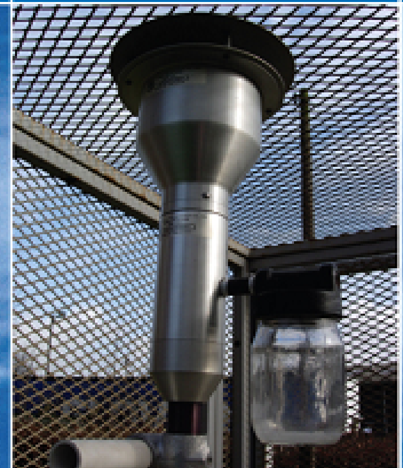
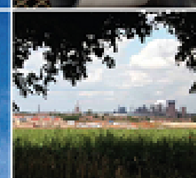
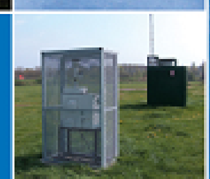
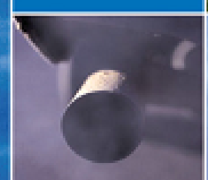
North Lincolnshire Council

Further Assessment of PM_{10} in the Scunthorpe area









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Executive Summary

Local Air Quality Management is a duty placed upon all Local Authorities. As a result of this process North Lincolnshire Council declared an AQMA in October 2005 in the Scunthorpe area. This was for a potential breach of the Air Quality objective for the number of daily exceedances allowed in relation to particulate matter of less than 10 micrometres in diameter (PM_{10}).

Subsequent monitoring presented in this report indicates that North Lincolnshire Council was correct to declare an AQMA and that the boundaries are approximately correct. However, further monitoring will be needed with regard to a newly identified breach of the annual mean objective for PM_{10} at the Santon monitoring site.

Traffic and Bonfire night celebrations have a limited impact on the PM_{10} concentrations in the area. It is clear that local industry is responsible for a significant number of the PM_{10} exceedances recorded in the Scunthorpe area; it is likely that there is not a single source responsible for the PM_{10}.

The data suggests that elevated concentrations are more likely to occur during the daytime, this is particularly true at the Santon site. However, night-time concentrations at Scunthorpe Town are still elevated when the wind originates from the direction of local industry.

In general, more exceedances occur during the summer than the winter. However, the results suggest that wind direction is the most crucial factor and exceedances are most likely to occur in Scunthorpe when the wind originates from an easterly or south-easterly direction, this is demonstrated by the plotting of pollution roses.

The impact that meteorological conditions have on PM_{10} concentrations mean that the true percentage improvement needed could be as high as 48% rather than a relatively simple reduction of two exceedances (for Scunthorpe Town) to ensure that the Air Quality objective is not breached regardless of the prevailing meteorological conditions.

To assist in preparation of the action plan and further source apportionment several further actions, including further Partisol monitoring, traffic counts and observation days are planned to further improve the understanding of the PM_{10} problem in Scunthorpe.

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Assumptions

The majority of PM_{10} measurements used in this further assessment have been recorded using a TEOM machine. To compare to the Air Quality objective a gravimetric equivalent concentration is required, DEFRA currently advises to correct the raw data from TEOM machines by multiplying it by a factor of 1.3 to achieve this. Unless otherwise stated all measurements given in this report are gravimetric equivalent.

Abbreviations

AADT	Annual Average Daily Traffic (Count).
AEA	AEA Energy and Environment (formerly known as NETCEN).
AQMA	Air Quality Management Area. A legally defined area identified as one in which the statutory Air Quality objectives will not be met. Unless otherwise stated this refers to the AQMA declared in Scunthorpe for breaches of daily PM_{10} Air Quality objective.
AQO	Air Quality Objective, an air quality standard that includes a date by which it must be achieved.
AQS	Air Quality Standard, the maximum acceptable level of a pollutant in the air that will not present a risk to the health of the most susceptible groups in the population.
AURN	Automatic Urban and Rural Network.
BOS	Basic Oxygen Steelmaking (plant).
COMEAP	Committee on the Medical Effects of Pollutants.
Defra	Department of the Environment, Food and Rural Affairs.
DMRB	Design Manual for Roads and Bridges version 1.02 (November 2003), a screening method for assessing the impact of road traffic.
EA	Environment Agency.
Ecl	East Common Lane (monitoring site).
EPAQS	Expert Panel on Air Quality Standards.
Exceedance	Any period of time where the concentration of a pollutant is greater than the appropriate limit value.

Fugitive	Emissions of pollutants from a vent point other than a stack.
HDV	Heavy Duty Vehicles.
HGV	Heavy Goods Vehicles.
Hrs	Hours (all times displayed using the 24 hour clock.)
Lcn Gdns	Lincoln Gardens (monitoring site).
NAQS	National Air Quality Strategy.
NO	Nitrogen oxide.
NO_2	Nitrogen dioxide.
NO_x	Oxides of nitrogen.
PAH	Poly-aromatic Hydrocarbon.
Part A process	An industrial process that is required to obtain authorisation from the Environment Agency under PPC. Regulation of emissions to air is included in the authorised document.
Part B process	An industrial process that is required to obtain authorisation from the local authority in order to operate under PPC. Regulation of emissions to air is included in the authorised document.
Percentile	The percentage of items in a set of data lying above or below a particular value, e.g. concentration of a pollutant.
$PM_{10\ (2.5)}$	Particulate matter less than 10 (or 2.5) micrometers in diameter.
PPC	Pollution, Prevention and Control Regulations
QA/QC	Quality Assurance/Quality Control: Procedures to ensure that data from pollutant monitoring equipment is representative of the site with good accuracy, precision and data capture.
SO_2	Sulphur dioxide.
Sthorpe	Scunthorpe.
TEOM	Tapered Element Oscillating Microbalance.
$\mu g\ m^{-3}$	Micrograms per cubic metre.

Chapter 1: Introduction

The layer of the atmosphere from the Earth's surface to a height of about 15 km is known as the troposphere. In the UK, the tropospheric pollutants that are thought to cause the most serious risk to human health are assigned an Air Quality Standard.

Part 1.1: Local Air Quality Management

The concept of Local Air Quality Management was introduced under Part IV of the Environment Act 1995. Chapter 82 of the Act placed a duty on all Local Authorities to review air quality in their area.

Air Quality objectives can be defined as a medium term target for the Government. They are based on Air Quality Standards set by the Expert Panel on Air Quality Standards (EPAQS) and are the maximum acceptable level of a pollutant in the air that will not present a risk to the health of the most susceptible groups in the population. The Air Quality objectives include a date by which the Standards must be achieved. The length of time to achieve the Standard for each pollutant takes into account the costs to industry, the expected rate of improvements in available technology and the health effects on the country's population.

The Air Quality (England) Regulations 2000 set Air Quality objectives for seven pollutants that must be achieved by varying dates, the latest being 31st January 2010. The Air Quality objectives for the seven pollutants are listed in Table 1.1.

Where an objective is unlikely to be achieved within a Local Authority the area must be designated an Air Quality Management Area (AQMA). The Authority must then make a further assessment into the sources of the pollutant and then develop and implement a local action plan setting out measures to reduce concentrations of the pollutant.

Pollutant	Objective		To be achieved by
	Concentration	Measured as	
Benzene	16.25 µg/m^3	Running annual mean	31/12/2003
	5 µg/m^3	Annual mean	31/12/2010
1,3 Butadiene	2.25 µg/m^3	Running annual mean	31/12/2003
Carbon Monoxide	10 mg/m^3	Maximum daily running 8-hour mean	31/12/2003
Lead	0.5 µg/m^3	Annual mean	31/12/2004
	0.25 µg/m^3	Annual mean	31/12/2008
Nitrogen dioxide	200 µg/m^3	1-hour mean not be exceeded more than 18 times a year	31/12/2005
	40 µg/m^3	Annual mean	31/12/2005
Particles (PM_{10} gravimetric)	50 µg/m^3	24 hour mean (midnight to midnight) not be exceeded more than 35 times a year	31/12/2004
	40 µg/m^3	Annual mean	31/12/2004
Sulphur Dioxide	350 µg/m^3	1-hour mean not be exceeded more than 24 times a year.	31/12/2004
	125 µg/m^3	24-hour mean not to be exceeded more than 3 times a year	31/12/2004
	266µg/m^3	15-minute mean not to be exceeded more than 35 time a year	31/12/2005

Table 1.1: The Air Quality objectives as given in the Air Quality (England) Regulations 2000.

Part 1.2: North Lincolnshire

North Lincolnshire is an area of around 85,000 hectares located on the southern side of the Humber estuary and occupying tracts of land on either side of the River Trent. A Parliamentary Order created the administrative area of North Lincolnshire in March 1995 and on 1st April 1996 the new Unitary Authority area of North Lincolnshire came into being.

North Lincolnshire covers a large, mainly agricultural area. The pattern of settlements in the area reflects this with market towns surrounded by many small villages. The exception to this is the substantial urban area of Scunthorpe and the adjoining town of Bottesford.

Almost half of North Lincolnshire's population, approximately 73,250 people, live in Scunthorpe and the adjacent town of Bottesford. Overall, 71 percent of the population live in this main urban area and other towns.

The local economy of North Lincolnshire was built on traditional industries such as steel manufacturing and related industries and agriculture. More recently there has been the establishment of two oil refineries and the introduction of several gas fired power stations.

The M180 and M181 motorways plus several primary and strategic routes, including the A18 and A15, are located within North Lincolnshire. By rail there are regular freight movements to and from the Scunthorpe steelworks and Humber port related industries. With several wharf facilities along the banks of the Humber and the Trent, North Lincolnshire is well positioned to take advantage of water transport.

Part 1.3: Significant Industrial Operations in Scunthorpe

Under PPC Corus and Multiserv are regulated by the Environment Agency as Part A1 processes. Corus manufacture steel, this is a process that involves several stages. Various parts of the steelworks site are shown in Figure 1.1 along with the locations of other companies that operate in the area that are relevant to PM_{10} concentrations. Multiserv process steelmaking slag from the steelworks processes, it is de-metalled on the industrial site.

In addition, North Lincolnshire Council regulates three smaller sites that are potential emitters of PM_{10} in the Scunthorpe area.

Appleby Group Ltd (Part A2) grind granulated blast furnace slag (a by-product from the steelworks) to produce a cementitous material for use in concrete manufacture and a more granular material for use within the glass industry as a raw material. There are two main processes: one takes solidified slag (similar in size to coarse sand), which is dried and ground down to a fine powder known as granulated blast furnace slag (GGBS). The other process produces a coarser product known as Calumite.

Carbon International (Part B) perform heating, drying, screening and packaging of metallurgical coke, calcined petroleum coke and graphite.

Tarmac Northern Ltd (Part B) process both blast furnace and steel slag arisings that are by-products from the iron and steel making operations from the adjacent Corus steelworks. The slag is imported to the works at Santon via a fleet of dumptrucks, the material is then screened and crushed to relatively large size fractions in an enclosed building. Further screening and crushing is then carried out to smaller size fractions within double-decked screens. There are two roadstone coating plants with stacks, both of which are regularly tested for total particulate matter emissions. There are also washing operations on site.

Figure 1.1: The main industrial operations in Scunthorpe relevant to PM_{10}.

See file: 'Figure 1.1 Industrial Operations'.

Part 1.4: Definition and Health Effects of PM_{10}

The definition of PM_{10} is the fraction of particulate matter capable of passing through an inlet of defined characteristics at 50% sampling efficiency with 10 µm aerodynamic diameter.[Reference: 1] PM_{10} has been assigned an Air Quality Standard as evidence suggests it has a range of effects on human health, concentrated specifically on the cardiovascular and respiratory systems as listed in Figure 1.2.

- Increased use of asthma medication.
- Attacks of asthma in pre-existing cases.
- Attacks of chronic obstructive pulmonary disease.
- Admission to hospital for cardiovascular causes.
- Deaths from heart attacks, strokes and respiratory causes.

Figure 1.2: A list of possible effects of PM_{10} on human health.[2]

The effects of particulate matter described in Figure 1.2 are most likely to be suffered by susceptible groups in the population who already have say, a pre-existing heart or lung condition. The PM_{10} fraction is currently monitored as it is thought that particles of this size can penetrate the larynx and enter the thoracic region of the respiratory system.[3] The smaller the particle the further it penetrates into the lung.

Epidemiological studies have consistently shown a link between health effects and PM_{10}. In a COMEAP (Committee on the Medical Effects of Pollutants) report on Cardiovascular Disease and Air Pollution a summary of the health effects of PM_{10} in a variety of studies was given. The percentage change in the outcome measure varied from 0.4 to 1.4% per 10 µg m^{-3} increase in PM_{10} concentrations.[4] Although this is a small affect the large potential exposure (i.e. a whole population within a given area) could mean the public health impact is large. It is thought there is no concentration that can give complete protection to particulate matter, as threshold levels have not been identified.[5]

PM_{10} are also linked to other problems, it can cause a reduction in local and regional visibility, it has been implicated in climate change through a possible cooling effect [6] and may also provide a surface for chemical reactions to occur. It is likely that future targets will concentrate on the smaller size fraction, $PM_{2.5}$ (particles less than 2.5 µm in diameter).

Part 1.5: Concentrations, Sources and Types of PM_{10}

Figure 1.3 shows the estimated spatial distribution of PM_{10} concentrations across the UK in 2004, if studied closely a yellow square representing a concentration of 23 to 28 µg m^{-3} can be seen at Scunthorpe's location.

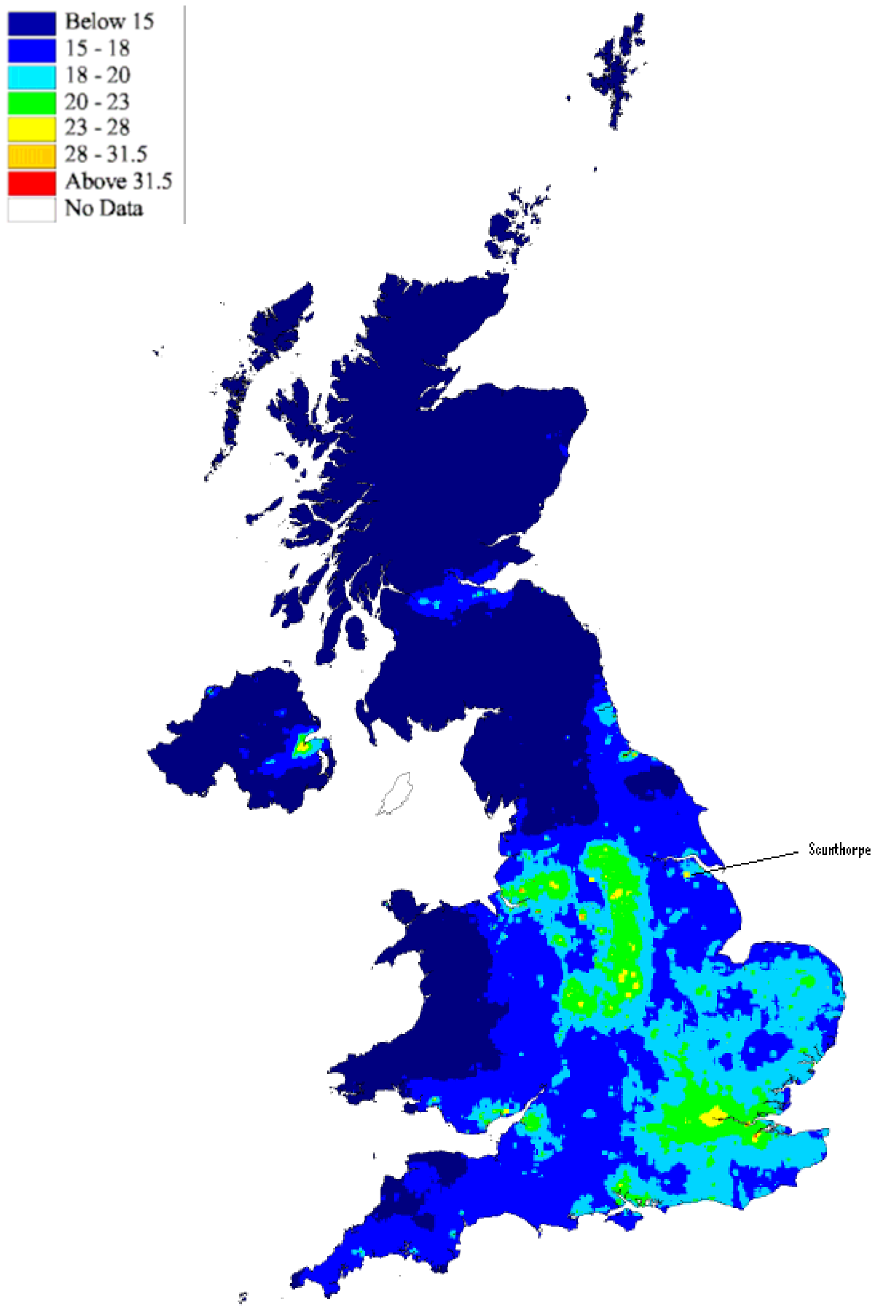

Figure 1.3: A map of the UK showing estimated annual mean concentrations of PM_{10}, µg m^{-3}, in 2004, with key (µg m^{-3}) in the left hand corner. [7]

PM_{10} can be classified into several different categories; primary PM_{10} are those particles that have been directly emitted into the atmosphere. Secondary particles are formed by the condensation of low volatile gases and small particles condensing onto existing aerosol particles in the atmosphere. Species that encourage the formation of secondary particles are inorganic sulphates and nitrates. E.g. ammonium sulphate and nitrate.

The smallest group of particles, with diameters of less than 0.05 µm, are usually referred to as nucleation mode particles. These particles are formed either by nucleation in the atmosphere or by nucleation processes that occur within the emissions from high temperature sources.[8]

Accumulation mode particles (0.05 µm and 1 µm) can then be formed by the growth of nucleation mode particles, primarily by vapour condensation and coagulation processes. Coarse particles are defined as those with a diameter between 2.5 and 10 µm, atmospheric lifetimes for these particles tend to be shorter than for smaller particles due to gravitational settling velocities. [8]

Typical anthropogenic sources are fossil fuel combustion emissions, wear and tear from road traffic, metal works and construction activities. Natural primary sources include wind blown dust or soil and sea salt, typically these are coarse particles due to their size. [8]

Figure 1.4 shows the PM_{10} emissions in the UK between 1970 and 2004 from various anthropogenic sources. It is clear that emissions (by mass) have decreased during that period, particularly from industry and power stations. Although modern combustion processes tend to emit less particulate mass, the number of nucleation and accumulation mode particles produced is greater than for the processes they replaced.[1]

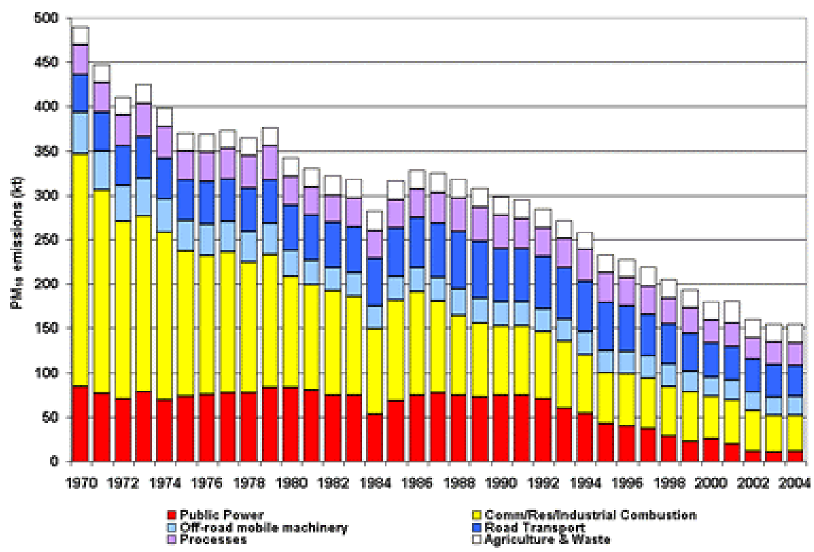

Figure 1.4: A graph showing the PM_{10} emissions from anthropogenic sources in the UK between 1970 and 2004. [9]

Part 1.6: PM_{10} Measurement Techniques

The PM_{10} Air Quality objectives are based on a gravimetric system of measurement. In a TEOM (Tapered Element Oscillating Microbalance) machine particles are collected on a filter that is mounted on a glass element; this oscillates with a natural frequency that then decreases as the mass of PM_{10} on the filter increases. Thus it is an in-direct measurement of particulate mass.

The majority of the data recorded for this report was measured using TEOM machines, see Figure 1.6. The main advantage of the TEOM is that it gives real-time measurements of PM_{10}; a reading is taken by the machine every other second with a 15-minute mean then recorded.

Problems arise when comparing TEOM results to the Air Quality objectives; this is because the element is maintained at 50°C thus resulting in the potential 'driving off' of volatile PM_{10}. To date the advice from Defra has been to multiply raw TEOM results by a factor of 1.3 to make a conversion to gravimetric equivalent results. However, as a result of the PM_{10} equivalence report published in 2006, further Defra advice is show in Figure 1.5 with regards to monitoring techniques: [10] This will be discussed more in Chapter 9 (Partisol).

> "For example, the issue is more critical where PM_{10} concentrations are close to the objective. It is not possible to precisely define what "close to the objective" means, but as an approximate guide, it is likely to be in the range of 30 to 40 days exceedance as measured by the TEOM multiplied by 1.3. In this case, robust and reliable PM_{10} data are necessary, so Local Authorities faced with this situation should consider upgrading their equipment as soon as is practicable, or consider restructuring their local networks so that analysers that meet the equivalence criteria are sited at the most critical locations."

Figure 1.5: Current Defra advice with regards to monitoring techniques.

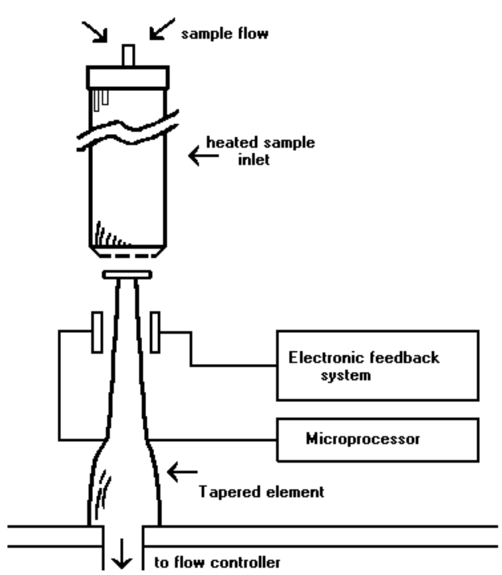

Figure 1.6: A schematic diagram of a TEOM machine. [11]

To avoid the problem with the correction factor an alternative machine, the Partisol 2025 (see Figures 1.7 a. and b.), can be used. This machine performs a direct measurement of PM_{10} collected on to a filter and is an 'equivalent' method with the additional advantage that further analysis of the filters is possible, for example to analyse for heavy metals.

To minimise visits to a Partisol, 14 daily filters are housed within a cartridge. Each filter is exposed between midnight and midnight with a changeover occurring automatically, every fortnight the cartridge is exchanged by the local site operator.

However, filters need to be exposed for at least 24 hours followed by analysis at an external laboratory. The cartridge is then sent off to AEA for gravimetric analysis and results are returned around two weeks later. This means real-time data is not possible as the results are only returned several weeks after exposure. The temporal resolution is also poor with only a 24-hour mean concentration being recorded compared to a 15 minute mean concentration being possible with a TEOM. Partisols are also a relatively expensive method of measurement compared to a TEOM.

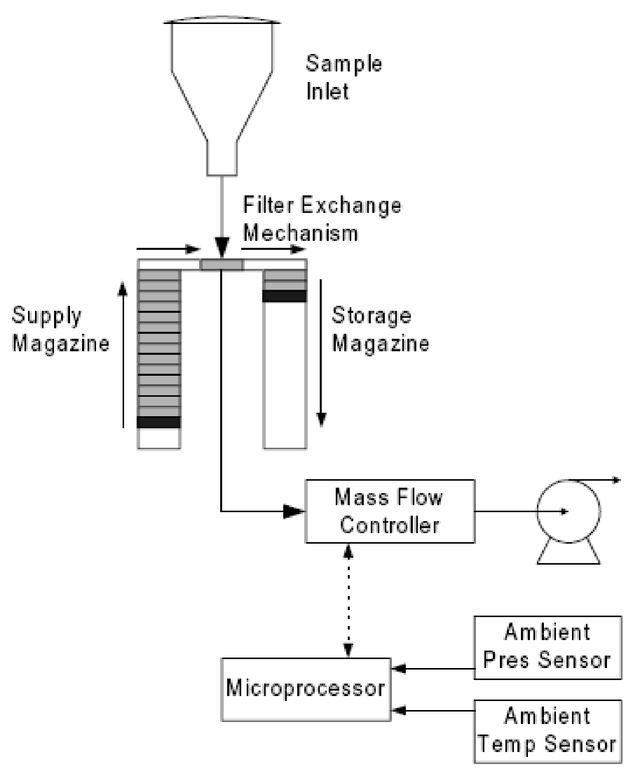

Figure 1.7 a.

1.7 b.
Figure 1.7: a. A schematic diagram and b. picture, of a Partisol 2025. [12]

Part 1.7: PM_{10} in North Lincolnshire

As a result of the Updating and Screening Assessment (2003) North Lincolnshire Council proceeded to a Detailed Assessment for PM_{10}. The subsequent detailed assessment found that there was potential for the daily Air Quality objective to be breached for PM_{10} and thus the declaration of an AQMA was necessary.

On the 26th October 2005 North Lincolnshire Council declared an AQMA for a potential breach of the Air Quality objective in relation to the number of daily exceedances of the allowed (maximum of 35) for PM_{10}. The area declared is shown in Figure 1.8; essentially the designated area encompasses the steelworks and other industry in the area as well as residential parts of the Town.

Figure 1.8: The boundary of the Scunthorpe PM_{10} AQMA.

See File: ‘Figure 1.8: AQMA’.

Chapter 2: Monitoring Sites and Data

Part 2.1: North Lincolnshire Council Monitoring Sites

North Lincolnshire Council currently operates continuous monitors for a variety of pollutants: NO_x, SO_2, PAHs and PM_{10}. In addition, a network of 36 diffusion tubes is maintained for NO_2 and a diffusion tube monitoring survey has previously been conducted for benzene.

A short description of each of the PM_{10} monitoring sites currently and previously operated by North Lincolnshire Council in the Scunthorpe area is given in this Part, this is followed by Figure 2.1 which shows the locations of each site. Table 2.1 then details the OS grid reference, the start date of monitoring (and finish dates where appropriate), the pollutants measured and the classification of each site. In 2006 North Lincolnshire Council operated seven TEOM PM_{10} monitors and a Partisol at Scunthorpe Town.

All TEOM sites have an air-conditioning unit within the enclosure. All sites with a TEOM machine are calibrated fortnightly with a filter change occurring once the mass on the filter reaches 80% or after 4 weeks, whichever is sooner. Since February 2007 the TEOM heads have also been cleaned on a monthly basis. In addition, each site is serviced and calibrated at six monthly intervals by either Signal Ambitech or Airmonitors.

Description of sites:

1. Allanby Street. (TEOM)
This monitoring station is located on a small patch of grass, adjacent to a local car park and close to the Town Centre. The high street is 105 m from the site and Britannia Corner, a busy road junction is 153 m away. It is approximately 1 km from the nearest part of the steelworks boundary.

2. Broughton. (TEOM)
The site is located within an Anglian Water enclosure within a residential area of the village of Broughton. It is approximately 3 km east of the steelworks site. The B1207 is 500 m west of the site and the area between this road and the steelworks is comprised of woods and fields.

3. East Common Lane. (TEOM)
This site is located behind a block of flats, 34 m from East Common Lane. To the west of the site is a residential area; whilst to the northeast and southwest are several industrial estates. The site is approximately 500 m from the site boundary of the steelworks.

4. Lakeside (Partisol 2025).
The original location for North Lincolnshire Council's second Partisol (before being moved to Santon) was at the southern end of the Lakeside Retail Park. The site was approximately 500 m from the A18, which itself is next to the boundary of the steelworks site. Most results from this site have been presented in previous LAQM reports.

5. Lincoln Gardens. (TEOM)
This TEOM is located within the grounds of Lincoln Gardens Primary School and is approximately 72 m south of Lincoln Gardens; it is approximately 2.5 km west of the closest boundary of the steelworks. To the east of the site is a park with the remaining area being residential.

6. Santon (Groundhog).
This monitoring station is housed within an enclosed air-conditioned unit to the north east of Scunthorpe on the Eastern boundary of the Corus Steel Works. Dawes Lane is 5 m to the south of the station, running from a rural location in the east through the steelworks and into Scunthorpe. A raised embankment 5 m north of the site carries freight traffic along one of the major rail lines into the steelworks. The surrounding area consists of grassland with a number of trees and a small residential area to the east. The manifold is approximately 3 m above ground level.

The monitoring equipment at this station consists of a Signal Ambitech Ambirak analyser, monitoring SO_2, NO_x, and a Rupprecht & Patterschnick TEOM monitoring PM_{10}. The installation of a PAH monitor is also planned for this location.

7. High Santon (Partisol 2025).
This monitoring station was installed on the 5th January 2007 in the northeast of Scunthorpe approximately 500 metres from the Eastern boundary of the Corus Steel Works. Dawes Lane is 5 metres to the north of the station, running from a rural location in the east, through the steelworks and into Scunthorpe. Through the steelworks the road is a private. A busy freight line runs approximately 15 metres to the north of the station and is one of the major rail lines into the steelworks. The surrounding area consists of open grass with a dwelling 5 metres to the south with about 35 neighbouring residential properties.

8. Scunthorpe.
This was the position of the AURN station until 17th March 2004; the site was located on the roof of North Lincolnshire Council offices on Cottage Beck Road, just to the south east of the current Scunthorpe Town site. The site was moved to Rowland Road (known as Scunthorpe Town) due to Health and Safety issues with its operation and as it was deemed that the site was not ideally located to be representative of sensitive receptors.

9. Scunthorpe Town (Rollalong).
This monitoring station is housed within an enclosed air-conditioned unit in the north east of Scunthorpe approximately 10 metres to the north of Rowland Road. The nearest busy road is Brigg Road (A1029) 124 metres to the northeast, at its closest point. In addition wind direction and wind speed are measured at this site and it is an affiliate member of the AURN for PM_{10} and SO_2.

The monitoring equipment at the station consists of an Enviro-Technology Services model 100A Fluorescent SO_2 analyser, a Monitor Labs Inc ML9841B chemi-luminescence analyser for NO and NO_x and a Rupprecht & Patterschnick TEOM 1400a PM_{10} monitor. The logging system used is an Odessa DSM3260.

10. Scunthorpe Town - Partisol.
The machine is a Partisol 2025 and is located 8 m to the west of the Rollalong enclosure, 14 daily filters are housed within a cartridge. Each filter is exposed between midnight and midnight with a changeover occurring automatically, every fortnight the cartridge is exchanged by the local site operator. The cartridge is then sent off to AEA for gravimetric analysis and results are usually returned within two weeks.

In addition to the Partisol and Rollalong at Scunthorpe Town a separate enclosure holds two co-located PAH monitors; a modified Andersen Instruments model and a Digitel DHA-80 High Volume Sampler.

11. Killingholme.
The site is located within the grounds of South Killingholme Primary School and is approximately 200 m north east of the dual-carriage A160. Two refineries are located to the northeast and east of the site. The site is approximately four km west of the coast and the Immingham docks (located within North East Lincolnshire Council area). The site is approximately 20 km east of the AQMA, however, some data has been used from this site as a comparison. Wind direction and speed, relative humidity, pressure and temperature are also measured at this site.

Figure 2.1 : A map showing the positions of North Lincolnshire Council's PM_{10} monitoring sites in the Scunthorpe area.

See file: 'Figure 2.1 AQM Stations'.

Site Name	OS Grid Reference	Start Date	Finish date	Pollutants measured	Site Type
Allanby St	SE 89273 11446	1st July 2005	-	PM10s (TEOM, R&P1400a)	Urban Industrial
Broughton	SE 96048 09411	10th March 2006	-	PM10s (TEOM, R&P1400a)	Urban Background
East Common Lane *	SE 90662 09791	3rd March 2005	-	PM10s (TEOM, R&P1400a)	Urban Industrial
Lakeside *	SE 91755 08242	23rd February 2005	10th August 2006	PM10s, (Partisol 2025)	Urban Industrial
Lincoln Gardens *	SE 89465 08938	1st December 2004	-	PM10s (TEOM, R&P1400a)	Urban Background
Santon *	SE 92947 11937	1st October 2005	-	PM10s (TEOM, R&P1400a), NOx, SOx.	Urban Industrial
High Santon *	SE 93271 12089	5th January 2007	-	PM10s, (Partisol 2025)	Urban Industrial
Scunthorpe *	SE 90559 10681	15th December 1997	18th March 2004	PM10s (TEOM, R&P1400a), NOx, SOx.	Urban Industrial
Scunthorpe Town *	SE 90315 10830	6th June 2004	-	PM10s (TEOM, R&P1400a), NOx, SOx.	Urban Industrial
Scunthorpe Town *	SE 90307 10830	1st December 2004	-	PM10s (Partisol 2025)	Urban Industrial
Killingholme	TA 14880 16120	1st March 2003	-	PM10s (TEOM, R&P1400a), NOx, SOx.	Urban Industrial

Table 2.1: OS grid references, start and finish dates, pollutants measured and site classification of North Lincolnshire Council's PM_{10} monitoring stations.
Note: * = site is currently operating in the AQMA, or if monitoring has ceased then operated in what is now the AQMA.

It should be noted the accuracy of the wind direction sensor at Scunthorpe Town and Killingholme is +/- 5^o and that the pollution rose takes results from 10^o sectors. All six Scunthorpe sites are within 7 km of the Scunthorpe Town site; it has been assumed that the meteorological data collected is applicable to all Scunthorpe sites.

Wind direction and wind speed data is not available from 27th July until the 30th August, although during this time only one exceedance was recorded at Scunthorpe Town, thus where necessary wind direction data has been used from Killingholme. Other meteorological data used in this report (rainfall, mm, and temperature, ^oC) has been supplied by Corus, and was measured on the steelworks site.

Part 2.2: Calibration Club

In order to minimise measurement uncertainty it is important to apply stringent quality assurance/quality control procedures to monitoring programmes. North Lincolnshire Council therefore subscribe to a service known as the 'Calibration Club' operated by AEA Energy and Environment.

The Calibration Club provides independent equipment audits at six-monthly intervals, an audit report detailing any required data management actions, a UKAS certificate of calibration and audits providing traceability to national metrology standards.

AEA Technology also carryout data management services on behalf of the council using the same procedures applied to the UK Government National Network monitoring stations. This service incorporates:

- Data collection, screening and provisional scaling.
- Full ratification of data sets and comparison to air quality objectives.

Part 2.3: Data used in this Report

In this report the following data will be studied: 1. Data from the Scunthorpe AURN and Scunthorpe Town AURN sites between 2000 and 2006. This will mostly concentrate on the daily and annual concentrations of PM_{10} measured. 2. Data from the six Scunthorpe sites mentioned in Part 2.1 of this Chapter using data from 2006.

Although several of the sites were recording data prior to 2006 it was decided detailed analysis would be undertaken for 2006 only. This would be more relevant as it would give a complete set of results from one year thus enabling easier comparisons, the exception to this is Broughton which commenced monitoring on 10th March 2006. In addition the whole data set represents a time period after the declaration of the AQMA.

The majority of the data studied in this report is provisional data, however, the following data used has been ratified:

1. Data up to the end of September 2006 from Scunthorpe Town.
2. Data up to the end of June 2006 from Santon.
3. Data up to the end of June 2006 from Killingholme.

In addition to data from Scunthorpe Town, data from four other AURN sites has also been downloaded from the Air Quality website (www.airquality.co.uk) for 2003 (all ratified) and 2006 (all ratified to the end of June). The sites selected were Newcastle Centre, Hull Freetown, Harwell and Northampton; these sites were selected to give a range of results from the eastern side of the UK and to assess the extent that Scunthorpe is affected by regional pollution.

Chapter 3: Policy Developments

Planning and Development Policy

Local development policy is currently delivered through the North Lincolnshire Local Plan (adopted May 2003). The Local Plan shows land within the AQMA that is committed for housing and land and that which has been identified as proposed industrial development and proposed housing development. Cleary, the introduction of new receptors and sources of PM_{10} in and around the AQMA will have implications for air quality and this must be addressed through the planning process.

The Council is currently producing a new statutory planning framework, known as the Local Development Framework that will supersede the Local Plan. The Core Strategy Document, which will be at the centre of this Local Development Framework, is due to be adopted in 2008. Whilst national policy is encouraging residential development on brownfield sites, the planning process must address air quality issues when determining planning applications on brownfield sites in and around the AQMA. Until such time as the Core Strategy Document is adopted, the determination of planning applications within North Lincolnshire will continue to be made with reference to the policies set out in the Local Plan along with the guidance set out in Planning Policy Statement 23: Planning and Pollution Control.

Transport Policy

Chapter 5 of North Lincolnshire Council's Local Transport Plan 2006-2011 refers to Air Quality. This document was produced in March 2006 and can be found at www.northlincs.gov.uk. The report outlines the following measures to be taken concerning the delivery of better air quality;

- Reduction of commuter traffic by encouraging more sustainable travel.
- Efficient management of the highway network.
- Implementation of measures to reduce vehicle emissions.

The LTP 2006-2011 states that there are no substantial congestion problems within North Lincolnshire, although specific routes associated with new residential development have been identified as likely to experience more congestion over the next five years. One of the developments referred to is the Lakeside development, which is within the southern part of the AQMA.

The LTP does not include plans for any new roads, re-routing or traffic reductions within the AQMA and surrounding area.

National Policy

The implementation of the Thematic Strategy on Air Pollution, part of the EU CAFÉ programme, will have implications for future particle objectives. Forward planning in terms of particulate monitoring and action planning within the AQMA may require provision of monitoring for $PM_{2.5}$.

Chapter 4: Analysis of Annual Data.

Part 4.1: 2006 Data

The six PM_{10} (TEOM) monitoring sites operated by North Lincolnshire Council in the Scunthorpe area during 2006 were:

- Allanby Street,
- Broughton,
- East Common Lane,
- Lincoln Gardens,
- Santon and
- Scunthorpe Town.

A Partisol 2025 was also in operation at Scunthorpe Town and results from this are discussed in Chapter 9.

Table 4.1 presents the annual mean concentration, exceedances of the daily limit value (50 µg m^{-3}), annual data capture and minimum and maximum daily mean concentrations for these 6 sites. It shows that in 2006 the three sites that exceeded the daily PM_{10} Air Quality objective (2005) were those sites within the AQMA:

- East Common Lane; 43 exceedances,
- Santon; 158 exceedances,
- Scunthorpe Town; 37 exceedances.

Meanwhile the sites outside of the AQMA recorded fewer exceedances and are all below the 2005 Air Quality objective.

	Annual Mean, ug m^{-3}	Number of Exceedances	Annual Data Capture, %	90.4th percentile, ug m^{-3}	Daily Minimum, ug m^{-3}	Daily Maximum, ug m^{-3}
Allanby Street	28.1	23	96.4	n/a	9	103
Broughton	22.4	2	73.2	35	8	59
East Common Lane	28.9	43	97.8	n/a	8	117
Lincoln Gardens	25.8	18	98.4	n/a	8	103
Santon	58.8	158	96.7	n/a	11	279
Scunthorpe Town	29.6	37	95.1	n/a	9	130

Table 4.1: The annual mean concentration of PM_{10}, number of exceedances of the daily air quality limit value, annual data capture (based on daily means) and 90.4^{th} percentile (where necessary) for the six monitoring sites operating in Scunthorpe in 2006.

The period data capture for Broughton (operational from 10^{th} March 2006) is marginally below the 90% requirement (89.9%), thus the 90.4^{th} percentile has also been calculated. The annual data capture at Broughton is 73.2%, however, it is clear from the data collected that the 2005 annual or daily Air Quality objective for PM_{10} is unlikely to be breached.

The days of exceedance for all sites are listed in the Appendix, Table A1.

In Figures 4.1, A1 and A2 the daily mean PM_{10} concentrations have been plotted for Scunthorpe Town and Allanby Street, Santon and Broughton, East Common Lane and Lincoln Gardens respectively. The data has been arranged like this as the sites are in approximately in line with each other with reference to the position of local industry.

The Figures show that the daily mean concentrations vary in a similar fashion to each other, i.e. when the concentration at East Common Lane is elevated then the concentration at Lincoln Gardens is elevated as well. This is also shown by the Pearson Correlation Coefficients, for Scunthorpe Town and Allanby Street this is 0.927, for East Common Lane and Lincoln Gardens the value is 0.870. However, for Santon and Broughton the value is only 0.363, this could be due to the distance between the sites.

In addition, the greater the distance between the monitoring site and the steelworks site and other industry the lower the annual mean concentrations and numbers of exceedances recorded.

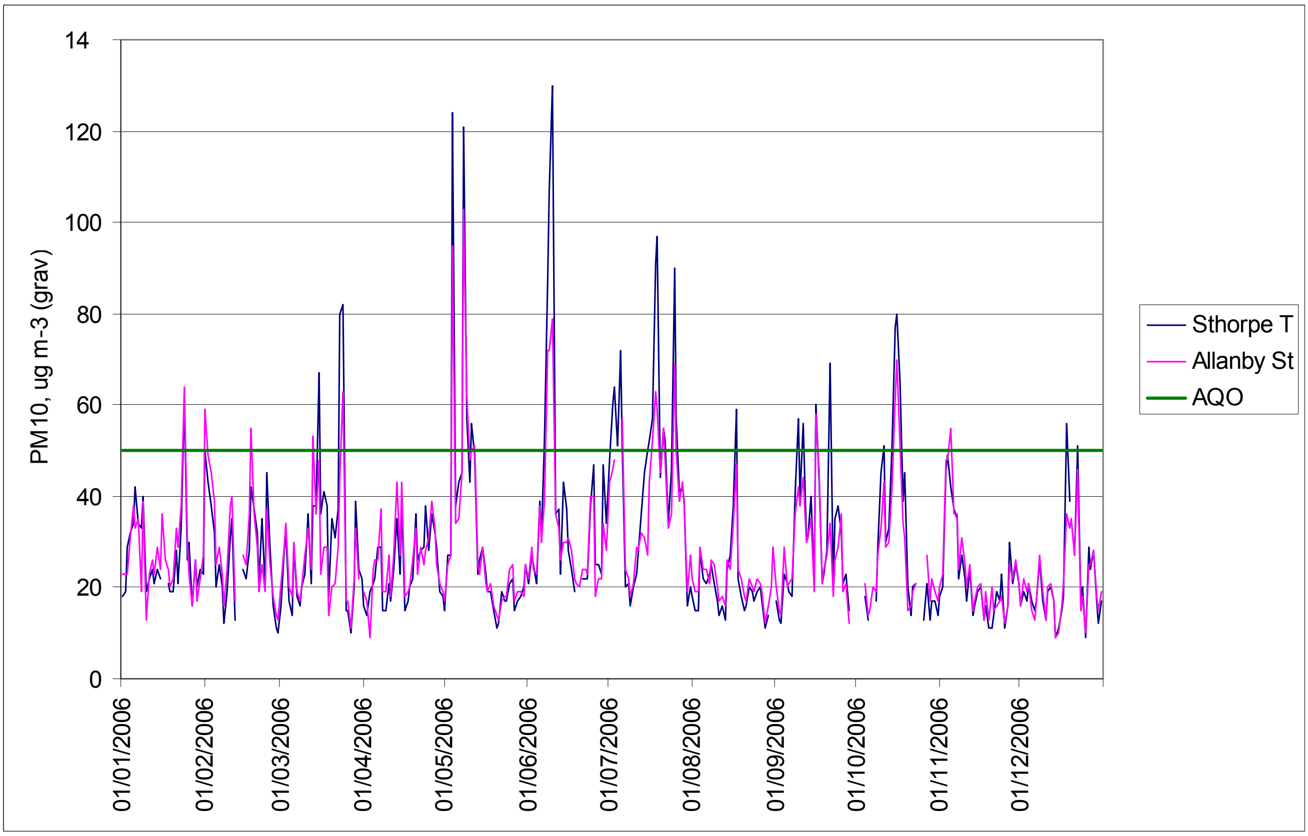

Figure 4.1: A graph of the daily mean PM_{10} concentrations at Scunthorpe Town (Sthorpe T) and Allanby Street during 2006.

There are a few exceptions to this, for example Allanby Street seems to record higher concentrations than Scunthorpe Town on several occasions in January and February 2006, whilst on the 28th March 2006 Lincoln Gardens records a much greater concentration than East Common Lane (103 μg m^{-3} against 20 μg m^{-3}). The manner in which the PM_{10} concentrations generally decrease with distance suggests that the problem could be a coarse PM_{10} (usually defined as particulate matter between 2.5 μm and 10 μm) problem as these particles generally travel shorter distances than smaller particles.

Note: The Pearson Correlation Coefficient tries to measures the strength of the linear relationship between two variables. The value can vary between -1.0 (indicating perfect negative correlation, 0 (indicating no correlation) and 1.0, which shows a perfect positive correlation. R^2 shows how much of the variance of Y is contained within X.

Part 4.2: Pollution Roses for 2006

TEOM machines record a mean PM_{10} concentration every 15 minutes; in addition the mean wind direction and speed are recorded at Scunthorpe Town every 15 minutes. This enables a pollution rose to be plotted for each site, as shown in Figure 4.2 which utilises all of the recorded data for 2006.

A pollution rose is a plot of the mean PM_{10} concentrations across a 10^o degree wind sector; it does not point directly to the source of the PM_{10} but rather indicates what the mean concentration of PM_{10} is when the wind is emanating from that particular direction. It does not take account of the time of day for when a particular concentration occurred. The macro tool creating the rose automatically excludes any data where the wind speed is less than 0.5 m s^{-1}. The roses have been plotted on a 1:25000 map of the area, with grid lines 1 km apart. The centre of each pollution rose has been plotted at the location of the monitoring site for where the PM_{10} data was recorded.

In Figure 4.3 the pollution rose has been annotated with additional blue lines to show the wind directions from where PM_{10} concentrations are greater than 40 µg m^{-3}, except for Broughton where the lines indicate concentrations greater than 25 µg m^{-3}, marked in the westerly direction only.

Figure 4.2 demonstrates that the steelworks site and associated industry are responsible for the high levels of PM_{10} concentrations in and around Scunthorpe. For example, the mean PM_{10} concentrations at Scunthorpe Town are greater than 40 µg m^{-3} only when the wind emanates from between 60^o and 150^o, for East Common Lane the directions between 20^o and 140^o are greater than 40 µg m^{-3}. The highest concentrations seem to occur from the southern part of the steelworks site at all monitoring sites, except at Santon where the higher concentrations occur from the northern part of the steelworks site.

Concentrations at the monitoring sites within Scunthorpe are between 20 and 27 µg m^{-3} only when the wind emanates from between 180^o and 330^o. This is much lower than the average concentrations for other wind directions.

Allanby Street shows lower mean concentrations than Scunthorpe Town when the wind emanates from similar directions this effect is also apparent when comparing Lincoln Gardens and East Common Lane. Overall concentrations at Broughton are lower compared to the other monitoring sites with the highest concentrations for the site originating from the northwest and east. The key thing to note is that a significant elevation in PM_{10} concentrations occurs as an easterly air mass moves from Broughton to Scunthorpe. This suggests regional sources are not to blame for the high PM_{10} concentrations.

The results from the Santon monitoring site will be discussed in more detail in Chapter 8 due to the magnitude of the breaches of the Air Quality objective. However, the lowest concentrations are experienced from the northeast and in contrast to the other sites concentrations are elevated between 240^o and 280^o, pointing to the northern part of the steelworks (and other industry) site.

Figure 4.2: 2006 Annual Pollution Rose. See file: ‘Figure 4.2 Annual Pollution Rose’

Figure 4.3: Annual Pollution Rose with lines. See file.

Part 4.3 Percentile Roses

A percentile pollution rose is shown in Figure 4.4, this details the 99^{th}, 95^{th}, 90^{th}, 75^{th}, 50^{th} and 25^{th} percentiles of the PM_{10} concentrations at each monitoring site according to wind direction, again plotted at the location of the position of the monitoring site. Percentile pollution roses show whether a site is recording high concentrations for only a short period of time (this is shown by the 99^{th} percentile varying in a different manner across different directions) or whether a consistent source is present when the wind is emanating from a particular direction (shown by the percentiles varying in a similar manner across different directions).

Thus Santon behaves differently at the 99^{th} percentile at 280^o and 330^o indicating potential 'peak' sources. At Scunthorpe Town the peaks are at 10^o, 50^o and 140^o. At Allanby Street these peaks occur at 30^o and 70^o, whilst the percentiles behave in a similar fashion at 120^o. At Santon this potentially indicates there are sources such as Tarmac and the coal handling plants, which could give rise to high concentrations for short periods of time. Where as at Scunthorpe Town the rose suggests that concentrations originating from the southeast are as a result of emissions from continuous sources.

Figure 4.4: Annual percentile pollution rose for 2006. See file.

Part 4.4: Wind Frequency and Direction

The percentage of time that the wind originates from each direction is important as well, this is demonstrated by the wind rose plotted in Figure 4.5. This clearly demonstrates that the most frequent wind direction is from the south-west. (Note; no wind direction data is available for August.)

The percentage of time that the wind emanates from directions at Scunthorpe Town recording the highest concentrations (120^o and 130^o) is 1.36%, which is equivalent to 4.97 days per year. Concentrations are greater than 50 ug m^{-3} when the wind emanates from 70^o to 150^o, this equates 10.93% or 39.9 days per year, which is greater than the 35 exceedance days allowed by the Air Quality objective.

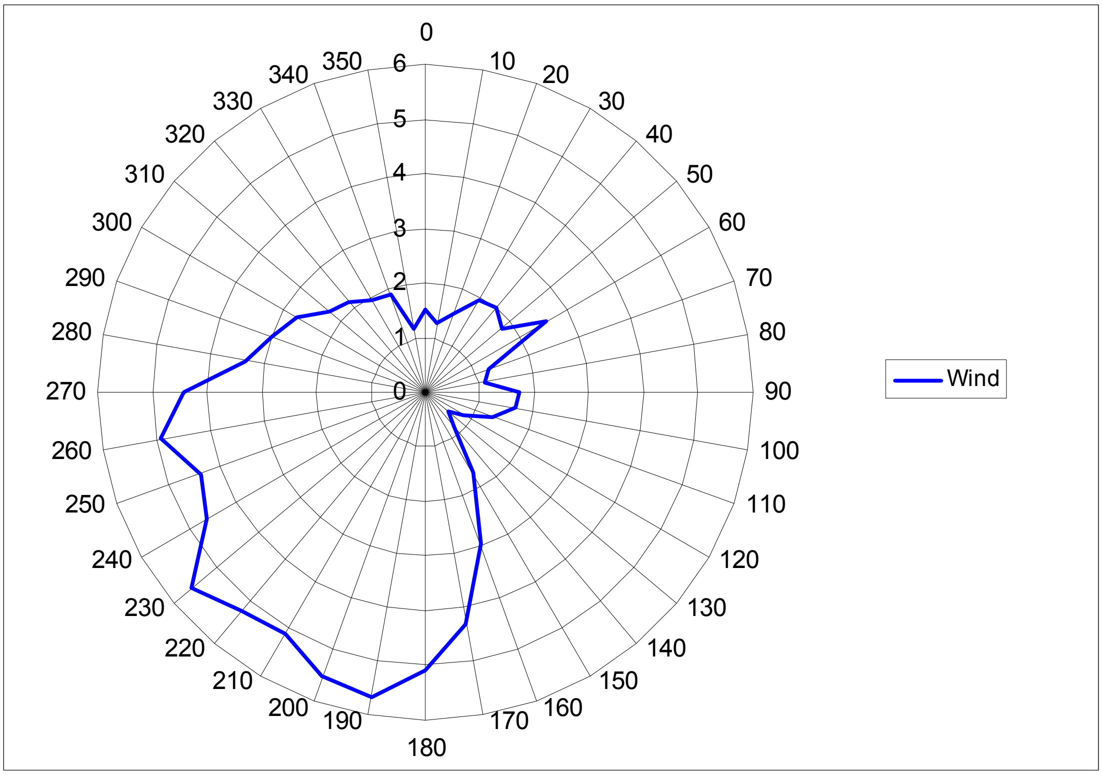

Figure 4.5: A wind rose indicating the percentage of time that the wind emanated from each 10^o sector (on the 'y axis'), for Scunthorpe Town in 2006.

Figure 4.6 shows the mean wind speed for each direction during 2006. The wind speed is lowest between 120^o and 230^o, with mean wind speeds being above 3 m s^{-1} between 30 and 120^o, the highest wind speed is from 60^o at 4.2 m s^{-1}.

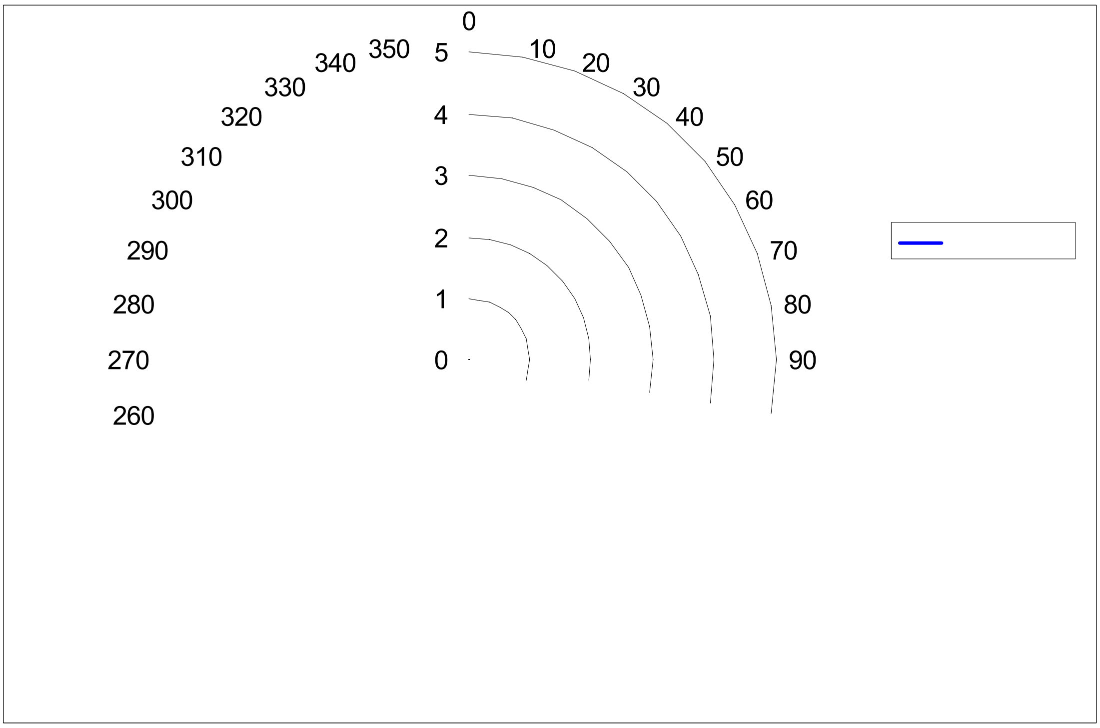

Figure 4.6: A diagram showing the mean wind speed ('y axis') for each 10^o sector for Scunthorpe Town, 2006.

Figure 4.7 initially shows decreasing PM_{10} concentrations with increasing wind speed between 0 and 3 m s^{-1} suggesting that dispersion may be occurring. However, concentrations then increase gradually as the wind speed increases to 7 m s^{-1}. Wind speeds between 7 and 8 m s^{-1} show an increase in PM_{10} concentrations, possibly indicating that material is being re-suspended from roads and other surfaces.

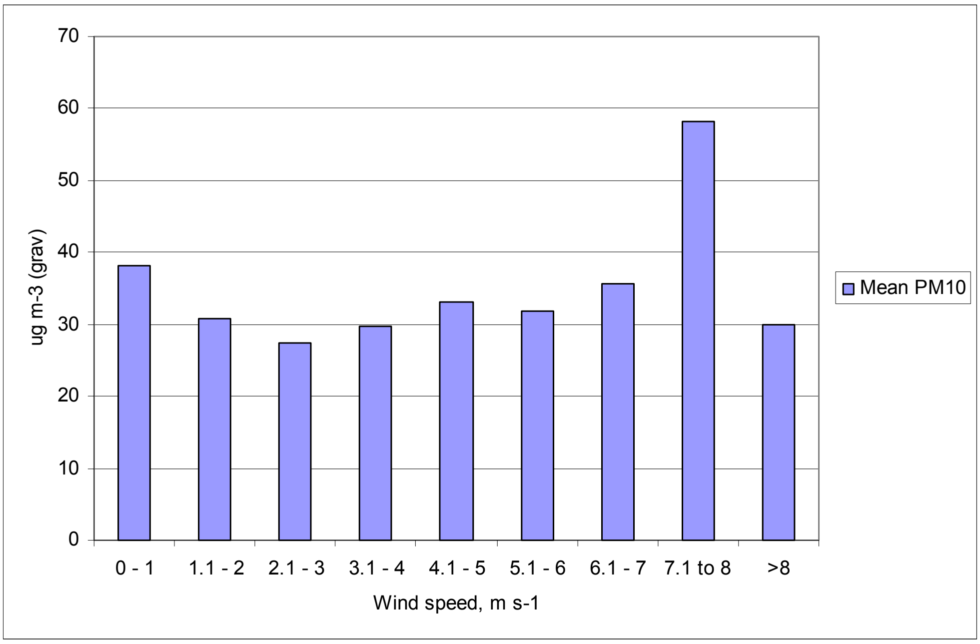

Figure 4.7: The mean PM_{10} concentrations according to wind speed, at Scunthorpe Town for 2006.

Part 4.5: 'Scunthorpe' and 'Scunthorpe Town' data, 2000 to 2006

This Part will concentrate on results from North Lincolnshire Council's main site, which is affiliated to the AURN and was originally located on the roof of the Council's offices in Cottage Beck Road and known as 'Scunthorpe'. Following a re-location in June 2004 the site has been positioned on Rowland Road, Scunthorpe and is known as 'Scunthorpe Town'.

Table 4.2 displays the annual mean, annual data capture, the number of exceedances of the daily limit value, annual median and where appropriate the 90.4th percentile for these two sites. Figure 4.8 represents the number of exceedances graphically.

Table 4.2 shows that between 2000 and 2006 the Scunthorpe AURN site did not breach the annual Air Quality objective of 40 µg m^{-3}, although it was close in 2003. In all years the annual median concentration is lower than the annual mean concentration at the Scunthorpe AURN site. The median value (50th percentile) demonstrates the concentration most frequently breathed in by a receptor.

However in 2001, 2002, 2003 and 2006 the daily mean Air Quality objective was breached. In 2004 the 90.4th percentile was greater than 50 µg m^{-3} and with 30 exceedances in nine months it is likely the daily Air Quality objective would have been breached. In 2000 the 90.4th percentile was 49.9 µg m^{-3}, very close to 50 µg m^{-3}.

Year	PM_{10}, Annual Mean, ug m^{-3}	Annual Data Capture, %	Number of Exceedances	Annual Median, ug m^{-3}	90.4th %ile, ug m^{-3}
2000	27.5	88.8	31	22	49.9
2001	31.8	93.7	49	26	n/a
2002	32.3	83.6	47	26	62.8
2003	39.4	98.6	95	31	n/a
2004*	28.1	75.1	30	22	52
2005	24.9	97.5	25	20	n/a
2006	29.6	95.1	37	23	n/a

Table 4.2: The annual mean, annual data capture, the number of exceedances, annual median and 90.4th percentile for Scunthorpe and Scunthorpe Town AURN site.

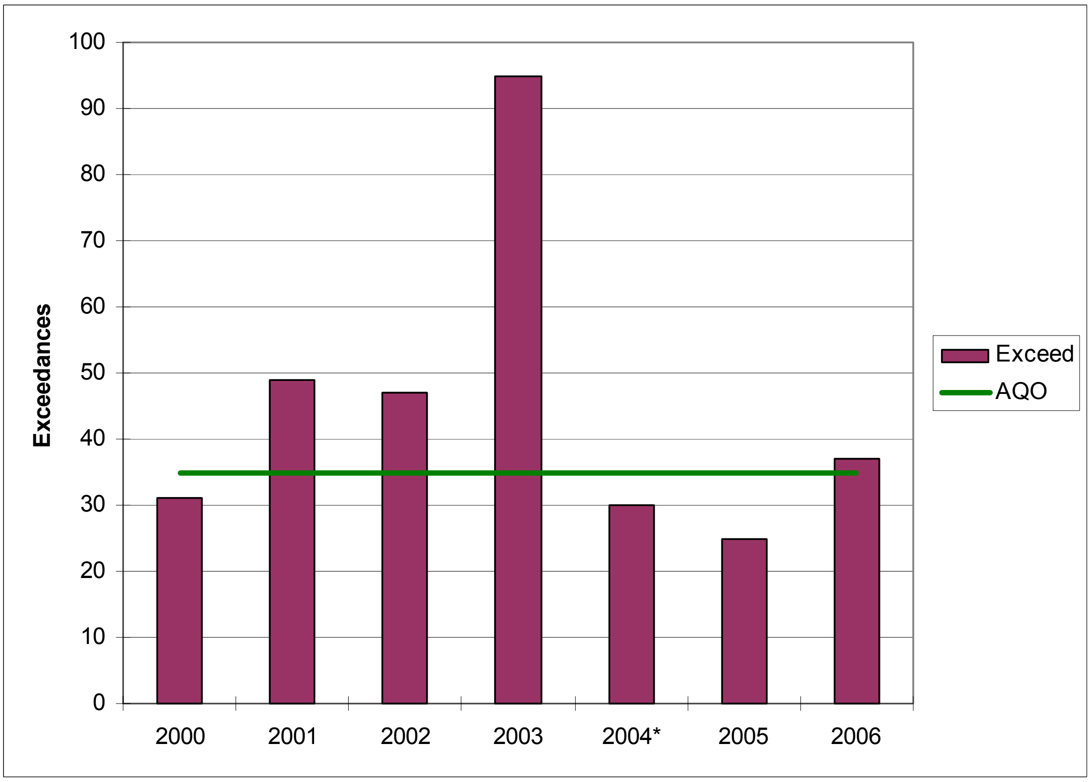

Figure 4.8: A graph showing the number of exceedances at Scunthorpe and Scunthorpe Town monitoring sites between 2000 and 2006, the green horizontal line represents the number of exceedances allowed under the Air Quality objective.

Note: * 2004 data is amalgamated data from Scunthorpe and Scunthorpe Town giving a total of 9 months monitoring.

Table 4.3a shows the mean concentration on non-exceedance and exceedance days whilst Table 4.3b gives details of the minimum and maximum daily mean PM_{10} concentrations recorded from 2000 to 2006. It shows that the mean concentration on an exceedance day is significantly greater than the mean concentration on a non-exceedance day.

Year	Non-exceedance mean, ug m^{-3}	Exceedance mean, ug m^{-3}
2000	23.6	64.5
2001	25.6	68.7
2002	25.5	69.7
2003	25.9	77.1
2004*	22.4	66.0
2005	21.9	64.8
2006	24.7	70.4

a.)

Year	Minimum daily mean, ug m^{-3}	Maximum daily mean, ug m^{-3}
2000	8	90
2001	6	146
2002	9	111
2003	9	152
2004*	5	138
2005	5	91
2006	9	130

b.)

Table 4.3: a.) The mean PM_{10} concentration across the non-exceedance daily means and exceedance daily means and b.) minimum and maximum daily mean PM_{10} concentrations at Scunthorpe and Scunthorpe Town monitoring sites from 2000 to 2006.

A comparison between summer (defined as April to September) and winter (October to March) exceedances for Scunthorpe Town between 2000 and 2006 is given in Table 4.4. Figure 4.9 shows the number of exceedances and mean concentrations at Scunthorpe Town according to month for 2006.

In general the number of exceedances is greater in summer than in winter. In 2006 at Scunthorpe Town, July contributed 13 of the 37 exceedances. This was a particularly dry and sunny month, with only 10 mm of rainfall and a maximum temperature of 30.4^{o}C. This contrasts with August, which experienced 163 mm of rainfall and only 1 exceedance. September and October recorded 9 exceedance days between them, some of these exceedances will be discussed in Chapter 7. However, it can be seen that the number of exceedances varies across the years by month and season; this suggests that the local meteorology could be an important factor in understanding the PM_{10} concentrations within the AQMA.

Year	Summer exceedances	Winter exceedances
2000	20	11
2001	32	17
2002	24	23
2003	47	48
2004*	16	14
2005	15	10
2006	26	11

Table 4.4: The number of exceedances in summer and winter at the Scunthorpe and Scunthorpe Town monitoring sites from 2000 to 2006.

Note: *2004 = 2 months of summer data missing (April and May).

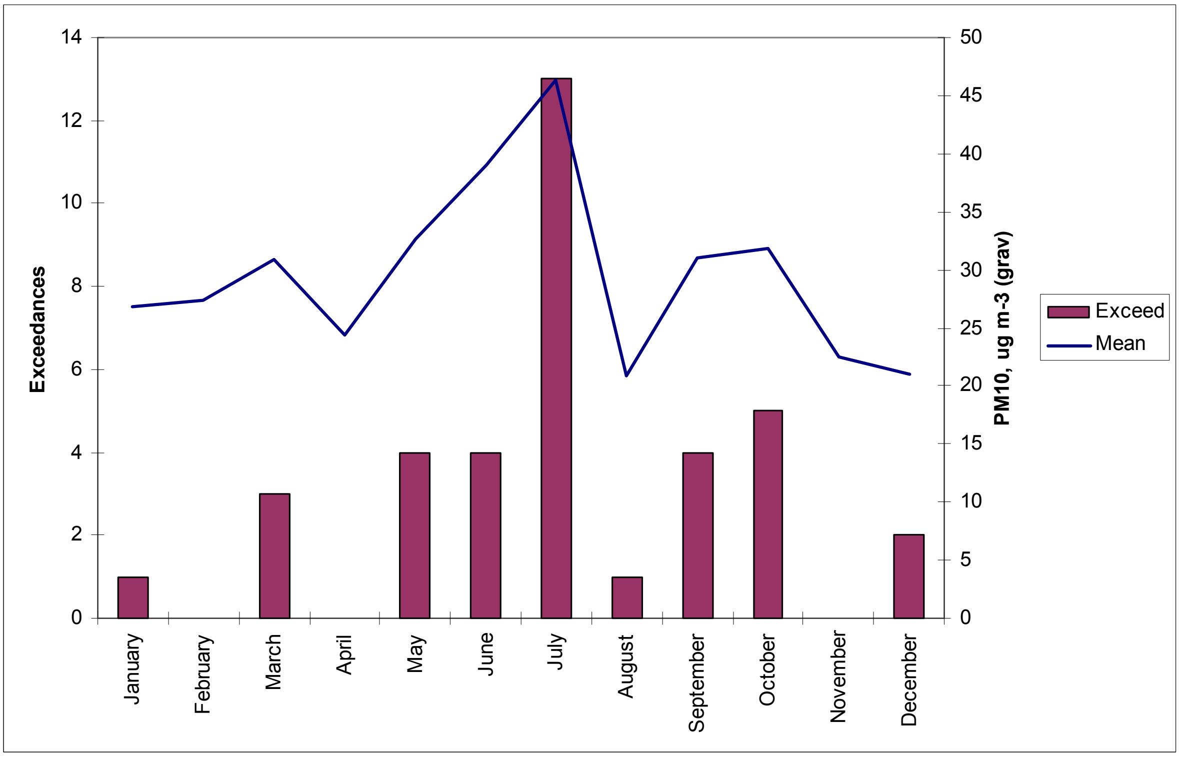

Figure 4.9: The number of exceedances and mean concentration by month from Scunthorpe Town monitoring site in 2006.

Thus the monitoring data shows that Scunthorpe has a problem with individual days of high concentrations rather than slightly elevated concentrations occurring everyday. This is further illustrated by Figure 4.10, which shows that a small increase in the annual mean leads to an exponential growth in the number of exceedances at the AURN site using data from 2000 to 2006. In the top right hand corner of Figure 4.10 is the equation of best fit for the data, the R^2 value indicates how well the points fit the line, if $R^2 = 1$ this would indicate a perfect fit.

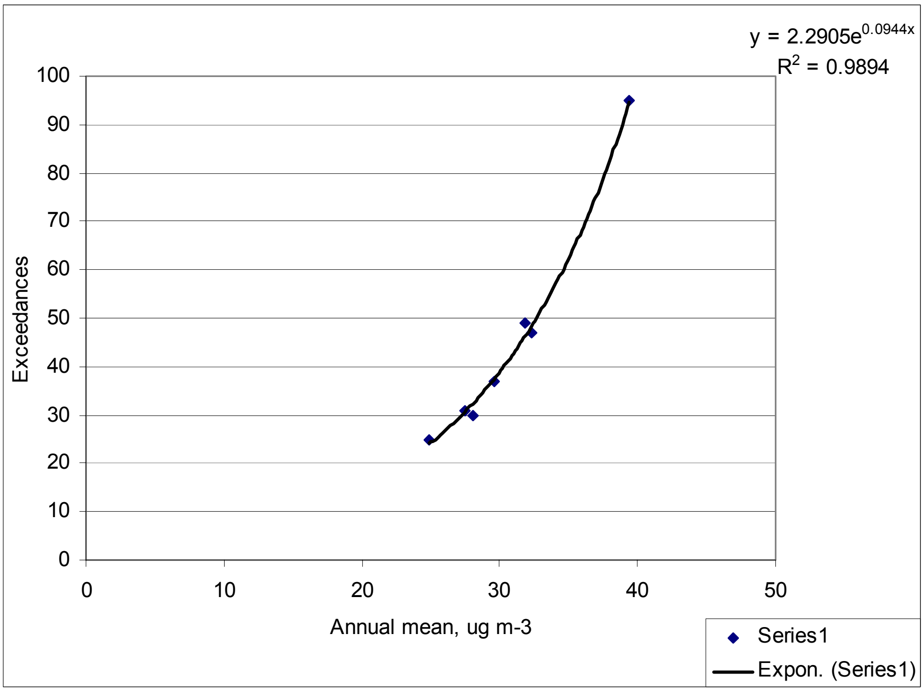

Figure 4.10: A graph showing the number of exceedances vs annual mean PM_{10} concentration at Scunthorpe and Scunthorpe Town between 2000 and 2006.

Note: The equation in the top right hand corner is the trend line as calculated by Microsoft Excel.

Part 4.6: AURN data

A comparison with other AURN sites has been performed using data from the Air Quality Archive website.[13] Table A2 lists the AURN monitoring sites with the greatest number of PM_{10} daily exceedances between 2000 and 2006 from the AURN network, 2006 data is shown in Table 4.5 with the number of exceedances for Harwell, Hull, Newcastle Centre and Northampton also shown. It shows that the Scunthorpe AURN site has been within the top six sites for all of these years.

The situation has improved in recent years compared to the rest of the UK with 2nd and 3rd places occurring between 2000 and 2004, although with construction works affecting the results from the Bradford Centre [13] site the position for 2006 should be 4th.

2006	
Exceedances	Site
149	Marylebone Road
67	Glasgow Kerbside
52	Camden Kerbside
47	Bradford Centre
37	**Scunthorpe Town**
35	Port Talbot
3	Harwell
6	Hull Freetown
2	Newcastle Centre
3	Northampton

Table 4.5: The AURN sites with six highest number of exceedances of the daily limit value followed by the number of exceedances at the four other selected AURN sites used in this report.

Part 4.7: 15-Minute Data

In Figure 4.11 the mean PM_{10} concentrations for Scunthorpe Town have been plotted by 15-minute periods. i.e. the first point represents the mean concentrations using all the available data points in 2006 for the time period 0000 to 0015, the second point 0015 to 0030 and so on. The data has been split into plots for data from Monday to Friday, Saturday and Sunday. Figure A3 plots the data from East Common Lane.

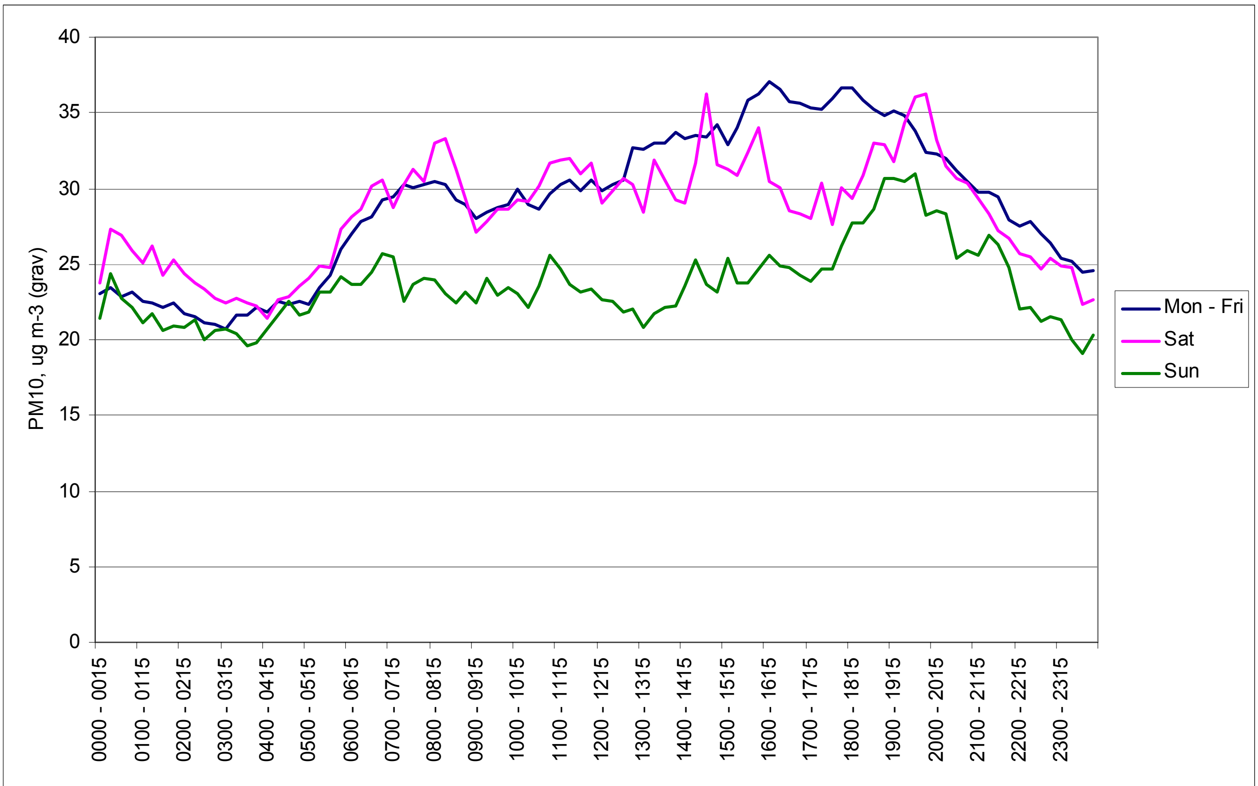

Figure 4.11: A graph of 15-minute data for Scunthorpe Town in 2006 separated according to days of the week, Monday to Friday, Saturday and Sunday.

At Scunthorpe Town and East Common Lane the concentrations are fairly similar during weekdays as they are on Saturdays, concentrations are slightly lower on Sundays. Concentrations are also lower overnight than during the day, particularly between 2300 hrs and 0500 hrs. This is discussed more in Part 7.5. While it appears that PM_{10} concentrations vary slightly according to the day of the week at Scunthorpe Town, the contrast is not as significant as that at Santon (see Part 8.2).

Part 4.8: Discussion

The data presented in this Chapter shows that North Lincolnshire Council was correct to declare an AQMA for potential breaches of the daily PM_{10} Air Quality objective in the Scunthorpe area. The monitoring results also demonstrate that the boundaries chosen are approximately correct, the only change that could be deemed necessary is an extension northwards around the Santon site. However, the High Santon Partisol data will help to decide whether an extension is necessary. The nearest receptor to the north of the Santon TEOM monitoring site is 1.3 km away yet the Partisol is only 500 m. If the High Santon site is not significantly breaching the daily objective then the current AQMA will not need a northwards extension.

Only in 2005 were results significantly below the daily Air Quality objective, with the number of exceedances at Scunthorpe Town being 25. During all other years the Scunthorpe AURN site has or has been very close to breaching the daily Air Quality objective based on either the number of exceedances or the 90.4th percentile where appropriate.

The monitoring site at Santon was installed on the 1st October 2005, thus this is the first reporting of an annual set of monitoring data. The original AQMA declaration was in relation to breaching the daily PM_{10} Air Quality objective. However, the current Santon site is breaching both the annual mean and daily PM_{10} Air Quality objectives. Further monitoring is currently being conducted via the recently installed High Santon Partisol (see Chapter 9), which will help determine the extent of the area that is experiencing an annual mean greater than 40 $\mu g\ m^{-3}$.

The improvement that will be required at Santon is significant, both in terms of the annual mean and number of exceedances. The high annual mean is a direct result of the number of exceedances, i.e. the concentrations are not similarly high throughout the day or year. At Santon the reduction in the annual mean required is 18.8 $\mu g\ m^{-3}$ in addition to a reduction of 123 exceedances. Reducing the number of exceedances will be the main target, as this will have a direct influence and reduction on the annual mean as well. As Chapter 8 will show a reduction in the daytime concentrations will be the crucial element.

At East Common Lane a reduction of 8 exceedances per year is needed and at Scunthorpe Town, 2 exceedances to achieve the Air Quality objectives. However, as shown at the Scunthorpe and Scunthorpe Town sites the number of exceedances varies from year to year and meteorological conditions may play a significant role in the number of exceedances being recorded in Scunthorpe. This, along with the 2003 results suggests that the improvements needed are possibly more complicated than a simple reduction of 2 exceedances.

Key Points:

- Sites within the AQMA breached the daily objective, those outside did not.
- Newly identified breach of the annual objective at the Santon site.
- Clear that industry is the most significant contributor to the PM_{10} problem in Scunthorpe.

Chapter 5: Source Apportionment

Part 5.1: Background Concentrations

As discussed in Chapter 1 there are multiple potential sources of PM_{10} that are both anthropogenic and natural in origin, thus there will always be a certain concentration of PM_{10} in the atmosphere. This part aims to calculate a background concentration that excludes local sources such as road traffic and local industry for the AQMA; this will be based on data provided by the Air Quality Archive.

The data provided by the Air Quality Archive already takes account of local transport and industrial sources where the information is available and therefore the data presented for the 1 km * 1 km grid squares within the AQMA cannot be used directly. However, in the LAQM Technical Guidance document LAQM.TG(03) a procedure is outlined which helps to avoid double counting due to a major road passing through a rural or suburban area. It recommends that the 1 km grid squares selected are those 4 km west and 4 km east of the point of interest, (Scunthorpe Town monitoring site was selected as the point of interest); in the case of Scunthorpe this cannot be done because the grid square 4 km west of Scunthorpe Town is still located within the urban area of Scunthorpe.

Thus the grid squares 4 km east (494500, 410500) and 4 km north (490500, 414500) were selected for the calculation of a background concentration. The square 4 km to the south was not selected, due to the M180 Motorway.

The background concentration was then calculated using the data from the Air Quality Archive and the appropriate projection factors from the LAQM tools. Background concentrations for the Scunthorpe AQMA and adjacent squares are given in Table A3. This gave a result of 18.912 µg m^{-3} for 2006 and has been used as the background concentration for all Scunthorpe sites.

Part 5.2: Road Traffic

The DMRB tool was used to assess the significance of the contribution that road traffic (tailpipe emissions only) makes to PM_{10} concentrations at each monitoring site. The input data used was estimated local traffic flow data for 2006 supplied by the Highways and Transport Services department of North Lincolnshire Council.

The traffic data used for all sites is for the road(s) closest to the monitoring station supplied by the Highways and Transport Department of North Lincolnshire Council. For Allanby Street, no 2006 prediction for traffic flow at Doncaster Road was given, therefore the actual figure from 1999 was used. Also, Dawes Lane is mainly a private road thus the traffic data used for Santon are those from the western end of Dawes Lane where the road is public. This is on the opposite side of the steelworks site to where the Santon monitoring site is located and the assumption has been made that traffic levels are similar.

A 30 mph (48.28 km/h) speed limit applies to all roads except Brigg Road, which has a 40 mph (64.37 km/h) limit. Average speeds, according to speed limit, used in the DMRB runs were obtained from a document supplied by the Highways and Transport Department of North Lincolnshire Council.

The data inputted into the DMRB is shown in Table 5.1, with the results for the DMRB runs are shown in Table 5.2, a run was not performed for Broughton as the number of exceedances or annual mean are not of concern.

Table 5.2 shows that at the Scunthorpe Town monitoring site, an estimated 3.79 exceedances of the daily PM_{10} limit value can be attributed to tailpipe emissions from road traffic. The other monitoring sites show either around 2.25 or 2.75 exceedances. Although the input data for the Santon site was not recorded near the monitoring site, the DMRB run does show that the number of vehicles running past the Santon monitoring site would have to be significantly higher for the tailpipe contribution from road traffic to be the sole explanation of the concentrations being recorded at the site.

Monitoring Station	Roads	Distance from road to site	Vehicle AADT	Average annual speed, km/h	Road type	HDV, %
Allanby St	Doncaster Road, East of Deyne Avenue	153	9388	43.13	B	6.2
	High Street (E of Oswald Rd)	105	5780	43.13	B	4.8
East Common Lane	East Common Lane - West Grange Lane North	34	6740	43.13	B	5.0
Lincoln Gardens	Lincoln Gardens - West of Collum Avenue	72	1900	43.13	B	2.6
Scunthorpe Town	Rowland Road	9	6800	43.13	B	8.5
	Brigg Road	124	19400	58.74	B	11.2
Santon	High Street East Railway crossing.	24	3370	43.13	B	14.2

Table 5.1: Inputs into the DMRB exercises.

DMRB: Assessment of Local Air Quality — OUTPUT SHEET

CLEAR RESULTS - CURRENT RECEPTOR

CLEAR RESULTS - ALL RECEPTORS

Current receptor

Receptor Name	Santon	Receptor number	5
Assessment year	2006		

Results

Pollutant	Annual mean				For comparison with Air Quality Standards		
	Background concentration	Road traffic component	Total	Units	Metric	Value	Units
CO	0.00	0.01	0.01	mg/m³	Annual mean*	0.01	mg/m³
Benzene	0.00	0.01	0.01	µg/m³	Annual mean	0.01	µg/m³
1,3-butadiene	0.00	0.02	0.02	µg/m³	Annual mean	0.02	µg/m³
NO_x	17.3	5.3	22.5	µg/m³	Not applicable		
NO_2	14.7	1.7	16.4	µg/m³	Annual mean*	16.4	µg/m³
PM_{10}	18.9	0.52	19.43	µg/m³	Annual mean	19.4	µg/m³
					Days >50µg/m³	3	Days

* See Footnote 4 in DMRB Volume 11 Chapter 3

Contribution of each link to annual mean

Link number	CO (mg/m³)	Benzene (µg/m³)	1,3-butadiene (µg/m³)	NO_x (µg/m³)	PM_{10} (µg/m³)
1	0.01	0.01	0.02	5.28	0.52
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

All receptors

Receptor number	Name	Year	CO*	Benzene	1,3-butadiene	NO_x	NO_2*	PM_{10}	
			Annual mean mg/m³	Annual mean µg/m³	Annual mean µg/m³	Annual mean µg/m³	Annual mean µg/m³	Annual mean µg/m³	Days >50µg/m³
1	Allanby St	2006	0.00	0.01	0.00	18.49	15.14	19.05	2.34
2	East Common Lane	2006	0.02	0.02	0.02	21.72	16.16	19.43	2.74
3	Lincoln Gardens	2006	0.00	0.00	0.00	17.66	14.87	18.96	2.25
4	Scunthorpe Town	2006	0.04	0.05	0.05	30.63	18.69	20.31	3.79
5	Santon	2006	0.01	0.01	0.02	22.55	16.41	19.43	2.74

(Pollutant concentrations at receptor)

Table 5.2: Results from the DMRB exercises.

Part 5.3: Local Industry Contribution

Table 5.3 shows the number of exceedances and magnitude of the annual mean that has been attributed to traffic as a result of the DMRB and analysis of Bonfire Night data (see Chapter 6). It is clear that tailpipe traffic emissions do not make a significant contribution to the PM_{10} problem in the Scunthorpe area. However, the DMRB model does not take into account any dust and other material re-suspension that may be occurring.

It has been assumed that the remainder of the PM_{10} in Scunthorpe can be attributed to local industry with the results shown in Table 5.3, the graphs and pollution roses shown in the rest of this report confirm the significance of the local industry contribution. However, in what form these contributions are made is a different question.

Part b of Table 5.3 has expressed these results in percentage terms, with all sites showing that traffic and Bonfire night contribute less than 18% of the exceedances of the daily limit value at all sites, with industrial sources being responsible for the remainder of the exceedances.

Absolute values	Exceedances			Annual mean, ug m-3		
Site	Traffic (DMRB)	Guy Fawkes	Industry	Background	Traffic (DMRB)	Industry
Allanby St	2.34	1	19.7	18.912	0.14	9.05
East Common Lane	2.74	1	39.3	18.912	0.52	9.47
Lincoln Gardens	2.25	1	14.8	18.912	0.05	6.84
Santon	2.74	1	154.3	18.912	0.52	39.37
Scunthorpe Town	3.79	1	32.2	18.912	1.40	9.29

a.)

Percentages	Exceedances			Annual mean, ug m-3		
Site	Traffic (DMRB)	Guy Fawkes	Industry	Background	Traffic (DMRB)	Industry
Allanby St	10.16	4.35	85.5	67.3	0.48	32.2
East Common Lane	6.36	2.33	91.3	65.4	1.78	32.8
Lincoln Gardens	12.50	5.56	81.9	73.3	0.19	26.5
Santon	1.73	0.63	97.6	32.2	0.88	67.0
Scunthorpe Town	10.25	2.70	87.0	63.9	4.73	31.4
Mean (exc Santon)	9.82	3.73	86.45	67.5	1.80	30.7

b.)

Table 5.3: The number of exceedances and annual mean expressed as a.) absolute values and b.) in percentage terms for all the Scunthorpe monitoring sites.

Part 5.4: Other Sources

It is acknowledged that there is potential for other sources of PM_{10} within North Lincolnshire, for example from agriculture (soil), sea-borne salt, and secondary PM_{10}. However, if there is an influence of sea-borne salt or secondary particulate matter emanating from an easterly direction then the site at Broughton will show that elevated concentration which is before the influence of any local industry. What is considered more important is the difference in concentrations occurring between Broughton and Scunthorpe Town or between Scunthorpe Town and the other AURN sites.

The background concentration data contains a proportion assigned to secondary particulate matter, whilst the values in Table 5.3 may exaggerate the industry contribution in that secondary particulate matter will directly cause some exceedances, the pollution roses in Chapter 7 and other discussion of exceedance days demonstrate that local industry compounds the PM_{10} problem in the AQMA.

Key points:

- Road traffic and bonfire night contribute to less than 18% of the exceedances at Scunthorpe Town monitoring station.
- Local industry likely to be the other significant contributor. (See remaining Chapters).

Chapter 6: Bonfire Night

In the UK the 5th November is bonfire night and is celebrated with bonfires and fireworks being lit. This is known to cause unusually high levels of PM_{10} in the atmosphere, this is especially true under inversion conditions, but less so under weather conditions with high wind speeds. [8]

Whilst celebrations are UK wide, the effects of any individual bonfire night events are generally localised due to the nature of the celebrations. Concentrations can vary depending on several factors:

- The distance between the monitoring stations and any celebrations.
- Whether the 5th November falls on a weekend or during the week.
- Meteorological conditions, rain, wind speed and direction etc.
- Whether other events such as Divali coincide with bonfire night and to what extent they are celebrated in a particular area.

In this Chapter data has been analysed from Scunthorpe's AURN monitoring site for 2000 to 2006 as well as data for 2006 from the six Scunthorpe sites. Figure 6.1 shows the daily mean PM_{10} concentration at Scunthorpe from 2000 to 2003 and at Scunthorpe Town from 2004 to 2006 over the period 30th October to 11th November for each year.

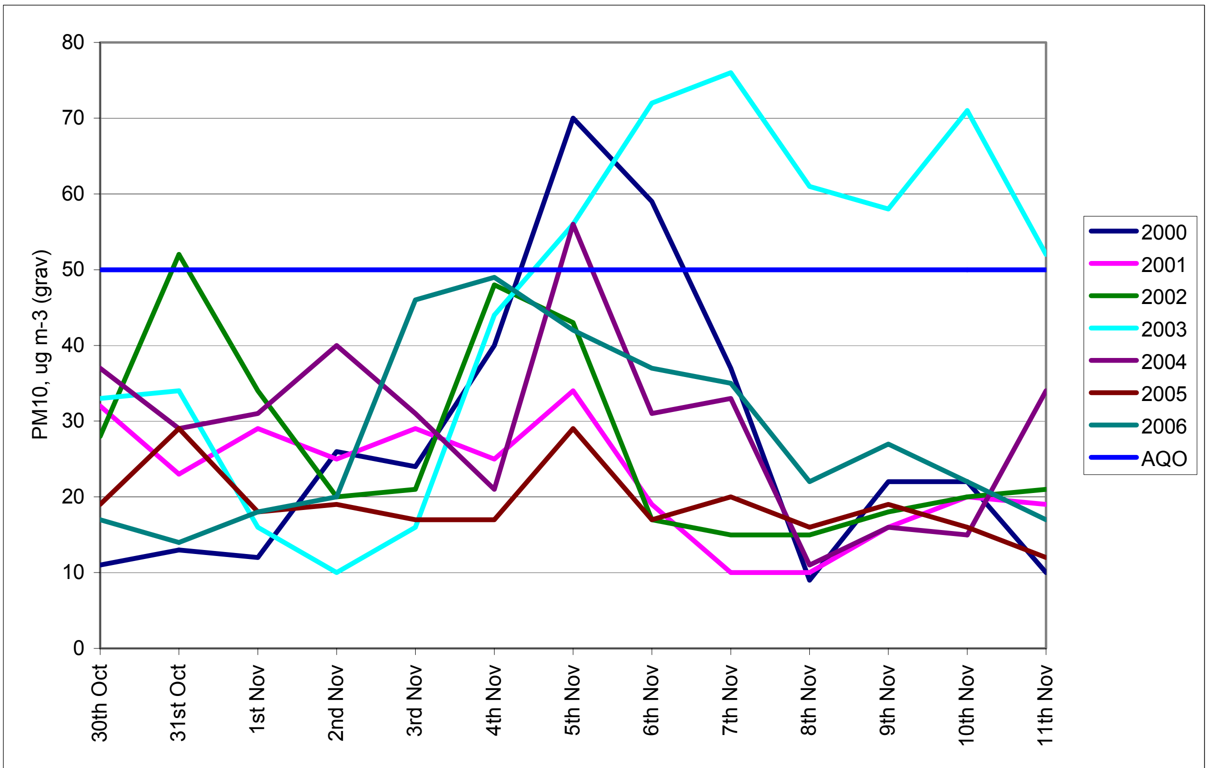

Figure 6.1: A graph showing the daily mean PM_{10} concentrations at the Scunthorpe AURN site from 30th October to 11th November between 2000 and 2006.

Figure 6.1 shows that the PM_{10} concentration can vary significantly from year to year, with the lowest daily mean concentration of 29 ug m^{-3} being recorded in 2005 on the 5th November compared to a concentration of 70 ug m^{-3} in 2000, other years that have exceeded the daily limit value on the 5th

November are 2003 and 2004. In most years the concentrations of PM_{10} are lower before and after bonfire night by about 30 μg m^{-3}. The one exception to this is 2003 when concentrations were consistently above the daily limit value in the week following bonfire night.

Figure 6.2 shows the daily mean PM_{10} concentrations at the six Scunthorpe sites, again from 30th October to 11th November 2006, whilst Figures 6.3 and 6.4 shows the 15-minute data from the 3rd to 6th November 2006.

Figure 6.2: A graph showing the daily mean PM_{10} concentration at the six Scunthorpe sites from 30th October to 11th November 2006.

Santon shows seven exceedances of 50 ug m^{-3} over the 13-day period, on all three nights of the bonfire weekend Santon records concentrations greater than the daily limit value, as shown in Figure 6.1. The 15-minute data shows high concentrations at 1730 on the 5th, but other sources maybe more important on the 3rd and 4th November as discussed in Chapter 8.

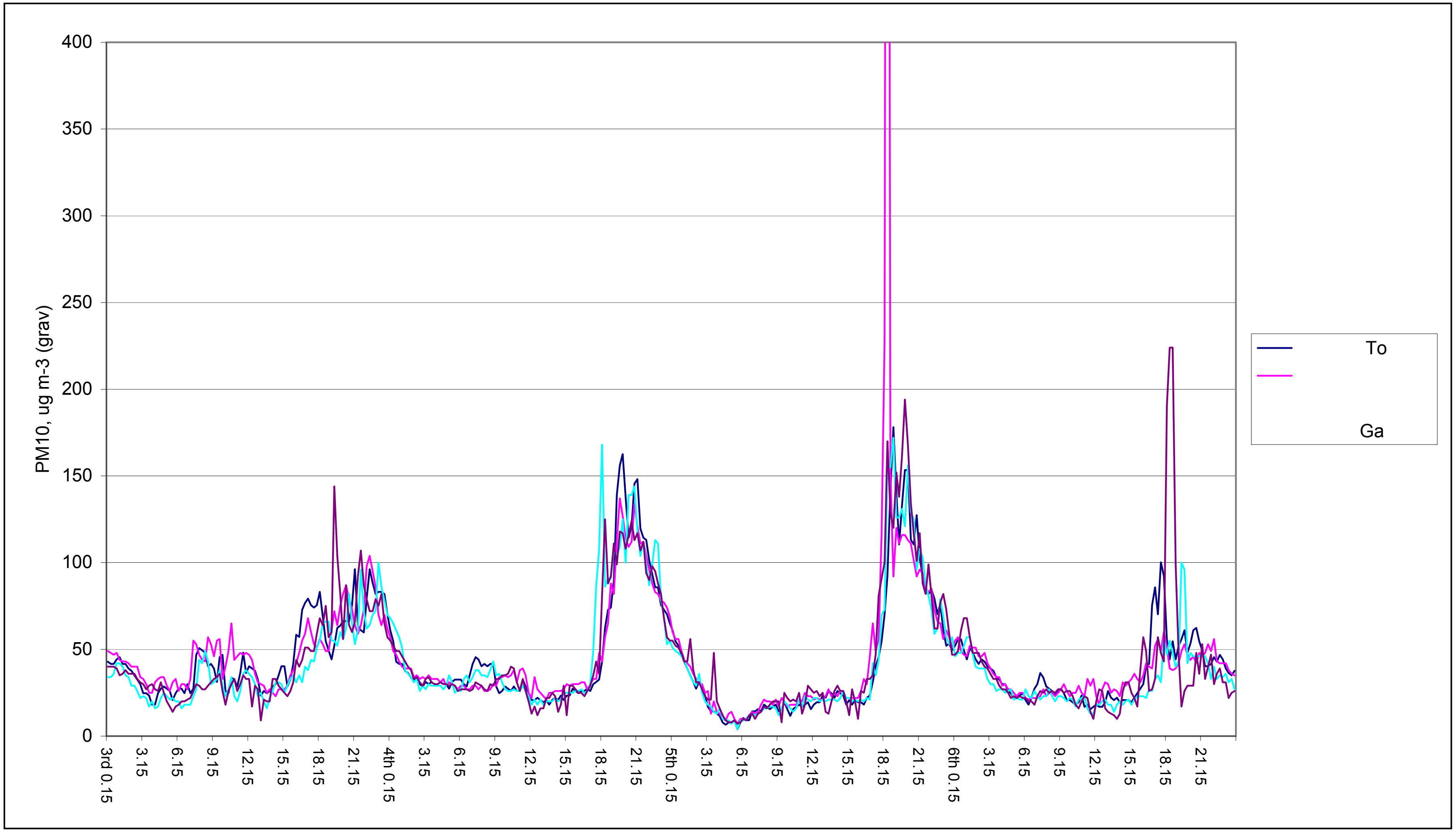

Figure 6.3: A graph of the 15-minute PM_{10} concentration from Scunthorpe Town, Allanby Street, East Common Lane and Lincoln Gardens between 3rd and 6th Nov 2006.

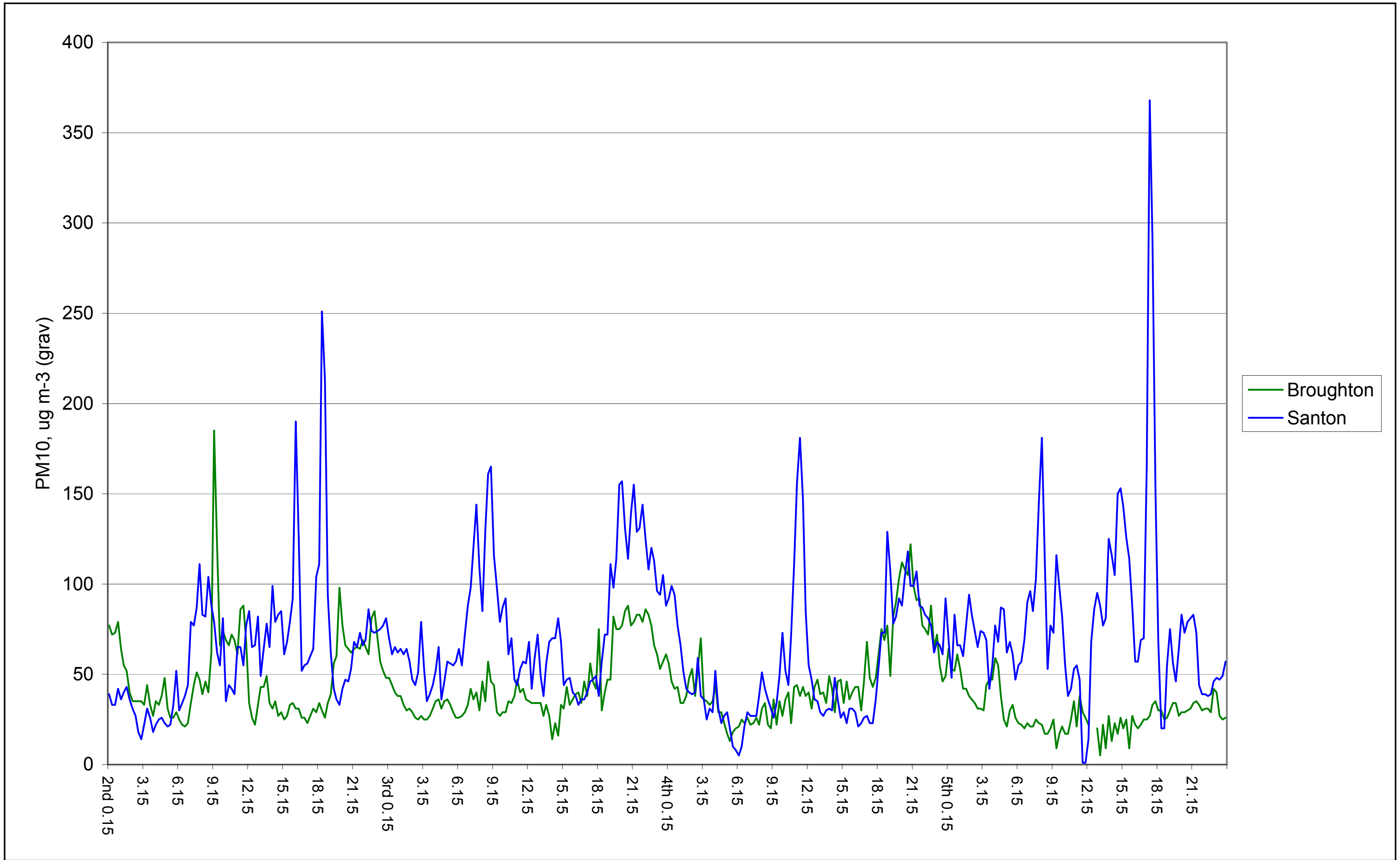

Figure 6.4: A graph showing the 15-minute PM_{10} concentrations at Santon and Broughton from 3rd to 6th November 2006.

Figures 6.3 and 6.4 demonstrate that on the 3rd to 6th November PM_{10} concentrations at all sites increase from around 1600 hrs and reach a peak at 2000 hrs, this occurs across all sites. Concentrations then decrease through the night and reach 'normal' concentrations by about 0600 hrs the following morning. This is as expected as most celebrations occur in the evening and shows that the PM_{10} are dispersed overnight (in 2006 at least).

To emphasise how local the effects of bonfire night can be, a maximum concentration of 1156 µg m^{-3} is recorded at Allanby Street at 1830 on the 5th November but this significant peak is not recorded anywhere else. Peak concentrations of 224 µg m^{-3} are also recorded between 1815 and 1845 hrs at Lincoln Gardens on the evening of the 6th November. However, this is not seen at any other site at the same time, although possibly related is a concentration of 96 µg m^{-3} recorded at East Common Lane some 30 minutes afterwards.

Although the number of houses around Santon is small compared to Scunthorpe, the local site operator for the Santon site reported on the 6th November that there were remains of a fire near the site, thus possibly helping to explain some of the evening concentrations recorded at Santon on the 5th November at 1800 hrs and on the evenings of the 3rd and 4th.

Two unusual observations during the period are that:

1. An unusual peak at Broughton on the 3rd November at 0915 hrs.
2. As discussed in Chapter 8 Santon shows peak PM_{10} concentrations in the middle of the day.

The Figures presented in this Chapter show that bonfire night celebrations cause elevated PM_{10} concentrations in the Scunthorpe area, particularly in the evening. However, it should be noted that PM_{10} concentrations are also likely to be elevated across North Lincolnshire. 2006 did not show an exceedance of the daily limit value at Scunthorpe Town, but in three of the seven years under analysis the AURN Scunthorpe site has shown an exceedance of the daily limit value. In addition, East Common Lane and Allanby Street recorded one exceedance of the daily limit value in 2006. Thus one exceedance of the daily PM_{10} Air Quality objective will be attributed to bonfire night celebrations for all sites.

Chapter 7: Further Analysis of Data (excluding Santon)

In Chapter 4 a pollution rose was plotted for 2006 to illustrate what the mean concentrations are when the wind is originating from a particular direction. In this Chapter the PM_{10} concentrations will be studied in greater detail for the individual days or episodes of exceedance days, as a contrast a few non-exceedance days will also be studied. A list of the individual exceedance days for each site is provided in the Appendix, Table A1. Santon will primarily be dealt with in Chapter 8, as it is clear that this site is showing a significant breach of the Air Quality objectives and is potentially influenced by additional sources.

Part 7.1: Exceedance Days

1.) 3rd to 13th May 2006 Episode

Scunthorpe Town recorded exceedances of the daily limit value on the 4th, 8th, 9th and 11th May 2006 with daily mean concentrations of 124, 121, 57 and 56 µg m^{-3} respectively. Figure 7.1 shows the daily means across this period at the six Scunthorpe sites, unfortunately East Common Lane and Broughton were not recording during some of this episode, but it is clear that an increase in PM_{10} concentrations was experienced at all sites at various points across the episode. Santon experienced the lowest concentration on the 8th May. This can be explained by the wind direction, which varied between 30° and 100° over the day.

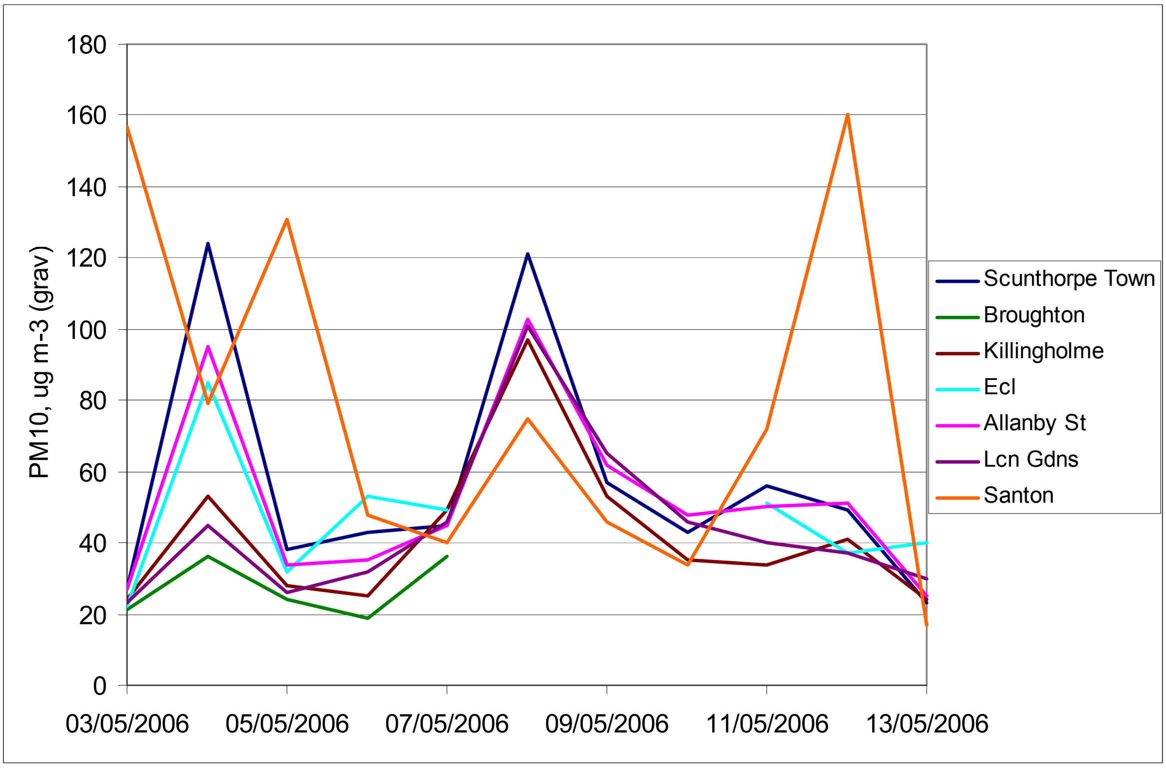

Figure 7.1: A graph showing the daily mean PM_{10} concentrations at the seven monitoring sites in Scunthorpe between the 3rd and 13th May 2006.

Figure 7.2 shows that the PM_{10} concentrations at the 4 other selected AURN sites were slightly elevated on the 4th May compared to the 3rd and 5th May. Scunthorpe Town follows a similar trend, however, a concentration 80 µg m^{-3} greater than Newcastle Centre is recorded.

On the 8th May the two AURN sites in the north of the UK (Hull Freetown and Newcastle Centre) record concentrations which exceed the daily limit value, however, Scunthorpe Town still records a concentration 43 µg m^{-3} greater than Hull and 24 µg m^{-3} greater than Killingholme. At Killingholme sea-borne salt and the refineries have potential to be influencing the concentrations recorded.

It is unfortunate that the Broughton monitoring site was not functioning on the 8th May. In spite of of local influences it is likely that an exceedance would have occurred on this day in Scunthorpe due to regional effects, however, it is clear that local sources compounded the problem. In Figure 7.3 a plot of the hourly concentrations at Hull, Newcastle and Scunthorpe Town shows the effect of local sources; concentrations at Hull and Newcastle clearly do not increase to the same extent as those at Scunthorpe Town.

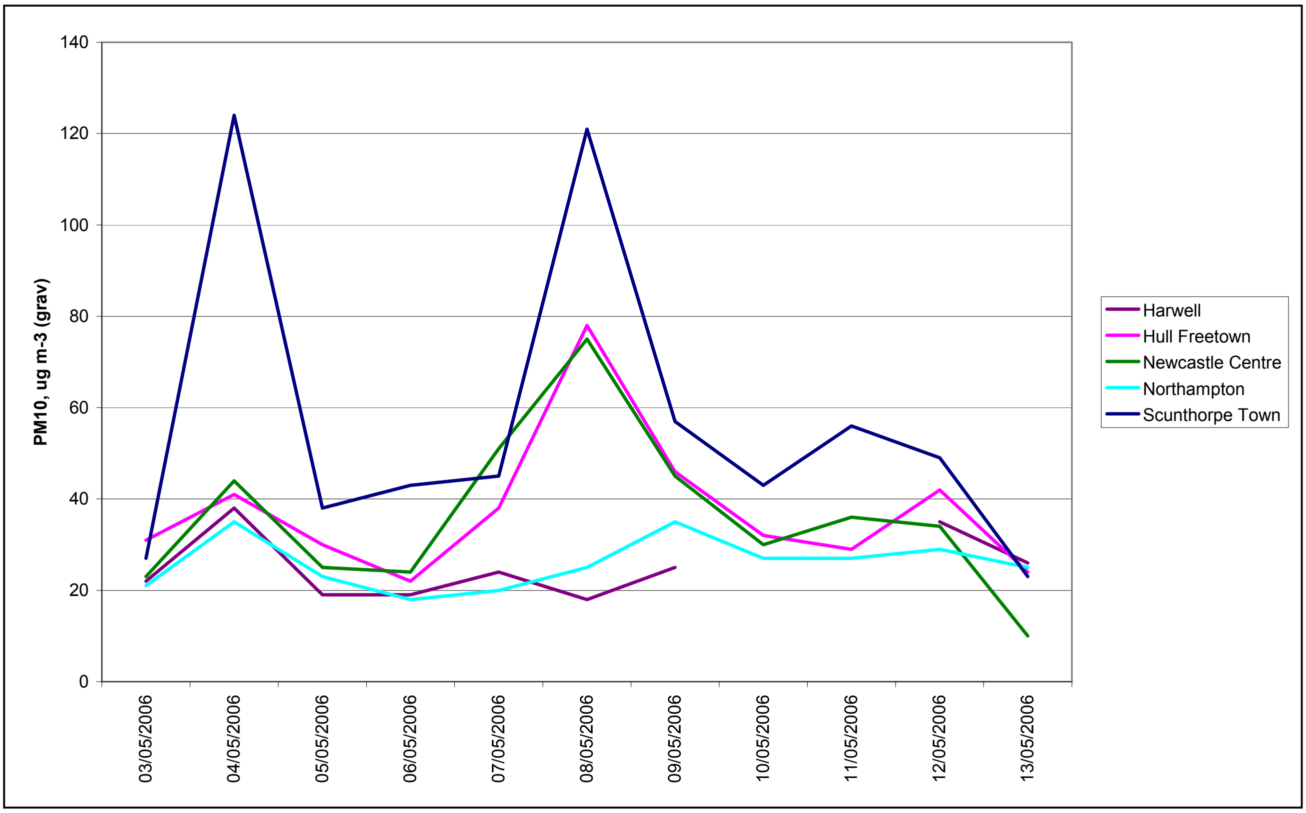

Figure 7.2: A graph of the daily mean PM_{10} concentrations at the four selected AURN sites and Scunthorpe Town between 3rd May and 13th May 2006.

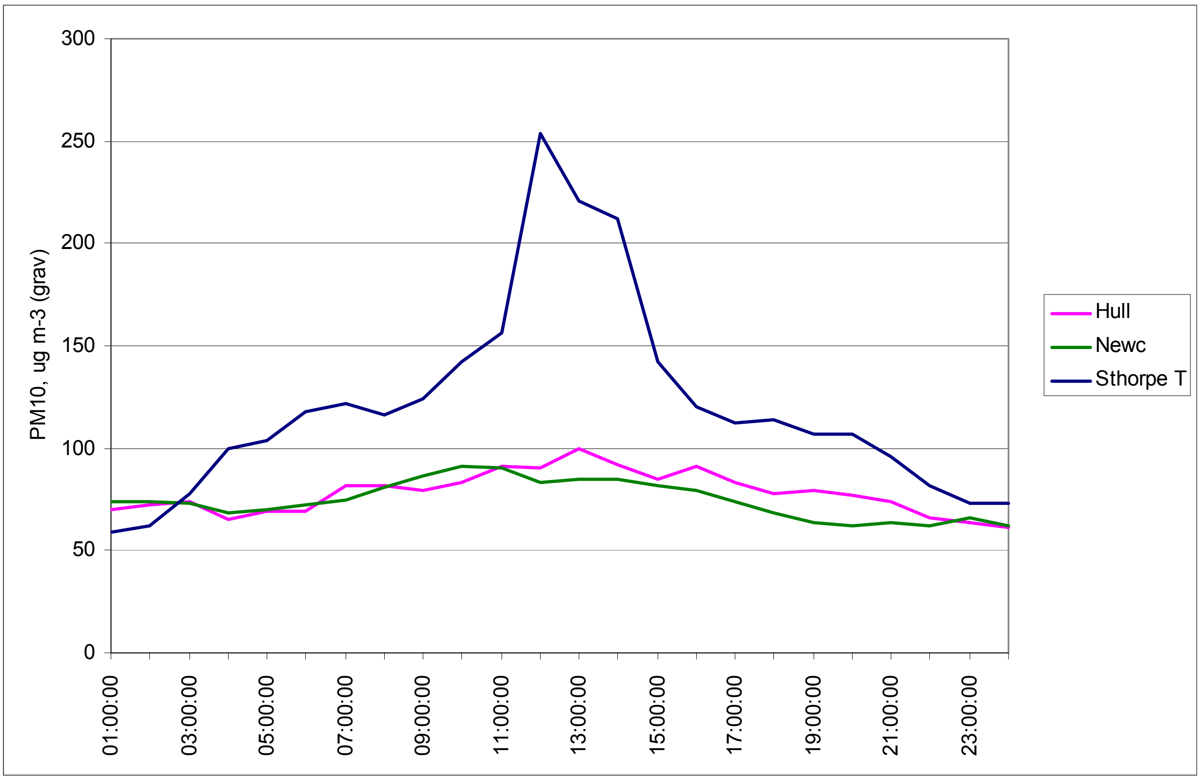

Figure 7.3: A plot of hourly PM_{10} concentrations at Hull, Newcastle Centre and Scunthorpe Town for the 8th May 2006.

Plots of the 15-minute PM_{10} data and wind direction for the 4th and 8th May 2006 are shown in Figures 7.4 a and b. Figure 7.4a shows that concentrations at Scunthorpe Town were greatest between 0600 hrs and 2030 hrs on the 4th May possibly suggesting a daytime source. However, during this time the wind direction originated between 80^o and 140^o. At the times that concentrations were lower the wind originated between 140^o and 170^o, this direction is away from local industry and ties in well with the annual pollution rose (Figure 4.2).

It is worth noting how the concentrations at Santon and Scunthorpe Town increase in a similar fashion between 0915 and 1115 hrs. Santon then experiences three significant peaks between 1200 and 1500 hrs, which are not recorded at Scunthorpe Town. This suggests that the PM_{10} sources at Santon are different to Scunthorpe Town. Broughton records concentrations greater than 50 µg m^{-3} between 1000 hrs and 1800 hrs, however, the concentration differences between this site and Scunthorpe Town and Santon are clear to see, with elevations of up to 200 µg m^{-3}.

In Figure 7.4b (the 8th) the wind direction changes in a different manner to the 4th May, it is less than 50^o before 0300 hrs and after 2100 hrs, during the remainder of the day the wind direction increases to a maximum of 120^o. Thus data from both days fits in with the annual pollution rose for Scunthorpe Town; that is the concentrations of PM_{10} are greatest when the wind originates from between 80^o and 140^o. This is confirmed by Figure 4.2, which clearly shows that the greatest concentrations during the episode arise when the wind direction is between 100^o and 130^o. Although Santon records concentrations of similar magnitude to Scunthorpe Town, these are in fact relatively low concentrations compared to some of the other concentrations recorded at Santon on other days. With a wind direction of 100° to 120° during these high concentrations this suggests that Dawes Lane could be a source of re-suspended material.

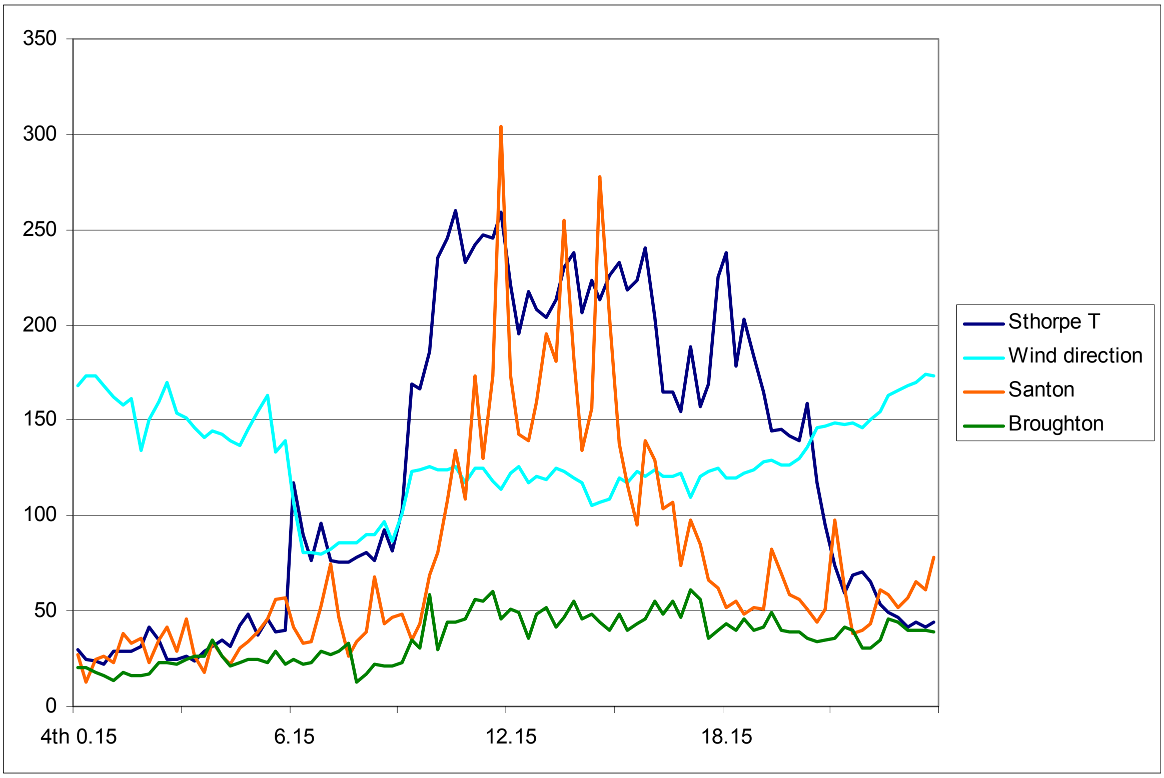

Figure 7.4 a.

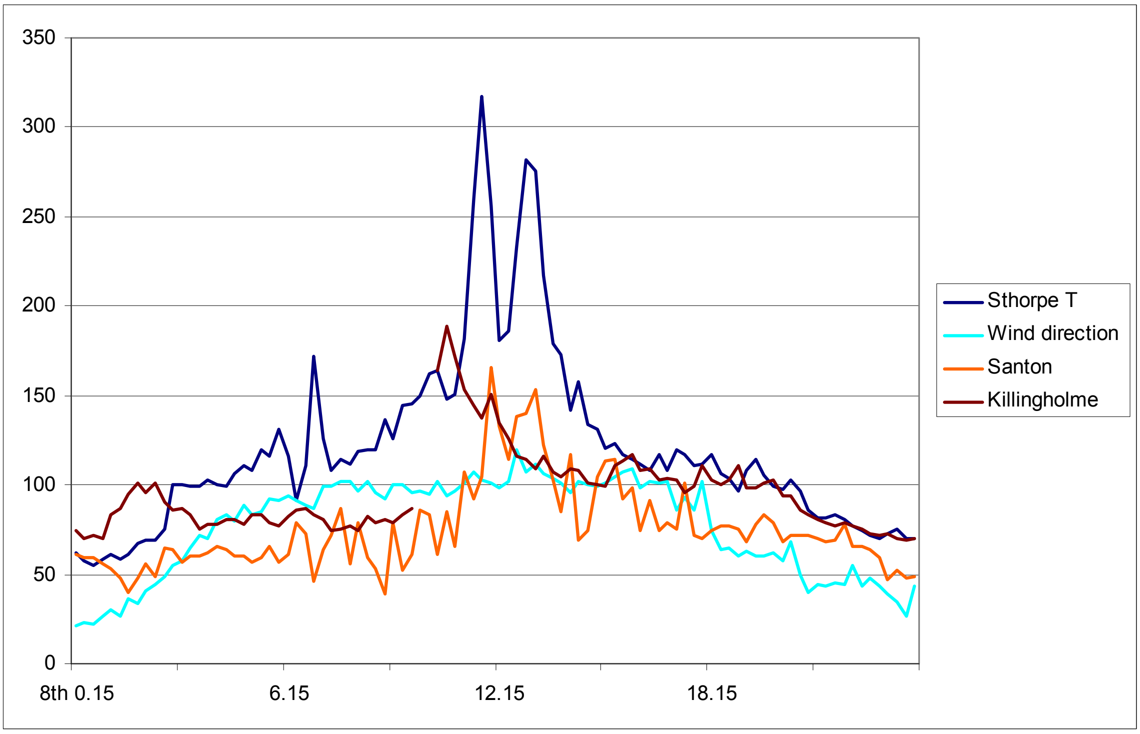

Figure 7.4 b.

Figure 7.4: A graph of the wind direction at Scunthorpe Town and PM_{10} concentrations at Scunthorpe Town, Santon and Broughton, using 15-minute data, for a.) 4th and b.) 8th May 2006.

Note: The y-axis represents wind direction, ^{o}, and PM_{10}, ug m^{-3}, gravimetric.

Figure 7.5 plots the wind direction vs the PM_{10} concentration at Scunthorpe Town for the episode and shows that the majority of the high PM_{10} concentrations are being recorded from a south-easterly direction, particularly 100^{o} to 130^{o}.

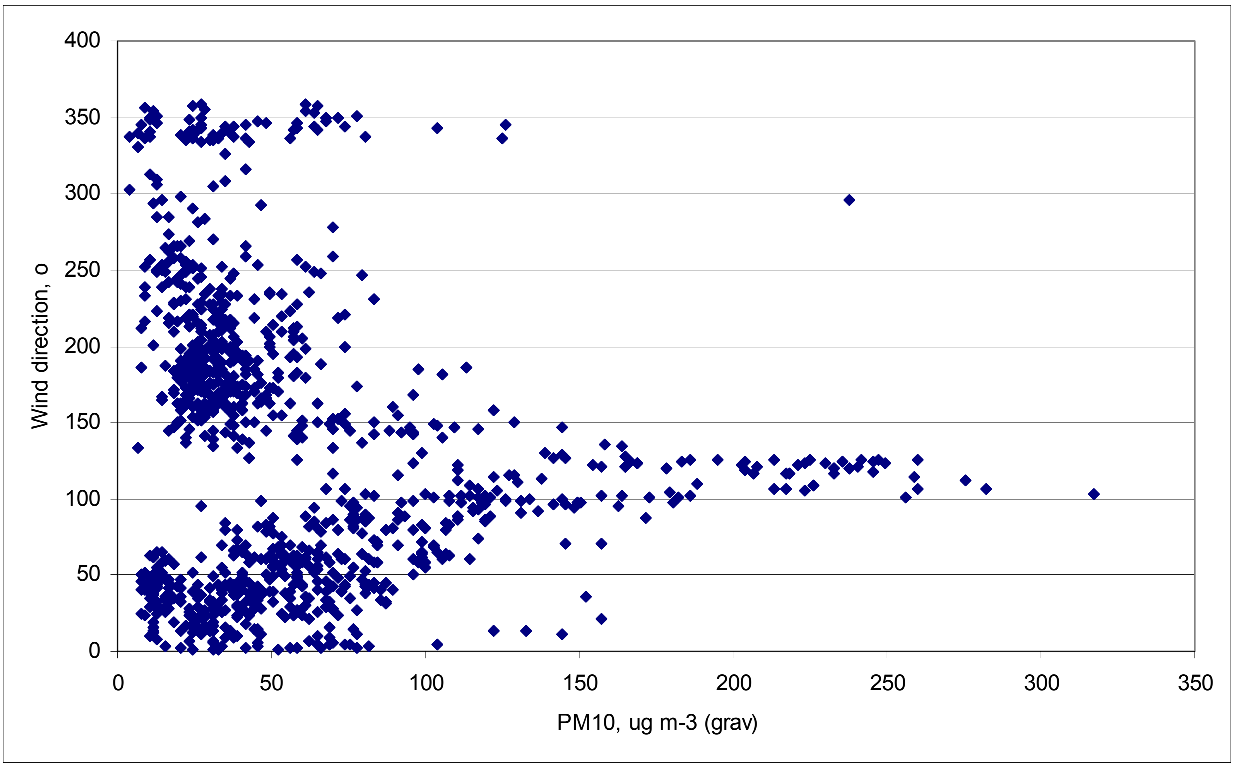

Figure 7.5: A graph representing the wind direction, °, vs the PM_{10} concentrations, μg m^{-3} (gravimetric) at Scunthorpe Town between the 3rd and 13th May 2006.

Figure 7.6, the pollution rose for the episode largely agrees with the above observations. However, there is one unusual peak at 300° that is recorded at all sites except for Broughton. Looking at the data, this peak is largely the responsibility of one elevated value occurring at 1245 hrs on the 12th May at 296°. The cause of this peak is not known, although in this approximate direction lies the gas-fired power station at Keadby. However, based on the annual pollution rose sources from outside North Lincolnshire have a small impact on Scunthorpe compared to other local sources.

Figure: 7.6: Pollution Rose for the May (3rd to 13th) Episode.
Please see file: 'Figure 7.6 May Pollution Rose'.

2.) 7th to 10th June 2006 Episode

During the period 7th to 10th June Scunthorpe Town exceeded the daily limit value, with concentrations of 52, 87, 107 and 130 µg m^{-3}. Figure 7.7 shows that Allanby Street, East Common Lane and Lincoln Gardens also exceeded the daily limit value over this period. The Figure shows that the sites closest to the steelworks site show higher concentrations than those further away. In addition, Killingholme concentrations are greater than Broughton, potentially showing the influence either of secondary PM_{10}, sea-borne particulate matter or the refineries.

Unlike the May and October episodes, the other AURN sites do not show a significant increase (a maximum of 10 µg m^{-3}) in their PM_{10} concentrations over the episode, see Figure 7.8. This suggests that secondary PM_{10} from the rest of Europe or sea salt etc. are not contributing significantly either to the AURN sites or the sites in Scunthorpe.

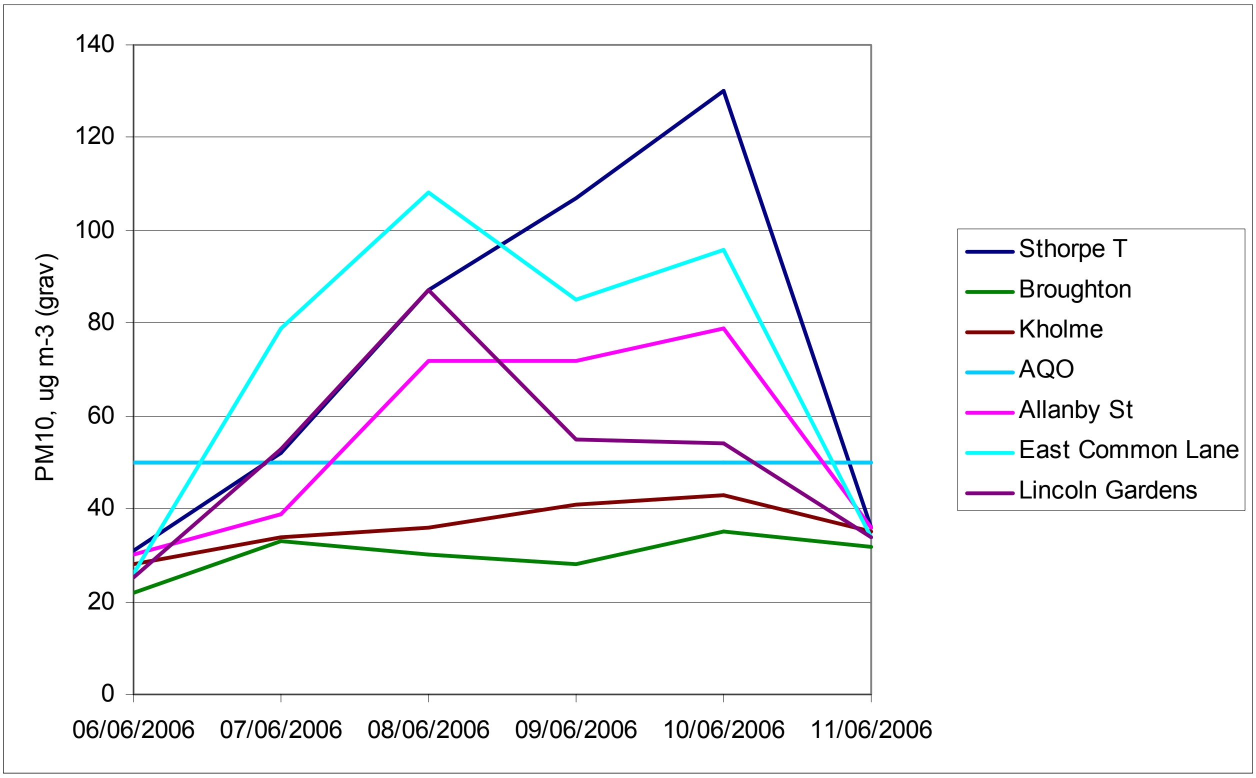

Figure 7.7: A graph showing the daily mean PM_{10} concentrations at the Scunthorpe sites and Killingholme (Kholme) from the 6th June to 11th June 2006.

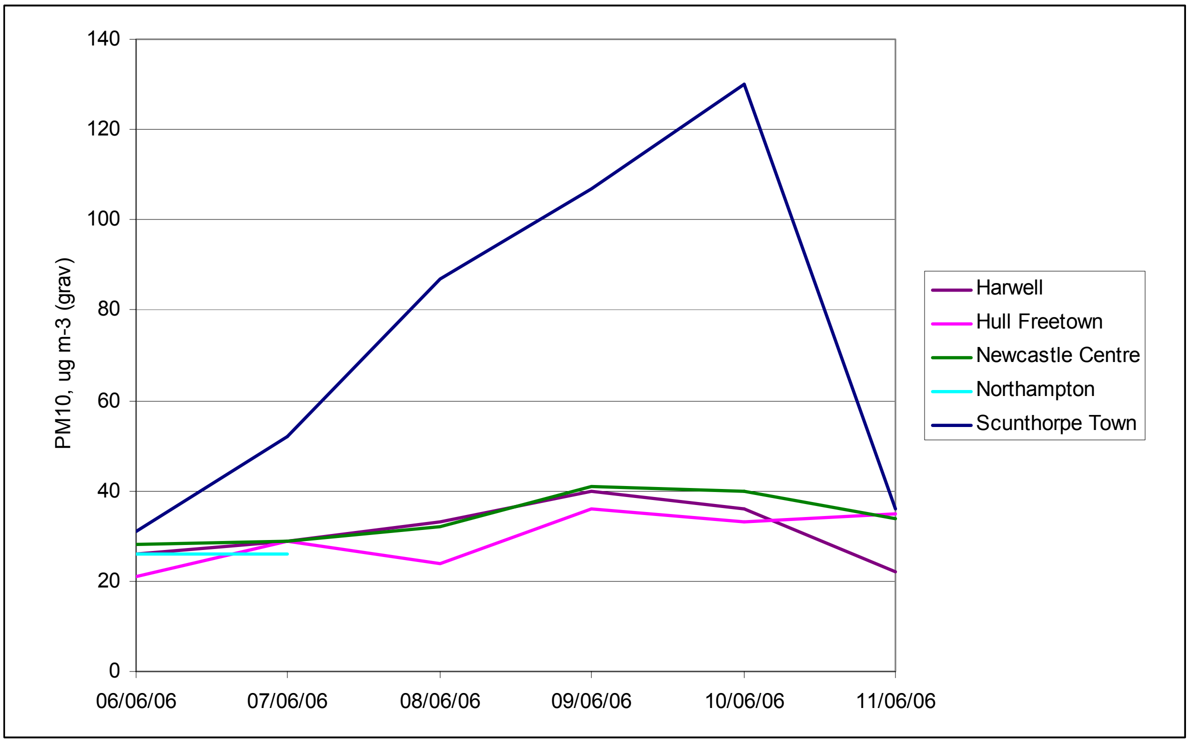

Figure 7.8: A graph showing the daily mean PM_{10} concentrations at the 4 other selected AURN sites and Scunthorpe Town from the 6^{th} to 11^{th} June 2006.

Figure 7.9 shows that when the wind originates from between 100 and 130^{o} the PM_{10} concentrations are elevated, in fact between 102 and 131^{o} the lowest concentration recorded is 55.9 µg m^{-3} over the episode. However, a variety of concentrations are recorded when the wind is from those directions possibly indicating a variety of sources could be contributing to the situation.

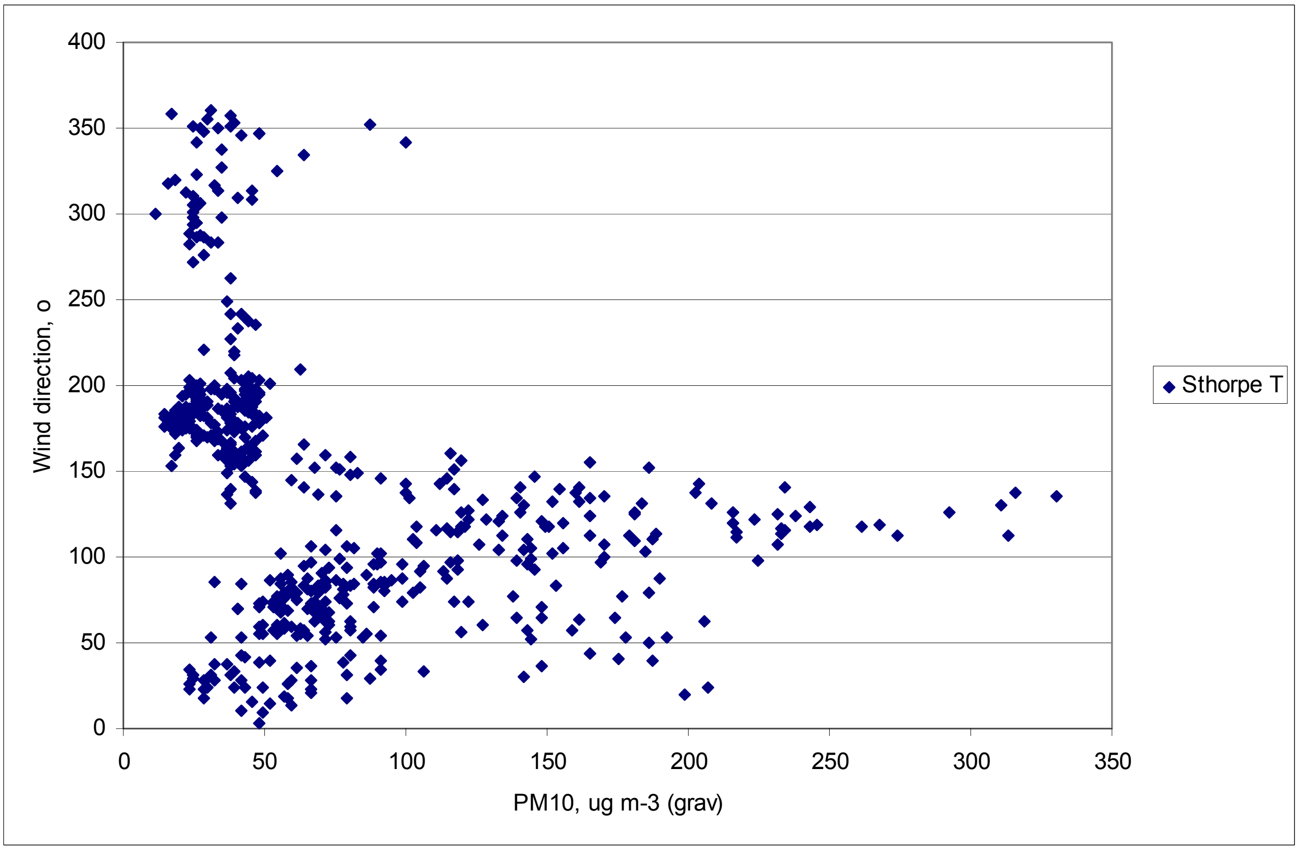

Figure 7.9: A graph of the wind direction vs PM_{10} concentrations at Scunthorpe Town between the 7^{th} and 10^{th} June 2006.

The manner in which the concentrations vary at Scunthorpe Town on the 9^{th} and 10^{th} is quite similar to Santon, i.e. that high concentrations are being recorded during the day with concentrations varying greatly from one 15 minute mean to the next, see Figure 7.10. However, the peaks on the 10^{th} are unlikely to be caused by the same sources as at Santon as the wind is not originating from the appropriate direction.

Whilst all the peaks at Scunthorpe Town on the 10^{th} occur during the day, this is again when the wind direction is between 100^{o} and 150^{o}. Concentrations fall off markedly in the evening, however, the direction changes to less than 100^{o} overnight. Concentrations then decrease to the same as those recorded at Broughton on the evening of the 10^{th}, although at this point the wind direction changes slightly to 160^{o}. The concentrations at Allanby Street follow Scunthorpe Town in a similar manner, they are mostly lower except for the morning of the 9^{th} where Allanby Street shows slightly higher concentrations than Scunthorpe Town.

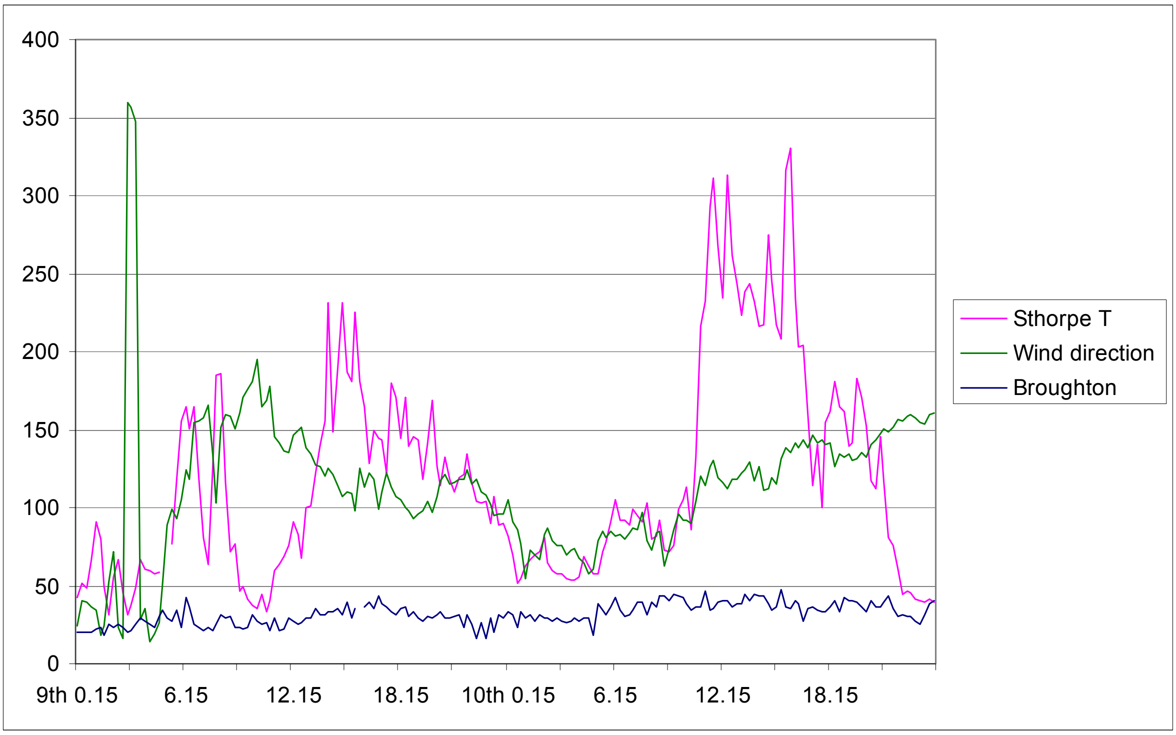

Figure 7.10: A graph showing the PM_{10} concentrations at Scunthorpe Town and Broughton and the wind direction on the 9th and 10th June, using 15 minute data.

Note: The y-axis represents wind direction, °, and PM_{10}, ug m^{-3} (grav).

The concentrations seen at Scunthorpe Town both in the May and June episodes reach similar peaks, approximately 250 to 300 µg m^{-3}.

3.) July 2006 Episode

July was responsible for 13 of Scunthorpe Town's 37 exceedances in 2006. These occurred in three episodes, between the 2nd and 6th July and the 15th to 19th July, two additional exceedances were recorded on the 25th and 26th July. A pollution rose for the episode has been drawn (see Figure 7.11). This shows similar patterns to the annual pollution rose in that elevated concentrations are only seen at the Scunthorpe sites when the wind originates from the east, with concentrations greater than 60 µg m^{-3} when the wind originates between 20^o and 130^o.

It can be seen from Figure 7.11 that the concentrations at Scunthorpe Town and other sites west of the steelworks experience elevated concentrations when the wind is originating from an easterly direction. The mean concentration at Broughton when the wind is emanating from an easterly direction is around 30 µg m^{-3}, whilst concentrations increase to greater than 80 µg m^{-3} at Scunthorpe Town from the same direction, reaching a peak at 120^o of 93.53 µg m^{-3}. So there is a clear elevation in PM_{10} levels in Scunthorpe compared to the levels that can be regarded as a background. Figure 7.12 shows how often the wind originated from each direction during the episode, it can be seem that easterly winds were present more often compared to the annual wind direction data (Figure 4.5).

Figure 7.11: Pollution Rose for the July episode. See file: 'Figure 7.11 July Pollution Rose'.

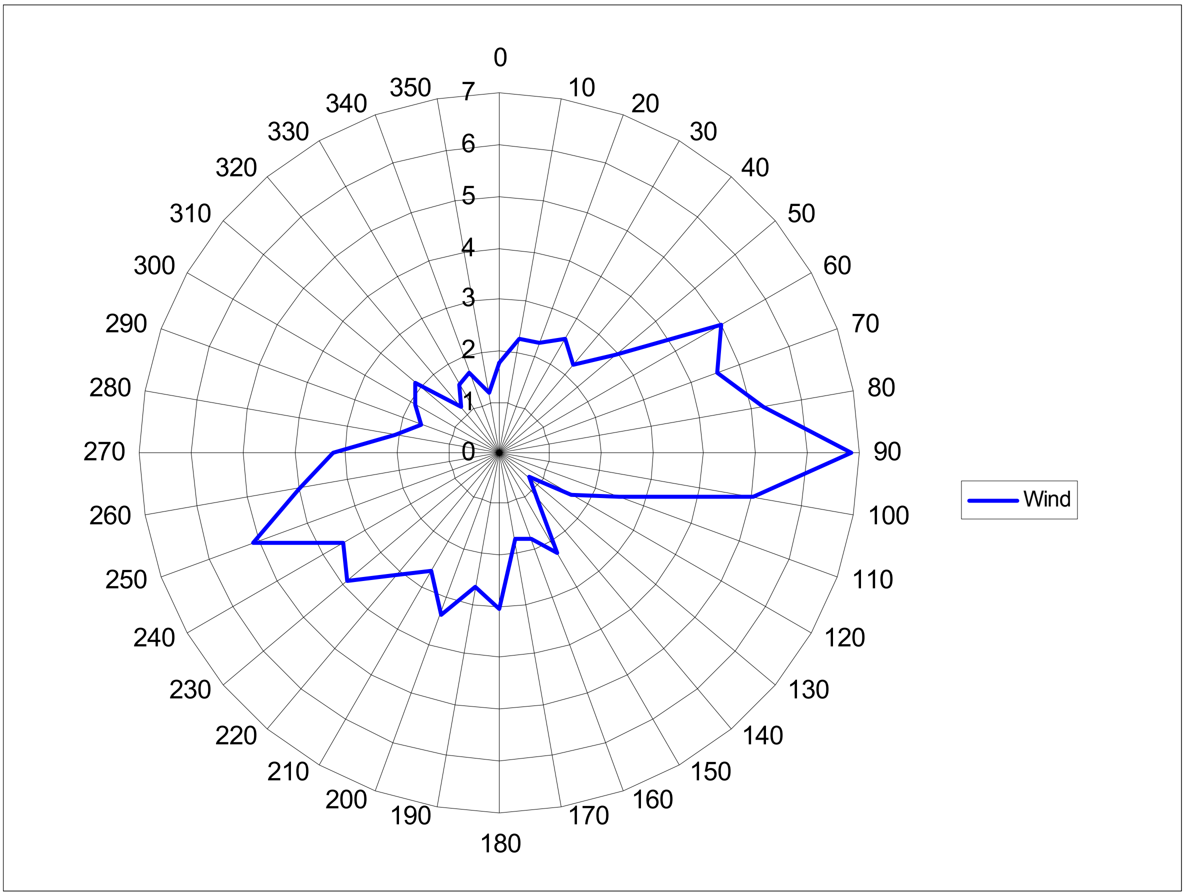

Figure 7.12: A graph of a wind rose which shows the percentage of time the wind originated from each sector between the 1st and 26th July 2006.

The 'background' concentrations seem to be elevated compared to the annual pollution rose, i.e. when the wind originates from the east Broughton records concentrations of about 30 µg m^{-3} and a similar value is recorded at Scunthorpe Town when the wind emanates from a south-westerly direction, this compares to concentrations just over 20 µg m^{-3} from the annual pollution rose. Thus suggesting that regional concentrations were slightly elevated over the episode. Concentrations only exceed 40 µg m^{-3} at Broughton when the wind is from a north-westerly direction, which suggests that the sources of PM_{10} at Santon may be having an effect.

4.) 14th to 17th October 2006 Episode

During the period 14th and 17th October 2006 Scunthorpe Town exceeded the daily mean limit value with concentrations of 51, 77, 80 and 65 µg m^{-3} respectively, Allanby Street, East Common Lane and Lincoln Gardens also showed exceedances on either two or three of these days. Santon and Broughton did not exceed the daily limit value. Elevated concentrations were also recorded in London and the southeast of the UK, the London air quality website stated the following for the episode.[14]

"Widespread 'moderate' PM_{10} particulate was measured throughout London and south east England between Friday 13th and Tuesday 17th October 2006. The episode was caused by a very significant influx of PM_{10} from continental sources with additional locally emitted PM_{10}.

On Friday an easterly air flow set in across south eastern England. The PM_{10} input from this airflow rose from around 20 ug m^{-3} on Saturday morning to reach a peak of between 40 - 45 ug m^{-3} Sunday afternoon"

Figure 7.13 shows that on Sunday 15th October Scunthorpe Town records a daily mean concentration 35 µg m^{-3} greater than Broughton (which did not exceed) and on Monday 16th October this elevation is 40 µg m^{-3}, for a majority of the episode the wind direction was from the east / southeast.

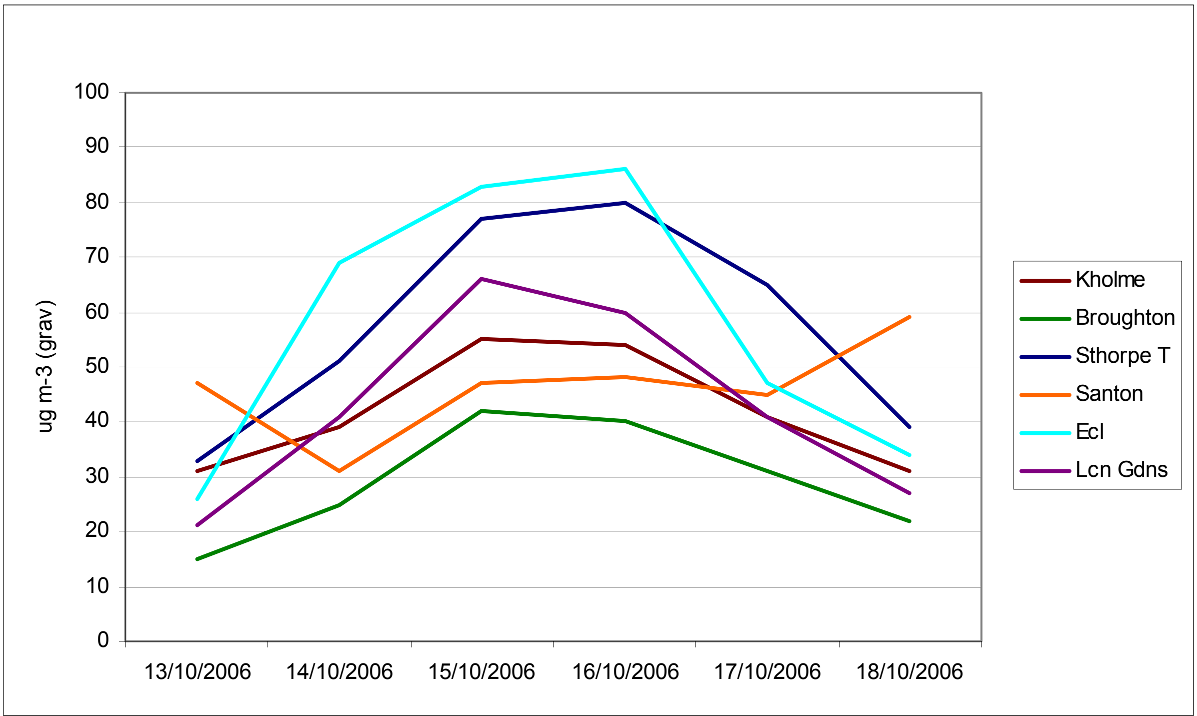

Figure 7.13: A graph showing the daily mean PM_{10} concentrations at the Scunthorpe sites between the 13th and 18th October 2006.

Looking closer at the 15-minute data (Figure 7.14), it is clear to see that throughout the episode Broughton records lower concentrations than at Scunthorpe Town. Only on the evening of the 17th when the wind switches from ~150° to 200° and early in the morning of the 14th when the wind switches to 0° are Scunthorpe Town concentrations similar to Broughton.

A maximum difference in concentrations between the two sites is reached during the night at 0000 hrs on the 16/17th with a difference of 90 µg m^{-3}, which is also when the Scunthorpe Town concentration reaches a maximum over the episode of 130 µg m^{-3}. It is more difficult to analyse 15-minute data in detail due to the time that it will take PM_{10} to travel from their source to the site. However, it is clear that the peaks are occurring at a variety of times in the day, that concentrations are lower when the wind emanates from between 25° and 100° and most of the high (greater than 100 µg m^{-3}) concentrations occur when the wind is between 130° and 150°.

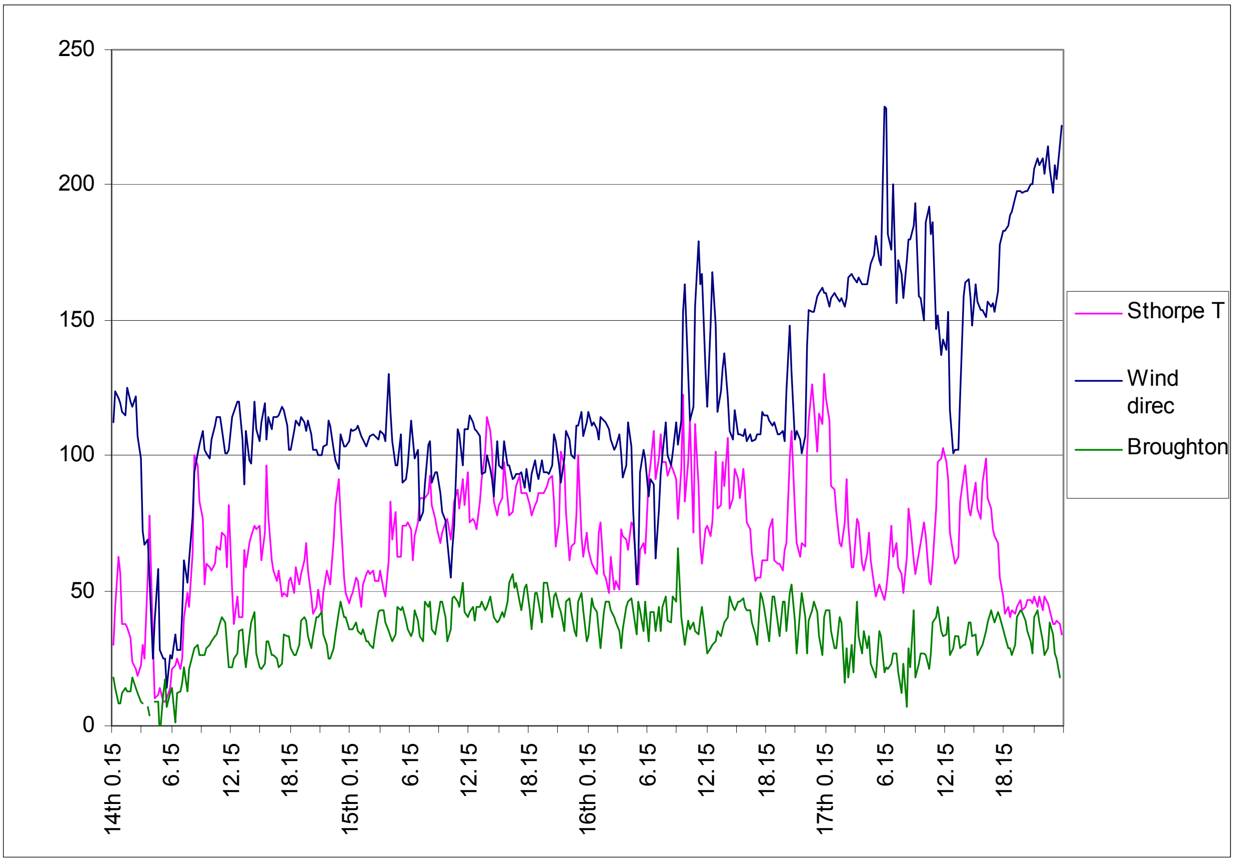

Figure 7.14: A graph showing the 15 minute PM_{10} concentrations at Scunthorpe Town and Broughton with the wind direction from Scunthorpe Town.

Note: The y-axis represents the wind direction, °, and PM_{10}, ug m^{-3}, gravimetric.

A comparison between the daily means at Scunthorpe Town and four other AURN sites is shown in Figure 7.15. Figure 7.15 clearly shows that all sites experienced an increase in PM_{10} concentrations over the episode suggesting that there was an influx of PM_{10} into the UK. On the 16th the highest concentration is recorded at Harwell, 52 µg m^{-3}. However, Scunthorpe Town records a concentration of 80 µg m^{-3}, this is 28 µg m^{-3} greater than Harwell and 31 µg m^{-3} greater than the closer site, Hull. Thus it is clear to see that the steelworks and associated industries are responsible for at least a 30 µg m^{-3}

increase in PM_{10} concentrations in Scunthorpe compared to both local and regional 'background' levels during this episode.

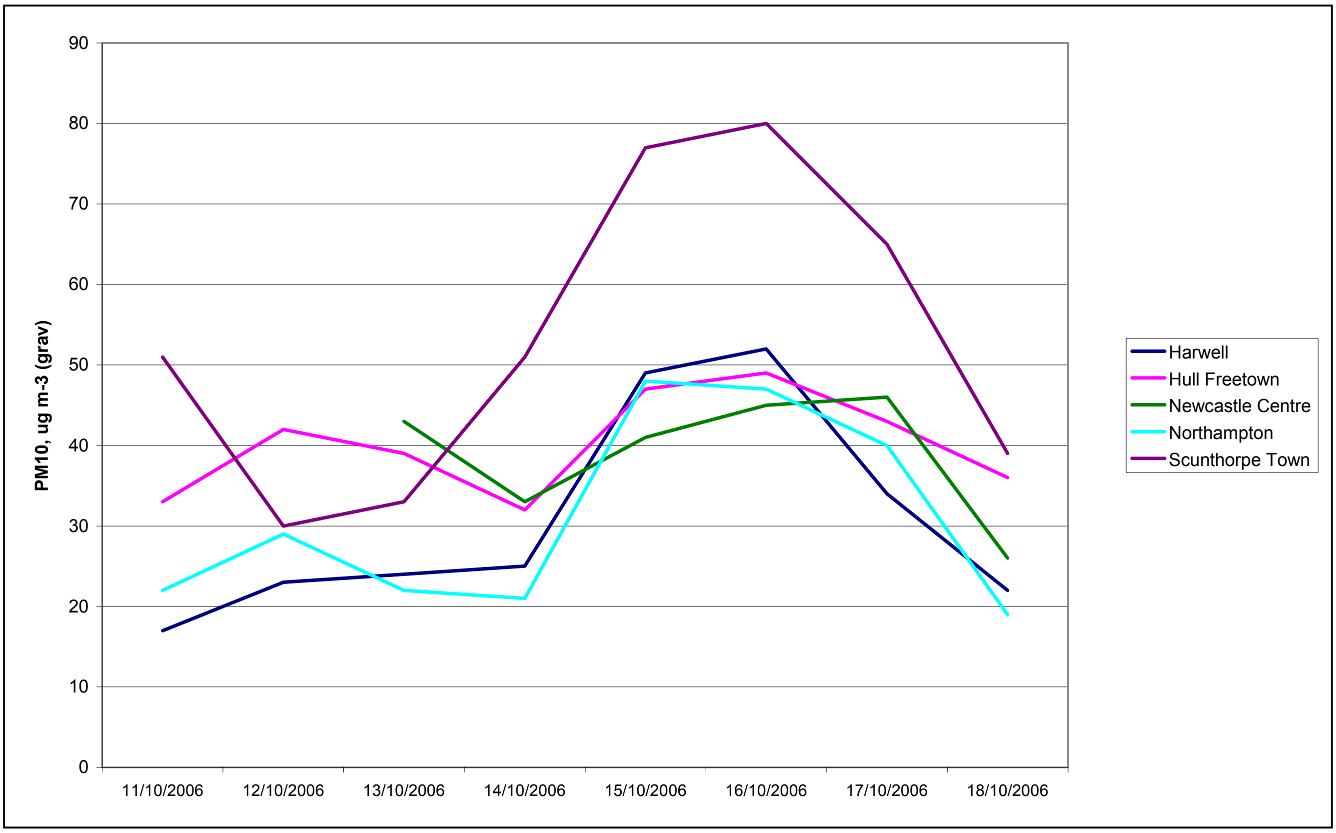

Figure 7.15: A graph of the daily mean PM_{10} concentrations at the four selected AURN sites and Scunthorpe Town from 11th to 17th October 2006.

Part 7.2: Non-exceedance Days

As a contrast to Part 7.1 of this Chapter two episodes of non-exceedance days (at Scunthorpe Town) will be briefly studied.

The pollution rose in Figure 7.16, shows that at Scunthorpe Town concentrations were less than 30 µg m^{-3} from all directions except for 160^o where the concentrations increase to 53.3 µg m^{-3}, the direction that is closest to local industry in this episode. Between the 8th and 15th November 2006 no sites in Scunthorpe breached the daily limit value, see Figure 7.17.

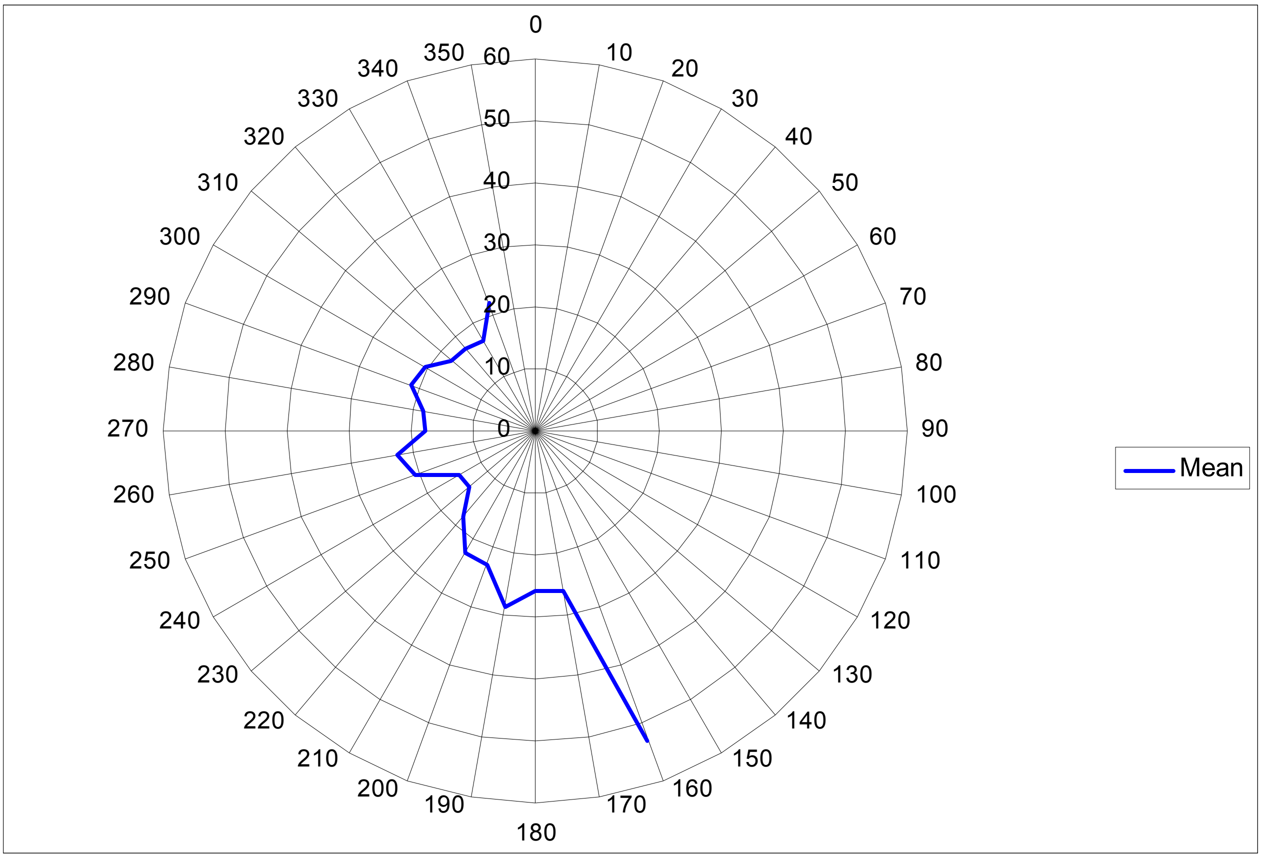

Figure 7.16: A pollution rose for PM_{10} concentrations at Scunthorpe Town for the period 8th to 15th November 2006.

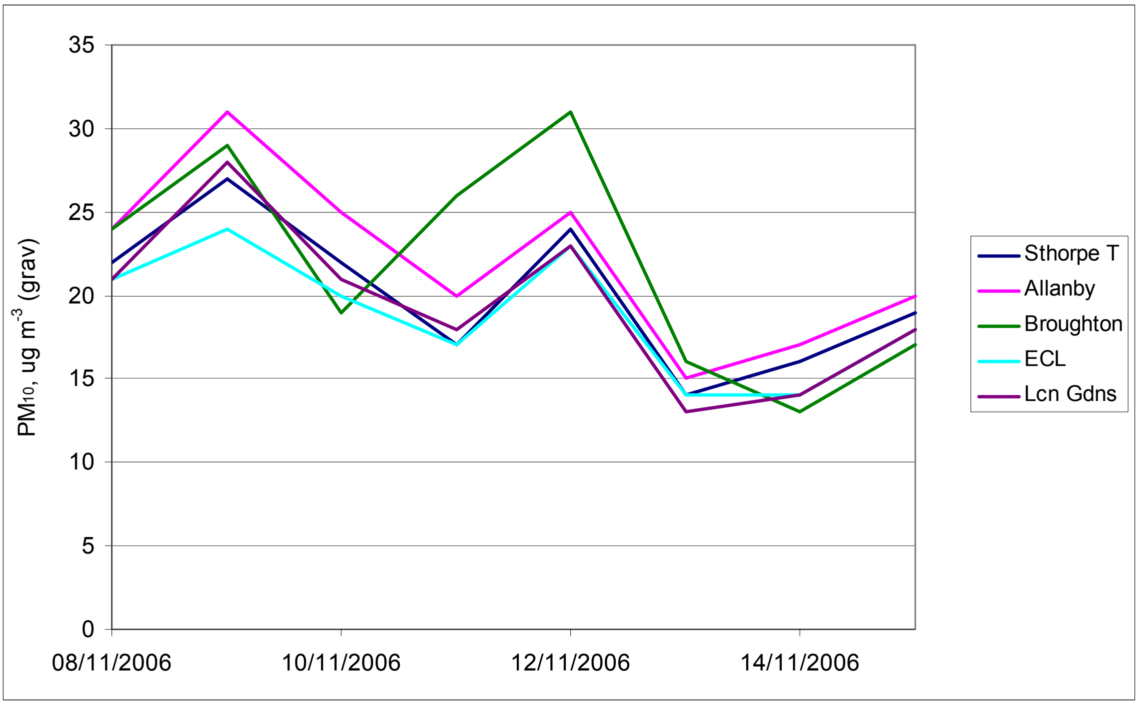

Figure 7.17: A graph showing the daily mean PM_{10} concentrations at the Scunthorpe sites from the 8th to 15th November 2006.

Similar results are seen for the 2nd to 8th February 2006, see Figures A4, A5 and A6, with low concentrations occurring from most directions and the wind originating from the west for the majority of the time. The exception is 200° to 220°. The wind frequency from this direction is low, thus indicating sources from outside Scunthorpe or it may be that PM_{10} were transported by a north-easterly wind past the monitoring site and with a change in wind direction they were transported back to the site.

Part 7.3: 2003 data

In 2003 the Scunthorpe AURN recorded 95 exceedances of the daily limit value for PM_{10}. It has been argued that 2003 was an exceptional year with regards to the meteorological conditions in the UK; the following has been extracted from the AQEG report into PM_{10}.[8]

"A severe episode occurred in August 2003 in Southeastern England during a heatwave that affected much of Europe… Secondary particle concentrations can also increase at other times of the year, as happened in Spring 2003."

Figure 7.18 shows the concentrations at the Scunthorpe monitoring site compared to four other selected AURN sites. Whether or not 2003 was a meteorologically exceptional year, it is notable that in 2003 the Scunthorpe site experienced one third of its exceedances in March and April, i.e. Spring 2003, and that throughout almost the whole year PM_{10} concentrations at Scunthorpe were higher than at the four other AURN sites studied.

It has been shown in this Chapter that easterly winds generally lead to a breach of the daily limit value in Scunthorpe. Figure 7.18 shows that although secondary particulate matter may have been transported from the rest of Europe, the concentrations at Scunthorpe AURN were elevated compared to the other four AURN sites selected in 2003 as well as 2006. This again suggests that although regional sources may increase PM_{10} concentrations in Scunthorpe other local sources either make a breach of the daily limit value more likely or if a breach can be attributed to regional effects the local sources significantly compound the magnitude of that breach.

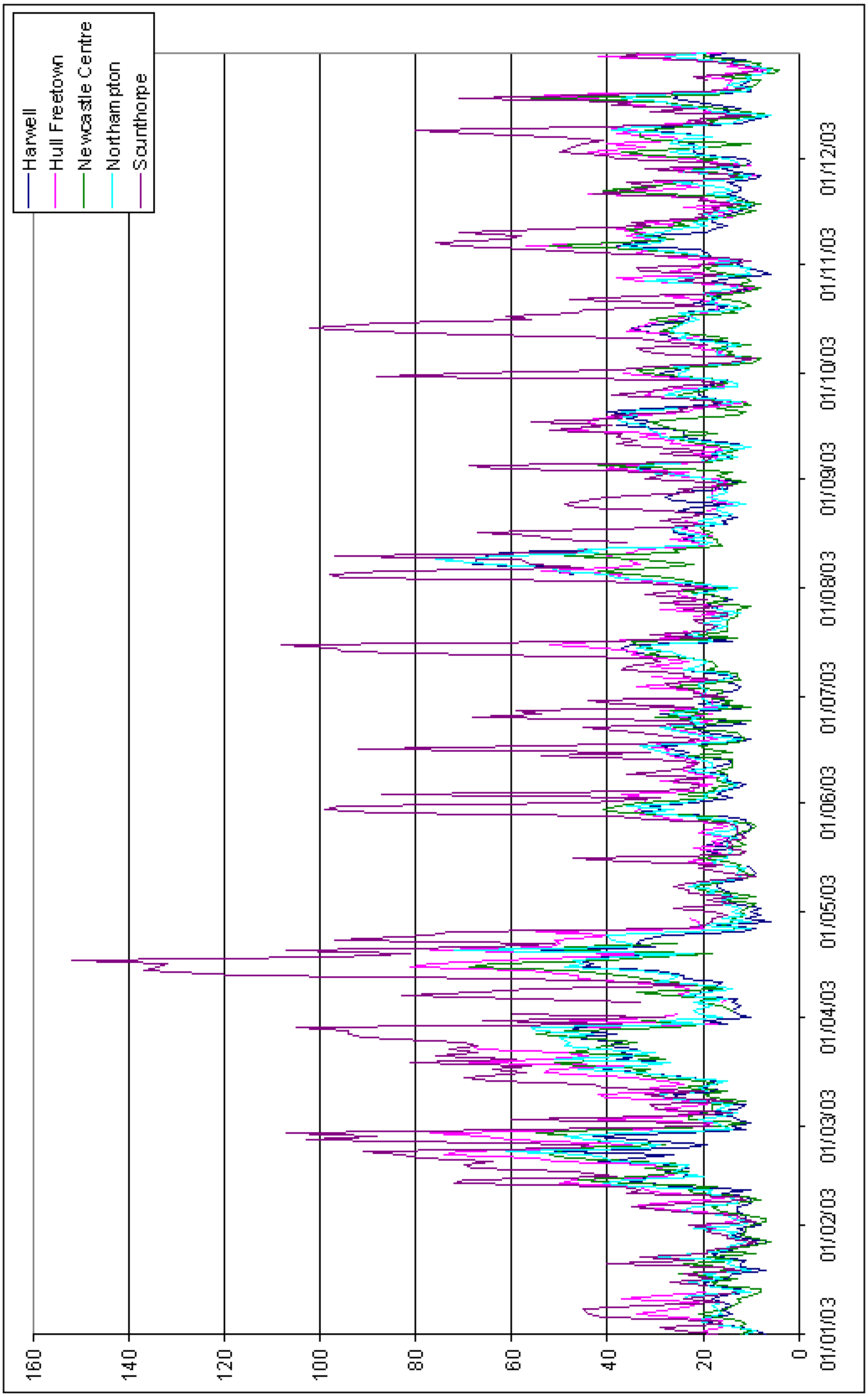

Figure 7.18: The daily mean PM_{10} concentrations, µg m^{-3}, at Scunthorpe and four other AURN sites during 2003.

Part 7.4: Rainfall

In addition to wind direction and speed, rainfall could have an impact on PM_{10} concentrations in the Scunthorpe area. Figure 7.19 plots the daily mean PM_{10} concentration at Scunthorpe Town for 2006 versus the amount of rainfall, mm, received on that particular day.

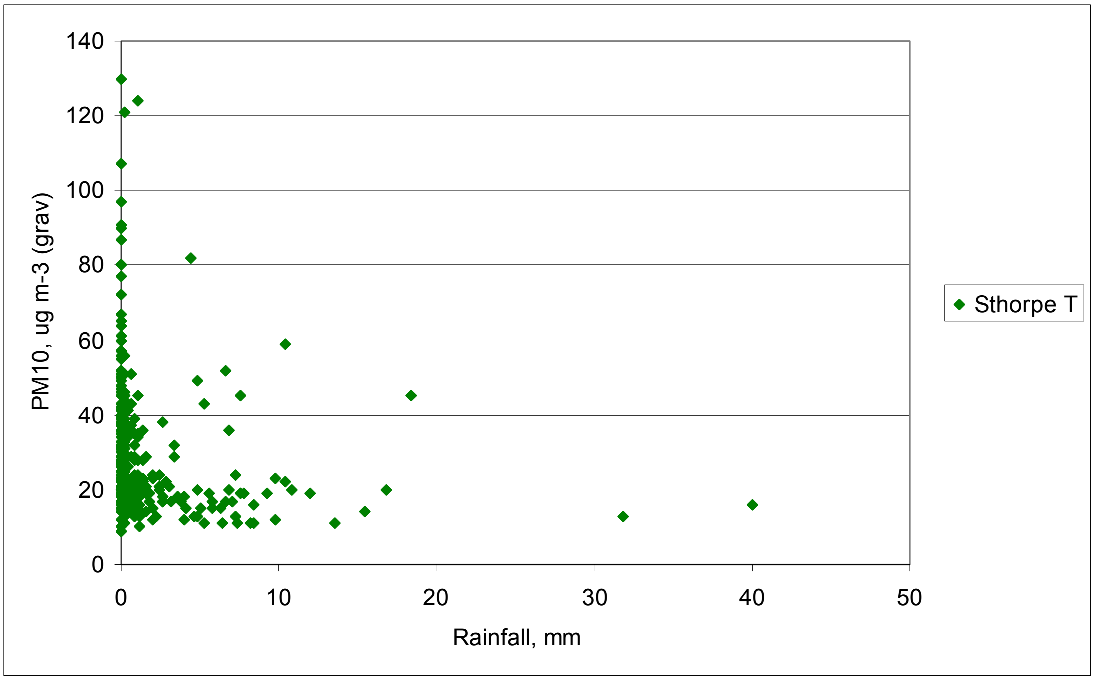

Figure 7.19: A scatter plot of the daily mean PM_{10} concentrations at Scunthorpe Town vs the rainfall, mm, recorded at the steelworks for 2006.

Figure 7.19 suggests that during 2006 the greater the rainfall the lower the PM_{10} concentrations were at Scunthorpe Town. The data from 2005 and 2004 also suggests this (Figures A7 and A8), however, there seems to be a couple of points that do not fit this trend in both datasets. Rainfall data has not been studied in more detail as the time of rainfall on a particular day is not known.

Part 7.5: Wind direction on Exceedance days

In Chapter 4 it was noted that the concentrations of PM_{10} are lower between 2300 hrs and 0500 hrs at Scunthorpe Town. However, after looking at other graphs in this Chapter it was noticed that the wind direction tends to alter overnight. To confirm this a wind rose was plotted using the data from the days where the daily limit value was exceeded at Scunthorpe Town, but separating out the data into two sections: 1. 2300 hrs to 0500 hrs (night, when concentrations are at their lowest) and 2. 0500 hrs to 2300 hrs (day). The result is shown in Figure 7.20.

The wind rose suggests that during the day the wind is originating from directions that have higher concentrations (easterly), whereas overnight the wind more frequently originates from directions where concentrations are lower (northeast and southerly).

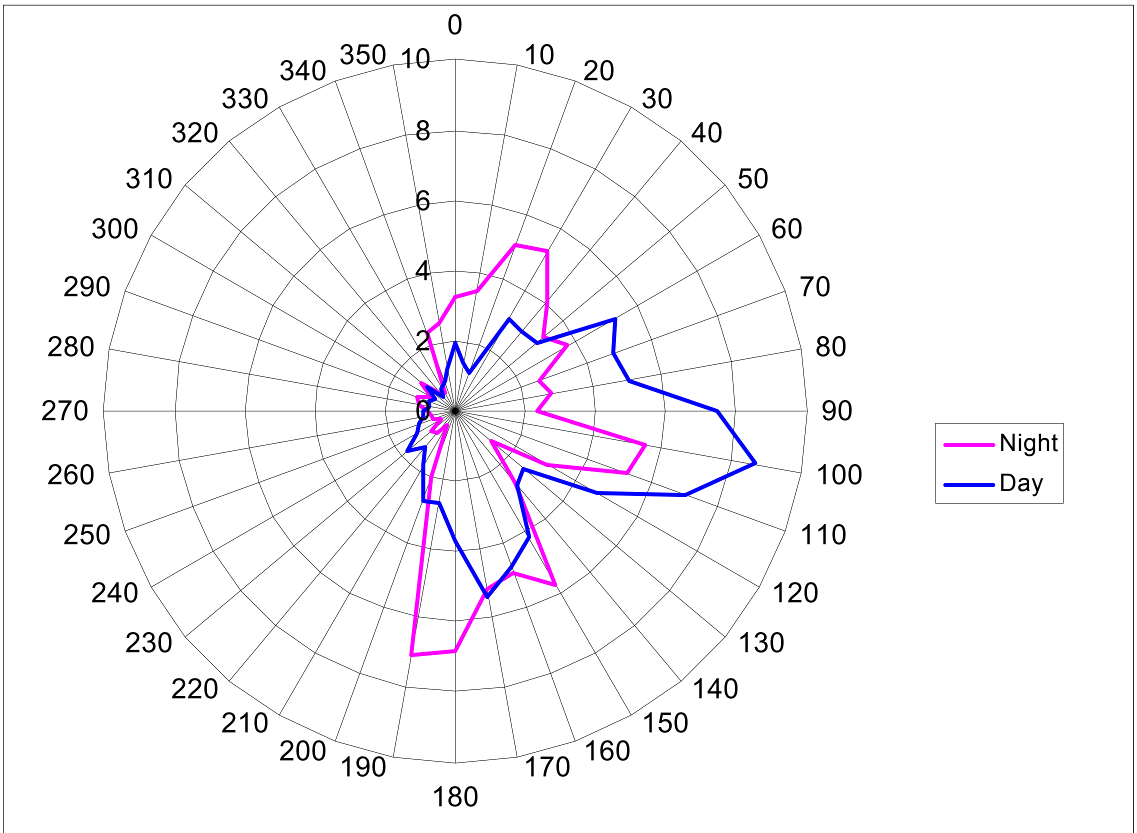

Figure 7.20: A wind rose plotting data from Scunthorpe Town exceedance days, split 2300 to 0500 hrs (overnight) and 0500 to 2300 hrs (day).

Figure 7.21 is a pollution rose using data from the Scunthorpe Town exceedance days, again the data has been separated into night and daytime periods and confirms Figure 4.11 that concentrations are higher during the day than overnight. Figure 7.22 is a similar plot, though this time PM_{10} concentrations from Broughton have been used but on the days where Scunthorpe Town recorded an exceedance.

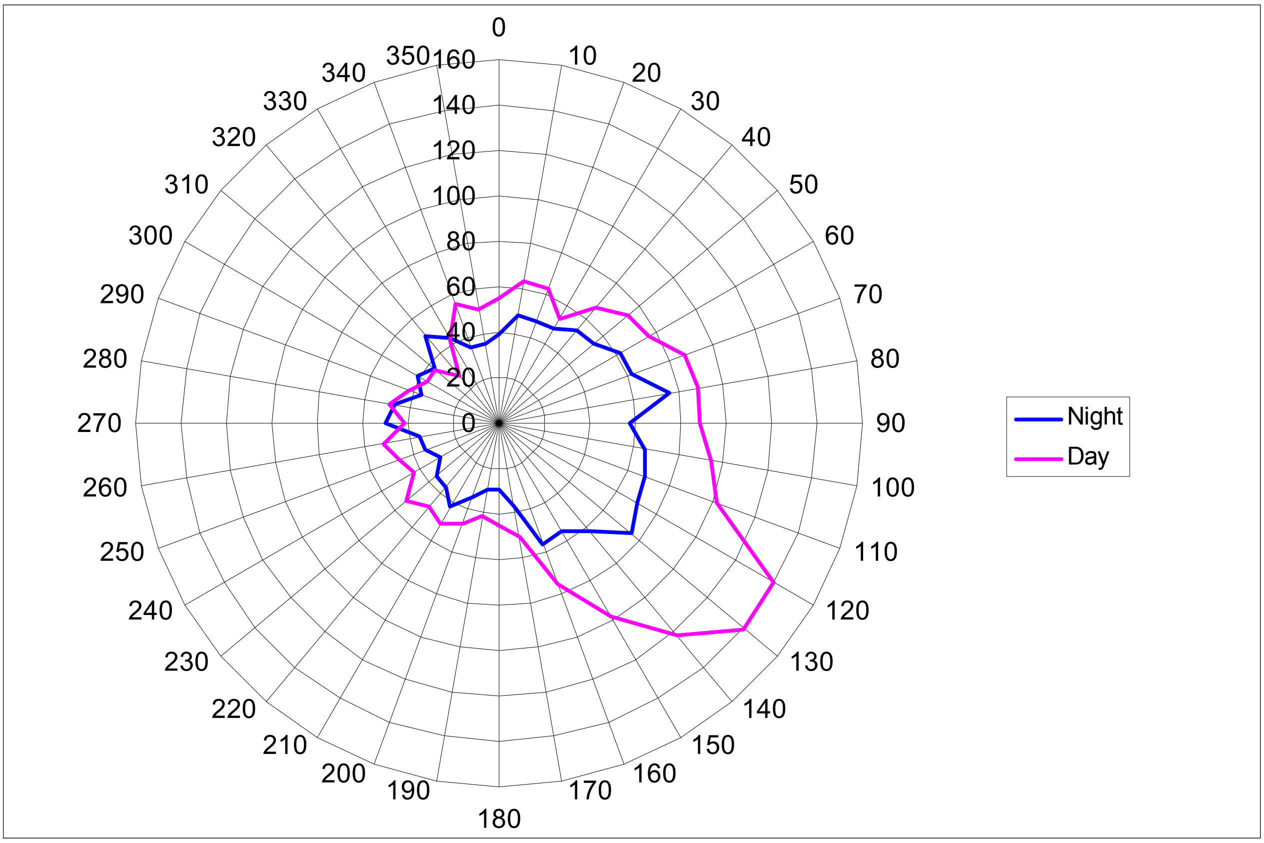

Figure 7.21: A pollution rose at Scunthorpe Town, using data from exceedance days, but with data split into 2300 to 0500 hrs (night) and 0500 to 2300hrs (day).

Figure 7.22 shows that the concentrations at Broughton are roughly the same during the day as they are at night, this is in contrast to Scunthorpe Town, where there is a marked difference, particularly between 0^o and 160^o (clockwise). Except for wind directions originating from the northwest concentrations are greater during the daytime, however, the increase in concentrations is greatest from easterly wind directions, particularly from 80^o to 160^o.

The highest mean concentration at Scunthorpe Town originates from 130^o, both during the daytime (141 µg m^{-3}) and at night (76 µg m^{-3}). These values are approximately 45 µg m^{-3} greater than concentrations experienced from a westerly direction at night and 110 µg m^{-3} greater during the daytime. In addition, elevations of up to 100 µg m^{-3} occur between Broughton and Scunthorpe Town during the daytime with a subsequent decrease to a 37 µg m^{-3} elevation at night for similar wind directions.

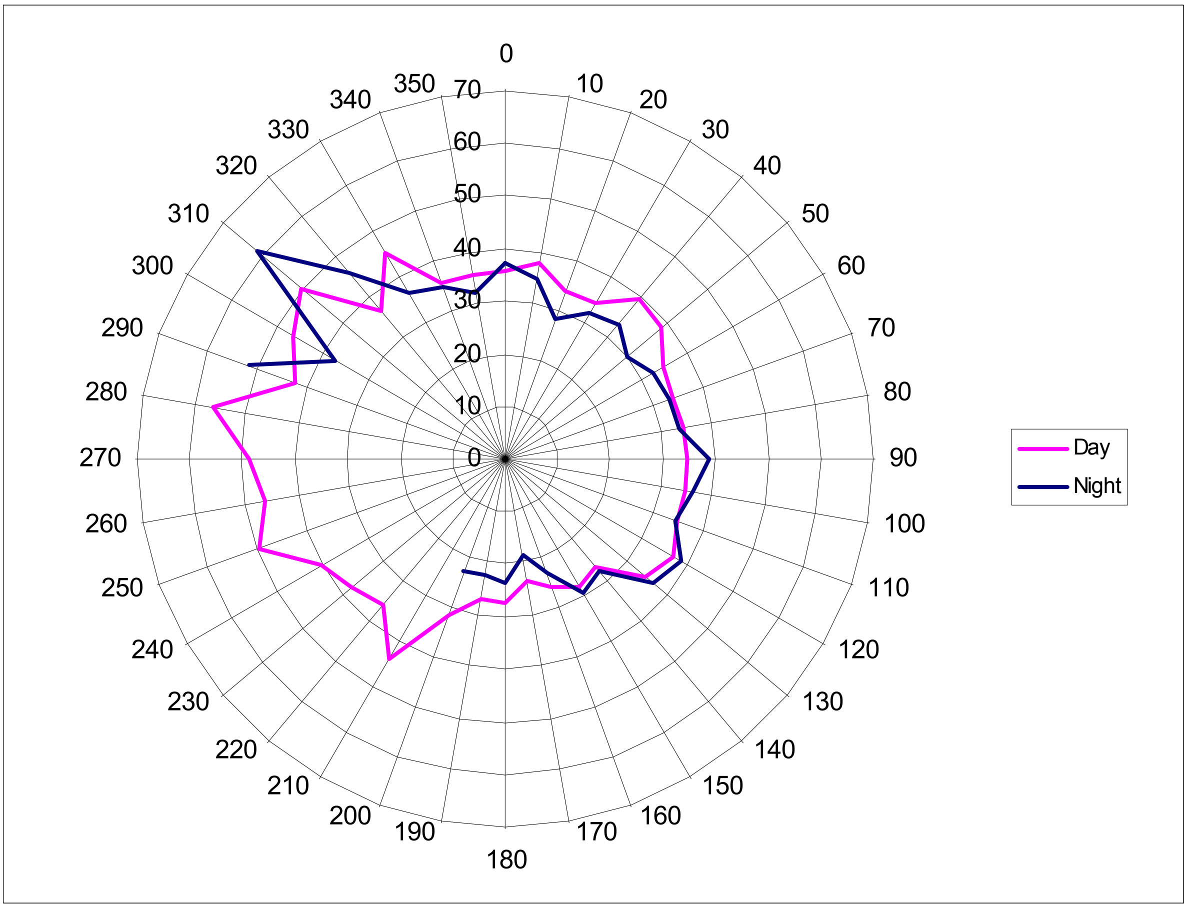

Figure 7.22: A pollution rose for Broughton with data selected based on Scunthorpe Town exceedance days and again split into day and night.

Note: The pollution rose at Broughton does not capture all the Scunthorpe Town exceedance data due to lack of data from Broughton on those particular days.

Part 7.6: Discussion and Summary

Essentially, the graphs and pollution roses in this Chapter confirm what the annual pollution rose suggests: that the highest PM_{10} concentrations arise when the wind is emanating from the east, particularly from 100^o to 120^o. It is clear that the elevated PM_{10} concentrations experienced in Scunthorpe are not as a direct result of regional (either the rest of the Humberside area, the UK or the rest of Europe) influences.

Although regional effects do slightly increase the concentration of PM_{10} in the Scunthorpe area local sources compound the problem more significantly, either increasing the chance of an exceedance or increasing the severity of an exceedance. Additionally, when the wind changes direction say from a northeast to a southwesterly direction it is possible that PM_{10} could be transported past the monitoring site, only for them to be transported back past the site. Thus it may appear that PM_{10} are being transported from outside the area when they are not (for example in the February non-exceedance episode).

It is difficult to source apportion the quantity that each potential source on the steelworks and other industry site are responsible for due to the number of sources that are relatively close to each other. They are also up to several kms away from the monitoring sites introducing a time lag between emission and detection. In terms of Scunthorpe itself the highest concentrations are originating from the southern part of the steelworks site. This covers the blast furnaces, ore handling beds, sinter plant and the BOS plant. The other potential source of PM_{10} from that direction is Appleby Group Ltd.

At Scunthorpe Town and East Common Lane daytime concentrations are higher than night-time concentrations. This suggests that daytime sources, such as vehicle movements, raw materials handling and other operations that disturb or create PM_{10} during the day are responsible for a more significant proportion of the problem than night-time operations. Elevations between night-time and daytime levels are most significant between 90^o and 160^o, where they are greater than 25 µg m^{-3}. Although the concentrations at night are significantly lower, they are still greater than the daily limit value between 40^o and 160^o. This would suggest that continuous sources are responsible for a smaller proportion of the PM_{10} than daytime sources. This could be processes that are operating all of the time or stockpiles of materials.

July, a dry month, was responsible for a large number of exceedances in 2006, it is evident that rainfall reduces the PM_{10} concentrations. The other episodes indicate that an easterly wind still determines when Scunthorpe experiences an exceedance.

It is clear that concentrations experienced by human receptors are dependent on the wind direction and meteorological conditions, although of course if the PM_{10} were not present in the first place the meteorological conditions would not be so crucial. The dependence on meteorological conditions suggests that the PM_{10} reductions needed are greater than a simple reduction of two exceedances (as needed for Scunthorpe Town based on 2006 data). This is particularly true bearing in mind the 95 exceedances recorded at Scunthorpe in 2003. I.e. Concentrations should not increase by more than around 20 µg m^{-3} as an air mass moves between Broughton and Scunthorpe Town.

The reduction required is partially more stringent because easterly air masses tend to carry a slight elevation due to secondary particulate matter. In addition, another problem is that the wind direction that results in low concentrations for Scunthorpe Town (southwest direction) results in high concentrations at Santon and vice versa. Although studying wind direction is useful, an extra element that would have been useful in this Chapter would be air mass back trajectories that plot the movement of an air mass over five days. Unfortunately these are only available to academia.

In 2006 mean concentrations on an exceedance day at Scunthorpe Town were 70.4 µg m^{-3}, thus a 29% reduction is needed to reduce PM_{10} concentrations to less than 50 µg m^{-3} on exceedance days. This percentage improvement increases to 48% if a background of 28 µg m^{-3} is assumed for an easterly wind direction (based on Broughton).

Key Points:

- Difference between daytime and night-time concentrations at Scunthorpe Town but not Broughton monitoring sites.
- Highest concentrations occurring when the wind is from a south-easterly direction and concentrations are elevated compared to neighbouring AURN sites.
- Improvement required is greater than 2 exceedances as variation in meteorological conditions must be taken into account.

Chapter 8: Further Analysis of Santon Data

In this Chapter data from the Santon TEOM monitoring site will be analysed in more detail due to the higher concentrations of PM_{10} being recorded at the site: in 2006 the annual mean objective and the permitted number of daily exceedances were both breached.

The potential sources of PM_{10} at the Santon site are numerous; firstly it is close to and downwind of the steelworks and associated industry. Secondly, the site is next to the Local Authority regulated site of Tarmac Northern who crush and screen slag from the steelworks, which is an inherently dusty process. Thirdly, Multiserv Ltd operate to the south / southeast of the site and finally on the transport side, the site is next to a railway line along which freight trains run up to 14 times per day as well as being next to the beginning of a private road (Dawes Lane) which runs through the steelworks site and is used by large numbers of HGVs.

Part 8.1: Pollution Rose

As already seen in the annual pollution rose Santon records mean concentrations greater than 40 µg m^{-3} when the wind originates between 80^o and 340^o (clockwise). The mean concentration is greater than 60 µg m^{-3} between 200^o and 300^o, this area covers most of the steelworks site and Tarmac operations. To compound matters this is also the direction from which the wind originates most often. The highest average concentration is recorded at 240^o (100 µg m^{-3}), this is directly in line with the boundary of the Tarmac site, the Coke ovens on the steelworks site and Dawes Lane.

The pollution rose for the July episode (1st to 26th July) in Part 7.11 shows similar results, yet the May episode (3rd to 13th May) distinctly shows a peak at 300^o of over 400 μg m^{-3}. The closest operation to the monitoring site in this direction is Tarmac, however, even this sector has multiple sources with the coal handling plant on the same trajectory.

The concentrations when the wind originates from the south and southeast (just above 40 µg m^{-3}) could be attributable to either Multiserv or Dawes Lane traffic, traffic directly passing the site on this road may impact results regardless of wind direction and speed. The Santon pollution rose identifies the highest concentrations as those coming from the northern end of the steelworks site, this is in contrast to the other sites (i.e. Scunthorpe Town), which identifies the highest concentrations as coming from the southern end of the steelworks site. This suggests that there are additional sources that are contributing to the high PM_{10} concentrations at Santon and in addition may be masking the contribution of sources from the southern end of the site.

The Santon percentile rose reveals that there is a large difference between the 99th percentile and the other percentiles, thus indicating that there are a large number of 'peak' concentrations occurring at this site. The notable peaks at 150^o, 280^o and 330^o also confirm this where the 99th percentile does not vary in a similar fashion to the other percentiles.

Part 8.2: 15 Minute PM_{10} Concentrations

In Figure 8.1 the mean PM_{10} concentrations for Santon have been plotted according to 15 minute periods, i.e. the first point represents the mean concentrations across 2006 for the time period 0000 to 0015 hrs, the second point 0015 to 0030 hrs and so on. The data has been split into plots for data from Monday to Friday, Saturday and Sunday.

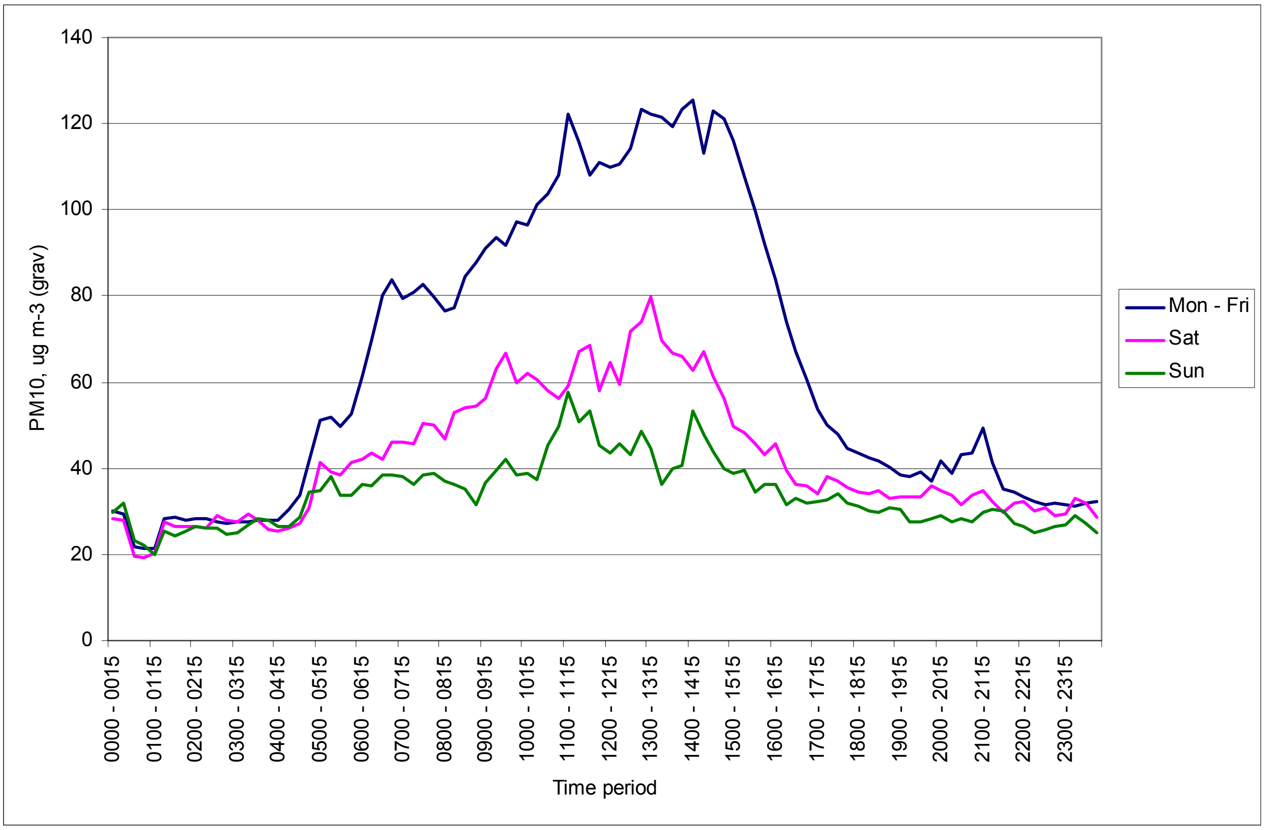

Figure 8.1: A graph of the mean PM_{10} concentrations across each 15-minute period, split into data for Monday to Friday, Saturday and Sunday for the Santon site.

Figure 8.1 shows that mean PM_{10} concentrations at Santon start to increase at 0400 hrs and increase throughout the day with the highest concentration reached at around 1400 hrs, a decrease is then seen throughout the afternoon. A small peak occurs at 2115 hrs, this is around shift changeover time at the steelworks, however, the peak is most significant in the Monday to Friday data and less so on Saturdays and Sundays.

Between 0400 and 2115 hrs the concentrations are greater than the annual mean limit value. Concentrations on Saturday show similar behaviour to weekdays in the morning, however, concentrations are lower throughout the day and decrease earlier compared to weekdays. The lowest concentrations are recorded on Sundays, however, concentrations are still over 50 μg m^{-3} between 1115 hrs and 1415 hrs.

On average concentrations at Santon are about 10 μg m^{-3} greater overnight compared to Scunthorpe Town. It must be stressed that these are mean concentrations across 2006 and that high concentrations do occur at various times of the day and the data does not take account of wind direction, but it does indicate that the greatest concentrations are occurring more frequently during the day than at night.

Part 8.3: Exceedances by Day and Month

Figure 8.2 shows the number of exceedances and mean concentration by month for Santon, it shows that the summer months record higher concentrations than the winter months and that the mean concentration closely follows the number of exceedances. It is quite noticeable in Figure A1 that daily means of greater than 100 µg m^{-3} were only recorded from the end of March through to the end of September 2006. The exception in 2006 was August, but during this month rainfall was significantly higher in August (163 mm) compared to July (10.2 mm), which may have helped to reduce concentrations.

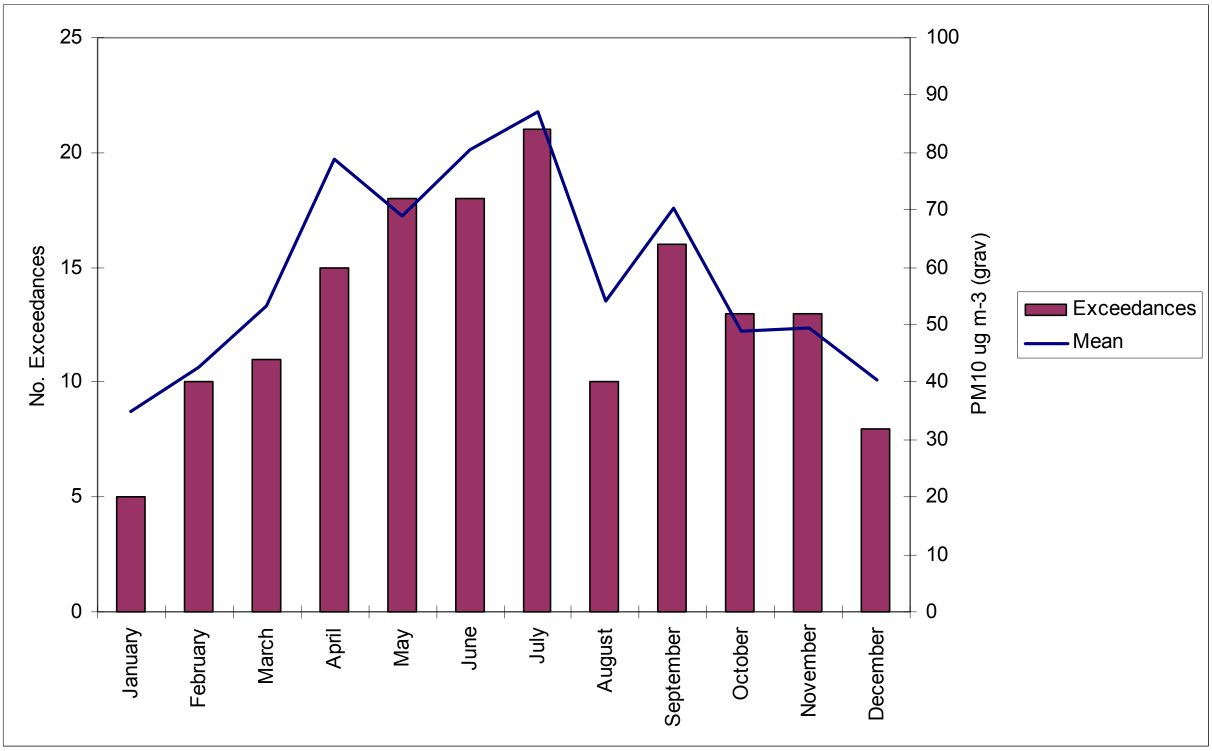

Figure 8.2: A graph showing the exceedances and mean PM_{10} concentrations by month.

Figure 8.3 shows the number of exceedances according to days of the week and indicates that Tuesdays through to Fridays are significantly more likely to record an exceedance than other days of the week. The mean PM_{10} concentration on exceedance days is greater than 90 µg m^{-3}, but at weekends the mean exceedance day concentration, although greater than the limit value, is significantly lower.

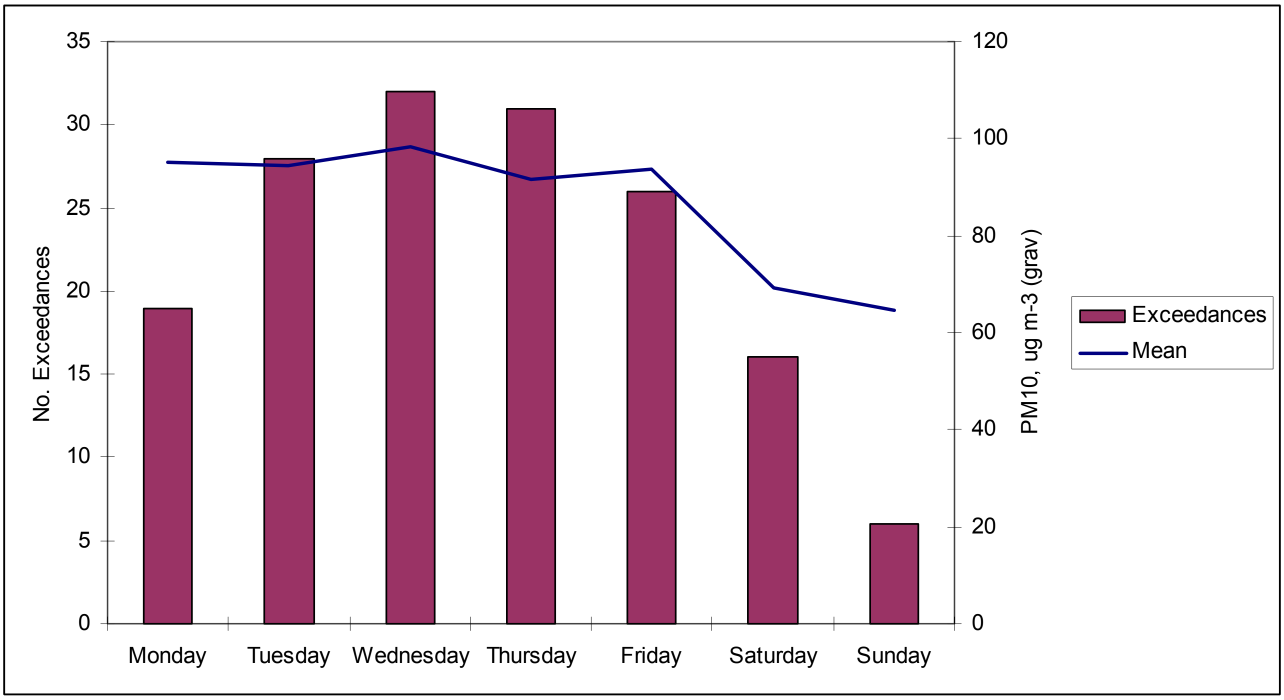

Figure 8.3: A graph showing the number exceedances and mean PM_{10} concentrations by day of week at the Santon monitoring site.

Part 8.4: Tarmac Working Hours

The working hours of Tarmac were obtained for August through to October 2006 so that these could be compared to the data at the Santon site. Operating hours were supplied for the Barber Green and Parker plants (stack emissions) and the dry crushing and screening operations. The two stacks at Tarmac are tested for total particulate matter concentrations and are below their permit level, it is not thought they contribute significantly to PM_{10} concentrations at Santon. Crushing operations generally operate between 0600 and 1800 hrs Monday to Friday and on Saturday mornings, but using specific hours is more useful.

In Figures 8.4 a to d, specific days have been selected which show the PM_{10} and SO_2 concentrations from Santon, the wind direction from Scunthorpe Town and the operating hours of the various parts of the Tarmac site. In Figures 8.4 a to d, the PM_{10} and SO_2 concentrations are shown, the wind direction along with whether the Parker and Barber Green stacks (represented by Parker?, BG?) and dry crushing activities were operating. The dates selected show a variety of scenarios.

On the 4th and 5th September (Figure 8.4a) Santon PM_{10} concentrations show the usual rise during the day, Tarmac crushing operations begin at 0600 hrs on the 5th September this coincides with the rise in concentrations, whilst on the 4th the concentrations start to increase just before Tarmac commence operations. The wind direction is between 250° and 300°, which encompasses the Tarmac site, coal handling and coke ovens of the steelworks. The wind direction changes at night, away from this direction and through to 140° (clockwise). A similar effect is shown on the 5th September, except the SO_2 concentration gradually rises throughout the day as well.

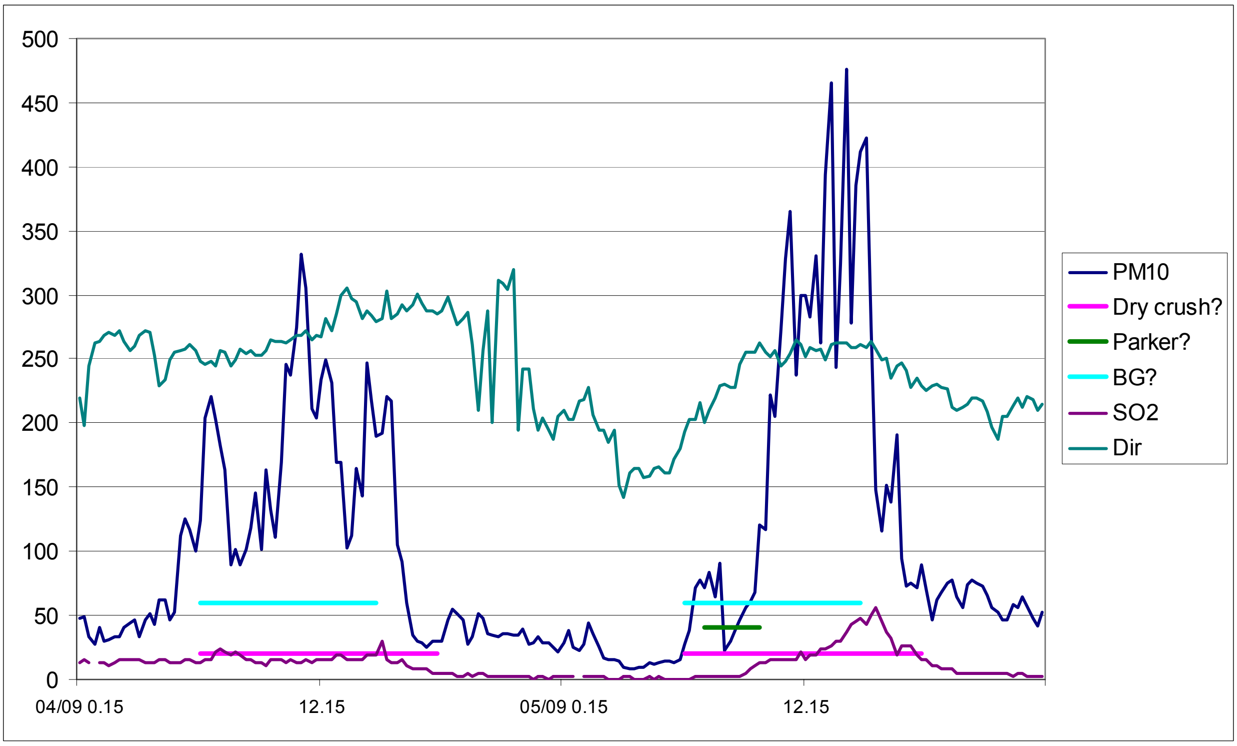

Figure 8.4a: 4th and 5th September

The 20th September (Figure 8.4b) seems to be a crucial date, PM_{10} concentrations are high and show the usual daytime rise, however, according to the data provided by Tarmac the dry screening and crushing processes were not operational. On the 20th the wind direction was about 200° to 210°, slightly away from the Tarmac site. However, the problem is that it is not known what the concentrations would have been on the 20th had the screening and crushing been in operation, as concentrations greater than 500 µg m^{-3} (15 minute values) have been recorded on other days. On the 19th concentrations had already reached 200 µg m^{-3} by the time the dry crushing operations commenced at 0730 hrs.

There seems to be a mixed link between SO_2 and PM_{10} concentrations, on the 19th September SO_2 concentrations initially coincide with PM_{10} concentrations (between 0915 and 1215 hrs) and at 2130 hrs, but the link is less strong between 1445 and 1700 hrs.

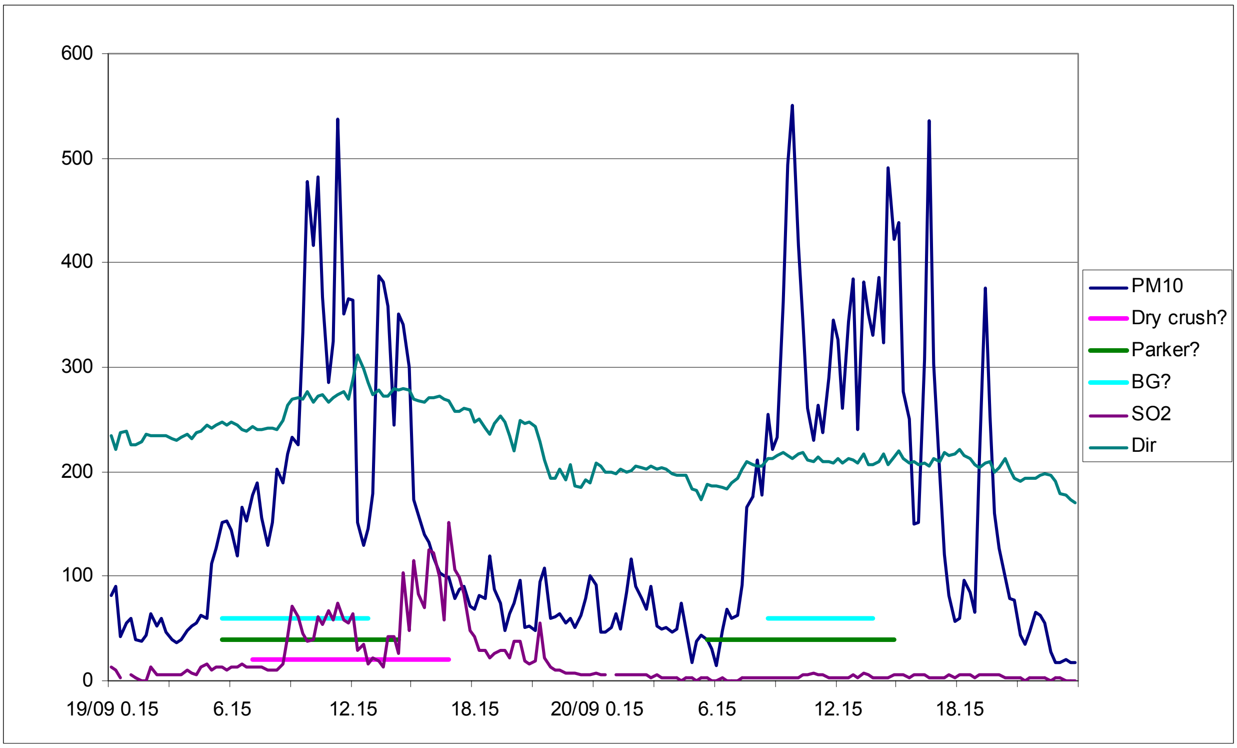

Figure 8.4b: 19th and 20th September

On the 11th October 2006 (Figure 8.4c) concentrations are significantly lower than in Figures 8.4a and b, this can be explained by the wind direction for the day, which reached a maximum of 190° throughout the day. On the 12th October concentrations are again elevated until 1600 hrs, during which SO_2 concentrations are slightly elevated, from 1600 hrs PM_{10} concentrations decrease rapidly. However, this is accompanied by a change in wind direction 240° to 156°.

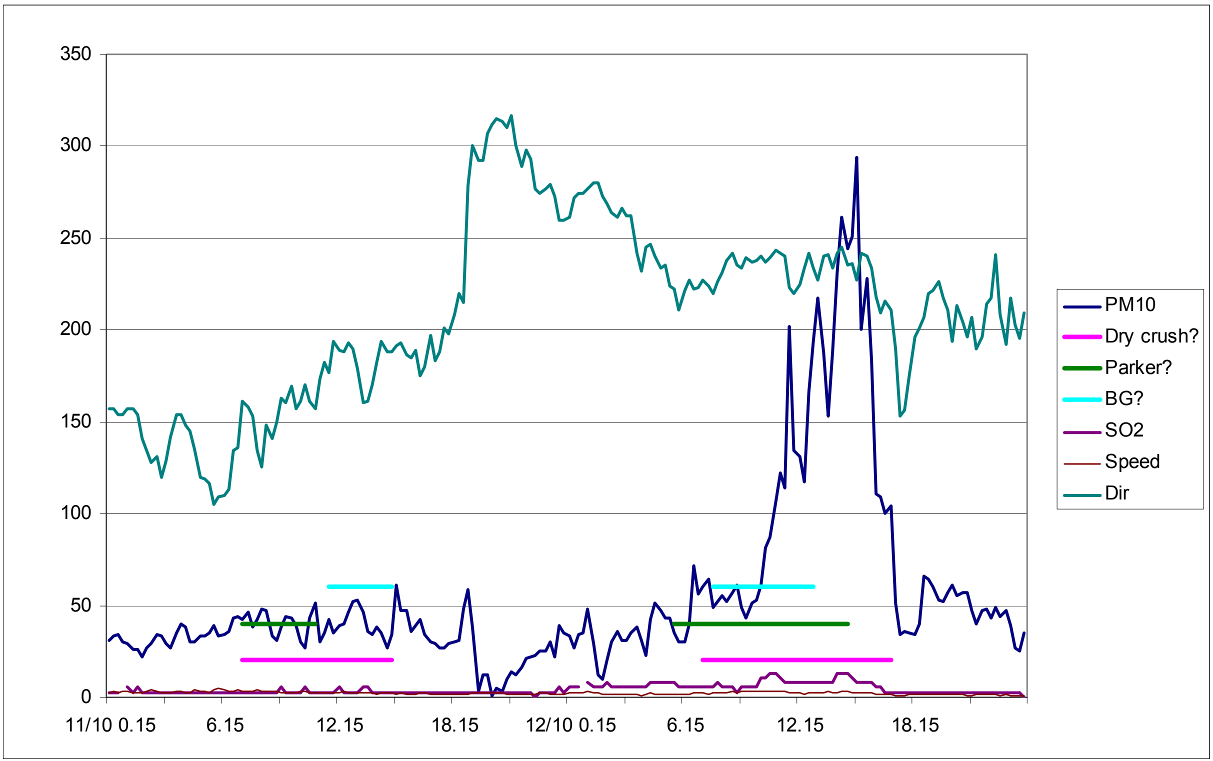

Figure 8.4c: 11th and 12th October

Figure 8.4d gives an example of concentrations on a Sunday; peak concentrations of 200 µg m^{-3} are still recorded at 1145 hrs and 1300 hrs, with slightly increased SO_2 concentrations of 10.6 µg m^{-3} and a wind direction of 240^o during the high concentrations.

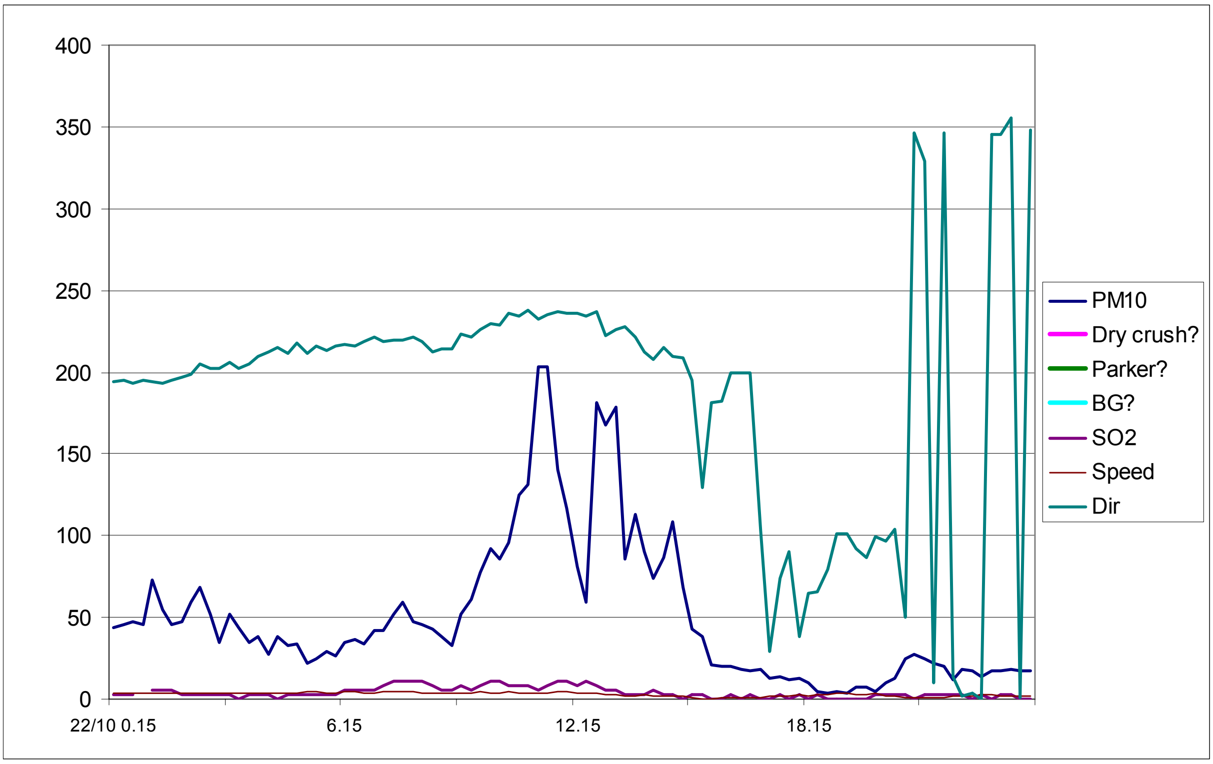

Figure 8.4 d: 22nd October 2006

Figure 8.4: Graphs showing the PM_{10} and SO_2 concentrations at Santon, the wind direction from Scunthorpe Town and whether the Tarmac's dry crushing, Barber Green and Parker operations were operating.

Part 8.5: Example Exceedance Episode, 23rd to 27th May 2006

One period of exceedance will be briefly studied in this Part, the 23rd to 27th May (Tuesday to Saturday) 2006, the daily mean concentrations at Santon were 124, 89, 65, 52 and 84 µg m^{-3} on these days respectively. All pollutants from Santon and wind direction are plotted in Figure 8.5.

As Figure 8.5 shows the majority of the high PM_{10} concentrations at Santon are recorded during the day, between 0600 and 1800 hrs. In line with the annual pollution rose, concentrations on the morning of the 26th are low with the wind originating from 90^{o} to 180^{o}. The wind continues to change until 1530 hrs when it settles into the ‘normal’ south-westerly direction; it is at this time when the greatest concentrations are recorded. It is noticeable that concentrations of up to 100 µg m^{-3} are recorded in the evening and early hours and on some occasions an increase in SO_2 concentrations is mirrored by an increase in PM_{10} concentrations (23rd and 24th May). Also important is the significant variety in concentrations that are recorded from one 15 minute reading to the next as well the fairly sudden increase in concentrations in the morning and decrease in concentrations during the evening on the 23rd and 24th.

In Chapter 7 a pollution rose (Figure 7.6) was drawn for 3rd to 13th May 2006, it is quite noticeable in the Santon part that the 99th and other percentiles show large concentrations at 300^{o} and 340^{o}, these would primarily point towards the Tarmac site.

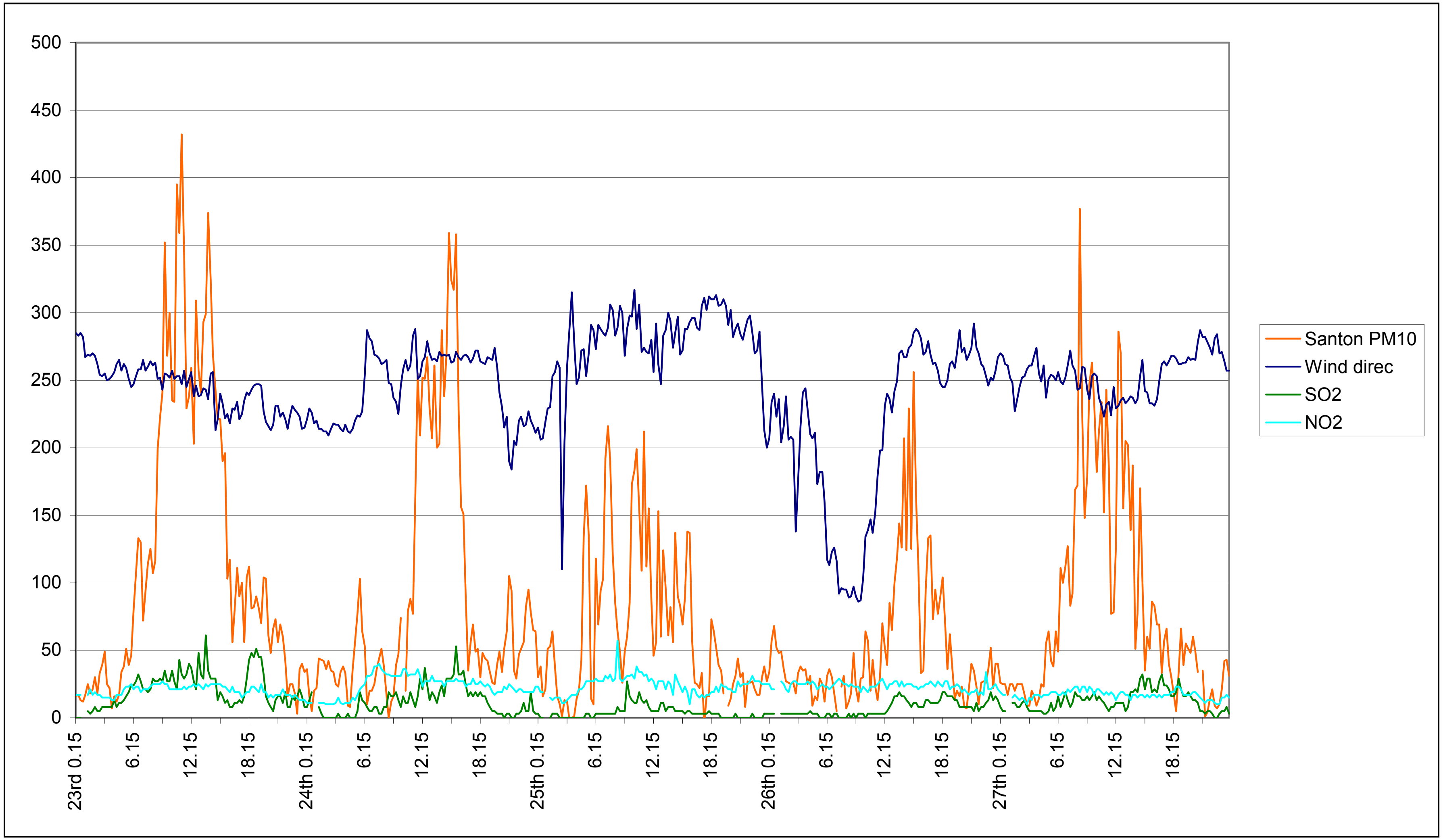

Figure 8.5: A graph showing the PM_{10}, SO_2 and NO_2 concentrations at Santon between 23rd and 27th May along with wind direction data from Scunthorpe Town.

Note: The y-axis represents the wind direction, °, and concentrations of pollutants, µg m^{-3}.

Part 8.6: SO_2 Concentrations

In light of the graphs shown in Figure 8.4 that show some link to SO_2 a similar graph to Figure 8.6 was drawn but this time SO_2 concentrations were used in addition to PM_{10} concentrations.

Again mean concentrations over a whole year are being plotted but it is clear that SO_2 and PM_{10} concentrations on average show a similar increase between 0400 and 1800 hrs, as well as similar trends over Monday to Friday, Saturday and Sunday. This may suggest a common source for SO_2 and a proportion of PM_{10}.

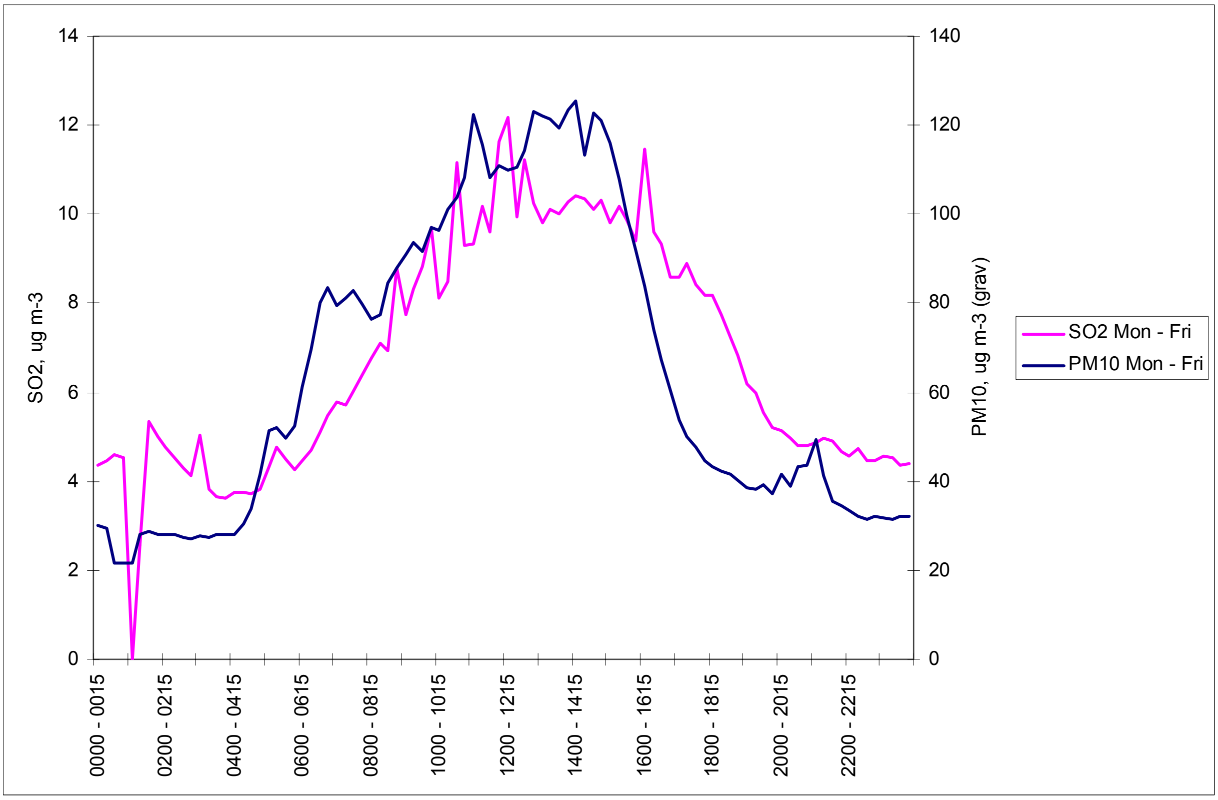

Figure 8.6: A graph showing the mean PM_{10} and SO_2 concentrations at Santon on Mondays to Fridays using 15 minute data.

Part 8.7: Train Movements

In North Lincolnshire Council's Updating and Screening Assessment report (2006) no locations were identified where railway locomotives are stationary for more than 15 minutes. However, trains that pass the Santon site contain potentially dusty material (coal and ore) and it was suggested that these train movements could be having an impact on the concentrations at Santon.

Scheduled train times were supplied for when the trains arrive at their destination, 'Santon F.O.T.' and 'Scunthorpe B.S.C.(c.H.P.)', the closest 15 minute period to these times is then highlighted in Figure 8.7 as red line, with July (weekdays) used as an example. Except for the a slight elevation in concentrations for the 0715 to 0730 period there seems to be little correlation between train times and elevated PM_{10} concentrations.

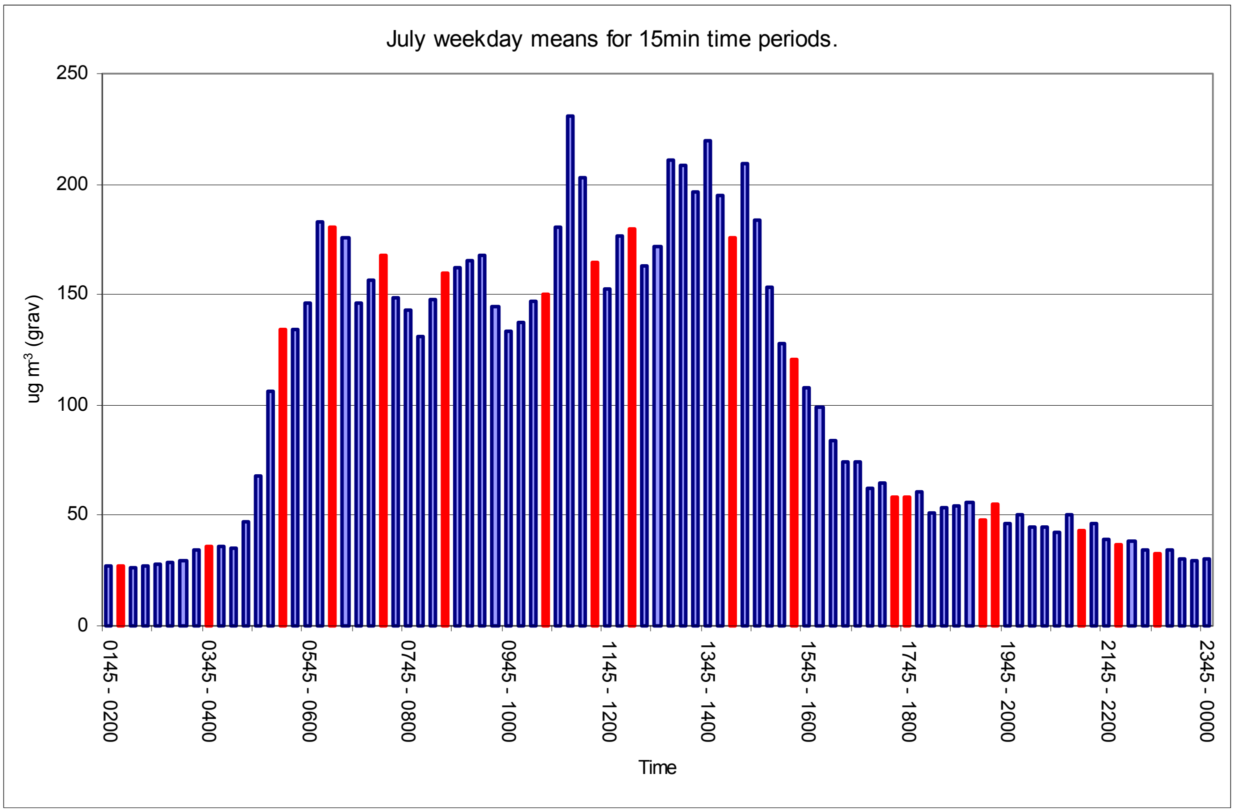

Figure 8.7: A graph showing the mean PM_{10} concentrations at Santon by 15 minute periods in July 2006, red blocks indicate when a train is likely to have passed.

However, the problem with any further analysis is that the TEOM records data as a 15 minute mean, whilst a train may pass the site in less than a minute, in addition only scheduled train times rather than actual train times were supplied, this makes further analysis difficult.

Part 8.8: Re-suspension of Dust

Dawes Lane and the whole of the steelworks site is very dusty, the site contains a significant number of unsealed roads which have the potential to release dust into the atmosphere, especially during dry weather conditions. Figures 4.7 and 7.4 suggest that dust and its re-suspension could be a significant issue.

If dust re-suspension is occurring on Dawes Lane directly opposite the monitoring site, then high concentrations may be detected regardless of wind direction and wind speed. The annual pollution rose shows that concentrations are above 40 μg m^{-3} when the wind originates from the southeast, this is in line with the road and re-suspension of dust could partially explain this observation.

Part 8.9: Broughton Exceedances

The two exceedances at Broughton occurred on the 13th April and 6th July 2006, on these dates the concentrations at Broughton and Santon were: 59 μg m^{-3} and 279 μg m^{-3} (the highest concentration at Santon) on the 13th April, and 52 μg m^{-3} and 149 μg m^{-3} (14th highest concentration at Santon) on the 6th July. This suggests that the PM_{10} recorded at Santon on these dates could be affecting the village of Broughton; Figure 8.8 shows the 15 minute data for wind direction, Scunthorpe Town, Broughton and Santon PM_{10} concentrations on 13th April.

Figure 8.8 shows that the concentrations dramatically increased between 0800 to 1700 hrs, peaking at 1174 μg m^{-3}, it can be seen that the concentrations are impacting on the Broughton site as they vary in a similar fashion, particularly between 1200 and 1800 hrs. The wind varies between 267^{o} and 309^{o} during the day, once the wind direction is greater than approximately 290^{o}, PM_{10} could be transported from the Santon area to Broughton. The annual pollution rose also shows this effect, with the only concentrations greater than 30 μg m^{-3} occurring from 270^{o} to 300^{o}. Scunthorpe Town does show a slight elevation in concentrations although the daily limit value is not breached. However, the wind direction is in the wrong direction for sources at Santon to be having a significant influence on Scunthorpe Town.

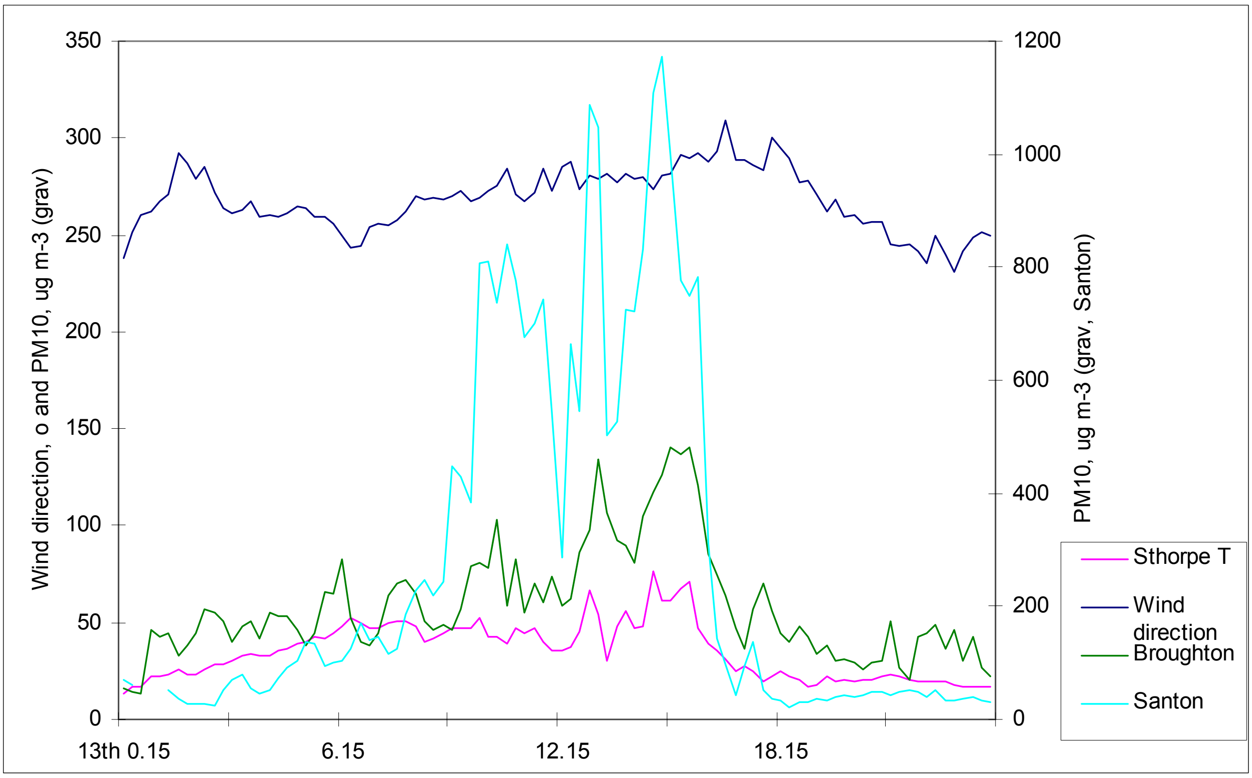

Figure 8.8: A graph showing the PM_{10} concentrations at Scunthorpe Town, Broughton and Santon on the 13th April 2006 (15 minute data), as well as the wind direction from Scunthorpe Town.

Note: The Santon concentrations are on the secondary axis (right side) due to their magnitude, whilst the wind direction and Broughton and Scunthorpe Town PM_{10} concentrations on the primary (left side) axis.

The results from the 6th July (Figure 8.9) are not as distinct as those from 13th April; however, the wind direction is again in approximately the right direction (it varies from 242^o to 309^o) for PM_{10} to be transported from Santon to Broughton.

The one peak that occurs at Scunthorpe Town at 0415 hrs is interesting, the peak itself occurs when the wind is from 272^o but in the hour before this the wind has switched from 50^o (clockwise) and has thus gone through the direction from where high concentrations are seen at Scunthorpe Town. A rise in PM_{10} concentration then occurs half an hour later at Santon. Wind speed is low at this time of the morning at about 1 m s^{-1} thus dispersion may have also been poor.

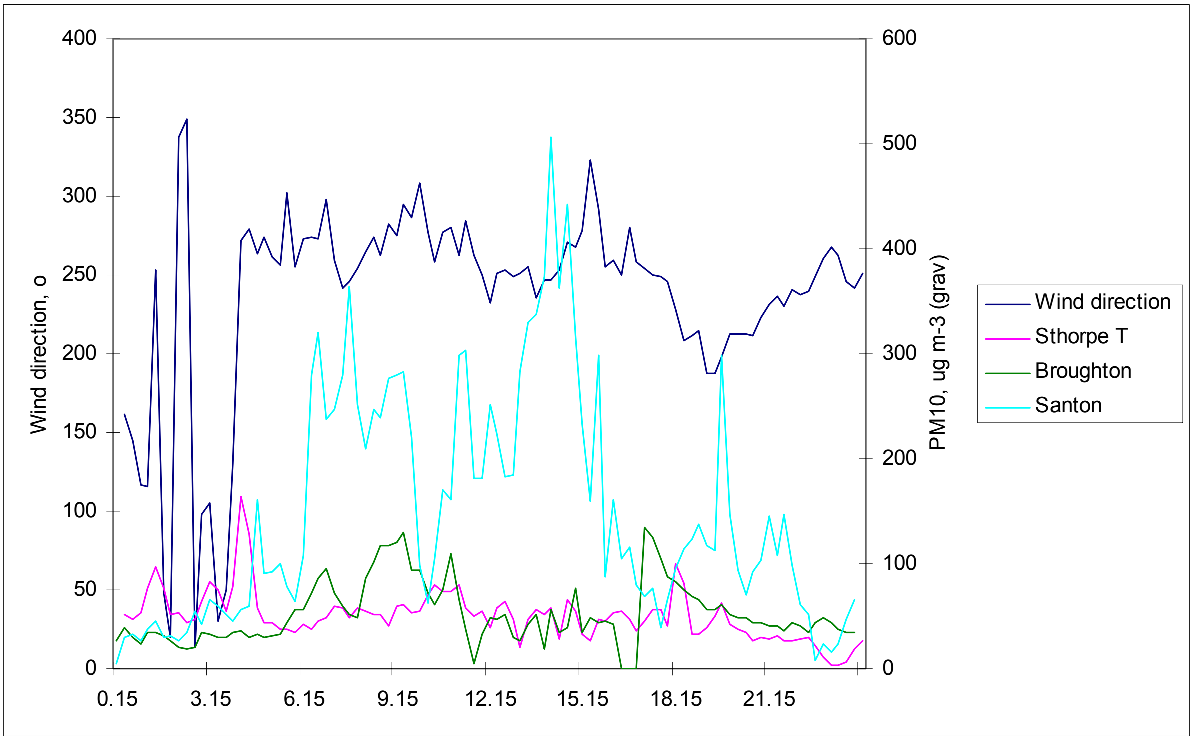

Figure 8.9: A graph of the PM_{10} data from Scunthorpe Town, Broughton and Santon and the wind direction on the 6th July (15 minute data).

The effect of rainfall has been discussed in Chapter 4 with regards to results at Scunthorpe Town.

Part 8.10: Summary

From the data presented in this Chapter, it appears that the site at Santon is experiencing PM_{10} sources in addition to those being recorded at the sites in Scunthorpe itself. In line with the annual pollution rose it is likely that the sources of PM_{10} at Santon are having a small impact on the Town itself when the wind direction is from the northeast. This extends to Broughton in that the Air Quality objective is not being breached, but it is noticeable that when the wind is emanating from the appropriate direction (~310^{o}) concentrations are slightly increased. However, with only 2 exceedances in 9 months of monitoring at Broughton this is not of concern.

It is difficult to source apportion due to the proximity of the sources and the hours during which these sources may or may not be operating. It is likely that the steelworks, Multiserv and Tarmac operations are all having an impact on the Santon site. A majority (though not all) of the high PM_{10} concentrations occur during the day, suggesting that key sources could be the re-suspension of dust from (unsealed and sealed) roads on the industrial site and Dawes Lane, as well as materials handling and general disturbance of dust that has historically been deposited in the area. Like Scunthorpe Town Figure A9 shows that as the amount of rainfall increases the PM_{10} concentration decreases at Santon.

Tarmac are the closest operator to the Santon TEOM site, as part of their permit dust is not allowed to escape the boundary, however, it could be that the PM_{10} fraction is escaping due to its lower mass. Tarmac are likely to be contributing to the Santon problem, but Figure 8.4b indicates that they are not the only problem with high concentrations recorded when the crushing and screening process at the Santon site was not operating.

Chapter 10 gives a brief outline of North Lincolnshire Council's future plans to help with source apportionment at the Santon site.

Key Points:

- Santon breaches the annual and daily objectives.
- Mean concentrations greatest during daytime hours and on Monday to Fridays.
- Multiple sources in the area, difficult to source apportion due to variety and closeness of sources.

Chapter 9: Partisol Results

The Air Quality objectives for PM_{10} are based on a gravimetric method of measurement. Any method that does not measure in this manner must be shown to be either directly equivalent to or shown to have a correction factor applied to it so that a fair comparison can be made between the results obtained and the Air Quality objective.

The current Defra advice [10] for correcting TEOM results to a gravimetric equivalent is to multiply the raw TEOM data by a factor of 1.3. The most recent PM_{10} equivalence report,[15] demonstrated the equivalence of the Partisol 2025 but showed that the TEOM was not equivalent. As a result TEOM results will come under further examination than usual. This is particularly relevant as the number of exceedances recorded at Scunthorpe Town was only slightly greater than the Air Quality objective, 37 for 2006 versus the objective of 35.

Part 9.1: Scunthorpe Town and Lakeside

Bureau Veritas were contracted to analyse Partisol filters from Scunthorpe Town and Lakeside until the 22nd August 2006. As part of a report into PM_{10} in Scunthorpe Bureau Veritas compared the results of a co-located Partisol 2025 and TEOM at Scunthorpe Town. The analysis was done for data between 15th December 2004 through to 25th July 2005 and over this seven month period the ratio of the Partisol to the TEOM results varied from 0.1 to 5. The report recommended a correction factor of 1.6 rather than the current 1.3, but with the recommendation that a full year of data is studied before taking a decision about changing the correction factor that is used to correct TEOM results. Using the 1.6 correction factor for the 2006 data at Scunthorpe Town would have given an annual mean of 36.3 µg m^{-3} and 64 exceedances of the daily mean limit value.

In 2005 Bureau Veritas recorded the number of exceedances (by Partisol) at Scunthorpe Town as 28, the total recorded by the TEOM (using a correction factor of 1.3) was 25. At Lakeside the Partisol (in the AQMA) was operating from 23rd February to 31st December and recorded 36 exceedances, breaching the Air Quality objective. However, during this period there was a change in the filter used and Trace Metals analysis was also performed which meant deviation from EN12341.

Since 23rd August 2006 AEA Energy and Environment have been contracted to analyse filters (Pall Gelman Emfab Quartz) for PM_{10} from the Partisol at Scunthorpe Town in line with EN12341, with results up to 2nd January 2007 available for inclusion in this report. Unfortunately results for the remainder of 2006 before 23rd August are not currently available. It should be noted that the results from Bureau Veritas and AEA are from two different parts of the year and so are not directly comparable at this stage. Initial statistics based on the AEA results are presented in Table 9.1.

Correction factor		Date
Mean	1.15998	-
Minimum	0.702	31st August
Maximum	2.113	23rd December

Table 9.1a.

Method	Exceedances
Partisol	8
TEOM * 1.3	11
TEOM * average (1.16)	7
TEOM * graphical	8

Table 9.1b.

Table 9.1: a. The mean, minimum and maximum correction factor from the AEA results, b. the number exceedances recorded by the Partisol, by TEOM * 1.3, by using the mean factor (1.16) on raw TEOM results and by using a graphical regression on the data.

Preliminary results from AEA Energy and Environment suggest that the 1.3 and 1.6 correction factors are an over-estimate, with an average correction factor from the results so far of 1.16. If this were applied to the 2006 TEOM data from Scunthorpe Town then an annual mean of 26.4 µg m^{-3} would have been recorded with 25 exceedances of the daily limit value, lower than the Air Quality objectives.

Table 9.1b shows that during the analysis by AEA the Partisol recorded 8 exceedances with the TEOM recording 11 exceedances, although it must be noted though that on one of these exceedance days the Partisol was not working. In addition, applying the average (or ‘graphical’) correction factor across the period highlights different days as recording exceedances. For example on the 11th October the Partisol records a concentration of 52 µg m^{-3}, the TEOM*1.3 result is equal to 51 µg m^{-3}, however using the average correction factor of 1.16 the result is below the Air Quality objective at 45.1 µg m^{-3}.

Figure 9.1a shows the range of correction factors that have been applicable across the analysis period, with a minimum of 0.702 on the 31st August and a maximum of 2.113 on 23rd December. It can be seen in Figure 9.1 that the Partisol results and TEOM*1.3 results do vary in a similar fashion, with a Pearson Correlation Coefficient of 0.953.

In general the greatest differences between the Partisol and TEOM*1.3 results seem to be occurring at low concentrations, with the exception of 21st September.

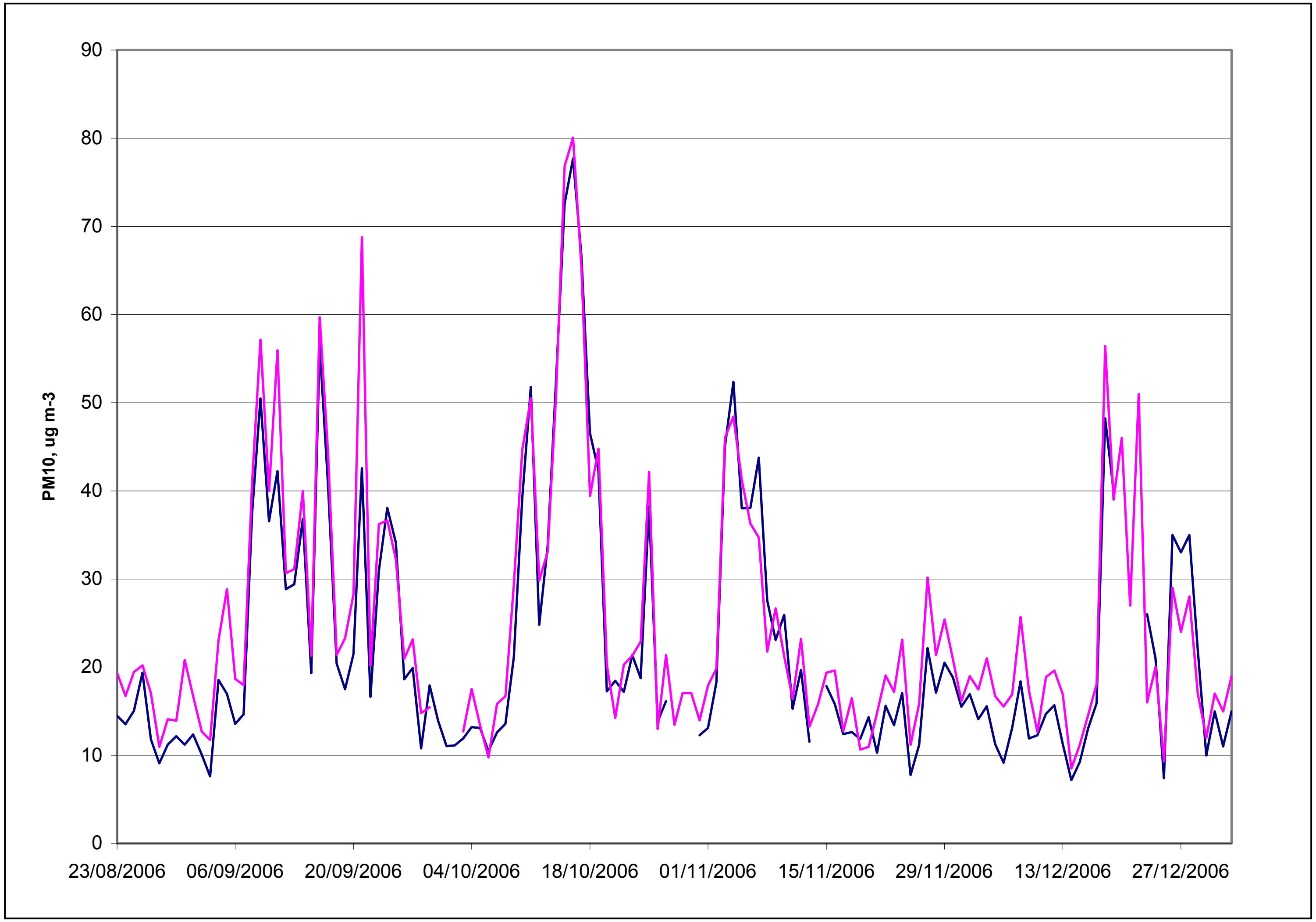

Figure 9.1: A graph plotting the PM_{10} concentration recorded by the Partisol (blue) and the TEOM with correction factor of 1.3 (pink) at Scunthorpe Town between 23rd August 2006 and 2nd January 2007.

Part 9.2: Santon

Due to construction works in the Lakeside area and the need to investigate the number of exceedances being recorded at Santon, the Partisol that was situated at Lakeside has been re-located to High Santon. This is approximately 500 m east of the current TEOM located at Santon as shown in Figure 2.1.

The results from this Partisol will give an indication of whether the high PM_{10} concentrations being recorded at the Santon TEOM are a hot spot for the three houses close to the monitoring site or whether the problem extends further into High Santon village, which contains approximately 40 houses. However, the results will not contribute to any co-location correction factor work, as the TEOM and Partisol are not at the same site. Although it maybe interesting to see if there is a 'pseudo correction factor' that can be applied to correlate the TEOM and Partisol results. The re-located Partisol commenced monitoring on the 5th January 2007.

Part 9.3: Discussion

The current advice to Local Authorities from Defra was mentioned in Chapter 1. At this moment in time North Lincolnshire Council does not consider that it is worthwhile upgrading any of its TEOM monitors, not only would this be expensive but also it would lose the potential for comparison between future and previous data sets. North Lincolnshire Council currently operate PM_{10} equipment that meets the equivalence criteria (Partisol 2025) at the two most crucial sites: Scunthorpe Town where a Partisol is co-located with a TEOM that is an affiliate member of the AURN and another Partisol in the area of the greatest number of exceedances; Santon.

The advantage of the TEOMs is that they record a 15 minute mean concentration, which is essential in being able to provide some sort of source apportionment, this is especially important given that the wind direction has been shown to change throughout the day. Whilst FDMS-TEOMs maybe suitable for determining daily means, because they switch between a 'purge' and 'base' mode every six minutes, their ability to source apportion is not as good as the TEOMs as data is not recorded at all times for each filter.

North Lincolnshire Council will wait until at least one full year of co-located monitoring has been carried out at Scunthorpe Town before making a decision on whether to carry on using the 1.3 correction factor or whether an alternative correction factor would be more appropriate to the Scunthorpe area. Ultimately though the Partisol will show whether the objectives are being breached. At least 3 months monitoring will be necessary at the re-located Santon Partisol until the extent of the PM_{10} problem in the area can be determined.

If a new correction factor is adopted it will be the results that are around 50 µg m^{-3} that will be the most critical. Figure 9.1 suggests that results from the two machines vary in a similar fashion. If the TEOM and Partisol both record a considerable exceedance (e.g. 100 µg m^{-3}) then a small difference in correction factor is unlikely to be significant. However, the difference will be critical if the daily mean is around the daily limit value. If a new correction factor was agreed upon then it is likely that the factor would also be applied to the Allanby Street, Broughton, East Common Lane and Lincoln Gardens monitoring sites. Although not co-located with the Scunthorpe Town Partisol they are close enough to and likely to be experiencing the same sources of PM_{10} such that the correction factor would be applicable to these sites.

Key points:

- Lakeside results breached objective, Scunthorpe Town did not in 2005 but filters were not ideal for PM_{10} analysis.
- Correction factor is likely to be less than 1.3 but TEOMs useful for source apportionment.
- Re-located Partisol in Santon to determine extent of annual breach.

Chapter 10: Conclusions and Future Plans

Part 10.1: Conclusions

- North Lincolnshire Council was correct to declare an AQMA for PM_{10} in Scunthorpe relating to the potential for the daily mean objective to be breached. The area chosen has shown to be approximately correct, although it should possibly extend slightly further north from the Santon monitoring site.
- Further monitoring is now being carried out in relation to a breach of the annual Air Quality objective for PM_{10} in the Santon area.
- 5 of the 37 exceedances at the Scunthorpe Town monitoring site can be attributed to traffic and Bonfire night celebrations.
- It is clear that local industry and its associated activities are responsible for a significant number of the PM_{10} exceedances in the Scunthorpe area, although it appears there may be additional sources at Santon compared to the sites in the Town of Scunthorpe itself.
- It appears there is not a single industrial source that is responsible for the PM_{10}. Multiple sources from local industry include stack emissions, crushing operations, fugitive emissions from stockpiles as well as the re-suspension of dust from roads and other surfaces.
- The data suggests that daytime activities are likely to be the most significant contributor to Santon's high concentrations with the highest concentrations originating from the north end of the steelworks and other industry site. A similar though less significant daytime influence is seen at Scunthorpe Town, however, for the Town itself the pollution roses and graphs suggest the problem lies at the southern end of the steelworks and other industry site.
- In general, more exceedances occur during the summer than the winter. However, it appears that wind direction is the most crucial factor and exceedances are most likely to occur at Scunthorpe Town when the wind originates from an easterly or south-easterly direction.
- As detailed in Part 7.6, taking into account the potential background PM_{10} concentrations, the true percentage improvement to ensure that the limit value (and thus objective) is not breached regardless of meteorological conditions could be as high as 48% rather than a relatively simple reduction of two exceedances (for Scunthorpe Town).

Part 10.2: Future plans

As a result of this Further Assessment North Lincolnshire Council will produce an Action Plan, however, in the meantime it is clear that further source apportionment work is necessary and the following actions are currently being planned.

- A TEOM was installed in Appleby village (classified as an urban background site) in early February 2007; this site is approximately 3 km northeast of the steelworks site and is outside the current AQMA. Future reports will include data collected from this site.
- Monitoring will continue at the Santon Partisol site for at least one year, a minimum of three months monitoring will be needed before a reasonable comparison to the results at the Santon TEOM site can be made.
- A traffic count will be done close to the Santon site to establish traffic levels and the number of HGVs using Dawes Lane.
- Continue liaison with the Environment Agency and Corus.
- A day will be spent at Santon in the spring/summer months to make observations and compare to real time data (2 second measurements). A similar exercise may be done from the roof of the Council car park and from Appleby village, both of which give good views over the steelworks and other industry in the area.
- Continued monitoring at the High Santon Partisol will help determine the extent of the annual mean objective breach. Monitoring will also continue at the Scunthorpe Town Partisol.
- A website is currently being developed which will give access for the public to real-time data from North Lincolnshire Council monitoring sites.
- Request Appleby Group to study part of 2006 PM_{10} and wind direction data and compare to their working hours.

Part 10.3: References

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12.) Airmonitors website, http://j.b5z.net/i/u/1640578/f/2025_brochure.pdf

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14.) London Air Quality Website
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All websites were accessible in March 2007.

Appendix

Sthorpe Town		
Date	PM10 (grav)	Status
24/01/2006	61	R
15/03/2006	67	R
23/03/2006	80	R
24/03/2006	82	R
04/05/2006	124	R
08/05/2006	121	R
09/05/2006	57	R
11/05/2006	56	R
07/06/2006	52	R
08/06/2006	87	R
09/06/2006	107	R
10/06/2006	130	R
02/07/2006	60	R
03/07/2006	64	R
04/07/2006	51	R
05/07/2006	72	R
06/07/2006	51	R
16/07/2006	52	R
17/07/2006	57	R
18/07/2006	91	R
19/07/2006	97	R
21/07/2006	55	R
22/07/2006	52	R
25/07/2006	90	R
26/07/2006	57	R
17/08/2006	59	R
09/09/2006	57	R
11/09/2006	56	R
16/09/2006	60	R
21/09/2006	69	R
11/10/2006	51	P
14/10/2006	51	P
15/10/2006	77	P
16/10/2006	80	P
17/10/2006	65	P
18/12/2006	56	P
22/12/2006	51	P

Allanby St		
Date	PM10 (grav)	Status
24/01/2006	64	P
01/02/2006	59	P
18/02/2006	55	P
13/03/2006	53	P
24/03/2006	63	P
04/05/2006	95	P
08/05/2006	103	P
09/05/2006	62	P
12/05/2006	51	P
08/06/2006	72	P
09/06/2006	72	P
10/06/2006	79	P
06/07/2006	57	P
17/07/2006	52	P
18/07/2006	63	P
19/07/2006	59	P
21/07/2006	55	P
25/07/2006	69	P
16/09/2006	58	P
15/10/2006	62	P
16/10/2006	70	P
17/10/2006	51	P
05/11/2006	55	P

Broughton		
Date	PM10 (grav)	Status
13/04/2006	59	P
06/07/2006	52	P

East Common Lane		
Date	PM10 (grav)	Status
06/01/2006	57	P
24/01/2006	55	P
26/01/2006	60	P
19/02/2006	58	P
20/02/2006	52	P
22/02/2006	53	P
24/02/2006	57	P
11/03/2006	51	P
15/03/2006	81	P
16/03/2006	51	P
17/03/2006	58	P
18/03/2006	55	P
20/03/2006	60	P
23/03/2006	59	P
24/03/2006	63	P
04/05/2006	85	P
06/05/2006	53	P
11/05/2006	51	P
07/06/2006	79	P
08/06/2006	108	P
09/06/2006	85	P
10/06/2006	96	P
14/06/2006	52	P
25/06/2006	83	P
01/07/2006	56	P
02/07/2006	98	P
03/07/2006	101	P
04/07/2006	66	P
05/07/2006	101	P
13/07/2006	53	P
14/07/2006	86	P
15/07/2006	63	P
16/07/2006	59	P
17/07/2006	54	P
18/07/2006	105	P
19/07/2006	117	P
25/07/2006	92	P
17/08/2006	57	P
16/09/2006	62	P
14/10/2006	69	P
15/10/2006	83	P
16/10/2006	86	P
04/11/2006	51	P

Lincoln Gardens		
Date	PM10 (grav)	Status
24/01/2006	54	P
28/03/2006	103	P
08/05/2006	101	P
09/05/2006	65	P
07/06/2006	53	P
08/06/2006	87	P
09/06/2006	55	P
10/06/2006	54	P
25/06/2006	56	P
02/07/2006	86	P
03/07/2006	71	P
04/07/2006	66	P
05/07/2006	97	P
18/07/2006	70	P
19/07/2006	79	P
16/09/2006	55	P
15/10/2006	66	P
16/10/2006	60	P

Santon					
Date	PM10 (grav)	Status	Date	PM10 (grav)	Status
11/01/2006	53	R	04/05/2006	79	R
17/01/2006	67	R	05/05/2006	131	R
18/01/2006	61	R	08/05/2006	75	R
19/01/2006	67	R	11/05/2006	72	R
24/01/2006	73	R	12/05/2006	160	R
01/02/2006	60	R	16/05/2006	127	R
02/02/2006	68	R	17/05/2006	85	R
03/02/2006	56	R	18/05/2006	112	R
06/02/2006	56	R	19/05/2006	81	R
07/02/2006	89	R	23/05/2006	124	R
11/02/2006	58	R	24/05/2006	89	R
14/02/2006	66	R	25/05/2006	65	R
15/02/2006	82	R	26/05/2006	52	R
16/02/2006	72	R	27/05/2006	84	R
17/02/2006	68	R	30/05/2006	62	R
01/03/2006	86	R	31/05/2006	51	R
02/03/2006	110	R	01/06/2006	52	R
03/03/2006	94	R	02/06/2006	80	R
10/03/2006	51	R	04/06/2006	51	R
23/03/2006	54	R	06/06/2006	144	R
25/03/2006	58	R	07/06/2006	62	R
27/03/2006	54	R	09/06/2006	85	R
28/03/2006	146	R	10/06/2006	52	R
29/03/2006	170	R	11/06/2006	74	R
30/03/2006	118	R	12/06/2006	166	R
31/03/2006	142	R	13/06/2006	84	R
01/04/2006	103	R	15/06/2006	64	R
03/04/2006	149	R	16/06/2006	120	R
05/04/2006	117	R	21/06/2006	147	R
06/04/2006	138	R	22/06/2006	166	R
07/04/2006	179	R	23/06/2006	126	R
11/04/2006	65	R	28/06/2006	94	R
12/04/2006	134	R	29/06/2006	109	R
13/04/2006	279	R	30/06/2006	118	R
17/04/2006	58	R	01/07/2006	59	P
18/04/2006	99	R	04/07/2006	53	P
22/04/2006	69	R	05/07/2006	54	P
24/04/2006	66	R	06/07/2006	149	P
25/04/2006	116	R	07/07/2006	148	P
26/04/2006	185	R	08/07/2006	118	P
27/04/2006	132	R	09/07/2006	90	P
02/05/2006	98	R	10/07/2006	200	P
03/05/2006	157	R	11/07/2006	199	P

Date	PM10 (grav)	Status	Date	PM10 (grav)	Status
12/07/2006	177	P	19/10/2006	53	P
19/07/2006	54	P	20/10/2006	56	P
20/07/2006	81	P	21/10/2006	59	P
21/07/2006	124	P	23/10/2006	53	P
22/07/2006	69	P	24/10/2006	56	P
23/07/2006	58	P	26/10/2006	59	P
24/07/2006	98	P	27/10/2006	55	P
26/07/2006	112	P	30/10/2006	73	P
27/07/2006	61	P	03/11/2006	64	P
28/07/2006	101	P	04/11/2006	77	P
29/07/2006	72	P	05/11/2006	55	P
31/07/2006	106	P	06/11/2006	79	P
01/08/2006	82	P	07/11/2006	52	P
02/08/2006	104	P	09/11/2006	55	P
05/08/2006	56	P	13/11/2006	71	P
08/08/2006	99	P	14/11/2006	78	P
09/08/2006	138	P	15/11/2006	52	P
10/08/2006	148	P	16/11/2006	64	P
15/08/2006	102	P	20/11/2006	76	P
16/08/2006	89	P	21/11/2006	66	P
23/08/2006	95	P	30/11/2006	55	P
25/08/2006	54	P	02/12/2006	55	P
01/09/2006	110	P	04/12/2006	86	P
04/09/2006	101	P	08/12/2006	53	P
05/09/2006	114	P	14/12/2006	67	P
06/09/2006	95	P	19/12/2006	58	P
11/09/2006	100	P	20/12/2006	52	P
12/09/2006	121	P	21/12/2006	57	P
13/09/2006	81	P	22/12/2006	73	P
16/09/2006	55	P			
17/09/2006	60	P			
18/09/2006	141	P			
19/09/2006	151	P			
20/09/2006	169	P			
21/09/2006	56	P			
26/09/2006	59	P			
27/09/2006	106	P			
28/09/2006	99	P			
04/10/2006	71	P			
06/10/2006	53	P			
07/10/2006	66	P			
12/10/2006	78	P			
18/10/2006	59	P			

Table A1: The dates for when the PM_{10} daily limit value was exceeded during 2006 at Scunthorpe Town, Allanby Street, Broughton, East Common Lane, Lincoln Gardens and Santon. All values in µg m^{-3}.

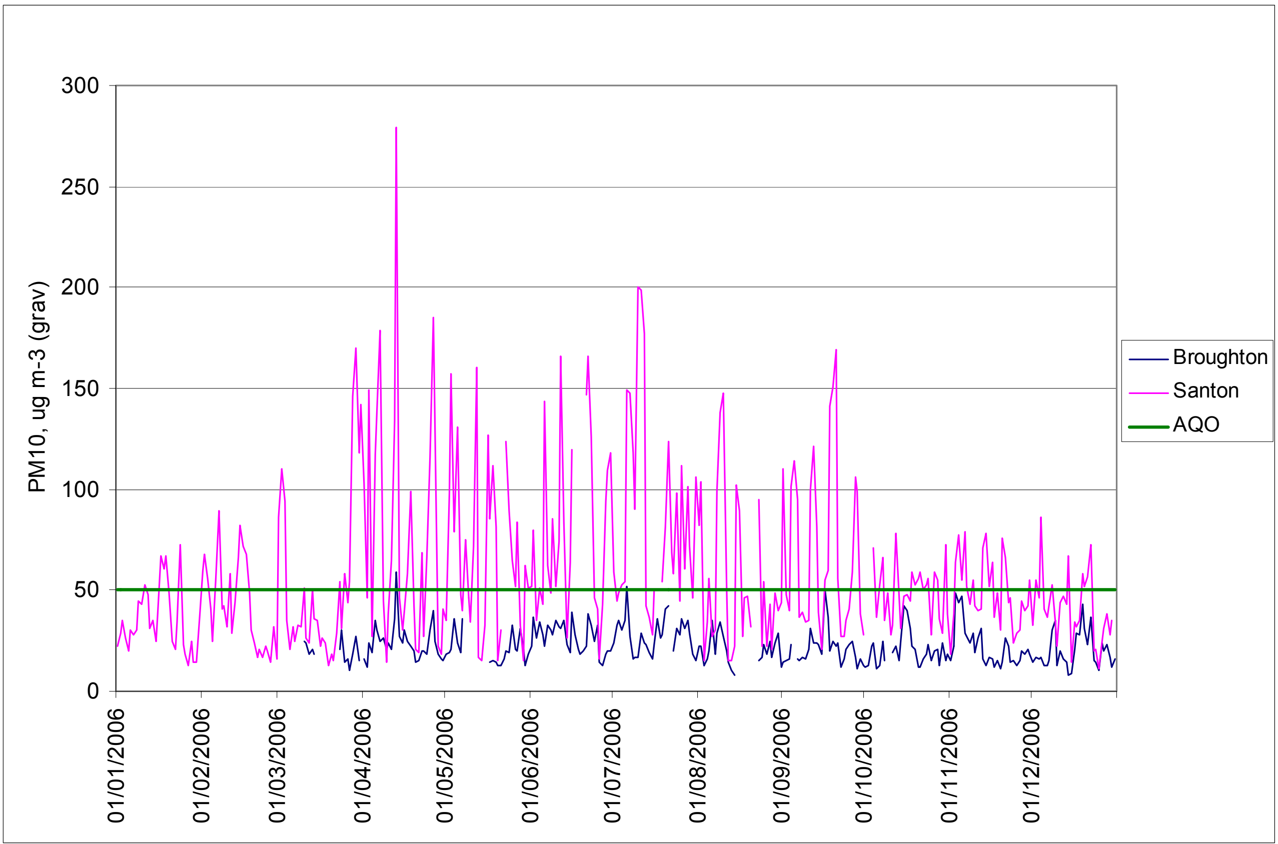

Figure A1: A graph of the daily mean PM_{10} concentrations at Broughton and Santon during 2006.

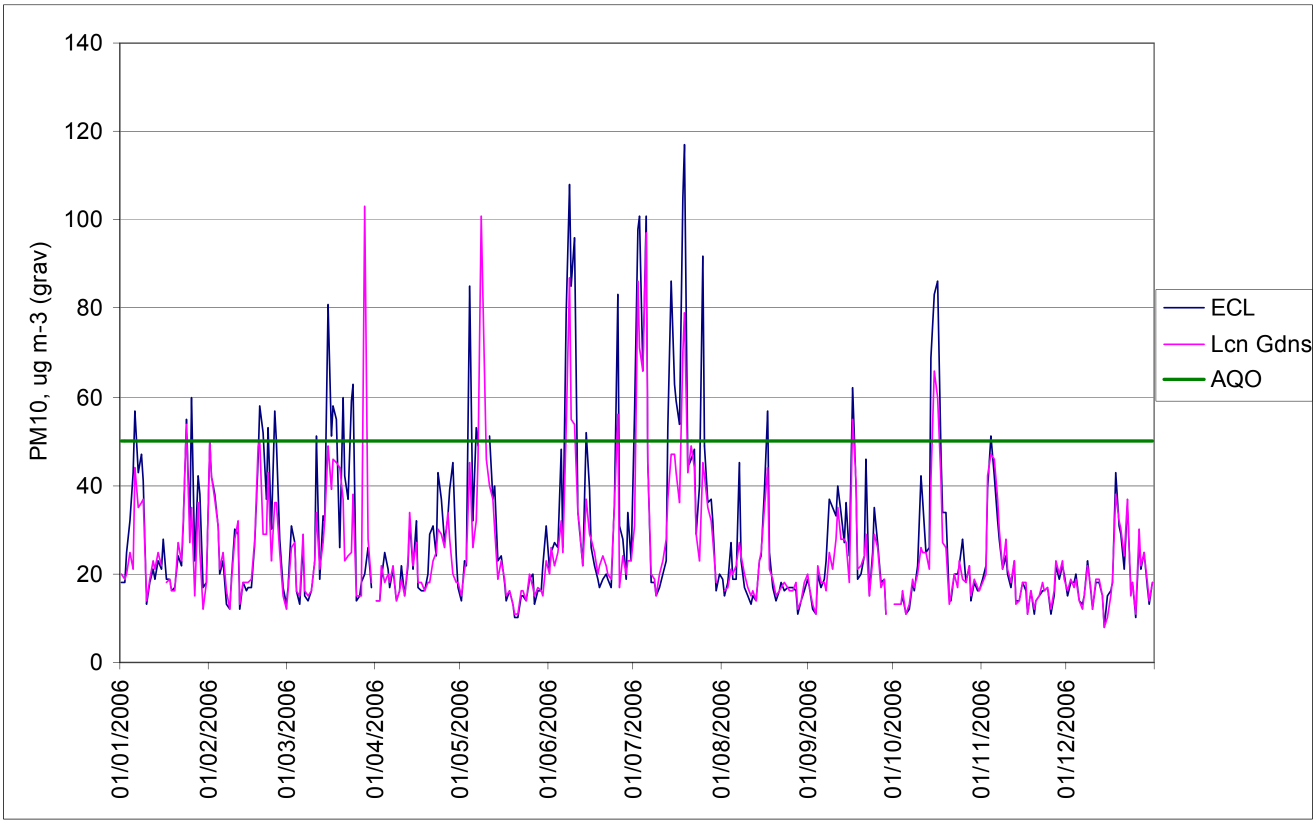

Figure A2: A graph of the daily mean PM_{10} concentrations at East Common Lane and Lincoln Gardens during 2006.

2006		2005	
Exceedances	Site	Exceedances	Site
149	Marylebone Road	118	Marylebone Road
67	Glasgow Kerbside	52	Camden Kerbside
52	Camden Kerbside	37	Bradford Centre
47	Bradford Centre	29	Port Talbot
37	**Scunthorpe Town**	27	Glasgow Kerbside
35	Port Talbot	**25**	**Scunthorpe Town**

2004		2003	
Exceedances	Site	Exceedances	Site
97	Marylebone Road	161	Marylebone Road
42	Camden Kerbside	**95**	**Scunthorpe**
38	Port Talbot	54	Bury Roadside
31	Glasgow Kerbside	53	Cardiff Centre
30	Bury Roadside	47	Camden Kerbside
24	**Scunthorpe Town**	47	Glasgow Kerbside
6	**Scunthorpe**		

2002		2001	
Exceedances	Site	Exceedances	Site
106	Marylebone Road	104	Marylebone Road
47	**Scunthorpe**	69	Manchester Piccadilly
29	Glasgow Kerbside	**49**	**Scunthorpe**
24	Port Talbot	39	Port Talbot
22	Bury Roadside	35	Glasgow Kerbside
21	London Bloomsbury	33	Bury Roadside

2000	
Exceedances	Site
157	Marylebone Road
56	Port Talbot
31	**Scunthorpe**
29	Camden Kerbside
25	Glasgow Centre
22	Manchester Piccadilly

Table A2: The sites within the AURN that recorded the greatest number of exceedances of the PM_{10} daily limit value between 2000 and 2006.

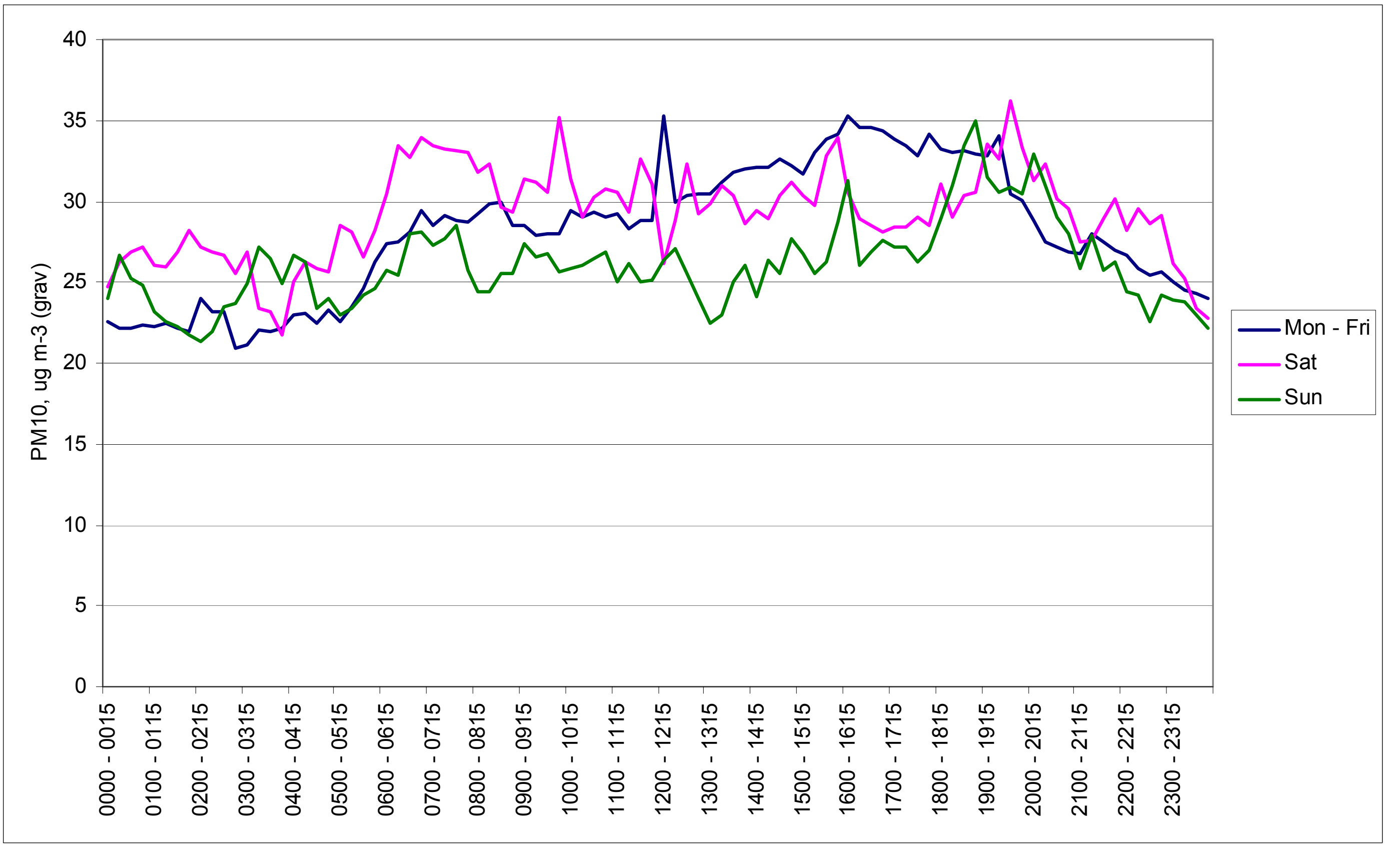

Figure A3: A graph of 15 minute PM_{10} data separated according to day of the week, Monday to Friday, Saturday and Sunday for East Common Lane in 2006.

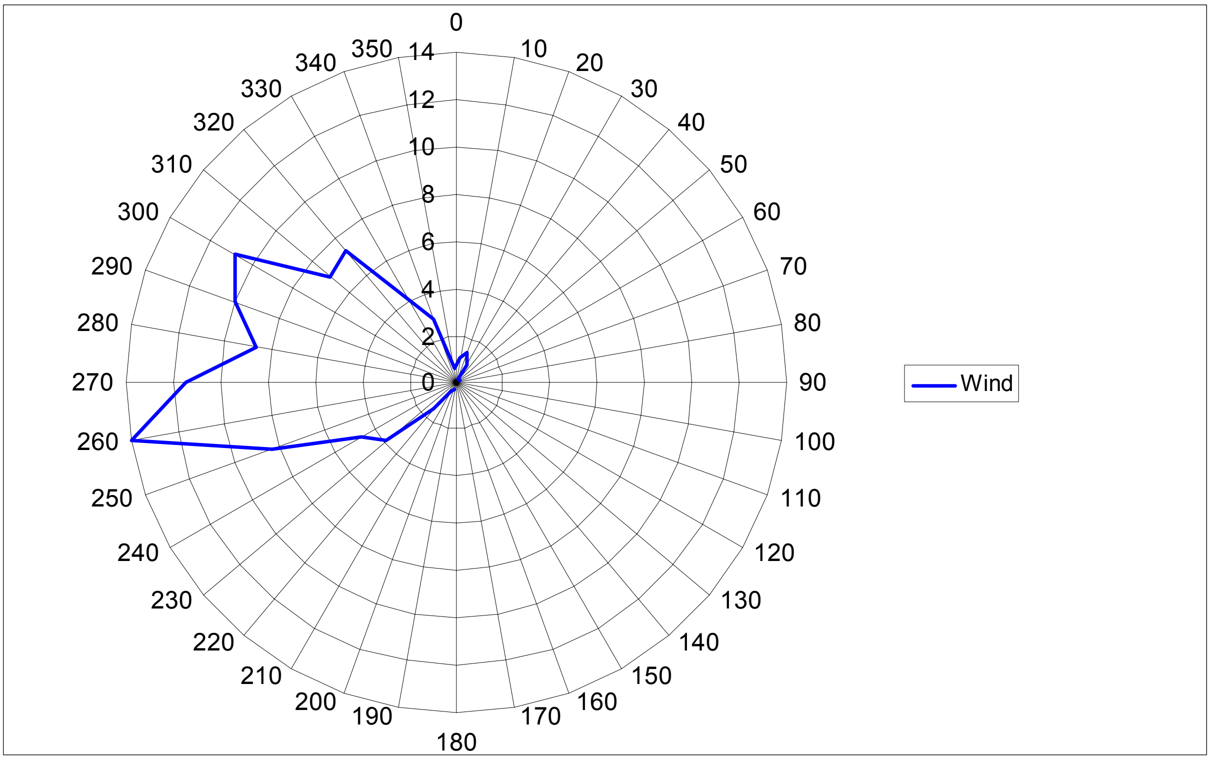

Figure A4: A wind rose for the period 2nd to 8th February 2006.

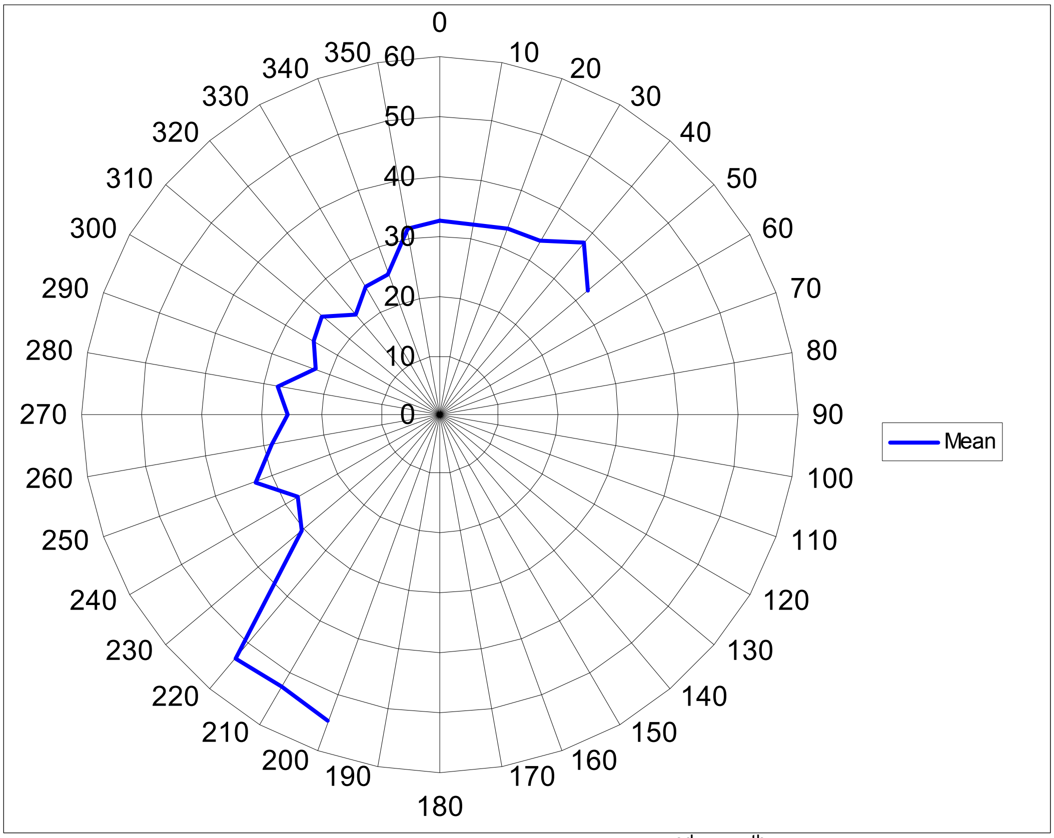

Figure A5: A pollution rose for the period 2nd to 8th February 2006.

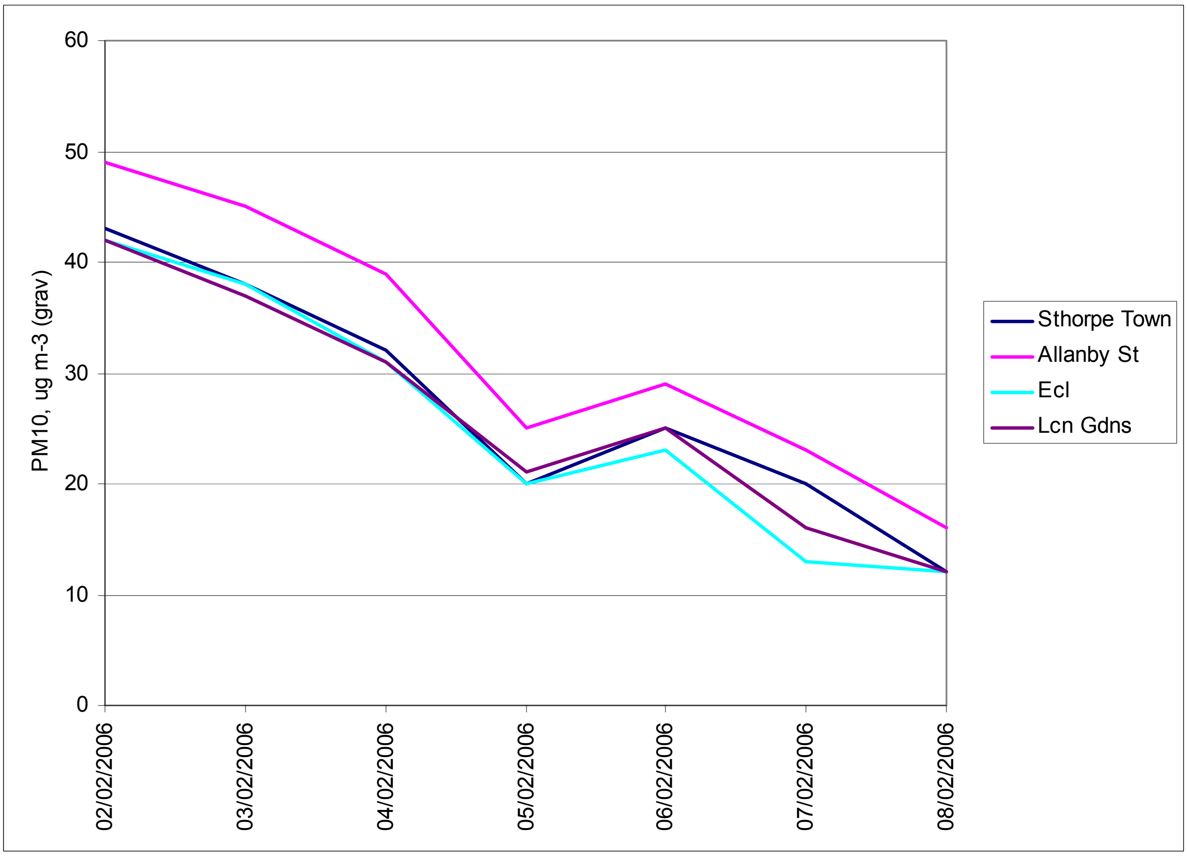

Figure A6: A graph of the daily mean PM_{10} concentration at the Scunthorpe sites between 2nd and 8th February 2006.

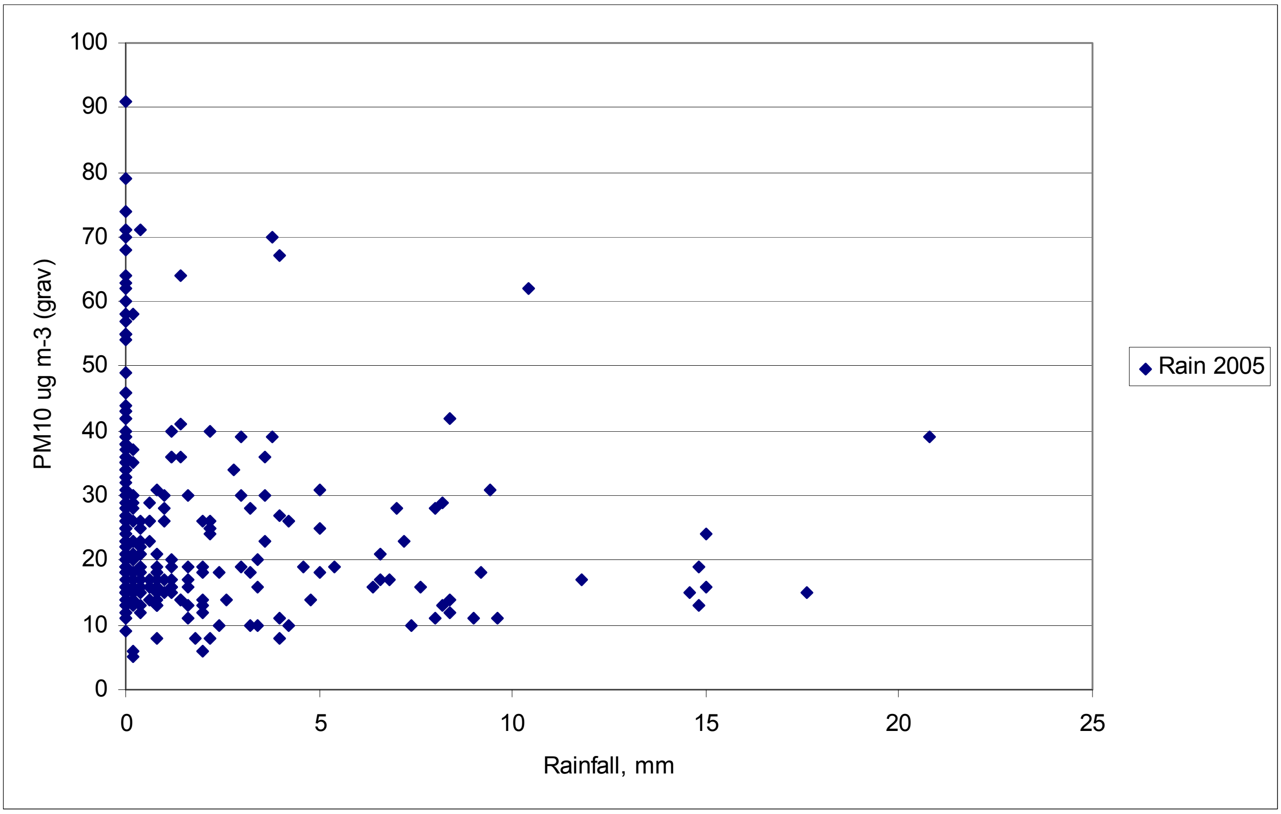

Figure A7: A scatter plot of the daily mean PM_{10} concentrations at Scunthorpe Town vs the rainfall, mm, recorded at the steelworks for 2005.

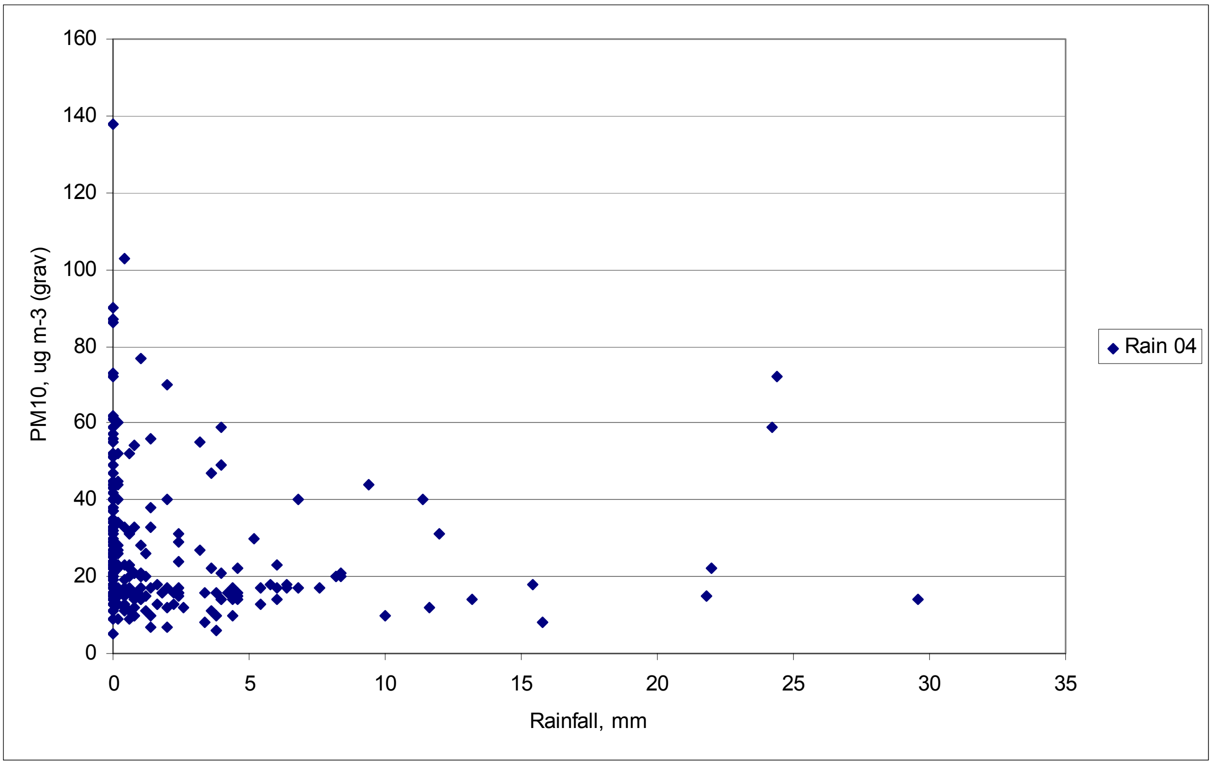

Figure A8: A scatter plot of the daily mean PM_{10} concentrations at Scunthorpe Town vs the rainfall, mm, recorded at the steelworks for 2004.

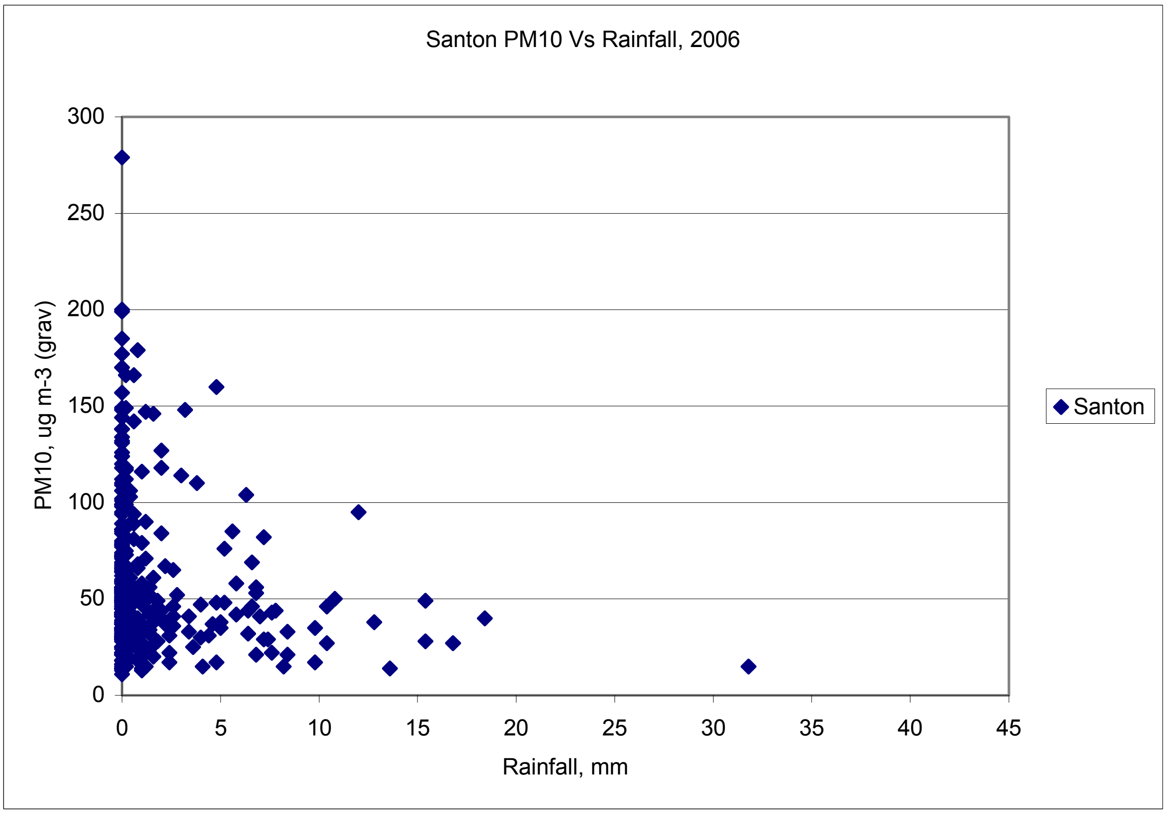

Figure A9: A scatter plot of the daily mean PM_{10} concentrations at Santon vs rainfall, mm, (recorded at the steelworks) for 2006.

X	Y	NOx 2004 ugm-3 as NO2 annual mean	NOx 2005 ugm-3 as NO2 annual mean	NOx 2010 ugm-3 as NO2 annual mean	NO2 2004 ugm-3 annual mean	NO2 2005 ugm-3 annual mean	NO2 2010 ugm-3 annual mean	PM10 2004 ugm-3 grav. annual mean	PM10 2005 ugm-3 grav. annual mean	PM10 2010 ugm-3 grav. annual mean	PM10 secondary 2004 ugm-3 grav. annual mean
490500	414500	19	18.4	15.1	15.6	15.3	11.8	19.3	19	17.7	8.34
490500	409500	41.1	41.1	35.7	25.4	25.5	23.4	31	31	31	8.34
490500	410500	42.6	42.6	37.4	26.1	26.2	24.2	31	31	31	8.34
490500	411500	40.1	40.2	35.5	25	25.1	23.4	31	31	31	8.34
490500	412500	25.7	25.1	21.1	18.6	18.4	16.8	21.2	21	19.6	8.34
491500	409500	27.7	27	22.3	19.5	19.3	17.4	30.4	29.7	28.3	8.34
491500	410500	27.9	27.4	23.1	19.6	19.4	17.7	31	30.5	29.1	8.34
491500	411500	25.6	25.2	21.4	18.6	18.4	17	28.5	27.6	26.3	8.34
491500	412500	23	22.5	18.9	17.4	17.2	15.8	20.7	20.5	19.2	8.34
492500	409500	24	23.5	19.3	17.8	17.7	16	27.5	26.7	25.4	8.34
492500	410500	23.8	23.3	19.6	17.8	17.6	16.1	27.9	27	25.7	8.34
492500	411500	22.5	22	18.7	17.2	17	15.7	27.8	26.9	25.7	8.34
492500	412500	20.6	20.2	16.9	16.3	16.1	13.3	20.4	20.1	18.9	8.34
494500	410500	18.1	17.5	14.3	15.2	14.9	11.2	19.8	19.4	18.1	8.34

Table A3: Background concentrations for the Scunthorpe AQMA and adjacent area.

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Environmental Health Division
Church Square House
PO Box 42
Scunthorpe
North Lincolnshire
DN15 6XQ

Telephone: +44 (0) 1724 297318
Fax: +44 (0) 1724 297898

Email: environmental.health@northlincs.gov.uk

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For information please call:

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Draft: April 2007
Final: April 2008 (with Final Action Plan)