NPL
National Physical Laboratory

Report

NPL REPORT
DQL-AS 028

CPEA 28: Airborne Particulate Concentrations and Numbers in the United Kingdom (phase 2)

Annual Report - 2005

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Annual Report for 2005 on the UK Airborne Particulate Concentrations and Numbers Network

Executive Summary

This Report was prepared by NPL as part of the 2005-2007 UK Airborne Particulate Concentrations and Numbers Monitoring contract with the Department for the Environment, Food and Rural Affairs. This is the Annual Summary Report for 2005 and contains:

- Summary of Network Operation and QA/QC procedures
- Data capture rates per instrument per month
- All Network data from 2005, validated and ratified
- Description and discussion of notable events during the year
- Comparison of 2005 particle numbers and concentration of sulphate, nitrate and carbon with levels in recent years.
- Policy update on relevant areas
- Update of research and equipment in the field

In summary, during 2005:

NPL took over the management of the Network from Casella Stanger in June, and appointed the Environmental Research Group at King's College London as Central Management and Control Unit. Several improvements to the Network were initiated, particularly in the areas of remote communications, data handling and quality assurance and control. Remedial work was carried out on instruments where necessary, and a rolling programme of audits, services and calibrations was started.

There are 23 instruments operating on the Network, and NPL has improved data capture for 18 of these, thanks to a dedicated Equipment Support Unit and a regular maintenance strategy.

Concentrations of nitrate, sulphate, chloride, carbon and particle numbers in the UK in 2005 are consistent with levels found in recent years. There have been no significant episodes of high air pollution during the year. Incidents to note are the terrorist attacks in London in July and the Buncefield Oil Depot fire in December, both of which are described in this report.

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Approved on behalf of Managing Director, NPL
By Stuart Windsor, Division of Quality of Life

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Introduction

This Report was prepared by NPL as part of the 2005-2007 UK Airborne Particulate Concentrations and Numbers Monitoring contract (CPEA 28) with the Department for the Environment, Food and Rural Affairs.

During 2005 the contractor operating the UK Airborne Particulate Concentrations and Numbers Network, on behalf of Defra, changed. From January to April, Casella Stanger (now Bureau Veritas) operated the Network. May was the handover month, during which, Casella Stanger gradually handed over all Network responsibilities to the National Physical Laboratory. From June to December, the National Physical Laboratory operated the Network.

This is the Annual Summary Report for the UK Airborne Particulate Concentrations and Numbers Network for 2005 and contains:

- Summary of Network Operation and QA/QC procedures
- Data capture rates per instrument per month
- All Network data from 2005, validated and ratified
- Description and discussion of notable events during the year
- Comparison of 2005 particle numbers and concentration of sulphate, nitrate and carbon with levels in recent years
- Policy update on relevant areas
- Update of research and equipment in the field

This report follows NPL's recent State of Network Report (September 2005), which fully assessed the current state of the Network and described improvements implemented by NPL, and the Strategic Network Review (November 2005). The Review proposed the optimum configuration for the existing instruments and made suggestions regarding the development of the Network. Executive Summaries for these reports are documented in Annex 3 and Annex 4.

Network Operation

Overview

New Structure for Network Operation

When NPL took over the network it changed the structure of the operation of the network to mirror that of the AURN, to include a Central Management and Control Unit (CMCU) and a Quality Assurance and Quality Control Unit (QA/QC). To perform the CMCU activities NPL employed the Environmental Research Group at King's College London (KCL). These activities include the routine collection of data from site, initial data validation and instrument fault finding, routine liaison with the Local Site Operators (LSO) and the Equipment Support Unit (ESU). The QA/QC activities were performed by NPL and include: site audits, inter-laboratory performance schemes and data ratification.

Improvements to Network Operation

Remote Communications for CPC and SMPS analysers

Under the previous contract, the data produced from these analysers were copied from the on-site computer collecting the data to mass storage media on a monthly basis by the Local Site Operator (LSO). This data was then sent to the CMCU. This meant that any non-catastrophic faults with analyser were not detected until the month's worth of data was examined and hence possibilities of low data capture rates were introduced.

New telephone lines have been installed at the Birmingham Centre, Port Talbot, Glasgow and North Kensington sites. Data is now being collected from all the particle counting analysers on a daily basis and immediately screened for faults. In future, the newly installed remote communication links could be used so that validated data could be sent to the Data Dissemination Unit on a daily basis for public dissemination.

Daily Sulphate Partisol Samplers

Shortly after handover it was noticed that clogging of the pores in the PTFE filters was causing a reduction in the sample flow rate at certain sites. The filter material was changed to 'Emfab', which is a PTFE coated glass fibre material. These filters have previously been assessed by NPL and found to be more suitable for ambient air monitoring of this type.

Remote Loading Of Partisol Filter Numbers

Previously the daily sulphate measurements made by the Partisol samplers relied on the manual entering of the filter number and cassette ID into the Partisol sampler's memory by the LSO. This is a slow and labour intensive process subject to user error. As the Partisol samplers were already fitted with remote communications it was decided that the CMCU would upload this information direct to the sampler, so that it was ready for the LSO at their fortnightly visit. This reduces data entry errors as the

CMCU records the unique filter numbers and cassette identification when filters are sent to LSOs.

CPC Calibrations

The CPC analyser counts the number of particles suspended in the sample air mass in two modes. At low particle number concentrations the CPC counts individual particles as they pass through the detector. At number concentrations of greater than 5×10^5 PC cm^{-3} the CPC changes to integration mode where the detector integrates the amount of light it receives and translates this signal into the number of particles in the air stream. The amount of light received by the detector in the integration mode is directly affected by the cleanliness of the optics and therefore the amount of light received will decrease over time. This will directly lead to a change in calibration over time.

CPC instruments were previously never calibrated in an as-found state before they were serviced and cleaned by the instrument supplier. Therefore this change in calibration was never quantified and the data never scaled for this change in calibration over time. NPL has instituted an as found calibration by the instrument supplier at every CPC service. This extra calibration information has been used to scale data and reduce the uncertainty of the data.

Real-time Carbon Analysers

The previous contractor ran these analysers with a 3-hour sampling period. NPL has changed the sampling period to hourly to increase measurement time resolution, which is especially useful for episode analysis. After a six month trial period the Harwell instrument was returned to the 3 hour sampling mode as the low concentrations measured at this rural site were close to the limit of detection.

NPL has introduced daily calibration of the carbon analysers using carbon dioxide in nitrogen gas standards. It has been shown that the response from the detectors changes, but may vary by up to 25% over a 10 day period. It is therefore essential to calibrate the instruments regularly.

Harwell Site Move

Equipment from this Network has been moved from buildings B573.2 and B573.T2 to B585, which is approximately 100m east of the original monitoring stations. Air Monitors, the Equipment Support Unit (ESU), moved the Automatic Carbon, Automatic Nitrate and Partisol analysers on 21 February 2006. Netcen installed the SMPS in the new building on 23 February 2006. The Meteorological mast was moved on 18 March 2006 and realigned under the instruction of Netcen. There are now full remote communications with all of the instruments. NPL plans to install the spare Network CPC into the new accommodation during 2006, co-located with the SMPS.

Instrumentation

A list of Network monitoring instruments can be found in Annex 1. Annex 2 contains a map showing the locations of the deployed instruments.

Particle Counting and Sizing Instruments

These instruments operate on the principle of passing the sample through clean air supersaturated with butanol, causing a butanol droplet to form around each particle so that they can be counted optically. In a CPC, total number concentrations are determined in this way, either by individual number counting (at low concentrations) or using an optical integrating method (at high concentrations). In the case of an SMPS, the sample entering the CPC has passed through a radioactive device (based on Krypton-85) that gives an electric charge to a fraction of the particles, and then through a controlled electrical potential that separates the charged particles according to their electrical mobility.

Automated Nitrate and OC/EC Instruments

Both systems operate on broadly similar principles. For the nitrate analyser the particulate content of the air is sampled onto a flash strip via an internal cyclone inlet. For the carbon analyser the particulate content of the air is sampled through a size selective inlet and then collected by an impactor. In the case of the Nitrate analysers, the system flash heats the particulate matter and the quantity of NO_x produced is analysed, and in the case of the Carbon analysers, CO_2 is produced. In the latter case the combustion is initially performed at a temperature of (320 – 370)ºC to determine the organic carbon content and subsequently at a temperature of (650 – 700)ºC to determine the elemental or 'soot' carbon content.

Partisol 2025

Particulate samples from air that has passed through a size-selective inlet are collected on an Emfab filter. Partisols provide daily particulate samples that are analysed in the laboratory for sulphate, nitrate and chloride content.

Data Quality

The summary of quality assurance and quality control procedures used during the measurement and ratification process are listed below:

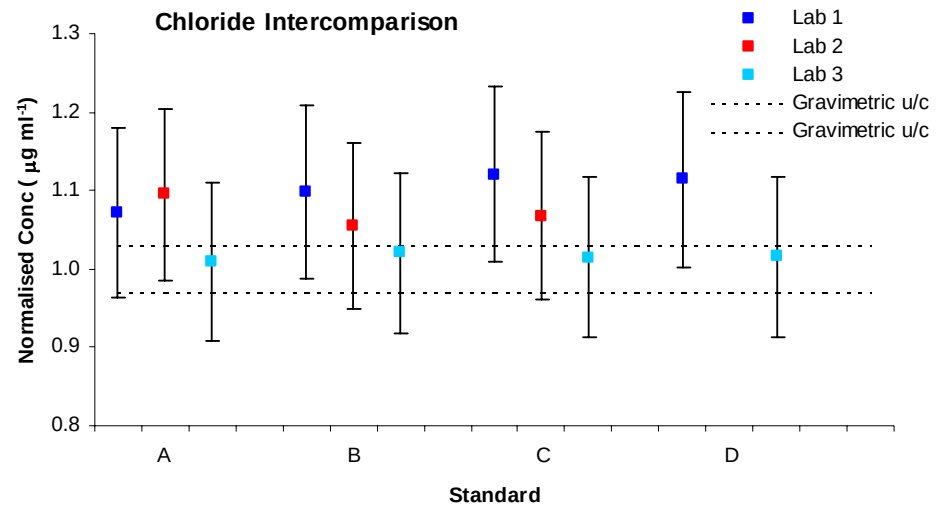
- Field filter blanks for Partisols are routinely analysed
- An intercomparison has been carried out for analysis of anions on filters
- NPL has introduced filter cassette transport cases to reduce contamination
- Continued training of, and regular communication with LSOs
- The KCL Duty Officer is available to advise LSOs 365 days per year
- New LSO manuals have been produced by NPL
- Data collection is automated by the MONNET system at King's College London
- Automatic and manual data validation is followed by rigorous ratification procedures
- Scheduled instrument services and calibrations have been brought up to date
- Calibration data produced by audit, by the ESU and regular calibrations carried out automatically or by the LSOs, are all used to produce an appropriate scaling factor to apply to the data
- Routine maintenance is carried out on all instruments as per manufacturers instructions
- The ESU are contracted to respond to breakdowns within 48 hours
- Development of full uncertainty budgets for all Network equipment is underway

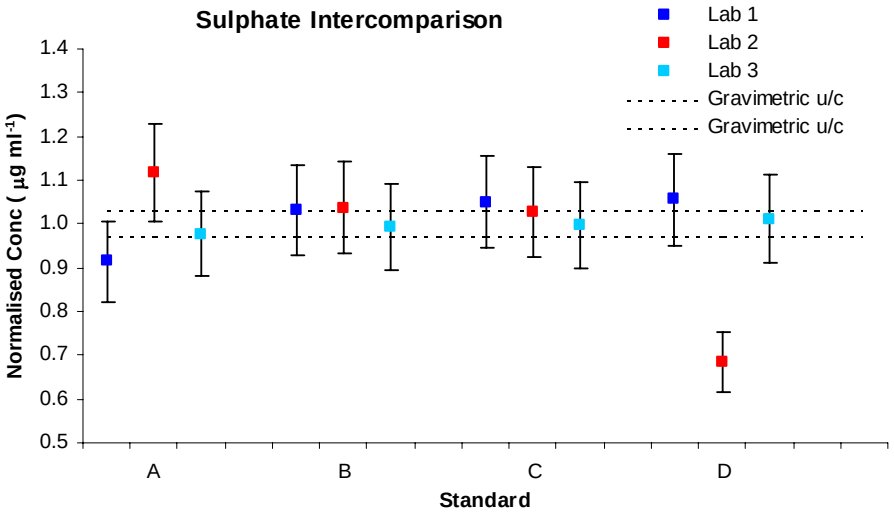
Anions on Filters Intercomparison

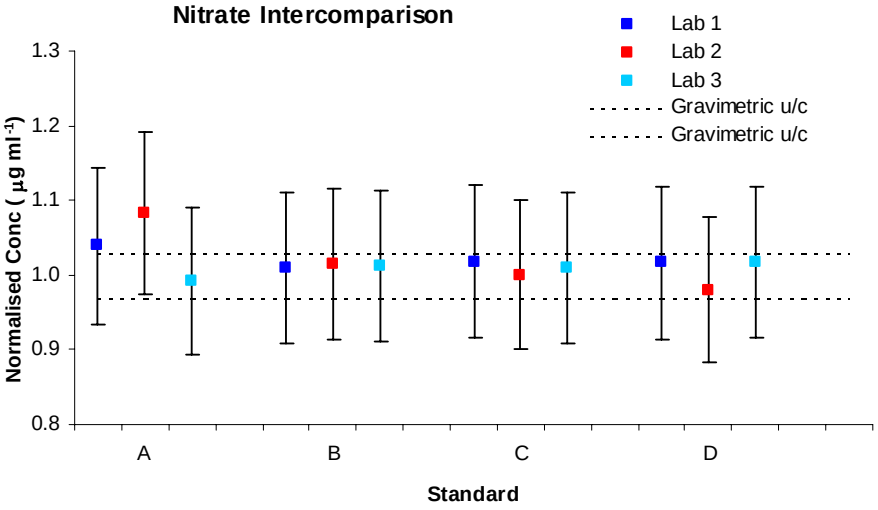
In June 2005, NPL coordinated an intercomparison between Birmingham University and KCL, who are currently contracted to perform these measurements. After sampling particulates onto an Emfab filter, the sulphate, nitrate and chloride anions are extracted into a known mass of aqueous solution. The extract is analysed by ion chromatography.

For the intercomparison, NPL gravimetrically prepared four standard solutions, each containing a different concentration of each anion (in the range expected from the Network). Aliquots of each solution were analysed by Birmingham University, KCL and an independent analyst at NPL. The results for each anion are shown in the graphs below. Each analysis has an associated expanded uncertainty of about 10% ($k = 2$).

Figures 1 to 3 show the results of the intercomparison. Within the stated uncertainties, results from the three laboratories agree well with each other (with one exception), and with the known concentrations.







Labs 1 to 3 are not listed in the order displayed in the Figure title.

Figures 1 to 3 Results of the ion chromatography intercomparison between NPL, Birmingham University and King's College London.

Network data

Data Capture

Overall data capture rates for each instrument type in 2005 are given in Table 1. Data capture is calculated as hourly, ratified data (unless otherwise stated) and instrument down times due to scheduled maintenance and calibration are not included in the calculation of data capture, in line with relevant European Air Quality Directives.

Instrument Type	Number of Network Instruments	Data Capture
Automatic Carbon	4	29%
Automatic Nitrate	3	89%
Partisol (daily)	4	80%
SMPS	3	63%
CPC	7	67%
Met data	2	92%

Table 1. Data Capture across the Airborne Particulate Network during 2005.

Tables 2a and 2b breakdown the data capture obtained by the two organisations that ran the network during 2005.

Instrument Type	Data Capture
Automatic Carbon	19%
Automatic Nitrate	93%
Partisol	72%
SMPS	58%
CPC	49%
Met data	-

Table 2a. Data Capture across the Airborne Particulate Network during 2005 under Casella Stanger Operation

Instrument Type	Data Capture
Automatic Carbon	63%
Automatic Nitrate	87%
Partisol	85%
SMPS	66%
CPC	84%
Met data	92%

Table 2b. Data Capture across the Airborne Particulate Network during 2005 under NPL Operation

Instrument Performance And Concentration Data

A summary of instrument breakdowns and repairs is listed in Annex 5.

The following sections discuss each instrument type. There is a monthly breakdown of data capture at each site along with reasons for data loss. The concentration data from each instrument is also presented in a graphical format and unusual or interesting occurrences are noted and discussed. Levels of particulates, carbon, nitrate and sulphate are consistent with levels found in recent years.

Full, validated data from 2005 will be used to form the basis of future topic reports, produced in collaboration with Birmingham University.

Automatic Carbon Analysers

Monthly data capture rates for the Automatic Carbon instruments during 2005 are displayed in the table below:

Site	Belfast	Harwell	North Kensington	Marylebone Road
January	0%	0%	40%	0%
February	0%	0%	100%	0%
March	0%	0%	100%	0%
April	0%	0%	90%	0%
May	0%	0%	30%	15%
June	-	-	-	-
July	-	-	-	-
August	-	-	-	-
September	31%	83%	89%	26%
October	27%	93%	90%	28%
November	65%	94%	72%	56%
December	0%	87%	72%	89%
Average	10%	29%	57%	18%

Table 3. Monthly data capture for Carbon instruments during 2005.

None of the Rupprecht and Patashnick (R&P) Carbon 5400 instruments were operating correctly at handover. Further details are given in the NPL State of Network Report, September 2005. All four deployed Carbon Analysers and the network spare were returned immediately to the ESU (Air Monitors) for investigation and remediation. They were each reinstalled on the Network during September. Since installation, the instruments have been problematic and have all required extensive repair. Therefore, the data is presented as validated only. The long-term future of these instruments is not assured. Spares and accessories are no longer being routinely produced by the equipment manufacturer, which had led to substantial delays to repair and service.

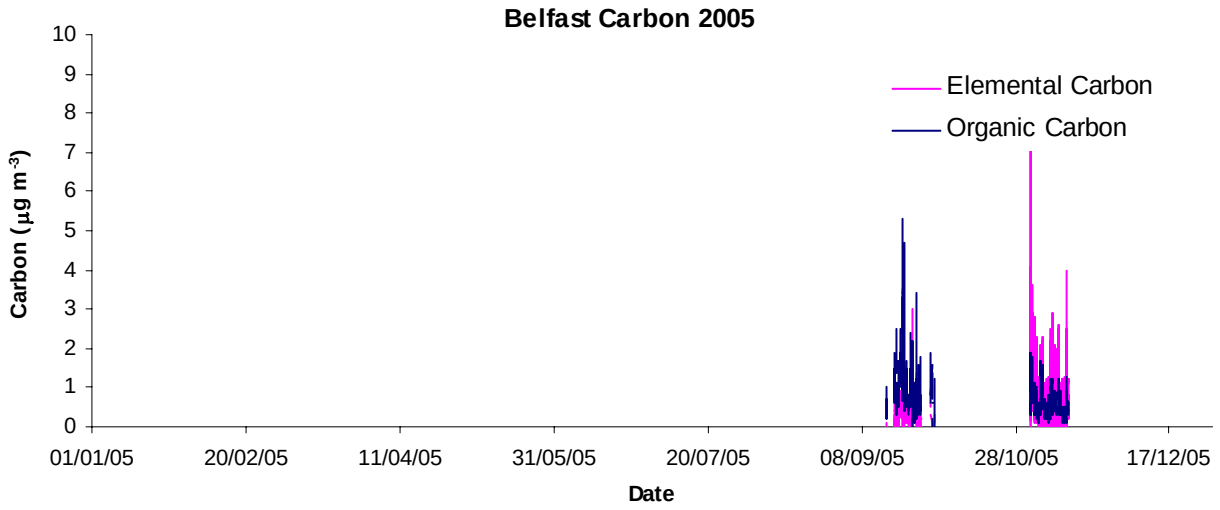


Figure 4a. Organic and elemental carbon concentrations at Belfast in 2005

In September 2005, the organic carbon levels are higher than the elemental levels. This is also seen in previous years. However, in November this trend is reversed, for no apparent reason. There was no change in activity at the site and no changes in the set-up of the instrument or data processing. This further points to the unreliability of the aging equipment. A similar reversal of the trend was seen at Harwell during 2004, as shown in the graph below:

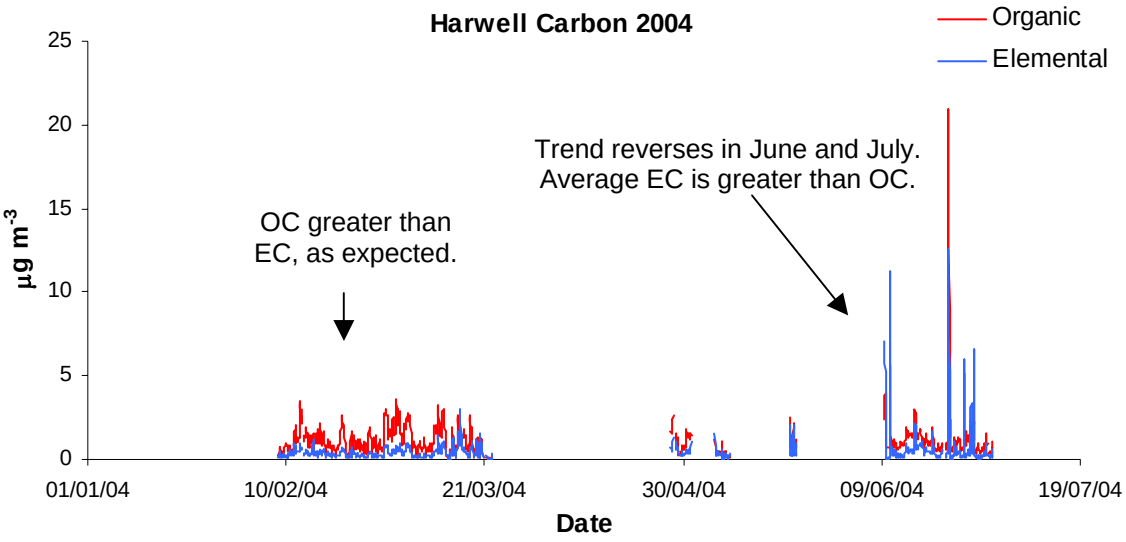


Figure 4b. Trend reversal of organic and elemental carbon at Harwell in 2004

In 2005, the average elemental carbon concentration continues to be greater than the organic carbon concentration at Harwell, despite the fact that the instrument was operated in the same way, with fortnightly routine maintenance and 6-monthly service. This also suggests a malfunction in the equipment that cannot be rectified by the ESU.

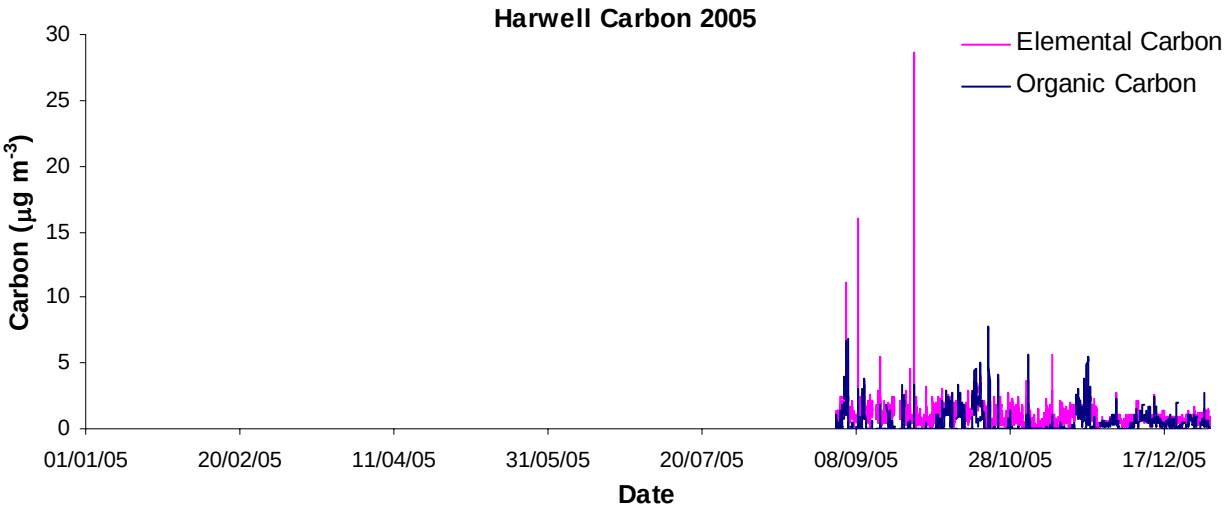


Figure 4c. Organic and elemental carbon concentrations at Harwell in 2005

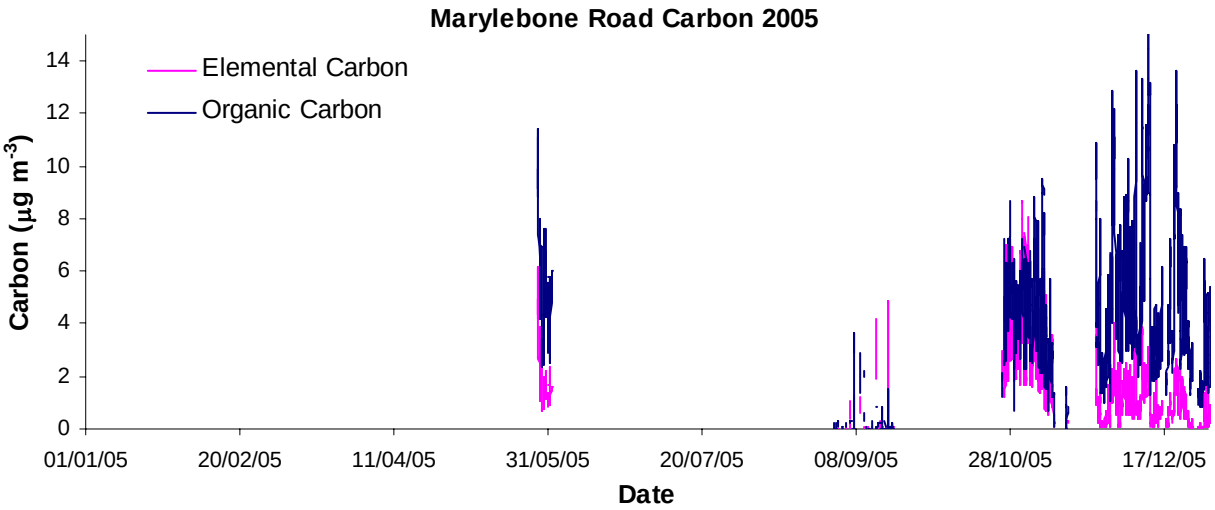


Figure 4d. Organic and elemental carbon concentrations at Marylebone Road in 2005

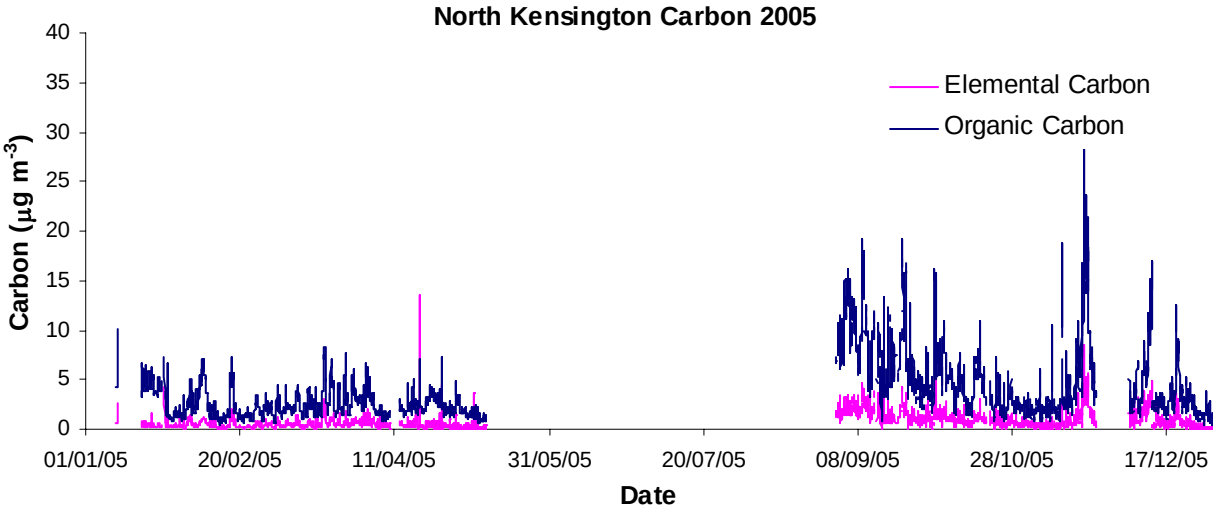


Figure 4e. Organic and elemental carbon concentrations at North Kensington 2005

Automatic Nitrate Analysers

Monthly data capture rates for the Automatic Nitrate instruments during 2005 are displayed in the table below:

Site	Belfast	Harwell	Marylebone Road
January	84%	84%	-
February	100%	100%	-
March	100%	91%	-
April	99%	100%	-
May	53%	86%	-
June	91%	83%	92%
July	100%	98%	86%
August	99%	100%	83%
September	99%	99%	77%
October	99%	92%	78%
November	95%	85%	84%
December	82%	21%	79%
Average	92%	86%	85%

Table 4. Monthly data capture for automatic nitrate instruments during 2005.

Graphs of the nitrate concentrations measured at each site are shown below:

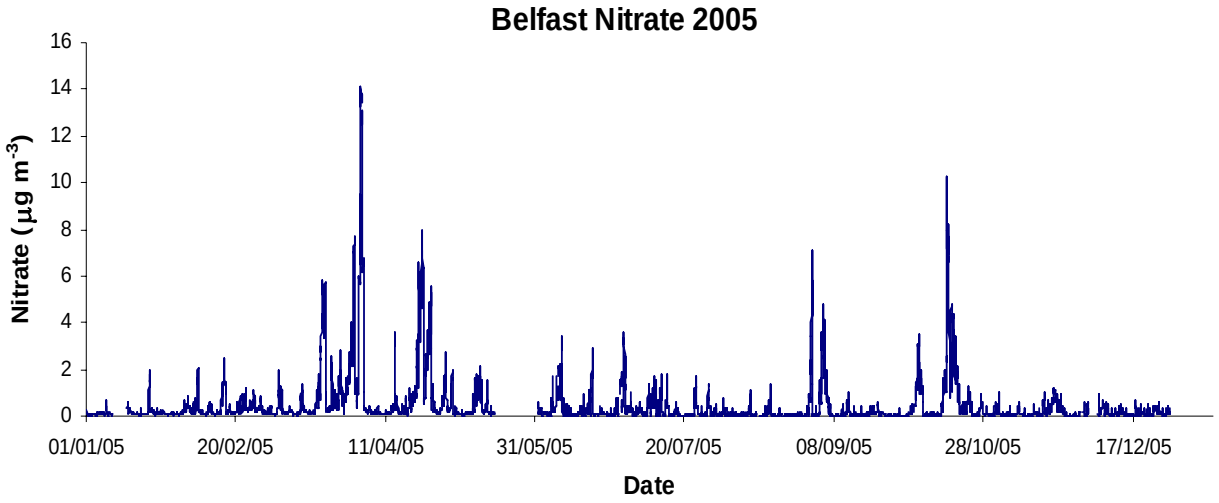


Figure 5a. Nitrate concentrations at Belfast in 2005

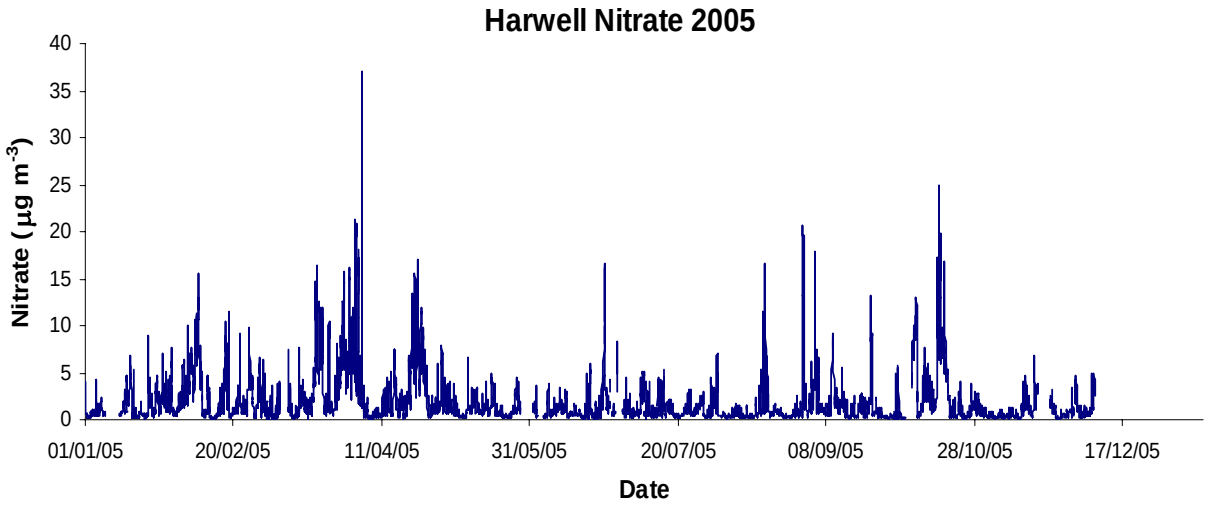


Figure 5b. Nitrate concentrations at Harwell in 2005

Data Capture is low from 07/12/05, at Harwell due to repeated flash strip failures. The Local Site Operator and ESU both responded promptly and this issue has was rectified by the end of December.

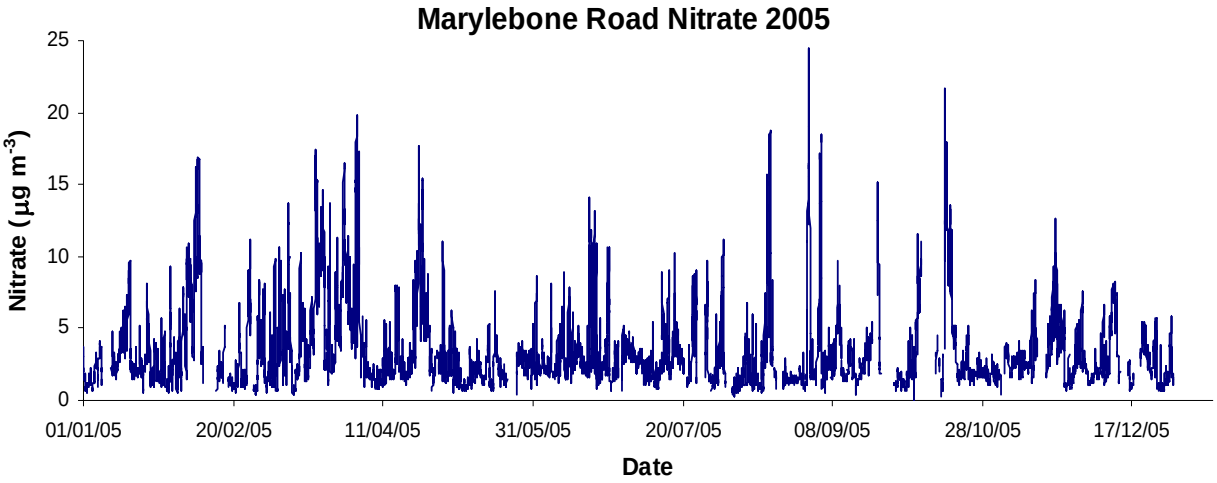


Figure 5c. Nitrate concentrations at Marylebone Road during 2005

Data from January to May has been kindly provided by KCL. It was not produced as part of this Network and therefore is not included in the calculation of data capture rates.

Partisol 2025

Monthly data capture rates for the Partisol 2025 instruments during 2005 are displayed in the table below:

Site	Belfast	Harwell	North Kensington	Marylebone Road
January	39%	100%	84%	97%
February	0%	61%	93%	71%
March	32%	97%	100%	81%
April	1%	87%	90%	67%
May	0%	97%	77%	100%
June	83%	39%	69%	81%
July	94%	86%	98%	81%
August	90%	95%	96%	80%
September	92%	94%	99%	94%
October	86%	95%	98%	98%
November	88%	96%	99%	90%
December	80%	87%	57%	42%
Average	62%	86%	88%	82%

Table 5. Monthly data capture for Partisol 2025 instruments during 2005

Particulates collected by the Partisol instruments are analysed for sulphate, as required by Defra. Analyses for nitrate and chloride are also carried out. This data is displayed in the following graphs:

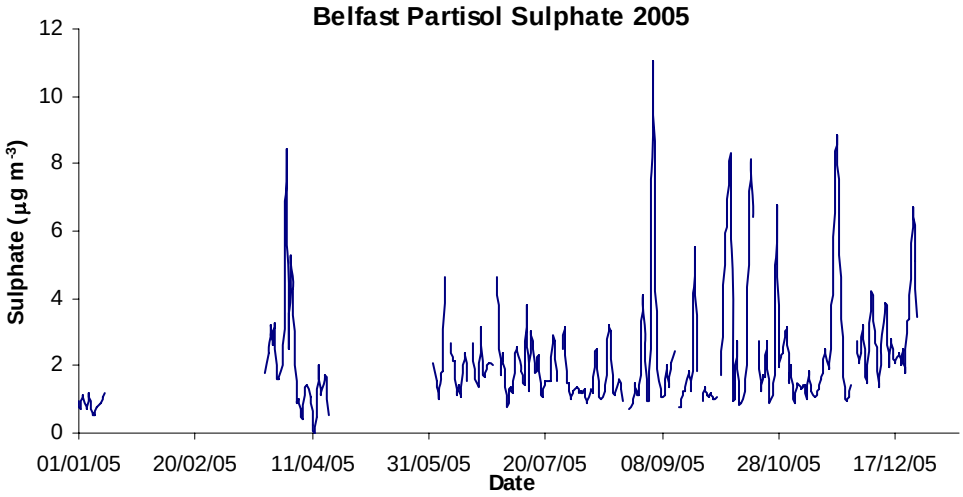


Figure 6a. Sulphate concentrations at Belfast during 2005

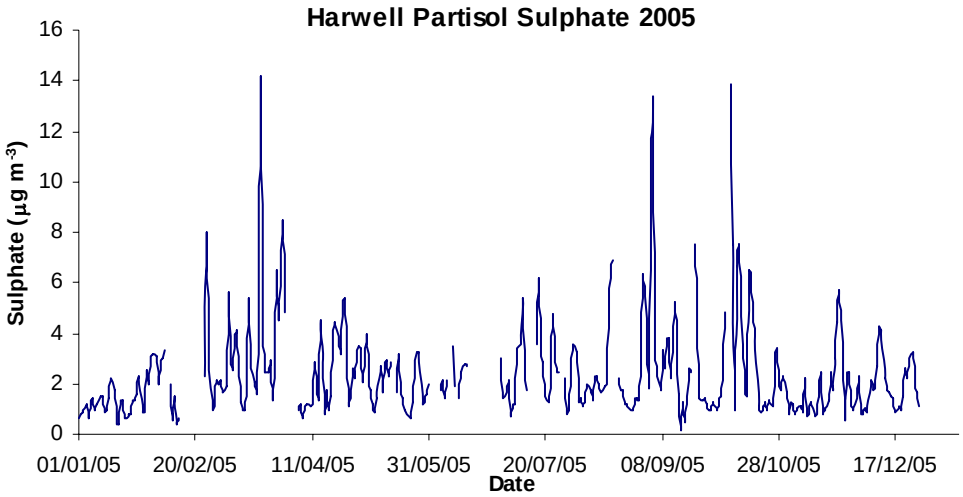


Figure 6b. Sulphate concentrations at Harwell during 2005

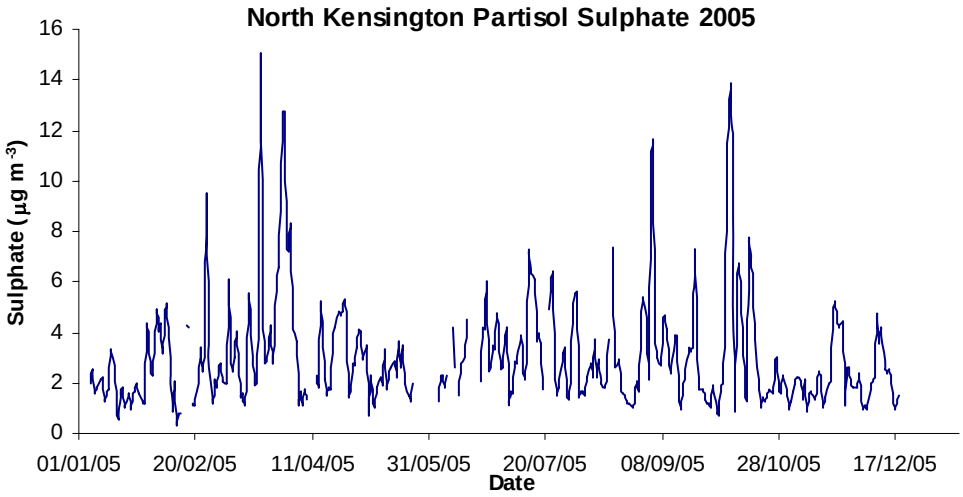


Figure 6c. Sulphate concentrations at North Kensington during 2005

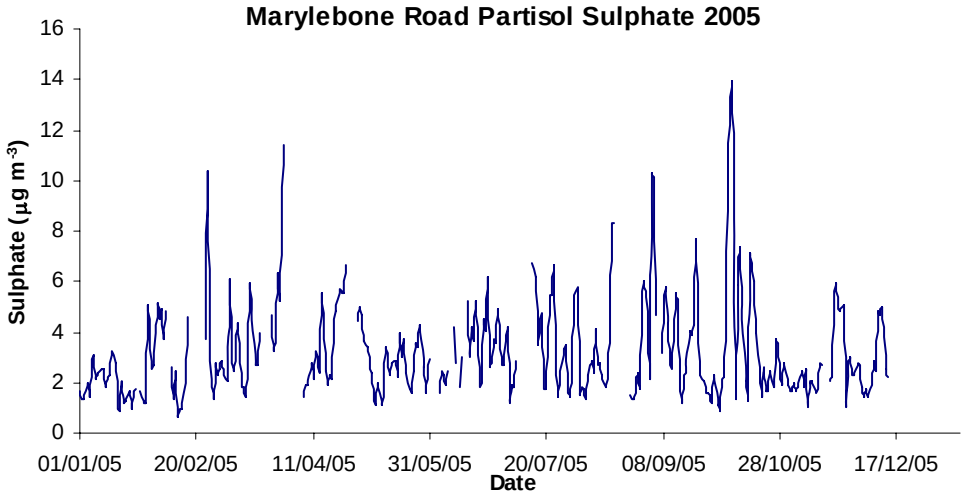


Figure 6d. Sulphate concentrations at Marylebone Road during 2005

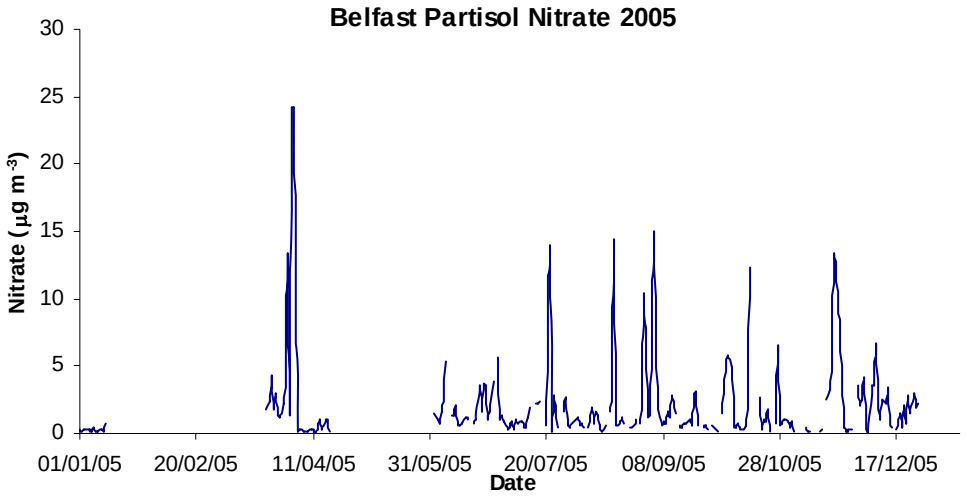


Figure 6e. Nitrate concentrations at Belfast during 2005

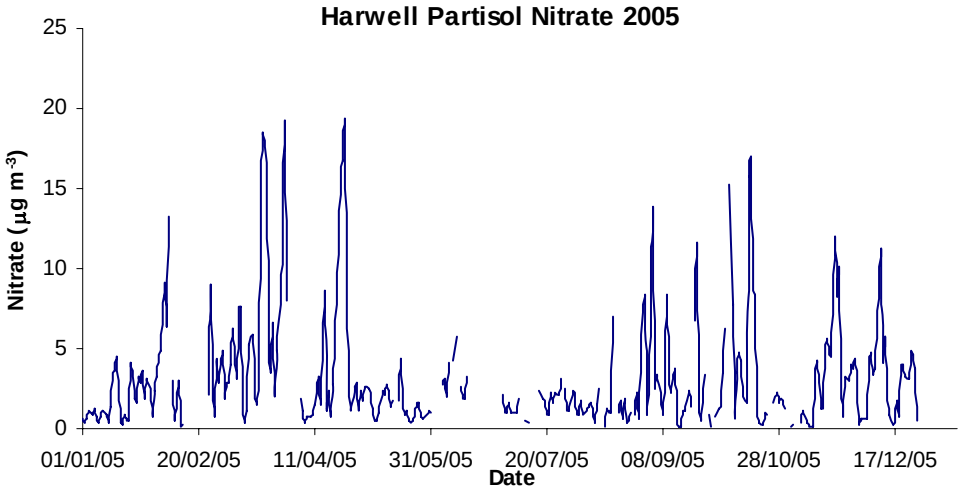


Figure 6f. Nitrate concentrations at Harwell during 2005

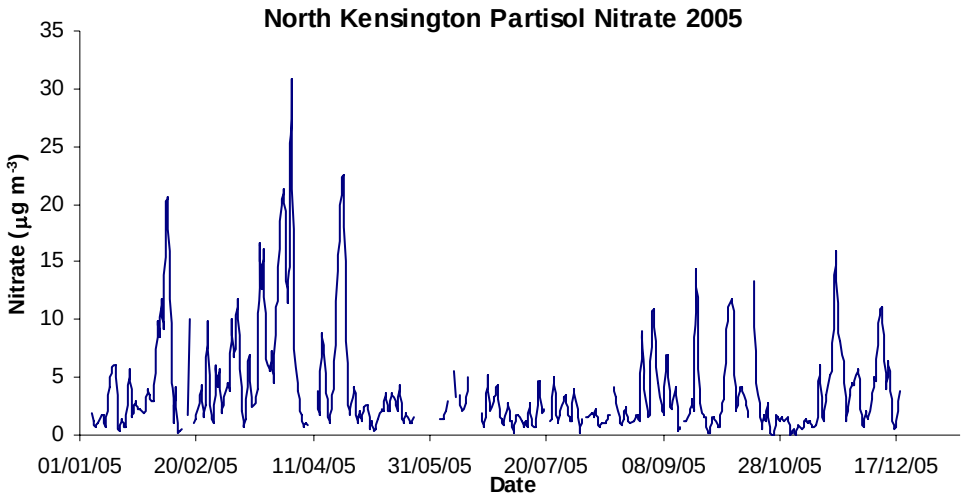


Figure 6g. Nitrate concentrations at North Kensington during 2005

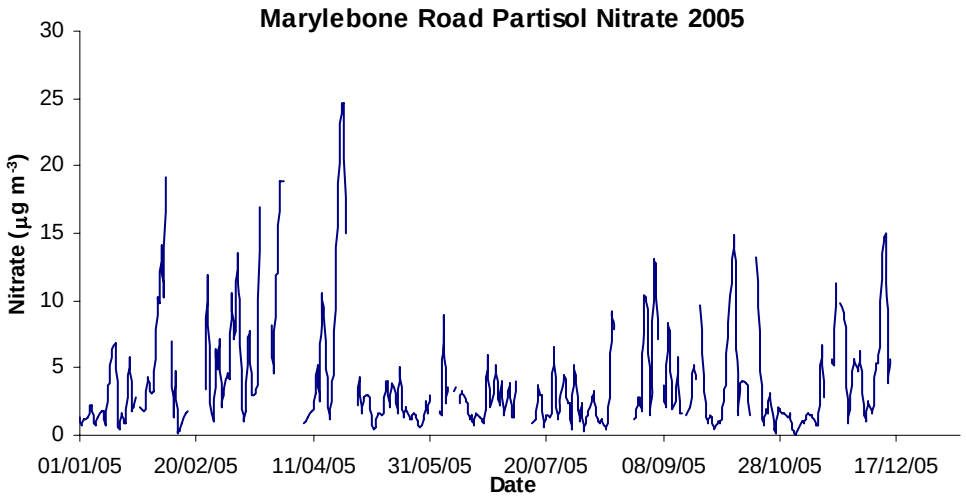


Figure 6h. Nitrate concentrations at Marylebone Road during 2005

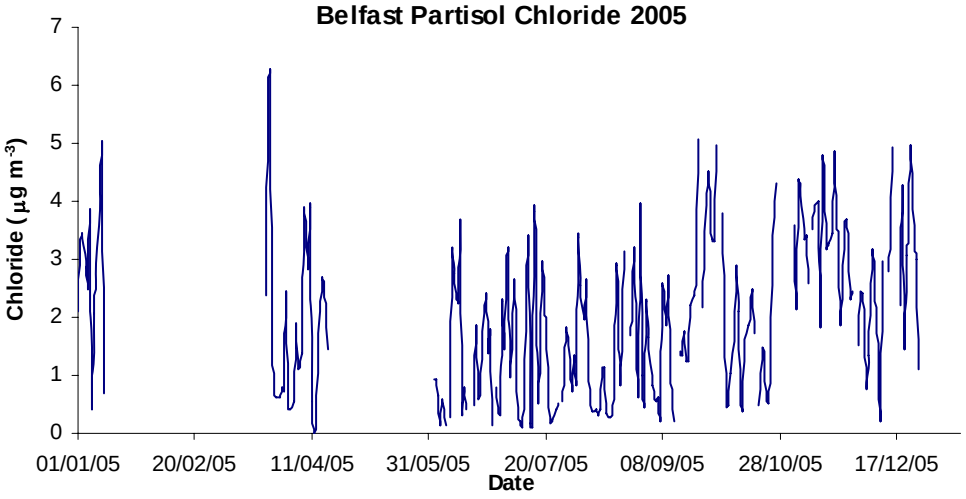


Figure 6i. Chloride concentrations at Belfast during 2005

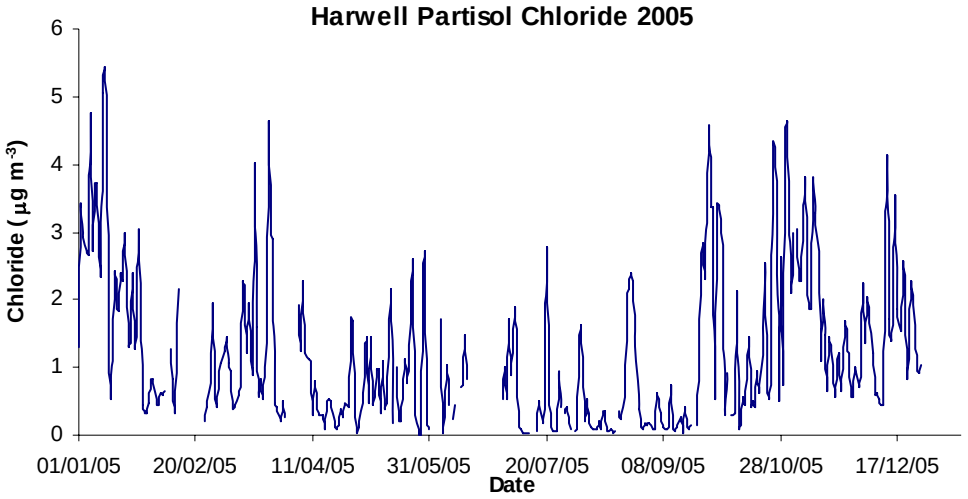


Figure 6j. Chloride concentrations at Harwell during 2005

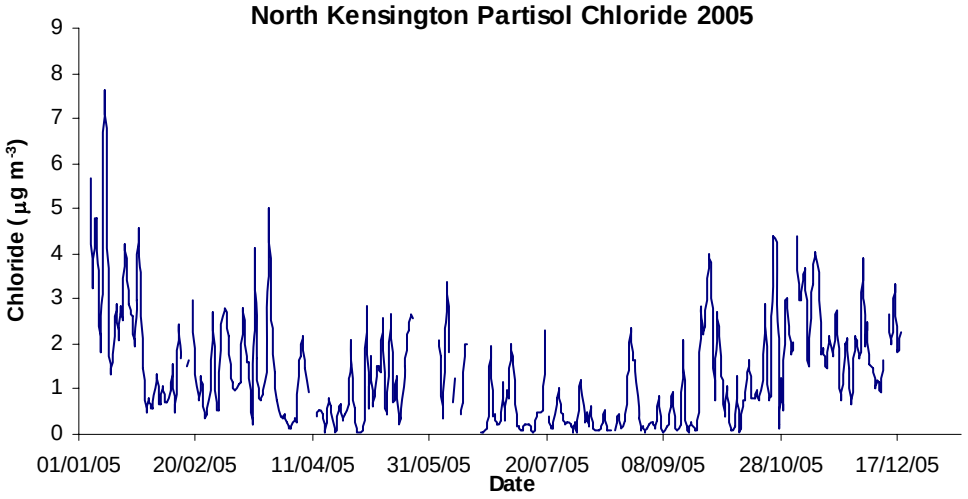


Figure 6k. Chloride concentrations at North Kensington during 2005

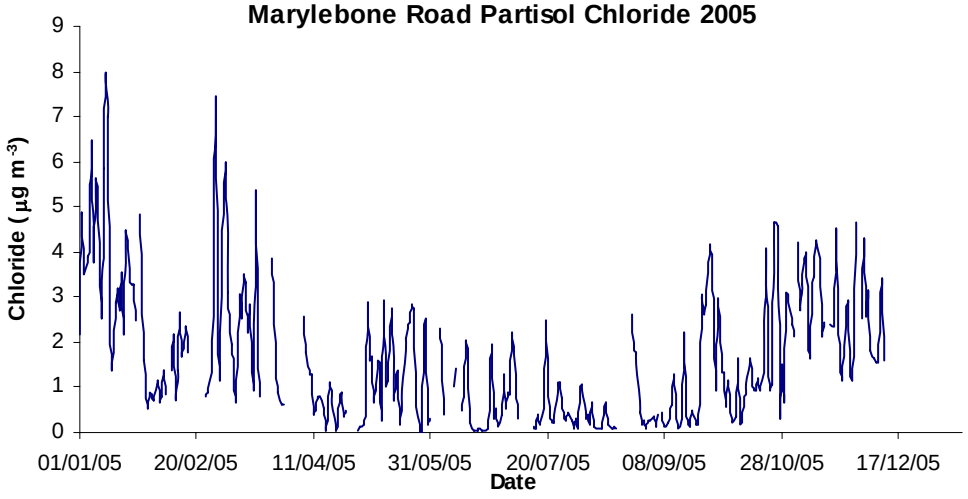


Figure 6l. Chloride concentrations at Marylebone Road during 2005

Comparison of Automatic Nitrate and Partisol 2025 Nitrate

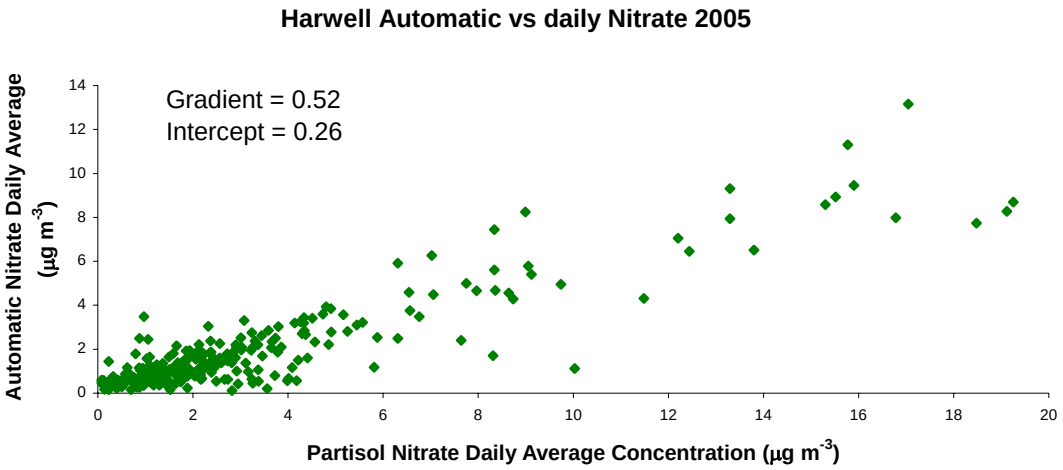


Figure 6m. Scatter plot of Nitrate concentrations at Harwell during 2005

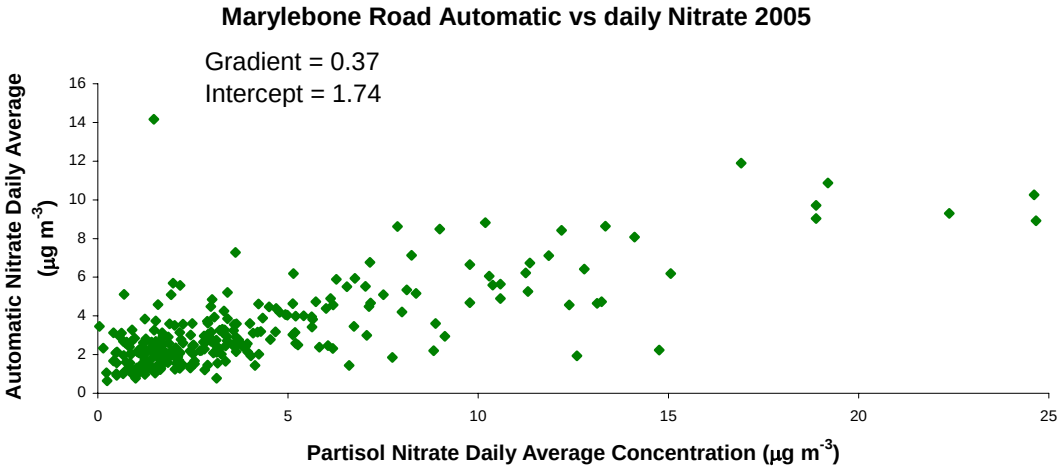


Figure 6n. Scatter plot of Nitrate concentrations at Marylebone Road in 2005

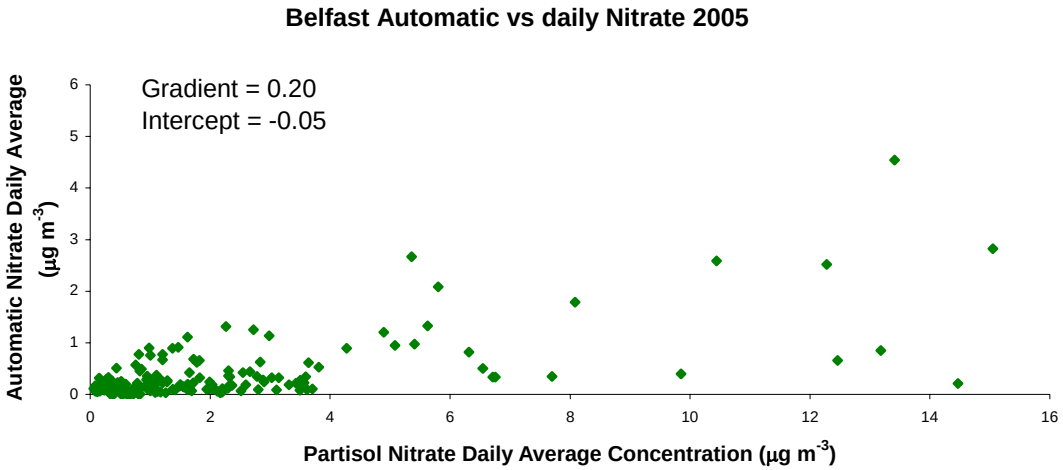


Figure 6o. Scatter plot of Nitrate concentrations at Belfast during 2005

Although there is a strong correlation between the automatic and Partisol results, the two methods do not have a 1:1 ratio. This may be due to the PM_{10} size fraction sampled onto the Partisol filters, whereas the Automatic Nitrate has a $PM_{2.5}$ cyclone. Further investigation is required.

The results for 2005 are consistent with those from previous years, as can be seen in the table of Yearly Means.

Scanning Mobility Particle Sizer (SMPS)

Monthly data capture rates for the SMPS instruments during 2005 are displayed in the table below:

Site	Harwell	London Bloomsbury	Marylebone Road
January	47%	0%	0%
February	100%	0%	0%
March	100%	88%	0%
April	73%	100%	75%
May	100%	85%	100%
June	96%	47%	0%
July	100%	84%	74%
August	100%	82%	55%
September	42%	83%	90%
October	60%	0%	61%
November	98%	59%	92%
December	55%	0%	100%
Average	81%	53%	54%

Table 6. Monthly data capture for SMPS instruments during 2005.

Total particulate counts at each site have been plotted in the figures below. Full data sets, including size distributions, have been made available for public dissemination.

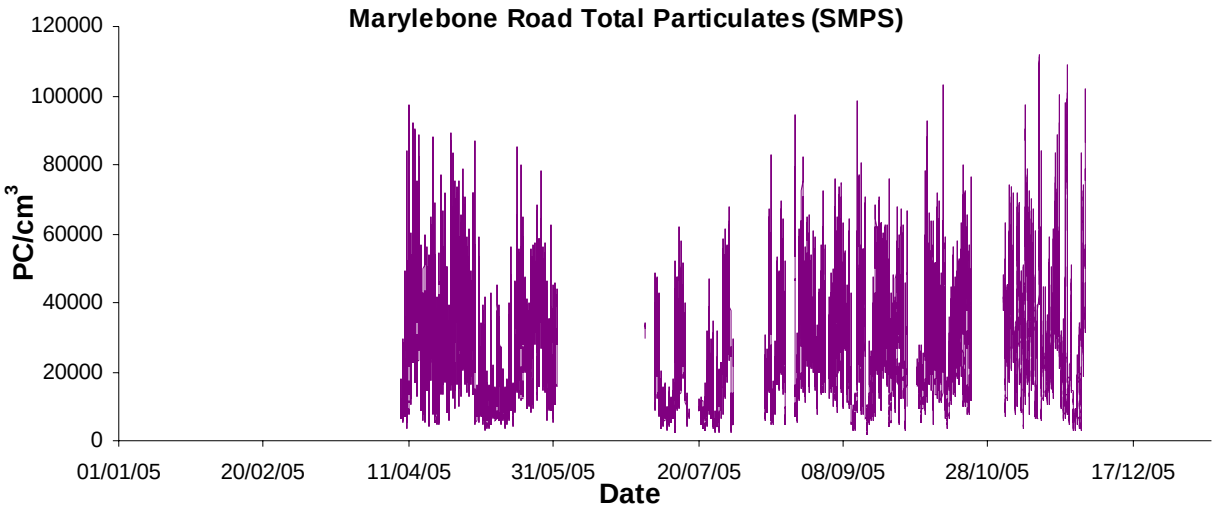


Figure 7a. SMPS total particle count at Marylebone Road during 2005

No data were recorded in June due to there being no laptop at the site. Data was also lost during August because of a power cut. A laptop failure in October also left several days without data while a spare laptop was configured and deployed.

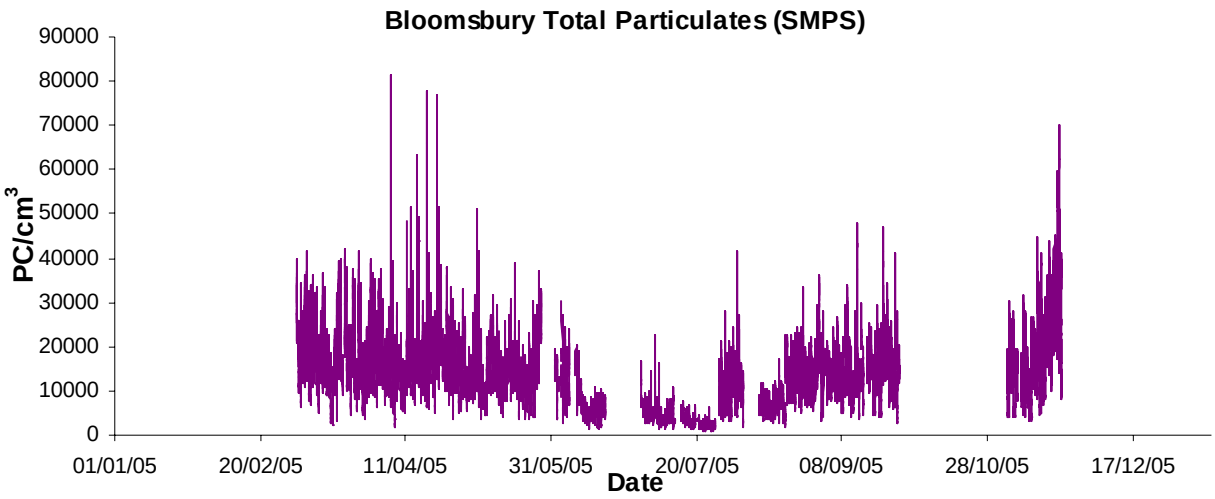


Figure 7b. SMPS total particle count at London Bloomsbury during 2005.

The SMPS at Bloomsbury has an ongoing problem causing unstable flow in the CPC. The CPC was returned to the manufacturer for repair for the entire month of October. The problem was not solved satisfactorily and erratic flows returned in November. The instrument was sent to TSI Instruments for further investigation and repair in December.

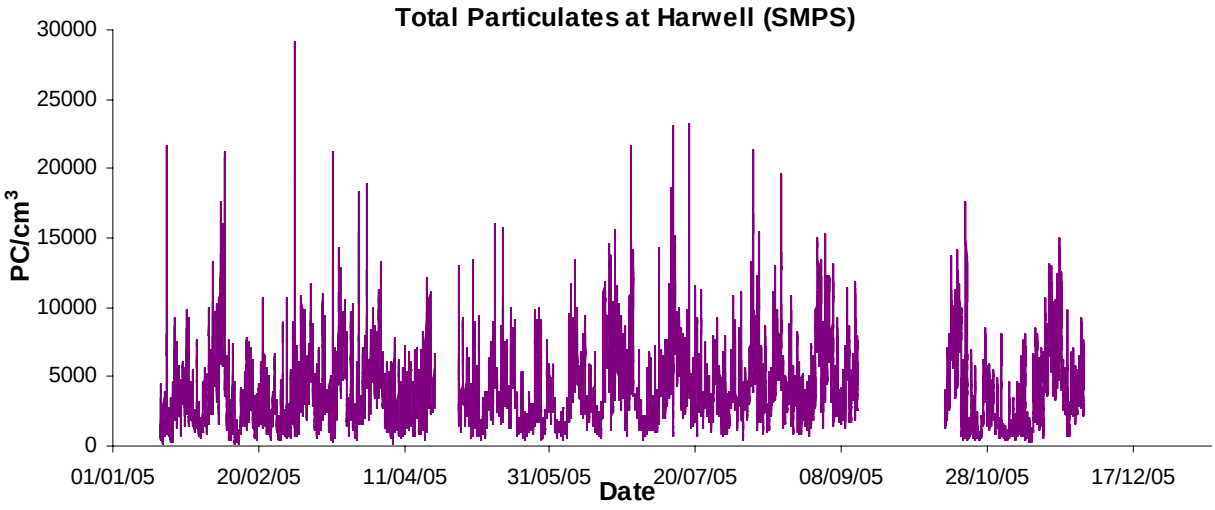


Figure 7c. SMPS total particle count at Harwell during 2005

Data capture is low at Harwell during the end of September and beginning of October because of a broken vacuum pump. NPL has taken steps to refurbish old pumps to keep as hot spares in the future. During December Harwell suffered from a laptop failure and also a fault on the phone line providing communications to the SMPS.

Particle size distribution data for the year is summarised on the following page in Figure 8.

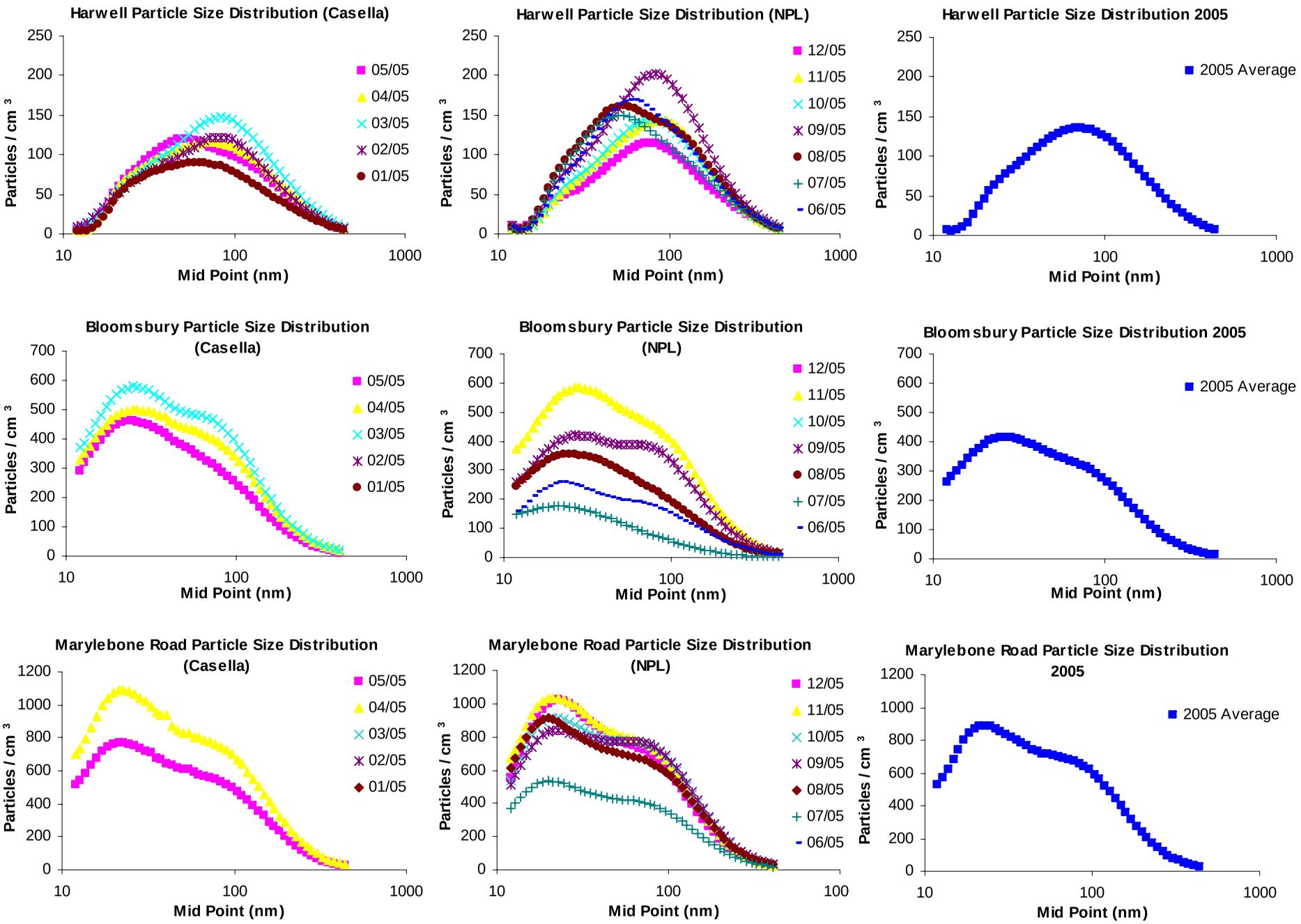


Figure 8 Particle Size Distribution from SMPS for each site for 2005

London Terror Attacks

During 7 July 2005, and in the days following the terrorist attacks in the Capital, many roads in Central London were closed to traffic. The graph below shows the total number of particulates measured by the SMPS instruments at Bloomsbury (Urban Centre) and Marylebone Road (Roadside) during July.

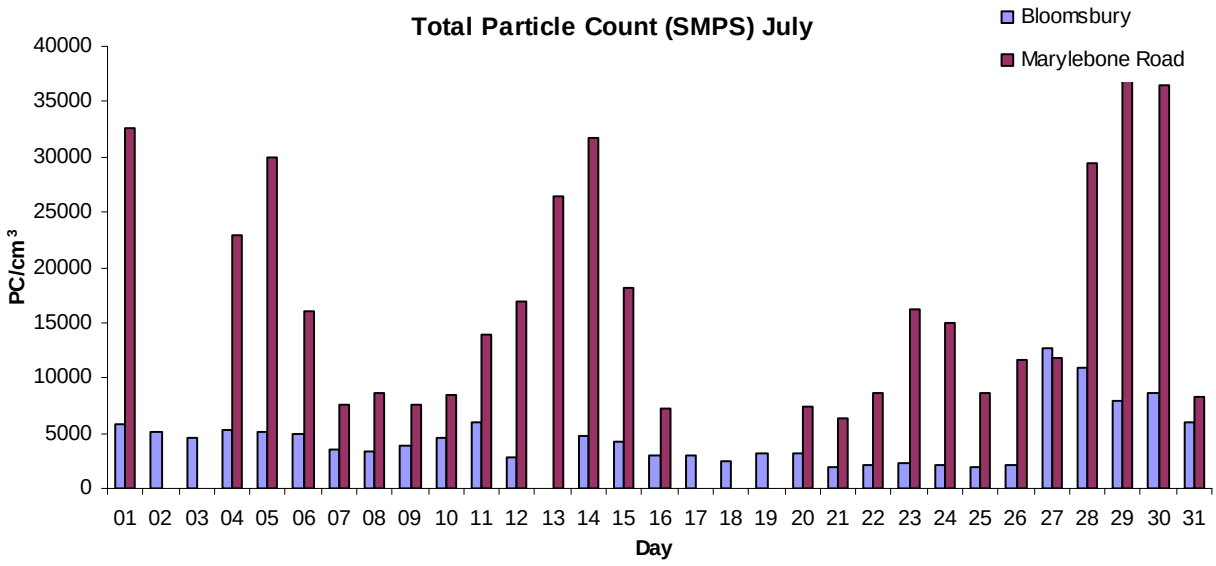


Figure 9a. Daily particle counts at Bloomsbury and Marylebone Road during July

It can be seen that the period 07/07/05 to 10/07/05 has lower particle counts at Marylebone Road than the same Thursday – Monday period in the following two weeks. This suggests that the decrease is due to the lowered traffic volume during that time. Counts at Bloomsbury appear to be relatively unaffected. However, it may also be explained by a shift in wind direction over this period.

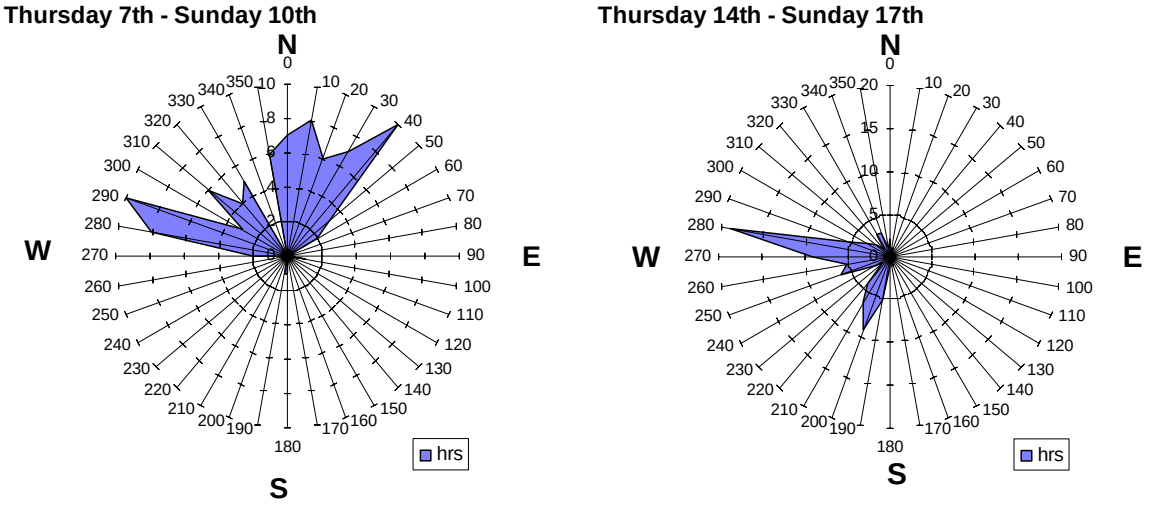


Figure 9b and 9c. Wind Roses for Harwell during two periods in July 2005

Due to the lack of a full dataset during this period, conclusive statements cannot be made without full consideration of all factors.

Condensation Particle Counter (CPC)

Monthly data capture rates for the CPC instruments during 2005 are displayed in the table below:

Site	Belfast	Birmingham	Glasgow	North Kensington	Marylebone Road	Manchester	Port Talbot
January	0%	63%	77%	100%	0%	0%	62%
February	88%	78%	93%	100%	0%	0%	100%
March	100%	0%	78%	93%	0%	0%	100%
April	80%	0%	55%	23%	0%	79%	97%
May	25%	0%	27%	0%	42%	80%	78%
June	84%	--	97%	9%	92%	64%	81%
July	100%	--	60%	62%	93%	100%	77%
August	100%	21%	46%	100%	91%	90%	91%
September	99%	85%	100%	82%	60%	89%	94%
October	99%	97%	80%	100%	100%	82%	87%
November	97%	45%	94%	100%	91%	71%	94%
December	83%	19%	97%	100%	89%	100%	100%
Average	**79%**	**50%**	**75%**	**72%**	**55%**	**63%**	**88%**

Table 7. Monthly data capture for CPC instruments during 2005.

Graphs of the particle numbers measured at each site are shown below:

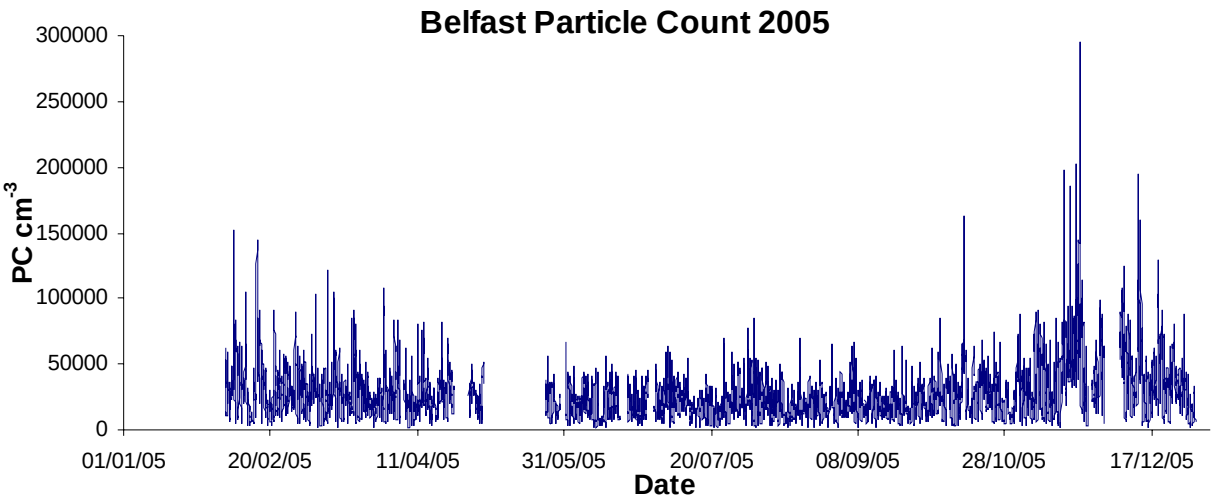


Figure 10a. CPC particle count at Belfast during 2005.

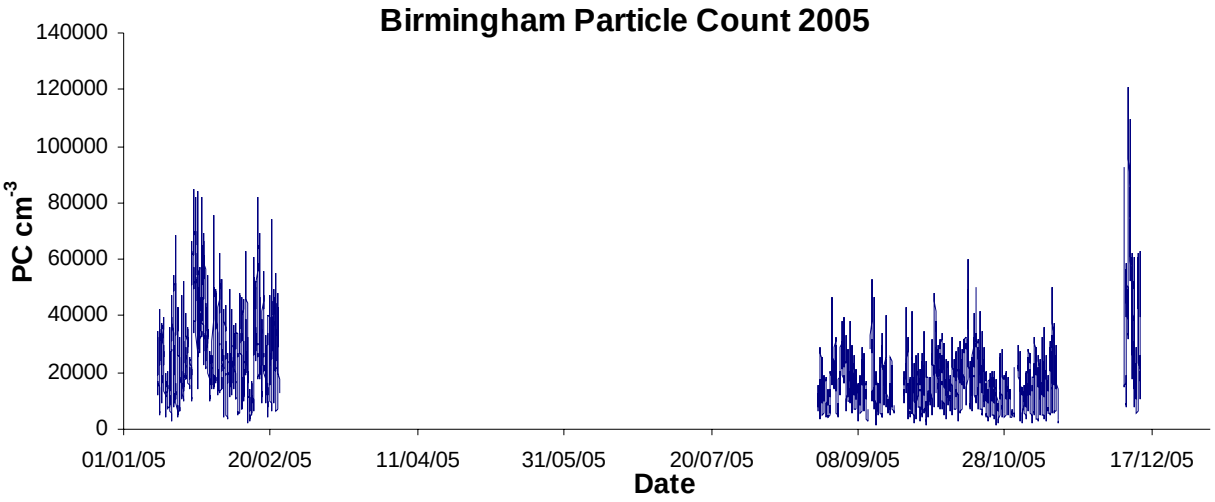


Figure 10b. CPC particle count at Birmingham during 2005.

The Birmingham CPC was not operational when NPL took over the Network contract. The instrument was immediately returned to the manufacturer (TSI Instruments) for repair. It was reinstalled on the Network on 25 August 2005. For two weeks during November, power to the site was switched off to enable transfer of power sources. The instrument was again returned to TSI for repair in December following flow problems.

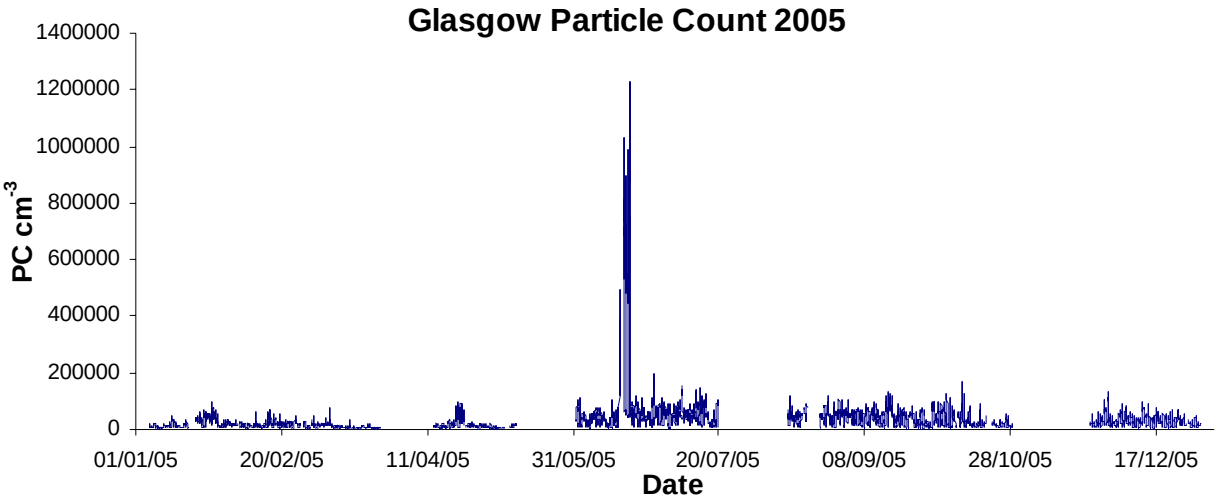


Figure 10c. CPC particle count at Glasgow during 2005.

Particle numbers from Glasgow are consistent with recent years, with the exception of four separate spikes seen from 15 June to 19 June. These spikes correspond well to elevated TEOM data in Glasgow Centre on those dates; however, the relative increase from the base level is far greater in the CPC data. This suggests a local source of fine particles was present during those days, producing a large number of particles with very little mass. Data capture statistics for November account for a three week scheduled service and calibration.

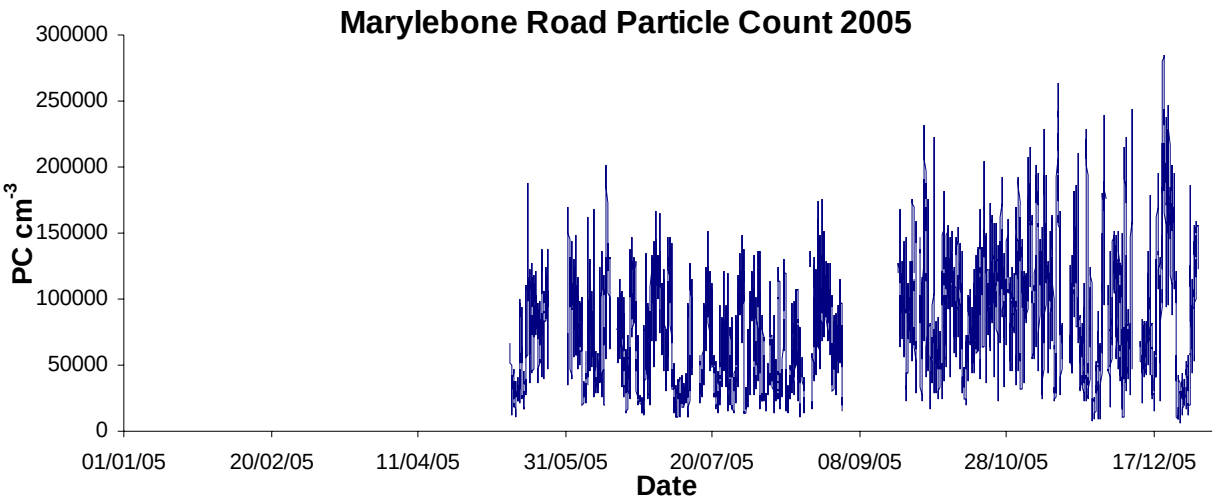


Figure 10d. CPC particle count at Marylebone Road during 2005.

Data capture statistics for September account for a two week scheduled service and calibration.

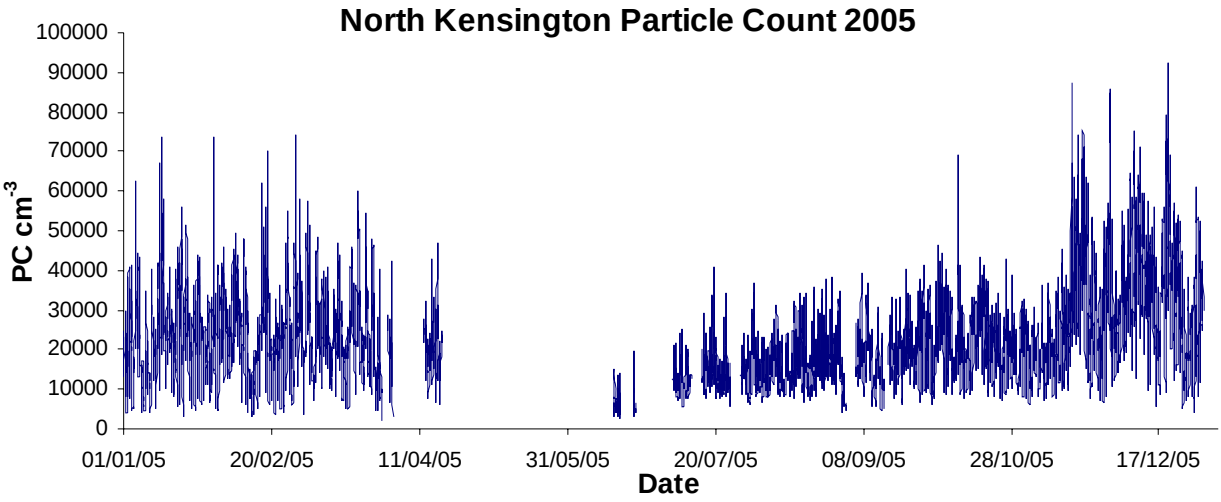


Figure 10e. CPC particle count at North Kensington during 2005.

A laptop hard drive failure during June caused a substantial data loss at North Kensington. The laptop was repaired by KCL but several sites have suffered similar problems due to the unsuitability of standard laptops being used continually. It is NPL's intention to replace all of the CPC laptops with desktops, or rugged notebooks where space is limited.

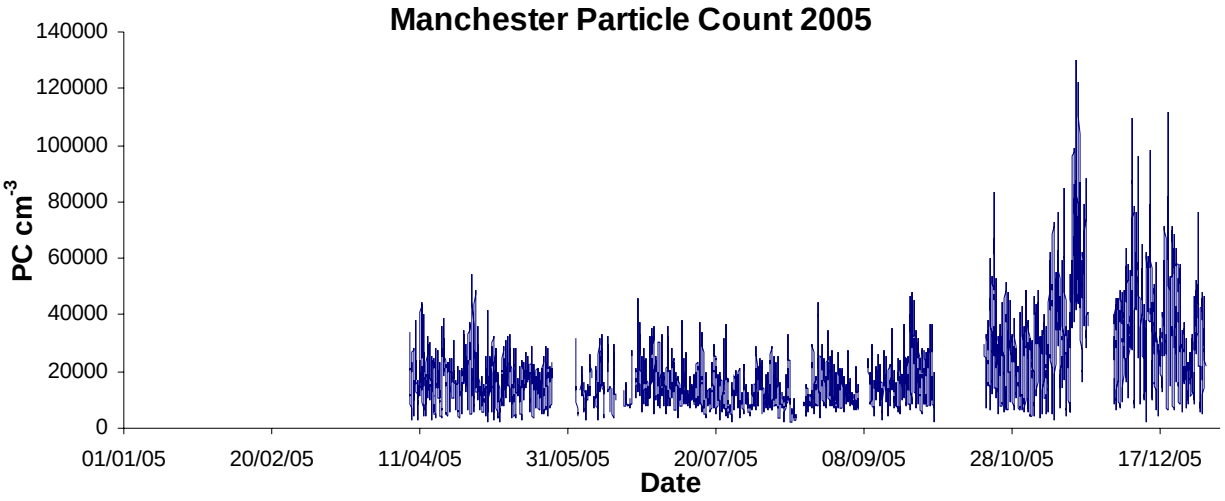


Figure 10f. CPC particle count at Manchester during 2005.

Data capture statistics for October account for a two week scheduled service and calibration.

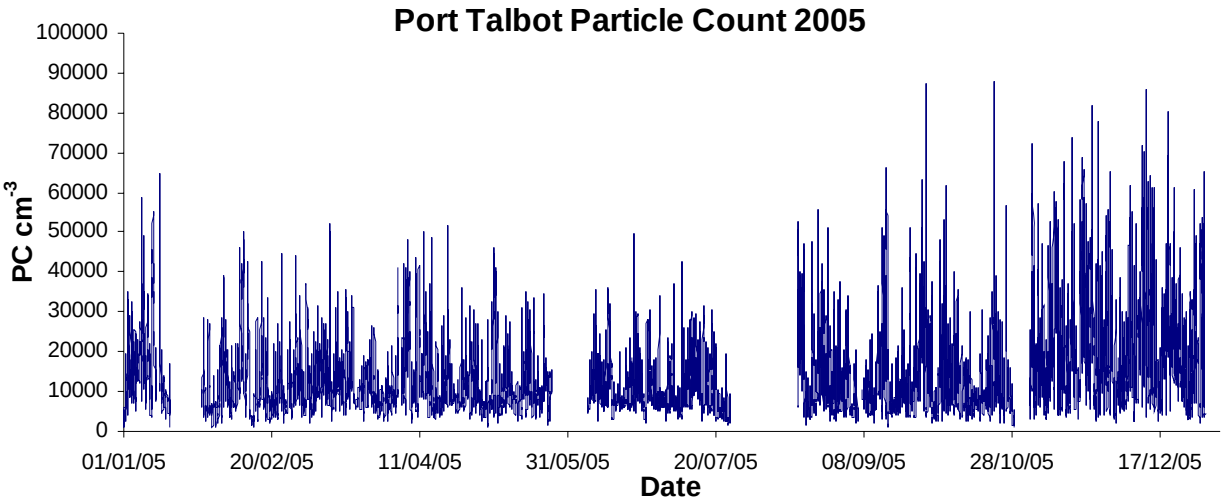


Figure 10g. CPC particle count at Port Talbot during 2005.

Data capture statistics for August account for a two week scheduled service and calibration.

SMPS versus CPC data

The discrepancy between particle counts from TSI SMPS and CPC instruments has been well documented, and Casella Stanger has reported a ratio of the measurements from the two instruments in previous reports to Defra. Currently this Network has a co-located SMPS and CPC at Marylebone Road. The monthly ratio of the CPC to SMPS total counts follows:

January	No data
February	No data
March	No data
April	No data
May	2.2
June	No data
July	2.7
August	2.4
September	2.3
October	2.5
November	2.6
December	2.6

Table 8. Monthly ratio of CPC to SMPS particle counts

The following figure shows the relationship between CPC particle number count and SMPS particle number count.

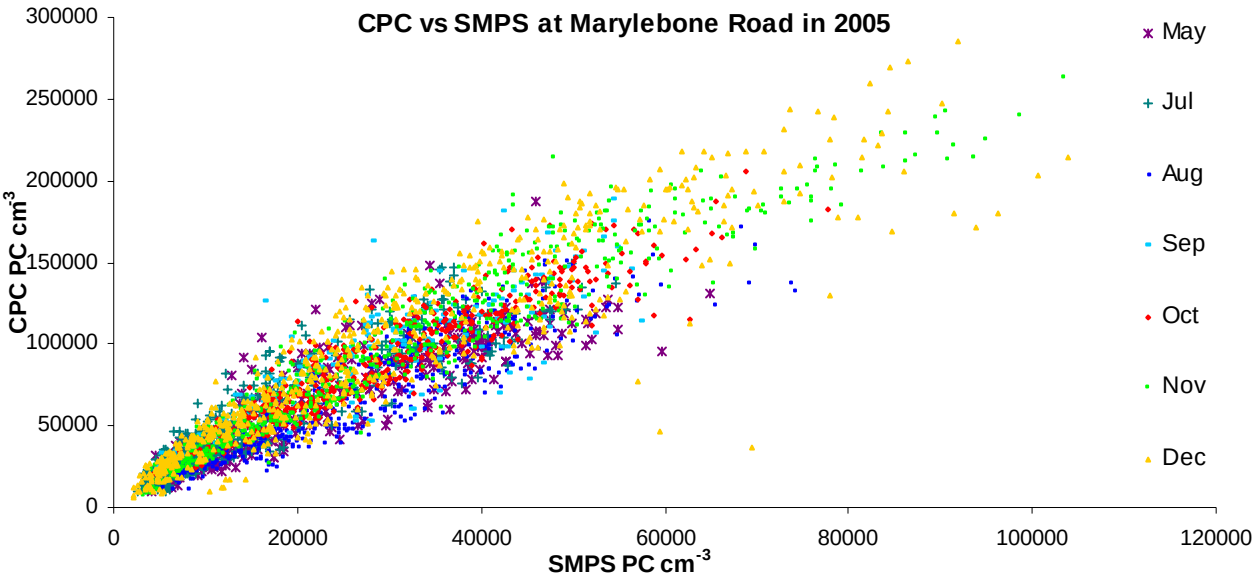


Figure 11. Scatter plot of CPC and SMPS particle counts at Marylebone Road in 2005

Buncefield Oil Depot Fire

On 11 December 2005 an explosion at the Buncefield Oil Storage Depot in Hertfordshire started a large fire. There was substantial public concern regarding the air pollution impact of the fire, however, the plume did not result in widespread high particulate concentrations at ground level.

The smoke from the fire was detected at monitoring sites in parts of east Surrey and Sussex causing PM_{10} concentrations to reach 'moderate' levels in Horsham and Lewes. The plume was also detected at monitoring sites in North London and St Albans but concentrations there remained 'low'.

The Environmental Research Group at King's College London closely monitored the levels of PM_{10} in London and the Home Counties for several days after the fire, and appropriate measures were taken to reassure the public that the fire presented no health risk.

Meteorological Mast

Monthly data capture rates for the Meteorological Masts during 2005 are displayed in the table below:

Site	Harwell	Rochester
January	-	-
February	-	-
March	-	-
April	-	-
May	-	-
June	0%	100%
July	100%	100%
August	99%	88%
September	99%	100%
October	100%	100%
November	96%	100%
December	100%	100%
Average	85%	98%

Table 9. Monthly data capture for Meteorological instruments during 2005.

Wind roses for Harwell and Rochester are presented in the following figures. This data will be made publicly available.

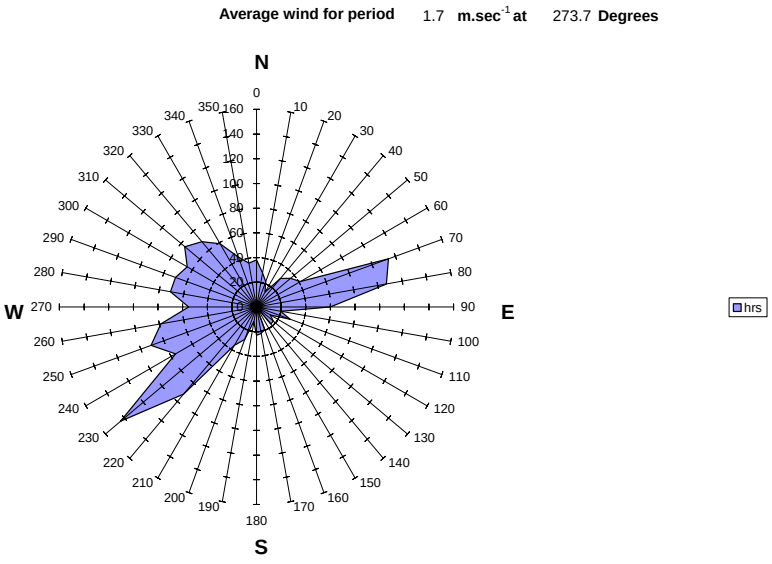


Figure 12. Wind rose for Rochester in 2005

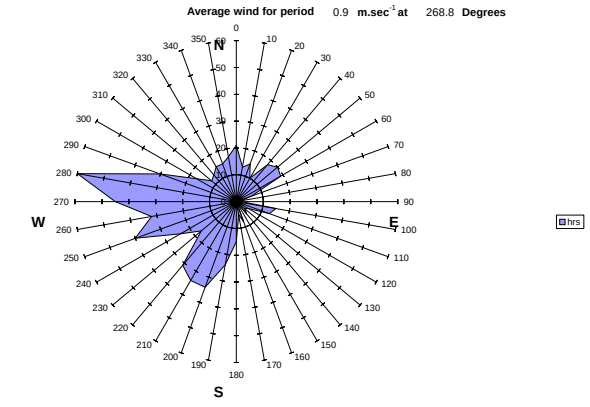


Figure 13a Wind rose for Harwell - July 2005

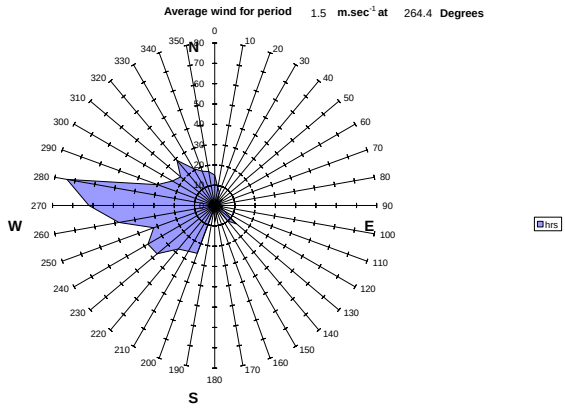


Figure 13b Wind rose for Harwell - August 2005

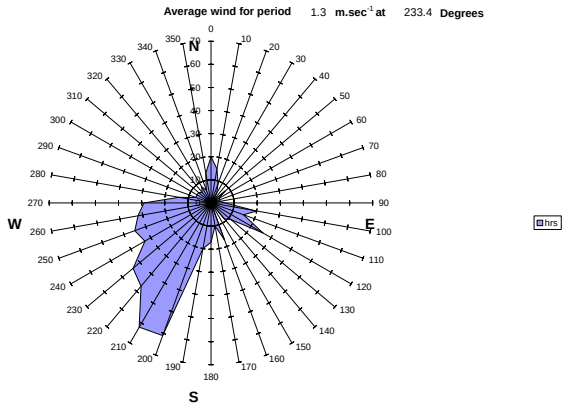


Figure 13c Wind rose for Harwell - September 2005

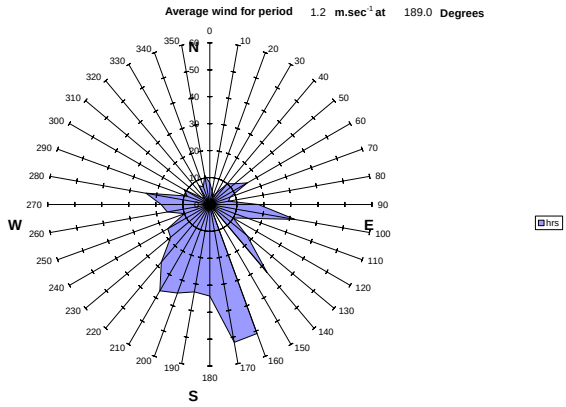


Figure 13d Wind rose for Harwell - October 2005

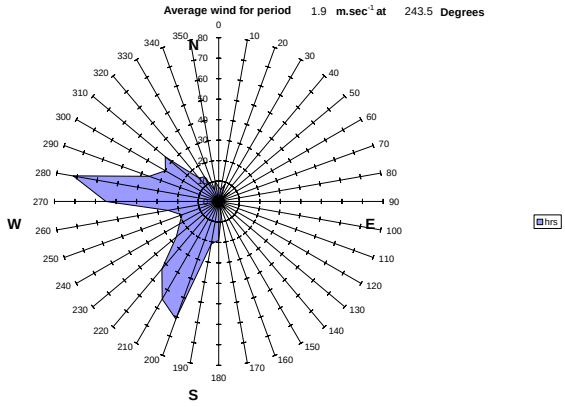


Figure 13e Wind rose for Harwell - November 2005

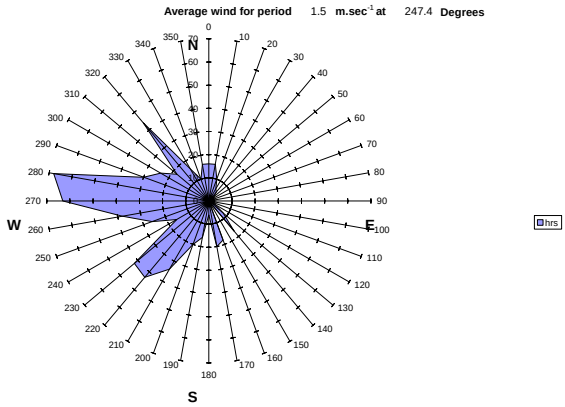


Figure 13f Wind rose for Harwell - December 2005

Yearly Means

Instrument	2002 Mean	2003 Mean	2004 Mean	2005 Mean	Units
Belfast Carbon (organic)	**1.88**	**2.96**	**2.99**	**0.87**	µg m^{-3}
Harwell Carbon (organic)	1.83	**2.22**	**1.18**	**0.44**	µg m^{-3}
Marylebone Road Carbon (organic)	**4.54**	4.54	**4.28**	**4.17**	µg m^{-3}
North Kensington Carbon (organic)	2.4	**3.07**	**2.37**	**3.78**	µg m^{-3}
Belfast Carbon (elemental)	**1.43**	**0.71**	**0.72**	**1.16**	µg m^{-3}
Harwell Carbon (elemental)	0.57	**0.77**	**0.54**	**1.03**	µg m^{-3}
Marylebone Road Carbon (elemental)	**3.83**	3.35	**2.42**	**1.64**	µg m^{-3}
North Kensington Carbon (elemental)	1.01	**1.15**	**0.64**	**0.84**	µg m^{-3}
Belfast Nitrate ($PM_{2.5}$)	N/A	0.70	0.52	0.44	µg.m^{-3}
Harwell Nitrate ($PM_{2.5}$)	N/A	2.66	4.27	1.94	µg.m^{-3}
Marylebone Road Nitrate ($PM_{2.5}$)	N/A	N/A	N/A	3.33*	µg.m^{-3}
Belfast Daily Nitrate (PM_{10})	1.82	3.24	1.52	2.15	µg.m^{-3}
Harwell Daily Nitrate (PM_{10})	2.85	3.90	2.76	3.17	µg.m^{-3}
Marylebone Road Daily Nitrate (PM_{10})	2.95	5.06	3.93	3.97	µg.m^{-3}
North Kensington Daily Nitrate (PM_{10})	3.52	4.32	3.38	3.91	µg.m^{-3}
Belfast Daily Sulphate (PM_{10})	2.26	1.87	1.78	2.18	µg m^{-3}
Harwell Daily Sulphate (PM_{10})	2.34	2.44	2.29	2.40	µg m^{-3}
Marylebone Road Daily Sulphate (PM_{10})	3.26	3.18	3.16	3.21	µg m^{-3}
North Kensington Daily Sulphate (PM_{10})	3.12	2.61	2.95	3.02	µg m^{-3}
Belfast Daily Chloride (PM_{10})	1.83	1.82	1.96	1.98	µg m^{-3}
Harwell Daily Chloride (PM_{10})	1.01	0.91	1.04	1.19	µg m^{-3}
Marylebone Road Daily Chloride (PM_{10})	0.85	1.45	1.54	1.64	µg m^{-3}
North Kensington Daily Chloride (PM_{10})	1.56	1.11	1.24	1.33	µg m^{-3}
Belfast CPC	29326	17632	16165	26190	PC cm^{-3}
Birmingham CPC	14930	17998	16752	20254	PC cm^{-3}
Glasgow CPC	18409	17075	14437	33718	PC cm^{-3}
Manchester CPC	18413	15622	13178	19965	PC cm^{-3}
Marylebone Road CPC	83106	N/A	70878	79606	PC cm^{-3}
North Kensington CPC	17864	21743	17664	22017	PC cm^{-3}
Port Talbot CPC	14067	15389	11583	13939	PC cm^{-3}

Red text indicates low data capture, therefore not a representative average for the year

SMPS instruments are omitted from this table because they are no longer supported by the manufacturer and, as such, cannot be serviced or calibrated.

* Average calculated from ERG data (Jan-May) and Network data from Jun-Dec

Table 10. Yearly average concentrations and particle counts for Network instruments for 2002 – 2005

Policy Update

Proposal for revised EU Air Quality Directive

The proposal, released as an Advanced Preliminary Version as COM(2005) 447 on 21 September 2005, aims to revise and combine the Framework Directive 96/62/EC, the first three "Daughter" Directives, covering sulphur dioxide, NOx, Particulate Matter (PM), lead, benzene, carbon dioxide and ozone, and the "Exchange of Information Decision".

Three aspects are relevant to this Network. Firstly, the existing PM legislation is based on control of PM_{10}, while the Proposal moves the emphasis to $PM_{2.5}$. Research-led measurements such as those on this Network should therefore make due emphasis on the $PM_{2.5}$ fraction. Secondly, there is more explicit allowance for pollution arising from "natural sources" to be disregarded. Again, research-led measurements should make the determination of the "natural" fraction of PM a clear aim.

Lastly, Annex IV includes the statement "Measurement of $PM_{2.5}$ must include at least the mass concentration and appropriate compounds to characterise its chemical composition. At least the list of chemical species below shall be included."

SO_4^{2-}	Na^+	NH_4^+	Ca^{2+}	Elemental carbon (EC)
NO_3^-	K^+	Cl^-	Mg^{2+}	Organic carbon (OC)

Many of these components are those currently measured by this Network. There is a need to clarify what is meant in practice by EC and OC.

EN standards

CEN TC 264 WG 15 published its standard for $PM_{2.5}$ mass, by gravimetry, in September 2005 (EN 14907:2005). The WG is now meeting to update the PM_{10} standard EN 12341:1998, possibly revising EN 14907 in parallel. NPL is closely involved with this working group.

There are no EN standards planned for ambient particle number, size, or composition.

ISO standards

There are some standards for particle counting and sizing being prepared within ISO TC24 SC4, though they are mainly not applicable to measuring particles in air. The most relevant is ISO/WD 15900 "Determination of Particle Size Distribution – Differential Electrical Mobility Analysis for Aerosol Particles". NPL is joining this group to learn more about global best practice and bring Network practice in line with it.

Instrumentation Update

The current options for composition measurement instruments are given below:

Reference (non-automatic) methods:

Nitrate and sulphate	Filter sampling (eg using Partisol) followed by standard Ion Chromatography (IC)
OC/EC	Sunset Labs or DRI Model 2001 – filter sampling followed by combustion, methanisation then FID

Automatic (hourly) measurements:

Nitrate	R&P 8400N – combustion then NO_2 measurement URG 9000A (ET) or Marga (SJAC) – solution of particles then automated IC
Sulphate	R&P 8400S – now discontinued Thermo Electron 5020 – combustion then uv fluorescence URG 9000A (ET) or Marga (SJAC) – solution of particles then automated IC
OC/EC	R&P 5400 – combustion to CO_2 then NDIR Sunset Labs - combustion to CO_2 then NDIR, with pyrolysis correction

VAM Update

NPL is funded by DTI, via the Valid Analytical Measurement (VAM) programme within the National Measurement System, to carry out research and provide measurement services and facilities for various types of analysis including gas and particulate analysis. Within VAM project 4.2, the work on ambient nanoparticle analysis has recently been expanded and aligned to provide support for many of the measurements within this Network.

The work is in two broad areas. Firstly, a laboratory facility is being developed, providing the means to generate, manipulate, detect and characterise a wide range of nanoparticles in the size range 5 to 500 nanometres. The equipment being installed includes particle generators for primary soot, salt and organic nanoparticles with a range of size distributions, and detectors that can detect both electrically charged and neutral particles over a concentration range of several orders of magnitude, including CPC and SMPS instruments. This work is aimed at quantifying instrumental issues in a laboratory environment, and determining the suitability of different instruments for different tasks.

Secondly, a field monitoring site for research purposes is being established in a dedicated climate controlled cabin, with the aim of carrying out short and medium term comparative trials in ambient air. This will be used for particle counting and sizing, particle mass, and particle composition measurements. It is intended to compare spare Network instruments with a range of other instruments and reference methods. In the case of particle composition, NPL has a Dionex Ion Chromatography instrument for reference analysis of filter samples, and will have a Sunset Labs instrument for “reference” analysis of OC/EC.

Topic Reports

Apart from the State of the Network Report (September 2005) and the Strategic Network review (November 2005), two Topic Reports have so far been produced within the present contract, on topics requested by Defra.

These are:

Assessment of natural components of PM_{10}
Alan Jones and Roy M Harrison
November 2005

Taking the natural components to be sodium chloride, bound water and secondary organic material, estimation and subtraction of the natural components had a substantial effect on the number of days exceeding the PM_{10} limit value ie from 101 to 52 days at Marylebone Road, and from 13 to 6 days at North Kensington.

What are the sources and conditions responsible for exceedences of the 24-hour PM_{10} limit value at a heavily trafficked London site?
Aurelie Charron, Roy M Harrison and Paul Quincey
March 2006

The sources of PM_{10} concentrations at Marylebone Road were separated into Regional, London Urban background, and Roadside components. On average the contributions have the approximate ratios 40:20:40 respectively. The Regional component was the main contribution to most of the exceedences.

Annex 1. Network Monitoring Instruments

Site	Type	Hourly $PM_{2.5}$ nitrate	Hourly PM_{10} organic and elemental carbon	Daily PM_{10} filter (sulphate)	CPC	SMPS
Belfast Centre	Urban centre	x	x	x	x	
Birmingham Centre	Urban centre				x	
Glasgow Centre	Urban centre				x	
Harwell	Rural	x	x	x		x
London Bloomsbury	Urban centre					x
London Kensington	Urban background		x	x	x	
London Marylebone Road	Kerbside	x[1]	x	x	x	x
Manchester Piccadilly	Urban centre				x	
Port Talbot	Urban background				x	

1 – owned by the Network but operated by King's College London

Equipment owned but not deployed:

1 hourly carbon; 2 hourly nitrate; 1 hourly sulphate; 1 CPC

Equipment models:

CPC	TSI model 3022A
SMPS	TSI model 3071
Hourly nitrate	Rupprecht and Patashnick 8400N
Hourly carbon	Rupprecht and Patashnick 5400
Hourly sulphate	Rupprecht and Patashnick 8400S
Daily sulphate	Rupprecht and Patashnick Partisol 2025

Annex 2. Map of Current Network Sites

Annex 3. State of Network Report September 2005.

CPEA 28: Airborne Particulate Concentrations and Numbers in the United Kingdom (phase 2).

Executive Summary

In June 2005 the National Physical Laboratory (NPL), under contract to the Department of the Environment, Food and Rural Affairs (Defra), took over the running of the Airborne Particulate Concentrations and Numbers in the UK Network from Casella Stanger. This report describes the state of the network as found by NPL and the changes implemented by NPL to improve its running.

In the first month of the contract NPL visited all of the sites to audit their performance. The aim of these audits was primarily to calibrate the analysers using a common set of measurement standards to help ensure intercomparability of data from the monitoring sites.

The main problems found with the Network were the operational state of the real-time carbon and nitrate analysers at the Harwell, Belfast, North Kensington and Marylebone Road sites and the condensation particle counter at the Birmingham site. At handover all of the above analysers were faulty. Also some instruments had not been serviced or calibrated since 2002. These faults have been rectified and the instruments returned to service.

The main changes made by NPL to improve the running of the network are the introduction of remote communications to all instruments on the network to improve data capture rates and eliminate delays in fault finding. In addition, all of the sites have been audited by NPL to improve data quality.

A significant number of instruments on the network were not in working order when the contract was handed over, so remedial work was initiated on the faulty equipment. Other equipment had not been calibrated or serviced for a number of years according to the available service records. This work is described in Section 3.

Local Site Operator (LSO) manuals have been rewritten to incorporate the changes in the network implemented by NPL. NPL undertook to write these LSO manuals in the first four months of the contract.

Annex 4. Strategic Network Review. November 2005.

Executive Summary

This strategic review of the equipment in the Network, has been undertaken by Prof Dick Derwent, Prof Roy Harrison and the National Physical Laboratory, the manager of the Network. This review proposes both the optimum configuration for existing instruments, to ensure that the Network addresses current research priorities, and prioritised developments to the Network. The monitoring recommendations from the Report of the UK Air Quality Expert Group (AQEG) 'Particulate Monitoring in the United Kingdom' 2005, have been taken into account.

The strategic review starts from the position that the Network has two distinct aims. The first is to provide information on the chemical composition of particulate matter, ideally at the hourly level of time resolution, on a continuous basis. The need for this information was highlighted in the AQEG report, to allow the relevant chemical processes to be modelled more reliably. Ultimately the aim is mass closure, accounting for the total mass, measured as PM_{10} or $PM_{2.5}$, in terms of the masses of its chemical components. However, the more immediate aim is to provide selected speciation of particulate matter at strategically important sites within the Network.

This entails continuous measurements of the sulphate, nitrate, organic carbon and elemental carbon concentrations in particulate matter. Priority is given to the London conurbation. A proposed new site at Rochester will characterize the particulate loadings in air masses entering the London conurbation from continental Europe. Further recommendations cover paired urban background and rural sites in Northern Ireland, Scotland and Wales, to characterise particulate matter in the different environments across the United Kingdom. These Network developments will also facilitate characterisation of long-range transport of particulate matter into the United Kingdom from the Atlantic Ocean through the recirculation of European pollution.

The second aim is to extend reliable datasets of airborne particle number and size at selected sites. Long time series measurements of particle number are important for epidemiological studies, while size distributions provide important additional information on the processes involved in particle formation and evolution. In this context, it is recommended that obsolete particle sizing equipment should be replaced to permit monitoring of the effects of any future curbs on diesel particulate emissions.

Further recommendations cover the evaluation of available equipment to inform future purchase, and measurements of sodium, calcium, ammonium and iron concentrations at selected sites to provide additional information on chemical composition.

Potential cost savings from the closure of certain sites are identified, although data from certain of these sites have been, or may be, used for other local purposes, e.g. epidemiological studies, and these should be considered before a decision to remove them is taken.

Annex 5. Instrument Repairs

Site	Instrument	Callout Date	Reason
Belfast	Carbon	29/09/2005	Lamps and Fuses Blown
Belfast	Carbon	23/10/2005	Collector Leak
Belfast	Carbon	15/11/2005	Collector Leak / CPC Board
Belfast	Carbon	09/03/2006	Lamps Blown
Birmingham	CPC	13/12/2005	Erratic Flows
Bloomsbury	SMPS	03/10/2005	Erratic Flows
Bloomsbury	SMPS	28/11/2005	Erratic Flows
Bloomsbury	SMPS	11/12/2005	Erratic Flows
Bloomsbury	SMPS	31/01/2006	Erratic Flows
Bloomsbury	SMPS	22/03/2006	Erratic Flows
Bloomsbury	SMPS	05/08/2005	Laptop Failure
Harwell	Nitrate	24/02/2006	Collector Blocked
Harwell	Nitrate	14/06/2005	IZS Run-on
Harwell	Nitrate	17/06/2005	Baseline Drift
Harwell	Nitrate	11/07/2005	Analyser Flow
Harwell	Nitrate	28/11/2005	Reaction Cell Pressure, Baseline drift
Harwell	Nitrate	13/01/2006	Repeated flash strip failures
Harwell	Partisol	14/06/2005	Temperature sensors out of calibration
Harwell	SMPS	14/09/2005	Pump Failure
Harwell	SMPS	23/02/2005	Erratic Flows
Harwell	SMPS	03/12/2005	Laptop Failure
Marylebone Road	Carbon	01/09/2005	Low measurements
Marylebone Road	Carbon	09/09/2005	Low measurements
Marylebone Road	Carbon	13/12/2005	Collector Leak
Marylebone Road	Carbon	03/02/2006	Erratic response
Marylebone Road	Carbon	05/04/2006	Flow and lamp faults
Marylebone Road	Nitrate	03/08/2005	Analyser flow
Marylebone Road	CPC	26/02/2006	Erratic Flows
Marylebone Road	SMPS	20/01/2006	Laser Broken
Marylebone Road	SMPS	16/07/2005	Laptop Failure
Marylebone Road	SMPS	22/10/2005	Laptop Failure
North Kensington	Carbon	13/10/2005	No calibrations
North Kensington	Carbon	12/01/2006	Pinch valves / delayed runs / calibration flat-lining
North Kensington	Carbon	06/03/2006	System reset and lamp problems
North Kensington	Carbon	11/04/2006	Lamp problems
North Kensington	Partisol	31/01/2006	Storage Pointer
North Kensington	CPC	01/06/2005	Laptop Failure