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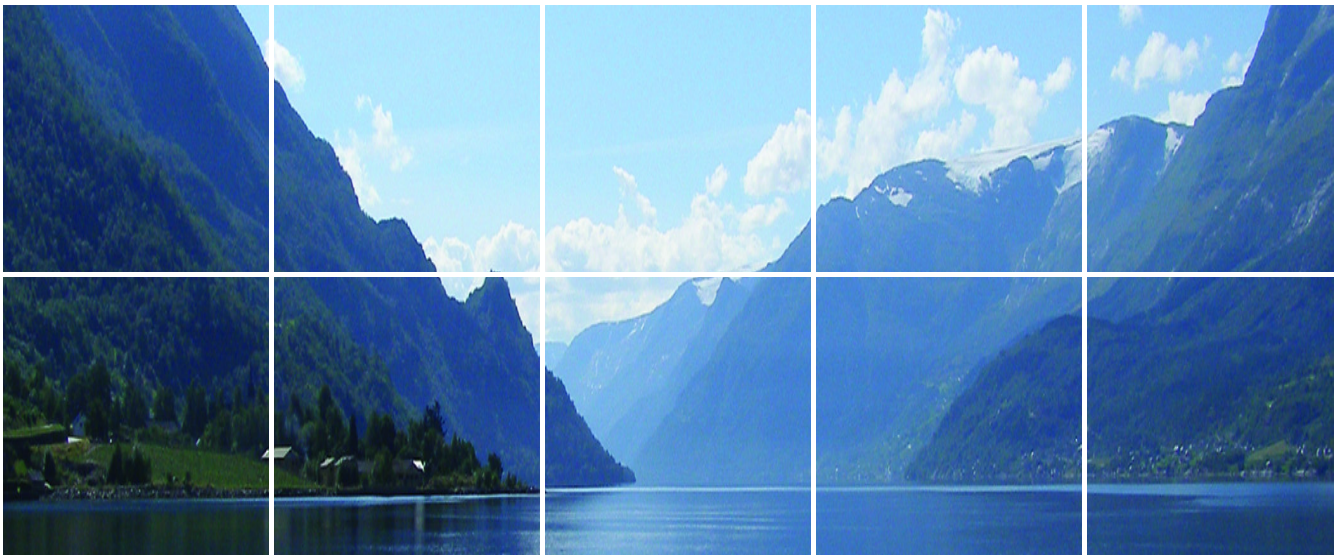

Measurement of PM_{10} and $PM_{2.5}$ in Scotland with Gravimetric Samplers

Report to The Scottish Government

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Executive summary

In 2006, The Scottish Government commissioned Bureau Veritas and AEA to undertake additional gravimetric measurements of PM_{10} and $PM_{2.5}$ at selected monitoring sites in Scotland.

Since only few measurements of these species were available from UK national monitoring networks, this additional monitoring was required to better characterise PM_{10} and $PM_{2.5}$ concentrations in Scotland and, in particular, to provide a general assessment of the concentrations of these species at rural and urban locations in relation to the Scottish Air Quality Objectives.

The additional measurements commissioned by The Scottish Government consisted of co-located measurements of PM_{10} and $PM_{2.5}$ at 5 locations in total using the Partisol gravimetric sampling technique already demonstrated as equivalent to the EU Reference Method. This work was carried out in parallel with UK national network measurements and used the same methods for sampling and measurement.

During the course of the measurement programme evidence emerged of issues with the data determined with these samplers in the UK. This has been the subject of detailed investigations, which have been fully reported elsewhere*. Now that these investigations are complete and reported, the Scottish data have been revisited to provide a reliable dataset which is consistent with similar measurements made throughout the UK. This report presents and analyses the final corrected Scottish PM_{10} and $PM_{2.5}$ gravimetric data. These data have also been incorporated into pollution climate maps showing estimated PM_{10} and $PM_{2.5}$ concentrations (on a 1km x 1km grid square basis) throughout Scotland. The resulting maps and an indication of the likely implications for exceedence of the Scottish Air Quality Objectives are also presented.

The main conclusions are as follows:

- From the 5 sites selected, the annual average Scottish Air Quality Objectives for PM_{10} and $PM_{2.5}$ were only exceeded at the Dumfries roadside site
- The mean annual average $PM_{2.5}$:PM_{10} ratio at the different sites was 0.66. The $PM_{2.5}$:PM_{10} ratio found in this study is consistent with values found throughout Europe
- Gravimetric data for the period Mar-Apr 2007 show a similar profile to that from other particle monitors in Scotland which showed elevated concentrations during this period
- Data from other types of gravimetric equivalent particulate matter monitors in Scotland are generally consistent with the data obtained in this study
- The pollution mapping exercise indicated that, at background locations, there is unlikely to be exceedences of the annual mean PM_{10} Objective of 18μgm^{-3} or the annual mean $PM_{2.5}$ Objective of 12μgm^{-3}. However, for both PM_{10} and $PM_{2.5}$, exceedences are likely at some roadside locations.

Hence, the data collected in The Scottish Government study and the updated pollution maps for Scotland, based on these data, provide a good overview of PM_{10} and $PM_{2.5}$ concentrations throughout Scotland.

* Analysis of trends in Gravimetric Particulate Mass Measurements in the United Kingdom. R Maggs et al, Bureau Veritas UK Ltd. January 2009 (BV/AQ/AGG06801/RM/2543)

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1 Introduction

In 2006, The Scottish Government commissioned Bureau Veritas and AEA to undertake additional measurements of PM_{10} and $PM_{2.5}$ at selected monitoring sites in Scotland. Some measurements of particulate concentrations were already being made as part of the Scottish Government, Defra and the other DA's Automatic Urban and Rural Network (AURN) – however these were limited in scale, mostly restricted to PM_{10} and undertaken with samplers subsequently shown not to be equivalent to the EU Reference Method for monitoring particulate matter in the atmosphere.

The additional measurements commissioned by The Scottish Government consisted of co-located measurements of PM_{10} and $PM_{2.5}$ at 5 locations in total using a gravimetric sampling technique already demonstrated as equivalent to the EU Reference Method. At two of these locations, $PM_{2.5}$ measurements were undertaken in the Scottish Government programme alongside current PM_{10} measurements already being undertaken within the AURN. The sampling equipment and procedures used for the additional Scottish Government measurements were identical to those used for measurements in the AURN.

The aim of the project was to obtain data to better characterise PM_{10} and $PM_{2.5}$ concentrations in Scotland and, in particular, to provide a general assessment of the concentrations of these species at rural and urban locations in relation to the Scottish Air Quality Objectives[1].

The Rupprecht & Patashnick 2025 Partisol sampler (now distributed by Thermo Fisher) was selected as the instrument to be used to obtain the data. This sampler had been demonstrated to be equivalent[2] to the EU Reference Method for the measurement of PM_{10}.

However, during the course of the measurement programme evidence emerged of issues with the data determined with these samplers in the UK. This has been the subject of detailed investigations, which have been fully reported elsewhere[3]. Now that these investigations are complete and reported, the Scottish data have been revisited with the aim of providing a reliable dataset which is consistent with similar measurements made throughout the UK.

This report describes the measurement programme and the preparation and analysis of the data. The data are analysed to provide the required information on PM_{10} and $PM_{2.5}$ concentrations and ratios at the individual monitoring sites. The results are compared with the Air Quality Objectives for Scotland.

In addition, the data from this study have been used to update pollution maps for particulate matter, for Scotland, which provide modelled PM_{10} and $PM_{2.5}$ concentrations (on a 1km x 1km grid basis) at background and roadside locations throughout Scotland.

2 The Measurement Programme

2.1 Partisol 2025 Sampler

The Partisol-Plus Model 2025 Sequential Air Sampler is a gravimetric sampler for suspended particulate matter. It is an automated sampling device that collects size-selected particulate matter on filters for later weighing or analysis. Its 16-filter sequential collection feature allows for unattended operation for up to two weeks between site visits.

The Partisol-Plus Sampler was demonstrated to be equivalent to the European Reference method in a detailed equivalence programme undertaken by Bureau Veritas[2].

The Partisol units used in the Scottish Government programme were operated with Quartz Filters (Whatman QMA) which were conditioned and weighed according to EN 12341. The procedures used by Bureau Veritas for filter weighing based on EN 12341 are accredited to ISO 17025 by The United Kingdom Accreditation Service (UKAS).

Figure 2.1 shows the 2 Partisol samplers on location at the Bush Estate AURN monitoring site.

Figure 2.1 Partisol PM_{10} and $PM_{2.5}$ Samplers at the Bush Estate AURN Monitoring Site

2.2 Measurement Locations

The Scottish Partisol monitoring programme consisted of particulate matter monitoring at 5 current AURN monitoring locations: Bush Estate, Dumfries, Eskdalemuir, Fort William and Inverness. These locations were agreed following consultation between Bureau Veritas and The Scottish Government. The site locations are presented in Figure 2.2.

Details of the parameters monitored, site grid references and site descriptions are given in Table 2.1.

Figure 2.2 Scottish Partisol Monitoring Locations

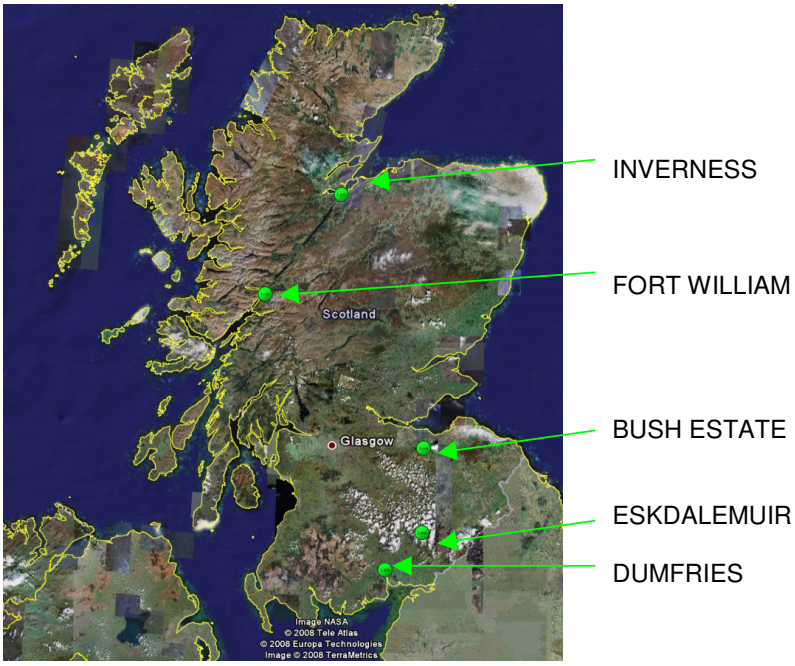


Table 2.1 Details of Monitoring Site Locations

Site	Parameters	Grid Reference	Description
Inverness	$PM_{2.5}$ (PM_{10} from AURN)*	NH657457	Roadside
Fort William	PM_{10}, $PM_{2.5}$	NN108744	Suburban
Bush Estate	PM_{10}, $PM_{2.5}$	NT246639	Rural
Eskdalemuir	PM_{10}, $PM_{2.5}$	NT235030	Rural
Dumfries	$PM_{2.5}$ (PM_{10} from AURN)*	NX970763	Roadside

* At Inverness and Dumfries, PM_{10} Partisol samplers were already in operation as part of the UK Automatic Urban and Rural Network (AURN). Hence, only $PM_{2.5}$ Partisol samplers needed to be added at these sites.

2.3 Dates of operation

The aim of the programme was to collect one year of data for each pollutant at each monitoring site. This has been achieved, however, due to the different logistical constraints encountered at the sites, the year of operation is not the same at each site. The actual dates of operation at each site are provided in Table 2.2.

Table 2.2 Period of Monitoring at each Site Location.

Site	Parameter	Start Date	End Date
Inverness	PM_{10}	Ongoing AURN	
	$PM_{2.5}$	6/12/06	31/05/08
Fort William	PM_{10}	27/03/07	01/04/08
	$PM_{2.5}$	27/03/07	01/04/08
Bush Estate	PM_{10}	01/11/06	30/10/07
	$PM_{2.5}$	01/11/06	30/10/07
Eskdalemuir	PM_{10}	01/03/07	04/04/08
	$PM_{2.5}$	01/03/07	04/04/08
Dumfries	PM_{10}	Ongoing AURN	
	$PM_{2.5}$	16/02/07	17/03/08

2.4 Sampler Quality Assurance

Prior to the commencement of data collection at each site an audit of the sampler flowrate was undertaken by AEA. The traceability of calibration and procedures for the audit are covered by AEA's accreditation to ISO 17025 by the United Kingdom Accreditation Service (UKAS). Where any sampler flow was found to deviate from the correct flow by more than 10% this was reported to Bureau Veritas who arranged for service of the sampler by the supplier. The sampler was then retested by AEA. All samplers were retested at 6-monthly intervals provided that the sampler was still on site and operational at the time of the audit visit. The results of these flow checks are provided in the UKAS Certificate of Calibration which is shown in Appendix 1.

2.5 Data Quality Assurance

As mentioned in the Introduction to this report, during the course of the measurement programme evidence emerged of issues with the data determined with the Partisol samplers in the UK. The results were clearly seen to be overestimating particulate matter concentrations, compared to other monitoring techniques. This was determined to be primarily due to water retention by the quartz filters, leading to high field blank values. This effect has been the subject to detailed investigations, which are fully reported elsewhere[3].

The Bureau Veritas report on the UK Partisol data[3] fully discussed the problems encountered with the UK data due to high field blank values. The report proposed correction of these data by subtracting the average blank concentration equivalent from the annual mean data (Table 2.3). The report discussed that it is possible that the overestimation of the particulate material on sampled filters is dependent on site location, though there is no way of identifying this at present. The report also discussed how there was no difference between blanks for PM_{10} and $PM_{2.5}$ and, as such, it was proposed that both PM_{10} and $PM_{2.5}$ instruments are corrected by an identical factor.

After wide consultation on this report, it was decided that the daily data should be corrected by subtraction of the monthly correction factor for the month in which the filter was sampled (Table 2.4), and that these data be used to calculate annual averages. This method maintains the link between daily and annual averages, has the advantage that sites with less than 100% data capture are corrected more accurately and also accounts for any seasonal variation. The monthly correction method used un-rounded daily concentration data to improve accuracy of the correction.

Use of this method results in occasional days when the corrected daily concentrations are less than zero. For the calculation of the annual averages, these negative values are left in the dataset as their removal would inaccurately bias the average. However, for daily data included in the UK database and archive, it is proposed to remove days when corrected concentrations are less than zero. However, for UK AURN data this has not yet been decided upon and, in this report on the Scottish data, the negative values have been retained within the dataset.

Tables 2.3 and 2.4 give the annual and monthly Partisol correction factors for all years investigated in the Bureau Veritas study. For the Scottish data, only correction factors related to 2006, 2007 and 2008 are relevant.

Table 2.3 Annual Average Field Blank Concentration Equivalent.

Year	Annual Blank Average / µg m^{-3}	Standard Deviation	Annual Blank Count
2000	2.71	0.18	2
2001	1.08	1.36	124
2002	0.94	2.08	352
2003	2.23	2.47	210
2004	1.49	1.62	257
2005	1.46	2.42	402
2006	3.34	3.23	329
2007	4.51	2.83	238

Table 2.4 Variation in Bureau Veritas weighed Whatman QMA Quartz filters filter weights used in Partisol 2025, by month placed in sampler.

Month	Count	Mean	Minimum	Maximum	Standard Deviation
November 2000	1	2.83	2.83	2.83	
December 2000	1	2.58	2.58	2.58	
January 2001	1	1.42	1.42	1.42	
February 2001	2	1.17	0.96	1.38	0.30
March 2001	15	-0.19	-1.67	0.58	0.64
April 2001	5	1.40	-2.21	4.71	2.48
May 2001	5	1.08	0.75	1.54	0.31
June 2001	4	0.27	-3.25	2.46	2.56
July 2001	19	0.96	-0.38	2.21	0.76
August 2001	35	1.43	-0.58	3.88	1.05
September 2001	5	1.65	-0.96	3.83	1.79
October 2001	4	0.83	-0.92	3.79	2.08
November 2001	15	0.11	-0.92	2.08	0.90
December 2001	14	2.69	1.04	4.08	0.72
January 2002	50	1.23	-4.25	7.71	2.88
February 2002	42	-0.65	-6.13	1.96	1.44
March 2002	48	-0.45	-4.29	1.96	1.39
April 2002	4	3.12	0.88	3.96	1.49
May 2002	7	1.52	1.00	2.58	0.51
June 2002	8	3.10	1.75	3.83	0.71
July 2002	3	4.90	3.71	5.79	1.07
August 2002	17	0.51	-1.21	2.50	0.98
September 2002	49	1.11	-6.75	5.42	2.03
October 2002	48	1.93	-6.46	5.75	1.69
November 2002	42	1.58	-1.63	4.46	1.57
December 2002	34	0.95	-1.96	7.50	1.77
January 2003	34	0.15	-4.29	4.04	1.60
February 2003	13	2.21	-0.21	3.79	1.00
March 2003	12	0.48	-1.54	3.42	1.49
April 2003	9	2.54	-0.29	5.50	1.88
May 2003	22	4.91	-0.33	10.33	2.03
June 2003	21	5.42	3.13	8.17	1.55
July 2003	15	5.13	2.00	8.63	2.35
August 2003	15	1.82	-0.79	6.17	1.91
September 2003	30	0.56	-1.13	3.04	1.00
October 2003	17	1.73	-0.79	3.54	1.32
November 2003	11	1.60	-0.33	3.63	1.18
December 2003	11	1.46	-0.13	3.71	1.04
January 2004	17	1.33	-0.67	2.33	0.75
February 2004	10	0.68	-0.46	2.54	0.91
March 2004	38	0.93	-2.67	3.21	1.35
April 2004	26	1.06	-1.96	3.88	1.60
May 2004	53	2.11	-3.08	5.63	1.77
June 2004	24	1.37	-1.04	3.50	1.37
July 2004	11	3.18	1.00	4.33	0.85
August 2004	28	2.80	-0.04	6.54	1.38
September 2004	16	1.89	-0.79	4.21	1.28
October 2004	13	0.55	-0.67	1.87	0.73
November 2004	10	0.15	-1.04	1.92	1.17
December 2004	11	-0.63	-2.37	1.92	1.00
January 2005	52	0.68	-2.75	3.50	1.08
February 2005	25	-0.63	-5.17	3.67	1.85
March 2005	11	1.22	-1.08	1.96	0.86
April 2005	44	1.08	-2.58	6.83	1.65
May 2005	19	4.28	0.83	13.29	3.09
June 2005	56	4.48	-1.04	8.42	2.02
July 2005	18	2.80	1.21	4.33	1.00
August 2005	30	2.27	-5.00	5.63	2.63
September 2005	51	-0.10	-4.71	2.83	1.57
October 2005	22	0.31	-3.38	4.54	1.70
November 2005	39	-0.23	-4.12	2.83	1.85
December 2005	35	1.84	0.33	3.38	0.71
January 2006	26	1.37	0.33	3.88	0.91
February 2006	28	1.05	-4.46	4.33	1.54
March 2006	50	1.24	-1.58	3.75	1.27
April 2006	28	-0.24	-7.42	6.38	2.94
May 2006	24	6.01	0.08	13.79	4.09
June 2006	14	6.85	2.13	12.62	3.52
July 2006	38	5.20	0.46	13.37	3.51
August 2006	31	6.55	1.29	11.50	2.40
September 2006	26	4.35	1.21	6.54	1.56
October 2006	13	3.49	1.29	5.08	1.29
November 2006	12	4.08	1.96	6.04	1.19
December 2006	39	3.33	-0.25	6.00	1.70
January 2007	38	2.23	-4.25	11.62	3.89
February 2007	5	10.48	6.50	15.83	3.63
March 2007	15	6.20	2.13	9.17	1.74
April 2007	8	5.97	3.88	8.29	1.63
May 2007	22	5.92	3.25	10.63	1.69
June 2007	19	5.64	2.21	9.00	1.69
July 2007	14	6.52	4.54	8.04	1.17
August 2007	41	4.94	1.25	8.21	1.37
September 2007	34	4.08	0.00	6.88	1.43
October 2007	4	5.20	3.25	7.96	2.00
November 2007	28	2.86	-3.42	9.79	2.47
December 2007	10	2.51	-2.96	7.54	3.14
January 2008	19	0.87	-2.00	3.04	1.72
February 2008	31	2.94	-1.04	9.21	2.56
March 2008	35	4.77	0.54	12.75	2.33
April 2008	55	3.67	-0.25	6.75	1.39
May 2008	52	4.61	-1.96	9.04	2.66
June 2008	30	4.24	-1.54	12.50	2.78

2.6 Data Uncertainty

This section provides a detailed assessment of the overall uncertainty of the data using the methodology defined in the appropriate EU Directive[4]. This is a complex calculation. The results, summarised in Table 2.5, show that the Partisol method meets the requirements of the EU Directive for PM_{10}. Though the same sampler and the same procedure are used for both PM_{10} and $PM_{2.5}$, the lower EU limit value for $PM_{2.5}$ means that the uncertainty requirements for this pollutant are not met, even in the UK national monitoring network. There are no specific uncertainty requirements associated with the Scottish Air Quality Objectives, but the methodology provided in the EU Directive has been applied. The results show that the uncertainty of the data is quite high (42% for PM_{10} and 68% for

$PM_{2.5}$) at the Scottish Air Quality Annual Average Objective values. This reflects the difficulty in measuring particulate matter accurately at these low concentrations.

The EU Directive[4] specifies a Data Quality Objective of 25% for individual PM_{10} and $PM_{2.5}$ measurements averaged over the period considered by the limit value, for a 95% confidence interval, and interpreted as being applicable in the region of the appropriate limit value. Hence, it is important to consider the expanded uncertainty of the corrected Partisol data relative to the EU reference methods. The limit values in the EU Directive apply throughout the UK (and to all other Member States of the European Union). However, within the UK Air Quality Strategy[1] the Scottish Government has set Air Quality Objectives at lower concentrations than the limit values set in the EU Directive. There is no specific data uncertainty requirement associated with the Scottish Air Quality Objectives, but for information, we have also assessed the Partisol data uncertainty at these values.

Table 2.5 shows the uncertainty calculation for different Limit Values. For PM_{10}, the 2006 Equivalence Report[2] calculated an expanded uncertainty of 7.99% at a daily limit value of 50µgm^{-3}, 9.93% at an annual limit value of 40µgm^{-3} and 21.84% for the Scottish Annual Objective of 18µgm^{-3}. Routine Partisol monitoring in the UK National Network, and hence in the Scottish Study, used the EN12341 standard method which differs from the approach used in the equivalence study where Emfab filters were used instead of quartz and the filters were weighed to the more rigorous EN14907 standard. Hence, it is necessary to add the uncertainty due to the correction of data by the monthly average blank values to the uncertainty calculated in the equivalence studies.

For daily data, the maximum uncertainty could be considered to be when the standard deviation of the monthly correction factors is greatest, which was 4.09µgm^{-3} in May 2006. For annual data, the maximum annual standard deviation was 3.23µgm^{-3} in 2006.

The standard uncertainty of the Partisol relative to the Reference Method is half the expanded uncertainty, at 4.00% or 2.00µgm^{-3}. The square of these errors are summed and the total square rooted to give a combined standard uncertainty of 4.55µgm^{-3} or 9.10 %, which is then doubled to give an expanded uncertainty 18.21% for daily PM_{10} data. Expanded uncertainty at the EU annual Limit Value of 40µgm^{-3} is calculated as 18.96% and, for the same method of measurement, calculated as 42.01% at the lower Scottish Air Quality Objective of 18µgm^{-3}.

For $PM_{2.5}$, a full equivalence study has not been undertaken, but a single dataset was taken during 2007 in Teddington[5], South West London. Concentrations were very low, and so the results have to be treated with caution. In this study the expanded uncertainty was calculated as 42.54% at 12µgm^{-3} (the Scottish annual $PM_{2.5}$ Objective) and 28.73 % at 25µgm^{-3} (the EU $PM_{2.5}$ limit value applying to the whole of the UK). Again, the same methodology as described above for PM_{10} has been used to calculate the total uncertainty of $PM_{2.5}$ measurements made in this study - 38.64% at the EU annual Limit value of 25µgm^{-3} and 68.61% at the lower Scottish annual Air Quality Objective of 12µgm^{-3}.

Table 2.5 Calculation of total expanded uncertainties for corrected Partisol data at different Limit Values and at the Scottish Air Quality Objectives.

Location	UK	UK	Scottish 31 Dec 2010	UK 2020	Scottish 2020
Period	Daily	Annual	Annual	Annual	Annual
Size Fraction / µm	10	10	10	2.5	2.5
Limit Value / µg m^{-3}	50	40	18	25	12
Expanded relative uncertainty / %	7.99	9.93	21.84	28.73	42.54
Standard relative uncertainty / %	4.00	4.97	10.92	14.37	21.27
Standard relative uncertainty / µg m^{-3}	2.00	1.99	1.97	3.59	2.55
Max standard deviation / µg m^{-3}	4.09	3.23	3.23	3.23	3.23
Combined standard uncertainty / µg m^{-3}	4.55	3.79	3.78	4.83	4.12
Combined standard uncertainty / %	9.10	9.48	21.01	19.32	34.31
Combined expanded uncertainty / %	18.21	18.96	42.01	38.64	68.61

It is important to note that the standard uncertainty expressed in µgm^{-3} is relatively constant, but expressed as a %, the error becomes increasingly significant at lower limit values. For EU compliance purposes, the Scottish PM_{10} data are considered at the EU limit values which are the same as those for the rest of the UK, and as such, correction of PM_{10} data by the monthly field blank method results in a compliant method throughout the UK.

For $PM_{2.5}$, the expanded relative uncertainty between the Partisol and the reference method is greater than 25% even before the addition of the error due to field blank correction. However, as the $PM_{2.5}$ Partisol differs from the PM_{10} Partisol only by the inclusion of a sharp cut cyclone, it is expected that it should compare favourably with the reference method. Indeed, it is noted that the error expressed as μgm^{-3} is comparable to that for PM_{10}. Hence, it is considered that that the correction of data *via* the monthly field blank method is equally applicable to both size fractions and it is only the lower $PM_{2.5}$ Limit Value and the even lower Scottish Air Quality Objective for $PM_{2.5}$ that automatically hinders the ability to produce $PM_{2.5}$ data which conforms to the EU Data Quality Objectives.

3 Data and Data Analysis

In this section, time series graphs, data summaries and comparison with Scottish Air Quality Objectives are presented and discussed.

Figure 3.1 shows time series plots of the data for each parameter and each site. Horizontal lines are included to show the Scottish Air Quality Objectives as follows:

PM_{10}

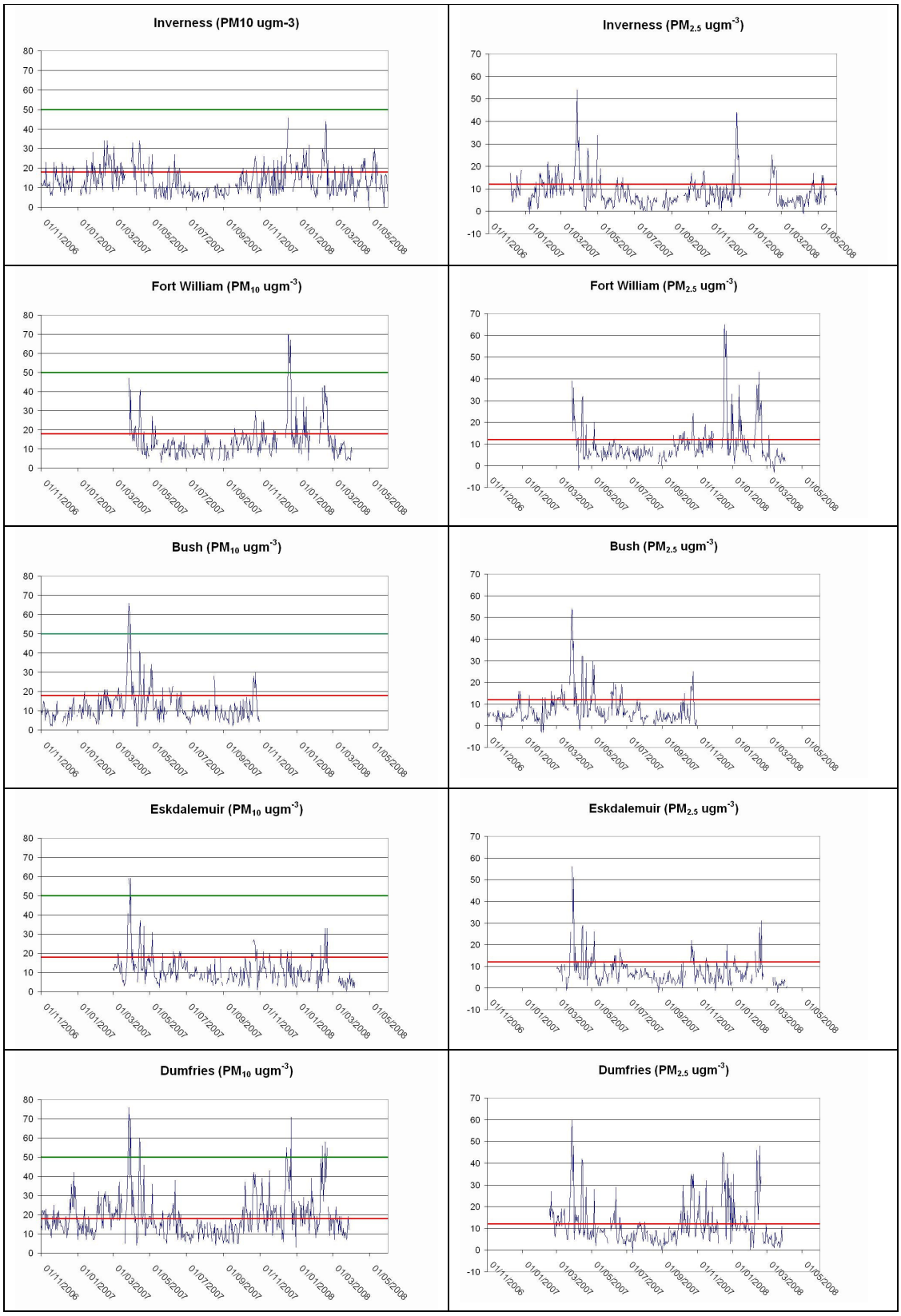
- Annual Average 18μgm^{-3} to be achieved by 31 Dec 2010
- Daily Average of 50μgm^{-3} not to be exceeded more than 7 times/year - to be achieved by 31 Dec 2010.

$PM_{2.5}$

- Annual Average 12μgm^{-3} to be achieved by 2020.

As discussed in Chapter 2, some negative data remain in the dataset so as not to bias the calculation of averages.

Figure 3.1 – Time Series plots of Daily Particulate matter concentrations



All sites show elevated levels during the period late March – early April 2007. This corresponds to a UK wide pollution episode which is further discussed in Section 3.3.

3.1 Comparison with Scottish Air Quality Objectives

Tables 3.1 and 3.2 show annual average concentrations (PM_{10} and $PM_{2.5}$) and number of exceedences of the 50µgm^{-3} daily Air Quality Objective (PM_{10}) for a representative 365-day period and for the calendar year 2007 respectively.

Table 3.1 Summary of Scottish Partisol data for Annual Periods

Site	Site type	Annual Period	PM_{10}			$PM_{2.5}$	
			Data Capture	Average µgm^{-3}	No. of days ≥ 50µgm^{-3}	Data Capture	Average µgm^{-3}
Inverness	Roadside	01/12/06 - 30/11/07	87%	13	0	90%	9
Fort William	Suburban	01/04/07 - 31/03/08	85%	14	5	90%	9
Bush Estate	Rural	01/11/06 - 30/10/07	92%	12	4	95%	8
Eskdalemuir	Rural	01/03/07 - 29/02/08	90%	12	3	89%	8
Dumfries	Roadside	01/03/07 - 29/02/08	95%	20	11	95%	12

Table 3.2 Summary of Scottish Partisol Data for Calendar Year 2007

Site	Site Type	PM_{10}			$PM_{2.5}$	
		Data Capture	Average µgm^{-3}	No. of days ≥ 50µgm^{-3}	Data Capture	Average µgm^{-3}
Inverness	Roadside	88%	14	0	90%	9
Fort William	Suburban	67%	14	5	68%	10
Bush Estate	Rural	78%	13	4	79%	8
Eskdalemuir	Rural	77%	12	3	77%	8
Dumfries	Roadside	95%	18	8	83%	12

Tables 3.1 and 3.2 show that the annual average Air Quality Objective for PM_{10} was only exceeded at the Dumfries roadside site. All other sites and periods showed concentrations below the 18µgm^{-3} Objective. Dumfries was also the only site to exceed the permitted 7 exceedences of 50µgm^{-3} daily objective.

For $PM_{2.5}$, again all sites were below the Scottish annual average Air Quality Objective of 12µgm^{-3} with the exception of Dumfries where the objective was equalled in the calendar year 2007.

3.2 Ratio of $PM_{2.5}$:PM_{10}

Table 3.3 shows the ratios of $PM_{2.5}$:PM_{10} calculated from the average concentrations determined for the selected annual period and for the calendar year 2007.

Table 3.3 Ratio $PM_{2.5}$:PM_{10}

	$PM_{2.5}/PM_{10}$ ratio	
	Annual Period*	**Calendar Year 2007**
Inverness	0.69	0.64
Fort William	0.64	0.71
Bush Estate	0.67	0.62
Eskdalemuir	0.67	0.67
Dumfries	0.6	0.67

*Defined in Table 3.2

Table 3.3 shows a reasonable degree of consistency between the $PM_{2.5}$:PM_{10} ratios at the different sites, with an arithmetic mean of 0.66. This is close to the arithmetic mean of 0.65 found for data from 72 monitoring stations throughout Europe[6] in 2004.

3.3 PM Episode, 24 March – 2 Apr 2007

During the period 24 March 2007 to 2 April 2007 an episode of particulate matter was observed throughout the UK. This episode has been analysed in a report[7] produced by AEA and the Met Office as part of the Air Quality Forecasting contract for The Scottish Government, Defra and the other DAs. Analysis of this episode with Scottish TEOM* and the available FDMS# data was also undertaken within the Scottish Annual Air Quality Report[8] 2007.

In this section, we show the Scottish Partisol Data for this period. Daily Partisol data for PM_{10} and $PM_{2.5}$ are shown in Figure 3.2. This figure also includes the Partisol data available for the remote/rural site at Auchencorth Moss in the Pentland Hills south of Edinburgh (See section 3.4). Note that there were no PM_{10} data for the Inverness site during this period.

Figure 3.3 shows the hourly TEOM data for the same period. The TEOM data have been multiplied by a factor of 1.3 to provide approximately gravimetric equivalent concentrations.

Analysis in the report[7] produced by the forecasting team shows that the air masses arriving in the UK had originated from the east during much of the period of the episode. There were two possible origins of the particles during this period – a dust storm in the Sahara desert and forest fires in Ukraine and Russia. The air mass back-trajectory analysis indicated that a significant proportion of the air mass arriving at the UK had come from Eastern Europe and only very small parts from the area of Southern Europe and the Sahara. Hence, the forest fires were the most likely source of the particulate material during the episode, although the Saharan dust may have contributed during the onset of the episode on 25 March. Figure 3.4 shows the typical airstream from Eastern Europe during the episode, Figure 3.5 clearly shows the change in conditions on 28 March with a mixed airsteam from both easterly (air from Europe) and westerly direction (clean air over the Atlantic Ocean).

The “gap” in the episode due to this brief change in weather conditions is clearly seen on both the Partisol and TEOM data plots. The reduction in concentrations in the case of the Partisol data is less marked as these data are averaged over a daily period, whereas the TEOM data are hourly.

* The TEOM analyser measures particulate material collected on filter material using a tapered element oscillating microbalance (TEOM). However, to avoid interference from water vapour the filter is heated to 50C. This results in the loss of some volatile particulate material and the TEOM has been shown not to be equivalent to the EU Reference Method.

The Filter Dynamics Measurement System (FDMS) can be added to the TEOM analyser to account for both the volatile and non-volatile components of particulate matter and report the combination as a mass concentration result. This is achieved by measuring the volatile portion of the sample independently from the total incoming sample and using this fraction in calculating the overall PM mass concentration.

Figure 3.2 Daily Partisol data for the episode period Mar-Apr 2007

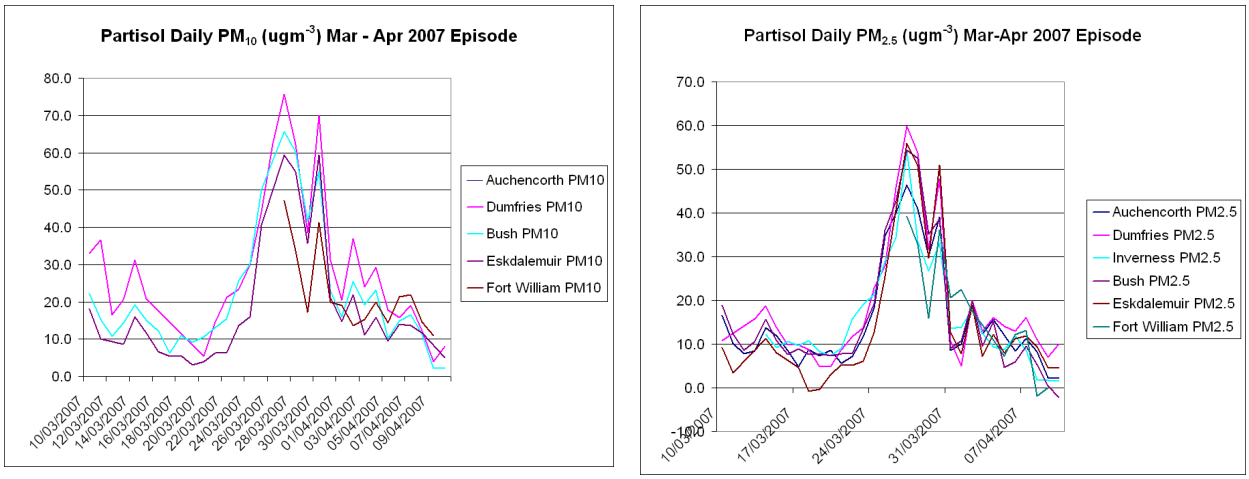


Figure 3.3 Hourly TEOM PM_{10} data in Scotland 24 March – 2 April 2007

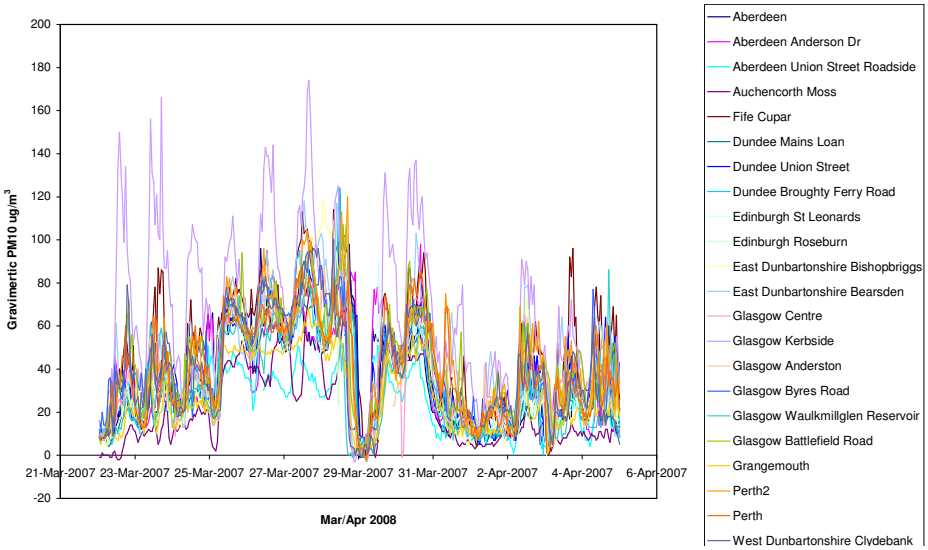


Figure 3.4 Air mass trajectories for 26 March 2007

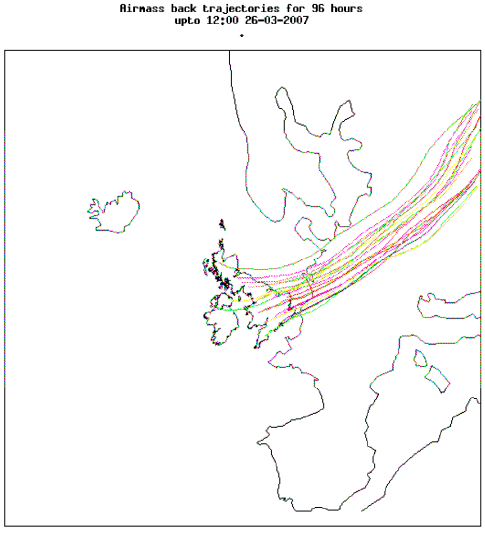
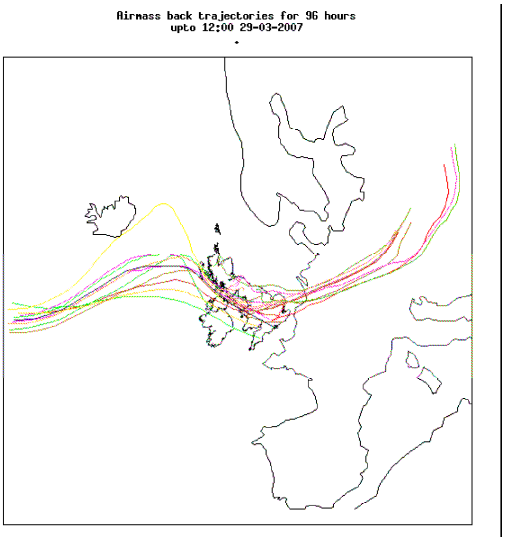


Figure 3.5 Air mass trajectories for 28 March 2007



3.4 Other PM_{10} and $PM_{2.5}$ data in Scotland

PM_{10} and $PM_{2.5}$ analysers and samplers that have been shown to be equivalent to the EU Reference Method in the UK Equivalence Programme[2] are gradually being rolled out in Scotland (and the remainder of the UK) within both the AURN and Local Authority run air quality monitoring networks. As part of a project funded by The Scottish Government, these data are integrated into the Scottish Air Quality Database and Website (www.scottishairquality.co.uk) and all data within this database are subject to the same QA/QC procedures as used for the UK national network.

Available ratified data for 2007 and 2008 (Jan – June) are presented in Table 3.4 and Table 3.5 below for PM_{10} and $PM_{2.5}$ respectively. However, in many cases the data capture is low as the analysers were only installed part way through these periods and hence, the data presented should be treated with caution.

Table 3.4 Summary of PM_{10} data from FDMS instruments in Scotland

Site	Site Type	Period	Data capture	PM_{10} Annual Average μgm^{-3}	No. days ≥ $50\mu gm^{-3}$
Auchencorth Moss	Remote	Jan – Dec 2007	98%	6	0
Edinburgh St Leonard's (FDMS from 10/07/07)	Urban Background	Jan – Dec 2007	52%	17	-
Glasgow Abercromby St	Roadside	Jan – Dec 2007	29%	24	6
Glasgow Broomhill	Roadside	Jan – Dec 2007	18%	25	3
Glasgow Nithsdale Road	Roadside	Jan – Dec 2007	22%	25	4
East Dunbarton Kirkintilloch	Roadside	Jan – Dec 2007	27%	21	1
Ayr High St	Roadside	Jan – Dec 2007	16%	17	0
Auchencorth Moss	Rural/	Jan - June 2008	96%	7	0
Edinburgh St Leonard's	Urban background	Jan - June 2008	99%	16	0
Glasgow Abercromby St	Roadside	Jan - June 2008	95%	19	5
Glasgow Broomhill	Roadside	Jan - June 2008	98%	20	6
Glasgow Nithsdale Road	Roadside	Jan - June 2008	85%	22	5
East Dunbartonshire Kirkintilloch	Roadside	Jan - June 2008	28%	22	3
Ayr High St	Roadside	Jan - June 2008	30%	16	0
Fife Rosyth	Roadside	Jan - June 2008	57%	16	0
South Lanarkshire East Kilbride	Roadside	Jan - June 2008	26%	19	0

As mentioned above, the data capture is low for many of these sites. However, the data are generally consistent with that from the Partisol – non-roadside sites are below the 18µgm^{-3} objective and roadside sites span a range from well below to well above the objective.

Table 3.5 Summary of $PM_{2.5}$ data from FDMS instruments in Scotland

Site	Site Type	Period	Data capture	$PM_{2.5}$ Annual Average µgm^{-3}
Auchencorth Moss	Remote	2007	97%	4
Auchencorth Moss	Remote	Jan - June 2008	93%	4

$PM_{2.5}$ data are only available for the rural/remote site at Auchencorth Moss. Table 3.5 shows that the concentrations are well below the Air Quality Objective of 12µgm^{-3}.

At Auchencorth Moss, PM_{10} and $PM_{2.5}$ are measured by both FDMS and Partisol Analysers. Table 3.6 compares the results for these different instruments.

Table 3.6 Comparison of FDMS and Partisol Data* at Auchencorth Moss

Species	Period	Partisol*		FDMS	
		Data capture	Annual Average µgm^{-3}	Data capture	Annual Average µgm^{-3}
PM_{10}	2007	36%	10	98%	6
$PM_{2.5}$	2007	92%	7	97	4

*Partisol data have been adjusted using the adjustment factors give in Table 2.3

The Partisol data given in Table 3.6 has been adjusted using the adjustment factors given in Table 2.3. Table 3.6 shows that the adjusted Partisol data are generally higher than FDMS data at Auchencorth Moss. This could, in part, be due to the Partisol being referenced to a quartz filter base and the FDMS being referenced to an Emfab filter base[3]. If the estimated filter material correction factor of 2.5µgm^{-3} (see Chapter 4) were added to the FDMS data or subtracted from the Partisol data then the results would be very close.

4 Mapping PM concentrations throughout Scotland

4.1 Introduction

As part of the Scottish Air Quality Database project, AEA provide mapped concentrations of pollutants on a 1x1km square grid basis. These pollution maps combine measurement data with the spatially disaggregated emissions information from the National Atmospheric Emissions Inventory (NAEI) to provide estimated pollutant concentrations for the whole of Scotland. The methodology for producing the Scottish maps is based on that used for producing air pollution maps for the whole of the UK and is fully described elsewhere[9].

For Scotland, the mapped particulate matter concentrations for 2007 incorporate all of the gravimetric PM_{10} and $PM_{2.5}$ data obtained from this monitoring programme. In addition, these maps used a dispersion kernel derived with Scottish meteorological data obtained from RAF Leuchars.

For the mapping exercise, two adjustment factors have been applied to the Partisol data:

- Field blank adjustment factor – (see Section 2.5 and Reference 3)
- Filter material adjustment factor - to convert from quartz filter based measurements to Emfab filter based measurements (see Section 3.4 and Reference 2).

The overall average field blank correction factor for 2007 for all Partisol measurement sites in the UK was 4.51µgm^{-3}. However, when the monthly correction factor is applied to the data there are slight differences in the overall annual correction factor from site to site when the data capture is less than 100% and data are missing at different periods at the different sites. The field blank correction factors that have been applied are as presented in Appendix B of Reference 3.

The adjustment to the Emfab filter base is to ensure consistency between FDMS data which are linked to an Emfab filter base and the Partisol data which are linked to a quartz filter base. Hence, an additional correction factor of 2.5µgm^{-3} has also been applied to the Partisol data.

As a result of applying the additional filter material adjustment, the mapped concentrations will be approximately 2.5µgm^{-3} lower than the field blank adjusted Partisol data.

4.2 Exceedence statistics based on mapped concentrations

For the purposes of the EU Air Quality Directive, Scotland has been split into 2 agglomerations (urban areas with population greater than 250,000) - Edinburgh Urban Area and Glasgow Urban Area and 4 zones - Scottish Borders, Central Scotland, North East Scotland and Highland. Whilst the concept of zones and agglomerations has no specific relevance in terms of the Air Quality Strategy and the Air Quality Objectives for Scotland, it never-the-less provides a useful framework for discussing the results.

The model outputs have been compared against the Air Quality Objectives for Scotland to determine the extent of exposure to specific concentrations. At background locations the area and population exposed are assessed. At roadside locations, the number of road links and the length of road exposed are assessed.

The model can only determine annual mean concentrations. Hence, to compare the model output with Objectives based on numbers of exceedences of daily values, it is first necessary to calculate an annual average equivalent to the set number of exceedences. This is achieved by analysis of the available monitoring data. The calculated annual mean equivalent of the UK wide daily objective of 35 exceedences of 50µgm^{-3} was found to be 31.5µgm^{-3}. The calculated annual mean equivalent of the Scotland daily objective of 7 permissible exceedences of 50µgm^{-3} was found to be 22µgm^{-3}. This is

based on the relationship between daily 98th percentile and annual mean concentrations across the whole of the UK from 1992 to 2007. Note that this relationship exhibits a lower correlation (0.72) than the 90th percentile (0.90) used to derive the annual mean equivalent for the UK daily objective.

The annual average and equivalent annual average Objectives applicable in Scotland are provided in Table 4.1.

Table 4.1– Air Quality Objectives adopted in Scotland and UK for Particulate Matter

Pollutant	Metric	Objective	Applies
PM_{10}	Annual mean	18 µg m^{-3}	Scotland only
PM_{10}	Annual mean *	22 µg m^{-3}	Scotland only
PM_{10}	Annual mean **	31.5 µg m^{-3}	UK
$PM_{2.5}$	Annual mean	12 µg m^{-3}	Scotland only
$PM_{2.5}$	Annual mean	25 µg m^{-3}	UK

* 22µg m^{-3} is the annual mean equivalent of the daily objective of 7 permissible exceedences of 50µg m^{-3}.
** 31.5µg m^{-3} is the annual mean equivalent of the daily objective of 35 permissible exceedences of 50µg m^{-3}.

Tables 4.2 and 4.3 present exceedence statistics for PM_{10} at background and roadside locations respectively. No exceedences of the annual mean objective of 18µgm^{-3} at background locations were identified by the Scotland-specific model. However, the model identified 67 road links exceeding this Objective across Scotland, 60% of which (41 road links) were located in Glasgow Urban Area. These 67 road links represent a length of road measuring 82.6km. No roadside exceedences of this Objective were identified by the model in the Highland or Scottish Borders zones. There were no exceedences of 22µgm^{-3} at background locations but for roadside locations there were 5 roads modelled to exceed this, representing 9.4km, most of which were in the Glasgow Urban Area.

Table 4.2 - Annual mean exceedence statistics for PM_{10} in Scotland at Background Locations.

Zone/Agglomeration	Total		>18 µg m^{-3}		>22 µg m^{-3} *		>31.5 µg m^{-3} **	
	Area (km^2)	Population	Area (km^2)	Population	Area (km^2)	Population	Area (km^2)	Population
Glasgow Urban Area	366	1083323	0	0	0	0	0	0
Edinburgh Urban Area	117	428762	0	0	0	0	0	0
Central Scotland	9314	1875411	0	0	0	0	0	0
North East Scotland	18595	972129	0	0	0	0	0	0
Highland	38359	333977	0	0	0	0	0	0
Scottish Borders	11145	250175	0	0	0	0	0	0
Scotland	**77896**	**4943778**	**0**	**0**	**0**	**0**	**0**	**0**

* annual average equivalent of 7 daily exceedences of 50µgm^{-3}
** annual average equivalent of 35 daily exceedences of 50µgm^{-3}

Table 4.3 - Annual mean exceedence statistics for PM_{10} in Scotland at Roadside Locations.

Zone/Agglomeration	Total		>18 µg m^{-3}		>22 µg m^{-3} *		>31.5 µg m^{-3} **	
	No. roads	Road length (km)	No. roads	Road length (km)	No. roads	Road length (km)	No. roads	Road length (km)
Glasgow Urban Area	209	306.5	41	52.7	3	8.1	0	0
Edinburgh Urban Area	61	103.2	7	11.1	0	0.0	0	0
Central Scotland	237	375.9	6	6.7	2	1.2	0	0
North East Scotland	138	233.5	13	12.1	0	0.0	0	0
Highland	11	34.5	0	0.0	0	0.0	0	0
Scottish Borders	38	59.9	0	0.0	0	0.0	0	0
Scotland	**694**	**1113.4**	**67**	**82.6**	**5**	**9.4**	**0**	**0**

* annual average equivalent of 7 daily exceedences of 50µgm^{-3}
** annual average equivalent of 35 daily exceedences of 50µgm^{-3}

Tables 4.4 and 4.5 present exceedence statistics for $PM_{2.5.}$ The Scotland specific model did not identify any exceedences of the annual mean $PM_{2.5}$ Objective of 12µgm^{-3} at background locations but did identify a small number of roadside exceedences. These roadside exceedences include 7 road links in total (4 in Glasgow Urban Area and 3 in Central Scotland zone) which represent 12.6km in length. There were no modelled exceedences of 25µgm^{-3} identified at either background or roadside locations

Table 4.4 – Annual mean exceedence statistics for $PM_{2.5}$ in Scotland at Background Locations

Zone/Agglomeration	Total		>12 µg m^{-3}		>25 µg m^{-3}	
	Area (km^2)	Population	Area (km^2)	Population	Area (km^2)	Population
Glasgow Urban Area	366	1083323	0	0	0	0
Edinburgh Urban Area	117	428762	0	0	0	0
Central Scotland	9349	1883014	0	0	0	0
North East Scotland	18625	976022	0	0	0	0
Highland	39108	341035	0	0	0	0
Scottish Borders	11182	250529	0	0	0	0
Scotland	**78747**	**4962686**	**0**	**0**	**0**	**0**

Table 4.5 – Annual mean exceedence statistics for $PM_{2.5}$ in Scotland at Roadside Locations

Zone/Agglomeration	Total		>12 µg m^{-3}		>25 µg m^{-3}	
	No. roads	Road length (km)	No. roads	Road length (km)	No. roads	Road length (km)
Glasgow Urban Area	209	306.46	4	9.99	0	0
Edinburgh Urban Area	61	103.18	0	0	0	0
Central Scotland	237	375.88	3	2.64	0	0
North East Scotland	138	233.53	0	0	0	0
Highland	11	34.46	0	0	0	0
Scottish Borders	38	59.86	0	0	0	0
Scotland	**694**	**1113.38**	**7**	**12.63**	**0**	**0**

4.3 PM_{10} and $PM_{2.5}$ Maps for Scotland, 2007

Figures 4.1 and 4.2 show the mapped PM_{10} and $PM_{2.5}$ concentrations for 2007 using the Scotland specific model. Only major urban roads are included in the modelling and roads marked in grey in the roadside maps are those road links that do not meet these criteria and so are not modelled.

As expected, the model identifies urban areas and large roads in Scotland as areas of the highest concentrations. However, using the corrected Partisol data results in generally lower concentrations than shown by the maps from previous years.

The corrected Scottish Partisol data (and corrected UK Partisol data) have also been incorporated into the process for preparing updated UK-wide particulate matter maps for 2007. The detailed report on the Scottish pollution mapping for 2007[10] shows that there are only small differences between the Scotland-specific and UK-wide maps. Hence, at present, for consistency throughout the whole of the UK, the UK-wide maps provide the background concentration data used by all Local Authorities as part of the Local Air Quality Management Review and Assessment process. Local Authorities will therefore be referring to these updated maps during the forthcoming round of Local Authority Review and Assessment.

Figure 4.1 – Gravimetric PM_{10} Annual Mean Concentration Maps for 2007 µg m^{-3} (Scotland-specific model)

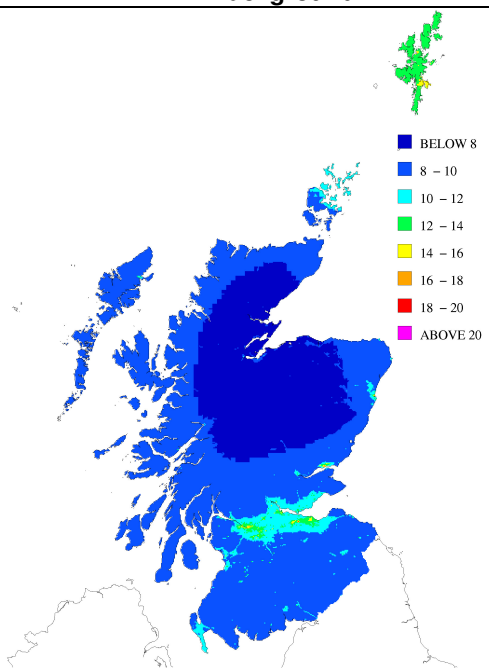
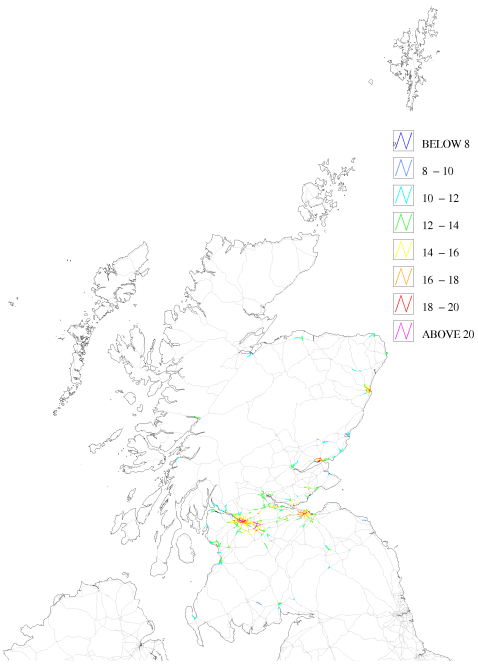
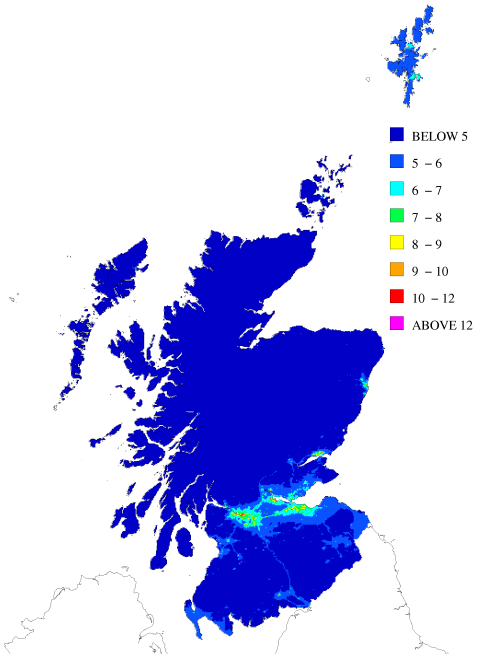
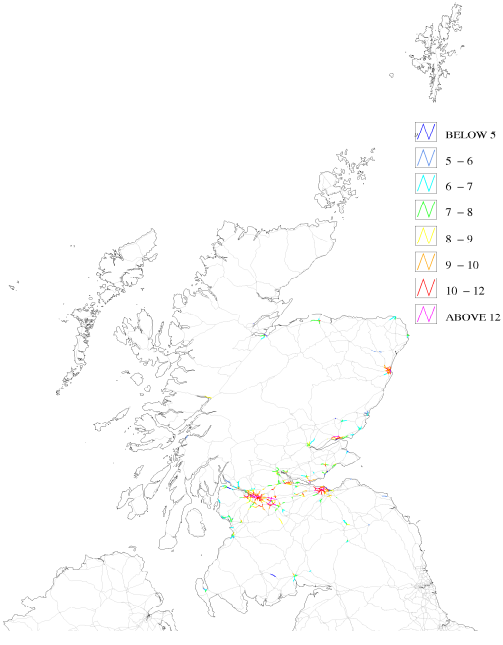
Background	Roadside
	

Figure 4.2 – Gravimetric $PM_{2.5}$ Annual Mean Concentration Maps for 2007 µg m^{-3} (Scotland-specific model)

Background	Roadside
	

5 Conclusions

One year of monitoring of PM_{10} and $PM_{2.5}$ has been undertaken with Partisol Gravimetric samplers at 5 locations throughout Scotland.

Final processing of the data has been delayed until a procedure for adjusting all Partisol data in the UK to account for field blanks had been developed and agreed by all parties. The overall agreed average field blank correction factor for 2007 for all Partisol monitoring sites in UK was 4.51μgm^{-3}. However, as a result of using a monthly based correction factor, there were slight differences in the annual correction factor at each site due to data capture being less than 100% and data missing at different periods at the different sites.

In this report, the data have been analysed to assess compliance with the Air Quality Objectives in Scotland, to evaluate ratios of $PM_{2.5}$:PM_{10} and provide additional data for analysis of a wide scale particle pollution episode which was observed in March/April 2007. The data were also compared with other gravimetric equivalent measurements of particulate material in Scotland.

Mapped particle mass concentrations using adjusted Scottish Partisol data are also presented. For the pollution mapping exercise, an additional correction of 2.5μgm^{-3} to account for the difference between quartz and Emfab filters has also been applied.

The main conclusions from this study are:

- Of the monitoring sites included in the Scottish PM_{10} and $PM_{2.5}$ gravimetric monitoring study, the annual average Air Quality Objective for PM_{10} was only exceeded at the Dumfries roadside site for the calendar year period 2007. All other sites and periods showed concentrations below the 18μgm^{-3} Objective. Dumfries was also the only site to exceed the permitted 7 exceedences of 50μgm^{-3} daily objective.

- For $PM_{2.5}$, all sites in this study were below the Scottish annual average Air Quality Objective of 12μgm^{-3} with the exception of the Dumfries roadside site where the objective was equalled in the calendar year 2007.

- There was a reasonable degree of consistency between the $PM_{2.5}$:PM_{10} ratios at the different sites, with an arithmetic mean of 0.66. This is close to the arithmetic mean of 0.65 found for data from 72 monitoring stations throughout Europe in 2004.

- Partisol data for the episode period in Mar-Apr 2007 show a similar profile to that from other particle monitors in Scotland.

- Data from other types of gravimetric equivalent particulate matter monitors in Scotland are generally consistent with the Partisol data.

- At background locations, the pollution mapping exercise for 2007 showed no exceedences of the annual mean PM_{10} Objective of 18μgm^{-3} or the annual mean $PM_{2.5}$ objective of 12μgm^{-3} in Scotland.

- For roadside locations, the pollution mapping exercise for 2007 identified exceedences of the PM_{10} objective 18μgm^{-3} at a total of 67 specific road links and exceedence of $PM_{2.5}$ objective 12μgm^{-3} at a total of 7 specific road links.

- The corrected Scottish Partisol data (and corrected UK Partisol data) have also been incorporated into the process for producing updated UK-wide particulate matter maps for 2007. These maps will be used by all Local Authorities in the forthcoming round of Local Air Quality Management Review and Assessment.

Hence, the data collected in The Scottish Government study have considerably improved the overall assessment of PM_{10} and $PM_{2.5}$ concentrations throughout Scotland.

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Appendix 1

Certificate of Calibration

AEA Energy & Environment
From the AEA group

CERTIFICATE OF CALIBRATION

Glengarnock Technology Centre, Caledonian Road, Lochshore Business Park, Glengarnock, Ayrshire, KA14 3DD. Telephone 0870 1905269 Fax 0870 1905151

UKAS CALIBRATION
0401

Approved Signatories: K. Stevenson, S. Eaton, D. Madle, S. Christiansen
Signed: K Stevenson
Date: 19/09/08

Date of issue: 20th February 2008
Cert No: 1881
Page 1 of 2

Customer Name and Address:
Scottish Government
Water, Air, Soils and Flooding Division
Environmental Quality Directorate
Scottish Government
Victoria Quay
Edinburgh
EH6 6QQ

Description: Calibration Factors for Particulate Sampling in the Scottish Government Partisol Network

AEA Identification Number: 43016001/PARTISOLS/01

Site	Date	Species	Analyser Serial No.	Parameter	Specified Value	Measured Value	Deviation %
Fort William	11th April 07	PM_{10}	21858	Total Flow	16.7	17.06	2.3
	11th April 07	$PM_{2.5}$	21857	Total Flow	16.7	17.05	2.3
	4th July 07	PM_{10}	21858	Total Flow	16.7	16.53	-0.8
	4th July 07	$PM_{2.5}$	21857	Total Flow	16.7	16.53	-0.8
	23rd Jan 08	PM_{10}	21858	Total Flow	16.7	16.81	0.8
	23rd Jan 08	$PM_{2.5}$	21857	Total Flow	16.7	15.48	-7.1

Site	Date	Species	Analyser Serial No.	Parameter	Specified Value	Measured Value	Deviation %
Inverness	18th July 07	$PM_{2.5}$	21861	Total Flow	16.7	16.89	1.32
	23rd Jan 08	$PM_{2.5}$	21861	Total Flow	16.7	16.58	0.54

Site	Date	Species	Analyser Serial No.	Parameter	Specified Value	Measured Value	Deviation %
Dumfries	3rd April 07	$PM_{2.5}$	21860	Total Flow	16.7	16.7	0.00
	24th July 07	$PM_{2.5}$	21860	Total Flow	16.7	16.71	0.24
	30th Jan 08	$PM_{2.5}$	21860	Total Flow	16.7	16.21	-2.76

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2 providing a level of confidence of approximately 95% The uncertainty evaluation has been carried out in accordance with UKAS requirements.
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Site	Date	Species	Analyser Serial No.	Parameter	Specified Value	Measured Value	Deviation %
Eskdalemuir	3rd April 07	PM_{10}	21854	Total Flow	16.7	16.49	-1.08
	3rd April 07	$PM_{2.5}$	21859	Total Flow	16.7	16.46	-1.26
	25th July 07	PM_{10}	21854	Total Flow	16.7	16.22	-2.70
	25th July 07	$PM_{2.5}$	21859	Total Flow	16.7	16.29	-2.28
	28th Jan 08	PM_{10}	21854	Total Flow	16.7	16.82	0.90
	28th Jan 08	$PM_{2.5}$	21859	Total Flow	16.7	16.58	-0.54

Site	Date	Species	Analyser Serial No.	Parameter	Specified Value	Measured Value	Deviation %
Bush Estate	28th Nov 06	PM_{10}	21863	Total Flow	16.7	16.3	-2.22
	28th Nov 06	$PM_{2.5}$	21865	Total Flow	16.7	16.2	-2.82
	12th July 07	PM_{10}	21863	Total Flow	16.7	16.87	1.20
	12th July 07	$PM_{2.5}$	21865	Total Flow	16.7	16.17	-3.00

Uncertainties:

Partisol PM_{10}	Total Flow	±2.2%
Partisol $PM_{2.5}$	Total Flow	±2.2%

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