Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

Ambient Air Monitoring

In

Kilkenny

29th April 2005 to 25th October 2005

Contents

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Summary

An assessment of air quality was carried out in Kilkenny city from 29th April 2005 until 25th October 2005. No limit values were exceeded during the measurement period.

Concentrations of sulphur dioxide, nitrogen dioxide and lead were below their respective lower assessment thresholds. Levels of PM_{10} exceeded the upper assessment threshold.

	Below Lower Assessment Threshold	**Below Upper Assessment Threshold**	**Above Upper Assessment Threshold**	**Above Limit**
PM_{10}				
NO_2				
SO_2				
Pb				

Kilkenny is in Zone C of the country. The implications of this assessment are that within Zone C (specified population centres with populations in excess of 15,000)

- Levels of PM_{10} will need to be monitored continuously
- Levels of SO_2, NO_2 and lead can be assessed using modelling or objective estimation techniques

The directive states that modelling or objective estimation techniques may be used to assess ambient air quality if levels of the pollutant in question in that zone are below the lower assessment threshold. Continuous monitoring is required if levels exceed the upper assessment threshold.

The national ozone monitoring network has already been established. Ozone concentrations were measured in Kilkenny from May to August 2005. During this period

- The population information and alert thresholds were not exceeded
- The target value for the protection of human health was not exceeded
- The long term objective for the protection of human health was not exceeded

Introduction

The European Union introduced a new approach to the monitoring, assessment and management of air quality in 1996 when it introduced a framework directive on air quality (96/62/EC, 2nd September 1996). The basic principle of the framework directive is that each country should be divided into zones and that the monitoring, assessment, management and reporting of air quality will be undertaken in relation to these zones. For the purposes of the directive, Ireland has been divided into four zones; Dublin (Zone A), Cork Urban Area (Zone B), specified population centres > 15,000 inhabitants (Zone C) and non-urban areas (Zone D). Kilkenny is in Zone C of the country.

Limit values are set for each individual pollutant which need to be met by a specific attainment date. Upper and lower assessment thresholds are also set for each pollutant, assessment thresholds are levels below the limit value, used solely in the determination of the level of monitoring needed for that pollutant in a particular zone. The extent of monitoring in any zone is determined by population size and air quality status. Measurement is mandatory in agglomerations (population >250,000) and where concentrations are above the lower assessment threshold. The greatest monitoring effort applies if concentrations are above the upper assessment threshold. Less intensive monitoring is required when concentrations are between the two assessment thresholds.

Limit values, assessment thresholds, measurement techniques and other specifics for each pollutant are defined in a series of daughter directives. The first daughter directive was adopted in April 1999 (1999/30/EC) and covered SO_2, NO_X, particulate matter and lead. The second daughter directive was adopted in November 2000 (2000/69/EC) and covers CO and benzene. The third daughter directive relates to ozone (2002/3/EC) and came out in 2002 while the fourth daughter directive (heavy metals and PAH, 2004/107/EC) was published in 2004. The first three directives have been transposed into Irish law as the Air Quality Standard Regulations 2002 (S.I No. 271 of 2002) and the Ozone in Ambient Air Regulations 2004 (S.I. No. 53 of 2004).

To comply with the directive the Environmental Protection Agency uses mobile laboratories to carry out assessments in areas with no history of air pollution measurements. The trailer in Kilkenny contained the following instruments:

- Monitoring instruments which continuously measure and record concentrations of the pollutants sulphur dioxide, nitrogen oxides and ozone.
- Instrument which continuously measures and records the levels of particulate matter.
- Sampler for particulate matter (the official method specified for this parameter by the EU commission involves collection of the particulate matter on a filter on site followed by laboratory determination of the filter's increase in weight).
- Sampler for lead and other metals in air (collection on filter for determination in the laboratory).

The sample inlets are at a height of ~3m.

For further information please contact

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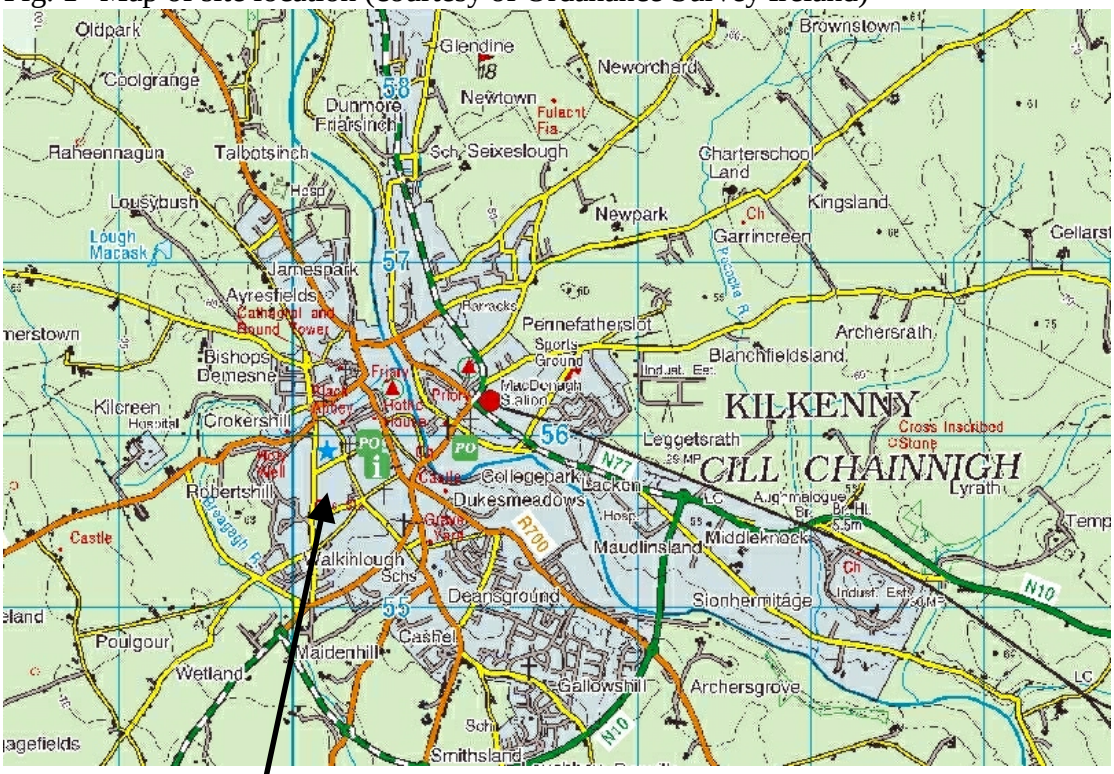
Time Period

Monitoring commenced in Kilkenny on 29th April 2005. The trailer was removed from the site on 25th October 2005.

Siting

The trailer was located in Kilkenny fire station on Gaol Road, Kilkenny in a largely residential district of the town. This location is approximately 400m from the town centre.

Fig. 1 Map of site location (courtesy of Ordanance Survey Ireland)



Site of Assessment

Monitoring Methods

Ozone

Ozone (O_3) was measured using an Advanced Pollution Instrumentation UV absorption O_3 analyser – Model 400E. This is a continuous analyser which measures the absorption of UV radiation by molecules of ozone.

Sulphur Dioxide

Sulphur dioxide was monitored using an Advanced Pollution Instrumentation SO_2 Fluorescent Analyser - Model 100A. This is a continuous analyser which measures the fluorescence of SO_2 molecules after excitation by ultraviolet radiation.

Nitrogen Dioxide and Oxides of Nitrogen

NO_x species were monitored using an Advanced Pollution Instrumentation Chemiluminescent $NO/NO_2/NO_x$ Analyser - Model 200A. This is a continuous analyser which utilises the chemiluminescent reaction between nitric oxide in the sample and ozone to measure NO concentrations. Any NO_2 present is then reduced to NO by a molybdenum converter giving a second value for total NO_x concentration. The amount of NO_2 present is found by subtraction.

Particulate Matter

A gravimetric method was used to monitor PM_{10} particles (as defined in European Standard, EN12341, July 1998, Central Secretariat, rue de Stassart, 36, B-1050 Brussels). An inertial impactor sampling head restricted the sampled particles to those with a diameter less than 10μm. The particles were collected on preweighed glassfibre filters (Whatman GF/A, 47mm). The filters were equilibrated at constant temperature and humidity (T = 293±1°K, R.H. = 50±3%) for at least 48 hours in a WTB Binder APT.Line KBF115 Climatic Chamber prior to weighing. An Ambient Dust Automatic Monitor (Model SM200CD with β source removed, OPSIS, S-24402, Furulund, Sweden) was used to change the filters daily at midnight.

Particulate matter was also measured using an OSIRIS Environmental Dust Monitor (Turnkey Instruments, 1&2 Dalby Court, Gadbrook Business Centre, Northwitch, Cheshire CW9 7TN). This instrument uses a light scattering technique to determine the concentration of airborne particles and dust; it is not an approved method. Results are given for total suspended particulates, PM_{10}, $PM_{2.5}$ and PM_1.

Lead and Other Metals

Ambient air was pumped through a Metricel membrane filter (Gelman, 37mm, 0.8μm) situated in a calming chamber. The filters were changed every 3-4 weeks. They were digested in conc. HNO_3 and analysed for lead and other metals using ICP-MS (Inductively Coupled Plasma-Mass Spectrometry).

All results for O_3, SO_2, NO_X and the continuous particulate monitor were integrated to give 1-hour average values as required for comparison with the Directive limit values.

Results
Ozone

No. of hours	4285	
Missing values	2244	
(including routine maintenance)	1	
No. of measured values	2041	
Percentage covered	47.6	
Maximum hourly value	109.4	$\mu g.m^{-3}$
98 percentile for hourly values	92.8	$\mu g.m^{-3}$
Mean hourly value	55.1	$\mu g.m^{-3}$
Maximum 8-hour mean	104.1	$\mu g.m^{-3}$
98 percentile for 8-hour mean	90.7	$\mu g.m^{-3}$

Directive (2002/3/EC) Target Values, Long Term Objectives, Information and Alert Thresholds

	Averaging Period	Limit Value	
Information Threshold for the protection of human health	1 hour	180 $\mu g.m^{-3}$	
Alert Threshold for the protection of human health	1 hour	240 $\mu g.m^{-3}$	
Target value for the protection of human health	Maximum daily 8hr mean	120 $\mu g.m^{-3}$ not to be exceeded more than 25 days per calendar year averaged over three years	2010
Target value for the protection of vegetation	AOT40 calculated from 1hr values from May to July	18,000 averaged over 5 years	2010
Long term objective for the protection of human health	Maximum daily 8hr mean within a calendar year	120 $\mu g.m^{-3}$	2020
Long term objective for the protection of vegetation	AOT40 calculated from 1hr values from May to July	6000 $\mu g.m^{-3}$	2020

The long term objective and the target value for the protection of human health were not exceeded during the measurement period (Figure 3). Similarly, the information and alert thresholds were not exceeded (Figure 2). No attempt was made to assess the effect of the measured ozone levels on vegetation as data was unavailable between 22nd June and 23rd Jul. The index used to measure ozone effects on plants (AOT40) is calculated between the months of May and July for vegetation and between April and September for forests.

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Fig. 2 Ozone Hourly Averages
Trailer 2 in Kilkenny 29/4/05 - 25/10/05

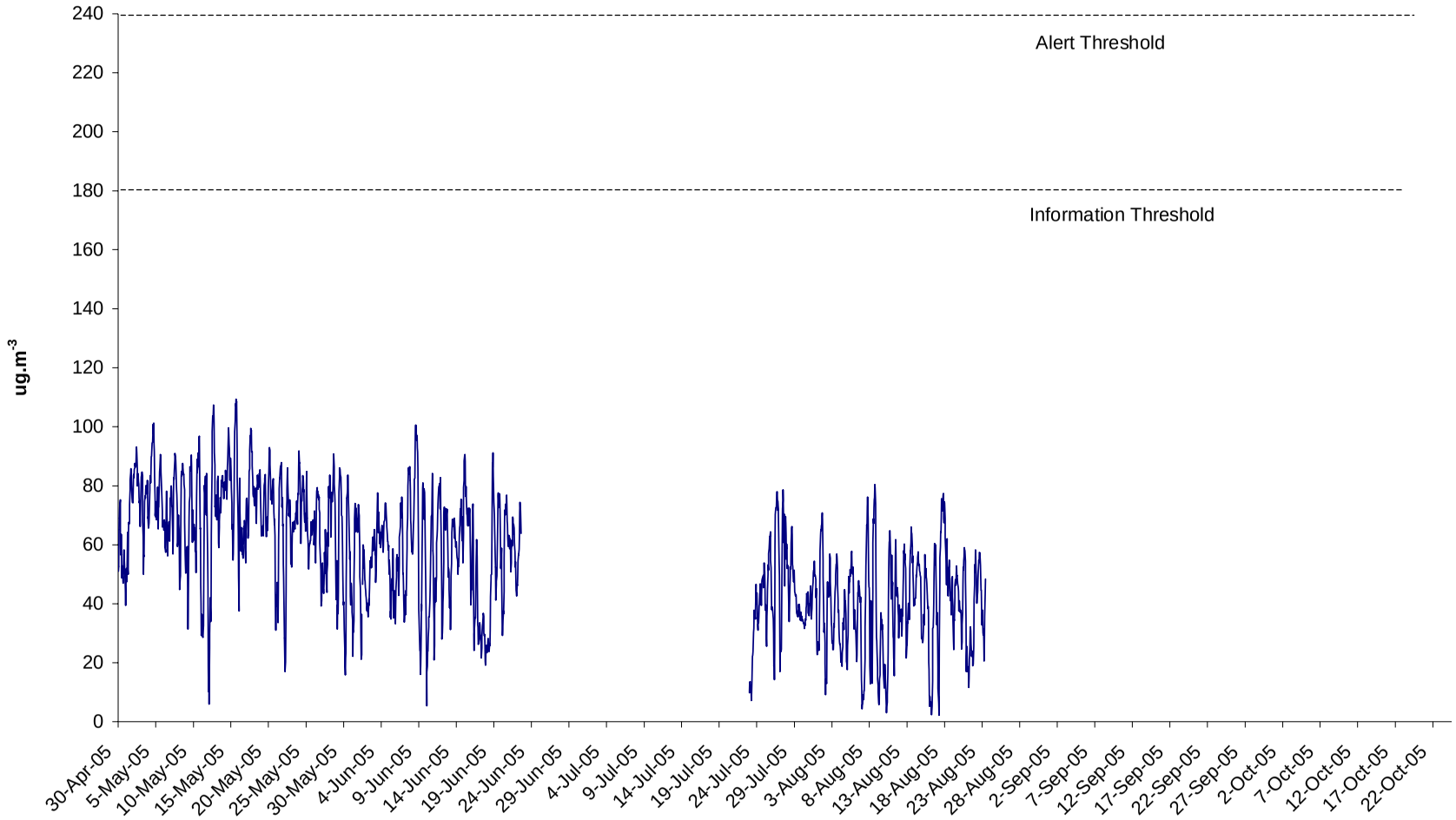
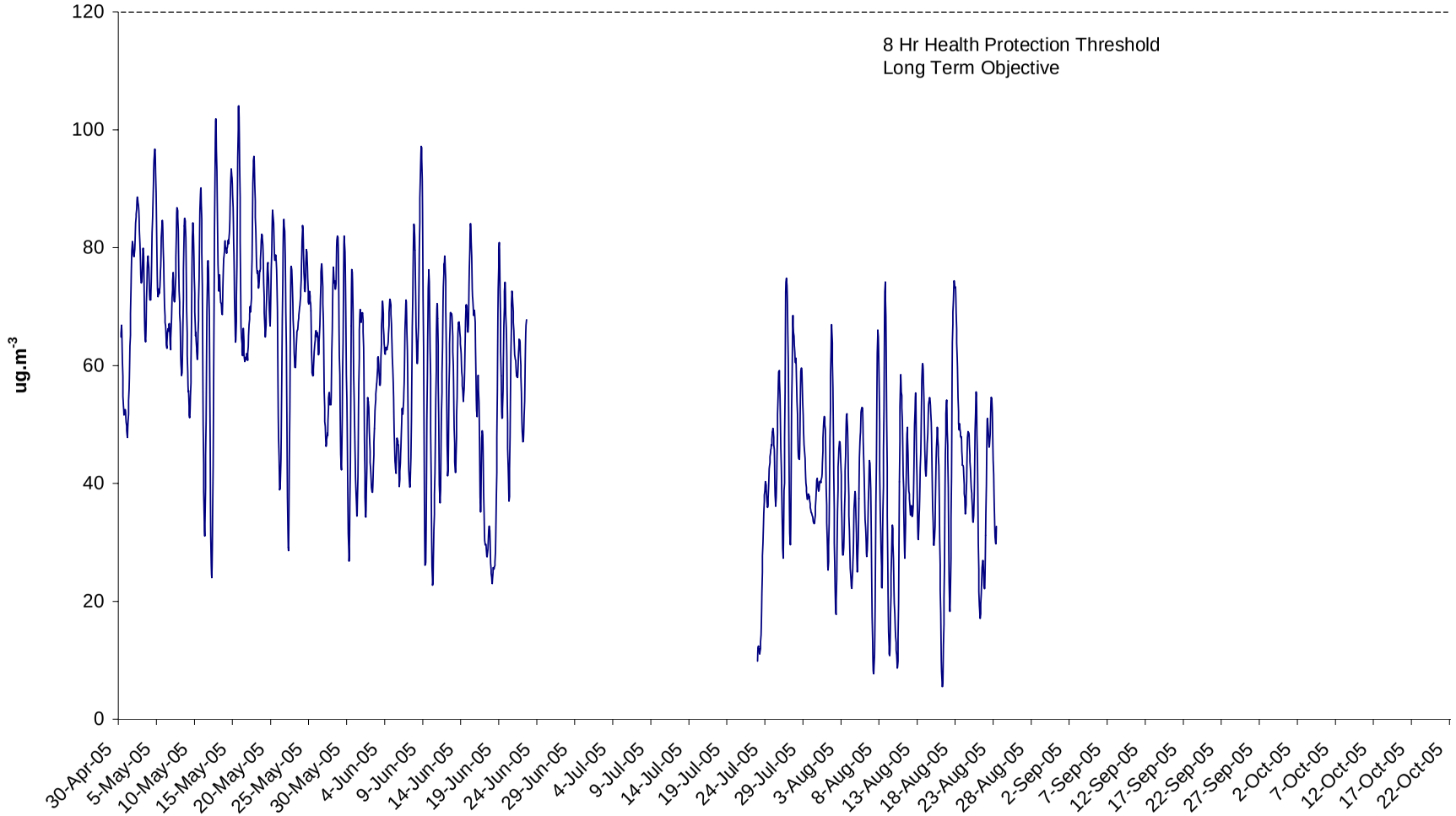


Fig. 3 Ozone 8 Hour Averages
Trailer 2 in Kilkenny 29/4/05 - 25/10/05



Sulphur Dioxide

No. of hours	4285	
Missing values	815	
(including routine maintenance)	2	
No. of measured values	3470	
Percentage covered	80.9	
Maximum hourly value	38.6	$\mu g.m^{-3}$
98 percentile for hourly values	11.7	$\mu g.m^{-3}$
Mean hourly value	4.8	$\mu g.m^{-3}$
Maximum 24-hour value	13.9	$\mu g.m^{-3}$
98 percentile for 24-hour values	10.6	$\mu g.m^{-3}$

Directive Limits (1999/30/EC)

	Averaging Period	Limit Value	Date by which limit value is to be met
Hourly limit value for the protection of human health	1 hour	350 $\mu g\ m^{-3}$ not to be exceeded more than 24 times a calendar year	1 January 2005
Daily limit value for the protection of human health	24 hours	125 $\mu g\ m^{-3}$ not to be exceeded more than 3 times a calendar year	1 January 2005
Limit value for the protection of ecosystems	Calendar year and winter (1 October to 31 March)	20 $\mu g\ m^{-3}$	19 July 2001
Alert threshold		500 $\mu g\ m^{-3}$ over three consecutive hours	

Directive Limits (1999/30/EC) continued

	Averaging Period	Limit Value	Date by which limit value is to be met
Upper assessment threshold for the protection of human health	24 hours	75 μg m^{-3} not to be exceeded more than 3 times a calendar year	
Lower assessment threshold for the protection of human health	24 hours	50 μg m^{-3} not to be exceeded more than 3 times a calendar year	
Upper assessment threshold for the protection of ecosystems	Calendar year and winter (1 October to 31 March)	12 μg m^{-3}	
Lower assessment threshold for the protection of ecosystems	Calendar year and winter (1 October to 31 March)	8 μg m^{-3}	

The hourly and daily limit values for the protection of human health were not exceeded during the measurement period. Similarly, the lower assessment threshold for the protection of human health was not exceeded (Figure 4). The average hourly value was lower than the lower assessment threshold for the protection of ecosystems.

Fig.4 Sulphur Dioxide 24 Hour Averages
Trailer 2 in Kilkenny 29/4/05 - 25/10/05

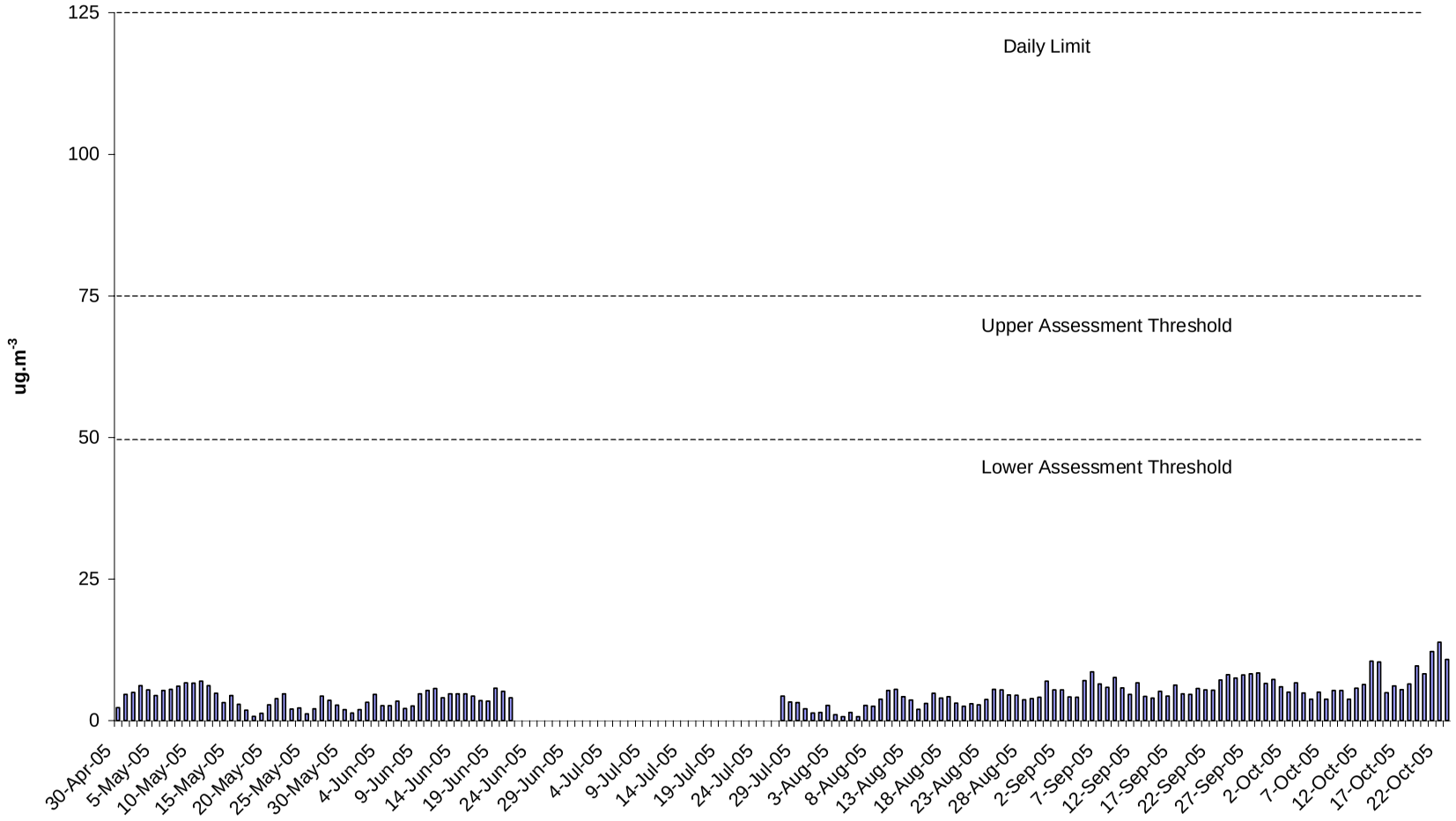
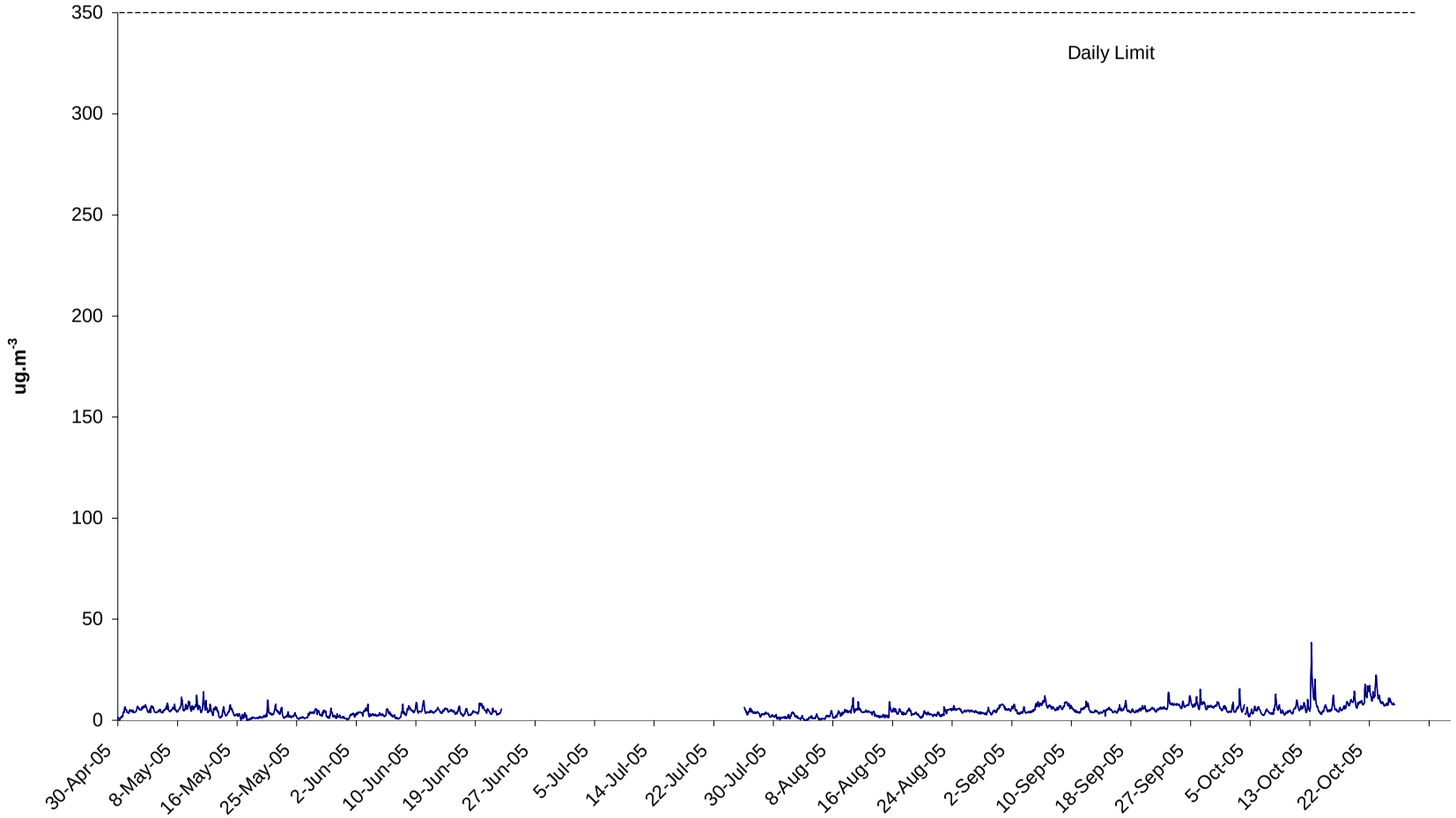


Fig. 5 Sulphur Dioxide Hourly Averages
Trailer 2 in Kilkenny 29/4/05 - 25/10/05



Nitrogen Dioxide and Oxides of Nitrogen

No. of hours	4285	
Missing values	730	
(including routine maintenance)	2	
No. of measured values	3555	
Percentage covered	82.3	
Maximum hourly value (NO_2)	64.2	$\mu g.m^{-3}$
98 percentile for hourly values (NO_2)	32.2	$\mu g.m^{-3}$
Mean hourly value (NO_2)	9.2	$\mu g.m^{-3}$
Mean hourly value (NO_x)	13.5	$\mu g.m^{-3}$ NO_2

Directive Limits (1999/30/EC)

	Averaging Period	Limit Value	Date by which limit value is to be met
Hourly limit value for the protection of human health	1 hour	200 $\mu g\ m^{-3}$ NO_2 not to be exceeded more than 18 times a calendar year	1 January 2010
Annual limit value for the protection of human health	Calendar year	40 $\mu g\ m^{-3}$ NO_2	1 January 2010
Annual limit value for the protection of vegetation	Calendar year	30 $\mu g\ m^{-3}$ NO_x	19 July 2001
Alert threshold		400 $\mu g\ m^{-3}$ NO_2 over three consecutive hours	

Directive Limits (1999/30/EC) continued

	Averaging Period	Limit Value	Date by which limit value is to be met
Upper assessment threshold for the protection of human health	1 hour	140 μg m^{-3} NO_2 not to be exceeded more than 18 times a calendar year	
Upper assessment threshold for the protection of human health	Calendar year	32 μg m^{-3} NO_2	
Lower assessment threshold for the protection of human health	1 hour	100 μg m^{-3} NO_2 not to be exceeded more than 18 times a calendar year	
Lower assessment threshold for the protection of human health	Calendar year	26 μg m^{-3} NO_2	
Upper assessment threshold for the protection of vegetation	Calendar year	24 μg m^{-3} NO_x	
Lower assessment threshold for the protection of vegetation	Calendar year	19.5 μg m^{-3} NO_x	

The hourly and annual limit values for the protection of human health were not exceeded during the measurement period (Figure 6). Similarly, the hourly and annual lower assessment thresholds for the protection of human health were not exceeded. The lower assessment threshold for the protection of vegetation was not exceeded.

NO, NO_2 and NO_X are measured as ppb (parts per billion) by volume. To convert to $\mu g.m^{-3}$, a factor (1.25 for NO, 1.91 for NO_2) is used. No formula is specified for NO_X, the directive requires it to be expressed as NO_2 (i.e. ppb*1.91). This applies even when most of the NO_X is present as NO.

Fig.6 NO_2 Hourly Values
Trailer 2 in Kilkenny 29/4/05 - 25/10/05

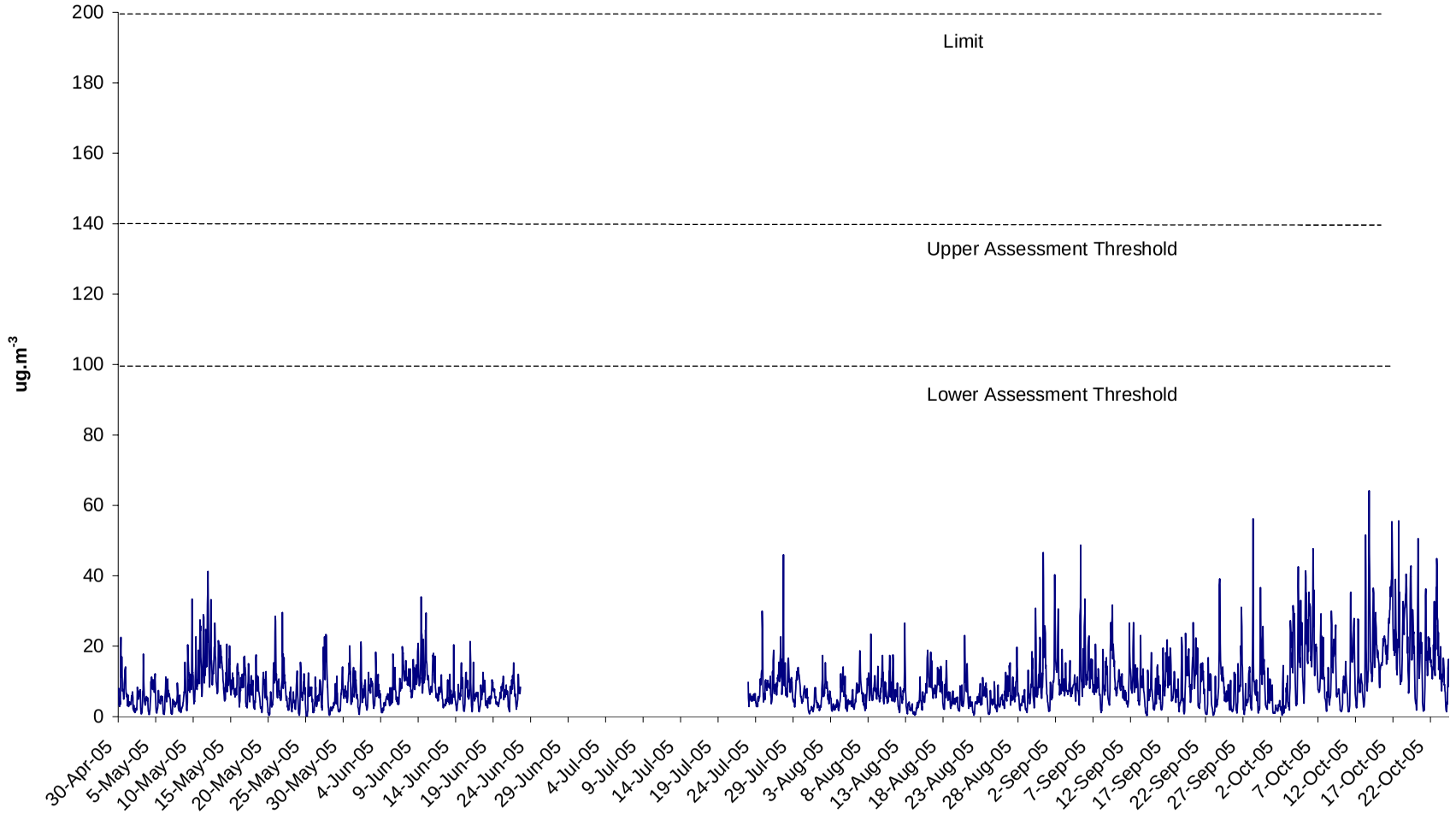
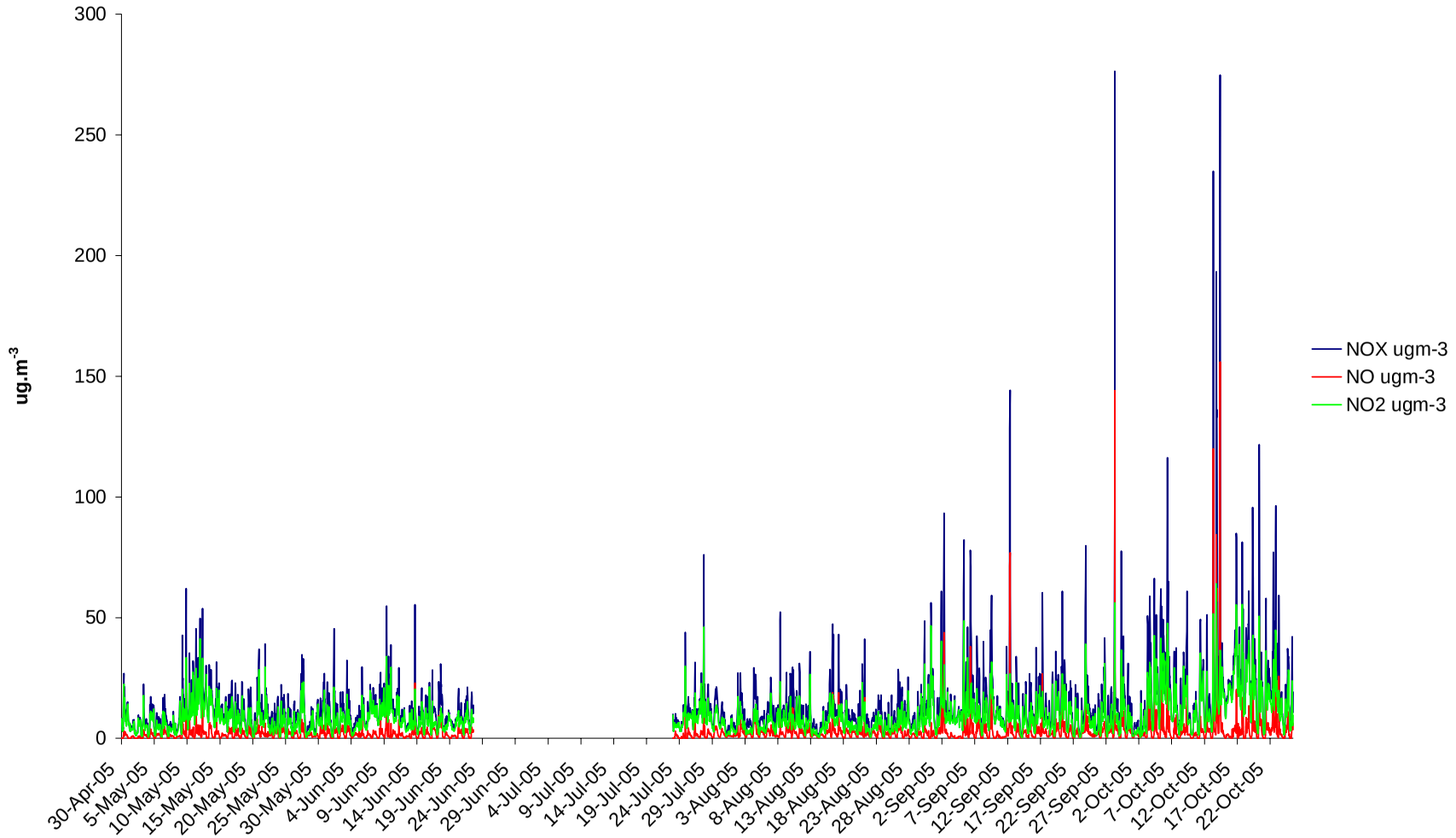


Fig. 7 NO_X Hourly Values
Trailer 2 in Kilkenny 29/4/05 - 25/10/05



Particulate Matter

PM_{10} : gravimetric method

No. of days	178	
Missing values	31	
(including routine maintenance)	0	
No. of measured values	147	
Percentage covered	82.6	
Maximum daily value	58.8	$\mu g.m^{-3}$
98 percentile for daily values	31.2	$\mu g.m^{-3}$
Mean daily value	12.8	$\mu g.m^{-3}$

Directive Limits (1999/30/EC)

STAGE I

	Averaging Period	Limit Value	Date by which limit value is to be met
24-hour limit value for the protection of human health	24 hour	50 $\mu g\ m^{-3}$ PM_{10} not to be exceeded more than 35 times a calendar year	1 January 2005
Annual limit value for the protection of human health	Calendar year	40 $\mu g\ m^{-3}$ PM_{10}	1 January 2005
Upper assessment threshold for the protection of human health	24 hour	30 $\mu g\ m^{-3}$ PM_{10} not to be exceeded more than 7 times a calendar year	*based on the indicative limit values for 1 January 2010*
Upper assessment threshold for the protection of human health	Calendar year	14 $\mu g\ m^{-3}$ PM_{10}	*based on the indicative limit values for 1 January 2010*

Directive Limits (1999/30/EC) Stage I continued

	Averaging Period	Limit Value	Date by which limit value is to be met
Lower assessment threshold for the protection of human health	24 hour	20 μg m^{-3} PM_{10} not to be exceeded more than 7 times a calendar year	*based on the indicative limit values for 1 January 2010*
Lower assessment threshold for the protection of human health	Calendar year	10 μg m^{-3} PM_{10}	*based on the indicative limit values for 1 January 2010*

STAGE II

	Averaging Period	Limit Value	Date by which limit value is to be met
24-hour limit value for the protection of human health	24 hour	50 μg m^{-3} PM_{10} not to be exceeded more than 7 times a calendar year	1 January 2010
Annual limit value for the protection of human health	Calendar year	20 μg m^{-3} PM_{10}	1 January 2010

The 2005 daily limit value for the protection of human health was exceeded on one occasion during the six month measurement period. The directive states that the limit value should not be exceeded more than 35 times in a calendar year. It is unlikely that the limit would be exceeded on the basis of one exceedence in a six month period.

The lower assessment threshold was exceeded on 22 days while the upper assessment threshold was exceeded on 5 days. The directive states that the assessment thresholds should not be exceeded more than 7 times in a calendar year. It is likely that the upper assessment threshold would be exceeded in a calendar year on the basis of 5 exceedences in the six month assessment period. The mean daily value exceeds the annual lower assessment threshold but not the upper assessment threshold.

Particulate Matter : $PM_{2.5}$

Article 5 of Council Directive 1999/30/EC of 22 April 1999 states that

"Member States shall ensure that measuring stations to supply data on concentration of $PM_{2.5}$ are installed."

The concentration of $PM_{2.5}$ was measured with an OSIRIS Environmental Dust Monitor in the mobile laboratory. This also measured total suspended particles (TSP), PM_{10} and PM_1. All measurements were hourly values.

The concentration of PM_{10} measured by the OSIRIS and that measured using the gravimetric method were compared to give a daily correction factor. The correction factor was used to estimate the concentration of $PM_{2.5}$ using the formula:

$$\text{24-hour average concentration of } PM_{2.5} = \text{OSIRIS 24-hour average concentration of } PM_{2.5} \times \frac{\text{gravimetric 24-hour average } PM_{10}}{\text{OSIRIS 24-hour average } PM_{10}}$$

Results:

No. of days	178	
Missing values	30	
(including routine maintenance)	0	
No. of measured values*	148	
Percentage covered	83.1	
Maximum daily value	40.1	$\mu g.m^{-3}$
98 percentile for daily values	15.8	$\mu g.m^{-3}$
Mean daily value	5.9	$\mu g.m^{-3}$
Median daily value	5.1	$\mu g.m^{-3}$

* no. of days with measurements from both the OSIRIS monitor and the gravimetric method.

Fig. 8 PM_{10} Daily Values
Trailer 2 in Kilkenny 29/4/05 - 25/10/05

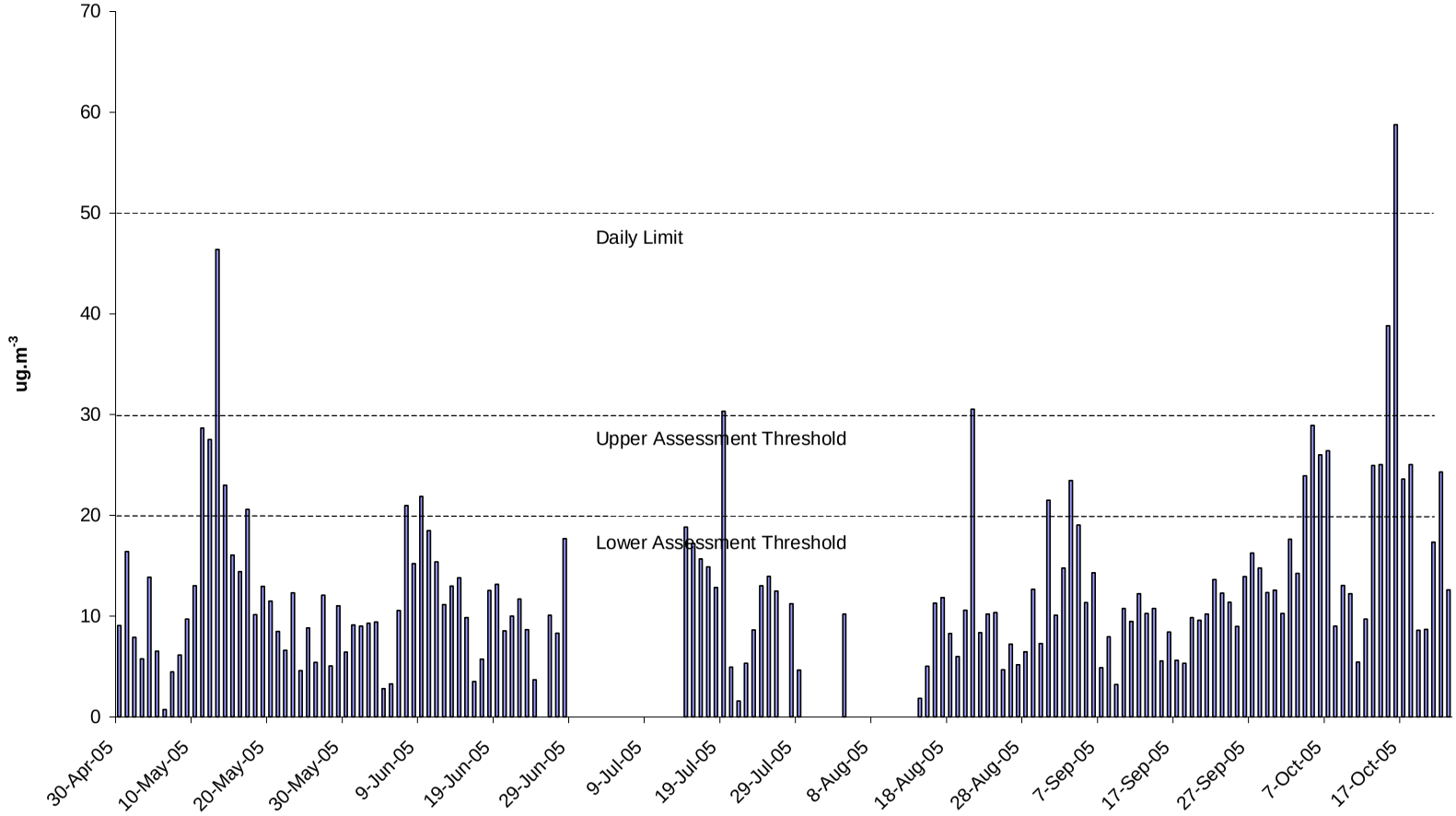
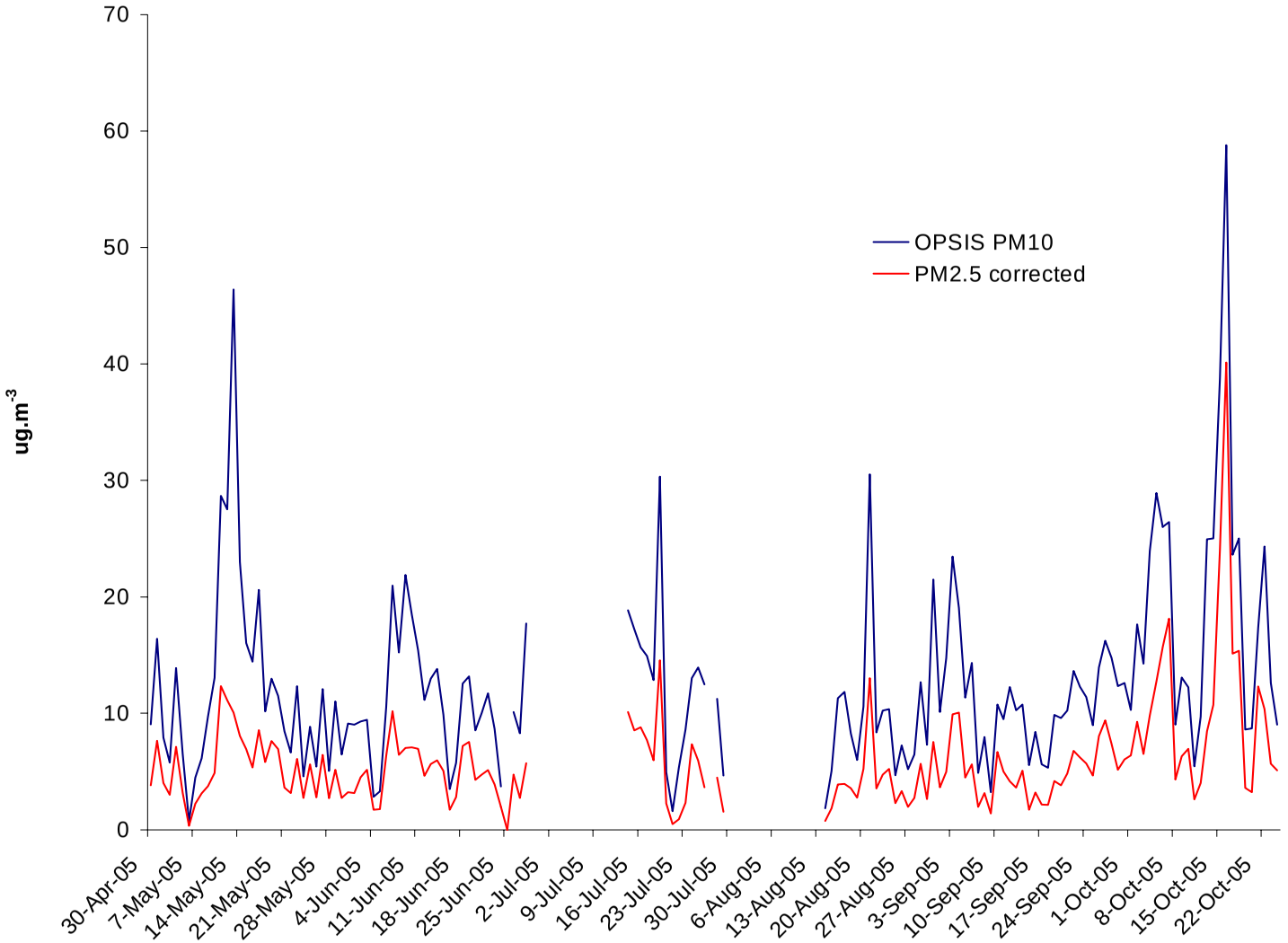


Fig. 9 PM_{10} and $PM_{2.5}$ Daily Values
Trailer 2 in Kilkenny 29/4/05 - 25/10/05



Lead

No. of days	179	
Missing days	0	
(including routine maintenance)	0	
No. of measured days	179	
Percentage covered	100	
Concentration of Pb	<0.01	$\mu g.m^{-3}$

Directive Limits (1999/30/EC)

	Averaging Period	Limit Value	Date by which limit value is to be met
Annual limit value for the protection of human health	Calendar year	0.5 $\mu g\ m^{-3}$	1 January 2005
Upper assessment threshold	Calendar year	0.35 $\mu g\ m^{-3}$	
Lower assessment threshold	Calendar year	0.25 $\mu g\ m^{-3}$	

Four filters were exposed to ambient air during the assessment. No lead was detected on any of these filters. The detection limit is different for each filter as it is influenced by the volume of air passed through the filter. The concentration of Lead is given above as less than the highest detection limit.

Other Metals:

Annex I of council directive 96/62/EC (Air Framework Directive) lists four metals other than lead to be taken into consideration in the assessment and management of ambient air quality. These are cadmium, arsenic, nickel and mercury . Target values for these metals as well as certain polycyclic aromatic hydrocarbons have been set out in the fourth daughter directive.

An indicative method was used during this assessment to measure prevailing concentrations of cadmium, nickel and arsenic in air. This method is detailed above and essentially involves pumping air through a filter for several weeks before digesting the filter and analysing the digest for lead and other metals using ICP-MS. The problem with this method is that the detection limit is influenced by any traces of metal in the filter paper as well as by the volume of air passed through the filter.
The results, although indicative, do provide some indication of the concentrations of these metals in air.

During this assessment

The maximum concentration of arsenic in air was lower than trace levels of arsenic known to exist on the filter papers.

The maximum concentration of nickel in air was lower than trace levels of nickel known to exist on the filter papers.

The maximum concentration of cadmium in air was lower than trace levels of cadmium known to exist on the filter papers.