7 Results

The concentrations of the PAH compounds measured at each site during the summer and winter sampling periods are given in Table 6. The table also gives the total PAH concentrations (i.e. the sum of the concentrations of all 15 PAHs measured) for each site, the arithmetic and geometric means of each compound across all sites, and ratio of the winter to summer geometric mean concentration for each compound.

For each compound, at each site, the average of the summer and winter values was calculated to give an estimate of the overall mean concentration. These estimates are given in Table 7.

When analysing the results it is important to remember the short duration of the measurements; two weeks (at most) at each site for each season. Furthermore, the measurement periods were not, in general, coincident at all twelve sites. Air pollution levels are, of course, very dependent on weather conditions, and it is therefore probable that some of the differences in PAH concentrations from site-to-site (in a given season) were due to changes in weather conditions from sampling period to sampling period. In an attempt to examine possible seasonal variations in PAH concentration a further site was monitored at RPT, Southwark Street, London, SE1 for two week periods in each month between June 1993 to March 1994. An additional aim of the RPT survey was to determine the relative importance of site to site and seasonal factors on variation in PAH concentration.

7.1 Concentrations - Overview

A general overview of the concentrations found is presented in Figure 1, which shows (for each site) the total PAH concentrations during the summer and winter sampling periods. It is evident that both the absolute concentrations and the winter/summer ratios vary considerably from site to site.

Typically it would be expected that winer PAH concentrations would be greater than those during the summer months which was the case at all sites with the exception of sites 4 (Hammersmith), 7 (Kensington & Chelsea) and the summer months were at the Kensington & Chelsea (site 7) and Wandsworth sites (site 12). The highest winter total PAH concentration was recorded at Ealing (Site 3) which is a site adjacent to a busy road.

Table 6 Results of Summer and Winter Sampling. PAH Concentrations at Each Site (ng m^{-3})

SUMMER

Site	Borough	NP	ACE/FL	PHE	ANT	FLH	PYR	BaA/CHR	BbF	BkF	BaP	DahA	BghiP	COR	Total
1	Bexley	0.1	0.27	0.30	0.1	0.28	0.4	0.1	0.43	0.002	0.17	0.08	0.45	0.35	3.03
2	Brent	0.32	0.28	0.31	0.1	0.2	0.25	0.12	0.45	0.002	0.14	0.09	0.58	0.59	3.43
3	Ealing	1.11	0.61	0.90	0.1	1.39	1.93	2.54	2.21	1.0	0.83	0.53	3.43	2.94	19.52
4	Hammersmith	0.58	0.41	0.62	0.1	1.21	1.35	1.96	1.62	0.65	0.69	0.29	2.4	2.04	13.92
5	Harrow	0.71	0.56	0.41	0.1	0.88	1.12	2.0	1.65	0.79	0.53	0.30	2.1	1.77	12.92
7	Kensington	1.66	0.75	0.56	0.1	3.65	5.01	2.75	2.39	1.11	1.27	0.35	3.40	2.61	25.61
8	Kingston	0.42	0.41	0.31	0.1	0.2	0.36	0.1	0.19	0.002	0.08	0.06	0.32	0.26	2.81
9	Newham	0.37	0.60	0.88	0.1	0.49	0.79	0.54	0.93	0.25	0.27	0.11	1.10	0.91	7.42
10	Richmond	0.1	0.39	0.44	0.1	0.90	0.83	0.36	0.72	0.08	0.30	0.19	0.89	0.77	5.99
11	Tower Hamlets	0.1	0.38	0.20	0.1	0.29	0.66	0.56	0.91	0.22	0.33	0.22	1.13	0.94	6.04
12	Wandsworth	1.58	0.36	0.98	0.1	2.23	1.99	0.97	4.63	0.85	1.22	0.75	9.8	7.89	33.35
13	Westminster	0.1	0.30	0.20	0.1	0.44	0.54	0.76	0.86	0.22	0.31	0.13	1.07	0.80	5.83
Arithmetic Mean		0.6	0.44	0.51	0.1	1.01	1.27	1.06	1.42	0.43	0.51	0.26	2.22	1.82	11.66
Geometric Mean		0.37	0.42	0.44	0.1	0.67	0.89	0.61	1.02	0.11	0.37	0.2	1.4	1.16	8.48

WINTER

Site	Borough	NP	ACE/FL	PHE	ANT	FLH	PYR	BaA/CHR	BbF	BkF	BaP	DahA	BghiP	COR	Total
1	Bexley	0.93	0.39	0.62	0.1	1.87	1.37	1.91	1.68	0.79	0.57	0.25	1.64	1.33	13.45
2	Brent	0.96	0.33	0.73	0.1	2.42	2.57	3.19	2.46	1.16	0.85	0.40	2.96	2.20	20.33
3	Ealing	0.51	1.09	1.91	0.22	3.89	5.74	7.99	4.11	2.06	2.09	0.55	5.08	3.98	39.22
4	Hammersmith	1.41	0.79	0.2	0.1	0.95	1.2	0.80	1.15	0.23	0.36	0.21	1.23	1.02	9.65
5	Harrow	2.09	0.65	0.55	0.1	2.22	2.52	3.92	2.84	1.44	1.09	0.69	3.94	3.32	25.37
7	Kensington	0.52	0.60	0.29	0.1	0.21	0.36	0.46	0.72	0.22	0.19	0.13	0.78	0.65	5.23
8	Kingston	0.39	0.1	1.12	0.1	2.28	1.67	2.95	2.28	1.16	0.85	0.30	2.02	1.27	16.49
9	Newham	1.64	0.49	0.38	0.1	1.81	0.81	1.61	1.83	0.75	0.51	0.39	2.33	1.83	13.27
10	Richmond	1.45	0.35	1.21	0.1	0.6	1.11	1.49	1.36	0.61	0.59	0.24	1.34	1.16	13.01
11	Tower Hamlets *	1.22	0.59	0.2	0.1	0.2	0.96	0.1	1.56	0.002	0.34	0.20	1.53	1.86	8.67
12	Wandsworth	2.4	1.01	1.38	0.1	0.8	1.42	1.95	1.71	0.81	0.90	0.44	2.8	2.01	17.73
13	Westminster	3.47	3.09	0.85	0.26	1.6	0.88	1.84	1.58	0.77	0.67	0.33	1.67	1.24	18.25
Arithmetic Mean		1.42	0.79	0.79	0.12	1.57	1.72	2.35	1.94	0.83	0.75	0.34	2.28	1.82	16.72
Geometric Mean		1.17	0.58	0.62	0.12	1.14	1.36	1.54	1.77	0.46	0.63	0.31	2.0	1.62	14.79
Winter/Summer Ratios of Geometric Mean		3.16	1.38	1.41	1.2	1.7	1.53	2.52	1.74	4.18	1.7	1.55	1.43	1.4	1.74

*Note: For this site the volume of air sampled during the winter period was considerably less than 500m^3 and therefore these data must be treated with some caution (see Section 6.3)

Table 7 Average Concentrations - Arithmetic Mean (ng m^{-3})

Site	Borough	NP	ACE/FL	PHE	ANT	FLH	PYR	BaA/CHR	BbF	BkF	BaP	DahA	BghiP	COR	Total
1	Bexley	0.52	0.33	0.46	0.1	1.08	0.89	1.01	1.06	0.4	0.37	0.17	1.05	0.84	8.24
2	Brent	0.64	0.31	0.52	0.1	1.31	1.41	1.66	1.46	0.58	0.5	0.25	1.77	1.4	11.88
3	Ealing	0.81	0.85	1.41	0.16	2.64	3.84	5.27	3.16	1.53	1.46	0.54	4.26	3.46	29.37
4	Hammersmith	1.0	0.6	0.41	0.1	1.08	1.28	1.38	1.39	0.44	0.53	0.25	1.82	1.53	11.79
5	Harrow	1.4	0.61	0.48	0.1	1.55	1.82	2.96	2.25	1.12	0.81	0.5	3.02	2.55	19.15
7	Kensington	1.09	0.68	0.43	0.1	1.93	2.69	1.61	1.56	0.67	0.73	0.24	2.09	1.63	15.42
8	Kingston	0.41	0.26	0.72	0.1	1.24	1.02	1.53	1.24	0.58	0.47	0.18	1.17	0.77	9.65
9	Newham	1.01	0.55	0.63	0.1	0.55	0.8	1.08	1.38	0.5	0.39	0.29	1.72	1.37	10.35
10	Richmond	0.78	0.37	0.83	0.1	1.36	0.97	0.93	1.04	0.35	0.45	0.18	1.21	0.97	9.5
11	Tower Hamlets *	0.66	0.49	0.2	0.1	0.25	0.81	0.33	1.24	0.11	0.34	0.21	1.24	1.4	7.36
12	Wandsworth	1.99	0.69	1.18	0.1	1.52	1.71	1.46	3.17	0.83	1.06	0.6	6.3	4.95	25.54
13	Westminster	1.79	1.7	0.53	0.18	1.02	0.71	1.3	1.22	0.5	0.49	0.23	1.37	1.02	12.04
Arithmetic Mean		1.01	0.62	0.65	0.11	1.29	1.49	1.71	1.68	0.63	0.63	0.3	2.25	1.82	14.19
Geometric Mean		0.9	0.54	0.57	0.11	1.13	1.3	1.4	1.55	0.53	0.57	0.27	1.9	1.54	12.91

*Note for this site the volume of air sampled during the winter period was considerably less than 500m^3 and therefore these data must be treated with some caution (See Section 6.3)

The wide variations in concentrations found, from compound to compound, site to site and season to season, are a general feature of the PAH concentrations found in urban areas, in surveys reported by other investigators. Efforts to explain these variations are made below.

7.2 Comparison of Roadside and Background Sites

It is of interest to make a general comparison of the PAH concentrations at roadside and background sites. The estimated mean concentration of each compound has been averaged across all roadside sites and are compared with Bexley which is a background site, and is illustrated in Figure 2.

The sites that can be described as 'roadside' are 2 (Brent), 3 (Ealing), 4 (Hammersmith & Fulham), 5 (Harrow), 7 (Kensington & Chelsea), 8 (Kingston-upon-Thames), 9 (Newham), 10 (Richmond), 11 (Tower Hamlets) and 12 (Wandsworth).

The Westminster site (site 13) was originally classified as 'background' owing to its rooftop location. However, in the light of the results obtained for this site as discussed in earlier surveys, this site has been withdrawn from the 'roadside/background' classification and is plotted separately in Figure 2. This leaves one 'background' site; site 1 (Bexley)

It can be seen that the roadside concentrations were consistently higher than the background ones. This result emphasises the importance of road traffic as a source of PAHs. It should be noted that concentrations of most PAH species recorded at Westminster were comparable with those obtained at Bexley. The notable exceptions were concentrations of NP, ACE/FL and ANT which exceeded both those for Bexley and mean roadside concentrations. The total mean PAH concentration at Westminster was greater than for the Bexley site. At both sites total mean PAH concentrations were lower than those recorded for the roadside sites.

The highest overall total PAH concentration was recorded at site 3 (Ealing) followed by site 12 (Wandsworth). The Ealing site is at the facade of building within a few metres of a busy road. The Wandsworth site is also adjacent to a busy road, but the sampler was located at the rear of the buildings adjoining the road.

The lowest overall concentration, with the exception of Tower Hamlets (site 11) was recorded at the 'background' site at Bexley (site 1). The data obtained from Tower Hamlets is subject to some question due to a low sample volume during the winter sampling period. However, it should be noted that relatively low concentrations of PAH were recorded at this site in last years survey.

Total concentrations at Westminster were comparable with those for the 'roadside' sites 2 (Brent) and 4 (Hammersmith)

7.3 Winter/summer Ratios

The winter and summer concentrations of each compound are shown in Figures 3 and 4 (absolute values) and Figure 5 (summer/winter ratios). In view of the volatility of the lower molecular weight compounds, and the relatively large fractions in the gas phase, these two figures are most informative for the compounds from benzo (f) fluoranthene (BbF) through to coronene (COR). The comments here are therefore largely confined to these compounds. Though it is of note that the winter/summer ratio for NP was high which reflects the high concentrations of this species monitored during the winter sampling.

The major PAH species present in car exhaust emissions are reported to be fluoranthene (FLH) and pyrene (PYR). Benzo (ghi) perylene (BghiP) is also reported to be one of the PAHs most often associated with vehicle emissions. One might expect, therefore, that FLH, PYR and BghiP would have a low winter to summer ratio which, as can be seen from Figure 3, is indeed the case. The ratios for the other PAH species in this range are comparably low with the exception of BkF. The higher winter/summer ratio for BkF is attributable to the relatively high winter concentrations recorded for this compound (Figure 4.).

The relatively high total summer concentration at site 12 (Wandsworth) is largely a result of the concentrations of BghiP and COR (9.8 ng m-3 and 7.89 ng m-3, respectively) recorded, again indicative of vehicle emissions as being the major PAH source at this site. This relative importance of BghiP and COR was repeated at all the sites sampled during the summer with the exception of sites 5 (Harrow), 7 (Kensington & Chelsea) and 8 (Kingston).

A point of note at the Westminster site is that the major contributors to the total PAH concentration monitored during the winter were NP and ACE/FL which suggests that there may be a local PAH source other than vehicle emissions.

7.4 Comparison with Results of the 1991/92 & 1992/93 LWEP PAH Surveys

For a number of sites, sampling has been undertaken at the same location throughout the 1991/92 and 1992/93 LWEP PAH surveys. For these sites (1, 2, 3, 7, 8, 9, 10, 11 and 13) some comparison of levels from year to year is possible.

For each of the sites, total PAH concentration during 1991/92, 1992/93 and 1993/94 are illustrated in Figures 6 (for the summer period) and 7 (for the winter period). Note that the site at Richmond (site 10) was relocated during the 1992/93 survey and therefore any comparisons must be made with caution for this site. Also summer measurements were not made at Tower Hamlets (site 11) in 1991/92.

As Figure 6 illustrates there is no clear annual trend in summer PAH concentration. Summer concentrations were higher in 1993/94 than in previous years at 4 sites (Ealing, Kensington & Chelsea, Tower Hamlets and Westminster), but lower than in 1991/92 and 1992/93 at 5 sites.

As Figure 7 illustrates total PAH concentrations monitored in the winter 1993/94 survey were generally lower than in the 1992/93 survey, even with the exclusion of the data from sites 7 and 13 (Kensington & Chelsea and Westminster), the reliability of which was discussed in the 1992/93 LWEP PAH report. In addition, at all but two sites (Bexley and Brent) total PAH concentrations were lower in 1993/94 than in 1991/92. However, it should be noted that this may reflect differences in meteorological conditions from one winter to the next rather than a genuine downward annual trend.

7.5 The PAH Profile

The use of the relative proportions of the individual PAHs in a given sample or series of samples - the 'PAH profile' - has often been tried as a method of determining the relative contribution of different sources.

For example, as was mentioned above, BghiP has been suggested as a marker for vehicle emissions. Coronene is also reported to be predominantly arises as a result of vehicle emissions, whereas benz (a) pyrene (BaP) is readily produced by coal and coke-burning as well as being present in vehicle emissions. There is no general consensus as to the use of

PAH profiles for source apportionment, and one reason for this must be that the effect of

atmospheric transport, degradation and deposition processes tend to blur any initial sharp differences in the emitted PAH concentrations. However, in order to investigate the use of profiles in this study, the graph shown in Figure 8 was constructed. The PAHs chosen were the six most carcinogenic of molecular weight 228 or greater, and the average of the summer and winter concentrations was used.

Figure 8 indicates that similar PAH profiles were obtained for each of the sites. At each site concentrations of BaA/CHR, BbF and BghiP were the highest and the concentration of DahA was consistently the lowest.

7.6. PAH Concentration at RPT, Southwark Street, London, SE1

The short sampling periods used in the LWEP PAH survey limit data analysis to some extent as they only provide a snapshot of the PAH concentration. In order to assist our understanding of the individual results for each site more extensive measurements of PAH were made at one site over the 1993/94 period. This site at RPT, Southwark Street, London, SE1, is a rooftop site some 30m above ground level in an area of heavy traffic. PAH concentrations were monitored for two week periods each month between July 1993 and March 1994, with the exception of October 1993.

The total PAH concentration (ng m^{-3}) for each sample period is illustrated in Figure 9. As might be expected the total PAH concentrations were highest between the months of September 1993 and February 1994 and lowest during the summer months of July and August. The arithmetic mean of the total PAH concentration over the sample period was 6.67 ng m^{-3} which compares with 8.24 ng m^{-3} at Bexley, 12.04 ng m^{-3} at Westminster and the mean value of 15.0 ng m^{-3} from the 'roadside' sites.

The PAH profile of the mean concentration of the most carcinogenic compounds for each sampling period at the Southwark Street site are shown in Figure 10. Throughout the survey BbF and BghiP were consistently the PAH species with the highest concentration again demonstrating the importance of vehicle emissions at this urban background site.

As Figures 9 and 10 illustrate, total PAH concentration and the concentrations of individual compounds varied from month to month, as might be expected. However, the relatively small variation between winter measurements (November to February) and summer measurements (July, August and March) suggest that the LWEP approach of taking two 'snapshot' samples provides a realistic estimate of annual mean PAH concentrations.

A comparison of Figure 10 with Figure 1 illustrates that the degree of seasonal variation at the fixed site in London, SE1 is considerably less than the degree of site to site variation. This suggests that the differences in PAH concentration between sites arise as a result of genuine site specific factors.

Table 8: Results of sampling survey at 61 Southwark Street. PAH concentrations (ng m^{-3}) at periods between 22.6.93 and 29.3.94

Sample Date	NP	ACE/FL	PHE	ANT	FLH	PYR	BaA/CHR	BbF	BkF	BaP	DahA	BghiP	COR	Total
22.6.93 - 13.7.93	0.18	0.23	0.2	0.1	0.33	0.21	0.1	0.36	0.002	0.08	0.07	0.35	0.27	2.48
3.8.93 - 17.8.93	0.1	0.42	0.37	0.1	0.2	0.29	0.1	0.38	0.002	0.12	0.09	0.41	0.31	2.89
21.9.93 - 5.10.93	0.65	0.2	0.42	0.1	1.07	0.73	0.57	1.37	0.45	0.4	0.17	1.31	1.15	8.59
10.11.93 -24.11.93	1.40	1.13	1.03	0.1	0.7	1.2	0.42	0.74	0.05	0.12	0.1	0.57	0.63	8.19
21.12.93 - 4.1.94	0.33	0.29	0.2	0.1	0.93	0.61	1.07	1.26	0.4	0.33	0.24	1.22	0.87	7.85
18.1.94 - 3.2.94	0.74	0.38	0.2	0.1	0.7	0.46	0.1	0.83	0.002	0.16	0.30	0.83	0.71	5.51
15.2.94 - 1.3.94	0.1	0.48	4.31	0.1	0.46	1.8	1.56	1.62	0.38	0.5	0.37	1.39	0.89	13.96
15.3.94 - 29.3.94	0.78	0.46	0.42	0.1	0.29	0.25	0.16	0.42	0.002	0.09	0.05	0.45	0.39	3.86
Arithmetic mean	0.54	0.45	0.89	0.1	0.59	0.69	0.51	0.87	0.16	0.23	0.17	0.82	0.65	6.67
Geometric mean	0.36	0.39	0.47	0.1	0.51	0.54	0.3	0.75	0.02	0.18	0.14	0.71	0.58	5.74

7.7 BaP Concentration as a Percentage of all the Major Carcinogenic PAHs

Benzo (a) pyrene (BaP) is the only PAH for which there are any authoritative recommendations as to an appropriate guideline or standard. It is often stated that the BaP concentration on its own is not a satisfactory index of the total carcinogenic potential of a mixture of PAHs, so it is of interest to find the BaP concentration expressed as a percentage of all the major carcinogenic PAHs. In the context of the present measurements, this is:

BaP conc. x 100 ÷ sum of conc. (BaA/CHR + BbF + BkF + BaP + DahA + BghiP)

This percentage has been calculated for the estimated annual average concentrations and the values are given in Table 9.

Table 9: BaP concentrations as a percentage of the sum of the concentrations of (BaA/CHR + BbF + BkF + BaP + DahA + BghiP)

Site	Borough	Percent BaP
1	Bexley	0.16
2	Brent	0.14
3	Ealing	9.49
4	Hammersmith & Fulham	8.54
5	Harrow	10.72
7	Kensington & Chelsea	9.85
8	Kingston upon Thames	0.27
9	Newham	7.62
10	Richmond	3.25
11	Tower Hamlets	9.79
12	Wandsworth	6.7
13	Westminster	9.25
Arithmetic mean		6.32

Low values were obtained for sites 1 (Bexley), 2 (Brent), 8 (Kingston) and 10 (Richmond). Percentages for the remaining sites were relatively consistent, varying between 6.7 and 10.72 %.

7.8 Comparison of Results with Guidelines for BaP

If BaP is used as an index of PAH carcinogenicity, then some comparison of the LWEP PAH survey results with the Dutch and German guidelines for BaP (5 and 10 ng m^{-3} respectively) is possible. However it must be noted that these guidelines relate to annual mean concentrations, and the short sampling periods used in this survey mean that any comparison can only be approximate.

The overall mean concentration of BaP ranged between 0.37 ng m^{-3} at Bexley to 1.46 ng m^{-3} at Ealing. This reflects the nature of the two sites in that Bexley is a background site located in a park, some 150 m away from the nearest road compared with the Ealing site which is on the facade of a building within a few metres of a busy road. The overall mean for the 12 sites is 0.63 ng m^{-3}.

The mean BaP concentration was lower in summer (0.51 ng m^{-3}) than winter (0.75 ng m^{-3}). The highest winter concentration was recorded at Ealing (2.09 ng m^{-3}).

The survey results indicate that mean BaP concentrations in London Boroughs were generally well below European guidelines over the sampling periods. Also the mean BaP concentration recorded during the 1993/94 survey did not exceed the guideline value of 1 ng m^{-3}, derived in Section 3.0 from USEPA estimates of 'acceptable risk'. However, this is in contrast to the results of previous surveys in which the overall mean BaP concentration was 1.5 ng m^{-3} (1991/92) and 1.91 ng m^{-3} (1992/93). Furthermore, this years value of 0.63 ng m^{-3} represents the average across all sites and sampling periods, and it is clear that the guideline value for BaP of 1 ng m^{-3} was exceeded or approached at sites 3 (Ealing, 1.46 ng m^{-3}), 12 (Wandsworth, 1.06 ng m^{-3}) and 5 (Harrow, 0.81 ng m^{-3}).

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7.9 Comparisons with the Results of Other Surveys

Owing to the limited sampling periods used in the TBV Science LWEP PAH survey, and variation in sampling technique, regime and so forth, it is not appropriate to make detailed comparisons between the results obtained from this survey with other surveys. Despite the limitations of the measurements, some tentative comparisons may be made between PAH values for our survey and those presented in Table 2 of this report.

Other urban surveys (i.e. those undertaken in South Kensington, Birmingham and Manchester) are of most relevance to the LWEP survey; rural values recorded at Folkestone and Ashford are, as would be expected, much lower than any of the urban measurements. Values of PAH species common to all these urban surveys are tabulated below to facilitate comparison between studies and it would appear that the results of all 4 urban surveys are broadly similar.

Table 10: Comparison of the Results of the 1992/93 LWEP PAH Survey with the Results of Other Surveys in Urban Areas of the UK

Compound and abbreviation		Average Particulate PAH Concentration (ng m^{-3})			
		LWEP Survey	South Kensington	Birmingham	Manchester
Phenanthrene	PHE	0.65	0.11	1.1	0.4
Anthracene	ANT	0.11	0.18	0.4	0.05
Fluoranthene	FLH	1.29	0.81	1.2	0.63
Pyrene	PYR	1.49	0.79	2.4	0.8
Benzo (k) fluoranthene	BkF	0.63	0.68	1.1	2.4
Benzo (a) pyrene	BaP	0.63	1.44	0.73	1.6
Benzo (ghi) perylene	BghiP	2.25	3.30	1.9	3.1
Coronene	COR	1.82	1.67	1.0	1.4

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8 Discussion

This survey was designed to give a snapshot of the PAH concentrations at roadside and background sites across London, and the short sampling periods used do not, therefore permit a detailed analysis of the intersite differences. The PAH survey conducted at RPT, London, SE1 aimed to provide an insight into the variation in concentration at one site over time.

Despite the limitations of the LWEP PAH survey it is possible to identify some general trends in the data set, some of which are supported by findings from the RPT, London, SE1 survey:

- As in previous LWEP PAH surveys wide variations in concentration were found, from compound to compound, site to site and season to season. This is a general feature of PAH concentrations surveyed in urban areas.

- 'Roadside' concentrations were consistently higher than Bexley (site 1) which represented a 'background' site, emphasising the importance of road traffic as a source of PAH.

- Concentrations of PAH recorded at the Westminster site were consistently higher than Bexley concurring with the 1992/93 survey results that this can not be regarded as a 'background' site. Concentrations of some PAH species (NP, ACE/FL and ANT) were higher at this site than at 'roadside' sites. These species are not the major indicators of vehicle emissions which may suggest an alternative PAH source at this site. It would be worth considering moving the sample point in Westminster in order to explore this possibility.

- The importance of vehicle emissions as a PAH source is demonstrated by the low winter to summer ratios of vehicle emission indicator species FLH, PYR and BghiP.

- The results from the fixed site monitoring at RPT, London, SE 1, indicate the importance of seasonal variation with respect to PAH concentration. In addition they illustrate the small within season variation. This provides some validation for the sampling approach adopted for the LWEP PAH survey, specifically that this approach does provide a realistic estimate of annual mean PAH concentrations and of genuine inter site differences.

- The PAH profiles for the six most carcinogenic compounds monitored were consistent across all sites, with concentrations of BghiP, BbFand BaA/CHR being consistently highest and those of DahA being consistently lowest.

- Use of BaP as an index of carcinogenicity indicates that concentrations of BaP in London were considerably below European guidelines. However, the guide concentration of 'acceptable risk' for BaP of 1 ng m^{-3} was exceeded or approached at 3 sites. This result is of interest considering the limitations of the survey and clearly demonstrates the potential for other exceedences is present.

- Comparison of the results of the 1993/94 LWEP PAH survey with other surveys in South Kensington, Birmingham and Manchester indicates that the results are broadly similar across all four surveys.

The fixed site monitoring conducted at RPT, Southwark St., London, SE1 provided some valuable information concerning the ambient PAH concentration at one site over time. The survey indicated the importance of vehicle emissions as the major PAH source in this area and the influence that seasonal factors exert on ambient PAH concentrations. For this reason we intend, as part of the 1994/95 survey, to repeat the monitoring at RPT, London, SE1 over the period of a year.

With regard to likely future trends in PAH concentrations in London, legislation relating to future control of diesel emissions from vehicles is of relevance, since diesel emissions are thought to be the primary source of PAH in urban areas. Some PAH species are emitted in higher concetrations from diesel engines including the known carcinogen Benzo (a) pyrene (BaP).

With respect to diesel emissions from cars, an amending European Community (EC) Directive (91/441/EEC) published in August 1991 consolidates European legislation on vehicle emissions and sets more stringent emission standards which are mandatory and have applied to all new cars registered from 1 January 1993, and to new models from 31 July 1992. To meet the standards diesel engine vehicles require "state-of-the-art" technology.

With respect to heavy goods vehicles (HGVs), EC Directive 91/542/EEC published in October 1991 tightened standards for gaseous emissions in two stages. The first stage reductions were planned for 1 July 1992 (new models) and 1 October 1993 (all new vehicles). The second stage is planned for 1 October 1995 (new models) and 1 October 1996 (all new vehicles) and matches the very stringent 'US 1994' diesel standards. The new limits will require an improvement in the quality of diesel fuel.

This European legislation will bring about a reduction in unit emissions of controlled pollutants, these being nitrogen oxides, carbon monoxide and hydrocarbons, from both cars and goods vehicles.

However, the effect these reductions will have on ambient PAH concentrations in urban air is not yet clear as the legislation will be operating against an increase in the diesel fleet. Currently, only 6% of the cars on the road are diesel but, if current sales are maintained it is predicted that within 10 years the diesel car population could rise to 20% (4).

The London wide PAH surveys provide a valuable database of information on hydrocarbon levels in London, particularly at roadside locations, and their continuation will enable the impact of recent legislation on London's air quality to be monitored.

Figure 1: Total PAH Concentration (ng/m3) During Summer and Winter Sampling