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Report to the Department of Environment, Food and Rural Affairs by the National Physical Laboratory:

Annual Report for 2007 on the UK Heavy Metals Monitoring Network

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NOT RESTRICTED

March 2008

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Approved on behalf of Managing Director, NPL
By A Brewin, Business Leader, Analytical Science Team

Annual Report for 2007 on the UK Heavy Metals Monitoring Network

Executive Summary

This Report was prepared by NPL as part of the 2004-2009 UK Heavy Metals Monitoring Network contract (an extension until September 2009 was granted in September 2007) with the Department for the Environment, Food and Rural Affairs. This is the Annual Summary Report for 2007 and contains, in particular:

- Measured monthly concentration levels of all metals at all sites and performance against relevant data quality objectives and the requirements of the First and Fourth EC Air Quality Daughter Directives (DDs).
- Highlighting of exceedences, interpretation of data and discussion of trends.
- Summary of Network operation, analytical and QA/QC procedures and a description of notable events during 2007.
- Details of the Network re-organisation required to meet the requirements of the Fourth Daughter Directive.
- Policy update on relevant areas, and the Network's science profile.

In summary, during 2007:

- **Lead**: No annual average site levels above the First Daughter Directive Lower Assessment Threshold were recorded.

- **Nickel**: One annual average site level above the Fourth Daughter Directive Target Value, and one annual average site level above the Fourth Daughter Directive Lower Assessment Threshold were recorded.

- **Cadmium**: One annual average site level above the Fourth Daughter Directive Lower Assessment Threshold was recorded.

- **Arsenic**: No annual average site levels above the Fourth Daughter Directive Lower Assessment Threshold were recorded.

- **Total gaseous mercury**: Measured levels across the Network remain low (with the exception of the site at ICI Weston Point, Runcorn).

- The general slow downward trend in annual average concentration values has continued.

- All First, and Fourth, Daughter Directive data quality objectives were met, including time coverage, data capture and measurement uncertainty requirements.

- Data capture across the Network was 94% for the year.

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1. Introduction

This Report was prepared by NPL as part of the 2004-2009 UK Heavy Metals Monitoring Network contract (an extension until September 2009 was granted in September 2007) with the Department for the Environment, Food and Rural Affairs.

This is the Annual Summary Report for the UK Heavy Metals Network for 2007 and contains:

- A summary of Network operation, performance analytical and QA/QC procedures and a description of notable events during 2007.
- Measured monthly concentration levels of all metals at all sites and performance against relevant data quality objectives and the requirements of the First and Fourth EC Air Quality Daughter Directives (DDs).
- Highlighting of exceedences, interpretation of data and discussion of trends.
- A description of analytical methods, including QA/QC procedures used by NPL.
- A summary of Network data quality statistics.
- Details of the Network re-organisation required to meet the requirements of the Fourth Daughter Directive.
- Policy update on relevant areas, and the Network's science profile.

2. Network Operation

2.1 Overview

NPL's management of the UK Heavy Metals Monitoring Network (the 'Network') in 2007 has invovled a great deal of activity. In summary:

- NPL staff visited and fully audited all sites on the Network. This included the calibration and basic maintenance of the Partisol and total gaseous mercury samplers and re-assessment of LSOs' procedures.
- The Equipment Support Unit (ESU) has made service visits to all Network sites twice during the year, and has included the flow calibration of instruments. This has resulted in a substantial decrease in the number of instrument breakdowns, and smaller uncertainties on sampled volumes.
- The new type of mercury vapour collection pump rolled-out across the Network by NPL at the end of last year has dramatically decreased the number of breakdowns and increased data capture.
- Data capture has remained at a very high level across the Network.
- The UK Heavy Metals Monitoring Network and the data it produces has received exposure in both trade[1] and learned journals[2,3,4].

- During 2007 NPL have provided metals analysis at two extra sites for the local authority in Swansea. These sites are being used to assess the same point source as the current Metals Network site in the area.

2.2 Site audits

During 2007 NPL visited all the Network sites to perform annual site audits. During these visits the site infrastructure, performance and integrity were assessed. The LSOs were also audited and received extra training where required. A list of sites on the Network, with locations, site codes, site names and abbreviated site names is displayed in Annex 1. (Changes to Network sites during 2007 are described in details later.)

During each site visit NPL has:

- Audited the procedures of the LSO on-site, and encouraged LSOs to feed-back into the running of the Network;

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[1] "Heavy Metals monitoring", Brown, R J C. Air, Water, Environment International, December 2007, 21.

[2] "The use of Zipf's law in the screening of analytical data: a step beyond Benford". Brown, R J C. Analyst, 2007, 132, (4), 344.

[3] "A practical uncertainty budget for ambient mercury vapour measurement", Brown, R J C, Brown, A S, Yardley, R E, Corns, W T, Stockwell, P B. Atmospheric Environment, 2008, DOI 10.1016/j.atmosenv.2007.12.012

[4] "Twenty-five years of nationwide ambient metals measurement in the United Kingdom: concentration levels and trends", Brown, R J C, Yardley, R E, Muhunthan, D, Butterfield, D M, Williams, M, Woods, P T, Brown, A S, Goddard S L. Environmental Monitoring and Assessment, 2008, DOI 10.1007/s10661-007-9914-9

- Assessed the current condition of all on-site equipment, including the condition of the PM_{10} sampling head and impactor plate;
- Calibrated the flows of both the particulate (for volumetric and standard flow), and gaseous phase (volumetric flow), monitoring equipment;
- Leak tested both the particulate, and gaseous phase, monitoring equipment;
- Calibrated the site rotameter (used by the LSOs for determining the flow rate through the total gaseous mercury sampling line).

The dates of individual site audits and the flow data recorded at each site may be found in Annexes 2, 3 and 4. A detailed report on the findings of the audits is available[5], but in summary:

- All of the sites have been audited and are performing well.
- The site infrastructure was assessed at all sites and only one significant problem was found, at Swansea, which resulted in the temporary closure of the site. Further details are given in Section 2.4.
- Audits of the flow-rate on the Partisol samplers and the mercury vapour sampling equipment were satisfactory and no remedial action was required. The difference from set point determined at the audit visit is used at the data ratification stage to adjust the volume of air recorded for each sample.
- Following electrical safety tests on all of the Network sites in 2006, the details of which are available in a separate report[6], NPL completed the identified remedial actions, and inspection certificates have now been issued.
- Nearly all of the LSOs audited were carrying out all of their functions correctly. However, there were a few cases where the audit procedure found that best practice was not being followed and corrective action was recommended:
    - At three locations the Partisol PM_{10} head impactor plate was found to be very dirty and required cleaning. The accelerator part of the head was also moderately dirty. The LSOs were reminded to clean the impactor plate monthly and the accelerator quarterly.
    - At one location there was excessive grease on the two o-rings that seal the Partisol PM_{10} head onto the sampler. This resulted in a build up of grease on the inside of the main sampling orifice. This build up of grease can remove particles from the sample air stream. The grease was removed and the LSO was instructed to remove regularly any grease build up in future.
    - At two locations the pre-filter was found to be missing from mercury vapour sampling line. The LSOs were informed of the problem and a new filter and holder were installed. The LSOs

[5] NPL Report AS (RES) 005, "UK Heavy Metals Monitoring Network Audit Report For 2007", Butterfield, D M, Yardley, R E, Lipscombe, B, NPL, November 2007.
[6] NPL Report DQL-AS (RES) 019, "UK Heavy Metals Monitoring Network Electrical Safety Inspection Report", Butterfield, D M, NPL, August 2006.

were also reminded to change the filter and holder unit when the filter becomes visibly soiled.

The auditing of the sampler flow rates also allowed a comparison of the ESU and NPL flow calibrators. (The ESU recorded the sampler flow rate during their service visits.) The flow measurements were in good agreement with an average difference of only 4%, which is within the uncertainty of the flow measurement itself.

2.3 Equipment servicing and breakdowns

During 2007 the ESU visited, fully serviced, and calibrated the Partisol samplers at every Network site twice, at 6-month intervals.

During 2007, NPL has called-out the ESU to deal with Partisol sampler failures at:

- Cardiff (repaired leaking O-ring).
- Motherwell (repaired disconnected pipe between pump and reservoir).
- Eskdalemuir (high flow rate; flow controller replaced).
- Leeds (low flow rate; pump diaphragm replaced).
- Manchester (low flow rate: pump replaced).
- Sheffield (failed pump; loose connection found and repaired).
- Brookside Metals (total instrument failure; replaced with spare sampler).
- Weston Point (repaired misaligned filter holder which was causing leaks).

Following the installation of new pumps for sampling total gaseous mercury across the Network, no breakdowns in the mercury sampling equipment were recorded in 2007. The beneficial effect of the installation of the new pumps on the rate of mercury sampling equipment failure is demonstrated in Figure 1.

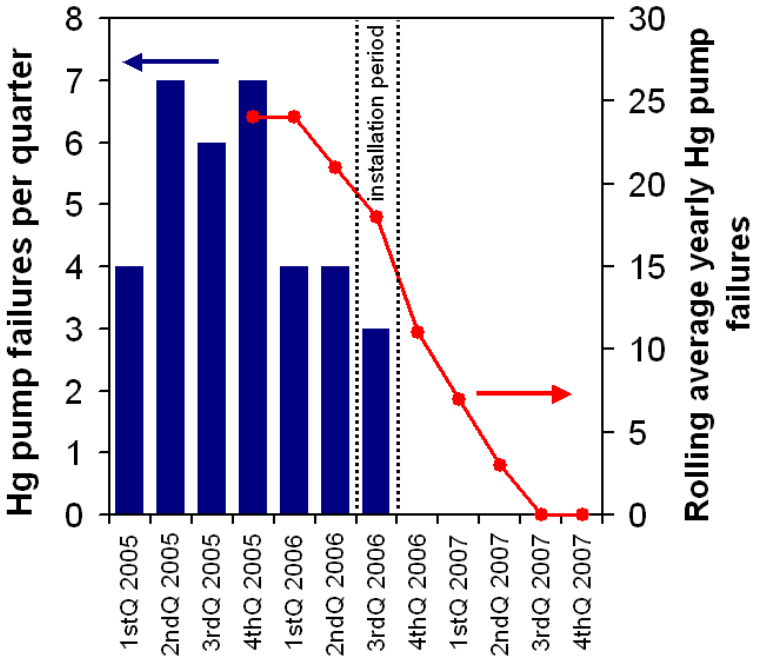


Figure 1. The number of total gaseous mercury sampling pump failures over the 18 months before, and 18 months after, new pumps were installed across the Network. The failure rate per quarter (dark blue bars) and the rolling average yearly failure rate (red circles) are displayed.

2.4 Site infrastructure and other issues

Site 49: Swansea

The building that the sampler at Swansea was located on was suffering from subsidence and had to be demolished in July 2007. The sampler was reinstalled in the same location after the building had been rebuilt. This site was recommissioned in December 2007, but subsequently left the Network at the end of 2007, and will be managed in future by the local authority in Swansea (although NPL will continue to provide the analysis for samples from this site). It has been replaced by two new sites at Swansea assimilated from local authority control.

Site 59: Weston Point

In January 2007 the site suffered numerous unexpected power trips and cut-outs. This happened again in April 2007. Fortunately data capture was not unduly affected. In May, during the service visit, the connection to the sampler was rewired and the problem has not re-occurred since.

2.5 Network re-organisation to meet the requirements of the Fourth Daughter Directive

Following the assessment of the monitoring required by the Fourth Daughter Directive with respect to heavy metals and PAHs in the UK[7], proposals were made to re-organise the Network to ensure compliance with these requirements. The proposed changes were agreed with Defra in the fourth quarter of 2007.

Overall the number of sites on the Network is to increase from 17 to 24 as a result of the re-organisation. These changes are to occur in the final quarter of 2007 and the first half of 2008.

The proposed changes to the Network, and the progress to date, is shown schematically in the time-line in Figure 2 below.

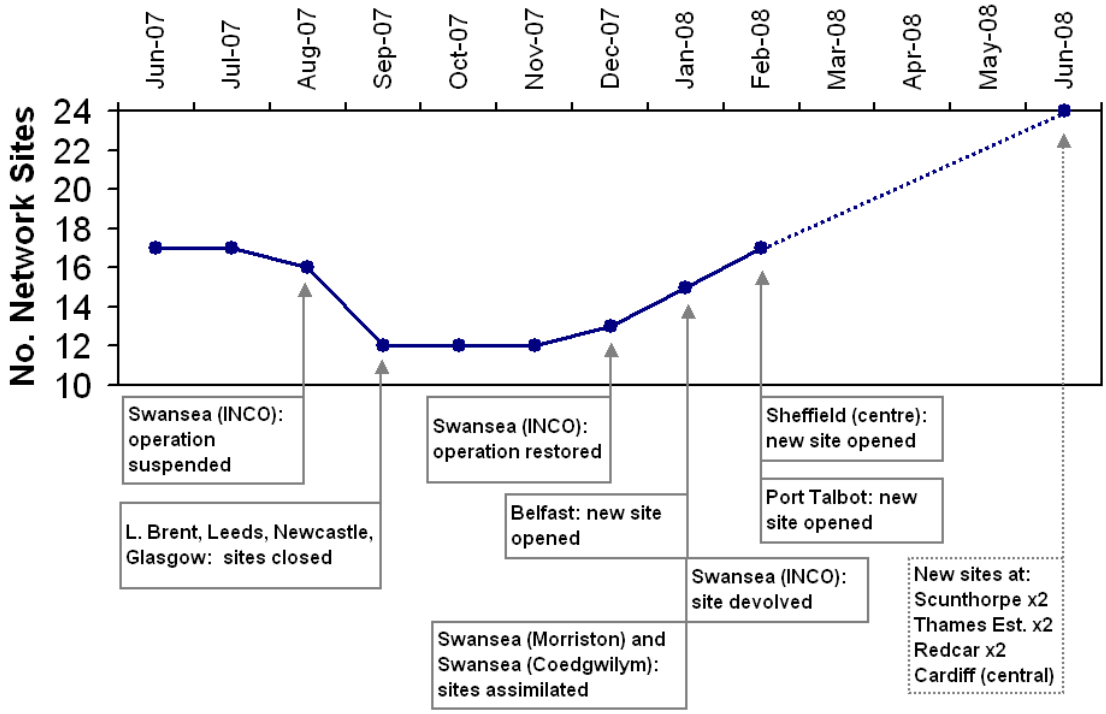


Figure 2. The timeline detailing Network re-organisation, and how the number of sites operating on the Network has varied, and is expected to vary, between June 2007 and June 2008 . The solid line represents completed work, the dotted line represents work to be completed.

A detailed description of the activities as part of the re-organisation of the Network in 2007 and the start of 2008 is given below:

1st June 2007: 17 Network Sites were operational.

[7] AEAT Report AEAT/ENV/2243 "Preliminary Assessment of PAH and heavy metal levels in the UK", Bush, T, AEAT, February 2007.

12th July 2007: Operation of the Network site at Swansea (INCO) was temporarily suspended (see section 2.4) during building works. This detail is included because the Swansea (INCO) site was to be devolved to local authority control once new sites in Swansea were assimilated from local authority control onto the Network. **16 Network Sites were operational.**

1st September 2007: The Network sites at London Brent (in operation, at two locations, since 1980), Leeds (in operation since 1980), Newcastle (in operation, at various locations, since 1989), and Glasgow (in operation since 1980) were closed. The Partisol samplers at these locations will be redistributed for use at new Network sites. **12 Network Sites were operational.**

29th November 2007: Operation of the Network site at Swansea (INCO) was restored. **13 Network Sites were operational.**

13th December 2007: The local authority sites at Swansea (Morriston Groundhog) and Swansea (Coedgwilym Cemetery) were assimilated on the Network. NPL had been providing the analysis for samples from these sites for the previous 18 months. The data collected from these sites will be included in the UK annual average from 2008 onwards. **15 Network Sites were operational.**

17th December 2007: A new Network site at Belfast (Belfast Centre) began monitoring. The data collected from this site will be included in the UK annual average from 2008 onwards. **16 Network Sites were operational.**

1st January 2008: The Network site at Swansea (INCO) (in operation since 2002) was devolved to local authority control. NPL will continue to provide analysis for the samples from this site. NPL will also provide the analysis for a new local authority site: Swansea (YGG Gellionnen). **15 Network Sites were operational.**

30th January 2008: New Network sites at Port Talbot and Sheffield (Sheffield Centre) began monitoring. **17 Network Sites were operational.**

March – June 2008 (projected): New network sites will be installed at: Cardiff (Cardiff Centre), Redcar (2 sites, Redcar Centre and North Ormesby), Scunthorpe (2 sites, Scunthorpe Centre and Santon), Thames Estuary (2 sites, 1 site either side of the Thames, most probably at Northfleet and Tilbury). **24 Network Sites will be operational.**

The new site in Belfast is an Urban Background site.

All the other new sites are Industrial Background sites.

These Industrial Background sites are designed either:

- To provide extra upwind or downwind coverage in existing monitoring locations (Sheffield (centre), Swansea (Morriston), Swansea (Coedgwilym)); or,

- To monitor at locations where there was no previous coverage (Redcar (centre) and North Ormesby, Scunthorpe (centre) and Santon, Northfleet and Tilbury, Cardiff (centre), and Port Talbot).

Once infrastructure and equipment are in place at a new Network site, the LSO and equipment must be audited by NPL before measurements for reporting as part of the Network are started.

Changes to the Network as a result of re-organisation, when competed, will be the result of a separate report by NPL. However, the Figure 3 demonstrates the expected impact of the re-organisation of the distribution of Network sites across the UK between June 2007 and June 2008.

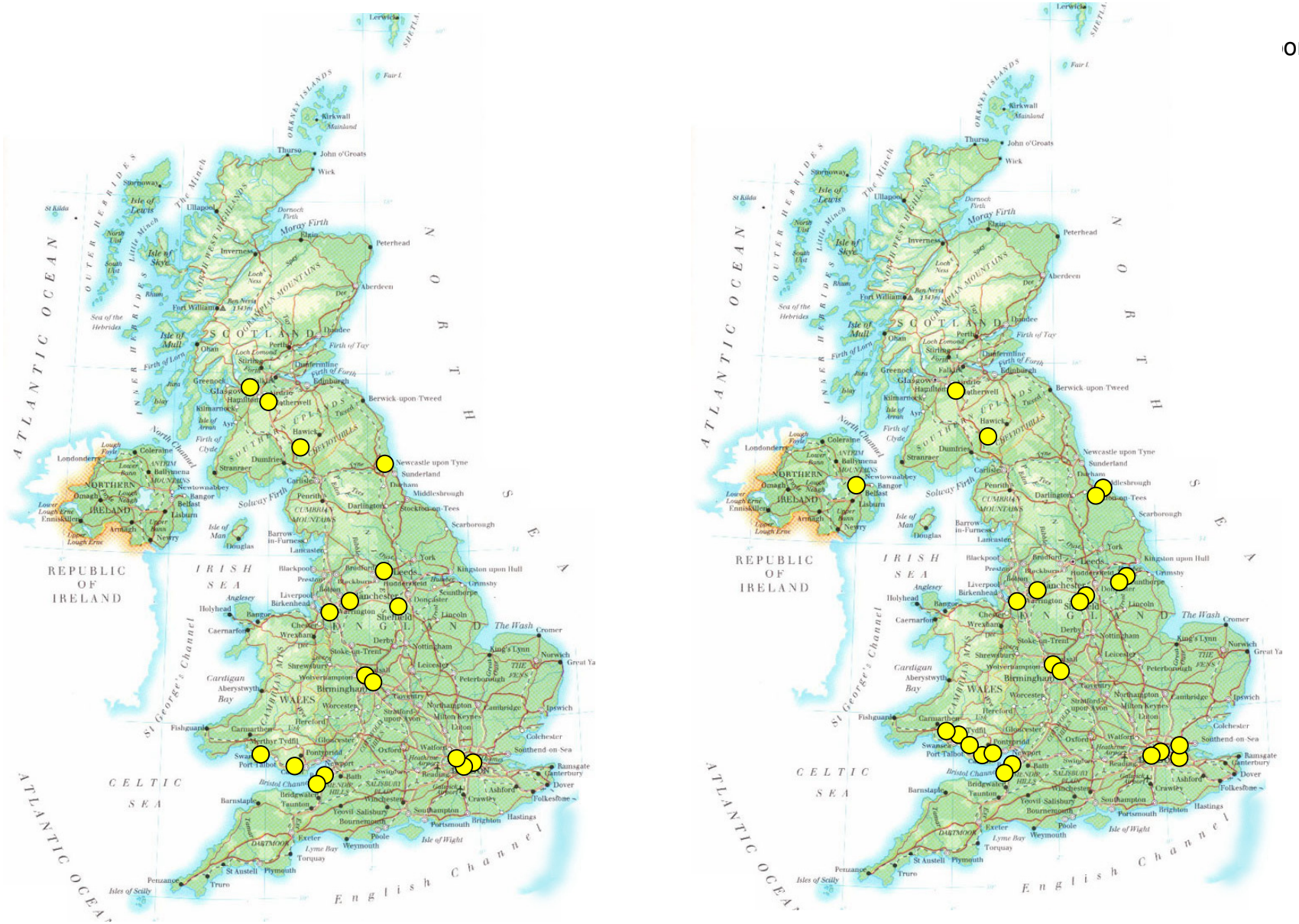


Figure 3. Location of sites on the UK Heavy Metals Network in June 2007 (left) and, projected, in June 2008 (right).

3. Sampling and Analytical Methodology

An overview of the sampling and analytical procedures used to analyse samples from the Network is given below.

3.1 Sampling Methodology: Particulate-phase metals

Particulate samples were taken at all sites in the Network using Partisol 2000 instruments (fitted with PM_{10} heads) operating at a calibrated flow rate, nominally of 1 $m^3.h^{-1}$, in accordance with EN 12341:1998. Samples were taken for a period of one week onto 47 mm diameter GN Metricel membrane filters.

3.2 Sampling Methodology: Total gaseous mercury

Sampling for total gaseous mercury took place at 13 of the 17 Network sites (Swansea, Sheffield, BZL Avonmouth and BZL Hallen do not sample for mercury vapour), using a low-volume pump (calibrated annually by NPL). Air was pumped through Amasil (gold-coated silica) tubes at a rate of 100 $ml.min^{-1}$ for either one week or four weeks, depending on the specific site and the expected ambient concentrations. A schematic diagram of the sampling set-up is given in Figure 4.

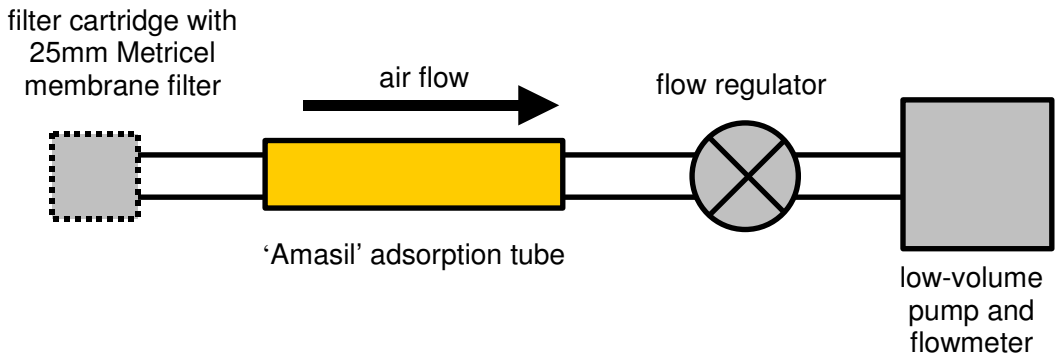


Figure 4. Schematic diagram of the total gaseous mercury sampling apparatus. The 25 mm diameter filter was used to remove any particulate material.

3.3 Analytical Methodology: Particulate-phase metals

Analysis for particulate-phase metals took place at NPL using a PerkinElmer Elan DRC II ICP-MS, following NPL's UKAS accredited procedure, which is fully compliant with the requirements of EN 14902:2005.

Upon arrival at NPL, the filters were cut accurately in half, and each portion digested at temperatures up to 220°C using a CEM Mars X microwave. The digestion mixtures used were:

- Hg & Pt: 5 ml of nitric acid and 5 ml hydrochloric acid.

- All other metals: 8 ml of nitric acid and 2 ml hydrogen peroxide.

ICP-MS analysis of the digested solutions took place using at least four gravimetrically-prepared calibration solutions. A QA standard was repeatedly analysed (after every two solutions), and the change in response of the QA standard was mathematically modelled to correct for the long-term drift of the instrument. The short-term drift of the ICP-MS was corrected for by use of an internal standards mixture (containing Y, In, Bi, Sc, Ga & Rh) continuously added to the all samples via a mixing block. Each sample is analysed in triplicate, each analysis consisting of five replicates.

The amount of each metal in solution (and its uncertainty) was then determined by a method of generalised least squares using XLGenline (an NPL-developed program) to construct a calibration curve.

3.4 Analytical Methodology: Total gaseous mercury

Analysis of total gaseous mercury samples took place at NPL using a PS Analytical Sir Galahad II analyser with a fluorescence detector, using NPL's UKAS accredited procedure which is based on the draft standard method currently being developed by CEN TC264 WG25 'Mercury'. The instrument was calibrated by use of a gas-tight syringe, making multiple injections of known amounts of mercury vapour onto the permanent trap of the analyser.

Sampled adsorption tubes were placed in the remote port of the instrument and heated to 900°C, desorbing the mercury onto a permanent trap. Subsequent heating of this trap then desorbed the mercury onto the detector. The full heating program used is shown in Table 1:

Stage	Adsorption Tube	Permanent Trap
Delay time	30s	30s
Heating period	60s	15s
Cooling period	200s	120s
Transfer delay time	60s	-

Table 1. Total gaseous mercury analysis method parameters

4 Method performance characteristics and quality control

In 2007 both facilities used to perform analysis of Network samples (the inductively coupled plasma-mass spectrometer (ICP-MS) and the atomic fluorescence analyser) were successfully moved into NPL's new state-of-the-art laboratory providing a greatly improved working environment, and increased space, for staff and instruments. The instruments were recommissioned and revalidated, using procedures and criteria pre-agreed with UKAS, with a minimum period of down-time.

UKAS carried out a surveillance assessment visit to NPL in November 2007. Both of the technical procedures used to analyse samples from the Network (metals in the particulate phase by ICP-MS, and mercury vapour by atomic fluorescence spectroscopy) were audited by UKAS, and both passed with no mandatory or suggested corrective actions.

NPL has also recently purchased an additional microwave digester and an additional ICP-MS, to further improve analytical capacity in order to efficiently manage the expected increase in samples as the Network expands following re-organisation. This new instrumentation will also minimise any analytical down-time owing to instrumental failure, and decrease sample turnaround times.

4.1 Limits of Detection: Particulate-phase metals

Indicative detection limits achievable by NPL using a UKAS accredited ICP-MS method, fully compatible with EN 14902:2005, are shown in Table 2. The solution limits of detection were calculated using the method outlined in EN14902:2005, repeatedly analysing a typical acid blank solution and taking into account the variability between individual instrumental readings. Values for the limits of detection have been calculated assuming a solution mass of 53 g and a volume of sampled air of 168 m^3 (equivalent to seven days sampling at 1.0 $m^3.h^{-1}$).

Analyte	Limit of Detection		
	Solution ($ng.g^{-1}$)	Filter (ng)	Air ($ng.m^{-3}$)
As	0.08	4.2	0.03
Cd	0.003	0.16	0.001
Cr	0.08	4.1	0.02
Cu	0.07	3.6	0.02
Fe	1.0	50	0.3
Mn	0.009	0.5	0.003
Ni	0.03	1.7	0.01
Pb	0.04	2.0	0.01
Pt	0.004	0.2	0.001
V	0.007	0.4	0.002
Zn	0.2	11	0.06
Hg	0.03	1.9	0.01

Table 2. Limits of detection for particulate-phase metals.

4.2 Limits of Detection: Total gaseous mercury

The limit of detection routinely achievable for analysis of total gaseous mercury at NPL using its UKAS accredited procedure, which is consistent with the draft standard method being developed by CEN TC264 WG25, is 0.02 ng per tube, equivalent to an air concentration of approximately 0.02 $ng.m^{-3}$ (assuming a volume of sampled air of 1.01 m^3, equivalent to one week's sampling at 100 $ml.min^{-1}$). This value was calculated using a minimum detectable peak height of three times the baseline noise (with the instrument detector being operated at its usual sensitivity setting).

4.3 QA/QC Procedures

The quality assurance and quality control procedures used during Network operation are listed below:

Sampling:

- Despatch and analysis of one field-blank filter and one field-blank adsorption tube per site per quarter.
- Thorough checks of the returned filters and adsorption tubes to check for damage during transport. Rejection of damaged filters or tubes.
- Logging of all samples on NPL's Network database. Rejection of any unidentifiable samples and full investigation of any discrepancies.

- Continued training of, and regular communication with, the LSOs. This includes assessment of performance during site audits.

Particulate phase metals (ICP-MS analysis):

- Optimisation of the ICP-MS prior to each set of analysis. Comparison of the optimised parameters with pre-defined criteria.
- Regular extraction of an appropriate certified reference material (e.g. NIST SRM 1648 or NIES No.8) to check the recovery of the digestion method. Recoveries must be within the limits specified by EN14902.
- Regular measurement of filter blanks to ensure appropriate blank subtractions are made from measured values.
- Maximum levels for the standard deviation of the five internal standard-corrected measured intensities of each analysis of each sample.
- The XLGenline goodness-of-fit for all calibration curves must be less than 2.
- Ratification of all data by an NPL Quality Circle of recognised NPL scientific experts independent of the analytical team.

Total gaseous mercury (atomic fluorescence analysis):

- Regular recovery tests carried out by analysing tubes spiked with a known quantity of mercury. Recoveries of between 95% and 105% must be achieved.
- Control limits on changes in instrument sensitivity between analyses.
- Analysis of clean tubes to ensure that blank levels are sufficiently low.
- Bracketing calibration procedure for each tube analysed in order to minimise the effect of instrumental drift.
- Ratification of all data by an NPL Quality Circle of recognised NPL scientific experts independent of the analytical team.

4.4 Measurement uncertainty

The average uncertainty from the analyses of single filters and tubes at NPL during 2007 are shown in Table 3. All figures are a combination of the analytical and sampling uncertainties and have been derived using full, GUM compliant, uncertainty budgets. All values are stated to a coverage factor of $k = 2$, providing a level of confidence of approximately 95%.

Analyte	Expanded relative uncertainty	
	Single measurement average	Daughter Directive maximum
As	30%	40%
Cd	24%	40%
Cr	28%	-
Cu	13%	-
Fe	15%	-
Mn	12%	-
Ni	15%	40%
Pb	16%	25%
Pt	n/a†	-
V	17%	-
Zn	14%	-
Hg(p)	34%	-
Hg(v)	17%	50%

Table 3. Average measurement uncertainties achieved at NPL during 2007. The 'Daughter Directive maximum' column shows the maximum permissible uncertainty permitted by the relevant (First or Fourth) Daughter Directive. Hg(p) and Hg(v) are particulate phase mercury, and total gaseous mercury, respectively.
† The majority of Pt measurements are below the limit of detection.

The measurement uncertainties displayed in Table 3 are representative of individual measurements averaged over a typical sampling period (here, one week), as required by the First and Fourth Daughter Directives. The vast majority of the measurements used to compile the data in Table 3 were of ambient concentrations well below the appropriate target values. It is calculated that in the region of the appropriate target value - where the Daughter Directive's uncertainty data quality objectives apply (except for Hg(v) where there is no target value) – these uncertainties will be significantly lower.

A comparison of these uncertainties with the measured annual means shows the expected empirical Horwitz relationship, with uncertainty of measurement increasing as concentration decreases.

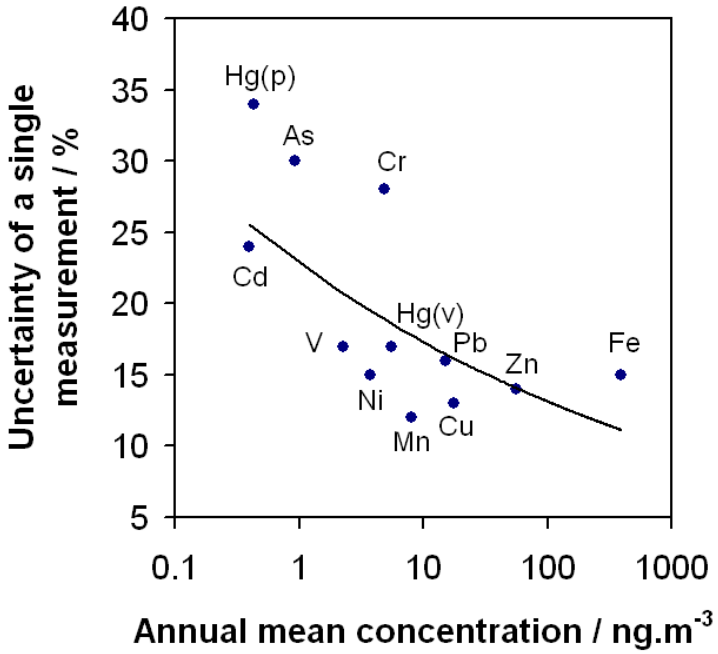


Figure 5. The relationship between the average uncertainties of the analytical measurements for each element and their annual mean measured concentrations. Hg(p) and Hg(v) are particulate phase mercury, and total gaseous mercury, respectively.

5 Network data quality

5.1 Data capture in 2007

All data capture figures are based on a target time coverage of 100%.

Data capture across the entire Network during 2006 was **94%**.

Of the data lost:

- 40% was excluded because the minimum number of valid sampling hours was not achieved during the sampling period,
- 40% was lost owing to equipment failure or site operation problems, and,
- 20% was excluded at the analytical stage (owing to contamination of sample, instrument failure, exclusion during data ratification etc.).

The breakdown of the overall data capture between the particulate and gaseous phase, and at each site, is displayed in the table below:

Location	Data Capture / %	
	Particulate phase	Gaseous phase
Whole Network	**93**	**96**
IMI Walsall	98	100
BZL Hallen	100	*N/A*
Swansea[+]	62	*N/A*
BZL Avonmouth	92	*N/A*
Sheffield	100	*N/A*
Weston Point	94	94
London Brent*	100	100
London Cromwell Rd	100	100
London Horseferry Rd	94	92
Leeds*	100	100
Glasgow*	86	100
Eskdalemuir	98	100
Motherwell	88	92
Manchester	92	100
Cardiff	100	100
Brookside Metals	92	96
Newcastle*	97	94

Table 4. Data capture across the UK Heavy Metals Monitoring Network during 2007.

[+]Operation of this site was suspended between July and December owing to building works at site (see Section 2.4). Data capture at this site based on a target time coverage not including the suspension was 92%.

*****Data capture has been calculated on the time period January-August inclusive as these sites closed on 1st September 2007.

The quarterly data capture, and the rolling annual average data capture, achieved by the Network over the last three years is displayed in Figure 6.

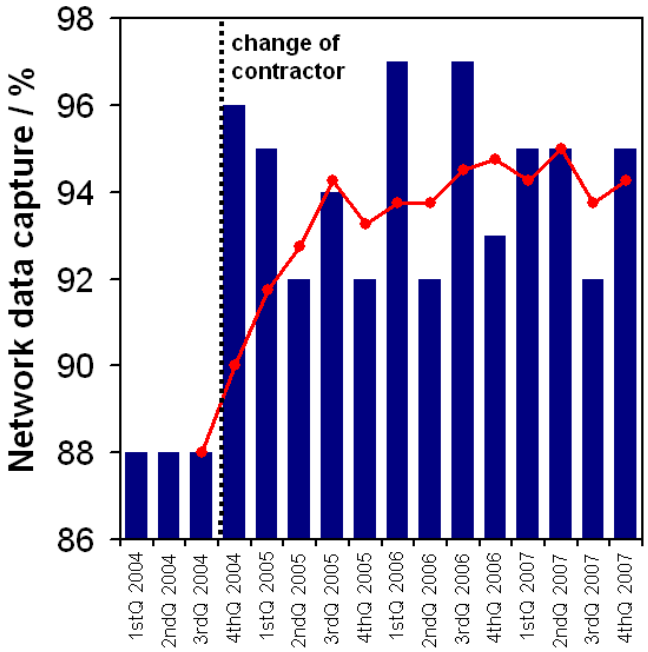


Figure 6. Network data capture from 2004-2007 (inclusive). Quarterly data capture is indicated by the blue bars, whilst the rolling annual average data capture is given by the red line.

5.3 Data processing and ratification

Analysis of the Network samples produces individual concentration values for weekly, or for some mercury adsorption tubes, monthly periods. These individual measurement results each have a stated measurement uncertainty, quoted at the 95% confidence level, associated with them.

Monthly concentrations at each site are then calculated as uncertainty-weighted means of weekly measurement data. Annual means at each site are produced by calculating the means of the monthly values. Network-wide annual means are then produced by averaging annual means from the individual sites.

An NPL QA/QC circle (the 'quality circle') ratifies ambient concentration data produced by the UK Heavy Metals Monitoring Network. NPL personnel performing the ratification procedure are independent of the Network analysis and management process.

It is the aim of the ratification procedure to distinguish between changing ambient concentrations (including long terms trends, seasonal variation and single pollution events), and analytical discrepancies within the large amount of Network data. Ratification takes place in accordance with several guidelines, outlined below:

1) Only data where the valid sampling hours are greater or equal to 75% of the total sampling hours will be eligible to produce valid concentration data, and count towards the total data capture percentage.

2) Data excluded following the ratification procedure will also not be eligible to produce valid concentration data, or count towards the total data capture percentage.

3) Upon production, weekly data for each element at each site is plotted in a time series, or displayed as a continuous list of values which may be easily compared. (Total gaseous, and particulate phase, mercury should be plotted, or listed separately).

4) In the first instance these data are assessed visually for any obvious discrepancies with due regard to long terms trends, short term variability and seasonal variation. Then outlier tests are performed to detect any potentially discrepant data. (Detection of gross errors or systematic transcription of data entry faults may also be detected using chemometric methods).

5) If valid reasons for obviously discrepant values are found (e.g. incorrect calculation, low exposure time, non-valid exposure volume, analytical error) these values may be either excluded or corrected (depending on the nature of the error).

6) As part of the internal quality and technical auditing procedures, a selection of ambient air concentrations calculated each month are thoroughly audited by a party independent of the analysis procedure. For these samples, the sample number, target analyte, auditor, audit date and status of the data is recorded in the designated Excel spreadsheet after auditing. These audits concentrate most heavily on Ni, As, Cd, Pb and Hg vapour analyses, as these are directly relevant to EC Directives.

NPL is currently developing a new type of uncertainty weighted averaging technique that aims to make better use of the individual statements of uncertainty produced with each analytical measurement. It is hoped that this technique, which will be introduced on a trial basis during 2008, will decrease the likelihood of annual averages being unduly skewed by high measured values with abnormally small associated uncertainties.

5.4 Measurement Uncertainty of Annual Average

Since the data capture across the Network has been high (and any gaps in coverage have occurred evenly throughout the year) the uncertainty in the annual mean values will be dominated by the analytical uncertainty, with only small uncertainty contributions due to less than 100% time coverage. These contributions are calculated using the method described in ISO 11222:2002 “Air quality - Determination of the uncertainty of the time average of air quality measurements”.

In all cases annual mean uncertainties are compliant with the data quality objectives for uncertainty in the First and Fourth Daughter Directives. Expanded uncertainties, quoted at the 95% confidence interval, for the annual mean concentration values of the relevant First and Fourth Daughter Directive metals are given in the table below:

Analyte	**Expanded Relative Uncertainty**	
	Annual Mean	Daughter Directive maximum
As	32%	40%
Cd	26%	40%
Ni	18%	40%
Pb	18%	25%
Hg(v)	19%	50%

Table 5. Expanded uncertainties, quoted at the 95% confidence interval, for the annual mean concentration values of the relevant Daughter Directive metals. Hg(v) refers to total gaseous mercury.

6 Network data

6.1 Measured Concentrations

The annual mean measured metals concentrations, averaged over all sites (Table 6), and at individual sites (Table 7), are given below:

Analyte	2007 Annual Mean Concentration / $ng.m^{-3}$
As	0.93
Cd	0.40
Cr	4.87
Cu	17.5
Fe	393
Mn	8.09
Ni	3.78
Pb	15.0
Pt	<0.01
V	2.25
Zn	56.6
Hg(p)	0.44
Hg(v)	5.60

Table 6. 2007 annual mean concentrations averaged over all sites on the UK Heavy Metals Monitoring Network. Hg(p) and Hg(v) are particulate phase mercury, and total gaseous mercury, respectively.

2007 Annual Mean Concentration / ng.m^{-3}													
Site	Analyte												
	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg (p)	Hg (v)
IMI Walsall	1.18	0.72	4.71	17.2	330	9.25	2.13	22.7	<0.01	1.58	85.9	0.41	2.65
BZL Avonmouth	0.96	0.34	2.78	6.4	316	7.21	3.91	17.7	<0.01	4.52	38.6	0.32	N/A
Swansea	1.01	0.28	3.94	5.0	188	4.42	28.04	10.5	<0.01	1.64	18.3	0.27	N/A
BZL Hallen	0.92	0.33	2.19	6.9	215	4.72	1.75	10.3	<0.01	3.30	22.9	0.43	N/A
Sheffield	1.32	0.46	24.96	16.8	453	26.22	11.17	26.3	<0.01	2.67	78.8	0.39	N/A
Weston Point	0.81	0.20	2.96	5.8	155	3.69	2.24	11.1	<0.01	1.73	16.8	1.80	41.46
London Brent	0.92	0.22	3.60	20.6	580	8.17	3.13	12.9	<0.01	2.64	30.1	0.32	1.86
London Cromwell	0.95	0.20	4.33	40.5	840	9.57	2.68	11.1	<0.01	2.91	28.3	0.20	2.59
London Horseferry	0.91	0.20	1.98	19.5	457	6.66	2.12	10.8	<0.01	2.87	24.5	0.24	2.15
Leeds	1.04	0.23	5.63	11.8	370	8.74	2.53	15.0	<0.01	1.91	25.9	0.44	1.41
Glasgow	0.47	0.15	6.85	11.6	292	4.59	3.21	7.2	<0.01	1.20	18.9	0.43	2.15
Eskdalemuir	0.31	0.07	1.33	2.7	26	1.50	0.94	3.3	<0.01	1.47	6.6	0.19	1.69
Motherwell	0.49	0.09	2.98	6.3	213	3.99	0.89	5.0	<0.01	1.31	12.5	0.41	2.34
Manchester	0.93	0.20	5.57	38.4	839	9.47	2.06	9.8	<0.01	2.02	31.4	0.31	1.82
Cardiff	1.02	0.29	3.89	24.4	642	9.53	1.81	13.8	<0.01	2.03	35.5	0.55	1.64
Brookside Metals	1.46	2.19	4.24	42.7	437	11.77	2.77	51.4	<0.01	1.94	411.6	0.45	2.44
Newcastle	0.87	0.14	2.88	6.2	206	4.27	2.41	5.5	<0.01	3.49	16.3	0.39	2.28

Table 7. 2007 annual mean concentrations measured at individual sites on the UK Heavy Metals Monitoring Network. The monthly measured metals concentrations from all Network sites are summarised in the tables in Annex 5. Hg(p) and Hg(v) are particulate phase mercury, and total gaseous mercury, respectively.

6.2 Measured concentrations with respect to the requirements of the First and Fourth Daughter Directives

The annual mean concentrations are compared against the relevant limit and target values, contained within the First and Fourth Daughter Directives, in the graph below:

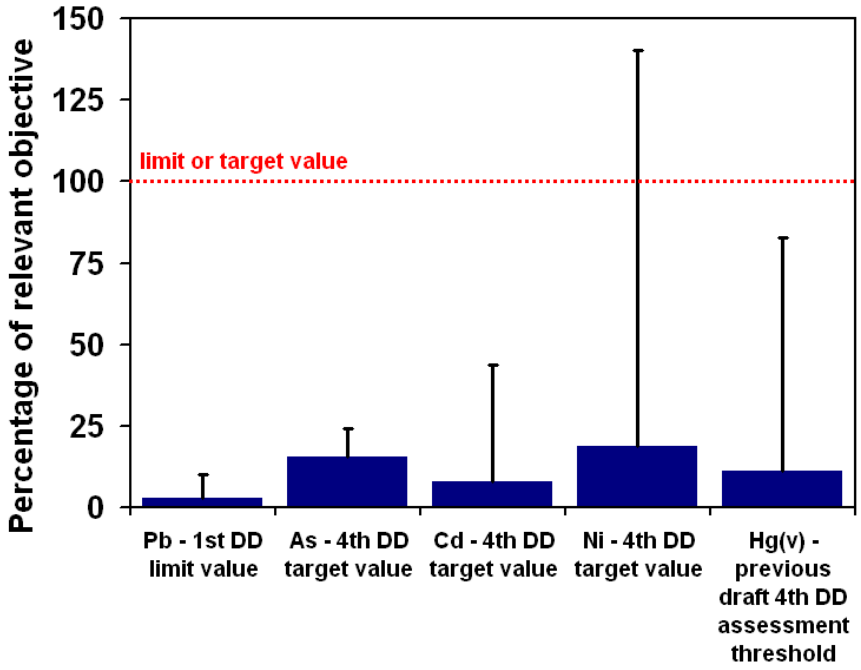


Figure 7. A summary of the annual mean measured concentrations of the heavy metals relevant to the First and Fourth Daughter Directives on the UK Heavy Metals Monitoring Network in 2007 as a percentage of the relevant air quality objectives. The bars indicate the annual mean of all sites; the lines indicate the annual means at the site with the highest concentrations. Hg(v) refers to the total gaseous mercury concentrations. The mercury objective is taken from a threshold value quoted in a draft of the Fourth DD.

In all cases the annual mean values are well below the limit and target values. In only one case does the highest annual average at an individual site exceed the target values.

Annual mean concentration values for the relevant First and Fourth Daughter Directive metals at all Network sites are displayed in the graph below:

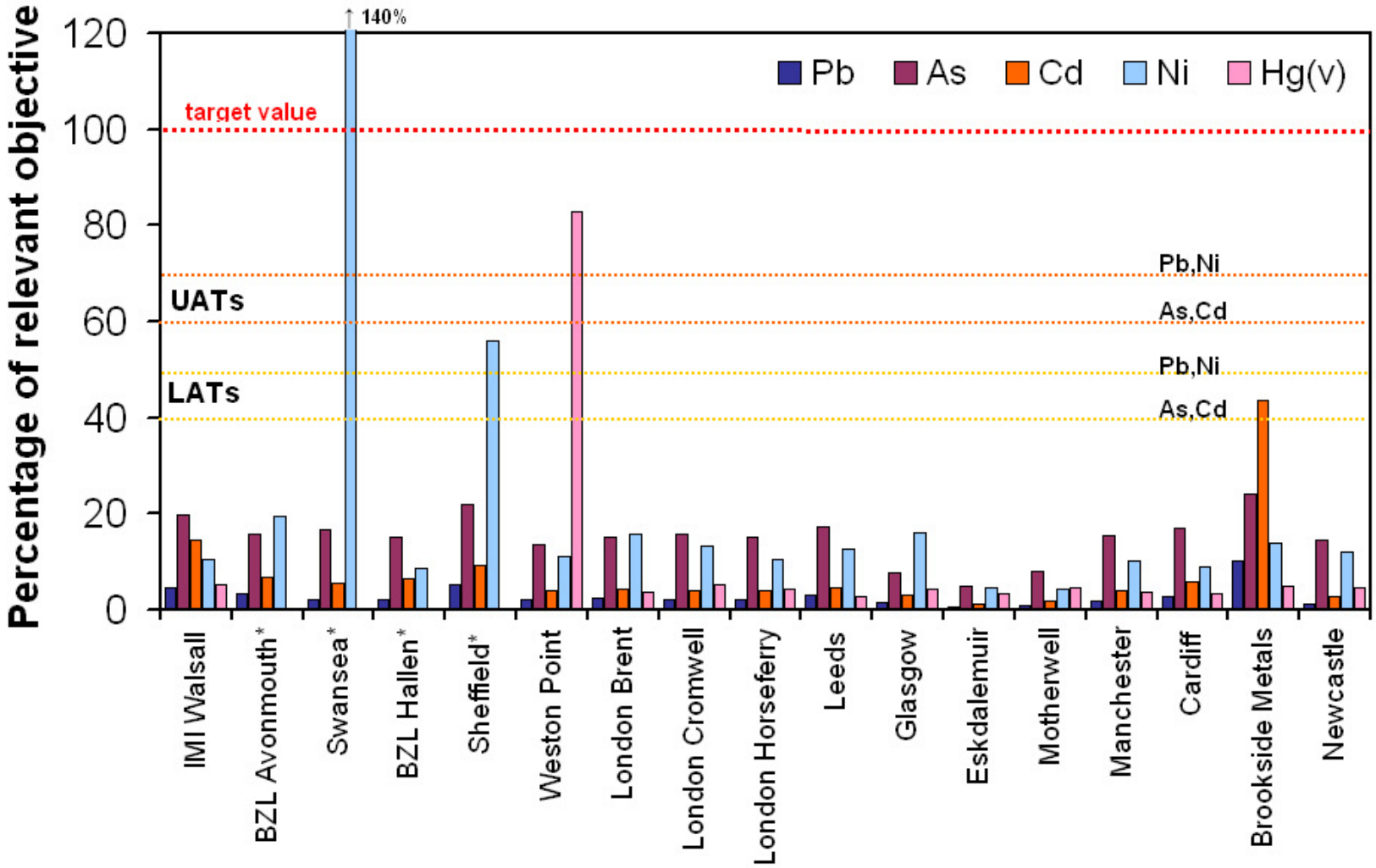


Figure 8. A summary of the annual mean measured concentrations of the heavy metals relevant to the First and Fourth DDs at all site on the UK Heavy Metals Monitoring Network in 2007 as a percentage of the relevant target values, lower assessment thresholds (LATs) and upper assessment thresholds (UATs). The mercury objective originates from a threshold value quoted in a draft of the Fourth DD. Sites with asterisks indicate that sites do not measure total gaseous mercury. Hg(v) refers to the total gaseous mercury concentrations.

The highest annual mean value for nickel has been found at site 49 (INCO Europe, Swansea). The highest annual mean values for arsenic, cadmium and lead are found at site 69 (Brookside Metals, Walsall). The highest annual mean value for total gaseous mercury has been found at site 59 (ICI Weston Point, Runcorn).

In only three instances do the measured annual mean values exceed the relevant lower assessment thresholds:

Annual Mean Concentrations above the Target Values:

- Nickel at Site 49 (INCO Europe, Swansea): 140% of the target value.

Annual Mean Concentrations above the Lower Assessment Thresholds:

- Cadmium at Site 69 (Brookside Metals, Walsall): 44% of the target value.
- Nickel at Site 58 (Avesta Steel, Sheffield): 56% of the target value.

Other Notable Concentrations:

- Total gaseous mercury at Site 59 (ICI Weston Point, Runcorn). The measured concentration represents 83% of the target value of 50 $ng.m^{-3}$ quoted in a draft version of the Fourth DD.

The site at Swansea is situated near to a nickel refinery, producing speciality nickel products and nickel-coated materials. The site at Sheffield is located next to a steel rolling mill and processing plant producing specialist steel strip, and coil, products. The site at Bilston Lane, in Walsall, is close to the UK's largest producer of gunmetal, brass, bronze and other copper alloy ingots.

All other annual mean values at all sites for Ni, As, Cd, Pb and Hg are below the relevant Lower Assessment Thresholds.

The change in measured concentration of the heavy metals relevant to the First and Fourth DDs from 2006 to 2007 at all sites, as a percentage of the relevant target values is shown in Figure 9. This plot shows that the majority of measured values have decreased with respect to the relevant target value over the previous year, most notably at Site 69 (Brookside Metals). Some sites have shown small increases in nickel concentration with respect to the target value, whilst there has been a large increase in the vapour phase mercury concentration at Site 59 (ICI Weston Point, Runcorn).

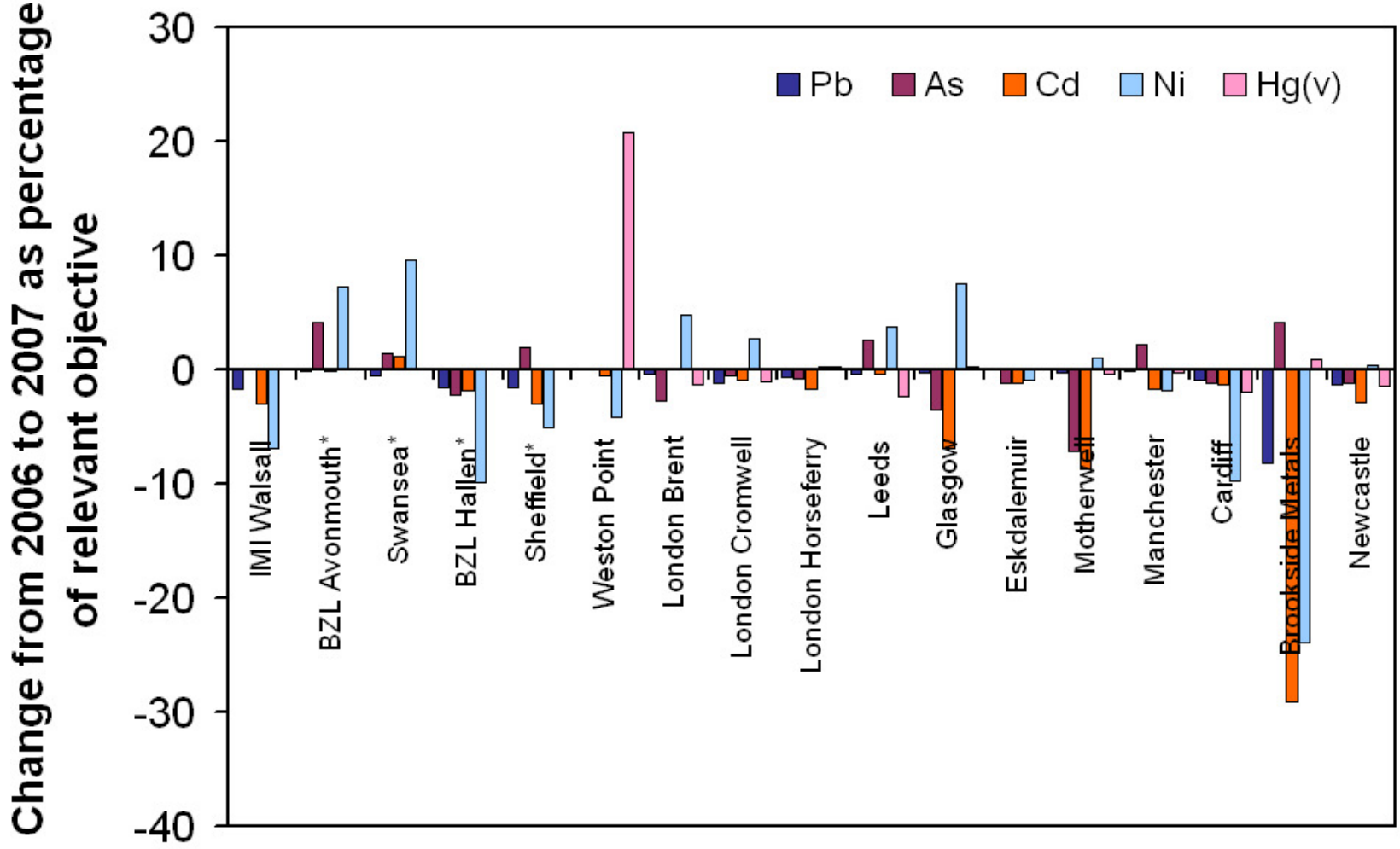


Figure 9. The change in the measured concentration of the heavy metals relevant to the First and Fourth DDs from 2006 to 2007 at all sites, as a percentage of the relevant target or limit values. The mercury objective originates from a threshold value quoted in a draft of the Fourth DD. Sites with asterisks indicate that sites do not measure total gaseous mercury. Hg(v) refers to the total gaseous mercury concentrations.

7 Trends in measured concentrations

Changes in the annual average metals concentrations measured, across the Network, over the past 25 years are shown in the table below:

Analyte	Changes in measured concentrations during the:			
	Last 25 Years	Last 10 Years	Last 4 Years	Last Year
As	not measured	not measured	-43%	-2%
Cd	-78%	-58%	-62%	-33%
Cr	-59%	10%	11%	-10%
Cu	-21%	-16%	-37%	-13%
Fe	-60%	-52%	-33%	-9%
Hg(p)	not measured	not measured	144%	11%
Hg(v)	not measured	not measured	-55%	11%
Mn	-72%	-43%	-12%	-12%
Ni	-62%	-51%	-2%	-6%
Pt	not measured	not measured	0%*	0%*
V	-90%	-55%	-16%	-18%
Zn	-54%	12%	-50%	-35%
Pb	-97%	-94%	-60%	-28%

Table 8. Trends in the measured annual average concentrations of metals measured by the UK Heavy Metals Monitoring Network. Hg(p) and Hg(v) are particulate phase mercury, and total gaseous mercury, respectively. *Since monitoring for Pt began in 2003, average annual concentrations levels have remained below the detection limit.

Measurements of annual mean concentrations for all elements have generally fallen year upon year over the period for which data is available. This trend has, in the most part, continued over the last year. The trends for individual elements are investigated in more detail below:

Arsenic: Arsenic has now been measured for five years across the Network; levels are low and have fallen slightly since last year.

Cadmium: Concentrations continue to fall and remain low across the Network, with the exception of one site (Brookside Metals).

Chromium: Concentrations have fallen in 2007, and remain low across the Network. The average UK concentration has more than halved over the last 25 years.

Copper: Recorded concentrations continue to fall across the Network and are generally very low. They have decreased by almost 40% over the last four years.

Iron: Concentrations have fallen in 2007 and continue to show an overall downward trend over the last quarter of a century, during which they have decreased by 60%. However, iron is still the most abundant metal measured by the Network (7 times more abundant than zinc). The sites showing the highest iron concentrations in 2007 were all roadside sites (Manchester, Cardiff and London Horseferry Road).

Particulate phase mercury: Concentrations remain very low across the Network but have risen slightly in 2007.

Total gaseous mercury: Concentrations have shown a small increase over the last year, but remain very low. Trends, and average recorded concentrations, for total gaseous mercury are strongly influenced by the very high levels at Site 59 (ICI Weston Point, Runcorn).

Manganese: Concentrations are low across the Network, have fallen slightly in 2007, and have decreased by more than 70% over the last quarter of a centrury.

Nickel: Concentrations decreased slightly in 2007. The high values recorded at sites 49 and 58 (Swansea and Sheffield, respectively) have a large influence on trends, and average recorded concentrations, for this element across the Network. However levels have changed very little over the last 4 years.

Platinum: Average annual values remain below the detection limit across all Network sites. Concentrations measured for platinum remain the lowest, by an order of magnitude, of any of the metals monitored across the Network.

Vanadium: Concentrations decreased in 2007, and remain generally low across the Network. They have decreased by 90% over the last 25 years.

Zinc: Concentrations showed a large decrease in 2007. Trends, and average recorded concentrations, for this element across the Network are influenced substantially by the high measured concentrations at Site 69 (Brookside Metals). This notwithstanding levels have halved over the last 25 years.

Lead: Concentrations decreased in 2007 and remain low across the Network. Over the last 25 years levels have decreased by an order of magnitude.

Concentration trends over the last 27 years for the metals relevant to the First and Fourth DDs are summarised in the graph below:

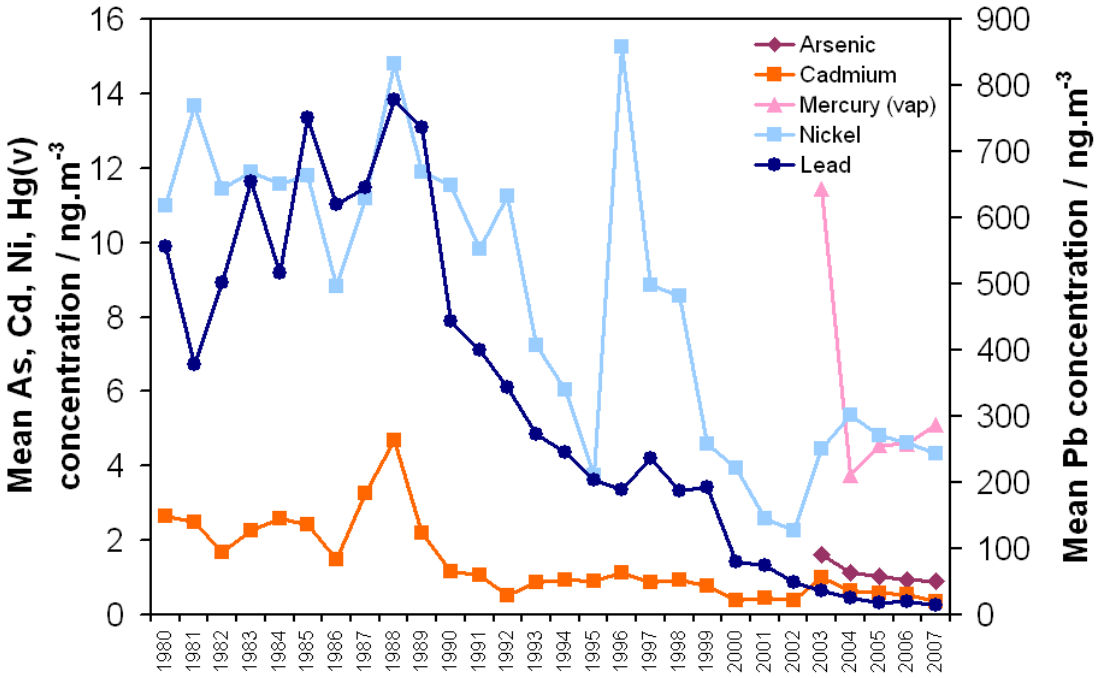


Figure 10. The annual mean concentration of Pb, As, Cd, Ni, and Hg(v) measured on the UK Heavy Metals Monitoring Network over the last 27 years.

8 Policy Update

A brief description of the progress of activities relevant to this Network is given below.

CEN TC264 WG25 – Mercury
WG25 met in Brussels in April 2007; Madrid in October 2007; and in Bled in January 2008.

The field trials undertaken by the group are now complete. These consisted of measurement campaigns at four locations for total gaseous mercury, and two locations for mercury deposition. The statistical evaluation of these field trials has now been completed by NPL, and a report detailing the findings of this work has been delivered to CEN[8]. This report has directed informed the sections on performance criteria and measurement uncertainty in the two draft standards, which have been produced by WG25, with substantial additional input from NPL.

The two draft standards, one detailing total gaseous mercury measurement, and the other detailing mercury deposition measurement, were sent for TC Enquiry at the end of January. The WG will next meet at NPL in April 2008, to discuss the outcome of the TC Enquiry stage.

CEN TC264 WG20 – Deposition of Heavy Metals
WG20 met in Oslo in June 2007 and in London in November 2007.

The field trials have now been completed and the WG has produced a draft standard. NPL's model for determining the uncertainty of the field trial data, and of individual measurements was used as a basis for the performance criteria and measurement uncertainty sections of the draft standard.

The WG will next meet in Helsinki in March 2008 to finalise the draft standard before submission for the CEN Enquiry stage.

BSI EH/002/03 – Ambient Atmospheres
BSI shadow committee EH/002/03 met at NPL in March and November 2007. NPL has provided the secretariat, resourcing and meeting location for the group since 2004, following BSI's withdrawal of secretarial support. A variety of matters were discussed relating to ambient and indoor air standards being developed by CEN and ISO.

The next meeting of EH/002/03 will be at NPL in March 2008.

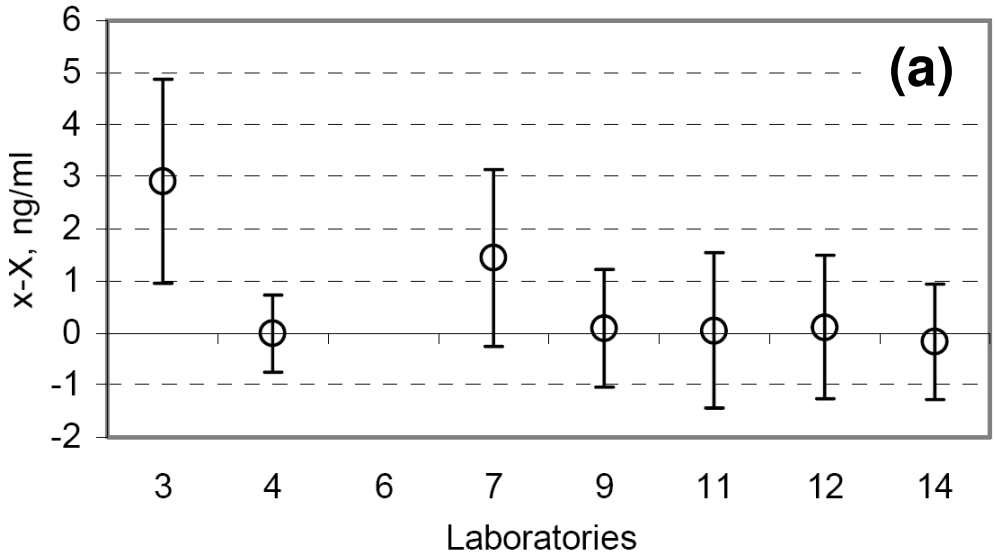
JRC-Ispra Heavy Metals Intercomparison
In the second quarter of 2007, NPL participated in a JRC-Ispra led intercomparison of the metals content of PM_{10}. NPL also supplied JRC-Ispra

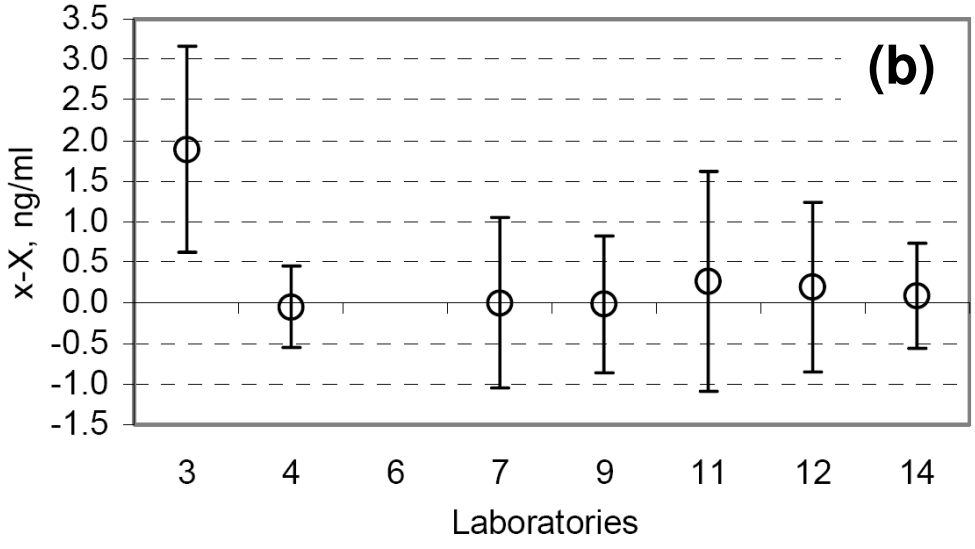
[8] NPL Report AS (RES) 010, "Final report on the statistical evaluation of the CEN TC264 WG25 total gaseous mercury and mercury deposition field trials", Brown, R J C, NPL, January 2008.

with the filters for the intercomparison. The objectives of this exercise were to:

- To assess whether the data quality objectives of the European Directives 1999/30/EC and 2004/107/EC relating to lead, arsenic, cadmium and nickel are met.
- To evaluate the repeatability and reproducibility of the methods of measurements.
- To investigate what the main sources of uncertainty and analytical deviations are, e.g. calibration, digestion, analysis and matrix effect.

The results of the intercomparison have recently been released. For samples where the participating National Air Quality Reference Laboratories can be directly compared, NPL's performance (as measured by the average deviation from the certified value) was in the top 2 of the 16 laboratories. NPL's uncertainties were on average the lowest quoted by any of the laboratories. Results from the comparison for the measurement of As, Cd, Ni and Pb in a liquid certified reference material are shown below in Figure 11, where NPL is laboratory 14.





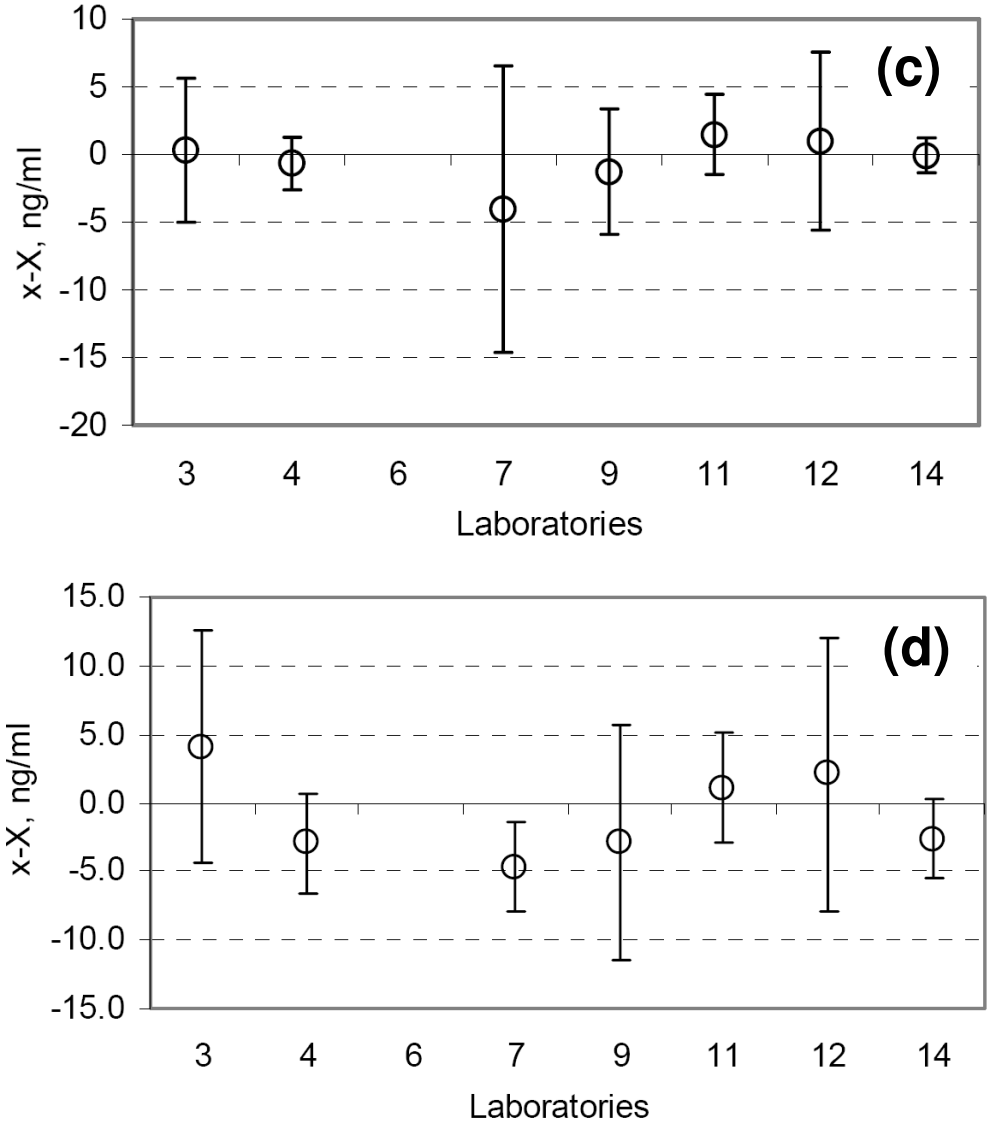


Figure 11. Deviations from the reference value for the measurement of (a) As, (b) Cd, (c) Ni, and (d) Pb in a liquid certified reference material, by National Air Quality Reference Laboratories in the JRC intercomparison. NPL is laboratory number 14. The error bars represent the expanded measurement uncertainty at the 95% confidence interval.

NPL participated in a workshop in December, in Ispra, to discuss the results of the intercomparison, whether the objectives of the Fourth Daughter Directive had been met, and whether any future QA/QC improvements need to be made.

Certified Reference Materials (CRMs) for Heavy Metals and PAHs

In the second quarter of 2007, NPL took part in the materials evaluation stage of the JRC-IRMM led project to develop a European reference material for metals and PAHs in PM_{10}. NPL provided analyses for four candidate reference materials supplied by JRC-IRMM for their content of a variety of metals. From the results received from all the European air quality reference

laboratories participating IRMM will choose a preferred material to form the basis of the reference material and move towards the certification stage, which NPL have also offered to participate in.

9 Science profile of the Network

NPL has produced four articles during 2007 that feature the data, analytical procedures and operation of the Network. These articles are detailed below:

- A peer-review article discussing the concentrations and trends over twenty-five years of ambient metals monitoring in the UK from 1980-2005. The paper also provides information on the current composition and operation of the Network. The full reference is: R. J. C. Brown, R. E. Yardley, D. Muhunthan, D. M. Butterfield, M. Williams, P. T. Woods, A. S. Brown, S. L. Goddard, "Twenty-five years of nationwide ambient metals measurement in the United Kingdom: concentration levels and trends", Environmental Monitoring and Assessment, 2008, 10.1007/s10661-007-9914-9.

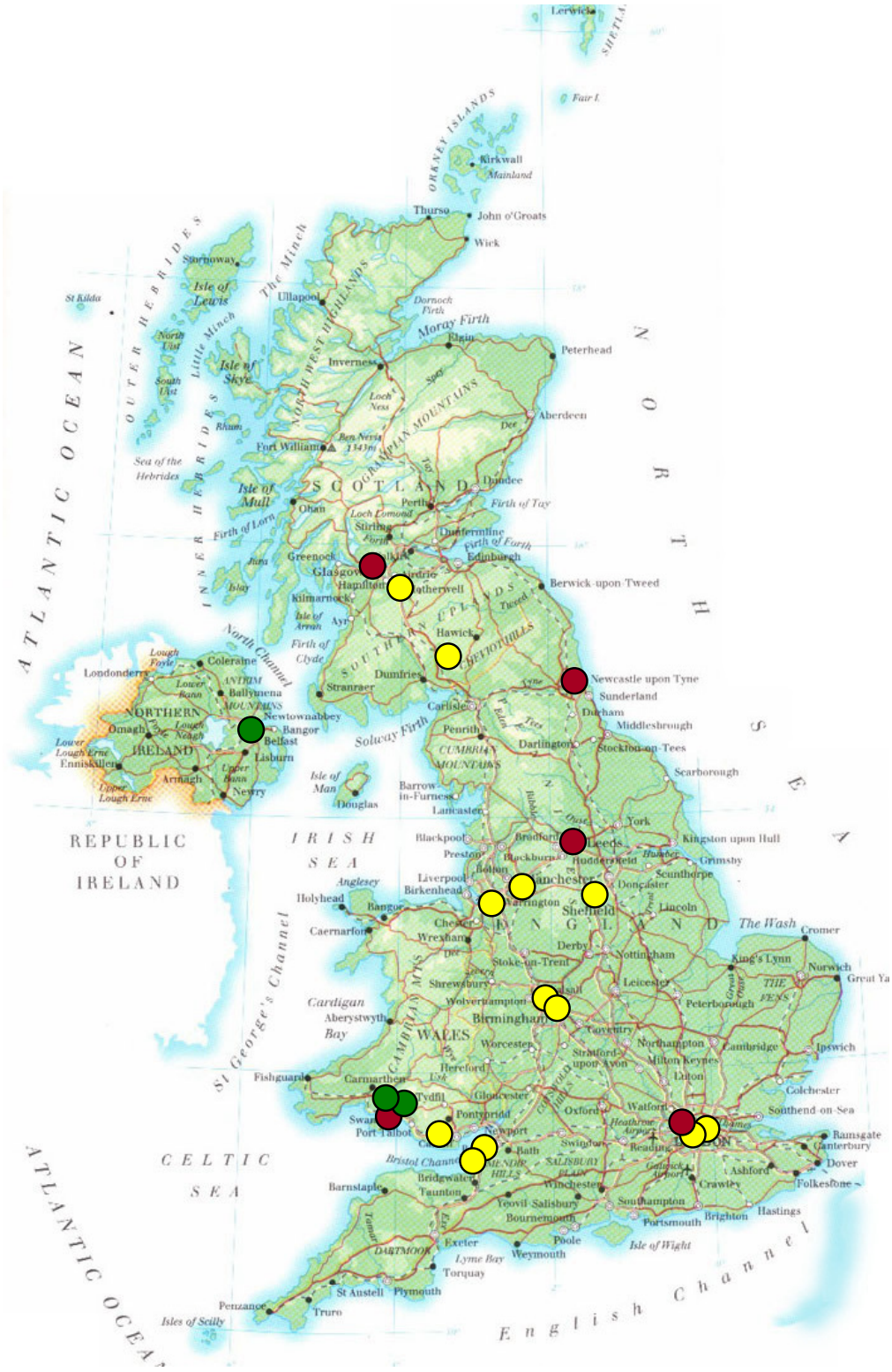
- A peer review article describing novel techniques used to screen analytical data for outliers and transcription errors during validation and ratification using exemplar data from the Network. The full reference is: R. J. C. Brown, "The use of Zipf's law in the screening of analytical data: a step beyond Benford", *Analyst*, 2007, 132, 344-349.

- A peer review article detailing the assessment and calculation of uncertainty contributions to mercury vapour measurements. The draft WG25 standard on total gaseous mercury measurement will reference this article as a recommended source for guidance for individuals following the standard and wishing to assess their own uncertainty. The full reference is: R. J. C. Brown, A. S. Brown, R. E. Yardley, W. T. Corns, P. B. Stockwell, "A practical uncertainty budget for ambient mercury vapour measurement". Atmospheric Environment, 2008, DOI 10.1016/j.atmosenv.2007.12.012.

- An article in Air, Water and Environmental Magazine highlighting the work of the Network in measuring the exposure of the general population to a variety of toxic compounds, informing policy development, and assessing compliance with legislative target values. The full reference is: R. J. C. Brown, "Heavy Metals Monitoring", Air, Water and Environment, No. 12, December 2007-January 2008, 21-25.

The first article detailing the trends in metals concentration levels over twenty-five years of monitoring generated much media interest, and resulted in a lot of positive exposure for the Network, its objectives, and operation. NPL gave interviews to 12 radio stations including BBC Radio Wales; Manx Radio, Isle of Man; BBC Radio Scotland and BBC Three Counties Radio. These interviews reached over 700,000 listeners in total. The story was also picked up by local press including: Yorkshire Evening Post; Birmingham Post; Express & Star; Shropshire Star; The Press & Journal (Aberdeen Edition) and online by a multitude of air quality and science websites (which can easily found by performing a 'Google' search for 'NPL Heavy Metals 25'). The article also been covered as a lead story in the January 2008 edition of 'Air Quality Management'.

Annex 1 - Location and details of sites on the UK Heavy Metals Network



This map shows the composition of the Network in 2007. The site key is as follows: yellow – sites unchanged during 2007; green – new sites opened or assimilated during 2007; red – sites closed or devolved during 2007. (Section 2.5 of this report describes in detail the changes that have occurred during 2007 as a result of Network re-organisation.)

Site Code: Site Name (Abbreviated Site Name)	Site Address	Site Classification	Pollutants measured
46: IMI Refiners Ltd, Walsall (IMI Walsall)	74 Primley Avenue, Walsall, WS2 9UW	Industrial Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
47: BZL Ltd, Avonmouth (BZL Avonmouth)	Avonmouth Medical Centre, Collins Street, Bristol, BS11 9JJ	Industrial Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
49: INCO Europe, Swansea (Swansea) – devolved Jan 2008	*Glais Primary School, School Road, Glais, Swansea, SA7 9EY*	*Industrial Background*	*As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn*
56: BZL Ltd, Avonmouth, Hallen Village (BZL Hallen)	West Country Caravans Ltd., Moorhouse Lane, Hallen, Bristol, BS10 7RU	Industrial Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
58: Avesta Steel, Sheffield (Sheffield)	BOC Gases, Bawtry Road, Brinsworth, Sheffield, S60 5NT	Industrial Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
59: ICI Weston Point, Runcorn (Weston Point)	Weston Point County Primary School, Caster Avenue, Weston Point, Runcorn, WA7 4EQ	Industrial Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
60: London Brent, North Circular (London Brent) – closed Sept 2007	*Tesco Superstore, North Circular Road, Brent, London, NW10 0TL*	*Roadside*	*As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)*
61: London, Cromwell Road (London Cromwell (Rd))	Natural History Museum, Cromwell Road, London, SW7 5BD	Roadside	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
62: London, Horseferry Road (London Horseferry (Rd))	Mortuary Car Park, Horseferry Road, London, SW1P 2EB	Urban Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
63: Leeds, Old Market Buildings (Leeds) – closed Sept 2007	*Old Market Buildings, Vicar Lane, Leeds, LS1*	*Urban Background*	*As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)*
64: Glasgow, St Annes Primary School (Glasgow) – closed Sept 2007	*St Annes Primary School, 37 David Street, Glasgow, G40 2UN*	*Urban Background*	*As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)*
65: Eskdalemuir, Met Office (Eskdalemuir)	Met Office, Eskdalemuir, Langholm, Dumfrieshire, DG13 0QW	Rural	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
66: Motherwell, Civic Centre (Motherwell)	Civic Centre, Motherwell, Lanarkshire ML1 1TW	Urban Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
67: Manchester M56, Junction 4 (Manchester)	Junction 4, M56, Newhall Green, Wythenshaw, Manchester	Roadside	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
68: Cardiff, Waungron Road (Cardiff)	Cleansing Depot, Waungron, Fairwater, Cardiff, CF5 2JJ	Roadside	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
69: Brookside Metals, Bilston Lane, Walsall (Brookside Metals)	Adult Training Centre, Bilston Lane, Shepwell Green, Willenhall, Walsall, WV13 2QJ	Industrial Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)
70: Elswick 6, Newcastle Upon Tyne (Newcastle) – closed Sept 2007	*Metro Radio Arena, Arena Way, Newcastle Upon Tyne, NE4 7NA*	*Industrial Background*	*As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn, Hg(v)*

Site Code: Site Name (Abbreviated Site Name)	Site Address	Site Classification	Pollutants measured
100: Coedgwilym Cemetery (Swansea) – assimilated Dec 2007	Coedgwilym Cemetery, Pontardawe Road, Clydach, Swansea, SA6 5PB	Industrial Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
101: Morriston Groundhog (Swansea) – assimilated Dec 2007	Morriston Groundhog, Wychtree Street, Morriston, Swansea, SA6 8EX	Industrial Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
103: Belfast Centre (Belfast) – opened Dec 2007	Lombard Street, Belfast, BT1 1RB	Urban Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
104: Port Talbot – opened Jan 2008	Port Talbot Fire Station, Commercial Road, Port Talbot, West Glamorgan, SA13 1LG	Industrial Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn
105: Sheffield Centre (Sheffield) – opened Jan 2008	Charter Square, Sheffield, S1	Industrial Background	As, Cd, Cr, Cu, Fe, Hg(p), Mn, Ni, Pb, Pt, V, Zn

Annex 2 - Site Audit reports

The following table details the dates of the audits, what equipment and which LSOs were audited.

Site	Date	Partisol 2000 Serial Numbers	Mercury Vapour Serial Numbers	LSO audited
Brookside Metals, Walsall	09/05/07	2000A204649811	NPL 12	Mel Weaver
BZL Avonmouth	23/05/07	2000A205009902	N/A	Steve Carter
BZL Hallen	23/05/07	2000A205049902	N/A	Steve Carter
Cardiff	22/05/07	2000A204919902	NPL 03	Phil Jones
Eskdalemuir	26/06/07	2000A204909902	NPL 07	--
Glasgow	27/06/07	2000A204899902	NPL 08	Dominic Callahan
ICI Weston Point	24/04/07	2000A205079902	NPL 01	John Carrington
IMI Walsall	09/05/07	2000A204989902	NPL 11	Mel Weaver
Leeds	08/10/07	2000A204739901	NPL 13	--
London Brent	11/07/07	2000A204999902	NPL Prototype	Dharsheni Muhunthan
London Cromwell Road	14/08/07	2000A205059902	NPL 09	Colin Gilham
London Horseferry Road	14/08/07	2000A204969902	NPL 10	Colin Gilham
Manchester	24/04/07	2000A204959902	NPL 05	Mike Concannon
Motherwell	26/06/07	2000A204979902	NPL 06	Pat Docherty
Newcastle	25/06/07	2000A205069902	NPL 02	--
Sheffield	08/10/07	2000A204719901	N/A	Andy Hawkins
Swansea	22/05/07	2000A205089902	N/A	Tom Price

- The Newcastle LSO was not available as the site was audited outside normal working hours.
- The Eskdalemuir and Leeds LSOs were not available at the time of audit due to other work commitments.

Annex 3 - Results of Partisol 2000 Particulate Metal Samplers Flow Audits

The sample flow for each sampler was measured using a BIOS Flow Calibrator, which was previously calibrated at NPL against weight loss from a cylinder, thus giving direct traceability to national standards. The reported flow rate is measured and reported at ambient conditions. A leak test was also performed on each sampler. The following table details the results of the Partisol 2000 audits.

Site	Measured flow / litres per minute (set point 16.67)	Difference from set point, %	Leak Test
Brookside Metals, Walsall	17.40	4.2	Passed
BZL Avonmouth	17.31	3.6	Passed
BZL Hallen	16.78	0.5	Passed
Cardiff	17.55	5.1	Passed
Eskdalemuir	17.37	4.6	Passed
Glasgow	17.38	4.1	Passed
ICI Weston Point	17.09	2.9	Passed
IMI Refiners Ltd, Walsall	17.27	3.4	Passed
Leeds	17.21	3.0	Passed
London Brent	17.25	3.3	Passed
London Cromwell Road	17.32	3.7	Passed
London Horseferry Road	17.23	3.2	Passed
Manchester	17.21	3.7	Passed
Motherwell	17.33	3.8	Passed
Newcastle	17.56	5.8	Passed
Sheffield	17.45	4.5	Passed
Swansea	17.75	6.3	Passed

The expanded uncertainty (k=2) in the flow measurements is 5.8% expressed at the 95% confidence interval. The average difference between the measured flows and the set point is 3.9%. This is within the uncertainty of the measurement. The difference from set point determined from the audits of the Partisol 2000s is used at ratification to adjust the volume recorded by the Partisol for each sample. If the difference from set point is greater than 10% then remedial action would be taken, for example calling out the Equipment Support Unit (ESU).

Annex 4 - Results of Total Gaseous Mercury Pump Flow Audits

The sample flow for each sampler was measured using a BIOS Flow Calibrator, which was previously calibrated at NPL against weight loss from a cylinder, thus giving direct traceability to national standards. The reported flow rate is measured and reported at ambient conditions. A leak test was also performed on each sampler. The following table details the results of the total gaseous mercury pump flow audits.

Site	Set point / ml per minute	Measured flow / ml per minute	Difference from set point / %	Leak Test
Brookside Metals, Walsall	99	100.0	1.4	Passed
Cardiff	100	109.8	9.8	Passed
Eskdalemuir	110	128.3	16.6	Passed
Glasgow	120	128.2	6.8	Passed
ICI Weston Point	100	104.7	4.7	Passed
IMI Refiners Ltd, Walsall	100	100.5	0.8	Passed
Leeds	100	123.0	23.0	Passed
London Brent	100	106.8	6.8	Passed
London Cromwell Road	95	102.3	7.7	Passed
London Horseferry Road	100	99.0	-1.0	Passed
Manchester	100	146.5	46.5	Passed
Motherwell	140	152.7	9.1	Passed
Newcastle	100	145.3	45.3	Passed

The expanded uncertainty (k=2) in the flow measurements is 5.8% expressed at the 95% confidence interval.

The average difference between the measured flows and the set point was 13.5%. This large difference is dominated by the Manchester, Newcastle and Leeds results. If these results are discounted then the average difference falls to 6.5%. Mercury sampling ceased at the Leeds and Newcastle sites on 1st September 2007, and the flow meter at Manchester has since been replaced.

The difference from set point determined from the audits of the mercury vapour samplers is used at ratification to adjust the volume recorded by the LSO for each sample. There is no threshold for remedial action on the mercury vapour samplers as the flow is adjusted by the LSO on a weekly basis and the flow can drift by more than 10% in one week.

Annex 5 – Average monthly measured metals concentrations at all Network sites

		Concentration ng.m^{-3}											
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
IMI Refiners, Walsall 46	Jan	0.70	0.46	3.02	15.3	223	7.68	0.66	16.3	0.00	0.57	62.9	0.09	1.74
	Feb	1.57	0.72	3.54	19.3	354	10.57	0.66	27.8	0.00	1.48	85.0	0.04	1.28
	Mar	1.45	0.75	4.15	18.3	439	11.44	1.55	24.4	0.00	3.01	87.1	0.61	1.38
	Apr	1.28	0.39	3.44	12.0	326	6.86	2.11	16.1	0.00	2.92	46.1	2.46	1.83
	May	0.74	0.81	10.90	20.2	384	9.61	7.93	22.5	0.00	1.35	231.0	0.41	1.72
	Jun	2.02	0.36	12.00	12.8	318	8.86	6.78	14.0	0.00	1.90	59.6	0.54	1.16
	Jul	0.56	0.85	6.75	16.5	275	8.76	2.84	22.5	0.00	1.43	88.5	0.10	1.40
	Aug	0.52	0.99	2.13	16.4	263	8.76	0.68	25.9	0.00	1.41	78.7	0.05	5.15
	Sep	0.56	0.49	2.33	10.2	204	5.39	0.30	14.2	0.00	0.88	40.0	0.22	4.12
	Oct	1.62	0.83	3.51	28.9	586	16.69	0.39	31.1	0.00	1.58	107.8	0.34	5.24
	Nov	2.27	1.13	2.20	21.4	305	8.93	1.29	39.8	0.00	1.19	77.6	0.03	4.39
	Dec	0.89	0.91	2.62	14.7	290	7.45	0.40	18.2	0.00	1.22	66.0	0.04	2.42
	Annual average	**1.18**	**0.72**	**4.71**	**17.2**	**330**	**9.25**	**2.13**	**22.7**	**0.00**	**1.58**	**85.9**	**0.41**	**2.65**

		Concentration ng.m^{-3}											
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
BZL Ltd., Avonmouth 47	Jan	1.03	0.30	1.76	8.1	435	11.01	6.81	22.1	0.00	13.24	71.4	0.23	N/A
	Feb	1.90	0.39	2.40	6.5	229	5.04	2.98	15.4	0.00	4.52	28.3	0.16	N/A
	Mar	0.48	0.16	1.84	3.7	320	7.73	5.59	11.4	0.00	6.59	36.5	0.09	N/A
	Apr	1.16	0.81	1.76	8.8	394	10.25	4.93	24.6	0.00	4.77	69.3	0.65	N/A
	May	1.53	0.18	3.72	9.7	724	11.73	1.19	56.6	0.00	4.42	78.4	0.47	N/A
	Jun	0.52	0.51	15.03	4.2	236	5.72	4.42	10.4	0.00	3.59	35.4	0.70	N/A
	Jul	0.28	0.13	1.84	2.1	202	5.16	3.59	5.7	0.00	2.71	13.2	0.29	N/A
	Aug	0.17	0.16	2.00	2.6	187	4.03	0.60	9.6	0.00	2.43	18.9	0.15	N/A
	Sep	0.75	0.37	1.80	5.4	356	9.19	12.55	16.2	0.00	3.74	33.1	0.20	N/A
	Oct	0.85	0.37	1.04	7.6	232	5.45	1.13	12.8	0.00	1.58	27.6	0.82	N/A
	Nov	0.99	0.25	0.14	7.9	252	5.38	1.12	12.5	0.00	1.88	25.3	0.10	N/A
	Dec	1.83	0.46	0.01	9.9	223	5.84	2.01	15.1	0.00	4.76	25.5	0.01	N/A
	Annual average	**0.96**	**0.34**	**2.78**	**6.4**	**316**	**7.21**	**3.91**	**17.7**	**0.00**	**4.52**	**38.6**	**0.32**	**N/A**

		Concentration ng.m^{-3}											
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
Swansea 49	Jan	0.75	0.14	3.68	3.7	72	1.27	29.39	4.8	0.00	0.18	4.8	0.23	N/A
	Feb	0.81	0.17	2.94	3.9	151	3.19	27.01	10.0	0.00	0.83	20.3	0.03	N/A
	Mar	1.07	0.25	3.19	3.6	271	5.46	20.72	8.4	0.00	1.64	15.4	0.52	N/A
	Apr	1.32	0.30	4.64	6.7	397	10.39	16.47	14.2	0.00	3.35	41.0	0.48	N/A
	May	2.37	0.99	7.18	10.1	283	5.39	21.33	27.5	0.00	1.66	15.2	0.50	N/A
	Jun	0.52	0.10	4.82	3.5	83	2.69	50.21	3.7	0.00	2.04	17.5	0.31	N/A
	Jul	0.44	0.07	3.07	3.3	96	2.42	46.97	2.7	0.00	1.61	12.9	0.09	N/A
	Aug	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Sep	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Oct	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Nov	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Dec	0.78	0.19	1.95	5.2	152	4.56	12.25	12.3	0.00	1.79	19.5	0.03	N/A
	Annual average	**1.01**	**0.28**	**3.94**	**5.0**	**188**	**4.42**	**28.04**	**10.5**	**0.00**	**1.64**	**18.3**	**0.27**	**N/A**

* site operation was suspended during August to November 2007 owing to building works

		Concentration ng.m^{-3}											
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
BZL Ltd., Hallen Village 56	Jan	0.92	0.21	1.48	4.4	178	4.70	0.94	11.0	0.00	2.27	36.3	0.15	N/A
	Feb	1.71	0.30	3.27	6.3	208	5.43	1.34	13.0	0.00	2.68	23.9	0.13	N/A
	Mar	0.72	0.30	1.07	4.8	183	4.97	1.08	11.5	0.00	2.54	31.5	0.38	N/A
	Apr	1.34	0.39	3.73	12.5	440	8.41	1.53	14.0	0.00	7.02	33.3	3.05	N/A
	May	0.95	0.42	11.63	17.0	514	8.08	7.73	9.2	0.00	12.63	32.5	0.55	N/A
	Jun	0.39	0.09	3.95	2.7	63	1.38	0.46	2.3	0.00	3.51	9.4	0.05	N/A
	Jul	0.45	0.43	0.01	3.3	135	3.44	0.07	10.2	0.00	1.34	15.0	0.04	N/A
	Aug	0.39	0.41	0.88	3.5	122	2.96	0.32	8.1	0.00	1.41	13.2	0.09	N/A
	Sep	0.62	0.48	0.10	4.9	172	4.59	5.32	11.5	0.00	1.06	21.4	0.10	N/A
	Oct	1.42	0.36	0.03	8.8	171	3.65	0.29	12.4	0.00	1.30	19.1	0.47	N/A
	Nov	0.89	0.27	0.01	7.6	203	4.11	0.05	9.7	0.00	0.92	16.9	0.08	N/A
	Dec	1.19	0.29	0.16	6.6	193	4.93	1.84	10.4	0.00	2.89	22.6	0.05	N/A
	Annual average	**0.92**	**0.33**	**2.19**	**6.9**	**215**	**4.72**	**1.75**	**10.3**	**0.00**	**3.30**	**22.9**	**0.43**	**N/A**

		Concentration ng.m^{-3}												
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
Sheffield														
58	Jan	0.69	0.32	31.88	10.7	389	31.62	12.75	21.8	0.00	2.17	85.7	0.11	N/A
	Feb	1.76	0.55	27.50	19.4	587	32.83	11.74	36.3	0.00	3.15	85.9	0.34	N/A
	Mar	1.27	0.42	27.30	12.6	497	37.63	13.32	30.9	0.00	3.12	97.4	0.43	N/A
	Apr	1.57	0.58	43.88	16.1	618	39.93	18.21	42.1	0.00	3.37	89.5	1.38	N/A
	May	2.44	0.80	36.74	15.4	387	24.44	21.65	21.9	0.00	7.46	205.6	0.91	N/A
	Jun	1.72	0.19	11.03	21.7	385	7.36	5.25	10.2	0.00	2.47	31.0	0.89	N/A
	Jul	1.06	0.21	19.61	23.0	519	16.82	10.33	14.4	0.00	2.17	58.0	0.10	N/A
	Aug	0.54	0.16	9.02	11.5	361	16.57	4.53	15.6	0.00	1.19	29.7	0.21	N/A
	Sep	0.67	0.24	28.95	11.3	401	28.85	9.59	15.5	0.00	0.94	46.8	0.01	N/A
	Oct	1.61	0.58	20.11	25.6	567	31.64	10.47	28.2	0.00	1.85	81.1	0.11	N/A
	Nov	1.45	1.16	17.97	21.6	363	21.82	8.78	60.5	0.00	1.72	68.3	0.07	N/A
	Dec	1.09	0.33	25.46	13.0	366	25.14	7.42	18.5	0.00	2.44	66.5	0.09	N/A
	Annual average	**1.32**	**0.46**	**24.96**	**16.8**	**453**	**26.22**	**11.17**	**26.3**	**0.00**	**2.67**	**78.8**	**0.39**	**N/A**

		Concentration ng.m^{-3}												
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
Weston Point, Runcorn														
59	Jan	0.54	0.11	0.87	3.4	108	2.22	0.08	8.5	0.00	1.88	8.0	3.44	48.26
	Feb	1.28	0.25	3.02	7.4	167	3.42	1.47	12.8	0.00	2.10	20.7	1.50	19.10
	Mar	0.48	0.08	0.86	4.3	107	2.31	0.86	15.8	0.00	1.61	14.5	3.16	48.47
	Apr	1.50	0.53	3.57	8.6	320	10.16	11.58	16.7	0.00	3.28	47.6	1.55	12.17
	May	0.39	0.10	7.58	4.5	162	3.74	3.45	5.6	0.00	1.97	13.8	1.85	42.28
	Jun	0.89	0.19	16.66	5.6	273	5.40	7.86	12.4	0.00	2.31	20.4	0.76	53.02
	Jul	0.56	0.06	1.22	3.2	77	1.76	0.10	2.8	0.00	0.90	6.8	1.67	71.09
	Aug	0.32	0.07	0.01	3.2	91	2.56	0.20	2.9	0.00	0.99	4.9	1.13	59.36
	Sep	0.37	0.16	0.21	5.9	151	3.30	0.08	6.6	0.00	1.94	7.8	1.15	37.96
	Oct	1.11	0.25	1.02	9.2	199	4.85	0.96	12.7	0.00	1.58	18.2	0.72	23.08
	Nov	1.69	0.55	0.41	10.6	120	2.83	0.12	28.9	0.00	1.07	31.6	1.45	37.09
	Dec	0.65	0.08	0.08	4.2	85	1.73	0.38	7.6	0.00	1.15	7.3	3.17	45.64
	Annual average	**0.81**	**0.20**	**2.96**	**5.8**	**155**	**3.69**	**2.26**	**11.1**	**0.00**	**1.73**	**16.8**	**1.80**	**41.46**

		Concentration ng.m^{-3}												
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
London Brent														
60	Jan	0.85	0.25	1.89	13.5	362	4.15	0.10	8.0	0.00	1.15	13.9	0.10	2.15
	Feb	1.52	0.30	4.72	31.1	926	10.45	2.08	17.8	0.00	2.81	28.9	0.79	1.98
	Mar	1.11	0.28	3.73	20.8	705	8.70	3.35	10.3	0.00	2.45	23.1	0.12	1.50
	Apr	1.49	0.28	4.46	18.4	558	10.22	1.57	11.7	0.00	3.62	51.2	1.14	1.87
	May	0.71	0.11	3.58	20.3	539	6.64	1.62	7.2	0.00	2.48	43.0	0.01	1.61
	Jun	0.86	0.31	6.18	26.0	673	14.84	3.76	35.7	0.00	4.07	57.0	0.12	1.66
	Jul	0.28	0.10	2.22	14.2	366	4.15	11.39	4.5	0.00	2.38	12.0	0.01	3.10
	Aug	0.53	0.11	2.04	20.4	509	6.20	1.23	8.2	0.00	2.16	11.5	0.24	1.03
	Sep	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Oct	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Nov	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Dec	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Annual average	**0.92**	**0.22**	**3.60**	**20.6**	**580**	**8.17**	**3.14**	**12.9**	**0.00**	**2.64**	**30.1**	**0.32**	**1.86**

* site closed in September 2007

		Concentration ng.m^{-3}												
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
London Cromwell														
61	Jan	0.85	0.14	5.25	41.2	896	8.17	0.16	10.1	0.00	1.18	24.7	0.05	2.12
	Feb	1.14	0.27	6.25	49.2	1103	11.30	2.28	16.9	0.00	3.08	35.0	0.11	7.81
	Mar	1.13	0.27	5.98	42.9	1039	11.57	5.30	10.5	0.00	2.98	26.7	0.03	1.76
	Apr	1.33	0.27	3.10	40.9	841	12.56	2.86	14.0	0.00	5.33	41.7	0.86	1.59
	May	0.61	0.11	4.59	36.8	692	9.05	5.91	7.4	0.00	2.10	34.9	0.26	4.48
	Jun	0.75	0.16	7.18	33.4	684	8.00	3.29	6.4	0.00	3.68	40.3	0.29	1.96
	Jul	0.48	0.09	4.01	42.5	861	8.23	5.92	7.4	0.00	2.95	16.3	0.01	2.53
	Aug	0.42	0.11	2.86	35.4	703	8.55	1.09	9.7	0.00	2.16	16.3	0.23	0.50
	Sep	0.79	0.13	3.90	40.8	838	10.04	0.87	10.8	0.00	2.33	22.3	0.25	1.53
	Oct	1.11	0.26	4.09	42.4	806	9.36	1.46	12.9	0.00	2.48	25.7	0.18	2.07
	Nov	1.00	0.16	2.09	43.7	836	8.59	0.03	12.8	0.00	0.68	20.2	0.06	4.03
	Dec	1.77	0.41	2.69	37.0	784	9.45	3.05	14.9	0.01	5.92	35.3	0.05	0.73
	Annual average	**0.95**	**0.20**	**4.33**	**40.5**	**840**	**9.57**	**2.68**	**11.1**	**0.00**	**2.91**	**28.3**	**0.20**	**2.59**

		Concentration ng.m^{-3}												
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
London Horseferry														
62	Jan	1.02	0.10	2.28	11.5	300	3.58	3.52	9.1	0.00	1.15	13.4	0.09	2.07
	Feb	1.08	0.27	3.18	21.5	512	6.92	1.26	14.2	0.00	2.76	27.0	0.07	1.81
	Mar	0.80	0.12	1.81	15.7	373	4.75	1.19	8.3	0.00	2.60	17.3	0.06	1.22
	Apr	1.06	0.23	1.87	21.9	490	9.61	1.72	15.7	0.00	5.02	34.4	1.00	1.54
	May	1.03	0.15	1.92	19.3	474	7.69	8.44	11.1	0.00	2.89	27.7	0.48	1.95
	Jun	0.73	0.24	3.83	15.0	441	6.54	1.91	7.4	0.00	4.30	31.7	0.28	3.56
	Jul	0.49	0.05	0.29	12.4	322	4.33	0.47	4.9	0.00	1.98	8.8	0.17	1.85
	Aug	0.76	0.10	1.33	19.2	455	6.10	1.60	7.2	0.00	2.15	15.2	0.16	2.68
	Sep	0.67	0.09	2.01	18.8	441	6.50	0.49	7.8	0.00	1.81	15.7	0.22	1.56
	Oct	0.90	0.28	2.45	31.7	670	9.54	1.44	13.8	0.00	2.80	31.4	0.25	3.93
	Nov	0.63	0.13	1.14	18.6	373	4.60	0.10	9.3	0.00	0.85	14.8	0.03	1.93
	Dec	1.73	0.62	1.65	28.4	635	9.71	3.46	20.6	0.00	6.17	56.6	0.08	1.69
	Annual average	**0.91**	**0.20**	**1.98**	**19.5**	**457**	**6.66**	**2.13**	**10.8**	**0.00**	**2.87**	**24.5**	**0.24**	**2.15**

		Concentration ng.m^{-3}												
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
Leeds														
63	Jan	0.50	0.09	1.58	6.3	156	3.47	0.15	8.1	0.00	0.19	11.9	0.06	1.62
	Feb	1.42	0.27	6.12	15.9	454	14.63	3.23	25.3	0.00	1.71	36.8	0.43	2.62
	Mar	1.14	0.32	3.66	8.2	296	6.84	1.09	14.6	0.00	2.93	27.1	0.60	0.09
	Apr	2.17	0.45	11.55	20.6	681	17.22	7.47	32.3	0.00	2.88	45.0	1.69	0.91
	May	0.58	0.13	7.69	13.2	393	6.09	1.75	9.0	0.00	1.43	19.1	0.46	N/A
	Jun	0.94	0.31	10.81	14.9	555	11.68	4.26	13.2	0.00	4.61	37.8	0.14	1.29
	Jul	0.77	0.15	2.10	8.0	220	5.10	1.11	8.9	0.00	0.72	17.5	0.03	1.55
	Aug	0.83	0.14	1.50	7.6	207	4.90	1.16	9.0	0.00	0.83	11.8	0.11	1.76
	Sep	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Oct	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Nov	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Dec	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Annual average	**1.04**	**0.23**	**5.63**	**11.8**	**370**	**8.74**	**2.53**	**15.0**	**0.00**	**1.91**	**25.9**	**0.44**	**1.41**

* site closed in September 2007

		Concentration ng.m^{-3}												
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
Glasgow														
64	Jan	0.21	0.06	7.36	14.2	164	2.85	4.44	6.1	0.00	0.38	14.7	0.04	1.87
	Feb	0.92	0.28	3.64	18.5	410	6.82	2.79	11.5	0.00	1.02	35.8	0.12	2.35
	Mar	0.66	0.31	1.85	10.5	226	4.01	0.42	11.7	0.00	1.20	28.8	1.12	1.82
	Apr	0.76	0.16	8.58	10.9	365	5.93	2.67	10.9	0.00	2.03	19.7	1.47	2.11
	May	0.30	0.05	21.29	7.5	292	4.54	10.48	4.3	0.00	1.25	13.3	0.36	3.03
	Jun	0.51	0.11	11.76	15.0	475	6.33	4.86	4.7	0.00	2.24	17.5	0.04	2.14
	Jul	0.22	0.19	0.08	9.6	236	3.47	0.01	5.3	0.00	0.91	15.1	0.13	2.37
	Aug	0.16	0.05	0.23	6.5	173	2.79	0.10	3.2	0.00	0.58	6.6	0.18	1.54
	Sep	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Oct	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Nov	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Dec	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Annual average	**0.47**	**0.15**	**6.85**	**11.6**	**292**	**4.59**	**3.22**	**7.2**	**0.00**	**1.20**	**18.9**	**0.43**	**2.15**

* site closed in September 2007

		Concentration ng.m^{-3}												
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
Eskdalemuir														
65	Jan	0.59	0.03	1.68	0.4	1	0.36	0.01	0.7	0.00	0.27	3.8	0.16	1.63
	Feb	0.20	0.03	0.05	0.6	1	0.40	0.01	1.6	0.00	0.47	2.5	0.04	1.22
	Mar	0.44	0.19	1.75	0.8	21	0.74	1.94	2.6	0.00	0.84	4.3	0.24	1.73
	Apr	0.28	0.05	0.16	1.8	62	1.48	0.31	2.2	0.00	1.54	7.0	0.65	0.04
	May	0.49	0.12	2.91	7.6	8	4.70	0.56	10.8	0.00	1.77	20.7	0.33	1.02
	Jun	0.93	0.18	6.91	17.5	54	5.90	7.63	13.1	0.00	9.99	25.2	0.07	1.53
	Jul	0.05	0.02	1.21	0.2	17	0.58	0.47	0.4	0.00	0.28	3.2	0.36	1.34
	Aug	0.01	0.01	0.10	0.6	78	0.83	0.01	0.4	0.00	0.48	0.8	0.08	1.93
	Sep	0.04	0.01	0.01	0.1	25	0.61	0.01	0.6	0.00	0.19	0.8	0.09	1.35
	Oct	0.38	0.06	1.13	1.1	31	0.82	0.27	2.3	0.00	0.59	4.5	0.23	1.41
	Nov	0.13	0.04	0.01	0.7	2	0.56	0.01	2.6	0.00	0.34	2.4	0.04	5.44
	Dec	0.13	0.06	0.02	1.2	16	0.98	0.10	2.9	0.00	0.90	3.7	0.02	1.59
	Annual average	**0.31**	**0.07**	**1.33**	**2.7**	**26**	**1.50**	**0.94**	**3.3**	**0.00**	**1.47**	**6.6**	**0.19**	**1.69**

		Concentration ng.m^{-3}												
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
Motherwell														
66	Jan	0.20	0.08	1.46	4.4	198	2.65	0.10	3.3	0.00	0.01	5.0	0.01	1.46
	Feb	0.61	0.15	1.65	9.6	283	5.69	0.07	7.7	0.00	0.73	12.6	0.01	1.66
	Mar	0.10	0.03	0.83	3.9	84	1.39	0.10	1.1	0.00	0.30	4.6	0.30	1.28
	Apr	0.65	0.13	5.07	8.6	332	6.85	1.07	6.2	0.00	1.98	29.1	3.00	2.04
	May	0.79	0.05	15.05	8.7	298	5.05	5.30	4.7	0.00	1.73	27.6	0.41	1.27
	Jun	1.00	0.10	7.82	10.5	465	10.39	3.06	11.0	0.00	7.90	26.8	0.74	1.07
	Jul	0.06	0.04	1.24	3.8	109	1.96	0.54	2.8	0.00	0.65	3.7	0.16	0.95
	Aug	0.24	0.02	2.53	3.3	159	2.66	0.10	1.3	0.00	0.10	3.5	0.07	1.88
	Sep	0.43	0.05	0.10	5.6	217	3.75	0.10	2.9	0.00	0.51	7.1	0.07	1.67
	Oct	0.38	0.09	0.01	6.3	140	2.68	0.28	3.5	0.00	0.77	6.4	0.05	8.38
	Nov	0.54	0.13	0.19	6.8	157	2.84	0.10	8.0	0.00	0.15	14.4	0.02	4.68
	Dec	0.84	0.22	0.10	4.8	109	1.96	0.01	7.8	0.00	0.97	9.8	0.03	1.71
	Annual average	**0.49**	**0.09**	**3.00**	**6.3**	**213**	**3.99**	**0.90**	**5.0**	**0.00**	**1.31**	**12.5**	**0.41**	**2.34**

		Concentration ng.m^{-3}												
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
Manchester														
67	Jan	0.49	0.10	4.24	28.4	637	6.26	0.55	5.8	0.00	0.54	20.6	0.24	3.26
	Feb	1.33	0.26	5.54	47.0	1014	10.84	0.78	14.6	0.00	1.54	37.4	0.11	1.77
	Mar	0.82	0.18	4.04	40.6	885	9.73	1.14	9.1	0.00	1.53	33.0	1.00	1.24
	Apr	1.43	0.38	5.27	46.3	1102	14.08	2.67	14.2	0.00	7.07	55.7	0.66	1.54
	May	0.68	0.12	9.61	35.7	821	8.98	2.99	6.1	0.00	4.17	41.8	0.88	2.66
	Jun	0.65	0.07	10.52	33.1	798	8.75	3.08	5.2	0.00	2.04	27.4	0.15	0.54
	Jul	0.46	0.07	9.08	27.2	646	6.89	8.58	4.6	0.00	0.93	17.1	0.01	2.04
	Aug	0.84	0.09	4.10	35.2	783	8.68	0.15	6.1	0.00	1.40	21.1	0.27	1.59
	Sep	0.68	0.09	4.36	34.5	743	8.68	1.29	4.8	0.00	0.71	22.6	0.13	0.15
	Oct	0.65	0.18	4.27	38.9	806	9.28	1.18	5.4	0.00	0.69	24.6	0.25	1.52
	Nov	2.18	0.56	3.36	51.9	935	11.24	0.89	30.6	0.00	0.99	40.9	0.02	2.18
	Dec	1.01	0.27	2.42	41.5	898	10.24	1.38	11.5	0.01	2.58	34.3	0.04	3.32
	Annual average	**0.93**	**0.20**	**5.57**	**38.4**	**839**	**9.47**	**2.06**	**9.8**	**0.00**	**2.02**	**31.4**	**0.31**	**1.82**

		Concentration ng.m^{-3}												
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
Cardiff														
68	Jan	0.69	0.31	2.69	22.0	591	7.67	2.25	6.6	0.00	0.76	19.7	0.05	1.88
	Feb	1.62	0.27	3.03	31.0	766	10.86	1.84	15.7	0.00	1.92	44.1	0.13	1.99
	Mar	1.10	0.27	4.16	26.6	844	12.35	3.06	12.6	0.00	2.00	33.8	1.12	1.28
	Apr	1.23	0.40	9.78	13.8	572	11.05	1.55	17.6	0.00	3.96	43.5	0.97	2.26
	May	1.36	0.66	4.43	9.9	353	7.44	2.34	45.8	0.00	3.34	79.4	1.19	1.50
	Jun	0.85	0.35	6.88	15.6	480	9.09	1.94	10.9	0.00	3.18	27.8	1.60	0.68
	Jul	0.42	0.10	2.51	22.5	523	6.51	2.63	5.1	0.00	1.16	20.7	0.01	1.52
	Aug	0.72	0.14	1.86	24.8	601	7.65	0.93	6.1	0.00	1.15	17.3	0.75	1.61
	Sep	0.39	0.16	1.87	30.2	718	10.14	0.36	7.8	0.00	0.75	21.6	0.58	1.08
	Oct	1.11	0.24	4.36	39.0	869	13.47	2.33	13.5	0.00	1.88	60.2	0.18	1.83
	Nov	1.62	0.28	3.14	29.0	628	8.29	1.07	10.6	0.00	1.11	23.2	0.02	2.06
	Dec	1.11	0.28	1.97	28.8	754	9.82	1.38	14.0	0.00	3.15	34.6	0.03	1.97
	Annual average	**1.02**	**0.29**	**3.89**	**24.4**	**642**	**9.53**	**1.81**	**13.8**	**0.00**	**2.03**	**35.5**	**0.55**	**1.64**

		Concentration ng.m^{-3}												
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
Brookside Metals														
69	Jan	0.86	2.01	2.61	41.8	263	8.59	0.47	48.8	0.00	0.71	704.0	0.08	1.72
	Feb	2.48	6.36	6.99	91.7	733	19.35	7.56	147.3	0.00	2.49	943.8	0.28	1.95
	Mar	3.23	1.66	6.42	66.2	1022	21.57	1.68	71.8	0.00	3.82	407.0	0.60	1.97
	Apr	1.44	0.43	4.02	16.0	489	12.77	1.82	20.9	0.00	3.78	62.6	0.88	1.73
	May	0.93	2.46	3.45	39.2	301	9.61	2.14	43.6	0.00	1.52	457.6	0.45	2.84
	Jun	0.97	1.68	3.93	30.2	383	9.80	2.17	33.7	0.00	2.52	289.0	0.57	2.62
	Jul	0.71	1.99	10.19	43.9	262	8.42	4.90	36.9	0.00	1.02	404.1	0.79	1.83
	Aug	0.83	0.79	1.77	22.5	242	7.36	0.65	26.0	0.00	0.99	135.2	0.43	2.49
	Sep	0.81	0.92	0.01	21.9	261	6.59	0.31	25.5	0.00	0.99	116.6	1.00	4.12
	Oct	1.64	3.55	3.29	47.3	539	14.94	4.31	66.1	0.00	1.95	541.1	0.18	3.75
	Nov	2.12	2.49	2.83	60.2	417	10.81	3.39	61.1	0.00	0.78	524.2	0.05	2.28
	Dec	1.44	1.89	5.36	31.6	335	11.44	3.83	35.8	0.00	2.66	353.5	0.14	1.93
	Annual average	**1.46**	**2.19**	**4.24**	**42.7**	**437**	**11.77**	**2.77**	**51.4**	**0.00**	**1.94**	**411.6**	**0.45**	**2.44**

		Concentration ng.m^{-3}												
Site	**Month**	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**	**Hg Vap**
Newcastle 70	Jan	0.01	0.08	1.50	3.4	108	2.08	0.01	2.9	0.00	0.09	7.1	0.07	3.23
	Feb	0.91	0.17	3.48	8.6	249	6.16	3.15	10.5	0.00	1.25	25.3	0.52	2.24
	Mar	0.91	0.26	1.18	6.2	225	4.52	0.39	5.5	0.00	2.22	15.0	0.52	1.68
	Apr	0.99	0.23	1.70	8.0	321	6.72	0.96	8.8	0.00	2.20	23.0	0.69	2.53
	May	2.51	0.12	7.80	5.9	192	3.84	10.17	5.2	0.00	16.38	18.7	0.61	2.24
	Jun	0.81	0.11	3.73	9.5	298	5.75	1.56	5.7	0.00	4.71	24.0	0.06	1.18
	Jul	0.64	0.07	3.52	4.8	158	3.20	3.01	3.5	0.00	0.68	12.8	0.05	3.96
	Aug	0.17	0.10	0.09	2.7	96	1.88	0.05	2.1	0.00	0.50	4.6	0.59	1.23
	Sep	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Oct	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Nov	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Dec	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Annual average	**0.87**	**0.14**	**2.88**	**6.2**	**206**	**4.27**	**2.41**	**5.5**	**0.00**	**3.50**	**16.3**	**0.39**	**2.28**

* site closed in September 2007