Ambient Air Monitoring

In

Ennis

24th January 2006 to 18th April 2007

Contents

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Summary

An assessment of air quality was carried out in Ennis, Co. Clare from 24th January 2006 until 18th April 2007. No limit values were exceeded during the assessment.

Concentrations of sulphur dioxide, nitrogen dioxide, benzene 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				
Benzene				
Pb				

Ennis 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, benzene 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. During the assessment in Ennis

- 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

PM_{10} levels measured in Ennis were high compared to other monitoring sites in Ireland. Further monitoring and data analysis were conducted to investigate the issue. The most likely cause is domestic solid fuel burning.

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).

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) while the fourth Daughter Directive relates to heavy metals and polycyclic aromatic hydrocarbons (2004/107/EC). The first three Directives were 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 located in Ennis contained the following instruments:

- Monitoring instruments which continuously measure and record concentrations of the pollutants sulphur dioxide, ozone, nitrogen oxides, carbon monoxide and particulate matter.
- Gas chromatograph which measures levels of benzene, toluene and xylene
- 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 the Air Quality Team

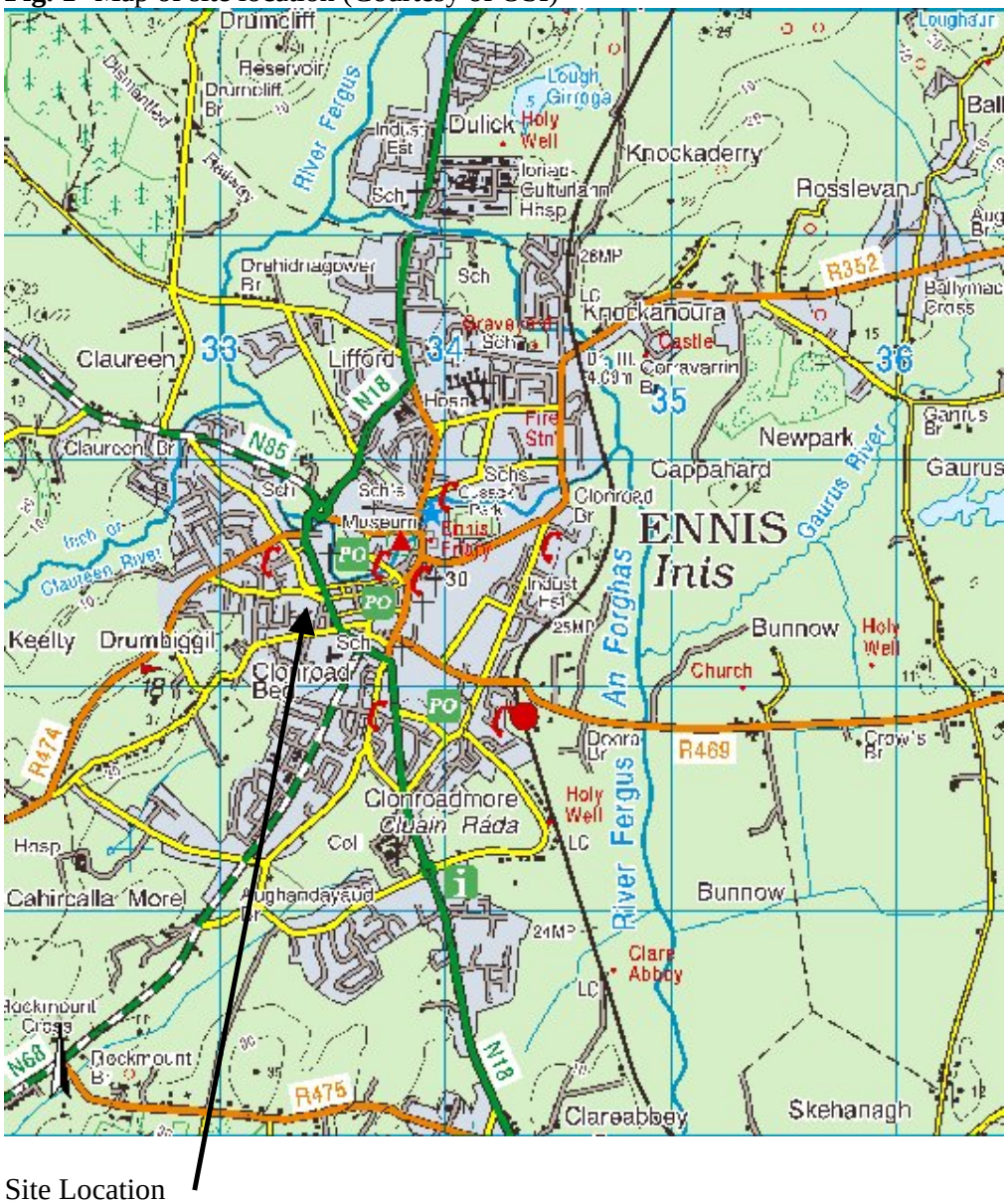
Time Period

The mobile laboratory was moved to Ennis on 24th January 2006. The trailer remained in Ennis until 18th April 2007.

Siting

The mobile laboratory was sited in the premises of Ennis Town Council in Drumbiggil. In this location the laboratory was sited less than 500m from the centre of the town and approximately 150m from the busy N18 road which runs through the town. The laboratory was located in a primarily residential area.

Fig. 1 Map of site location (Courtesy of OSI)



Site Location

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

Concentrations of PM_{10} were measured using the standard gravimetric method up to the middle of May 2006 and thereafter using with an instrument which employed tapered element oscillating microbalance technology (TEOM, Rupprecht & Patashnick Co. Inc., 25 Corporate Circle, Albany, New York).

The gravimetric method is 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.

The TEOM is a continuous method in which the air from the sampling head is passed through a filter placed on a tapered element. A mass transducer relates changes in the frequency of the tapered element to changes in particulate matter on the filter, the difference between the filter's current weight and its initial weight gives the total mass of collected particulate matter. An inertial impactor sampling head restricted the sampled particles to those with a diameter less than 10μm. PM_{10} concentrations measured by the TEOM were multiplied by a correction factor of 1.3 to compensate for the loss of volatile matter as recommended by the EC working group on particulate matter.

Benzene

Benzene was measured using a gas chromatograph (BTX Analyser GC855 supplied by Syntech Spectras, G. Meirstraat 11, 9728 TB Groningen, Nederland). This gas chromatograph samples automatically over a fifteen minute cycle and is equipped with a photoionisation detector.

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 CO, 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	10760	
Missing values	1235	
(including routine maintenance)	24	
No. of measured values	9525	
Percentage covered	88.7	
Maximum hourly value	139.6	µg/m^3
98 percentile for hourly values	94.6	µg/m^3
Mean hourly value	54.3	µg/m^3
Maximum 8-hour mean	118.4	µg/m^3
93.1th percentile – maximum daily 8-hour mean	92.2	µg/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 µg/m^3	
Alert Threshold for the protection of human health	1 hour	240 µg/m^3	
Target value for the protection of human health	Maximum daily 8hr mean	120 µg/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 µg/m^3 h averaged over 5 years	2010
Long term objective for the protection of human health	Maximum daily 8hr mean within a calendar year	120 µg/m^3	2020
Long term objective for the protection of vegetation	AOT40 calculated from 1hr values from May to July	6000 µg/m^3	2020

The information and alert thresholds for the protection of human health were not exceeded during the assessment (Fig. 2). Similarly, the target value and the long term objective for the protection of human health were not exceeded during the assessment (Fig. 3). The impact of ozone on vegetation is quantified using an index called AOT40, this index is calculated using daytime hourly ozone values during the months of May, June and July. However, the AOT 40 index was not calculated as there was a large amount of missing data during the months of June and July.

Fig. 2 Ozone Hourly Averages
Ennis 24/1/06 - 18/4/07

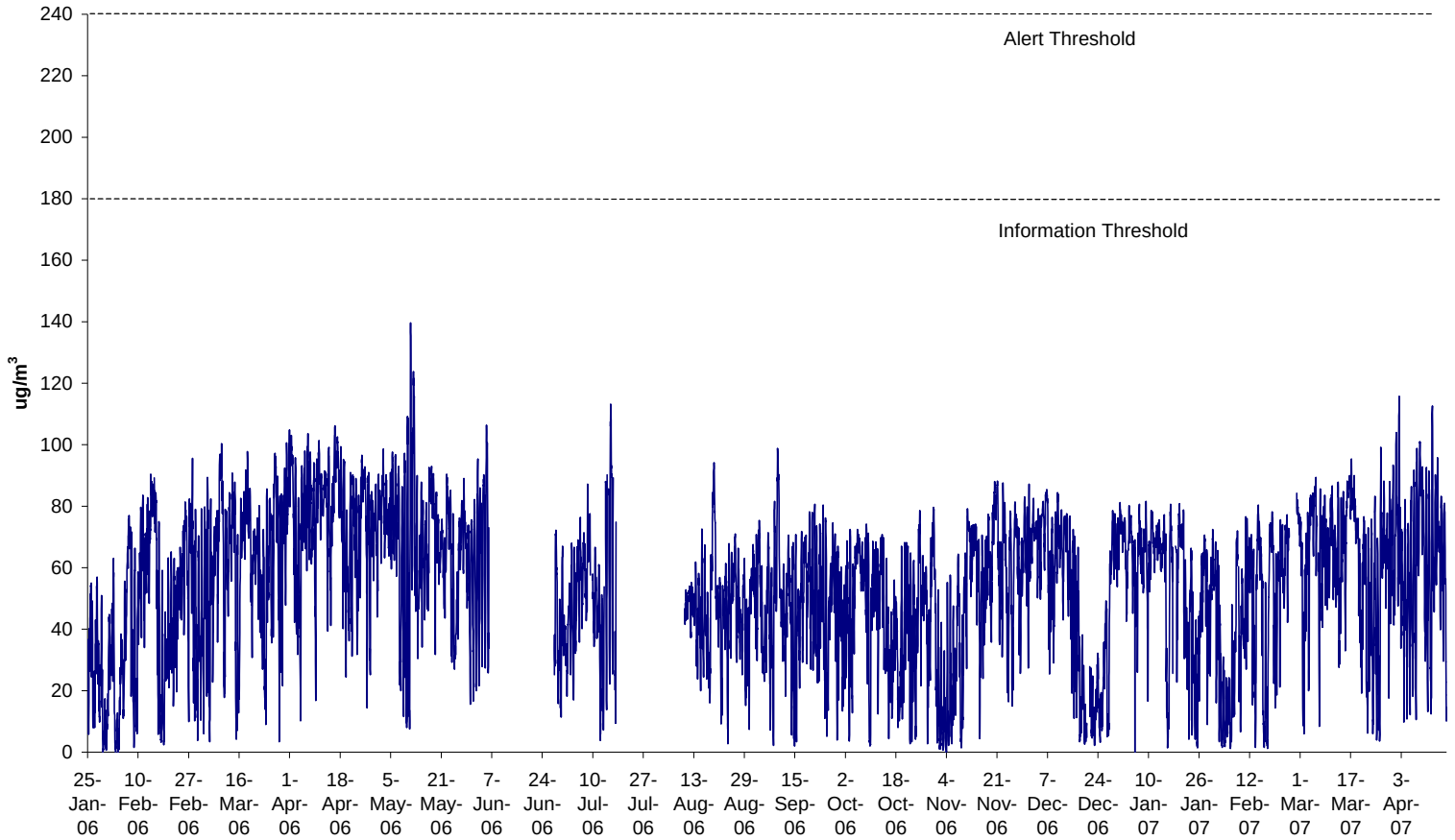
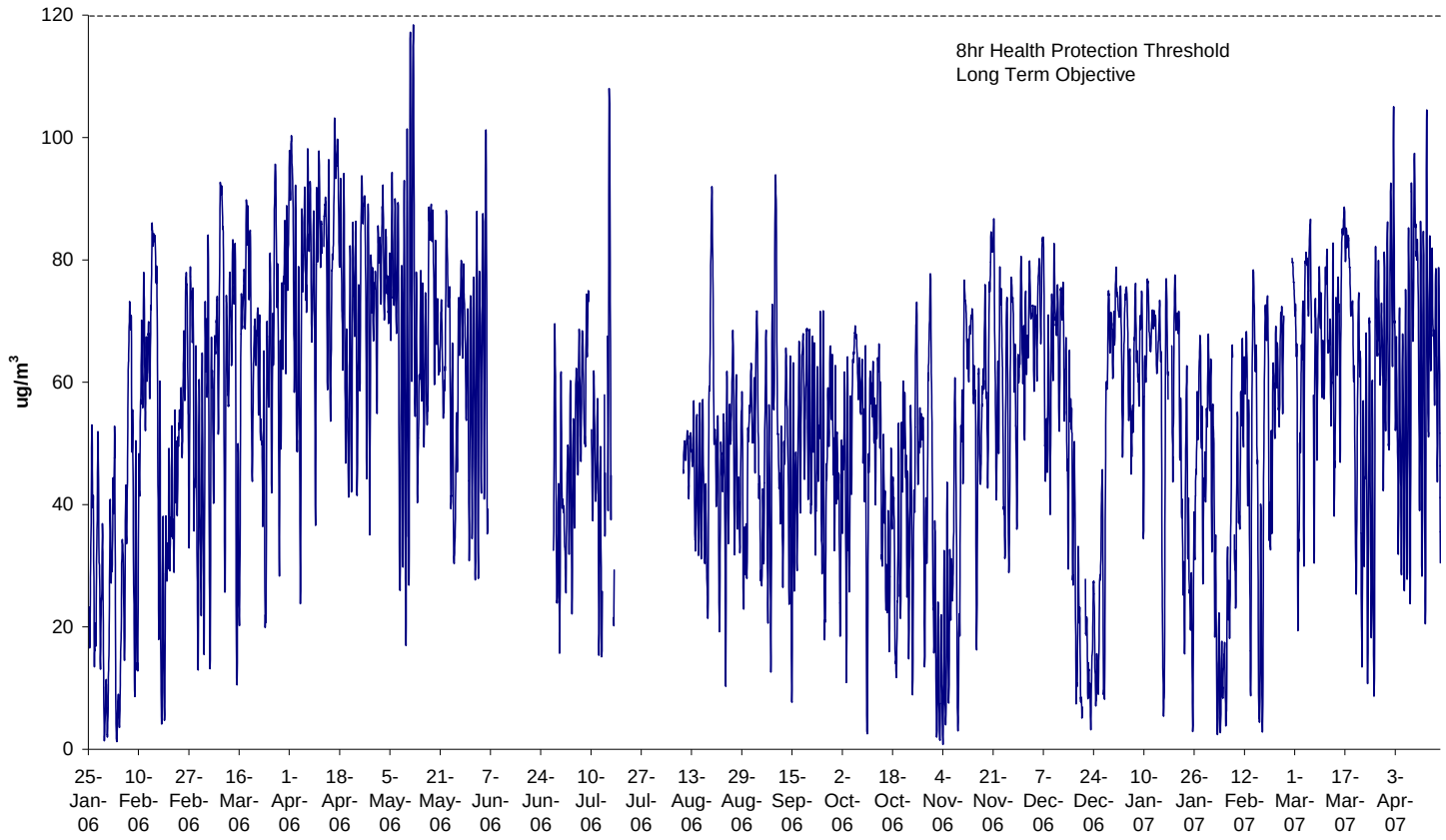


Fig. 3 Ozone 8hr Averages
Ennis 24/1/06 - 18/4/07



Sulphur Dioxide

No. of hours	10760	
Missing values	1665	
(including routine maintenance)	2	
No. of measured values	9095	
Percentage covered	84.5	
Maximum hourly value	106.9	µg/m^3
99.7 percentile for hourly values	68.4	µg/m^3
Mean hourly value	9.9	µg/m^3
Mean value Winter Period 1/10/06 – 31/3/07	12.1	µg/m^3
Maximum 24-hour value	45.5	µg/m^3
99.2 percentile for 24-hour values	38.1	µg/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 µg/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 µg/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 µg/m^3	19 July 2001
Alert threshold		500 µg/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 assessment. Similarly, the lower assessment threshold for the protection of human health was not exceeded during the assessment (Fig. 4). The mean value for the October 2006-March 2007 winter period exceeded the upper assessment threshold for the protection of vegetation. However, this limit may not be applicable to air quality monitoring in urban areas.

Fig. 4 Sulphur Dioxide 24hr Averages
Ennis 24/1/06 - 18/4/07

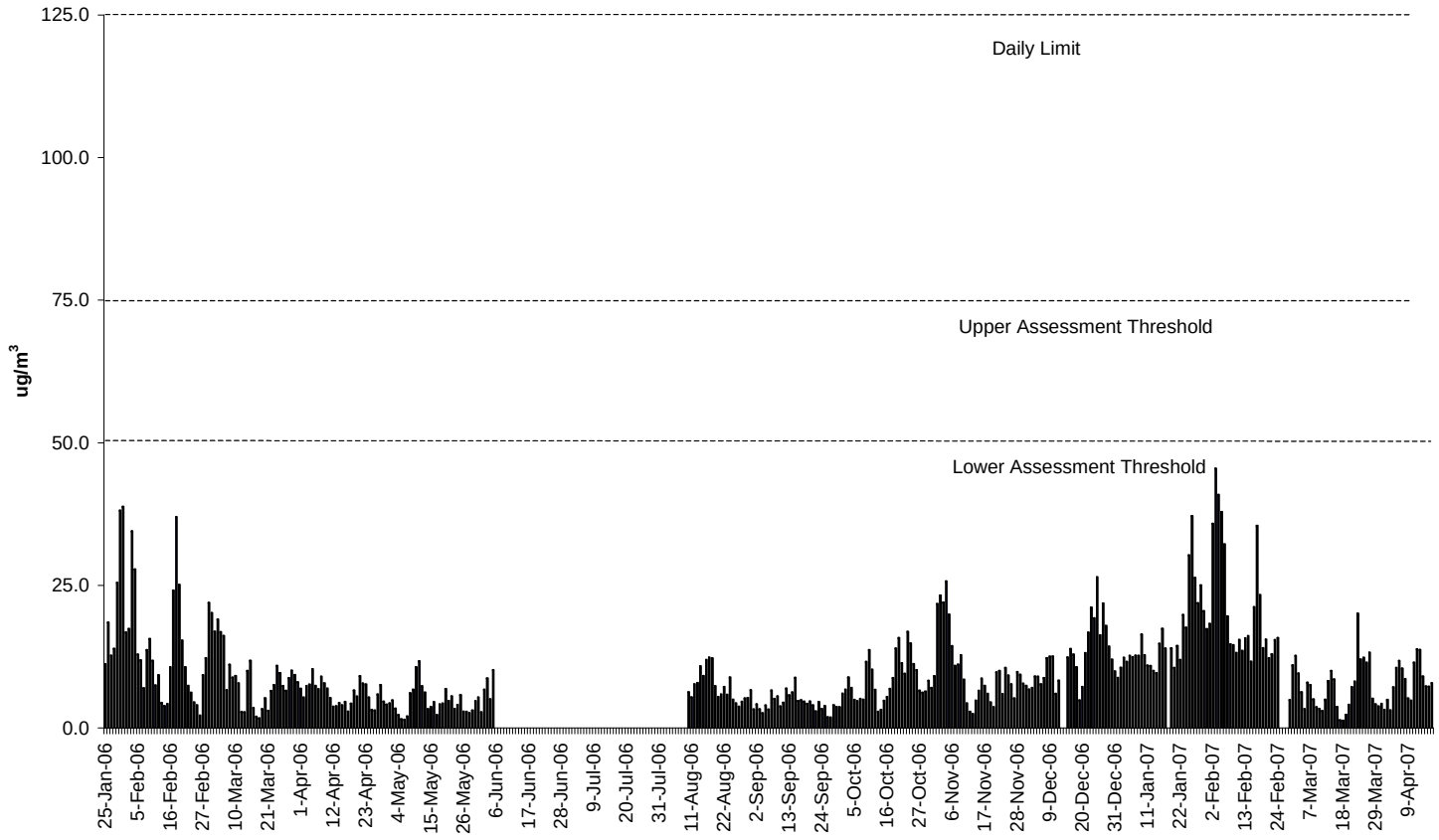
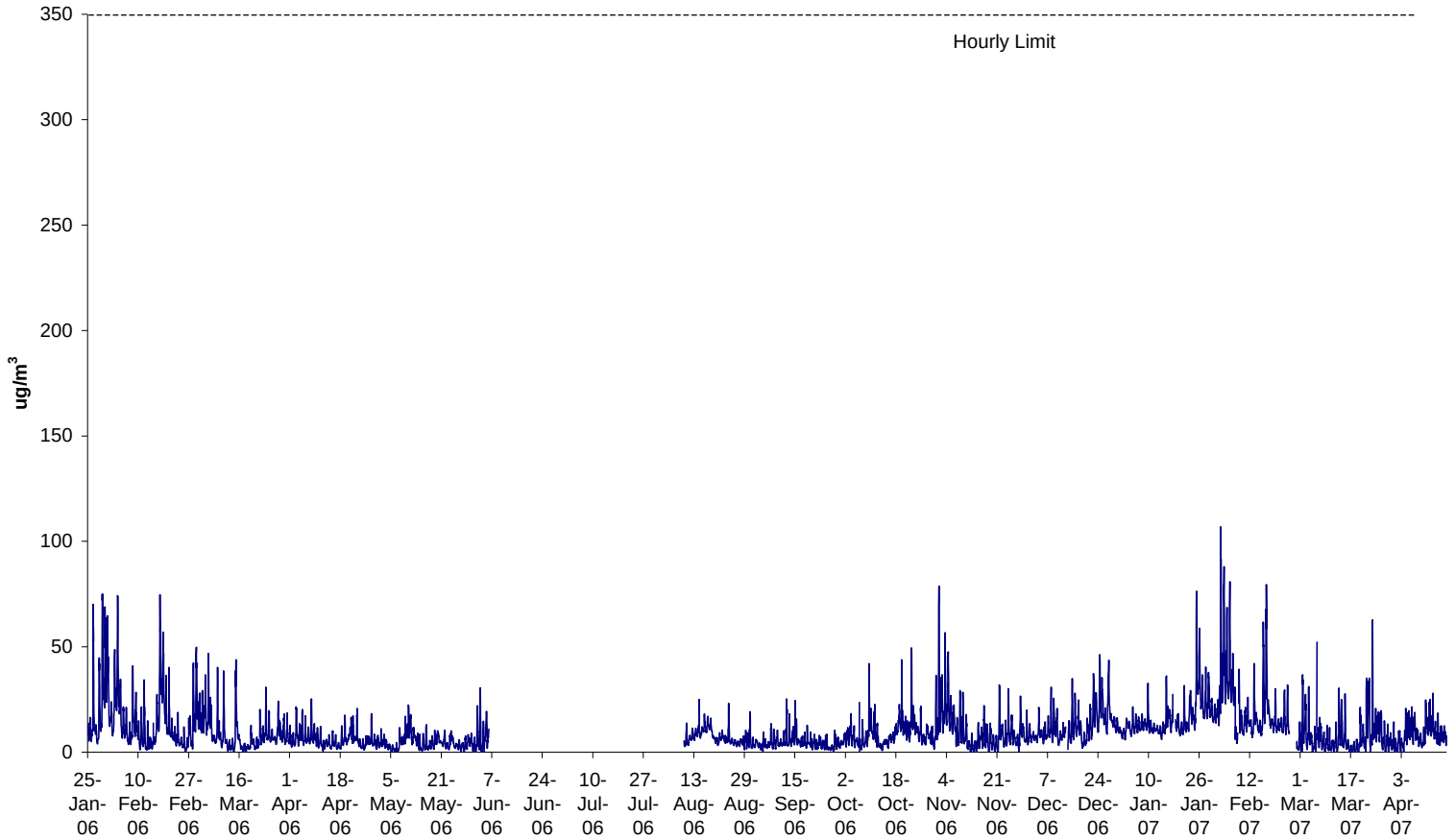


Fig. 5 Sulphur Dioxide Hourly Averages
Ennis 24/1/06 - 18/4/07



Nitrogen Dioxide and Oxides of Nitrogen

No. of hours	10760	
Missing values	3374	
(including routine maintenance)	28	
No. of measured values	7386	
Percentage covered	68.9	
Maximum hourly value (NO_2)	128.3	$\mu g/m^3$
99.8 percentile for hourly values (NO_2)	49.7	$\mu g/m^3$
Mean hourly value (NO_2)	13.1	$\mu g/m^3$
Mean hourly value (NO_x)	19.7	$\mu g/m^3$ 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	

Daily and annual limit values for the protection of human health were not exceeded during the assessment. The hourly lower assessment threshold for the protection of

human health was exceeded 5 times during the assessment (Fig. 6). However, Ennis is classified as below the hourly lower assessment threshold for NO_2 as 18 exceedances are permitted in a calendar year. Additionally, the annual lower assessment threshold for the protection of human health was not exceeded. The lower assessment threshold for the protection of vegetation was exceeded during the assessment. However, this limit may not be applicable to air quality monitoring in urban areas.

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
Ennis 24/1/06 - 18/4/07

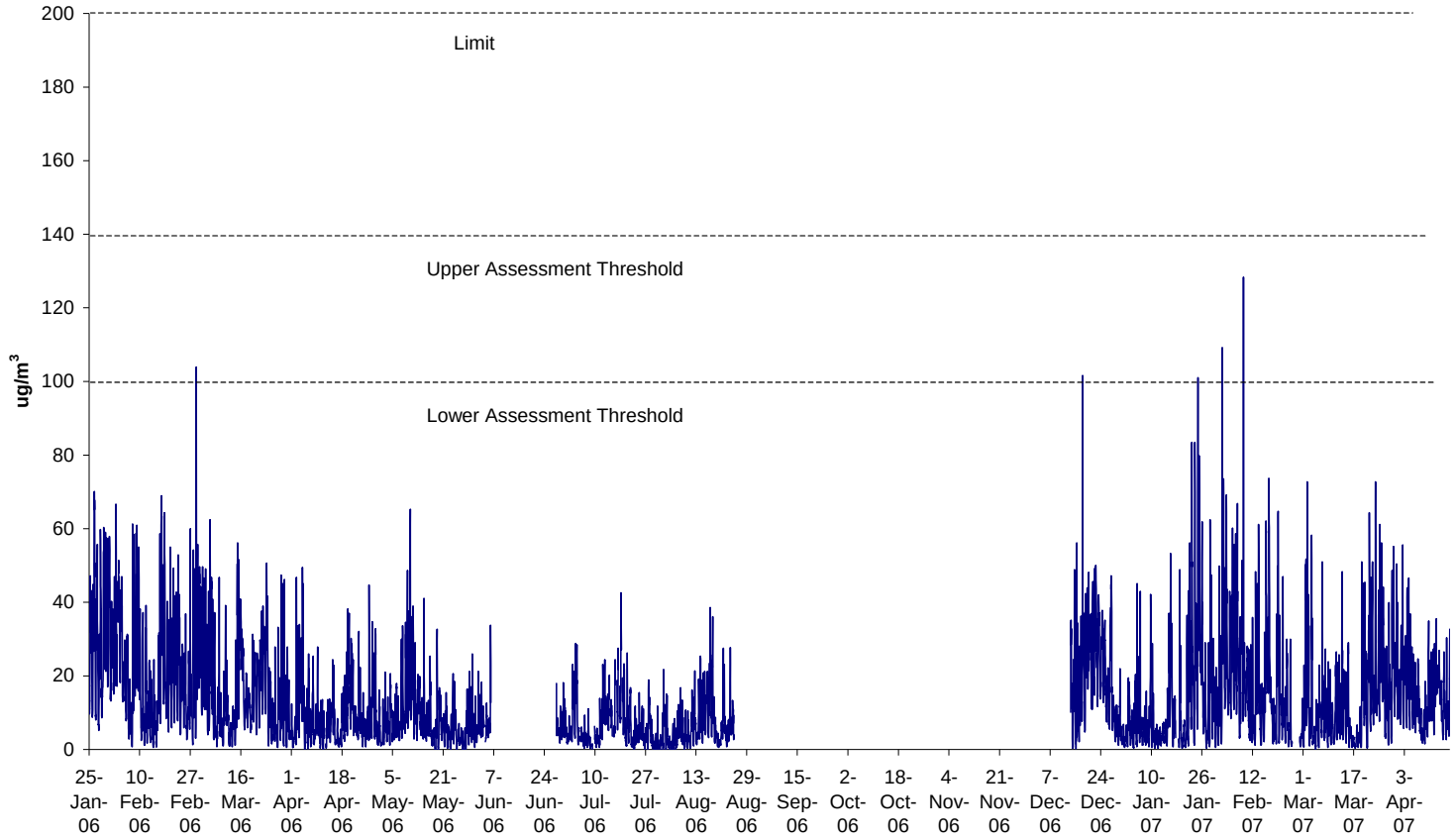
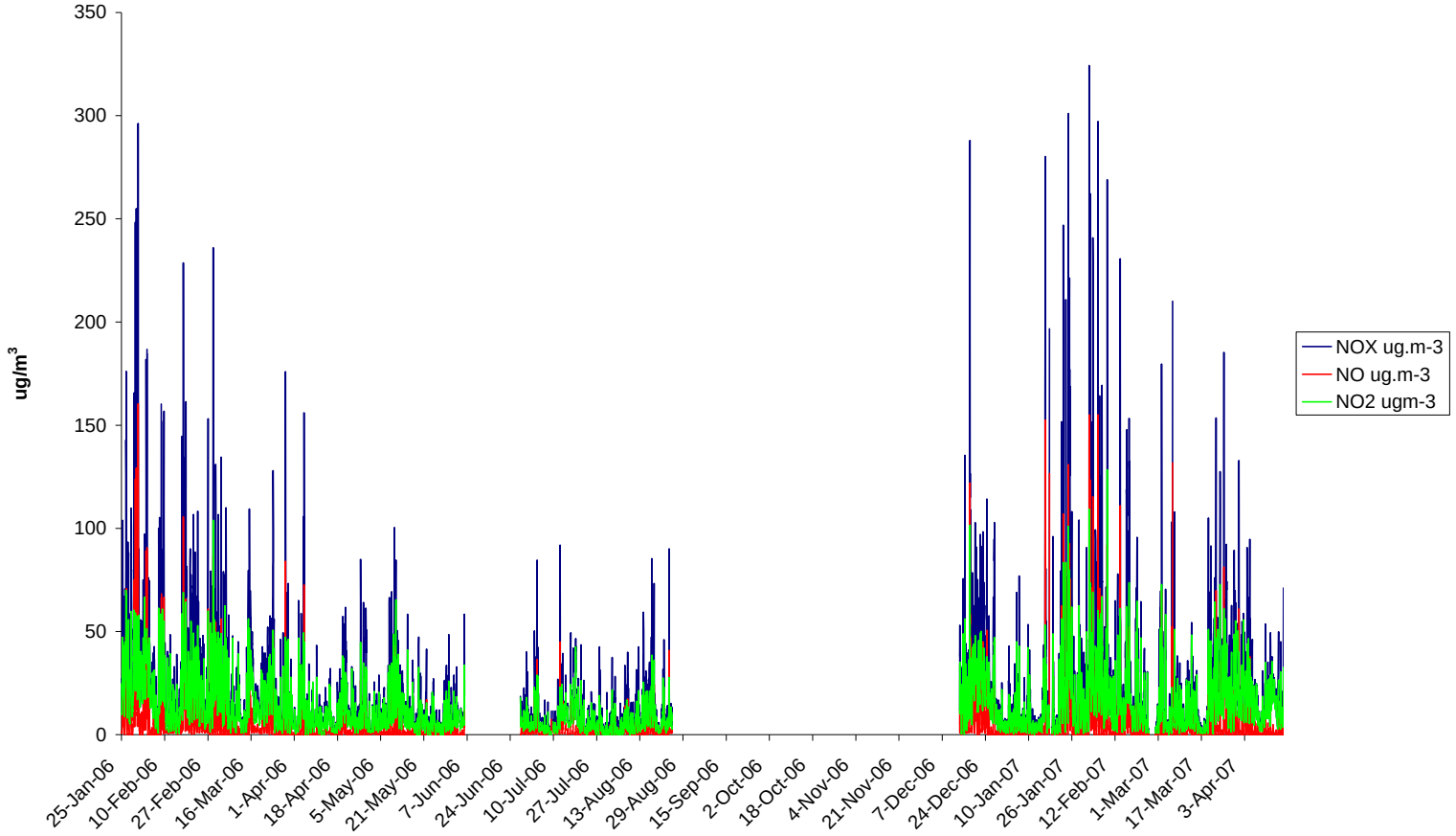


Fig. 7 NO_X Hourly Values
Ennis 24/1/06 - 18/4/07



Particulate Matter

PM_{10} :

No. of days	448	
Missing values	82	
(including routine maintenance)	0	
No. of measured values	366	
Percentage covered	81.7	
Maximum daily value	102.6	$\mu g/m^3$
90.4 percentile for daily values	48.7	$\mu g/m^3$
Mean daily value	28.8	$\mu g/m^3$
Mean Winter Value (Oct. 06-Mar. 07)	35.0	$\mu g/m^3$
Mean Summer Value (Apr. 06-Oct. 06)	21.1	$\mu g/m^3$

Directive Limits (1999/30/EC)

	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) continued

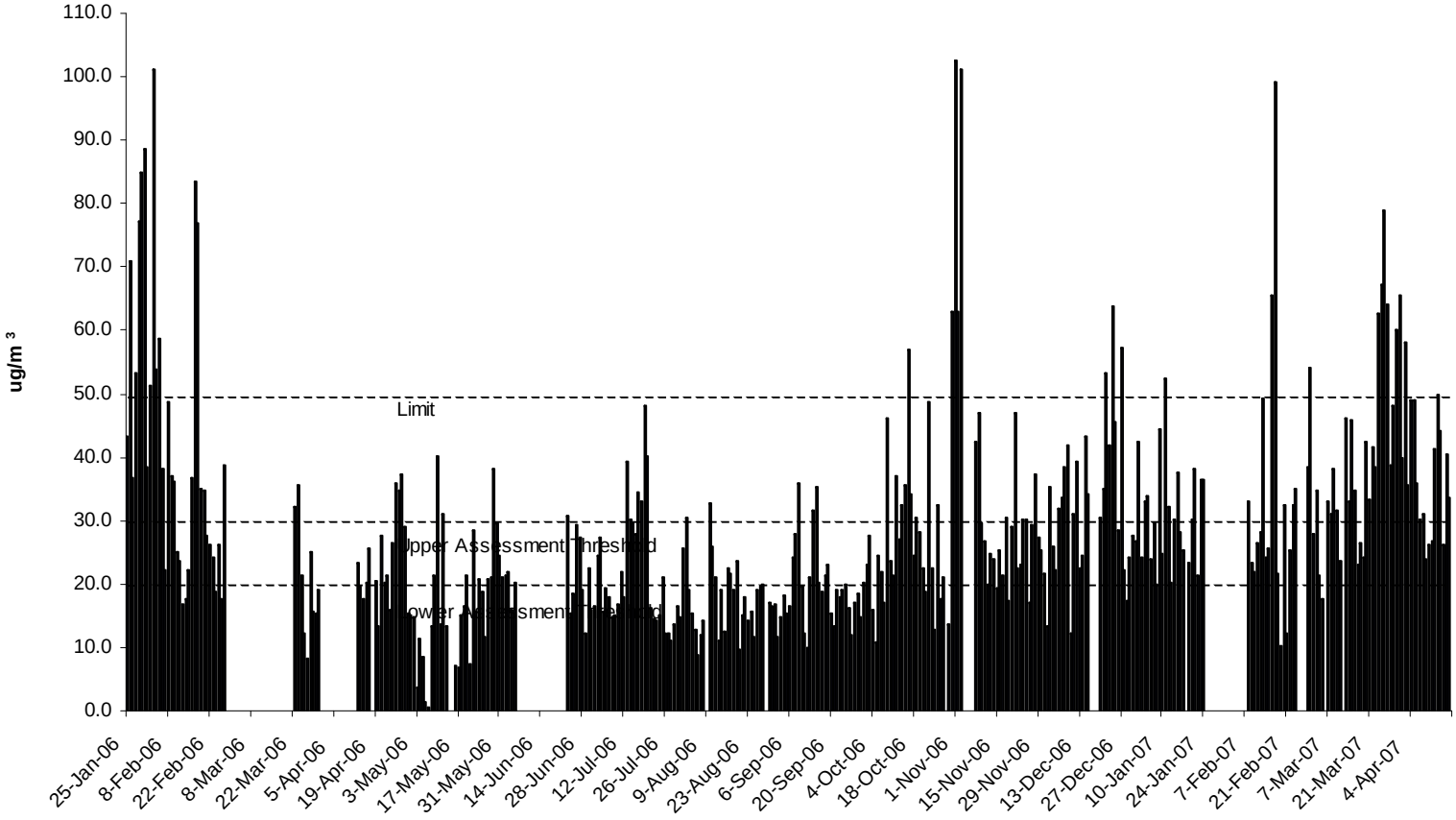
	Averaging Period	Limit Value	Date by which limit value is to be met
Lower assessment threshold for the protection of human health	24 hour	20 µg/m^3 PM_{10} not to be exceeded more than 7 times a calendar year	*based on the indicative limit values for 1 January 2010*
Lower assessment threshold for the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

PM_{10} was measured using the standard gravimetric method up to the middle of May 2006 and thereafter using the oscillating microbalance method. There were 30 values greater than the daily limit during the 14.5 months of the assessment (Fig. 8). However, 35 exceedances are permitted in a calendar year and consequently the daily limit was not exceeded during the assessment. Similarly, the annual limit value was not exceeded during the assessment. The daily lower assessment threshold was exceeded on 244 days while the daily upper assessment threshold was exceeded on 132 days. Ennis is classified as above the upper assessment threshold as only 7 exceedances are permitted in a calendar year. The annual upper assessment threshold was also exceeded.

High concentrations of PM_{10} were more prevalent in the winter than in the summer. The daily limit value was exceeded on two occasions during the six month period April 2006 to October 2006, the mean daily value for this period was 20.1 µg/m^3. In contrast, the daily limit value was exceeded on 18 occasions during the following six winter months, the mean daily value for the winter period was 35.0 µg/m^3.

PM10 levels measured in Ennis were higher than at other stations in Ireland. Further monitoring and data analysis was carried out to determine the cause. Details of this are on page 30.

Fig. 8 PM_{10} Daily Values
Ennis 24/1/06 - 18/4/07



Benzene

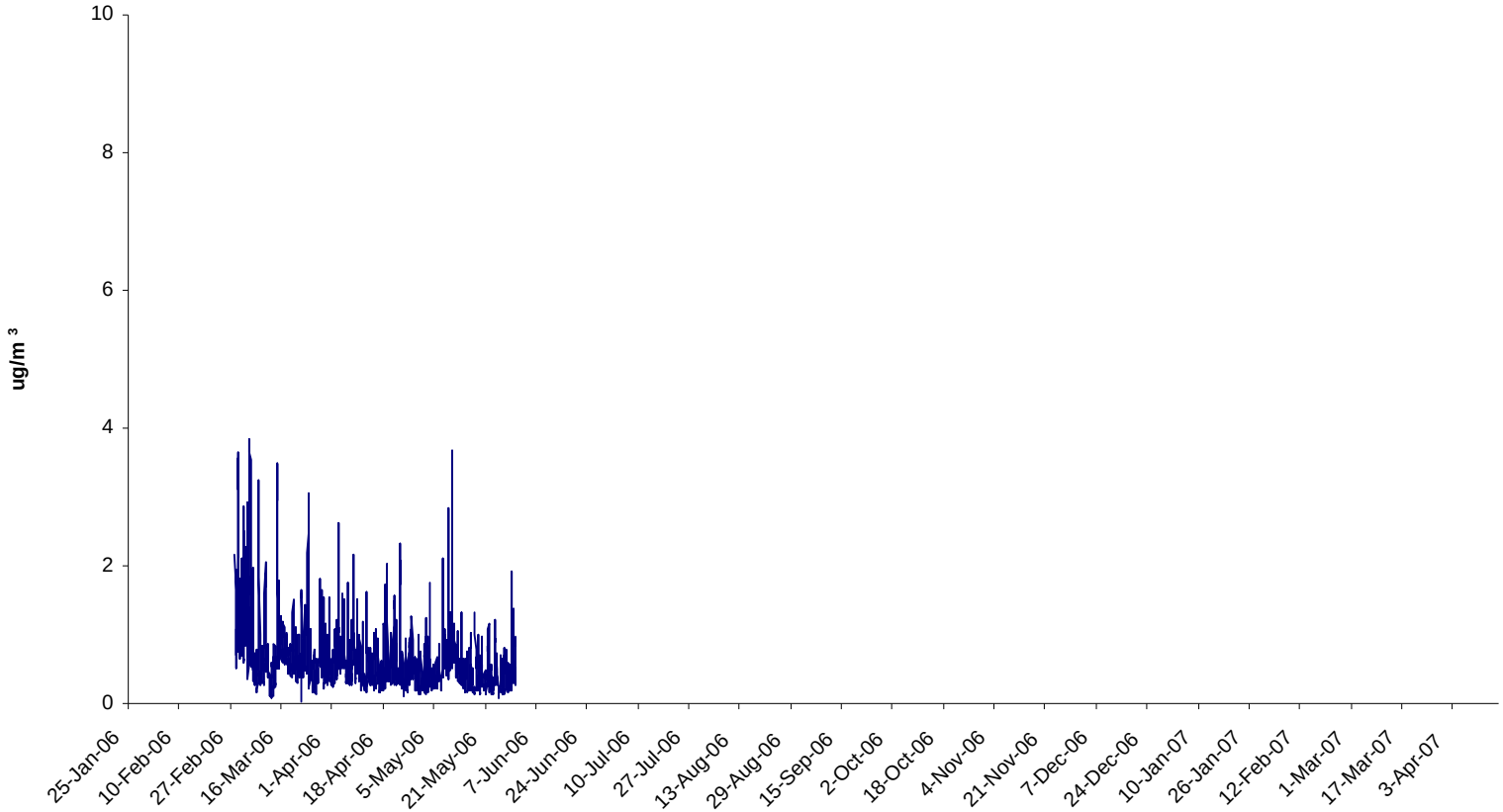
No. of hours	10760	
Missing values	8562	
(including routine maintenance)	7	
No. of measured values	2198	
Percentage covered	20.5	
Maximum hourly value	3.8	µg/m^3
98 percentile for hourly values	2.0	µg/m^3
Mean hourly value	0.6	µg/m^3

Directive Limits (2000/69/EC)

	Averaging Period	Limit Value	Date by which limit value is to be met
Limit value for the protection of human health	Calendar year	5 µg/m^3	1 January 2010
Upper assessment threshold for the protection of human health	Calendar year	3.5 µg/m^3	
Lower assessment threshold for the protection of human health	Calendar year	2 µg/m^3	

The lower assessment threshold was not exceeded during the assessment.

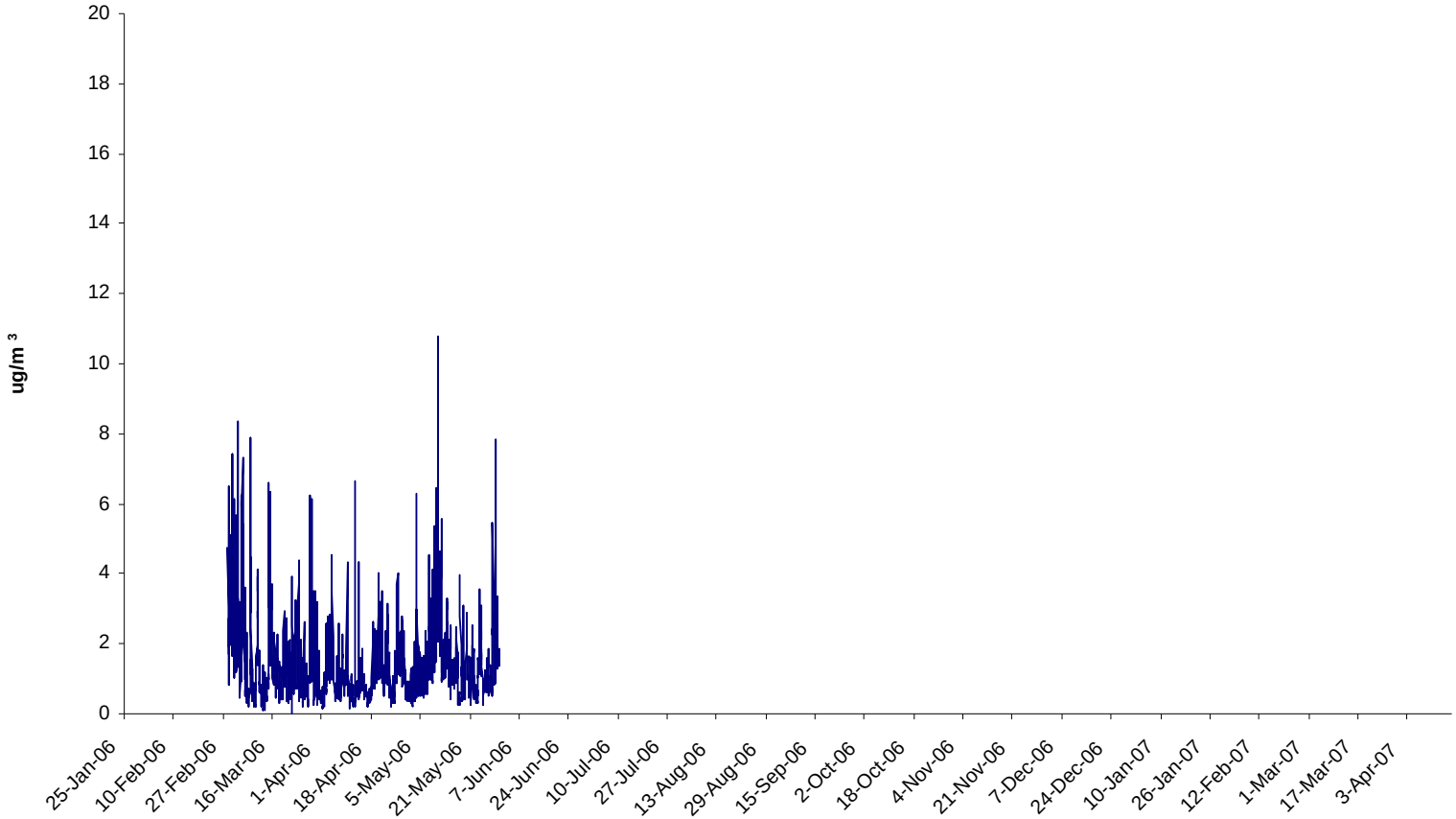
Fig. 9 Benzene Hourly Values
Ennis 24/1/06 - 18/4/07



Toluene

No. of hours	10760	
Missing values	8562	
(including routine maintenance)	7	
No. of measured values	2198	
Percentage covered	20.5	
Maximum hourly value	10.8	µg/m^3
98 percentile for hourly values	4.5	µg/m^3
Mean hourly value	1.4	µg/m^3

Fig. 10 Toluene Hourly Values
Ennis 24/1/06 - 18/4/07



Lead

No. of days	449	
Missing days	35	
(including routine maintenance)	0	
No. of measured days	414	
Percentage covered	92.2	
Concentration of Pb	0.02	µg/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 µg/m^3	1 January 2005
Upper assessment threshold	Calendar year	0.35 µg/m^3	
Lower assessment threshold	Calendar year	0.25 µg/m^3	

The lower assessment threshold was not exceeded during the assessment.

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 . Limit values and measurement methods for these metals as well as certain polycyclic aromatic hydrocarbons were subsequently set out in the fourth Daughter Directive (2004/107/EC).

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. With this method, 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

Cadmium was detected on one filter only. The concentration of cadmium on this filter was 0.3ng/m^3.

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

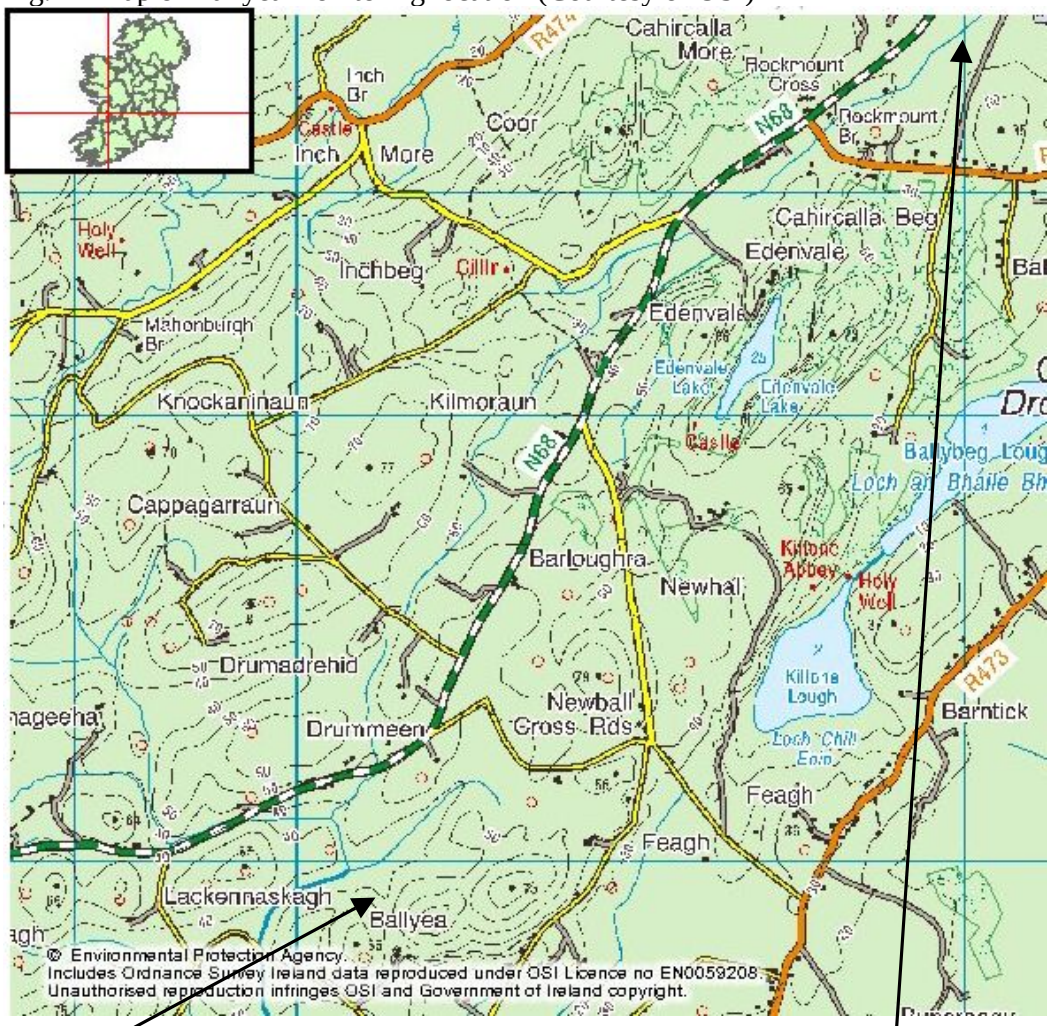
The maximum concentration of arsenic in air was lower than trace levels of arsenic known to exist on the filter papers

Investigation of elevated PM_{10}

PM_{10} levels measured in Ennis were higher than at other stations around the country. To investigate whether the levels were due to local emissions or not, monitoring was carried out upwind of Ennis at Ballyea, immediately after the Ennis assessment ended.

Siting
Ballyea is approximately 7km south west of Ennis. The prevailing wind is south westerly therefore Ballyea is upwind of Ennis.

Fig. 11 Map of Ballyea monitoring location (Courtesy of OSI)



Site Location

Ennis Town

Parameters
The monitoring unit was installed at Ballyea on 18 April 2007 and removed on 30 April 2007. Only PM_{10} and SO_2 were measured. The same monitors were used in Ballyea as were used in the Ennis assessment.

PM_{10} Results

Figure 12 compares PM_{10} results from Ennis and Ballyea using those from Old Station Road in Cork City Centre as control. While the Ennis results are consistently higher than the Cork results, those from Ballyea are not. Cork results were stable during this period.

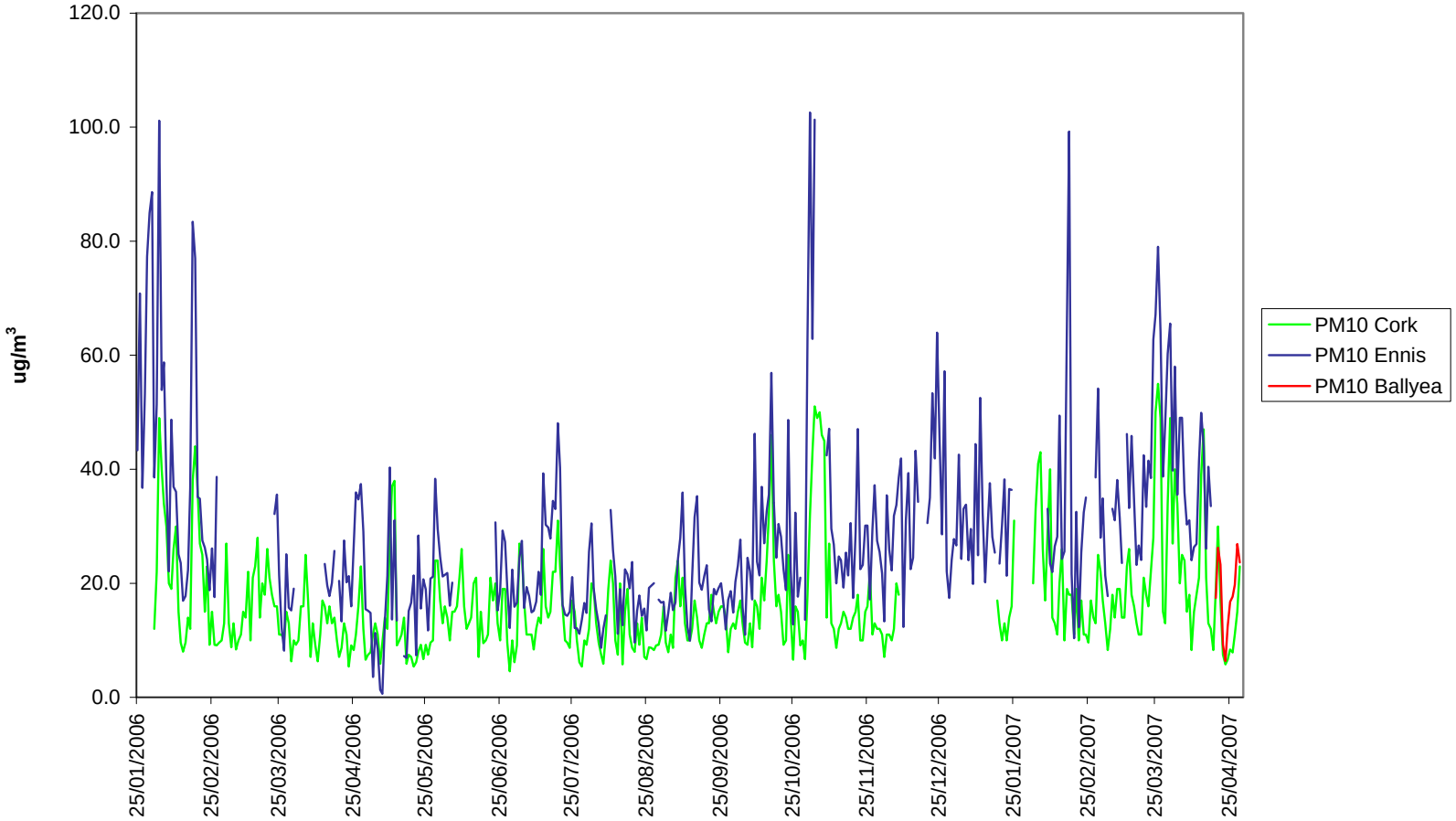
The table below shows the mean of some different datasets to compare Ennis to Ballyea and both to Cork City.

Dates	Ennis	Ballyea	Cork City
25/01/2006 – 17/04/2006 (full Ennis assessment period)	**28.8**		**16.5**
19/04/2007 – 29/04/2007 (full Ballyea assessment period)		**18.2**	**13.7**
19/04/2006 – 29/04/2006 (compare Ennis 2006 data with Ballyea 2007 data)	**25.7**	**18.2**	**11.3**

The statistics show that PM_{10} in Ennis is higher than that in Ballyea indicating that the source of the high PM_{10} is local to Ennis town.

This is an indicative conclusion as the monitoring period in Ballyea was short. Further monitoring of PM10 in Ennis is recommended to ensure levels are below the limit value.

Fig.12 PM10 Daily Averages 25/1/06-29/4/07
Cork, Ennis and Ballyea



Sulphur Dioxide Results

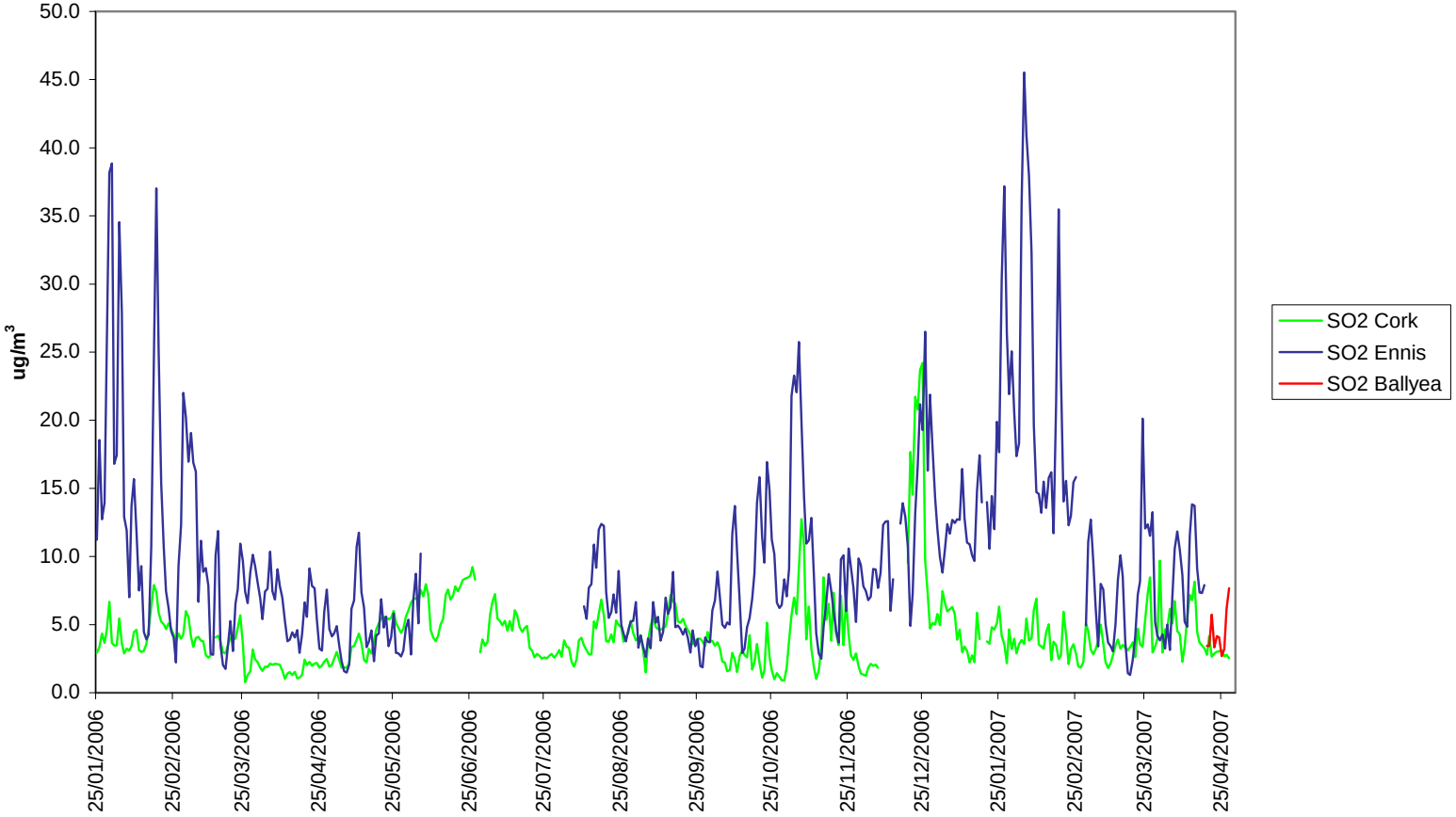
Figure 13 compares SO_2 results from Ennis and Ballyea using those from Old Station Road in Cork City Centre as control. The SO_2 levels measured in Ballyea appear to be lower than those measured in Ennis but there is not enough data to confirm this.

The table below shows the mean of some different datasets to compare Ennis to Ballyea and both to Cork City.

Dates	Ennis	Ballyea	Cork City
25/01/2006 – 17/04/2006 (full Ennis assessment period)	**10.0**		**4.3**
19/04/2007 – 29/04/2007 (full Ballyea assessment period)		**4.4**	**3.3**
19/04/2006 – 29/04/2006 (compare Ennis 2006 data with Ballyea 2007 data)	**6.1**)	**4.4**	**2.1**

The statistics indicate that SO_2 in Ennis is higher than that in Ballyea though the difference is not as marked as that of PM_{10}. This is consistent with solid fuel sources.

Fig.13 SO_2 Daily Averages 25/1/06-29/4/07
Cork, Ennis and Ballyea



Diurnal Effects

High concentrations of PM_{10} typically coincided with elevated concentrations of sulphur dioxide (Fig. 14). This suggests that the source of PM_{10} is combustion of solid fuel and not traffic. If the PM_{10} were from traffic there would be correlation with NO_x and not with SO_2.

Figure 15 shows hourly levels of SO_2 and PM_{10} for a five day period in February 2007. The highest PM_{10} and SO_2 occurs in the afternoon and evening. This is the peak time for domestic heating emissions and indicates the source of the pollutants is solid fuel use in the home.

Conclusion & Recommendations

PM_{10} levels in Ennis are high compared to other monitoring stations in Ireland. The monitoring results indicate that the cause of the elevated PM_{10} is domestic fuel emissions.

Ennis is part of the Solid Fuel Trade Group voluntary agreement on bituminous coal. This agrees that 75% of the solid fuel sold in Ennis will be smokeless. Evidence was unavailable as to whether this agreement has been complied with.

The EPA recommends a permanent PM_{10} measuring station be set up in Ennis to monitor levels and ensure a timely response if the PM_{10} limit is breached.

Fig.14 PM_{10} & SO_2 Daily Averages
Ennis 24/1/06-18/4/07

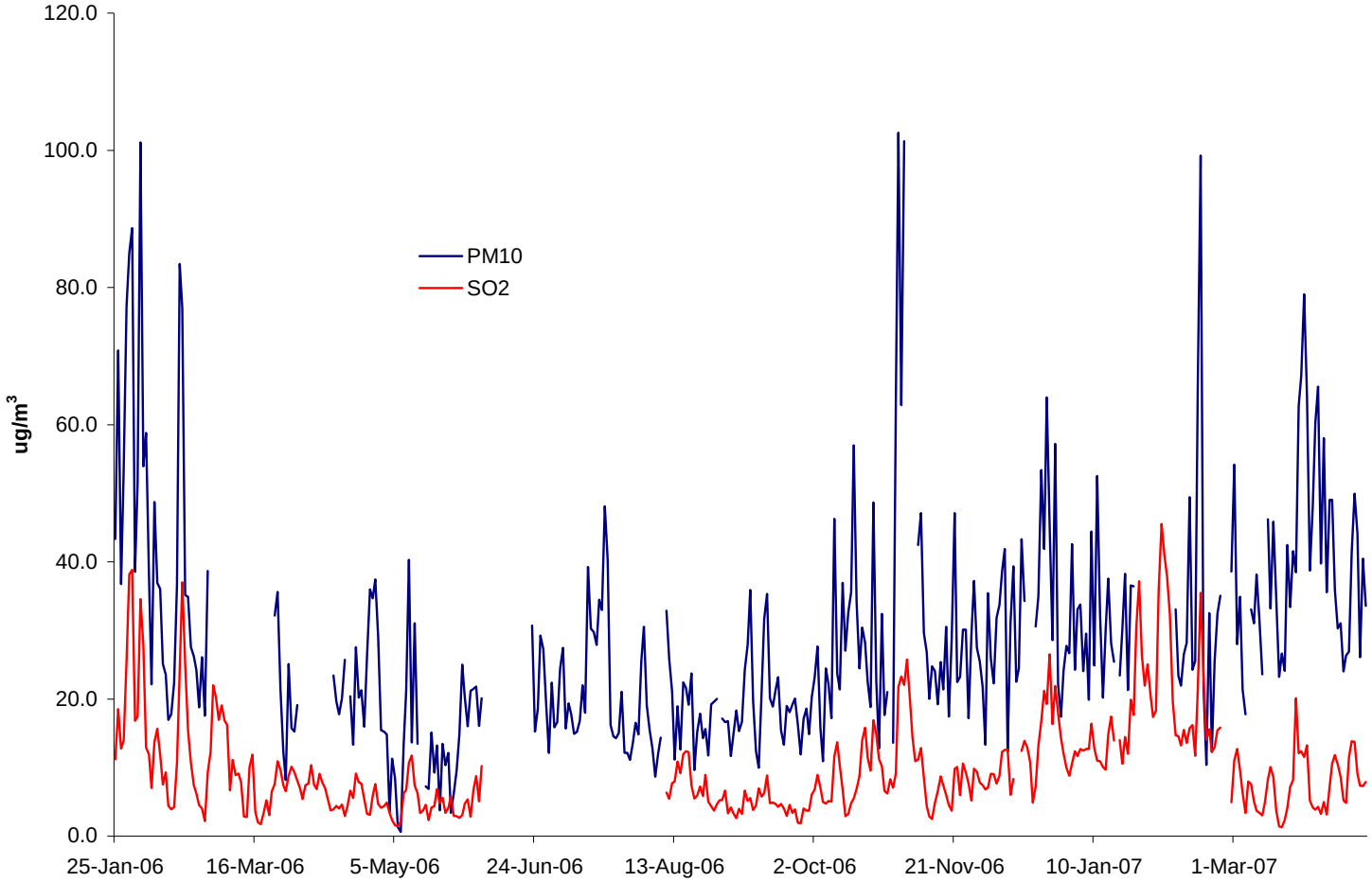


Fig. 15 PM_{10} and SO_2 Hourly Averages in Ennis
9 - 13 February 2007