporary emission sources. Exceptions to this are the major developments, such as Heathrow, which have been studied in specific detail as part of the public enquiry process.

A2.12.6 Part A process emissions are considered to have a small impact on the NAQS PM10 and NO_2 objective. The predicted decrease in emissions for 2005 are insignificant and therefore, as a precautionary approach, these emissions are assumed to remain at their present level. This is not the case for SO_2, where Part A processes are the dominant source during short term peak episodes, as seen occasionally through the measurements of the LAQN. Attempts to obtain present and future emissions information have been extremely difficult and no definitive reduction factor for 2005 could be found. However, information on expected improvements to IPC regulated processes was obtained through personal communication from the Environment Agency. Details of these are given below:

- Installation of bag filters/lime injection at Blagden Packaging;
- Expectation of Exide Batteries to close;
- Conversion of Ford Motor Company to gas firing from coal;
- Negligible release from London Underground Greenwich due to emergency standby test firing on oil once a month by the end of 1999;
- Possibility of London Underground Lotts Road to close in 2000;
- Closure of Shell UK Ltd.