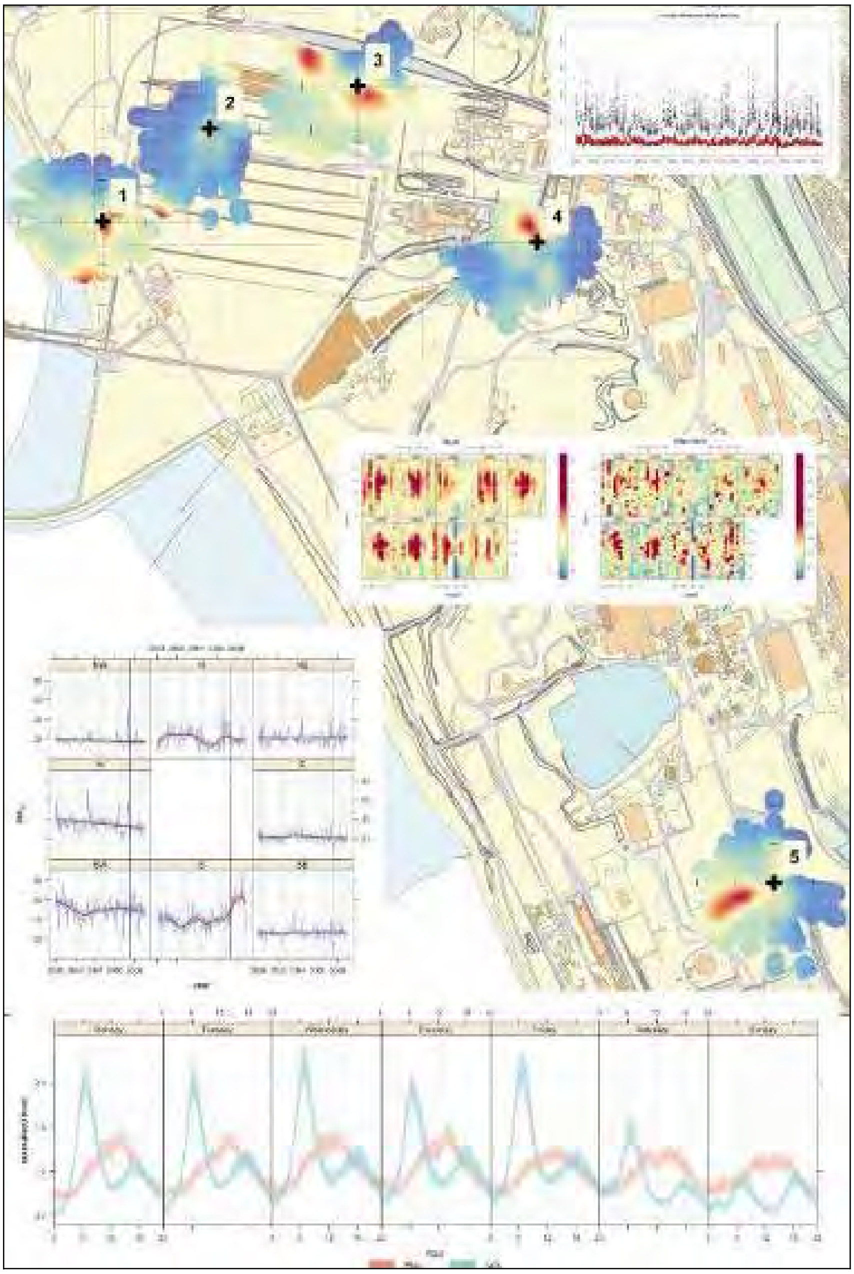
An Independent Review of Monitoring Measures Undertaken in Neath Port Talbot in Respect of Particulate Matter (PM_{10})

Contract Number RPP0001/2009



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Document Control Sheet

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i Executive Summary

The purpose of this Executive Summary is not to provide a comprehensive summation of all the observations and conclusions identified during this study but rather provide a synopsis of the main findings of this independent review. The points raised in this Executive Summary are supported by in-depth discussion and data analysis in the main document and therefore the reader should not draw any conclusions without reading the main document in detail.

The Air Quality Management Resource Centre (AQMRC), University of the West of England, Bristol (UWE) was appointed by the Welsh Assembly Government following a competitive tendering process to undertake a project entitled 'An Independent Review of Monitoring Measures Undertaken in Neath Port Talbot in Respect of Particulate Matter (PM_{10}) - Contract Number RPP0001/2009'. Within the Tender Specification prepared by the Welsh Assembly Government, clear project aims have been highlighted as follows:

- Provide an independent amalgamation and review of the monitoring, modelling, source apportionment and atmospheric particle characterisation work undertaken in respect of PM_{10} pollution in the Neath Port Talbot area since 2000;
- Draw upon the projects undertaken by, and experiences of, relevant stakeholders including Neath Port Talbot County Borough Council (NPTCBC), contracted consultants, WAG, the Environment Agency Wales (EAW), the Port Talbot Steelworks site operators and several university researchers;
- Provide advice to WAG on further measures to pinpoint sources of particulate matter within the area; and
- Assist the Welsh Minister's understanding of the issues and implementation of actions in the affected area to ensure that concentrations of PM_{10} attain the air quality standards as set out in the Air Quality Standards (Wales) Regulations 2007.

Following the Environment Act 1995 all local authorities have a statutory duty to review and assess air quality within their administrative area. NPTCBC have undertaken their review and assessment duties since the commencement of Round 1 in 1998. In Round 1 the Council identified an exceedence of the PM_{10} 24-hour air quality objective and the Taibach Margam Air Quality Management Area for PM_{10} (24-hour objective) was declared on the 1st of July 2000. Subsequently, as required by the Environment Act 1995, NPTCBC undertook a Stage 4 / Further Assessment of air quality in which their source apportionment study identified the Port Talbot Steelworks as the primary source of PM_{10} emissions. As required by the legislation NPTCBC has developed the Taibach Margam Air Quality Management Area (PM_{10}) Air Quality Action Plan (NPTCBC AQAP) in collaboration with various stakeholders including the site operators and Environment Agency Wales (EAW) and has subsequently continued with their statutory Local Air Quality Management (LAQM) duties. A synopsis of all the key conclusions and recommendations from this study are provided below and they have been categorised according to the primary objectives of the project tender specifications as outlined in Section 2.1.

Objective 1 – Independent Review of Air Quality Data & Objective 2 – PM_{10} Source Identification.

Fulfilment of Objective 1 required a comprehensive independent review of all monitoring, dispersion modelling, source apportionment and atmospheric particle characterisation work that has been undertaken to support the declaration of the Taibach Margam AQMA.

Fulfilment of Objective 2 required a detailed analysis of available data to identify sources of PM_{10} that may contribute to concentrations within the vicinity of the Taibach Margam AQMA.

This study concluded that the predominant source of PM_{10} is the steelworks with modest contributions from other sources being identified. Even with an extensive data analysis, the identification of specific sources on the Port Talbot steelworks site and the apportionment of their contribution to PM_{10} concentrations have been difficult due to the integrated and complex nature of the site and the influence of meteorology and topography on concentrations. However, detailed analysis of monitoring and meteorological data has allowed for temporal and spatial analysis to be undertaken and an examination of exceedence days to be carried out. This analysis resulted in the examination of specific trends, events, influencing factors and pollutant relationships. The conclusions of this study substantially advance the understanding of the generation, dispersion and impact of PM_{10} in the Neath Port Talbot area and will assist and inform the future development of plans and programmes for the management of PM_{10} by the site operators, EAW, NPTCBC and WAG. The key conclusions are categorised according to the headings of this report and are outlined below.

NPTCBC Review and Assessment

All reports since the inception of LAQM produced by NPTCBC have been reviewed. While some improvements could be made to the quality information included in the reports submitted (e.g. Review and Assessment Progress Reports), NPTCBC have submitted their LAQM Review and Assessment reports in accordance with the Environment Act, 1995 and each of the reports have met the minimum reporting requirements of the Technical Guidance and Policy Guidance (existing at the time the Review and Assessment report was written).

Dispersion Modelling Studies

Three major dispersion modelling studies have been carried out, each with their own inherent limitations and assumptions (e.g. limited number of sources considered, assumptions in the representativeness of the meteorological data utilised, uncertainties associated with the emission factors utilised etc). While care should be taken in drawing any conclusions from these studies, they have provided a useful insight into the area of impact associated with the steelworks.

Source Apportionment Studies

While the usefulness of the chemical speciation studies undertaken in 1998-1999 is limited today due to the significant changes in emissions patterns on the site that have resulted from subsequent mitigation measures, they did provide a good indicator of the main source of PM_{10} in Neath Port Talbot and supported the prioritisation of options in the NPTCBC AQAP.

Justification for the Taibach Margam AQMA

Upon reviewing the supporting documents utilised in the declaration of the Taibach Margam AQMA the authors concur that the decision to declare an AQMA was, and continues to be, justified.

Taibach Margam Air Quality Management Area (PM_{10}) Air Quality Action Plan (NPTCBC AQAP)

The NPTCBC AQAP appears to have been developed with ample consultation and public dialogue, and has also established a commendable NPTCBC AQAP steering group (i.e. the AQAP Team) to oversee the implementation of the NPTCBC AQAP and the continued engagement of its stakeholders. It should be noted that the NPTCBC AQAP was developed at a time when there was a limited understanding of the various sources involved and when developed the NPTCBC AQAP met the minimum requirements as outline in the then current guidance documents. However, the following observations of the NPTCBC AQAP should not be view as criticisms but rather be considered as points to note should the NPTCBC AQAP be updated:

- Only limited quantitative consideration has been given to actual reductions in PM_{10} concentrations;
- There appears to be substantial effort and resources concentrating on options not directly associated with the main source of PM_{10} emissions (i.e. the steelworks sources). Whilst these options are commendable in terms of background pollution concentrations and general public health, they may bring about minimal reductions in PM_{10} concentrations and minimum improvements towards attaining the air quality objectives;
- There is limited attribution of responsibility for meeting the agreed actions therefore specific departments should be clearly identified for the implementation of options to reduce any ambiguity in terms of accountability;

- More detailed cost-benefit analysis may assist in identifying specific funding streams to assist in the implementation of actions; and
- More consideration should be given to identifying more detailed and appropriate suite of implementation indicators for each option i.e. indicators to track the implementation of specific options.

WAG Short-Term AQAP

The WAG short-term AQAP for the South Wales Zone consultation document incorporates the issue of PM_{10} in Port Talbot and clearly outlines the framework that the Welsh Ministers have established. In the short-term AQAP, WAG has a document which may be amended and utilised to create a ‘future’ AQAP document for the South Wales Zone. The ‘future’ AQAP may benefit from broadening the scope to include the consideration of air quality in future policy development to ensure continued compliance with the air quality objectives and improvements in local air quality in future years.

EAW PM_{10} Permit Review

The EAW PM_{10} Permit Review is a comprehensive document which provides detailed analysis of PM_{10} permitting, data analysis and supporting information pertinent to the Port Talbot steelworks. This document illustrates the complexity of regulating this site due to the geographical fragmentation of activities, operators and contractors around the site and the sharing of regulatory responsibility between EAW and NPTCBC. There is limited quantification of fugitive emissions of PM_{10} around the site and ultimately any impact of improvements on PM_{10} concentrations are difficult to determine.

NPTCBC Corus Permit Review

The NPTCBC Corus Permit Review considers the permitting of Civil & Marine Limited and Tarmac Western Limited. The review concludes that environmental and regulatory benefits may be gained by the transfer of the Part B Tarmac Western Limited process to EAW regulation.

Monitoring Data Analysis

The following bullet points summarise the key conclusions drawn by the authors from the analysis undertaken using Openair software package of the monitoring data supplied by the AURN, EAW and the site operators.

- The predominant sources of PM_{10} are not in immediate proximity to the monitoring locations (evidenced by negligible impact at low windspeeds).
- The relationship of elevated concentrations with higher windspeeds suggests that sources may include both/either stacks (where turbulence

results in the grounding of plumes) or dust (where wind is able to resuspend it).

- PM_{10} concentrations are dominated by sources to the SW of the AURN stations, indicating sources on the steelworks site as the most likely cause of elevated PM_{10} concentrations in the area.
- There are strong correlations between the direction of the main PM_{10} sources, and sources of CO and SO_2. However, temporal analyses indicate that not all PM_{10} events are related to elevated concentrations of these combustion pollutants. This suggests that PM_{10} events may be being caused by either combustion sources, or dust sources or a combination of the two.
- In some cases, elevated PM_{10} is related to CO but not SO_2. There appears to be an almost inverse relationship between these pollutants at high concentrations, suggesting more than one possible combustion related source, and potentially a ‘heat’ rather than a combustion source leading to the high CO concentrations.
- Average concentrations of CO and SO_2 show similar fluctuations over time to PM_{10} at the AURN sites, particularly the increase in concentrations from the southern sector when the location moved to the Fire Station site.
- Neither NOx or Ozone concentrations appear to be associated with the steelworks site.
- $PM_{2.5}$ at the Fire Station AURN monitor and the EAW Taibach 2007 campaign indicate that $PM_{2.5}$ tends to be dominated by sources to the north-east, probably traffic and potentially the motorway. The EAW monitoring at the Corus Sports and Social Club indicated that $PM_{2.5}$ was dominated by sources to the north east, potentially the main A48 through Margam, or the northerly parts of the steelwork site.
- PM_{10} pollution related to the steelworks site generally follows a distinctive diurnal profile, with concentrations beginning to rise at around 6am, and continuing to rise until about noon. They then level out and then begin to drop sharply from around 4pm. This pattern may result from daytime activities, on-site resuspended dust and/or increased daytime insolation leading to increased plume grounding due to convective turbulence.
- $PM_{2.5}$ follows a different diurnal profile to PM_{10} which much more closely matches that which would be expected from road sources (e.g. dual peaks matching peak traffic hours).
- The dominance of the PM_{coarse} fraction in the PM_{10} monitored from the area of the steelworks tends to suggest dust (mechanically generated) particles rather than combustion source particles as the major problem. However, if CO is coming from a heat or other non-conventional combustion source then this might also lead to non-dust coarse fraction particles.

- Average concentrations of PM_{10} associated with the steelworks site have reduced over time, however, the frequency and magnitude of peak hourly concentrations does not appear to have reduced markedly.
- Directional analysis of the monitoring data has identified the following as the most likely potential source 'activities' on the steelworks site contributing to elevated PM_{10} concentrations at the AURN and EAW monitoring sites:
    - *Cambrian Stone granulation (based on AURN and Taibach07 monitoring data)
    - *Metal plating pits (based on AURN and Taibach07 monitoring data)
    - Furnace slag pits (based on AURN and Taibach07 monitoring data)
    - Multiserv briquetting (based on AURN and Taibach07 monitoring data)
    - Multiserv steel slag solidification/demetalling/cutting (based on AURN and Corus S&S monitoring data)
    - Multiserv scarfing activities (based on Corus S&S monitoring data only)
    - Hot and cold mills (based on Corus S&S monitoring data only)
    - Steel plant (based on Corus S&S monitoring data only)
    - Demetalled BOS slag storage (based on Corus S&S monitoring data only)
    - Furnace slag storage and crushing (based on Corus S&S monitoring data only)

    * Indicates these sources are the most likely ones identified by the triangulation of polar plots.
- The directional analyses suggest that the blast furnaces and sinter plant stack are unlikely to be significantly contributing to concentrations at the monitors.
- The Corus on-site Topas monitoring data indicate that there is a wide-range of particle sources on the steelworks site. The strongest of these is located to the NE of the GCI monitoring station. The next most significant source appears to be wind-raised dust in the blending plant. The various particle sources tend to vary considerably with regard to the size of particles they relate to.
- Diurnal variations at the Hospital site indicate that concentrations from the south followed a slightly different profile to concentrations from the west, rising more suddenly at 6am rather than showing a gradual increase across the morning.

- There appears to be a strong seasonal influence on the occurrence of elevated PM_{10} concentrations, with far more events in the 2^{nd} quarter of the year, followed by the 1^{st} and 3^{rd}.
- Pollution events take a wide range of forms, with some exceedences of the daily mean objective being caused by a single very high hourly peak, others due to prolonged concentrations just above the objective concentration. The wide range of events between these two extremes suggests that exceedences may be being caused by a range of sources and conditions.
- There are indications that pollution events are often being caused by a difference in magnitude of concentrations coming from regular sources, rather than due to 'unusual' events.
- There is no clear evidence to suggest that the Fire Station AURN site is located in a significantly less polluted area than the Hospital site. Any description of it as a less polluted area would have to rely on very specific definitions of 'polluted'. In the short length of time that the AURN monitor has been operating there, although average PM_{10} concentrations have been lower than at the Hospital site and hourly and daily mean exceedences of the objective concentration have been less frequent, when pollution events have occurred they appear to have resulted in higher concentrations of PM_{10}, CO and SO_2. Evidence from comparisons of the AURN data with the EAW monitoring in the Taibach 2007 campaign suggest that where lower concentrations or fewer exceedences of PM_{10} are being recorded at the Fire Station AURN, then these are more likely to be caused by micro-scale siting issues of the monitor (i.e. differences in concentration caused by local flow patterns, caused by obstacles such as the railway embankment or the nearby trees) than by its general location in the AQMA. It is important to note that the monitoring method used at the AURN changed in February 2007 shortly before the relocation of the AURN site. The new method (TEOM FDMS) will tend to record lower concentrations than the previous method using a conventional TEOM multiplied by a factor of 1.3.

Objective 3 – Future Studies

Fulfilment of this objective necessitates advice to WAG and other project stakeholders on further studies that may be undertaken to pinpoint exact sources of particulate matter in the area, improve their understanding of PM_{10} from the steelwork site and assist in the management of PM_{10} in the future. The following recommendations are suggested:

- **Recommendation 1 – Better use of data available in NPTCBC Review and Assessment reports**: WAG should encourage NPTCBC to make better use of the data available to the authority in future Review and

Assessment Reports, in particular Progress Reports, and this information could be could be reported in a more integrated format.

- **Recommendation 2 – Generation of an emissions database and undertaking a new dispersion modelling study**: Advances in dispersion modelling software, improvements in the understanding and quantification of the sources in the Neath Port Talbot area and improvements in the understanding of particulate science may result in a more accurate assessment of PM_{10} should a new dispersion modelling study be undertaken. The scope and structure of any new dispersion modelling study should be clearly established though continued engagement with the various stakeholders and there may be some benefit in creating a dispersion modelling steering group to oversee this work. However, any new dispersion modelling study would also have inherent uncertainties and assumptions particularly in the estimation of emissions from stockpiles and other fugitive sources, therefore, the generation of an emissions database to collate input data for any dispersion modelling study would be a logical initial step. Additionally, any dispersion modelling study should follow all relevant guidance, in particular in relation to model verification, and should be fully transparent with regards to any assumptions, all input data utilised and any adjustments made to the model output (the expansion of the monitoring network in the vicinity should assisting substantially with model verification). Undertaking a new dispersion modelling study, particularly in conjunction with any future monitoring data analysis, may assist in providing a better understanding of the contribution of specific sources on the steelworks site, may allow more detailed consideration of the cumulative impact of future sources on local PM_{10} concentrations and may allow for a comprehensive assessment of the point of maximum impact to determine the appropriate siting of monitoring equipment. A new study may also assist with the updating of NPTCBC AQAP and the development of a WAG 'future' AQAP. It is vital that any new modelling study is based on a thorough analysis and quantification of all potential on-site fugitive dust sources and any other PM_{10} emissions. This in itself will play a vital role in further analysis of monitoring data. The feasibility of the generation of an emissions database and a full and comprehensive dispersion modelling study of existing and future PM_{10} sources should be investigated by WAG.

- **Recommendation 3 – Undertaking new chemical analysis of particulates in the area**: While the original studies of particulates in 1998-1999 provide a good indication of the main source of PM_{10} in Neath Port Talbot (i.e. the steelworks), they are now quite dated and advances in particulate speciation methodologies, improvements in the understanding of the sources involved and improvements in our understanding of particulate science since this study has been undertaken may result in a more accurate composition analysis of particles. Especially considering the significant range of changes that have occurred on the steelworks site that may have changed the balance of particulate composition, it is therefore recommended that consideration be given to carrying out a programme of particle speciation studies to be undertaken concurrently with local monitoring. To accompany the future chemical analyses of filters at ambient monitoring stations, it may also be useful to undertake compositional analysis of emissions from a wide range of processes on the site in order assist in ‘fingerprinting’ of individual activities on the site (also see Recommendation 7(m) below).

- **Recommendation 4 – Updating NPTCBC AQAP**: The NPTCBC AQAP is now a dated document and while most of the options identified in the NPTCBC AQAP have either been implemented or are ongoing, the understanding of PM_{10} sources in the vicinity has advanced substantially. It is recommended that WAG engage with the NPTCBC Air Quality Action Plan Team to investigate the possibility of the NPTCBC AQAP being updated in light of the advanced information contained in reports such as the EAW PM_{10} Permit Review and this review document. Additionally, this update should also act upon any updated national guidance and the feedback received from the consultants employed by WAG who have formally appraised the original NPTCBC AQAP and subsequent NPTCBC AQAP-PR. In updating the NPTCBC AQAP, an important step would be attempting to quantify the reductions in emissions which should have occurred as a result of the measures being put in place.
- **Recommendation 5 – Utilising the WAG Short-Term AQAP**: It is recommended that WAG incorporate the findings of this independent review into the utilisation of their short-term AQAP for the South Wales Zone to generate a ‘future’ AQAP. Additionally, WAG should ensure that their ‘future’ AQAP is a dynamic and evolving document so that the findings from any future studies recommended from this review can be incorporated.
- **Recommendation 6 – Further information on agreed course of actions following the EAW PM_{10} Permit Review and NPTCBC Corus Permit Review**: Following on from these Permit Reviews and subsequent discussions with the various stakeholders, WAG may wish to request a summary document outlining the agreed course of actions i.e. which of the recommendations are being taken forward or conversely which recommendations are not being taken forward and the reasons for this from both the EAW and NPTCBC. Additionally, it may be useful to have a full and concise list collated of all known (or potential) sources of PM_{10} on the steelworks site (See Recommendation 2). The EAW and the site operators may be best placed to identify and collate this information.
- **Recommendation 7 – Additional analysis of data**: Following the extensive data analysis undertaken as part of this review, WAG should explore the possibility of undertaking the following actions with their project stakeholders:

- **Recommendation 7(a) - Official feedback from WAG, EAW, site operators and NPTCBC on analysis undertaken as part of this study:** WAG, EAW, NPTCBC and the site operators should provide official technical commentaries on the analyses presented in this report to determine whether they can provide any suggestions as to the cause of any of the pollution patterns identified (e.g. known sources of CO and SO_2).
- **Recommendation 7(b) - Creation of a regularly updated database containing all locally collected monitoring data available for interrogation by all stakeholders.** The wide range of analyses presented here indicate that there is no simple and straight-forward way in which data can be presented. What is important is that a verified, common dataset is available to all parties, and that common tools are used to analyse this. Openair has a significant advantage over spreadsheet based tools in the reproducibility of graphs and plots as it is command line driven. This allows the analyses carried out on data to be recorded so that they can be verified by all interested parties, and re-run with different parameters if necessary. With the large increase in available data that is occurring, it is not the standardisation of final output that is important, but the standardisation of the base data and the methods for its analysis.
- **Recommendation 7(c) – Use of tools such as Openair in a 'live' setting:** Rather than trying to summarise the complexities of the problem using a number of plots and tables in a written report, tools like Openair should increasingly be used in a 'live' setting with local regulators and process operators so that they can ask specific questions of the data and interactively drive the analyses.
- **Recommendation 7(d) – Comparative analysis of on-site and off-site monitoring:** Results from on-site monitoring need to be analysed in the context of off-site monitoring in order to identify pollution patterns during off-site pollution events and identify any events that may be unconnected to the steelworks emission sources. .
- **Recommendation 7(e) – Further analysis of hourly PM_{10} concentrations on individual exceedences days needs to be undertaken**: This should include correlating them with other pollutants and meteorological conditions (including windspeed and rainfall). A categorisation system for Exceedence Days needs to be developed, potentially based on diurnal profiles and number of Hours>50, and subsequent analysis of individual Exceedence Days. This can then be used as a framework in which to manage some of the specific analyses set out below.

- **Recommendation 7(f) – The relationship between Hours>50 and exceedences of the Daily Mean objective should be investigated.**
- **Recommendation 7(g) – Statistical analyses such as Principal Components Analysis or Cluster Analysis may be used for creating a typology of exceedences.**
- **Recommendation 7(h) – Further analysis of the seasonal variations in pollution** should be carried out, particularly with regard to any potential changes in source activities.
- **Recommendation 7(i) – Correlations between PM_{10} patterns and activities on the steelworks site (including daily and weekly shift patterns) should be identified.**
- **Recommendation 7(j) – Closer analysis of the occurrence of Hours>50 needs to be undertaken**, particularly with regard to how concentrations of PM_{10} and other pollutants for these hours correlate with wind speed and direction as monitored at a number of the monitoring sites. Further in-depth analysis of the relationship of meteorological parameters and exceedences of Hours>50 may allow weather forecasts to be utilised, leading to alerts and stricter control of activities on-site. There have been examples, such as sources of SO_2 in the Avonmouth industrial area, where such strategies have been trialled.
- **Recommendation 7(k) – The activities identified through the directional analyses should all be analysed for emission patterns** – particularly with regard to what pollutants they emit and any diurnal, or other temporal patterns of emissions.
- **Recommendation 7(l) – Analysis of Meteorological data:** The main analyses in the report have been undertaken using the local wind data from each pollution monitoring site as it is judged to be more representative of wind direction at both the monitoring sites and the steelworks. However, where further analysis (such as chemical analysis of filters, or correlation of PM_{10} with CO or SO_2) indicates that the likely source related to a *particular* pollution event is an elevated stack, then consideration should be given to incorporating the met data from the Mumbles site as it may be more indicative of wind conditions at height. For all other analyses the met data used should primarily be from the relevant pollution monitoring station as this is liable to be the most indicative of the direction of airflow arriving at the monitor inlet as it is likely to be more representative of ground-level wind flow on the eastern side of the bay than the Mumbles data. Further work in terms of mapping wind-fields in the area may prove useful, particularly around the steelworks site itself due to complex flow patterns caused by building structures and heat sources on the steelworks

site, and the general coastal location close to the large hills to the east.

- **Recommendation 7(m) – There is a need to carry out a new chemical analysis study** in order to be able to help differentiate between those events caused by high windspeeds (i.e. plume grounding due to wind driven turbulence and wind-raised dust) as well as between those that might be associated with dust from daytime activity on the site and plume grounding due to convective turbulence. This could also be used to help determine the influence of sources not related to the steelworks site, such as road traffic, sea-salt and secondary particles. In this study, it might also be useful to try and analyse occasional filters from sites such as Swansea and Narberth, or from other local monitoring sites, in order to verify the constituents of roadside and regional PM_{10}, rather than relying on generalised evidence or previous studies.
- **Recommendation 7(n) – Continued stakeholder engagement:** The recommendations generated in this study are not a definitive list and WAG may identify further opportunities and studies through the findings of future work and continued stakeholder engagement.

ii Table of Contents

iii List of Figures

iv List of Tables

v Glossary of Terms

Abbreviation	Definition
$\mu g/m^3$	Micrograms per cubic metre
µm	Micrometres
ACCU	Automatic Cartridge Collection Units
ADMS	Atmospheric Dispersion Modelling Software
AQAP	Air Quality Action Plan
AQAP-PR	Air Quality Action Plan Progress Report
AQEG	Air Quality Expert Group
AQMA	Air Quality Management Area
AQMRC	Air Quality Management Resource Centre
AURN	Automatic Urban and Rural Network
BADC	British Atmospheric Data Centre
BOS	Basic Oxygen Steelmaking
CERC	Cambridge Environmental Research Consultants
CO	Carbon monoxide
DA	Detailed Assessment
Defra	Department for Environment Food and Rural Affairs
EAW	Environment Agency Wales
FA	Further Assessment
FDMS	Filter Dynamics Measurement System
GIS	Geographic Information System
IPPC	Integrated Pollution Prevention and Control
Kish	Plates of carbon that come out of solution as steel cools

LAQM	Local Air Quality Management
LAQM.PG(09)(W)	Local Air Quality Management Policy Guidance (Wales)
LAQM.TG(09)	Local Air Quality Management Technical Guidance
MIDAS	Met Office Integrated Data Archive System
mg/m^3	Milligrams per cubic metre
m/s	Metres per second
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen
NPTCBC	Neath Port Talbot County Borough Council
O_3	Ozone
PM_{10}	Particulate matter which passes through a size selective inlet with a 50% efficiency cut-off at 10 μm aerodynamic diameter
$PM_{2.5}$	Particulate matter which passes through a size selective inlet with a 50% efficiency cut-off at 2.5 μm aerodynamic diameter
PM_{COARSE}	Fraction of measured particle mass concentration determined from PM_{10} minus $PM_{2.5}$
PM_{LOCAL}	Fraction of measured particle mass concentration determined from local PM_{10} minus background PM_{10}
PT-RAPS	Port Talbot Residents Against Power Stations
R&A-PR	Review and Assessment Progress Report
SO_2	Sulphur dioxide
TEOM	Tapered Element Oscillating Microbalance
TOPAS	Turnkey Optical Particle Analysis System
UK	United Kingdom
USA	Updating and Screening Assessment
UWE	University of the West of England, Bristol

VCM	Volatile Correction Method
WAG	Welsh Assembly Government

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viii Important Notes

There is an abundance of data and publications related to PM_{10} in the UK and PM_{10} in the vicinity of steelworks worldwide. The omission of any publication, documentation or dataset from this review is not to suggest that it is not relevant to air quality in the Neath Port Talbot area, however, in some instances the authors may have had to prioritise the review of one document or dataset over another. Following the project boundaries of this study (i.e. tender specifications, time restrictions and budget) the majority of documentation reviewed and data analysed relates specifically to air quality management and PM_{10} in the Neath Port Talbot area.

Any data analysis undertaken has started from a 'blind' analysis standpoint i.e. any replication of other analysis undertaken is not deliberate, nor have previous analyses been replicated, and the conclusions that have been derived in this study are on the basis of our analysis only. We have not commented on any data analysis which has previously been undertaken by any other parties.

1 Introduction to the Project

The Air Quality Management Resource Centre (AQMRC), University of the West of England, Bristol (UWE) was appointed by the Welsh Assembly Government following a competitive tendering process to undertake a project entitled 'An Independent Review of Monitoring Measures Undertaken in Neath Port Talbot in Respect of Particulate Matter (PM_{10}) - Contract Number RPP0001/2009'.

AQMRC, UWE is one of the leading organisations for the study and resolution of air quality management problems in the UK. AQMRC, UWE has a long standing history of working with a large number of local, national and international collaborators, including: the Welsh Assembly Government (WAG), Defra, Scottish Government; Department of Environment, Northern Ireland; Greater London Authority; numerous local authorities in the UK, the Environment Agency for England and Wales, environmental consultancies, other research establishments and a range of international partners. The UWE Project Team for this study include Dr Enda Hayes, Dr Tim Chatterton and Professor Jim Longhurst from UWE. In addition, the extensive experience of Professor Jimi Irwin, former Head of Risk and Forecasting at the Environment Agency and visiting professor at UWE was utilised.

Within the Tender Specification prepared by the Welsh Assembly Government, clear project aims have been highlighted as follows:

- Provide an independent amalgamation and review of the monitoring, modelling, source apportionment and atmospheric particle characterisation work undertaken in respect of PM_{10} pollution in the Neath Port Talbot area since 2000;
- Draw upon the projects undertaken by, and experiences of, relevant stakeholders including Neath Port Talbot County Borough Council, contracted consultants, the WAG, the Environment Agency Wales (EAW), the site operators and several university researchers;
- Provide advice to the WAG on further measures to pinpoint sources of particulate matter within the area; and
- Assist the Welsh Minister's further understanding of the issues and implementation of actions in the affected area to ensure that concentrations of PM_{10} attain the air quality standards as set out in the Air Quality Standards (Wales) Regulations 2007.

2 Policy Background and Project Objectives

The Environment Act 1995, places obligations on all local authorities to undertake periodic reviews and assessments of air quality in their areas. These reviews and assessments form the cornerstone of the system of Local Air Quality Management (LAQM). The LAQM regime plays a key role in assisting Government and the Devolved Administrations to achieve the air quality objectives as defined within the Air Quality Strategy for England, Scotland, Wales and Northern Ireland, the Air Quality Regulations pertaining to each area of the devolved United Kingdom and their subsequent Amendments. It also assists the Government and the Devolved Administrations towards achieving the Air Quality Limit Values as set out within the European Union Directives.

The Review and Assessment process is a phased risk management process, with the level of detail required being commensurate with a judgement by a local authority of the level of risk of exceeding the objectives specified in the Air Quality Regulations. Should a risk of exceeding an air quality objective be identified and the public be shown to be exposed for a time period exceeding that specified in the Regulations then a local authority must declare an Air Quality Management Area (AQMA). The local authority is then required to prepare an Air Quality Action Plan (AQAP) specifying the measures that they intend to implement and the likely timescale in which these measures might reduce pollutant concentrations and/or exposure, in pursuit of achieving the objectives. The local authority is also obliged to undertake a Further Assessment (FA) in order to supplement and confirm the conclusions of the Detailed Assessment (DA), and to provide additional information that will assist in the preparation of the AQAP. All authorities are also required to provide regular Progress Reports (R&A-PR and AQAP-PR) to ensure continuity in the LAQM process and, where applicable, to advise on progress with measures identified in the AQAP. All of this work must be undertaken with regard to statutory guidance issued under the Environment Act 1995 which includes Policy Guidance and Technical Guidance.

2.1 Tender Specification

The Tender Specification for this project sets out a number of project objectives. These objectives have been categorised as follows to ensure that this report directly addresses all project objectives and provides deliverables that adhere to the aims of the project.

2.1.1 Objective 1 - Independent Review of Air Quality Data

This objective includes a comprehensive independent review of all monitoring, dispersion modelling, source apportionment and atmospheric particle characterisation work that has been undertaken to support the declaration of the Taibach Margam AQMA and any subsequent research. This should include (but is not limited to):

- A review of all monitoring undertaken within the vicinity of Taibach Margam AQMA including site descriptions, QA/QC, uncertainties, technical/practical issues, trends etc.
- A review of all dispersion modelling undertaken, including model inputs, model parameters, verification (and adjustment) of model outputs and an investigation of all modelling assumptions and uncertainties etc.;
- Consideration of all source apportionment and atmospheric particle characterisation studies that have been undertaken;
- Detailed consideration and suggestions for the cause of any data anomalies; and
- Consideration of any climatic, meteorological and topographical influences on local air quality.

2.1.2 Objective 2 – PM_{10} Source Identification

The historically available data will be scrutinised to identify and understand sources of PM_{10} that may contribute to concentrations within the vicinity of the Taibach Margam AQMA and, where possible, quantified. This should include (but not be limited to):

- Anthropogenic activities: Industrial, transport, domestic etc.;
- Regional and transboundary pollution; and
- Natural sources.

2.1.3 Objective 3 - Future Studies

Provide advice to WAG and other project stakeholders on further studies that may be undertaken to pinpoint exact sources of particulate matter in the area.

3. Project Deliverables

Following the award of this project to UWE and a subsequent project initiation meeting on 6th February 2009, the following project deliverables were identified and agreed upon.

3.1 Contract Execution Plan

As outlined in the Tender Specifications a Contract Execution Plan was submitted following the project commencement. This Contract Execution Plan set out the initial methodologies followed by UWE in undertaking this project. However, due to difficulties in obtaining relevant data and additional tasks identified during the data analysis phase of the project, the timeline specified in this Contract Execution Plan was altered. This document was delivered to the Welsh Assembly Government on the 18th February 2009.

3.2 Final Project Report (Technical and Non-Technical)

The Project Team will provide a draft project report (in English) as outlined in the Tender Specifications. A final project report will be submitted shortly afterwards at an agreed timescale with WAG. In addition, a brief non-technical report will be provided with the final document to assist the Welsh Minister's and/or other non-technical parties in understanding the various issues and recommendations. As the final project report will be a detailed technical document, translation into Welsh to comply with the Welsh Language Scheme may be difficult. It may be more appropriate for the non-technical document only to be translated into Welsh. Following discussions at the project initiation meeting WAG will be responsible for the translation of any aspects of this project into Welsh.

3.3 Electronic Data Resource

Upon completion of this project, UWE will provide the Welsh Assembly Government with an electronic file of all data, reports and additional resources utilised in the fulfilment of the project requirements. It is envisaged that this catalogue of information will act as a central resource which may be added to in the future by WAG and may assist them with any additional work in this area.

4. Introduction to PM_{10}

Fine particles include PM_{10}, $PM_{2.5}$ and PM_1. They are composed of a wide range of materials arising from a number of potential sources including:

- Combustion sources such as road traffic or industrial processes;
- Secondary particles, mainly sulphate and nitrate formed by chemical reactions in the atmosphere; and
- 'Coarse' particles such as suspended soils and dusts, sea salt, biological particles and construction particles.

Most of the monitoring in the UK focuses on the PM_{10} fraction although there is a growing interest in the finer fractions of $PM_{2.5}$ and PM_1 in terms of the potential for these fractions to have a greater impact on health. Particles can be carried deep into the lungs where they may cause an inflammatory response and a worsening of the condition of people with pre-existing heart and lung diseases.

The Air Quality Standards (Wales) Regulations 2007 specifies the PM_{10} air quality standards in Wales as:

- an annual mean concentration of 40 $\mu g/m^3$; and
- a 24-hour (daily) mean concentration of 50 $\mu g/m^3$ not to be exceeded more than 35 time per annum.

A detailed introduction to particulate matter can be found in Particulate Matter in the United Kingdom (AQEG, 2004).

5. Introduction to Neath Port Talbot

The County Borough of Neath Port Talbot covers an area of 44,217 hectares. Rising from sea level in the west to 600 metres at Craig Y Llyn, above Glynneath, Neath Port Talbot is predominantly an upland area dissected by the valleys of the Afan, Neath, Dulais and Tawe rivers which all flow to the sea in Swansea Bay. These valleys are separated from each other by ridges of high forest or moorland. A narrow coastal strip extends around Swansea Bay where the main centres of population are found. The surrounding valleys are rural in aspect with scattered communities, many of which still contain significant numbers of Welsh speakers.

The County Borough has a population of 134,400 (Revised 2001 Census) and contains 66,585 dwellings (Digest of Welsh Local Area Statistics 2001). While over recent decades the overall population trend has been of gradual decline, the 2002 and 2003 Mid Year Estimates (MYEs) showed an increase of 900 people. The 2001 Census confirmed that the population of the County Borough reflects the consequences of decades of population loss with an ageing population which also has high levels of long term ill health and low levels of economic activity and access to private transport. The County Borough is served by the M4 motorway with the A465 “Heads of the Valleys” road providing links to the M50, M5 and M6. The Intercity Rail service includes mainline stations in Neath and Port Talbot.

The area has a strong manufacturing base. The steel industry remains by far the largest industrial employer in the County Borough with around 3,000 employed directly at the Port Talbot works although contraction of the labour force has affected employment, contractors and suppliers. Coal mining is still important in the valley communities where small mines, opencast sites and coal processing/washeries provide valuable local jobs. (NPTCBC, Updating and Screening Assessment)

6. Local Air Quality Management - Review and Assessment

Following the Environment Act 1995 all local authorities have a statutory duty to review and assess air quality within their administrative area. Neath Port Talbot County Borough Council (NPTCBC) have undertaken their review and assessment duties since the commencement of Round 1 in 1998. In Round 1 the Council identified an exceedence of the PM_{10} 24-hour air quality objective and the Taibach Margam Air Quality Management Area for PM_{10} (24-hour objective) was declared on the 1st of July 2000 (Figure 1). Subsequently, as required by the Environment Act 1995, NPTCBC undertook a Stage 4 / Further Assessment of air quality in which their source apportionment study identified the Port Talbot Steelworks site as the primary source of PM_{10} emissions. As required by the legislation NPTCBC has developed an AQAP in collaboration with various stakeholders including The site operators and EAW and has subsequently continued with their statutory LAQM duties.

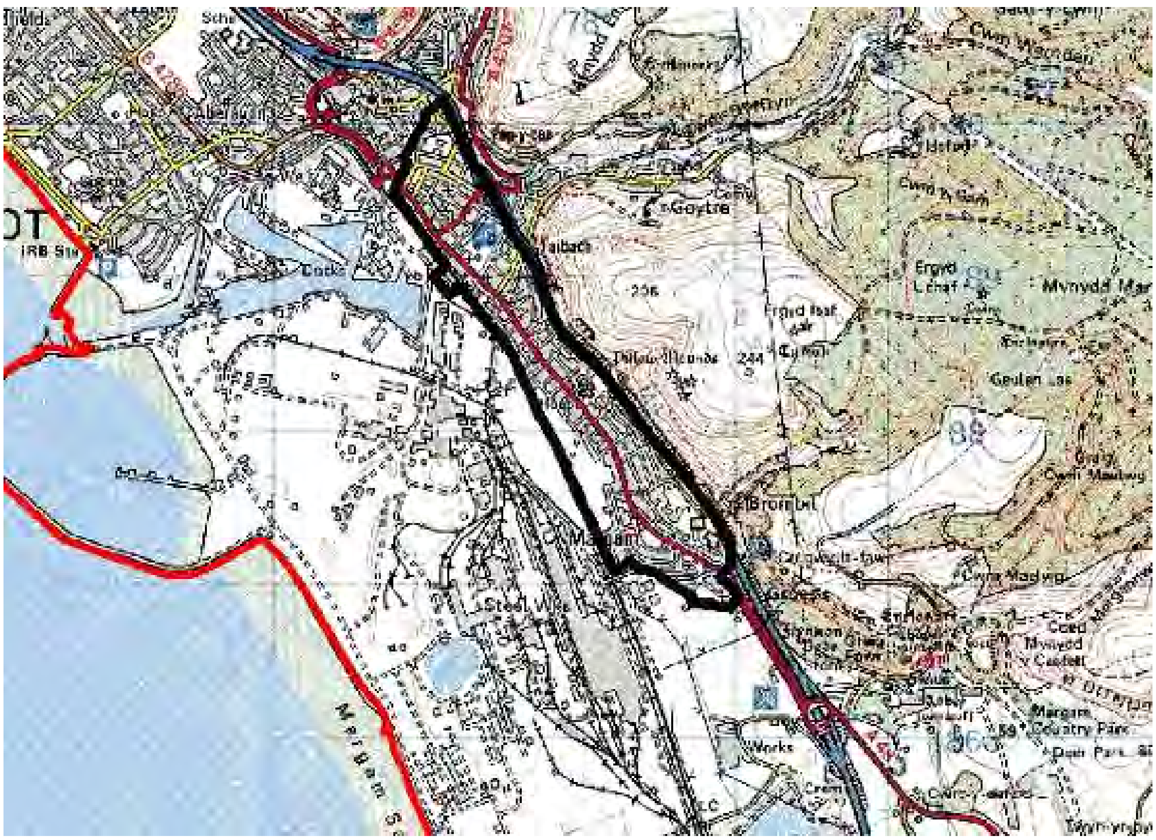


Figure 1: NPTCBC Air Quality Management Area

The following section reviews and summarises the Review and Assessment Reports that have been submitted by NPTCBC since 1998. When reviewing these reports the following considerations were given:

- Defra and the Devolved Administrations have published Technical Guidance for local authorities to assist them in undertaking their LAQM duties. The Technical Guidance was first issued as LAQM.TG4(98) and has formally been updated three times as LAQM.TG4(00), LAQM.TG(03) and most recently LAQM.TG(09). In addition, supporting information in the form of Frequently Asked Questions, additional guidance documents, support tools etc. have been, and are constantly, developed and updated. This consideration of NPTCBC's Review and Assessment documents has considered the Technical Guidance that NPTCBC would have followed at the time of writing their reports.

- There are seven air quality pollutants of concern that local authorities are required to report upon when undertaking their Review and Assessment, this report will only consider the PM_{10} elements. NPTCBC has identified no problems with any of the other pollutants.

- No consideration is given to the monitoring data presented in these reports as this data is examined in substantial detail in subsequent sections of this report (Sections 10-15).

Figure 2 below provides an illustration of the LAQM reporting timeline followed by NPTCBC since the inception of LAQM.

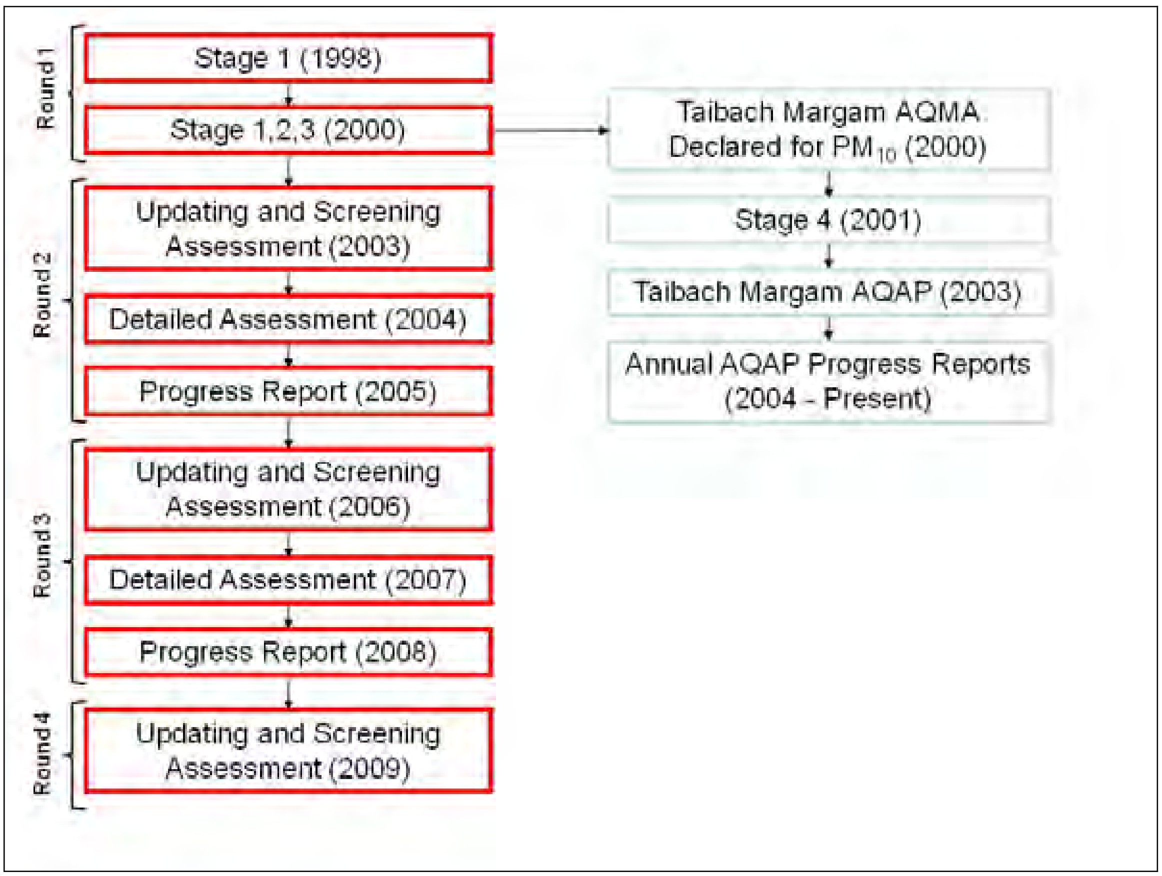


Figure 2: NPTCBC LAQM Report Submissions

6.1 Introduction to Round 1 of Review and Assessment

Local authorities in Great Britain began the process of Review and Assessment in 1998. The first round of the process concluded in 2001 and resulted in some 129 local authorities declaring one or more AQMAs. During Round 1, a three-stage approach was recommended, whereby each stage of the Review and Assessment process increased in depth and complexity.

Stage 1 of the process was a compilation of emissions data from various sources (transport, industrial and other significant sources) and background concentrations of the seven relevant pollutants. Each authority had to identify sources in their authority area, having regard to those of their neighbouring authorities.

On completion of this initial stage, pollutants could be omitted from the process where there was little likelihood of the air quality objectives being breached by the relevant target date. Stage 2 of the review and assessment process was a more sophisticated screening phase, using simple screening models and any local air quality monitoring data available. Pollutants were once again omitted from the process where on the basis of the more detailed examination they were judged unlikely to exceed the air quality objective by their target date.

Stage 3 and the final stage was a more complex study of the locations and pollutants identified by the earlier stages. This often required more advanced monitoring and air pollution dispersion modelling for predicting specific locations of future pollutant exceedences.

6.1.1 Stage 1,2,3 Review and Assessment

In May 1998, NPTCBC submitted an initial proposal outlining the Council's plan for undertaking Review and Assessment (R&A Reference DRA1-036). This report concluded that the first phase study on the Port Talbot area of the Borough indicated that the PM_{10} standard was regularly breached. Concentrations were at their highest when the wind direction was from west-south-west of the Groeswen Hospital monitoring site. The report proposed that monitoring would continue at Groeswen Hospital and efforts made to apportion the relative contribution of sources from different wind directions.

In February 2000, NPTCBC submitted a combined Stage1,2,3 Review and Assessment report (R&A Reference RA123-355). Stage 1 and Stage 2 of this assessment concluded that roads, domestic solid fuel use, landfill and Part B processes were not of concern. However, a third stage review would be required for Part A processes in the vicinity of the Groeswen Hospital AURN site. The Stage 3 assessment consisted of the consideration of monitoring data, ADMS-Urban dispersion modelling studies of traffic and industrial sources to predict PM_{10} concentrations in 2005, and source apportionment studies utilising pollution wind roses and Automatic Cartridge Collection Units (ACCU) filters. The Stage 3 report concluded that an Air Quality Management Area would be required.

6.1.1.1 Air Quality Modelling – First Phase Air Quality Review and Assessment

The atmospheric dispersion modelling study in the Stage 1,2,3 report was undertaken by Cambridge Environmental Research Consultants (CERC) on behalf of NPTCBC. The model utilised was ADMS-Urban. Meteorological data were taken from Rhoose (Cardiff airport) and also from a local weather station (it was not specified where this station was located). The dispersion modelling output was compared with continuous monitoring and contour plots were generated where possible. The study concluded:

- The complex terrain affects both the direction and height of the plume relative to the ground.
- The model significantly under-estimated PM_{10} concentrations suggesting inaccuracies in the emission rates and/or that some sources had not been considered or characterised.

Upon reviewing the dispersion modelling report, the following observations are made:

- ADMS-Urban dispersion modelling software is commonly used in Review and Assessment studies by local authorities and can be considered a suitable tool for assessing the impact of PM_{10}.
- Point source data was included for BP Llandarcy, BP Baglan and British Steel Port Talbot using peak or average emission rates but limited information is provided in the modelling report.
- It appears that the only road transport sources considered were NPTCBC roads, no consideration was give to the vehicle movements along the 50km of roads on the steelworks site which have a contribution not only due to vehicle emissions but also from the re-suspension of particulate matter.
- It appears that no consideration has been give to area sources within the study area e.g. stockpiles of raw and processed materials and fugitive releases from buildings.
- Meteorological data was utilised from Rhoose (Cardiff Airport) and Swansea. While this meteorological data may have been the only suitable data available at the time is cannot necessarily be considered as representative of Neath Port Talbot, particularly due to the potential impact of local winds associated with the coast and nearby hills.

6.1.1.2 PM_{10} Source Apportionment

Appendix 7- 10 of the combined Stage 1,2,3 Review and Assessment report also includes the findings of source apportionment studies undertaken in Round 1.

In 1998 and 1999, the Earth Resource Centre, University of Exeter used Automatic Cartridge Collection Units (ACCU) in conjunction with a Tapered Element Oscillating Microbalance (TEOM) at the Groeswen Hospital site to collect samples for the examination of soluble and insoluble particles using ion chromatography, scanning electron microscopy, and energy dispersive x-ray analysis. The results identified the presence of iron fly ash in the range of 0.2-0.6µm (especially in samples with an origin from the south-west) and minor components of angular iron particles.

In 1999, the Division of Materials and Minerals, Cardiff University also used ACCU's in conjunction with the Groeswen Hospital TEOM site to collect samples for the examination of particles using analytical transmission electron microscopy, ion chromatography and inductive couple plasma spectrometry. When there were no air pollution events (background) the average composition of the soluble fraction was 93 and 82% of the total for the two sets of samples while the average insoluble fraction was 5% and 13%. During periods of moderate to high pollution the average composition of the insoluble fraction in samples taken from the west and south-west directions increased by 26-30% and the main contributor was found to be iron oxide. The same team analysed TEOM filters and compared these samples to different parts of the steel-making process (including the blast furnace, BOS plant, sinter plant and coke ovens). Spherical iron particles were found on the TEOM filters which resembled materials that had originated from the blast furnace.

Upon reviewing this section of the Stage 1,2,3 Review and Assessment Report, the following observations are made:

- While these studies provide a good indication of the main source of PM_{10} in Neath Port Talbot (i.e. the steelworks), they are now quite dated and advance in particulate speciation methodologies, improvements in the understanding of the sources involved and improvements in our understanding of particulate science since this study has been undertaken may result in a more accurate composition analysis of particles. Especially considering the significant range of changes that have occurred on the steelworks site that may have changed the balance of particulate composition, it is therefore recommended that consideration be given to carrying out a programme of particle speciation studies to be undertaken concurrently with local monitoring. To accompany the future chemical analyses of filters at ambient monitoring stations, it may also be useful to undertake compositional analysis of emissions from a wide range of processes on the site in order assist in fingerprinting of individual areas of the site are emitting.

6.1.2 Stage 4 Review and Assessment

In accordance with the Environment Act 1995, NPTCBC submitted a Stage 4 / Further Assessment Report (R&A Reference RA4-914) in October 2001, following the declaration of the Taibach Margam Air Quality Management Area.

This Stage 4 / Further Assessment derived its conclusions and recommendations from the dispersion modelling of all major PM_{10} sources on the steel works site which was undertaken by Corus and EAW dispersion modelling of PM_{10} emissions from the No. 5 Blast Furnace. As identified in the report a notable difference between the Corus and EAW dispersion modelling studies is the difference in the plume rise factor in relation to the No 5. Blast Furnace. The Corus study suggests that the blast furnace contributed approximately 10% of the PM_{10} concentrations at the Groeswen monitoring site while the EAW study suggests the contribution was 80%. The Stage 4 / Further Assessment also states that transport has not been identified as a major contributor to PM_{10} in the area. The report concluded that the AQMA, declared on the basis of monitoring data rather than dispersion modelling, was justified.

Upon reviewing this section of the Stage 4 / Further Assessment Report, the following observations are made:

- The report did not provide full details of any monitoring undertaken such as site descriptions, QA/QC of monitoring data, any adjustment made to data etc. While this information was absent its presence would not have been likely to change the conclusions of the report.

6.1.2.1 Corus Modelling Report, 2001

In March 2001, Corus carried out a dispersion modelling study of all major sources on the steelworks site. This was included as Annex 1 to the Stage 4 / Further Assessment Report (R&A Reference RA4-914). ADMS 3 dispersion modelling software was utilised and 22 pollutants sources, including stacks, stockyards and fugitive emissions from roof vents, were considered. The following dispersion modelling inputs were considered:

- Emission data for a total of 22 sources, including:
    - Combustion processes;
    - Other stack emissions; and
    - Fugitive emissions.
- Terrain file derived from OS topographical data; and
- Five years of hourly sequential meteorological data from Rhoose (Cardiff Airport).

The report identified a number of inherent dispersion modelling difficulties encountered due to model limitations, assumptions and uncertainties such as estimation of fugitive emission rates, consideration of building effects and the treatment of stockyard sources as point source rather that area source. The report concluded that emissions from the Corus plant made a more significant contribution to short-term concentrations rather than long-term concentrations.

Upon reviewing this section of the Stage 4 / Further Assessment Report, the following observations are made:

- ADMS 3 dispersion modelling software is commonly used in Review and Assessment studies by local authorities and can be considered a suitable tool for assessing the impact of PM_{10} particularly from industrial sources. However, there are limitations with dispersion models in particular in locations of complex terrain and coastline conditions therefore the results from this study should be treated with caution.
- This report appears to be a much more robust study of particulate matter from the Corus site than the previous Stage 1, 2, 3 dispersion modelling study, especially with regard to the inclusion of more sources. However, inherent dispersion modelling limitations, assumptions and uncertainties may have a substantial influence on the modelling outputs.
- No consideration was give to the vehicle movements along the 50km of roads on the steelworks site which have a contribution not only due to vehicle emissions but also the re-suspension of particulate matter. Although it should be noted that ADMS 3 would not have been able to consider these sources in detail.
- Additionally, it does not appear that consideration had been given to conveyors on the site.
- Meteorological data was utilised from Rhoose (Cardiff Airport). While this meteorological data may have been the only suitable data available at the time it cannot necessarily be considered as representative of Neath Port Talbot, particularly due to the potential impact of local winds associated with the coast and nearby hills.

6.1.2.2 EAW Modelling Report

The EAW carried out a dispersion modelling study of just the No.5 Blast Furnace source using Breeze AERMOD dispersion modelling software. More detailed consideration was given to the characteristics of the emission release from the blast furnace and it was therefore modelled as a volume source. Pre and post abatement emissions scenarios were tested using Cardiff, Neath and Swansea meteorological data. The report concluded that predicted improvements in air quality due to the cast house fume abatement would be significant.

It is difficult to draw any major observations due to the limitations of the information provided in the report. However, upon reviewing this section of the Stage 4 / Further Assessment Report, the following observations are made:

- Only emissions from the No.5 Blast Furnace were considered however as the purpose of this study was to investigate the influence of cast house fume abatement, the conclusions reached were significant in terms of the development of the Air Quality Action Plan.

- Meteorological data was utilised from Cardiff, Neath and Swansea. While this meteorological data may have been the only suitable data available at the time is cannot necessarily be considered as representative of Port Talbot, particularly due to the potential impact of local winds associated with the coast and nearby hills.

6.2 Introduction to Round 2 of Review and Assessment

Following an update to the national Technical Guidance (LAQM.TG(03)) and Policy Guidance (LAQM.PG(03)), the structure of the Review and Assessment process changed in Round 2. Local authorities were now required to submit an Updating and Screening Assessment (USA) report at the beginning of each round of Review and Assessment, starting in 2003. If a local authority identified a potential risk of exceeding an air quality objective then they would proceed to a Detailed Assessment (DA) the following year. Alternatively, to provide continuity to the air quality reporting process if no risk existed then the local authority was required to submit an annual Progress Report (R&A-PR) in the years between USAs. Figure 3 provides a flow diagram of the process.

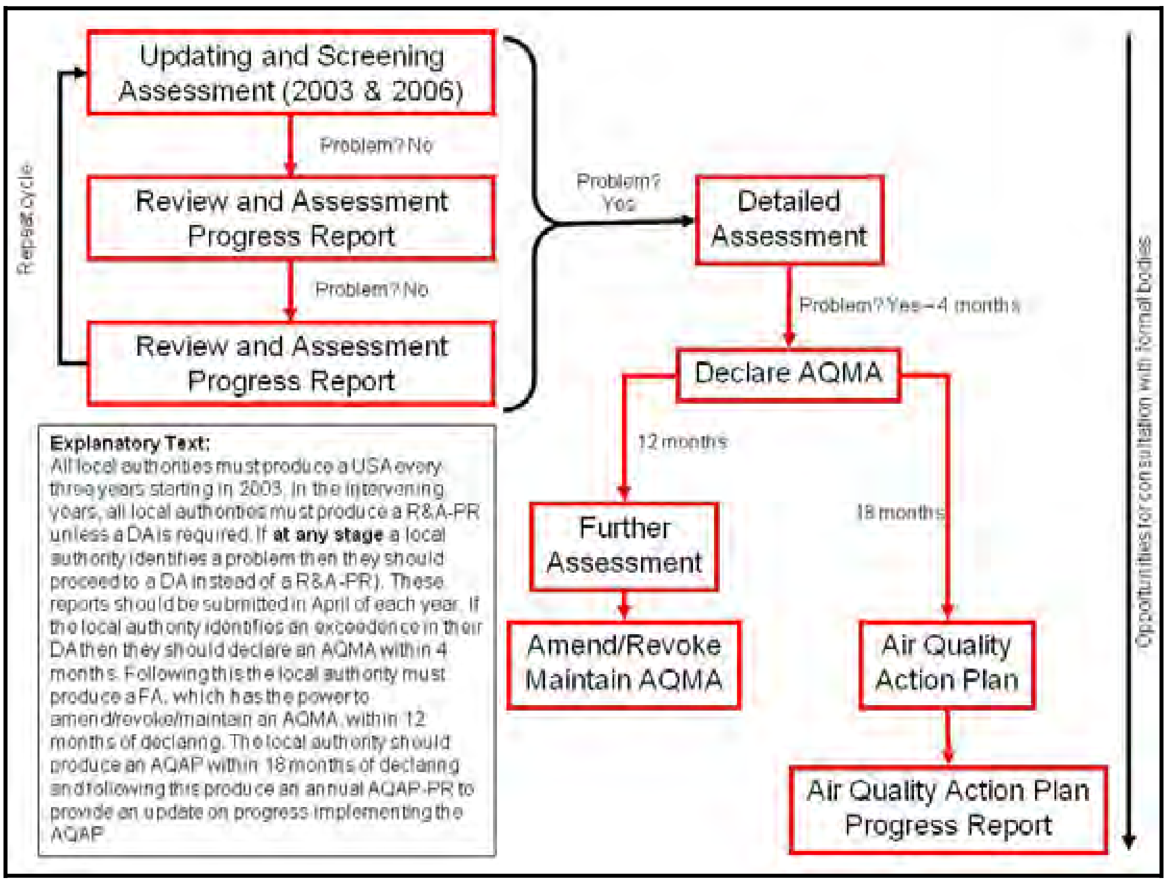


Figure 3: Flow Diagram of Round 2 and Round 3 of Review and Assessment

6.2.1 Updating and Screening Assessment, 2003

In August 2003, NPTCBC submitted their Round 2 Updating and Screening Assessment (R&A Reference USA-177) and following the official appraisal of that document a revised report was submitted in December 2003 (R&A Reference LP2-124). This report reviewed all monitoring data carried out and screened potential sources of PM_{10}. As previously stated, the relevant monitoring data is considered in detail in later sections, however, the assessment of PM_{10} sources concluded:

- Busy junctions: The intersection of Eastland Road, Bilton Road and Geoffey Street where relevant exposure exists within 10 metres of the kerb was screened using the DMRB screening model. No exceedences of the annual mean or 24-hour objectives were considered likely.
- Roads with high flows of buses or HGV's: No roads were identified with a proportion of HGV or buses greater than 25%.
- New roads constructed or proposed: No roads meeting the criteria had been identified since the last round of Review and Assessment.
- Roads with significantly changed traffic flows: No roads meeting the criteria had been identified since the last round of Review and Assessment.
- New industrial sources: The conclusions of the Environmental Impact Assessment of the Combined Cycle Gas Turbine at Baglan were considered but it did not predict any breaches of the air quality objectives.
- Industrial sources with substantially increased emissions: No industrial sources meeting the criteria had been identified since the last round of Review and Assessment.
- Areas of domestic solid fuel burning: No areas meeting the criteria had been identified since the last round of Review and Assessment. Towns which had traditionally relied on coal such as Glynneath now had access to natural gas.
- Quarries/Landfill/Opencast Coal/Handling of dusty cargoes at ports etc.: The Onllwyn washery was identified but TEOM monitoring at this location had concluded that there were no further issues.
- Aircraft: There are no airports within the NPTCBC administrative area.

The report concluded that a Detailed Assessment for PM_{10} would be required following the re-construction of the No.5 Blast Furnace to assess compliance with the air quality objectives.

Upon reviewing the Round 2 Updating and Screening Assessment, 2003, the following observations are made:

- Although the report is very 'checklist' in structure (i.e. it does not include much supporting information to justify the conclusions reached) it covers all of the minimum requirements set out in the Technical Guidance (LAQM.TG(03)).

6.2.2 Detailed Assessment, 2004

In December 2004, NPTCBC submitted their Round 2 DA of PM_{10} at in the Taibach Margam AQMA and NO_2 at Victoria Garden, Neath (R&A Reference DA-140). The DA was carried out for PM_{10} in order to assess compliance with the air quality objectives following the re-construction of the No.5 Blast Furnace (a source that the Round 1 combined Stage 1,2,3 and Stage 4 / Further Assessment report identified as a substantial contributor of particulate matter). The DA only considered monitoring data within the AQMA and concluded that an exceedence of the 24-hour air quality objective was still occurring and the AQMA was still justified.

Upon reviewing the Round 2 DA, 2004, the following observations are made:

- Although the report only considers monitoring data, the re-construction of the No.5 Blast Furnace did not appear to have the impact on air quality concentrations that was suggested by previous dispersion modelling studies. This corroborates the difficulties and uncertainties in accurately assessing PM_{10} from the site using dispersion models and also the impact of other sources on local PM_{10} concentrations.

6.2.3 Progress Report, 2005

In May 2005, NPTCBC submitted their Round 2 Review and Assessment and Air Quality Action Planning Progress Report (R&A Reference PR-225 and PR-487). The report concludes that there were no new developments of concern and that a DA was not required. The report derived its conclusions and recommendations from NPTCBC Annual Air Quality Report and the Baglan NO_2 monitoring studies.

Upon reviewing the Round 2 Progress Report, 2005, the following observations are made:

- Although the report is very limited it does meet the minimum requirements as set out in the Progress Report Guidance (LAQM.PRG(03)). Better integration of information contained in the appendices into the main report would have improved the report quality substantially.

6.3 Introduction to Round 3 of Review and Assessment

The main reporting requirements of Round 3 of Review and Assessment remained the same as Round 2. However, lessons learned in Round 2 published in the form of Frequently Asked Questions and new additional supporting guidance had resulted in the refinement of some of the criteria for USA reports.

6.3.1 Updating and Screening Assessment, 2006

In April 2006, NPTCBC submitted their Round 3 Updating and Screening Assessment (R&A Reference USA3-011). This report reviewed all monitoring data carried out and screened potential sources of PM_{10}. As previously stated, the relevant monitoring data is considered in detail in later sections of this report (Sections 10-15), however, the assessment of PM_{10} sources concluded:

- Busy junctions: Six junctions where relevant exposure exists within 10 metres of the kerb were screened using the DMRB screening model. No exceedences of the annual mean or 24-hour objectives were considered likely.
- Roads with high flows of buses or HGV's: No roads were identified with a proportion of HGV or buses greater than 25%.
- New roads constructed or proposed: No roads meeting the criteria had been identified since the last round of Review and Assessment.
- Roads close to the objective during the last round of Review and Assessment: No roads meeting the criteria had been identified since the last round of Review and Assessment.
- Roads with significantly changed traffic flows: No roads meeting the criteria had been identified since the last round of Review and Assessment.
- New industrial sources: No new industrial sources meeting the criteria had been identified since the last round of Review and Assessment.
- Industrial sources with substantially increased emissions: No industrial sources meeting the criteria had been identified since the last round of Review and Assessment.
- Areas of domestic solid fuel burning: No areas meeting the criteria had been identified since the last round of Review and Assessment. Towns which had traditionally relied on coal such as Glynneath now had access to natural gas.
- Quarries/Landfill/Opencast Coal/Handling of dusty cargoes at ports etc.: The Onllwyn washery was identified but TEOM monitoring at this location had concluded that there were no further issues.
- Aircraft: There are no airports within the NPTCBC administrative area.

The report concluded that a DA for PM_{10} would not be required however a DA for NO_2 (annual mean objective) was required at numerous locations.

Upon reviewing the Round 3 Updating and Screening Assessment, 2006, the following observations are made:

- The quality of the report had improved substantially since the Round 2 USA and it covered all of the minimum requirements set out in the Technical Guidance (LAQM.TG(03)).

In addition to this USA, NPTCBC published a Local Air Quality Strategy “Air Wise – The Way Forward to Cleaner Air” in 2006 in which the Council recognised the importance of air quality for the local community and committed themselves to achieving the air quality objectives and improving air quality in general.

6.3.2 Detailed Assessment, 2007

In April 2007, NPTCBC submitted their Round 3 DA for NO_2 (R&A Reference DA3-004). This report reviewed all monitoring data carried out and concluded that an AQMA was not required for NO_2. Additionally, in 2007, NPTCBC submitted two annual air quality reports which included all monitoring undertaken in the administrative area.

6.3.3 Progress Report, 2008

In May 2008, NPTCBC submitted their Round 3 Review and Assessment and Air Quality Action Planning Progress Report (R&A Reference PR3-333). The report identified several developments within the area but concluded that there were no new developments of concern and that a DA was not required. The report derived its conclusions and recommendations from the NPTCBC Annual Air Quality Report.

Upon reviewing the Round 3 Progress Report, 2008, the following observations are made:

- Although the report is very limited it does meet the minimum requirements as set out in the Progress Report Guidance (LAQM.PRG(03)). Better integration of information contained in the appendices into the main report would improve the report quality substantially.

6.4 Introduction to Round 4 of Review and Assessment

Both the Technical Guidance (LAQM.TG(09)) and Policy Guidance (LAQM.PG(09)(W)) went through a substantial update in time for the fourth round of Review and Assessment. Lessons learned since the last Technical Guidance were published in the form of Frequently Asked Questions and new additional supporting guidance resulted in the refinement of some of the existing criteria and the addition of new source for screening in the USA reports. The reporting format was also changed in that the assessment is carried out on a source-by source basis, rather than by considering each pollutant in turn. Additionally Progress Reports were now required in all years when an authority is not completing an USA even if a DA is also required. Figure 4 provides a flow diagram of the revised process

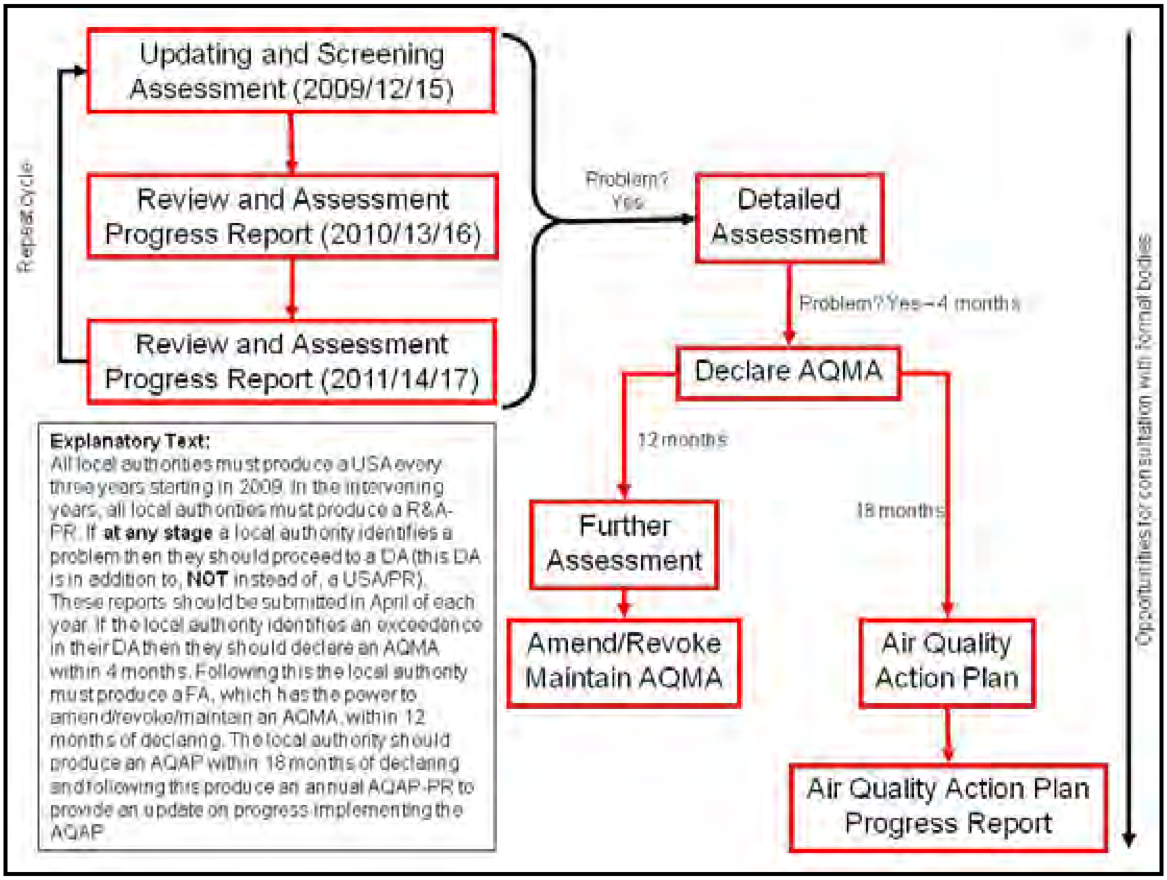


Figure 4: Flow Diagram of Round 4, 5 and 6 of Review and Assessment

6.4.1 Updating and Screening Assessment, 2009

In June 2009, NPTCBC submitted their Round 4 Updating and Screening Assessment (R&A Reference USA4-127). This report reviewed all monitoring data carried out and screening potential sources of PM_{10}. As previously stated, the relevant monitoring data is considered in detail later sections, however, the assessment of PM_{10} sources concluded:

- Roads with high flows of buses or HGV's: No roads were identified with a proportion of HGV or buses greater than 20%.
- Busy junctions: 18 junctions where relevant exposure exists within 10 metres of the kerb were screened using the DMRB screening model. No exceedences of the annual mean or 24-hour objectives were considered likely.
- New roads constructed or proposed: Stage II of the Port Talbot Peripheral Distributor Road was granted planning permission in August 2007. The Environmental Statement used DMRB to assess the impact on PM_{10} concentrations which was found to increase PM_{10} concentrations at the corner of West End, Taibach (inside the AQMA) by 0.6µg/m^3.

- Roads with significantly changed traffic flows: No roads meeting the criteria had been identified since the last round of Review and Assessment.
- Industrial Sources/Biomass Combustion: Two new industrial sources were identified including Western Bio-energy Ltd and Prenergy Power Ltd.
    - Western Bio-energy Ltd was subject to an EPR permit issued in January 2008. The Air Quality Assessment for this biomass combustion plant indicated that the plant, situated outside the southern end of the AQMA, would not appear to have a significant impact on PM_{10}.
    - Prenergy Power Ltd was granted planning permission in November 2007 by the Secretary of State to operate a renewable energy power station generation approximately 350MW of electricity through the combustion of approximately 2.5-3 million tonnes of woodchip per annum. Air Quality Assessments, including dispersion modelling indicated that the impact of PM_{10} would be insignificant in respect of the air quality objectives.
- Biomass Combustion – Combined Impacts: No locations of concern meeting the criteria have been identified.
- Poultry farms: No locations of concern have been identified as meeting the criteria.
- Fugitive or Uncontrolled Sources: No locations of concern have been identified as meeting the criteria.

The report concluded that a DA for PM_{10} would not be required however a DA for NO_2 (annual mean objective) is required. NPTCBC will submit a DA and a Progress Report in 2010.

Upon reviewing the Round 4 Updating and Screening Assessment, 2006, the following observations are made:

- The Western Bio-energy Ltd dispersion modelling study only appears to model emissions from the stack. No consideration appears to have been given to a fugitive releases from woodchip storage or movement. Additionally no consideration has been given to the increase in HGV movements, for example through the delivery of fuel. While the release of particulate matter from these sources may be minimal and may be unlikely to impact on the existing AQMA, they will contribute to the cumulative PM_{10} in the area.
- Given the existing concentrations of PM_{10} in the Neath Port Talbot area the addition on any new sources of particulate matter in, or close to, the AQMA should be carefully assessed. While individual sources may not lead to exceedences of the air quality objectives, the cumulative impact of these sources and the associated infrastructure should be considered.

6.5 Review and Assessment - Conclusions and Recommendations

The following points summarise the main conclusions and recommendations from the review on the Review and Assessment Reports submitted by NPTCBC.

- Review and Assessment Reporting:
    - NPTCBC have submitted their LAQM Review and Assessment reports in accordance with Environment Act, 1995 and the reports have met the minimum requirements in the Technical Guidance and Policy Guidance.
    - WAG should encourage NPTCBC to make better use of the data available to the authority in future Review and Assessment Reports, in particular Progress Reports, and this information could be could be reported in a more integrated format.
- Dispersion Modelling studies:
    - The three major dispersion modelling studies undertaken all have their own inherent limitations and assumptions, therefore, caution should be exercised in drawing conclusions from these studies.
    - Advances in dispersion modelling software, improvements in the understanding and quantification of the sources in the Neath Port Talbot area and improvements in the understanding of particulate science will result in a more accurate assessment of PM_{10} should a new dispersion modelling study be undertaken. The scope and structure of any new dispersion modelling study should be clearly established though continued engagement with the various stakeholders and there may be some benefit in creating a dispersion modelling steering group to oversee this work. However, any new dispersion modelling study would also have inherent uncertainties and assumptions particularly in the estimation of emissions from stockpiles and other fugitive sources, therefore, the generation of an emissions database to collate input data for any dispersion modelling study would be a logical initial step. Additionally, any dispersion modelling study should follow all relevant guidance, in particular in relation to model verification, and should be fully transparent with regards to any assumptions, all input data utilised and any adjustments made to the model output (the expansion of the monitoring network in the vicinity should assisting substantially with model verification). Undertaking a new dispersion modelling study, particularly in conjunction with any future monitoring data analysis, may assist in providing a better understanding of the contribution of specific sources on the steelworks site, may allow more detailed consideration of the cumulative impact of future sources on local PM_{10} concentrations and may allow for a comprehensive assessment of the point of

maximum impact to determine the appropriate siting of monitoring equipment. A new study may also assist with the updating of NPTCBC AQAP and the development of a WAG ‘future’ AQAP. It is vital that any new modelling study is based on a thorough analysis and quantification of all potential on-site fugitive dust sources and any other PM_{10} emissions. This in itself will play a vital role in further analysis of monitoring data. A new study may also assist with the updating of NPTCBC AQAP (see Section 6.4) and the WAG Short-term AQAP (see Section 7).

    - Undertaking a full and comprehensive dispersion modelling study of existing and future PM_{10} sources study may be resource intensive but the feasibility of such a study should be investigated by WAG.

- Source apportionment studies:
    - While these studies provide a good indication of the main source of PM_{10} in Neath Port Talbot (i.e. the steelworks), they are now quite dated and advances in particulate speciation methodologies, improvements in the understanding of the sources involved and improvements in our understanding of particulate science since this study has been undertaken may result in a more accurate composition analysis of particles.
    - WAG should consider carrying out a programme of particle speciation studies to be undertaken concurrently with local monitoring and analysis ensuring that they are well co-ordinated.

7. Taibach Margam Air Quality Management Area (PM_{10}) Air Quality Action Plan, 2003

Following the declaration of the Taibach Margam AQMA for PM_{10} on the 1st July 2000, NPTCBC produced Taibach Margam Air Quality Management Area (PM_{10}) Air Quality Action Plan (2003) (NPTCBC AQAP) in accordance with Section 84 of the Environment Act, 1995. Having gone through the first round of air quality Review and Assessment and AQMA Stage 4 / Further Assessment (see Section 5), NPTCBC concluded that

> "...the PM_{10} stage III review and assessment which had shown by means of pollution roses and source apportionment that blast furnace fume was a significant local contributor to PM_{10} air quality objective exceedences. In parallel to this it has been found in the initial review and assessment exercise that M4 derived PM_{10} is not a significant factor in relation to local exceedences of the PM_{10} objective."

7.1 NPTCBC AQAP - Development and Consultation

The NPTCBC AQAP was developed by working with a range of stakeholders to generate a list of initial options by means of a workshop which have then been refined, ranked and prioritised by the Air Quality Action Plan Team and the Corus Tripartite Working Group. The options have been categorised into five main headings of industrial, land-use planning, transport, domestic or general environmental. The Air Quality Action Plan Team has monitored the implementation of the AQAP and has ensured that the other parties on which the plan relies stay involved in the process.

7.2 NPTCBC AQAP - Options and Implementation

Table 1 outlines the actions have been included in the NPTCBC AQAP. As required in LAQM, the Council must provide an annual Progress Report (NPTCBC AQAP-PR) on the implementation of their Air Quality Action Planning measures. The most recent NPTCBC AQAP-PR was submitted in 2008 (there is another NPTCBC AQAP-PR due in 2009 but this was not available at the time of writing this review) and Table 1 also provides an indication of progress made against each option.

Table 1: Options and implementation progress of NPTCBC AQAP

Ref	Category	Action	Time	Responsible Bodies	Implementation Progress
A1	Industrial	Rebuilding of Number 5 blast furnace with complete cast house fume arrestment at the Port Talbot Steelworks, to meet BAT standard as indicated in the Best Available Techniques Reference Document on the production of Iron and Steel.	> 1yr	Corus plc and EAW	• Completed – the new improved blast furnace to BAT standard became operational in January 2003.
A2	Industrial	Dust reduction programme/improvement at the Port Talbot Steelworks. This is an on-going programme aimed at identifying and quantifying sources of dust and assessing the significance of the impact.	1-5yr	Corus plc, Cambrian Stone Ltd., Short Brothers Ltd. And EAW	• Subject to IPPC Permit
A3	Planning	Planning strategy as set out in the (then draft) UDP – proposals for new or expanded activities or developments which would be likely to create additional PM_{10} within the AQMA, or cause adjacent areas to exceed National Standards, will be likely to be resisted.	1-15yr	NPTCBC as the Local Planning Authority	• The UDP was adopted on the 26th March 2008. It provides the development plan for the County Borough and is the first consideration when planning applications are determined. Policies GC1, GC2 and ENV15 provide a policy base for addressing air quality.
A4	Transport	Provision of an alternative route for traffic bypassing the A48	1-5yr	NPTCBC, WAG and European Union	• Stage 1B completed in June 2007. • Stage 2 between Port Talbot Industrial Estate and M4 Junction 38 due to start in 2010.
A5	Transport	Green Transport Plans (Travel Plans)	1-5yr	NPTCBC as the Local Planning Authority, developers, companies, organisations and the regional Green Travel Plan Co-ordinator	• Ongoing throughout development control and the South West Wales Integrated Transport Consortium (SWWITCH).

A6	Transport	School Travel Plans	1-5yr	NPTCBC, the Head Teachers and Governors of the schools within the AQMA and the children and parents of the schools in the area.	• School travel plans now implemented at 48 schools in total. • More to be added by the end of 2008.
A7	Domestic	Discourage bonfires in the area by a combination of promotion and also diversion of green waste for composting	1yr	NPTCBC and the Community	• Green waste weekly kerbside collection available throughout County Borough. • Wood and green waste compost bins available for residents to purchase.
A8	General Env	Tree Planting – increase the amount of broadleaf tree cover in the County	1-15yr	NPTCBC, Ground Work Trust NPT, Forest Enterprise, Coed Cymru, Industrial and Commercial Partners, Schools, Cardiff University, the Community etc	• Target to be added to Community Plan redraft. • A tree planting group has been established. • Meeting with WAG to discuss grant finding for this under Environmental Improvement Fund. • Corus plc have already planted a number of trees as part of this screening work.
A9	Transport	Low emission vehicles with the Council fleet of LGVs and to encourage the use of low and zero emission vehicles by private operators of fleet and commercial vehicles.	1-5yr	NPTCBC, Freight Transport Association, First Cymru and other bus operators, private operators, taxi operators etc.	• Upgrading of all new vehicles to Euro IV/V as a minimum. • Introduction of 5% biodiesel for all fleet vehicles during 2007. • One hybrid car now added to the pool car fleet. • Fleet Service was accredited with ISO 14001 Environmental Management Systems in 2007.

A10	Transport	Roadside emission testing	1-5yr	NPTCBC with Police assistance and additional possible partnership with other authorities through the WAQF.	• Programme of Testing is under review by WAG.
A11	Transport	Transport in the Community – filling gaps in transport needs for all the community that conventional public transport simply does not or cannot cater for, for whatever reasons be it economical, geographical or social exclusion	1-15yr	NPTCBC, all transport providors both public, ambulance service, social transport, taxis etc.	• Piloted in the Upper Afan Valley and Neath Valleys. • Now extended to the Amman Valley
A12	General Env	Street sweeping – the AQMA falls into Zone 3 for the purposes of street cleaning (wet sweeping).	1yr	NPTCBC	• Additional street sweeping (Wet) can be instituted by Area Supervisors, however, current regime of sweeping considered effective.

7.3 NPTCBC AQAP - Observations

Upon reviewing the NPTCBC AQAP and supporting documents, the following observations are made:

- UK policy emphasises the importance of local authority involvement and engagement with a broad range of statutory and non-statutory community stakeholders, the reality of such engagement is often very complex and uncertain. In undertaking the development of the NPTCBC AQAP substantial consultation and engagement with numerous stakeholders has been undertaken, and NPTCBC should be commended for this.
- The formation of the Air Quality Action Plan Team to oversee the development of the NPTCBC AQAP, to maintain the continuing engagement with key stakeholders and to direct the implementation of options is key to this NPTCBC AQAP. This is commended and should continue.
- While the options highlighted in the NPTCBC AQAP may bring about varying reductions in PM_{10} concentrations only limited quantitative consideration has been given to the actual reduction in terms of PM_{10} concentrations. Any new dispersion modelling study or additional monitoring data analysis may assist in determining the potential reduction in PM_{10} concentrations deliverable through the various NPTCBC AQAP measures.
- The primary action, re-construction of No.5 Blast Furnace (A1), is fundamental to the success of the NPTCBC AQAP but monitoring data since the commissioning of the new blast furnace indicates that it may not have had the substantial effect expected. Therefore, the importance of other options, particularly the dust reduction improvement programme at the Port Talbot Steelworks (A2) may now be considered more of a priority.
- The Stage 4 / Further Assessment states that transport has not been identified as a major contributor to PM_{10} in the area yet the NPTCBC AQAP places substantial efforts into addressing traffic issues with 6 of the 12 options identified being transport related (A4, A5, A6, A9, A10 and A11). While the implementation of these options may have a positive effect on air quality both within and outside of the AQMA (not just for PM_{10} but also other pollutants), they are not focussing on the predominant sources of PM_{10} (i.e. the steelworks). However, these actions could influence background concentrations of PM_{10} in the area and, as they are focussing on road transport, they may also have a beneficial impact on $PM_{2,5}$ concentrations and accrue more health benefits.
- Other options identified such as discouraging bonfires, street sweeping and tree planting are unlikely to have a substantial influence on PM_{10} concentrations in the AQMA although the addition of more vegetation on the verges and open areas of the steelworks site may reduce events related to wind-blown dust in dry weather conditions.

- Responsible bodies\partners are identified for each of the options however to remove any ambiguity in terms of accountability, specific departments or even officers should be identified for each option.
- While limited cost benefit analysis has been included, more detailed information may assist in identifying specific funding streams to assist in the implementation of actions.
- In order to clearly identify implementation targets for each options more detailed and appropriate indicators may be appropriate. This would also help with the annual NPTCBC AQAP progress reporting.
- The information included in the NPTCBC AQAP Progress Reports is very limited, and in particular lacks supporting information for the statements made.

7.4 NPTCBC AQAP - Recommendations

Upon reviewing the NPTCBC AQAP and subsequent NPTCBC AQAP-PRs the following recommendations are made:

- The NPTCBC AQAP is now a dated document and while most of the options identified in the NPTCBC AQAP have either been implemented or are ongoing the understanding of PM_{10} sources in the vicinity has advanced substantially. It is recommended that WAG investigate, with the NPTCBC Air Quality Action Plan Team, the possibility of the NPTCBC AQAP being updated in light of the advanced information contained in reports such as the EAW PM_{10} Permit Review (See Section 8) and this review document. Additionally, this update should also act upon any updated national guidance and the feedback received from the consultants employed by WAG who have formally appraised the original NPTCBC AQAP and subsequent NPTCBC AQAP-PR.
- In updating the NPTCBC AQAP, an important step would be attempting to quantify the reductions in emissions which should have occurred as a result of the measures being put in place.

8. WAG Short-Term Air Quality Action Plan

In August 2008, the Welsh Assembly Government carried out a formal consultation on a short term air quality action plan for zones in Wales and a short term air quality action plan for the South Wales zone incorporating a local plan of action in respect of PM_{10} levels in Neath Port Talbot. These short term air quality action plans were developed in accordance with the requirement imposed on the Welsh Ministers by Regulation 11 of the Air Quality Standards (Wales) Regulations 2007.

Wales has been divided into two zones for the purposes of the 2007 Regulations; North Wales and South Wales. The South Wales zone consists of two agglomerations; the Swansea Urban Area (which geographically incorporates Swansea and Neath Port Talbot) and the Cardiff Urban Area (which geographically incorporates Cardiff and the Vale of Glamorgan) (Figure 5). The review of this consultation document focuses implicitly on the elements that related to PM_{10} in NPTCBC's administrative area.

The section of the report relevant to this independent review provides a background to PM_{10}, the PM_{10} air quality objectives, how and where PM_{10} is monitored in Neath Port Talbot and summarises historical monitoring data. Section 4.35, Part 1 clearly states that the requirements of the Air Quality Framework Directive (EC Directive 96/62/EC) are transposed into legislation in Wales by the Air Quality Standards (Wales) Regulations 2007 and therefore as the competent authority the Welsh Ministers are responsible for the implementation of that Directive. This consultation document sets out the actions, or proposed actions, to be undertaken by the Welsh Ministers with regards to PM_{10} in Neath Port Talbot. Some of the key points include:

- Although there will likely be other contributing sources of PM_{10} (including for example road transport, sea salt and transboundary PM_{10}) the focus of the Welsh Ministers work will be on sources within the $28km^2$ boundary of the steelworks site.
- The Welsh Ministers are working with the regulators (EAW and NPTCBC), site owners and/or operators and relevant WAG departments to discuss potential sources and proffer potential options to mitigate these sources.
- A detailed review has been requested by WAG from the regulators of the environmental permits (see Section 8).
- The Welsh Ministers will consider the outcomes of any review, in particular of any specific actions identified which may reduce the risk of exceedences, and will seek discussions with the regulators to have the review outcomes adopted and implementation timescales identified.
- To ensure the implementation of options, Welsh Ministers will consider the issue of directions under powers contained in the Environmental Permitting (England and Wales) Regulations 2007.

- The Welsh Ministers will undertake continuous monitoring and review the outcomes of these mitigating options as appropriate.
- Progress updates on the implementation of options will be carried out in at least 6 monthly intervals.

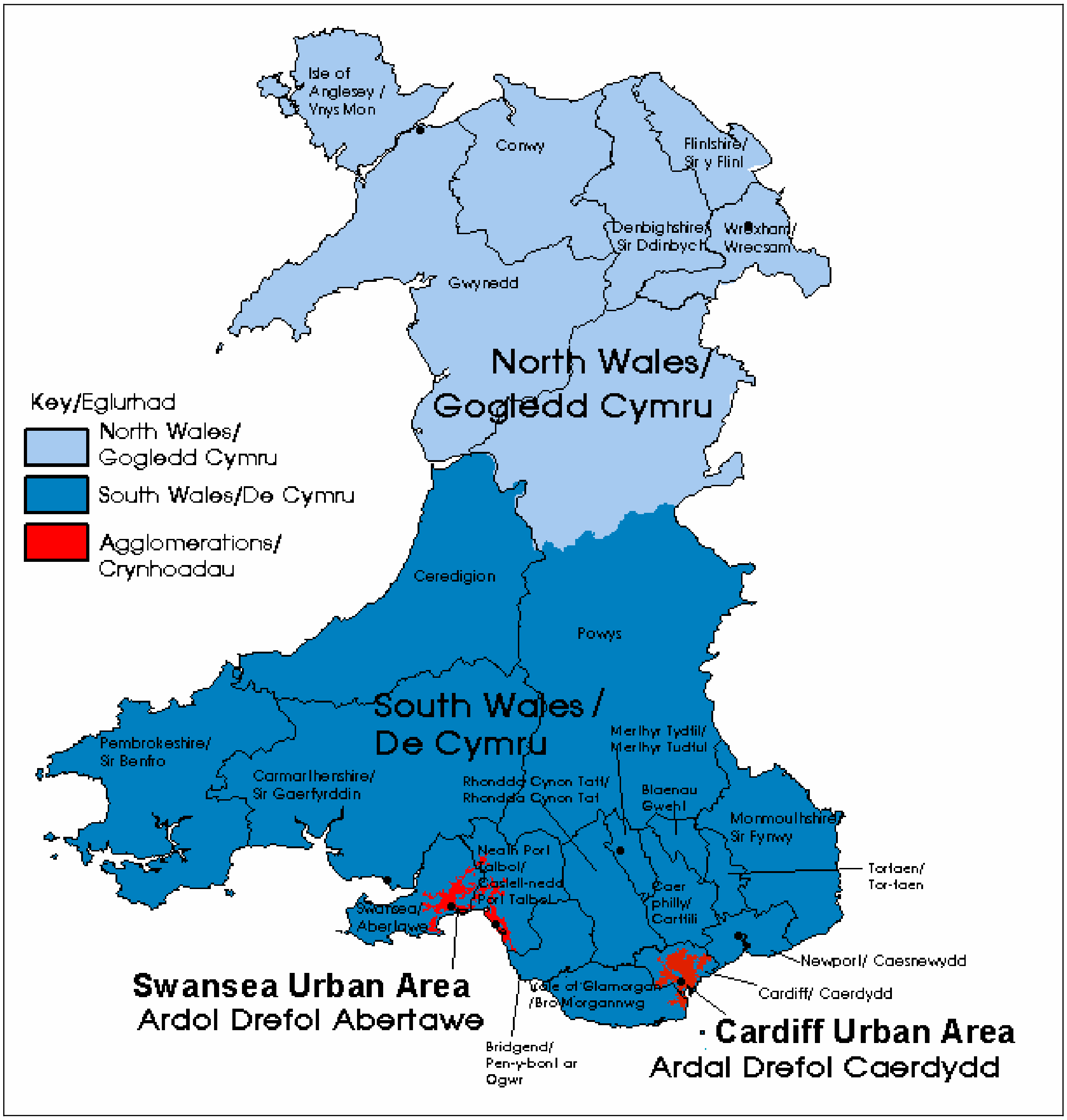


Figure 5: Map of zones and agglomerations in Wales

(Source: http://www.new.wales.gov.uk/desh/publications/enviroprotect/airquality/airqualitymap07/map.pdf?lang=en)

While the purpose of reviewing this document was not to respond to the specific consultation questions, the following observations are made:

- While the short-term AQAP establishes plans to address existing sources of PM_{10}, the document may be amended and utilised to generate a ‘future’ AQAP which may benefit from broadening the scope to ensure that improvements in local air quality continues to be maintained in future years through the consideration of air quality in future policy development in land-use planning, transport planning etc.
- It is recommended that WAG incorporate the findings of this independent review while utilising the short-term AQAP for the South Wales Zone to create a ‘future’ AQAP. Additionally, WAG should ensure that their short-term AQAP and any ‘future’ AQAP are dynamic and evolving documents so that the findings from any future studies recommended from this review can be incorporated.

9. PM_{10} Permit Reviews

The Environment Agency Wales (EAW) and Neath Port Talbot County Borough Council (NPTCBC) were both requested by the Welsh Assembly Government (WAG) to review the PM_{10} aspects of the environmental permits for the operators on the steelworks at Port Talbot.

9.1 EAW PM_{10} Permit Review

The EAW PM_{10} Permit Review not only considers the legal requirements of a PM_{10} permit review but also the extra aspects to gain understanding of PM_{10} emissions from the Port Talbot steel works and ensure improvements. The EAW PM_{10} Permit Review was completed in January 2009. As part of this independent analysis of PM_{10} in the Neath Port Talbot area this section of the report considers and summarises the main points from the EAW PM_{10} Permit Review.

The EAW PM_{10} Permit Review is a comprehensive yet succinct document providing a detailed analysis of PM_{10} permitting and supporting information from the Port Talbot steelworks. The introduction to the report provides background to the permit review, identifies the regulatory frameworks for both industrial activities and air quality and provides an introduction to the steel-making process.

The main processes of the integrated steel production at Port Talbot are discussed including the description of the main processes. These include:

- Raw Materials – The raw materials utilised at Port Talbot Steelworks are coal, coke, iron-bearing ore including scrap metal, fluxes and lime & limestone. Most of the coal, coke, iron ore and some fluxes are imported and arrive at the plant via the deep water harbour. There are two main stockyards, the Ore Stockyard for storage of ore, fluxes, some coal and coke and the Coke Ovens' Stockyard for storage of coal and coke. The main steel making processes are as follows:
- Coke Ovens – a coal blend is carbonised in a series of heated ovens with minimal air. The resultant coke that is formed is utilised in the blast furnace.
- Sinter Plant – Blended iron ores, some coal and fluxes are sintered to produce a fused and partially reduced form of iron that can be used more efficiently than iron ore to make molten iron directly in the blast furnace.
- Blast Furnace – converts iron ore into molten iron using carbon in the form of coal and coke.
- Basic Oxygen Steel-making (BOS) – Molten iron, transferred from the blast furnaces in torpedoes, can be used as produced or desulphurised depending on the grade of steel required. The resulting steel slabs are either taken to the hot-rolling mill or placed in storage.
- Metal Plating – if the BOS plant cannot process molten iron, for quality, safety or maintenance reasons, the molten iron is transferred from the

torpedoes into plating pits before it goes solid. Once cold the metal is broken up and returned to the BOS plant as part of the scrap charge.

- Steel Slag Processing – This manages the BOS desulphurisation slag and steel slag where both slags are poured into dedicated cooling pits, stored and then processed. Demetalled steel slag is stored for weathering before it is crushed to size for sale and off-site use. Demetalled desuphurisation slag currently has no use and is therefore treated as waste and sent to landfill.
- Slab Processing – If surface blemishes are noted in cast slabs upon inspection then these can be removed by scarfing (i.e. cutting away the surface of the metal).
- Hot & Cold Mills – Steel slabs are heated to red hot before being rolled into a long thin coil or metal.
- Power Plants – These generate both electricity and steam for the energy intensive process of making and rolling steel. The cleaned 'waste' gases from the Coke Ovens and Blast Furnace are used as fuels in a number of power plants on the site.

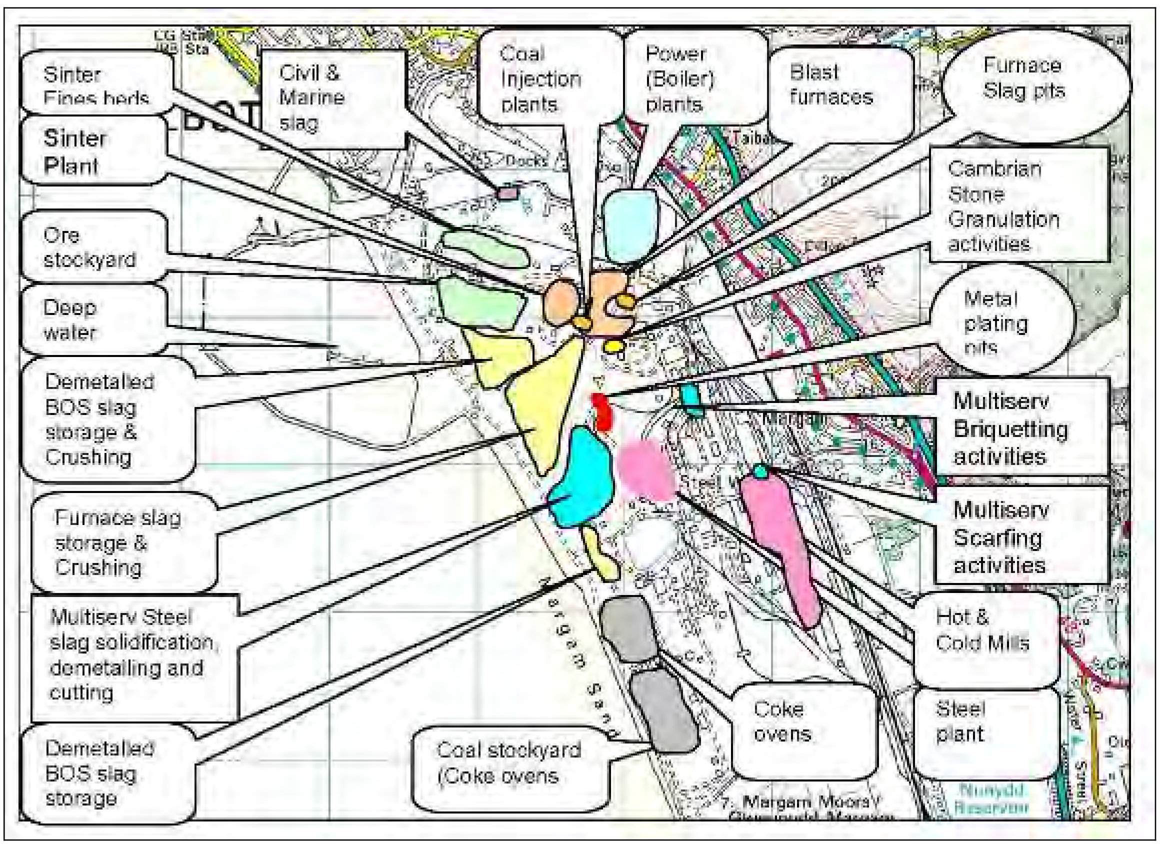


Figure 6: Map of main processes on the Port Talbot Steelworks site

(Taken from EAW PM10 Permit Review)

The following section of this independent analysis reviews and summarises the various sections of the EAW PM_{10} Permit Review which are of relevance to this project.

9.1.1 EAW PM_{10} Permit Review - Part I

This section reviews the boundaries of the regulated operations on each of the three permitted activities on the site, namely, Cambrian Stone, Corus and Multiserv, and compares these boundaries with the latest EAW guidance on boundaries. What is evident from this section is the difficulties associated in clearly identifying the processes (which are sometimes geographically fragmented around the Port Talbot site) and subsequent environmental responsibilities of the three permitted activities (and their contractors) on the Port Talbot site with the additional complexity of two regulatory bodies (EAW and NPTCBC) having responsibility for different elements of the site and process. The close working relationships that have been generated between the activity and regulatory bodies via the various forums should ensure that identification and regulation of the variety of potential PM_{10} sources should remain a dynamic and evolving process.

9.1.2 EAW PM_{10} Permit Review - Part II

This section considers, in conjunction with NPTCBC, any gaps (or overlaps) which should be regulated. This section (and Part 1) identified the following gaps in source regulation:

- The storage of blast furnace slag;
- The storage of demetalled steel slag;
- The storage of granulated slag at the dock gates; and
- Releases from the ABP dock road and sewage treatment works.

This section concludes that there should be some realignment of regulation on the site between the EAW and NPTCBC and again reflects the complexity of the regulation of this site.

9.1.3 EAW PM_{10} Permit Review - Part III

This section reviews the current permit conditions that relate to PM_{10} and fugitive releases for the three permitted activities and compares these conditions to those in the latest EAW permit templates and how they impact on air quality. The conclusions from this section reflect the difficulty in the precise identification, quantification and management of PM_{10} emissions from both fugitive and, in some cases, point sources. Additionally many conditions relate to particulate matter and not specifically PM_{10}.

9.1.4 EAW PM_{10} Permit Review - Part IV

This section compares the three current permits to other steelwork permits issued by the Environment Agency for consistency of approach and identification of best practice. Other than the Port Talbot site there are two other integrated steelworks in the UK (both of which are owned and operated by Corus) namely Scunthorpe in Lincolnshire and Redcar on Teesside. This section concludes that limits set at Port Talbot are far more stringent than at the other two steelworks in the UK. However, there appears to be uncertainty surrounding the regulation of slag granulation at Port Talbot and, as identified in other sections of the PM_{10} Permit Review, there appears to be fragmentation of the regulation of slag handling (EAW), and crushing and storage (local authority) which needs to be addressed. Examples of better practice have been identified in the Scunthorpe and Redcar Permits which may applicable to the Port Talbot Permit.

9.1.5 EAW PM_{10} Permit Review - Part V

This section compares the conditions that relate to PM_{10} and air quality improvements for other installations that contribute or have contributed towards air quality standard failures. This section draws upon experiences at other industrial processes with air quality issues including PM_{10} in the vicinity of the Scunthorpe Steelworks, PM_{10} in the vicinity of LaFarge Cement Works in Kent, PM_{10} in the vicinity of a Waste Transfer Station in London and SO_2 in the vicinity of an ESSO Refinery in Hampshire. This section concludes that the consideration of live ambient air quality monitoring data in a 'stop-observe-review' approach on 'high' PM_{10} days could be beneficial in source identification and the pro-offering of potential solutions.

9.1.6 EAW PM_{10} Permit Review - Part VI

This section reviews the reported PM_{10} releases from each of the three permitted activities, how they have been measured, calculated or estimated and how they have changed historically. This section of the report only considered the EAW regulated processes and not the local authority regulated processes. Again the lack of differentiation in conditions between particulate matter in general and PM_{10} was evident. The review finds that a wide variety of both point and fugitive PM_{10} sources contribute to the overall PM_{10} emissions from the site.

9.1.7 EAW PM_{10} Permit Review - Part VII

This section compares the current PM_{10} performance with the latest BAT guidance such as the latest BREF notes and UK technical guidance notes. It found, in terms of existing ELVs at Port Talbot, that performance compliance was >90% for most particulate sources with the exception of the sinter de-dust stack which was just below 90% compliance. This section also identified inadequacies in the BREF notes in terms of consistency, usefulness and content.

9.1.8 EAW PM_{10} Permit Review - Part VIII

This section reviews the work undertaken on the identification of the sources of PM_{10} from within each permitted activity. The report concludes the following for each of the three permitted activities:

- Cambrian Stone:
    - Relatively small number of activities with the potential to produce PM_{10};
    - Granulate stacking is low risk as material is wet;
    - Granulate stockpiling is greater risk as requires improvements in management;
    - Granulate transports can produce PM_{10} and good management is essential; and
    - The annual review of fugitive emissions by Cambrian Stone satisfies the permit conditions but the conditions should be more prescriptive to identify and abate sources of fugitive dusts.
- Corus:
    - The numerous speciation studies to date do not show a profile indicating one single source of PM_{10} and subsequently any PM_{10} reduction programme focussing on the abatement of single source is over-simplifying the PM_{10} issues on the site;
    - Sea-salt and sand can be contributing factors;
    - All processes within the Corus activity have now bought into the PM_{10} reduction programme; and
    - Any requirements for additional monitoring and subsequent analysis, interpretation and reporting need to be clearly set.
- Multiserv:
    - The processes mainly contribute through the release of fugitive emissions due to the movement of materials in unenclosed areas; and
    - Difficulties in quantifying both the fugitive emissions from the sources and the improvements in air quality brought about by dust abatement programmes are again identified.

9.1.9 EAW PM_{10} Permit Review - Part IX

This section reviews the monitoring results and improvement items and other responses submitted under the PPC permits. This section contains specific permit condition recommendations and concludes that:

- Cambrian Stone is not a significant contributor of PM_{10}; and
- Corus could make greater use of their condition responses to engage and inform the wider community about their work.

9.1.10 EAW PM_{10} Permit Review - Part X

This section reviews the regulatory work undertaken since the PPC Permits were issued. The main conclusions (not specifically related to permitting issues) include:

- Cambrian Stone:
    - Cambrian Stone have breached their permit five times (in 6 years since issue), all of which have been for the late submission of reports and no environmental impact was recorded;
    - The amount of regulatory effort afforded to Cambrian Stone activities (approximately 2 visits per annum) is a reflection of the perceived contribution of granulation; and
    - Other activities on the site such as slag movement, storage and crushing (regulated by the local authority) may make a more significant contribution to PM_{10} emissions and concentrations in Port Talbot.
- Corus:
    - Corus have had numerous breeches of their permit with many warnings issued; and
    - Corus is the largest regulated site in Wales and therefore has the greatest regulatory effort focussing on improving air quality in Port Talbot through efforts directed at minimising releases of PM_{10}.
- Multiserv:
    - Multiserv have been issued with warnings mainly relating to kish episodes and fugitive releases; and
    - EAW have increased their regulatory effort as a result of complaints (regarding kish) and concerns about the control of fugitive emissions.

9.1.11 EAW PM_{10} Permit Review - Part XI

This section considers what further improvements are required to reduce PM_{10} releases. It identifies and makes recommendations for the following PM_{10} reduction measures to be implemented:

- Corus will be asked by way of improvement conditions to investigate improvements towards BAT for:
  - Sinter plant main stack;
  - BOS plant secondary fume collection; and
  - Blast furnace cast-house fume arrestment.
- Other key improvement conditions will cover:
  - Improved material movement;
  - Improved traffic and road surface management; and
  - Moving towards granulation of 100% of blast furnace slag.

9.1.12 EAW PM_{10} Permit Review - Part XII

This section reviews the scope of current ambient air quality monitoring and the location of monitoring equipment inside and outside the steelworks. The monitoring both inside and outside the steelworks site has, or is in the process of being, increased substantially.

9.1.13 EAW PM_{10} Permit Review - Part XIII

This section provides proposals for future assessments of ambient air quality data to determine what further actions are required to reduce ambient levels of PM_{10} near the steelworks. The section concludes that monitoring should be located in the vicinity of Taibach Community Centre and Princes Street (area of predicted highest concentrations based on the Corus Dispersion Modelling Study – see Section 5.1.2.1). Additionally, a co-ordinated system of collation, assessment and presentation is recommended. Further details relating to the conclusions from this section of the EAW PM_{10} Permit Review can be found in subsequent sections of this report (Sections 10-15).

9.1.14 EAW PM_{10} Permit Review - Part (a)

This section reviews the historical PM_{10} breaches looking for patterns to help identify causes. UWE have carried out similar analyses as part of this independent review. Further details relating to the conclusions from this section of the EAW PM_{10} Permit Review can be found Sections 11, 12, 13 and 14 of this report.

9.1.15 EAW PM_{10} Permit Review - Part (b) and Part (i)

This section considers what actions are currently taken and could be taken on days when high PM_{10} concentrations are recorded. On a recorded exceedence day on an off-site monitor the following actions are undertaken (for the full methodology see Part i of the PM_{10} Permit Review):

- Check if it is a regional pollution event by checking other PM_{10} results across South Wales. If such as event is found then a request to put to AEA Technology to investigate further (AEA Technology hold the contract for quality assurance and assessment of UK air quality data for Defra, Scottish Government, Welsh Assembly Government and the Department of the Environment Northern Ireland through the AURN).
- If such an event is not found then further investigations are undertaken to identify a local source by consideration of a log of on-site activities, processes, actions etc.

Analysis of this data on exceedence days and on 'near-miss' days, in addition to fingerprint analysis of samples taken on exceedence days may help identify sources of PM_{10}.

9.1.16 EAW PM_{10} Permit Review - Part (c)

This section looks at ways of identifying PM_{10} sources within the steelworks from the monitoring data collected during 2007. UWE have carried out similar analysis as part of this independent review. Further details relating to the conclusions from this section of the EAW PM_{10} Permit Review can be found in subsequent sections of this report (Sections 10-15).

9.1.17 EAW PM_{10} Permit Review - Part (d)

This section provides a summary of the particulate and PM_{10} release improvements that have taken place within the steelworks in recent years. This section bullet points the improvements for Cambrian Stone, Corus and Multiserv, however the main improvements are:

- Cambrian Stone introduced granulators to each blast furnace resulting in an increase in the proportion of blast furnace slag that is granulated as opposed to air cooled.
- Corus have implemented extensive improvements around the site and have a future programme of work in place. The main improvements include, but are not limited to:
    - Secondary fume collection on the BOS plant;
    - Cast-house fume arrestment on blast furnaces 4 and 5;
    - Upgrading of sinter plant electrostatic precipitators; and

    - Refurbishment of the coke ovens.

- Multiserv have introduced a number of improvements to reduce particulate releases from their activities and in particular minimise the number of kish related complaints received.

What is noticeable from this section of the PM_{10} Permit Review is the proactive approach of the operators in identifying the sources of PM_{10} and proffering solutions to their management.

9.1.18 EAW PM_{10} Permit Review - Part (e)

This section provides the copies of the following papers which have been utilised in the development of the PM_{10} Permit Review:

- Tate, B., Hollingsworth, P., Leonard, R., Ng, B., Shi, J.P., Air quality monitoring, assessment and management at Port Talbot, UK.
- Broom, D., M., P., Air quality monitoring, assessment and management at Port Talbot, UK.
- PowerPoint presentation slides including a summary of the pollution rose interpretation by Mark Broom, EAW.
- Mensink, C., Berghmans, P., Bleux, N., Cosemans, G., Deutsch, F., Janssen, L., Liekens, I., Torfs, R., Van Rompaey, H., Source analysis and emission abatement measures for PM_{10} hot spot regions in Flanders.

This section also reviews the analysis of PM_{10} pollution roses and their use in locating potential sources. UWE have carried out similar analyses as part of this independent review. Further details relating to the conclusions from this section of the EAW PM_{10} Permit Review can be found in subsequent sections of this report (Sections 10-15).

9.1.19 EAW PM_{10} Permit Review - Part (f)

This section considers what data analysis could be carried out every year to aid PM_{10} data comparison and to help trend identification. UWE have put forward recommendations for future studies, including the analysis of monitoring data, as part of this independent review. Further details relating to the conclusions from this section of the EAW PM_{10} Permit Review can be found in subsequent sections of this report (Sections 10-15).

9.1.20 EAW PM_{10} Permit Review - Part (g)

This section reviews how the operators and regulators work together to reduce PM_{10} from the steelworks site as a whole. Port Talbot steelworks have two regulators in EAW and NPTCBC and the operators include Corus as the site owners and their contractors, Darlow Lloyd, Multiserv and Cambrian Stone.

There is a team of regulators at Port Talbot with one lead regulator who decides the strategy for the site; this ensures continuity and consistency of approach. The regulators and operators hold regular (usually quarterly) meetings to discuss and review PM_{10} issues.

9.1.21 EAW PM_{10} Permit Review - Part (h)

This section provides an insight into observations, conclusions recommendations and findings with NPTCBC as the EAW PM_{10} Permit Review progressed. The close liaison between NPTCBC and EAW has been ongoing for a number of years and both groups are represented in a number of forums. This close working relationship is expected to continue over the coming years.

9.1.22 EAW PM_{10} Permit Review - Part (i)

This section provides assistance to NPTCBC in the development of a protocol for the identification of regional and national events. See Section 8.15 above.

9.2 NPTCBC Corus Permit Review

The NPTCBC Corus Permit Review considers the permitting of Civil & Marine Limited and Tarmac Western Limited. The NPTCBC Permit Review provides an introduction to the site, the activity and provides a copy of both permits in the appendices. The review concludes that:

- The Part 2 Civil & Marine Limited permit has been amended to include changes to emission limits and the addition of conditions aimed at further minimising dust emissions; and
- Regulatory benefits may be gained by the transfer of the Part B Tarmac Western Limited process to EAW regulation.

9.3 PM_{10} Permit Review - Observations

These comprehensive yet concise documents provide a detailed analysis of PM_{10} permitting, PM_{10} data analysis and supporting information from the Port Talbot steelworks. The following observations are made:

- What is initially evident is the complexity of regulation of this site due the sharing of regulatory duties between the EAW and NPTCBC. Additionally, regulation also appears to be hindered by the geographical fragmentation of activities, operators and contractors around the site. Continued embedded liaison between the regulators and site activities is essential for successful future air quality management. The NPTCBC conclusion that regulatory benefits may be accrued by the transfer of Tarmac Western Limited process to EAW regulation should be investigated.

- Throughout the EAW PM_{10} Permit Review, conditions refer to 'particulate matter' rather than PM_{10} specifically.
- There is very limited quantification of fugitive emissions of PM_{10} from most activities around the site and subsequently any the impact of improvements on PM_{10} concentrations are difficult to determine.
- All of the conclusions and recommendations in both Permit Review documents should either bring about reductions in PM_{10} emissions from the site or improve the general management of air quality through the permitting process. However, following on from this PM_{10} Permit Review it would be beneficial for a summary document to be produced outlining the agreed course of actions i.e. which of the recommendations are being taken forward or conversely which recommendations are not being taken forward and the reasons for this. Additionally, it may be useful to have full and concise list collated of all known (or potential) sources of PM_{10} on the steelworks site (the EAW and the site operators may be best placed to collated this information).

10 Data Analysis

10.1 Description of Analysis Methodology

The analysis of available data for this study has been presented in 4 main categories. The period of data considered begins at 1/1/2000 (as outlined in the project tender specifications). There have been some significant changes to sources on the steelworks site subsequent to 2000, particularly involving blast furnace operation, and the selection of 2000 as the start date allows the time series to cover all of these, along with a short period prior to this. It was not considered efficient to devote extensive analysis time to very old data that is likely to be irrelevant to the current situation due to changes in emission patterns.

The first two sets of analyses described below utilise the entire datasets from the monitoring stations and examined them in terms of a) spatial patterns and b) temporal patterns of pollution. These analyses have not made any distinction between days or hours where measured concentrations have exceeded the 50µg/m^3 objective concentration and they therefore give an indication of the general pollution patterns experienced in the area. The third set of analyses has focussed more particularly on those days or hours where the 50µg/m^3 objective concentration has been exceeded. The final set of analyses looks specifically at differences in pollution concentrations between different monitoring sites, particularly the Hospital and Fire Station AURN sites.

This aim of this study has been to provide a thorough independent analysis of the available data, making use in particular of the newly available Openair air pollution analysis software. In analysing the data, several hundreds of graphs have been generated – in this report we have selected those which are considered either to provide fundamental representations of the datasets (e.g. the polar plots) or that are thought to show something particularly useful or informative. As will be discussed in this section, there is a significant amount of work to be done in analysing the available data, particularly in terms of correlating monitoring data with activities on the steelworks site, and in terms of investigating the spatial patterns of pollution on and off site that will be possible with the new monitors that have been recently established by Corus and NPTCBC. The text accompanying the figures and tables is not intended to completely describe everything that may be evident from the graphs, although the key observations made by the authors are discussed, nor have all the possible graphs been included in the report, however, all data and coding used to create the plots is available upon request (except meteorological data from Mumbles Head and Ordnance Survey data), as is the freely available open-source software used to do the analyses.

The patterns that have been identified within this study do not easily resolve themselves in terms of individual identifiable sources that can be explained simply; the patterns of pollution are complex and further progress in reducing pollution is likely to come about through detailed understanding of many processes using tools like Openair in a ‘live’ setting rather than simply to produce graphics for reports.

One of the problems in analysing the data has been differences in the length of datasets available. This is particularly the case where short term datasets may potentially produce misleading results where statistical processes interpolate data (such as in polar plots). The other problem is with the very long data set for the Hospital AURN site as the creation of plots from the whole dataset can potentially create a misleading impression of an average pattern of pollution from a series of periods when source emissions differed significantly. It has been deemed impractical to produce graphs in the report for every possible activity period conceivable; where it has been necessary, data from the long Hospital AURN series has been split into separate sections so that differences in patterns can be identified.

10.2 Data Used Within this Study

Four main sources of data were used within the project. These were data from:

- Port Talbot (Groeswen) aka "Hospital", Port Talbot (Margam) aka "Fire Station" and Narberth monitoring stations forming part of the UK Automatic Urban and Rural Network (AURN) (obtained through Martin Hooper at NPTCBC, and the www.airquality.co.uk website);
- Four Environment Agency Wales monitoring studies (obtained from Mark Broom at EAW);
- Five monitoring sites within the steelworks site (obtained from Gavin Landeg at Corus);
- The Met Office MIDAS Land Surface Observation Station at Mumbles Head (obtained from the British Atmospheric Data Centre).

Summaries of the data for each site can be found in Appendix A showing distributions of values and periods of missing data.

1/1/2000 was selected as the start date for the study (as set in the project tender specifications). 31/3/2009 was the end date, chosen as it was the last fully ratified data available from the AURN (N.B. this date is after the end date for Met data from the AURN sites, and data from the steelworks monitoring sites).

All PM_{10} data used is either TEOM converted using a 1.3 correction factor (as recommended on LAQM.TG(03) prior to the new LAQM.TG(09) guidance and the introduction of the new Volatile Correction Model), or from a TEOM (FDMS) unit and therefore considered to be 'gravimetric equivalent' already. All data has been treated equivalently and no detailed analysis has been carried out to detect whether the change in instruments may have led to a discernable change in pollution measurements. The AURN monitor changed to a TEOM (FDMS) unit on 18/02/2007, less than 6 months before the site relocation to the Fire Station site. A cursory analysis of the impact of this change in monitoring technique has been carried out, the results of which suggest that (as might be expected) the TEOM (FDMS) monitor records lower concentrations of PM_{10} than the TEOM*1.3 method. Therefore, in all analyses of PM_{10} concentrations over time, it should be taken into consideration that, monitored concentrations of PM_{10} are likely to appear to decrease in 2007 due to the change in monitoring method, irrespective of any change in monitoring location.

Data from Topas monitors used by the steelworks operators are not considered to be gravimetric equivalent and concentrations should be considered as indicative only.

$PM_{(coarse)}$ has been calculated as PM_{10} minus $PM_{2.5}$. This represents the fraction of PM_{10} most likely to be attributable to dust sources, such as resuspended dust, or dust released from mechanical grinding or crushing operations.

$PM_{(local)}$ has been calculated as PM_{10} minus PM_{10} concentrations recorded at the Narberth AURN background site. This represents PM_{10} attributable to local sources and will remove diurnal and seasonal effects of regional particle pollution (especially secondary particles).

The location of the monitoring station in the EAW Taibach campaigns is the approximately the same as the AURN Fire Station site being within a few metres of each other.

All co-analysis of pollution and wind speed/direction has been undertaken using meteorological measurements from the specific pollution station (unless clearly stated otherwise).

Where data has been converted from 15-minute to hourly means, or hourly to daily means, routines have been used in Openair to ensure that proper vector averaging has been applied to the wind direction.

No adjustment has been made to basic pollution data subsequent to its receipt by UWE.

Data analysis has been undertaken using *Openair* software (http://www.openair-project.org/) (a new open-source air pollution analysis package developed at the University of Leeds), Microsoft Excel, and ArcGIS. Openair is based on the open-source programming language statistical package *R* (http://www.r-project.org/). Openair is designed as a more efficient and effective tool for analysing air pollution data than conventional methods such as spreadsheets. The software consists of a number of functions designed specifically to manipulate and present data relating to air pollution. Further information on any of the functions used can be found in the Openair manual available at the Openair project website.

10.3 Site Names

Data from the AURN sites is labelled as ***AURN*** where the entire dataset (covering both sites) is referred to. Otherwise the data is labelled as ***Hospital*** or ***Fire Station*.**

Data from the EAW monitoring sites is referred to as ***Arts Centre*, Corus S&S*,* *Taibach 04***, or ***Taibach 07***.

Data from the steelworks Topas monitors is referred to either by site name: ***Harbour***, ***Blending Plant***, ***Fines Beds***, ***GCI*** or ***Coke Ovens***; or by the site number ***1*** to ***5*** (respectively).

10.4 Units

Unless otherwise stated, all units for pollutants (other than Carbon monoxide) are in µg/m^3. Carbon monoxide is reported in mg/m^3.

Windspeed is in m/s (data from Mumbles has been converted from knots using a factor of 0.515).

Wind direction is in degrees (360° indicates north).

Different scales have frequently been used on similar plots – this is often because patterns of pollution have been considered to be more important than absolute concentrations. The reader is alerted to this fact and advised to pay close attention to scales on the axes when comparing plots. In many cases, where practicable, differences in scales have been indicated.

Table 2: Details of Monitoring Locations and Data Used in this Study.

Operator	Site	Start	End	X-Ref	Y-Ref	PM_{10}	$PM_{2.5}$	PM_1	CO	NOx	O_3	SO_2	Wind Spd	Wind Dir.	Other Met	Time Res.
AURN	Port Talbot (Groeswen) aka ***Hospital***	01/01/2000	22/06/2007	278000	188200	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓	1hr
	Port Talbot (Margam) aka ***Fire Station***	27/07/2007	31/03/2009	277400	188700	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	1hr
	Narberth (Remote site-Pembrokeshire)	01/01/2000	31/03/2009	214600	212700	✓	✗	✗	✗	✓	✓	✓	✗	✗	✗	1hr
Env. Agency (Wales)	***Arts Centre****	27/01/2002	22/10/2002	277197	189213	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	15min
	Taibach 2004	20/07/2004	18/01/2005	277403	188724	✓	✗	✗	✗	✗	✗	✗	✓	✓	✗	15min
	Corus Sports & Social Club (***Corus S&S***)	18/01/2007	02/10/2007	278963	186844	✓	✓	✗	✗	✗	✗	✗	✓	✓	✗	15min
	Taibach 2007	16/12/2006	29/08/2007	277403	188724	✓	✓	✗	✗	✗	✗	✗	✓	✓	✗	15min
Port Talbot Steelworks §	1. ***Harbour***	09/08/2008	02/03/2009	275616	187987	✓	✓	✓	✗	✗	✗	✗	✓	✓	✗	15min
	2. ***Blending*** Plant	09/08/2008	02/03/2009	275942	188271	✓	✓	✓	✗	✗	✗	✗	✓	✓	✗	15min
	3. ***Fines*** Beds	09/08/2008	02/03/2009	276394	188402	✓	✓	✓	✗	✗	✗	✗	✓	✓	✗	15min
	4. ***GCI*** (Granular Coal Injection)	09/08/2008	02/03/2009	276940	187924	✓	✓	✓	✗	✗	✗	✗	✓	✓	✗	15min
	5. ***Coke*** Ovens	09/08/2008	02/03/2009	277662	185965	✓	✓	✓	✗	✗	✗	✗	✓	✓	✗	15min
Met Office	***Mumbles*** Head	01/01/2000	31/03/2009	262700	187000	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	1hr

* This site has largely been excluded from analyses due to quality issues with the associated met. data, and the fact that no exceedences were identified during the monitoring period).
§ Corus were unable to provide numeric grid references for monitoring sites - but locations have been verified on a map.

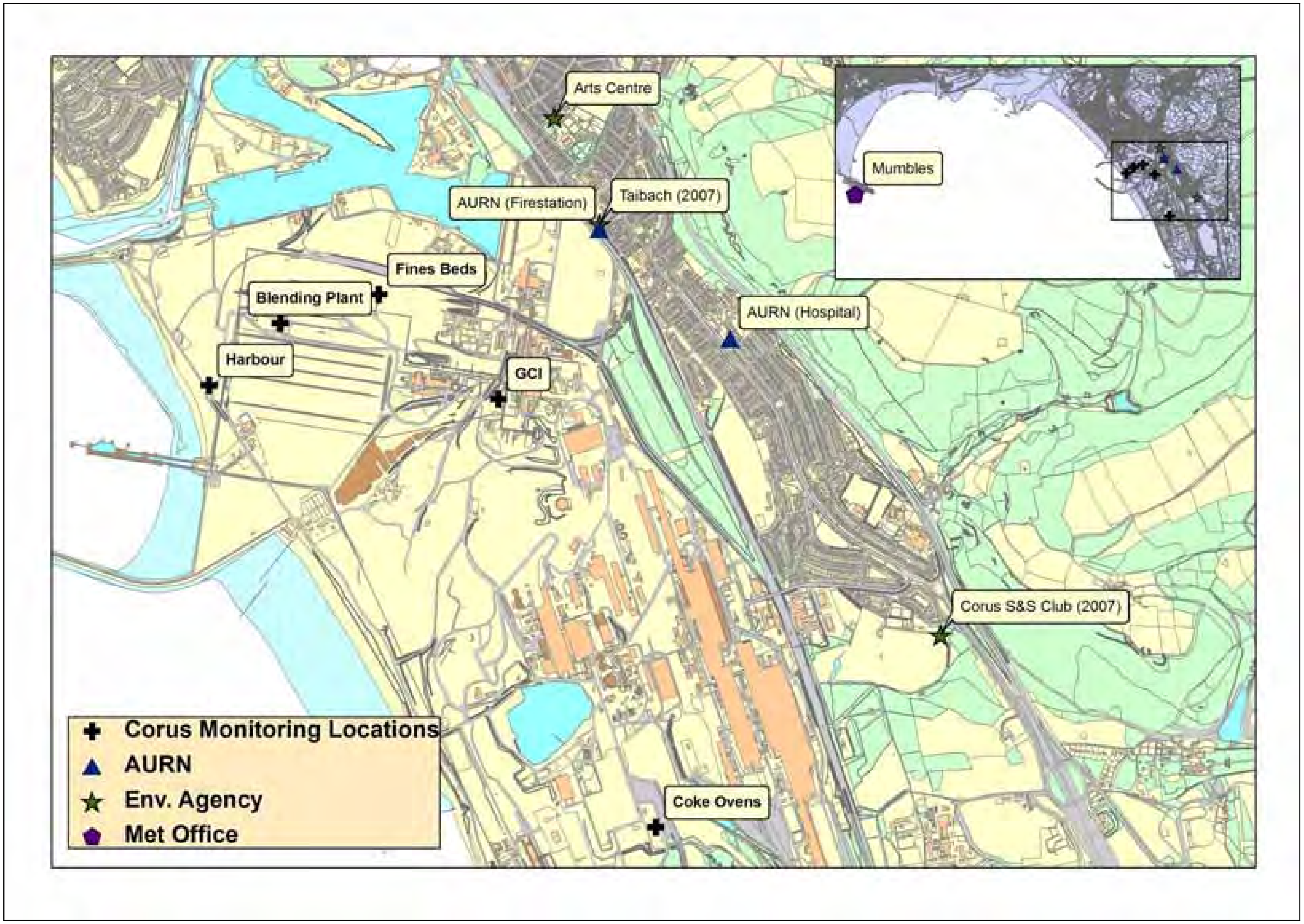


Figure 7: Location of Monitoring Sites Used in this Study

11 Spatial Analysis of PM_{10} Concentrations

11.1 Description of Polar Plots

The main analyses in this section have been carried out using the *polar plot* function in Openair. These are bivariate plots of pollution concentrations indicating how pollution concentrations vary by windspeed and wind direction. These plots are calculated using statistical smoothing techniques to show a continuous surface. The monitoring station is represented by the graph origin at the centre of the plot. The angles show the wind direction (e.g. the upper quadrants show concentrations with winds coming *from* the north), the distance from the origin indicates the windspeed (e.g. the further out the high concentrations appear the higher the windspeeds when they were monitored, calm conditions appearing closer to the origin).

11.2 Polar Plots from AURN Monitoring Stations

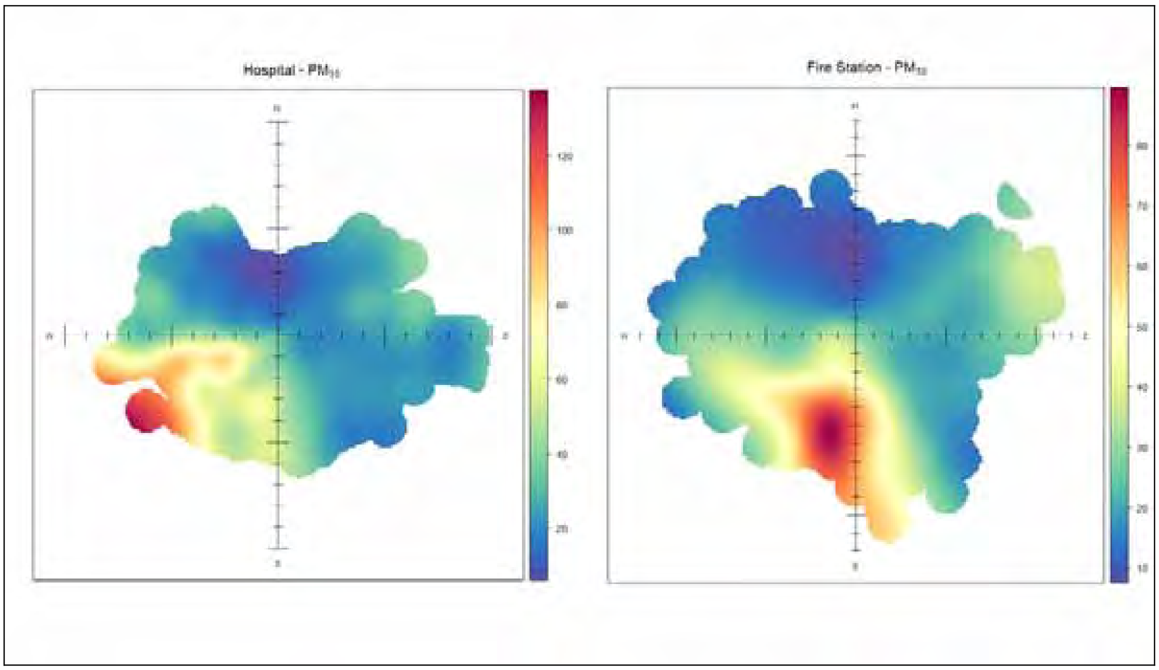


Figure 8: Polar Plots for PM_{10} at Hospital and Fire Station AURN Sites

Figure 8 shows concentrations of PM_{10} plotted with windspeed and direction at both the Port Talbot AURN sites (using all post-2000 data from each site). In clearly indicating that the highest concentrations of PM_{10} are monitored under south-westerly wind conditions, these graphs form the basic understanding of this analysis, that sources at the steelworks site to the SW of the AURN monitoring locations, are likely to be making the greatest contribution to PM_{10} concentrations in the local area. Concentrations of PM_{10} are highest at medium to high wind speeds, potentially indicating:

- predominant sources are not in immediate proximity to the monitoring sites; and
- concentrations are likely to be related to sources where emission or dispersion characteristics are affected by windspeed (such as wind-raised dust, or turbulent grounding of plumes).

11.3 Polar Plots from Hospital AURN

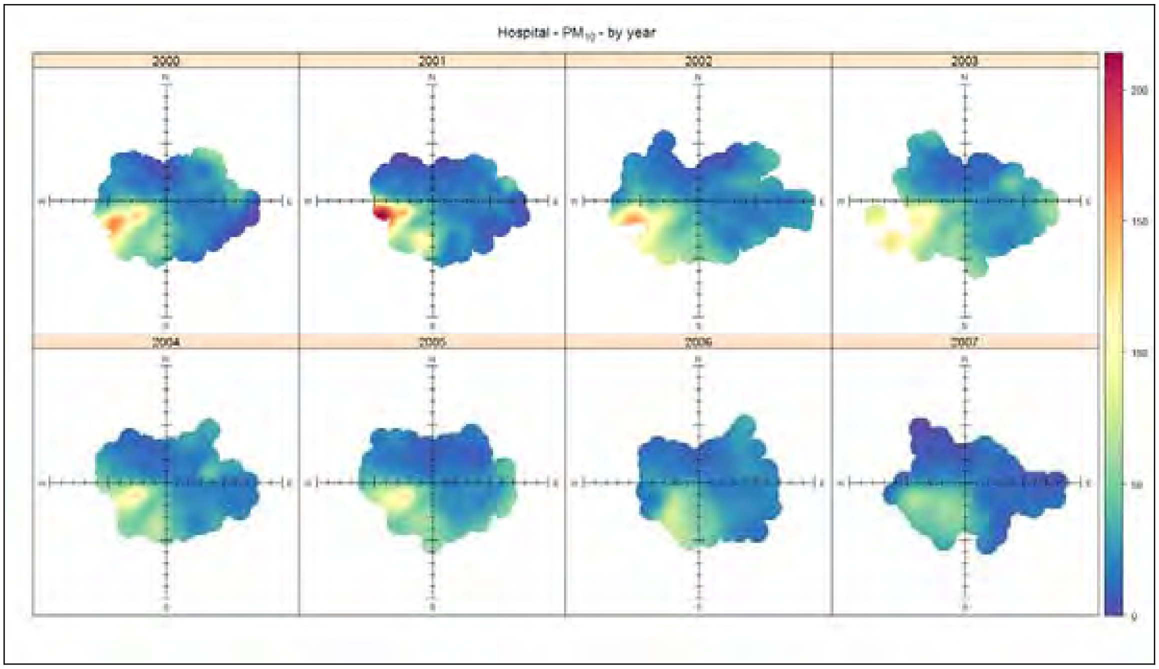


Figure 9: Polar plots for PM_{10} by Year at Hospital AURN (2000-2007)

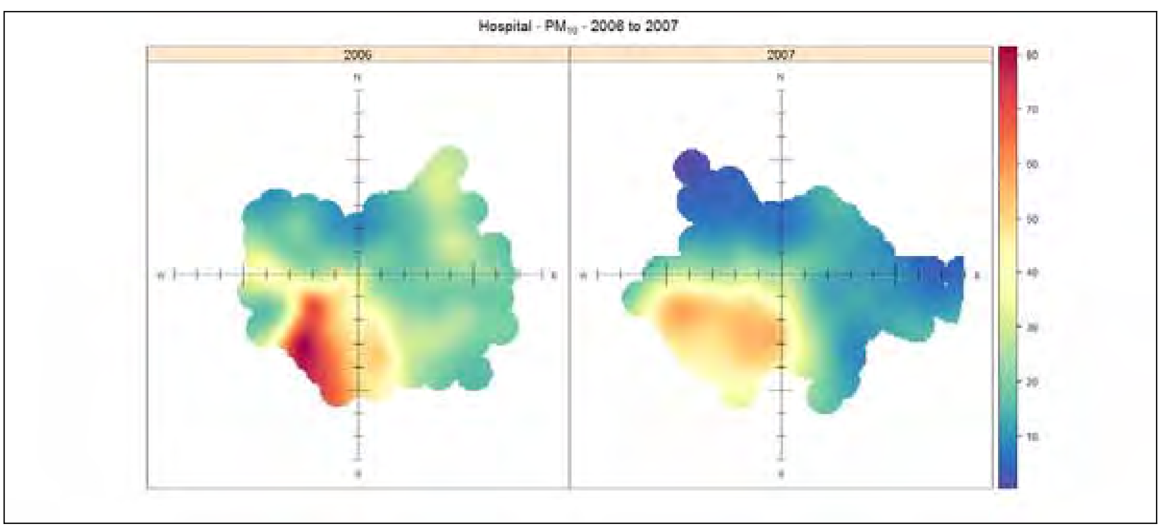


Figure 10: Polar Plots for PM_{10} by Year at Hospital AURN (2006-2007) Rescaled

Figure 9 and Figure 10 show concentrations of PM_{10} by windspeed and direction, for each individual year of data at the Hospital AURN site. The latter graphs have been replotted with their own legend and scale bar to more clearly indicate recent patterns. The plots indicate that concentrations declined between 2000 and 2007, particularly with respect to a dominant source WSW of the monitoring site. In most graphs there tends to be a split between stronger sources to WSW and the SSW. In Figure 10, the source SSW appears to be dominant. This suggests that there are possibly a range of sources at the site, and higher concentrations may not be attributable to a single discrete source (such as a single stack).

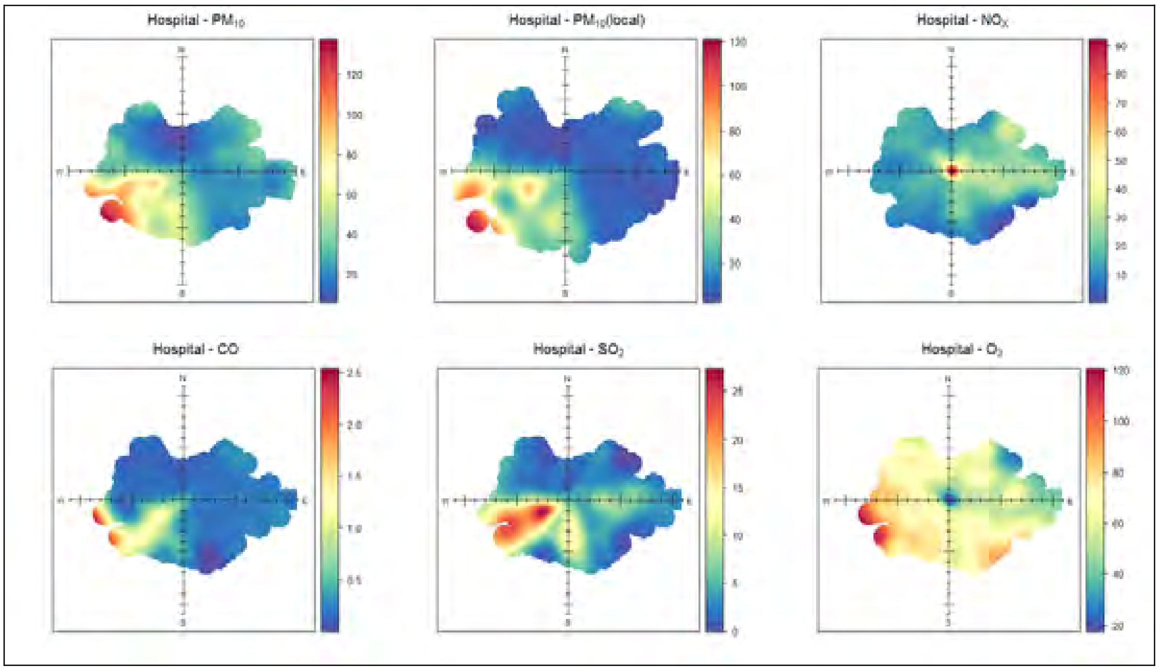


Figure 11: Polar plots for all pollutants at Hospital (2000-2007)

Figure 11 shows polar plots for all pollutants at the Hospital AURN site from 2000-2007.

- The plot of PM_{local} suggests that local sources of PM_{10} are even more focussed on the SW quadrant.
- The plots of CO and SO_2 show strong similarities in the SW to the PM_{10} plots, indicating that some of the PM_{10} is likely to be attributable to combustion sources.
- The plot of NOx shows a very different pattern, with highest concentrations occurring at very low windspeeds, and a tendency for concentrations to be higher under easterly winds. This suggests that NOx concentrations are liable to be dominated by low-level, sources such as transport, probably with a significant contribution from the motorway to the east, but tending to disperse in windier conditions.

- The plot of ozone (O_3) shows ozone originating from most directions. Ozone is a secondary pollutant formed by chemical reactions in the atmosphere, it is also destroyed through chemical reactions with NOx. The central core of the graph shows an inverse relationship to the NOx plot confirming this relationship. There is a notable hotspot on the graph to the WSW, further investigation has shown that this is associated with 2003 in particular, when the UK experienced severe ozone pollution episodes and it does not appear to be clearly associated with steelwork sources to the SW of the monitor. Concentrations of ozone by year are shown below in Figure 12 indicating that elevated Ozone concentrations are not correlated with any particular wind direction.

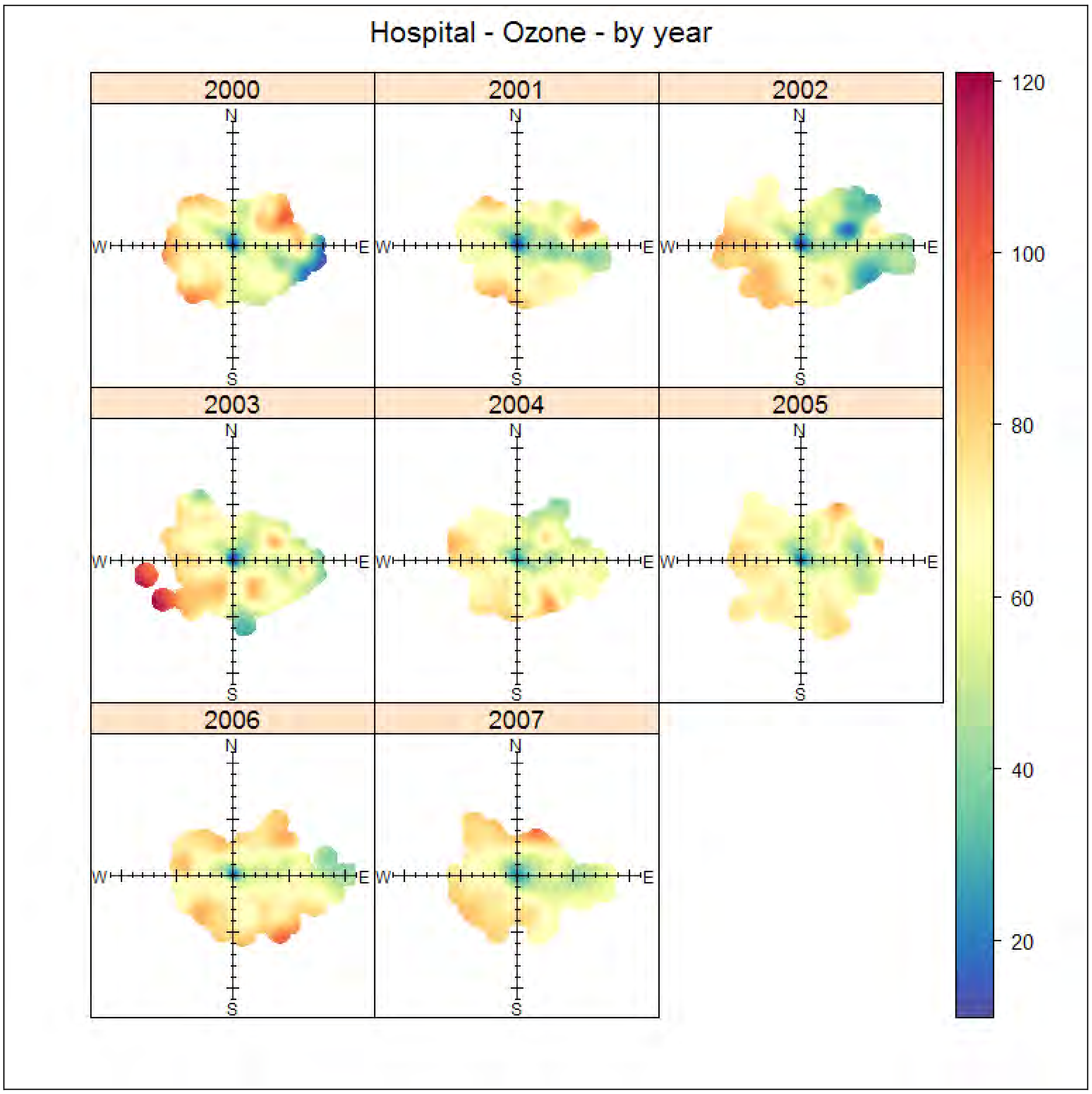


Figure 12: Polar Plots of Ozone by Year at Hospital AURN (2000-2007)

11.4 Polar Plots from Fire Station AURN

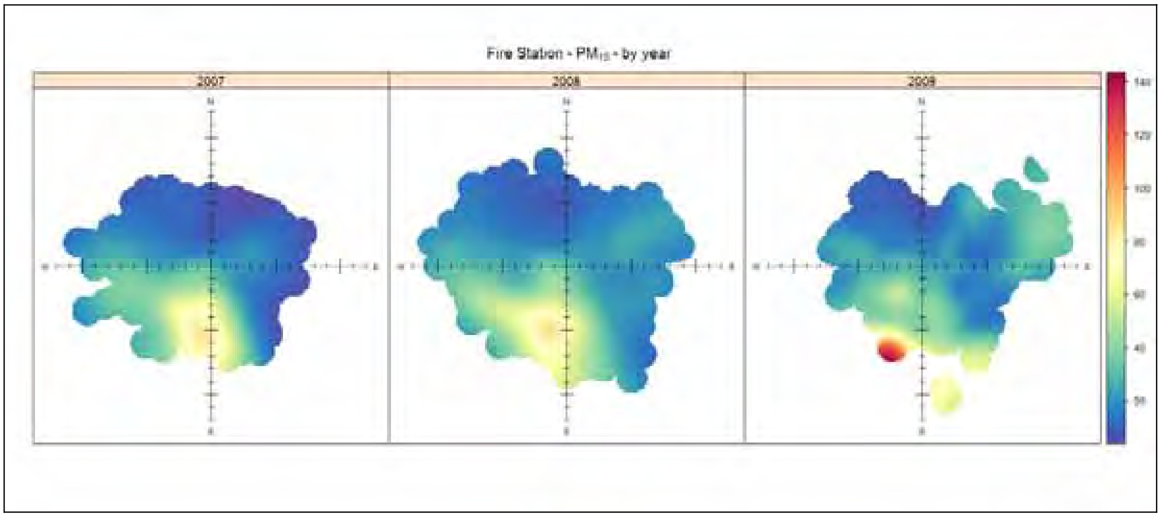


Figure 13: Polar plots for PM_{10} by Year at Fire Station AURN (2007-2009)

Polar plots of concentrations at the Fire Station AURN site show the highest concentrations coming from the SSW (N.B. 2007 and 2009 plots are constructed using less than 6 months data).

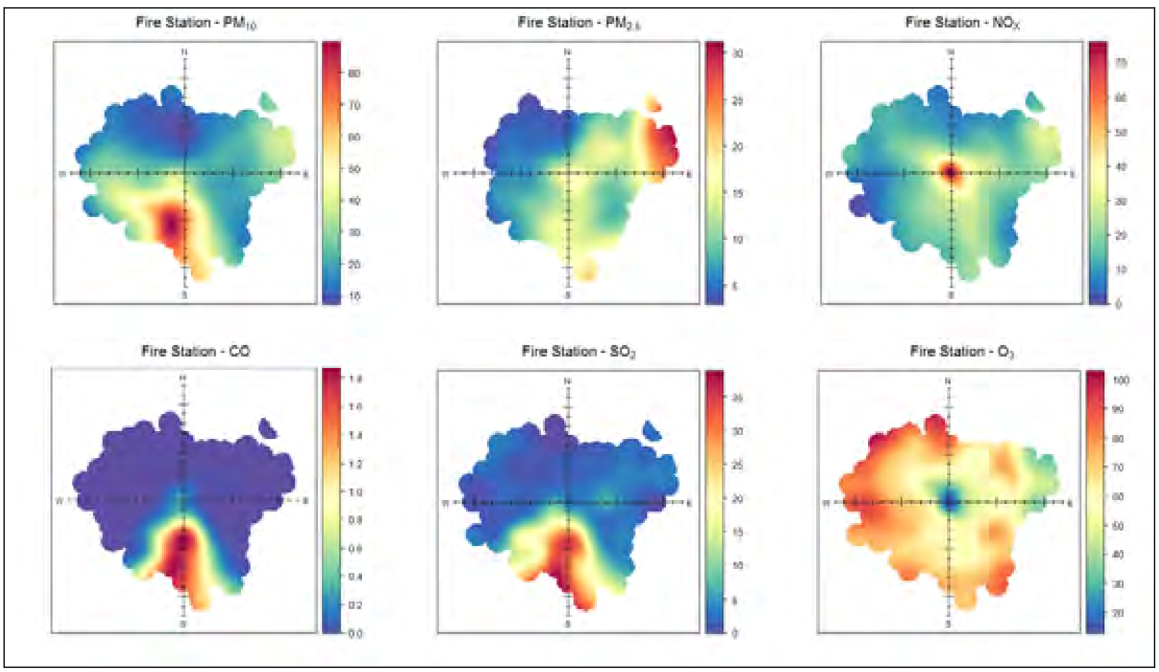


Figure 14: Polar plots for all pollutants at Fire Station AURN (2007-2009)

Figure 14 shows polar plots for all pollutants at the Fire Station AURN site:

- o As with Figure 11, PM_{10} shows a strong correlation with CO and SO_2 indicating a potential combustion source for the PM_{10}.

- NOx and O_3 show an inverse relationship, and the distinct O_3 hotspot is not present
- $PM_{2.5}$ is shown (instead of PM_{local}) and indicates that finer fractions of PM appear to be coming from sources to ENE rather than the SW. This strongly suggests that $PM_{2.5}$ may be dominated by smaller combustion particles associated with traffic (particularly the motorway), whilst PM_{10} is dominated by the coarser particle fraction from sources related to the steelworks site. This is contrary to the correlation of PM_{10} with CO and SO_2 as combustion pollutants and suggests that a significant proportion of PM_{10} from the SW quadrant may be associated with larger 'dust' type particles[1]. Caution is expressed about the potential for traffic to cause elevated concentrations of pollution at high windspeeds as this would lead to increased dispersion.

11.5 Triangulation of Sources Based on AURN Polar Plots

The polar plots from the AURN sites can be taken to provide a reasonable indication of the direction of the predominant pollution sources in respect to the monitors. Some analyses of available meteorological data have been undertaken and are presented in Appendix B**.** These demonstrate that air flows in the area of the steelworks vary considerably, however it is considered that the wind direction at each pollution monitoring station will be the most representative of the direction of the source. Figure 15 shows the polar plots located on a map of the local area. Sectors have then been defined relating to the strongest concentrations areas in each polar plot. Where the sectors overlap is then identified as the likeliest location for the main pollution source. In Figure 16, the likely source area has been overlaid on a map of key locations of key processes on the steelworks site. The key processes in or close to the likely source sector are:

- Cambrian Stone granulation activities
- Metal plating pits
- Furnace slag pits (just outside)
- Multiserv briquetting activities

Neither the blast furnaces or the sinter plant stack lie in this area.

[1] AQEG,2005 (section 2.2.3 and elsewhere) suggest that particles >1μm are generally the result of mechanical generation rather than nucleation (from combustion or atmospheric processes) and condensation or coagulation.

Figure 15: AURN Polar Plots Located on Map and Used to Identify Likely Source Area

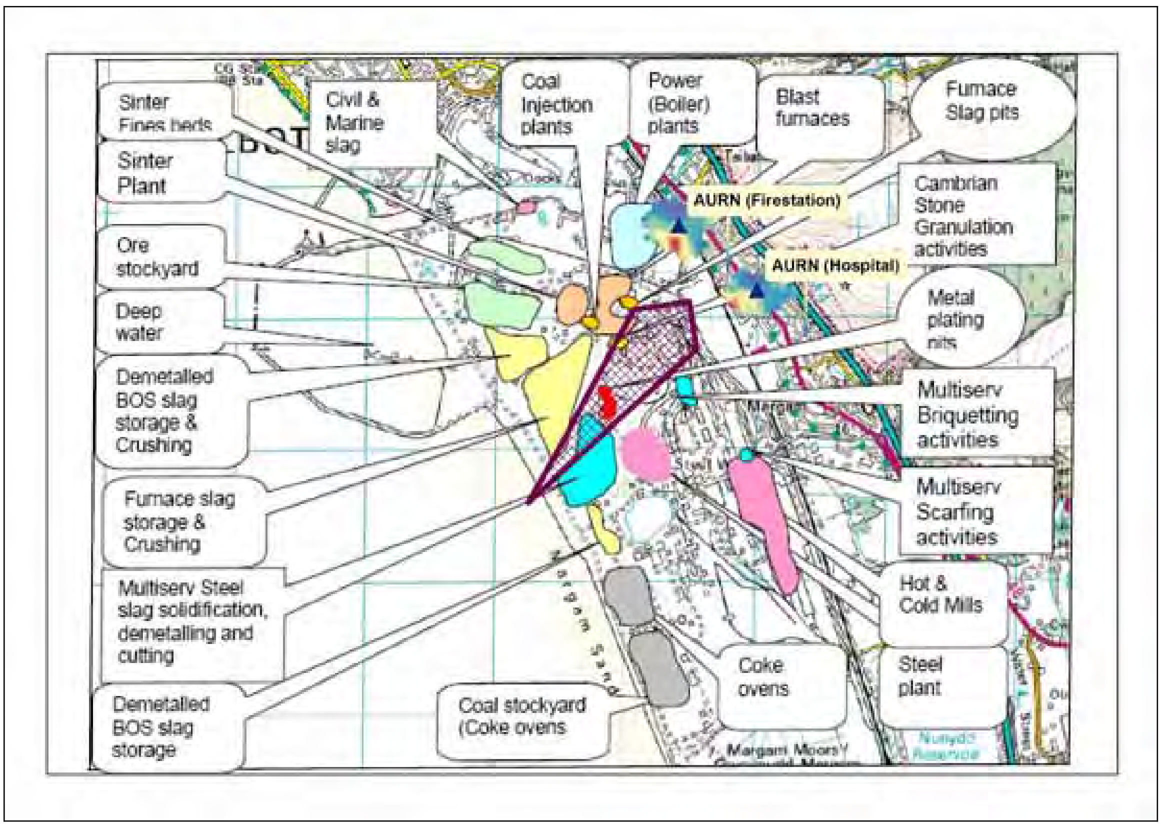


Figure 16: Likely Source Area Plotted on Map of Steel Making Process from EAW Permit Review

11.6 Polar Plots from EAW Monitoring Stations

Polar plots have also been generated from the data available from Environment Agency Wales monitoring data. As the Environment Agency was unable to provide verified meteorological data associated with the Arts Centre monitoring, no polar plots have been presented for this location.

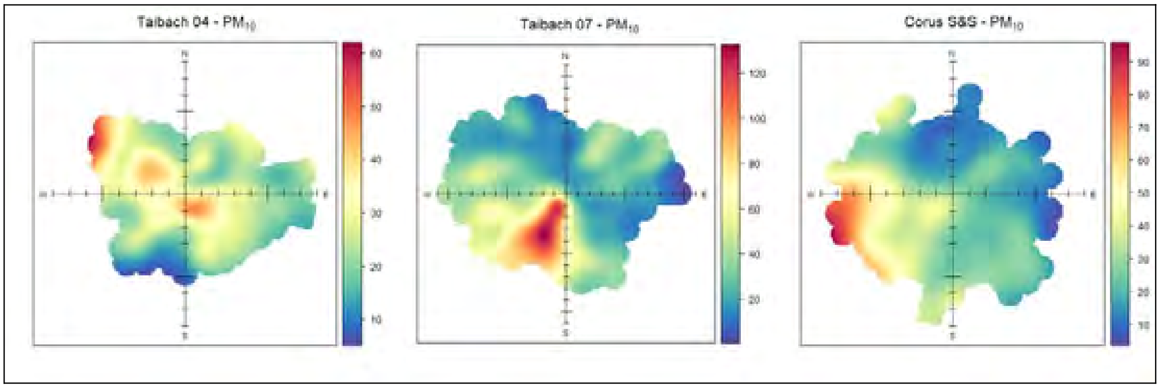


Figure 17: Polar Plots for PM_{10} at EAW Monitoring Sites at Taibach and Corus S&S Club

Figure 17 shows polar plots for three of the EAW monitoring campaigns. Results from Taibach 07 strongly mirror those from the AURN Fire Station site (the locations are the same). The main sources with regard to the Taibach 04 monitoring campaign however do not lie in the SW quadrant. Some impact of higher concentrations from the SW (as opposed to SSW) is evident, however, the main source impacts at high windspeeds from the NW. There are also hotspots at low windspeeds from the SE and low to medium windspeeds to the NW. In the consultation with WAG, EAW and the site operators in the preparation of the report, no firm suggestions have been made for the NE sources.

Data from the Corus Sports and Social Club monitoring campaign show predominant sources to the west (and WSW) of the monitor.

Figure 18: EAW Polar Plots Located on Local Area Map Indicating Likely Source Areas

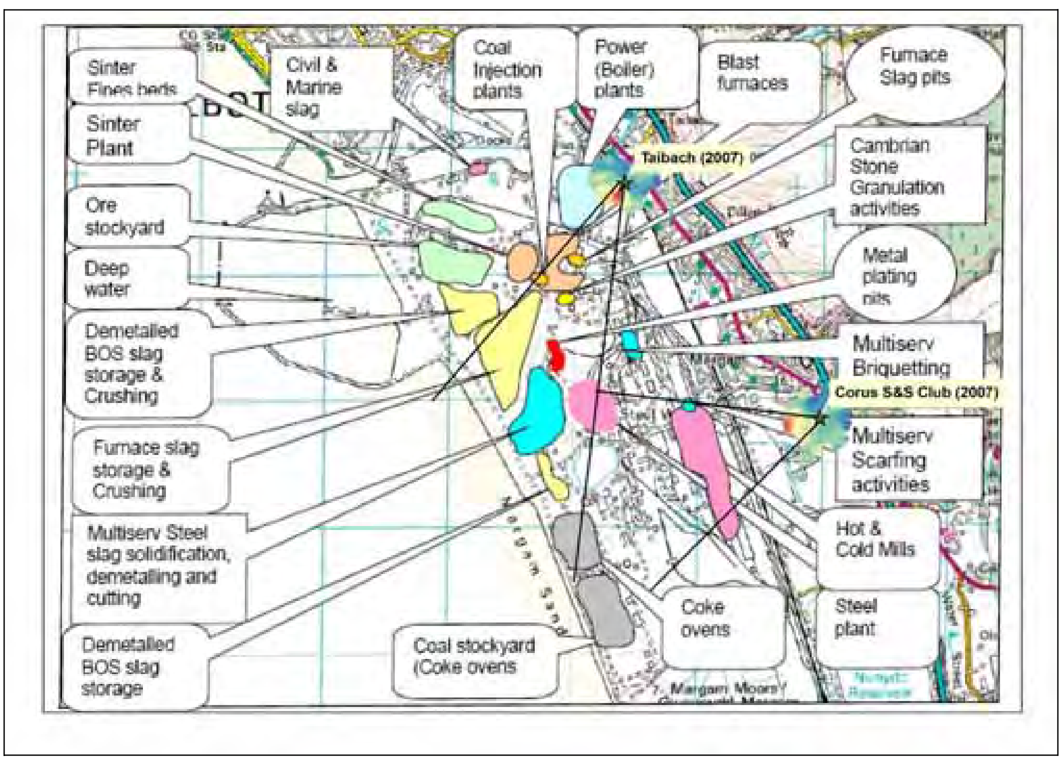


Figure 19: Polar Plots of EAW 2007 Data on Map of Steel Making Process from EAW Permit Review

Figure 18 shows the polar plots from Taibach 2007 and Corus Sports and Social Club campaigns plotted on a map of the local area. Due to the location of the Corus S&S monitoring much further south than the Taibach/AURN sites, it is considered unlikely that the pollution impacting on these sources is from the same specific sources. Placing the plots on the map of steel making activities (Figure 19) suggests that activities potentially impacting on the Corus S&S Club monitoring location may include:

- o Multiserv scarfing activities;
- o Hot and cold mills;
- o Steel plant;
- o Multiserv steel slag solidification, demetalling and cutting;
- o Demetalled BOS slag storage; and
- o Furnace slag storage and crushing.

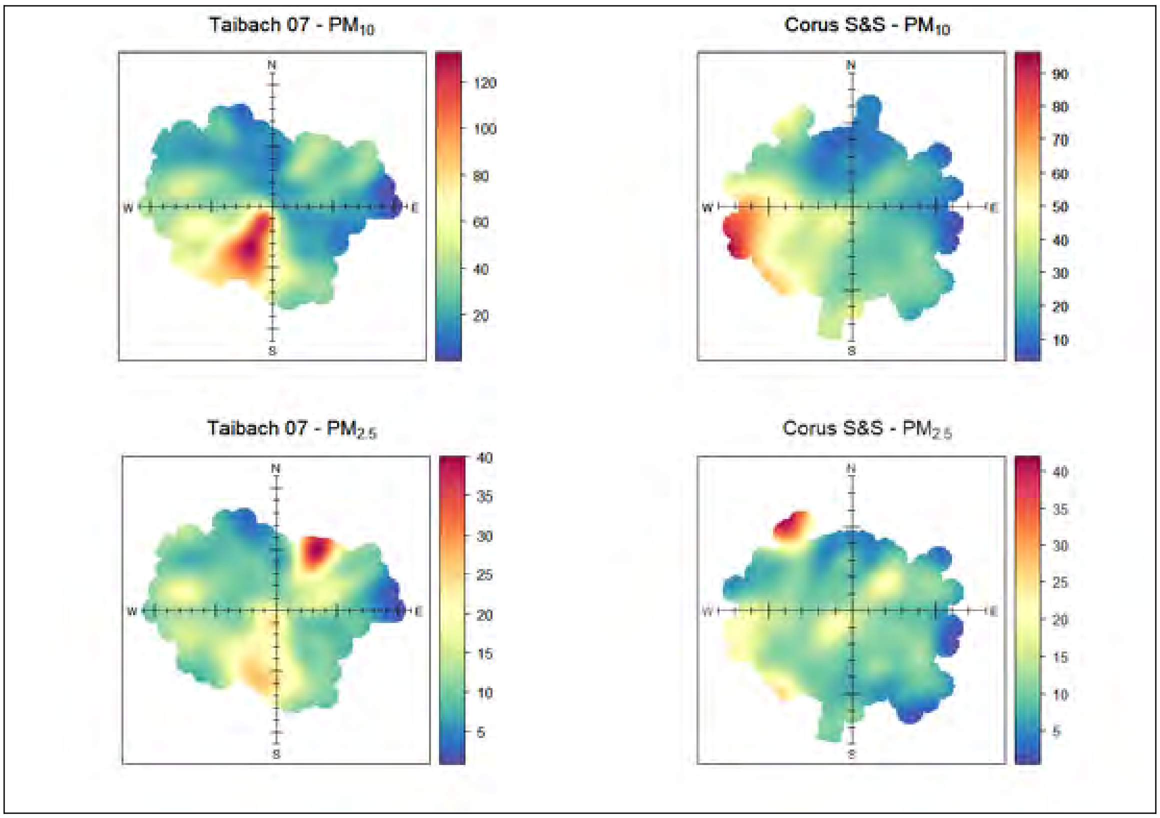


Figure 20: Polar Plots of PM_{10} and $PM_{2.5}$ at EAW Monitoring Sites (Individual Sclaes)

Figure 20 shows a comparison of polar plots for PM_{10} and $PM_{2.5}$ for the Taibach 07 and Corus S&S Club monitoring campaigns. As with the AURN Fire Station measurements, the Taibach 07 data indicates that $PM_{2.5}$ at this location is mainly related to sources to the NE of the monitoring location (although it does show a visible contribution from the SSW). At the Corus S&S Club site, the main source of $PM_{2.5}$ appears to be to the NE at quite high windspeeds. This is potentially in the direction of the A48 as it runs through Margam, although caution is again expressed in relation to the potential for traffic sources to cause elevated pollution concentrations at high wind speeds.

11.7 Polar Plots from Steelworks Topas Monitoring Stations

The data obtained from the network of Topas monitors operated by Corus on the steelworks site provide a very useful indication of concentrations on the site itself. Until August 2008, all available monitoring data was located to the west of the site and only able to provide a very approximate indication of where on the steelworks site might be emitting significant amounts of PM. The data obtained from the Topas monitors (see Figure 23) provides strong evidence that there is a wide variety of PM sources on the steelworks site.

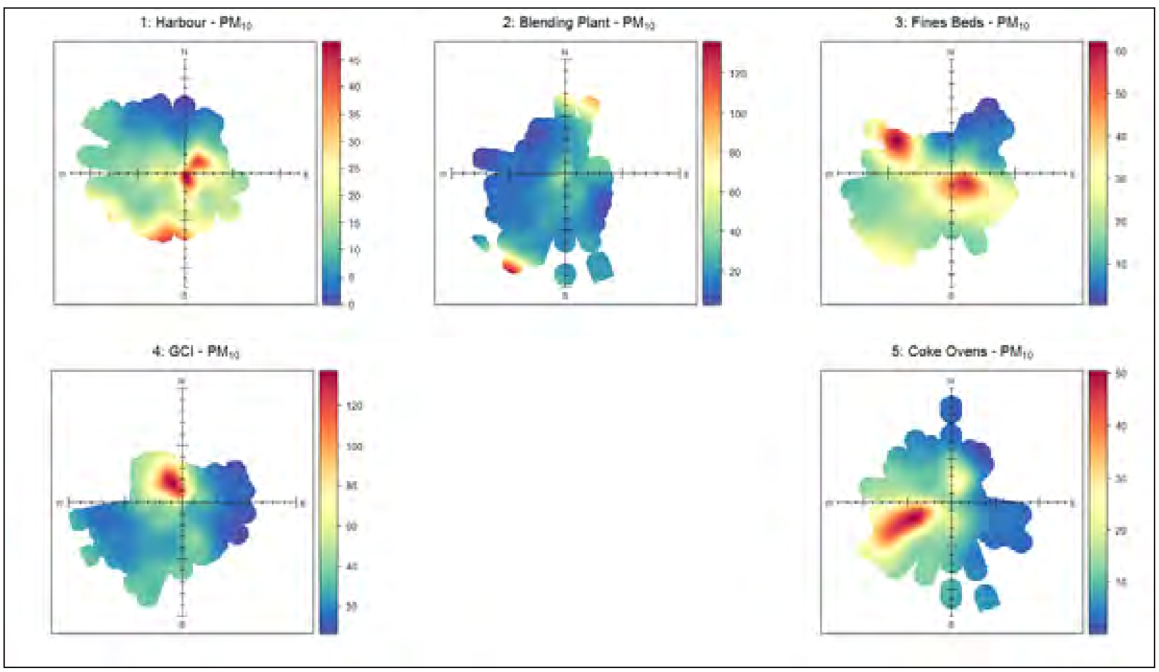


Figure 21: Polar Plots for PM_{10} at Corus Topas Monitoring Sites (Individual Scales)

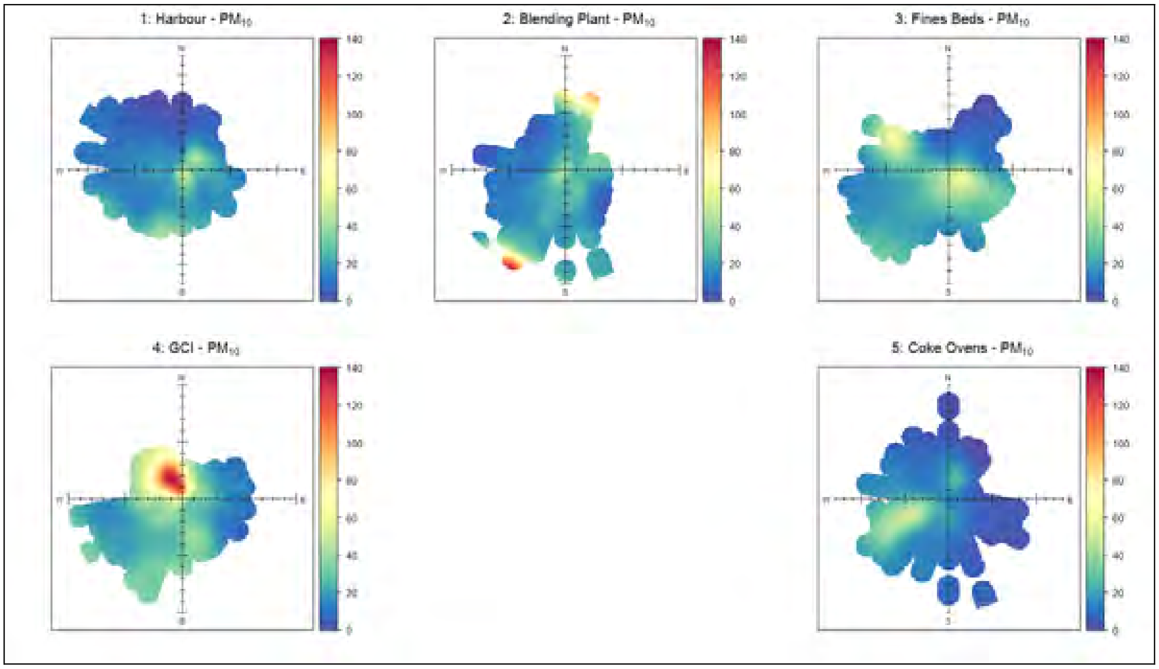


Figure 22: Polar Plots for PM_{10} at Corus Topas monitoring sites (Same Scaling)

Figure 21 and Figure 22 show concentrations of PM_{10} by wind speed and direction at each of the Corus Topas sites. Figure 21 shows the plots with a scaling set on the basis of each individual site, Figure 22 shows the plots with scaling set according to the highest sites. The plots indicate that the highest concentrations appear to be at the Blending Plant under high wind conditions from the NNE and SW/SSW (potentially wind raised dust) and at the GCI (Granular Coal Injection) plant at low wind speeds from the NW.

Each site appears to be impacted by its own set of sources, indicating that there are numerous sources of PM_{10} within the steelworks site. What is not immediately clear from the data analysis so far is how these on-site concentrations impact on off-site concentrations. It is evident that these dispersed sources are likely to generally elevate PM_{10} concentrations off-site, but a question remains as to whether the monitored exceedences of the air quality objective result from combined impacts of diffuse sources, the particular impact of a very strong single source, or a combination of the two.

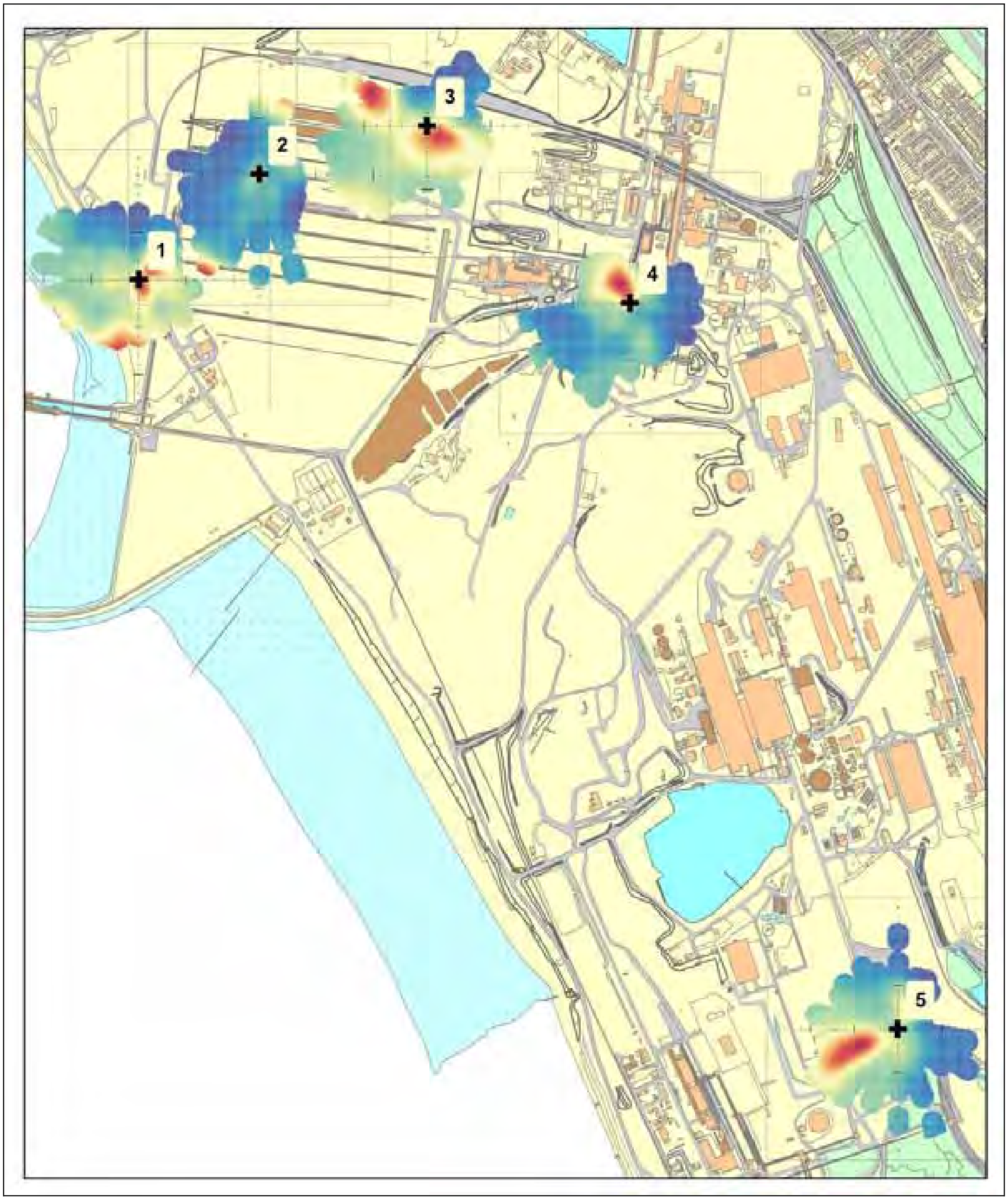


Figure 23: Corus Topas Polar Plots for PM_{10} Located on Map (Individual Scales)

Figure 23 shows polar plots of the Corus Topas data overlaid on a map of the site indicating the location of the strongest contributions to monitored PM_{10} at each location.

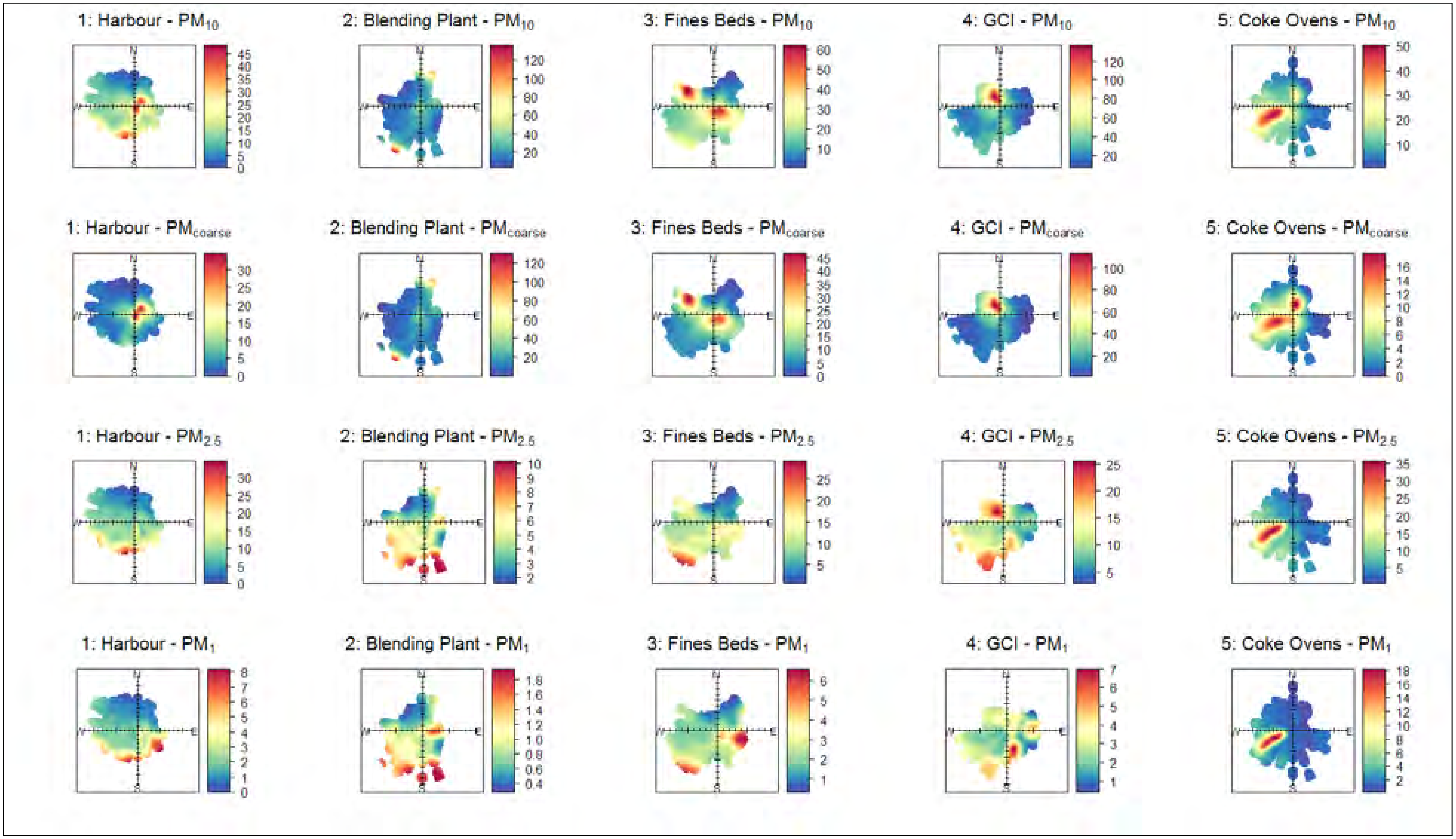


Figure 24: Polar Plots of Different PM_{10} Fractions at Corus Topas Monitoring Sites

Figure 24 shows polar plots for 4 different fractions of PM_{10} (Total PM_{10}, PM_{coarse}, $PM_{2.5}$ and PM_1). The plots clearly indicate that each of the sites is being affected by a range of sources – both in terms of direction and in terms of the size of particles impacting on the site.

- **Harbour:** Sources of PM_{coarse} impacting at low wind speeds to the SE and NE of the monitor (probably road dust). Sources of $PM_{2.5}$ and PM_1 impacting at higher wind speeds to S and SW. Source of PM_1 impacting at medium wind speeds to SE. N.B. Concentrations of $PM_{2.5}$ are reaching the same concentrations as PM_{coarse} at this location.
- **Blending Plant:** Large sources of PM_{coarse} to the SW and NNE of the monitor. Much less significant sources of $PM_{2.5}$ and PM_1 distributed to the south.
- **Fines Beds:** PM_{10} is dominated by sources of PM_{coarse} to the SE (at low wind speeds) and the NW at medium wind speeds. Significant source of $PM_{2.5}$ to the SW and source of PM_1 to the E.
- **GCI:** Very strong source of both PM_{coarse} and $PM_{2.5}$ to the NW under low wind speeds. Strong sources of $PM_{2.5}$ and PM_1 to the SSW and SSE**.**
- **Coke Ovens:** Concentrations here are dominated by a very tightly defined source to the SE emitting PM across all fractions (probably the Coke Ovens themselves). There is also a source of PM_{coarse} impacting at low wind speeds just to the north of the monitor (again this is probably dust from a roadway).

These analyses show the complexity of the sources located on the steelworks, particularly with regard to whether or not sources of particles contribute significantly to PM_{10} levels due to the considerable difference in mass between the finer and coarser fractions. There is potential for considerable work to be done in the future correlating patterns of pollution being measured off-site, with that being measured at the on-site monitoring locations.

11.8 Summary of Spatial Analysis

The analysis of off-site monitoring from the AURN and EAW monitoring sites clearly suggests that the steelworks site is the major contributor to PM_{10} concentrations at those monitoring sites. It is probably important to note that the contribution to $PM_{2.5}$ concentrations from the site is much less significant than sources to the NE of the Fire Station/Taibach monitoring site (which *may* be attributable to road traffic, particularly the M4 motorway).

Both the on-site monitoring and the difference between the directions indicated by the AURN and Corus S&S Club monitoring suggest that there are a wide range of sources of PM_{10} on the site that may impact on areas of Port Talbot differently. Areas further south on the A48 are likely to be exposed to significantly different patterns of pollution to those further north where the AURN sites have been located.

The correlation between the source direction for PM_{10} with that for CO and SO_2 strongly suggests that there is a significant chance that a combustion source is playing a major role in the generation of PM_{10}. The highest concentrations of PM_{10} are being monitored at times of medium to high windspeeds (not low). Whilst this may again support an argument for emissions to be coming from a stack source (with high windspeeds leading to increased turbulence and grounding of plumes), these windspeeds are also associated with a greater risk of wind-raised dust from stockpiles, conveyor belts or road surfaces. The absence of high PM_{10} concentrations at low windspeeds suggests that traffic is not likely to be a major contributor to concentrations.

12 Temporal Analysis of Monitoring Data

This section of the report looks at temporal patterns in the pollution data. This consists of a number of different analyses:

- Examination of long-term trends in the AURN pollution record, including differences between the pollution monitored at the Hospital and Fire Station AURN sites (this however, is also considered in more explicit detail in Sections 13 and 14).
- Examination of variations in pollution concentrations by time of day, week and year.
- Calculation of seasonal variations in the occurrence of pollution events.

12.1 Long-term Analyses of Pollution Concentrations at the AURN Sites

As already demonstrated by year on year changes in concentration in the polar plots of PM_{10} at the Hospital site (see Figure 9), there is some evidence that concentrations of PM_{10} have been declining overall since 2000. In this section the long-term time series from the AURN monitors is analysed to further determine trends in pollution concentrations since 2000. In most analyses the time series considered consists of monitoring data from both the Hospital and Fire Station AURN sites. Whilst this would not be recommended as normal practice it has been done here for two reasons, firstly to help investigate whether there is an identifiable difference in concentrations between the two monitoring locations that might be in addition to general trends of decreasing concentrations and seasonal variation, and secondly to have at least one clearly identifiable point of change in the monitoring record.

With regard to changes in monitoring, a number of potential ‘landmarks’ have been identified since 2000 that define possible shifts in patterns of pollution (both in terms of source and measurement). These are:

- **June 2001:** Ceasing of material shipment to Llanwern.
- **November 2001:** Commencement of single blast furnace operation following explosion.
- **January 2003:** Commencement of dual blast furnace operation.
- **July 2007:** Relocation of AURN to Fire Station.

On the 14th December 2008 Blast Furnace 4 was taken offline. This has not been taken into account in these analyses as there is only 3 months data after this date, however, it should be taken into consideration when any of the analyses indicate that pollution concentrations appear to reduce at the Fire Station site.

12.2 Trends in Pollution by Wind Sector

In this section, trends in the long-term dataset covering both AURN sites is split into time series for average monthly concentrations for each wind sector.

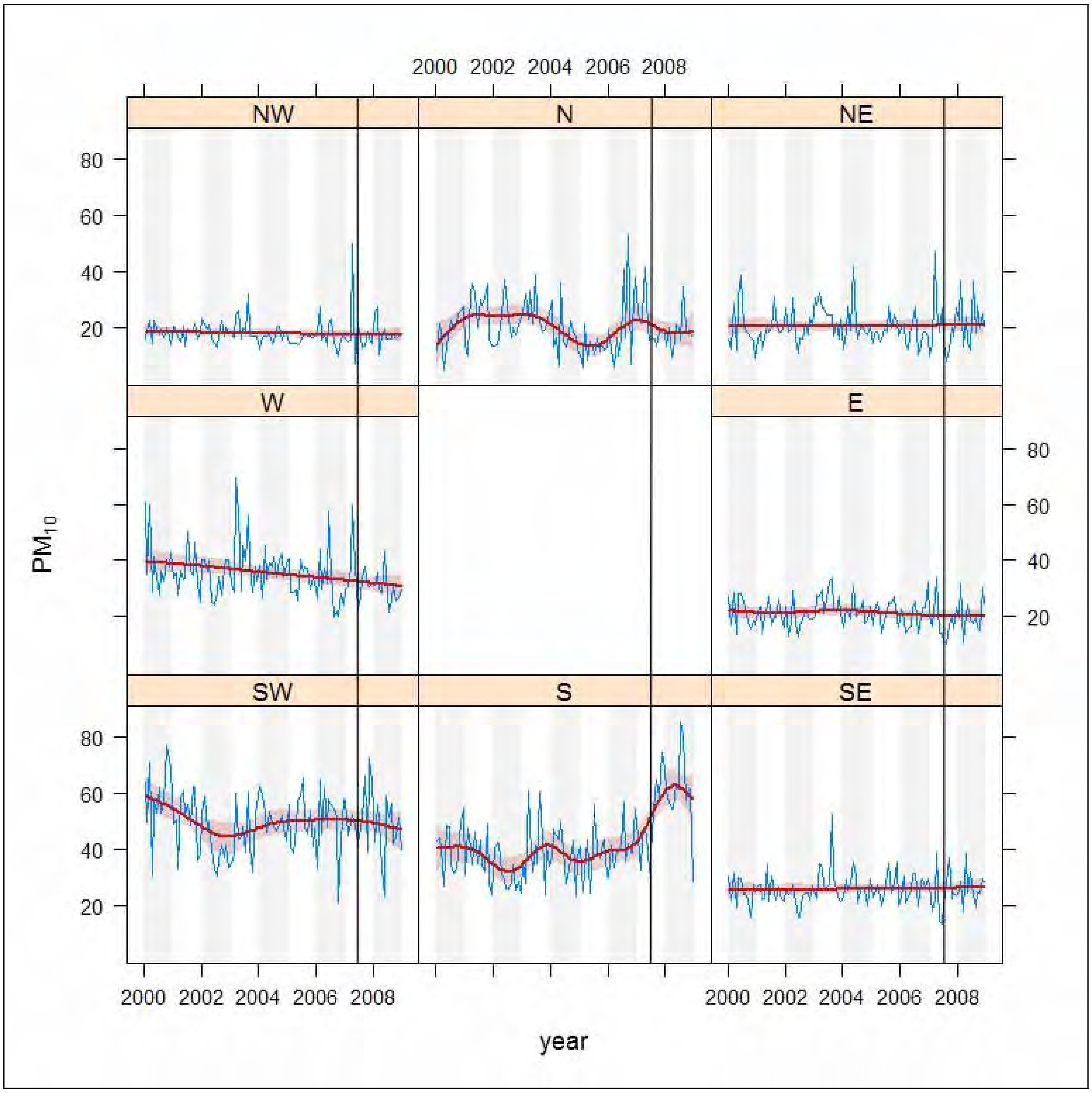


Figure 25: Trends in PM_{10} Concentrations at AURN Sites by Wind Sector (2000-2009)

Figure 25 shows a plot created using the *smooth.trend* function in Openair. This shows monthly averages for PM_{10} at the AURN sites (in blue), with a smoothed average (red). Data have also been deseasonalised prior to the trend analysis. The vertical grey lines indicate the date that the AURN site monitor was relocated to the new Fire Station site.

The key points to be derived from this graph are:

- The data from the NE, E, SE and NW sectors do not show any particularly distinct trends.
- Data from the northern sector shows fluctuations. This pattern indicating PM_{10} sources to the north of the monitoring sites has been found in other analyses undertaken. It does not appear to significantly contribute to any exceedences of the daily mean PM_{10} objective and concentrations resulting from northerly winds are much lower on average than those from the S to W sectors. No source has been clearly identified to the north, however a strong hypothesis (following discussion with NPTCBC, WAG, EAW and the site operators) is that dust or smoke from wild fires on top of the nearby hills may be a contributor. Some further analyses of this are presented in Appendix C.
- For the westerly sector the trend has been for a gradual decrease in concentrations over the whole period. Concentrations following the relocation of the monitoring site appear to lie within this general trend.
- To the SW and S the trend shows a much more varied pattern. The trend shows a dip and then a rise that appears to relate to the period of single blast furnace operation between November 2001 and January 2003. Following the relocation of the monitor in summer 2007 there is a slight reduction apparent in concentrations from the SW but a very marked increase in concentrations from the S (it should be remembered here that the monitoring method changed to TEOM (FDMS) in February 2007). Differences between the monitored concentrations at the two sites are examined further in Sections 13 and 14.

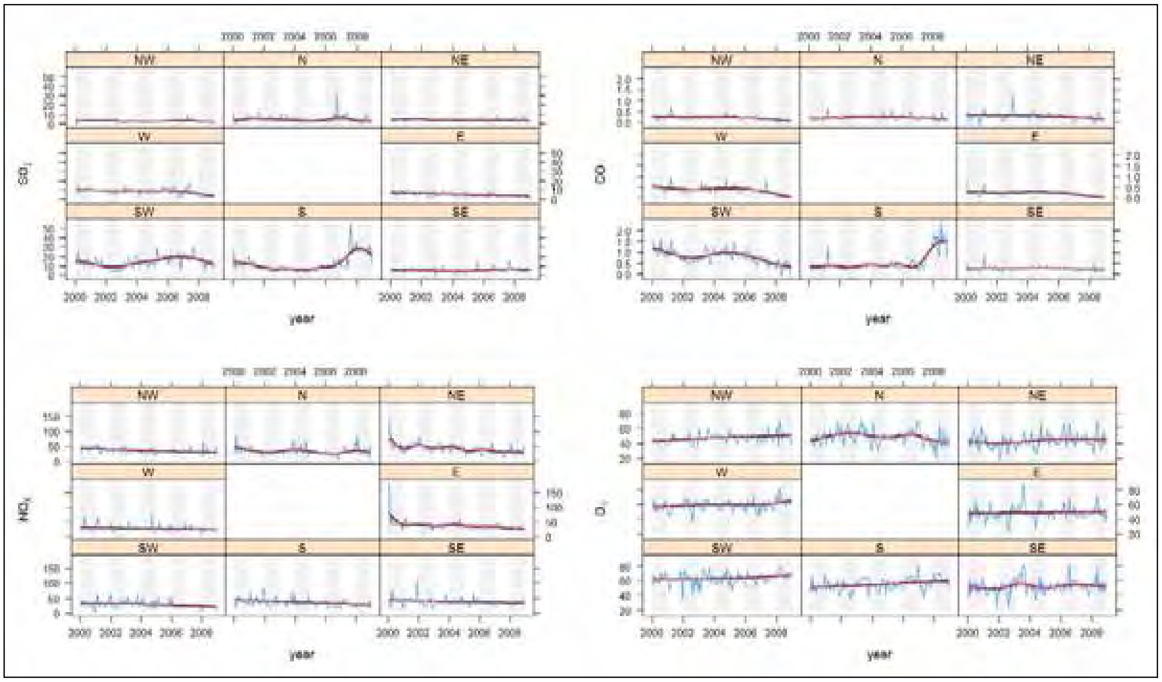


Figure 26: Trends in Other Pollutant Concentrations at AURN Sites by Wind Sector (2000-2009)

Figure 26 shows concentrations of other key pollutants (SO_2, CO, NOx and O_3) at the AURN stations. Combustion source pollutants SO_2 and CO show similar fluctuations in the SW sector to PM_{10} (a reduction during the period of single blast furnace operation and then a subsequent increase when 2 furnace operation resumed). Both show a sharp reduction in the W and SW sectors following relocation of the monitoring site. Concentrations of SO_2 and CO monitored from the southern sector both increase sharply with the relocation of the site.

The analyses for NOx show a general reduction in concentrations over time from most sectors, whilst for ozone they show a general increase (with some sectors showing a pronounced rise relating to the summer ozone episodes in 2003 and 2006).

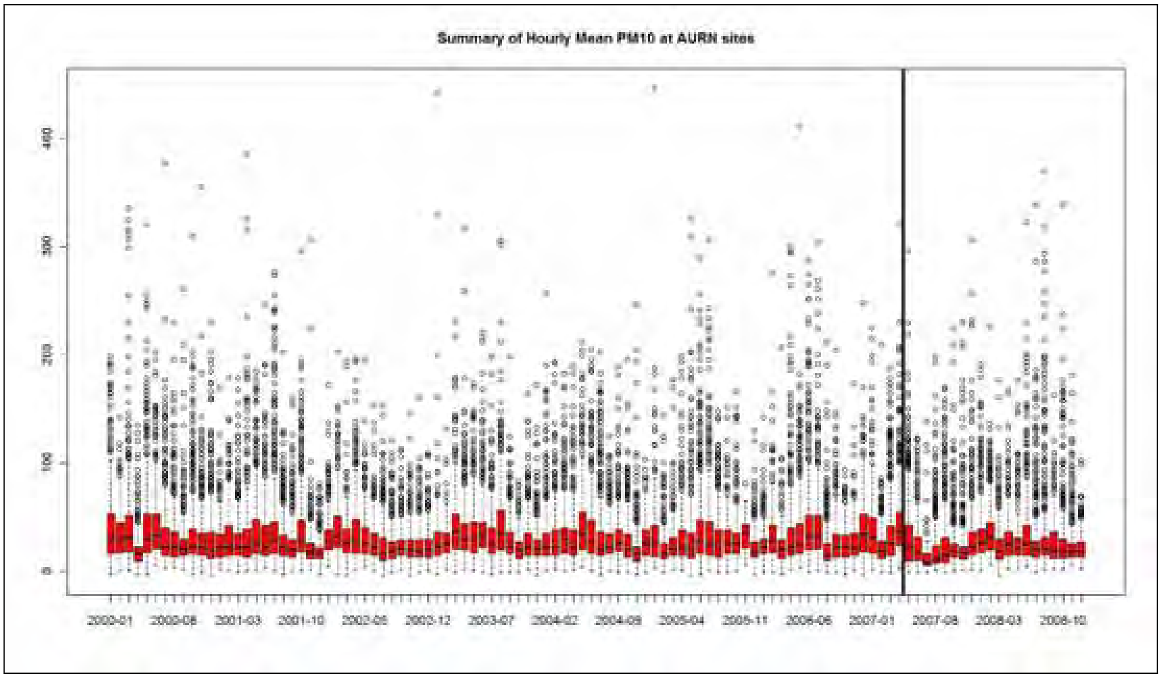


Figure 27: Summary of Hourly Mean PM_{10} at AURN Sites

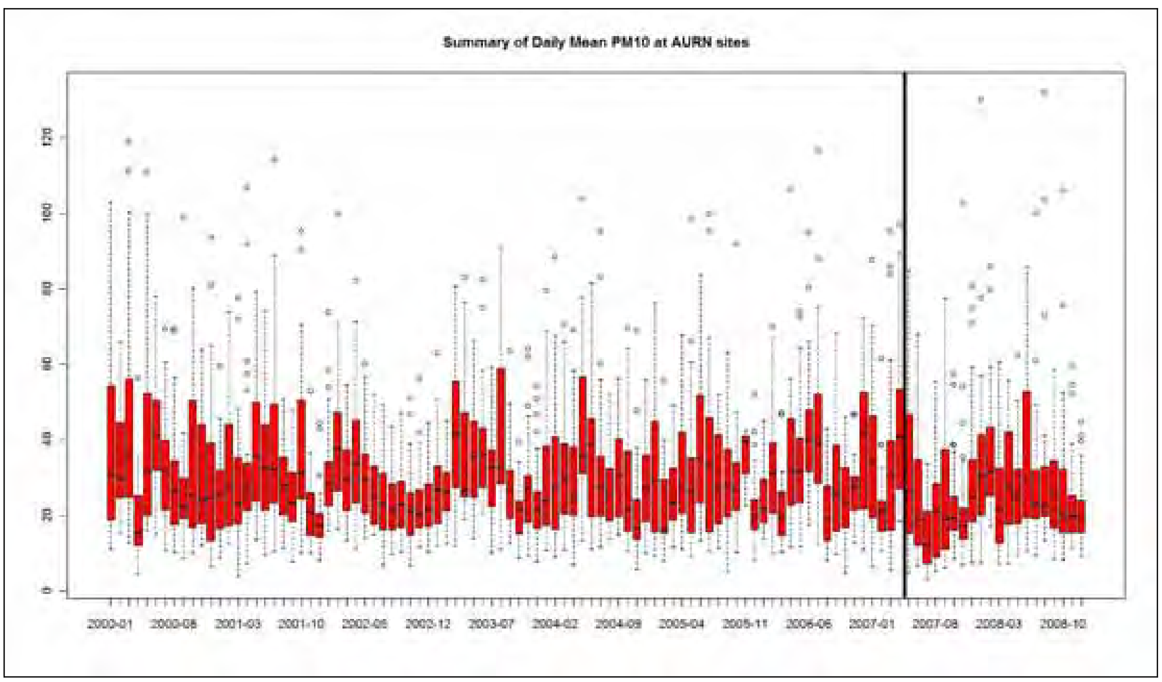


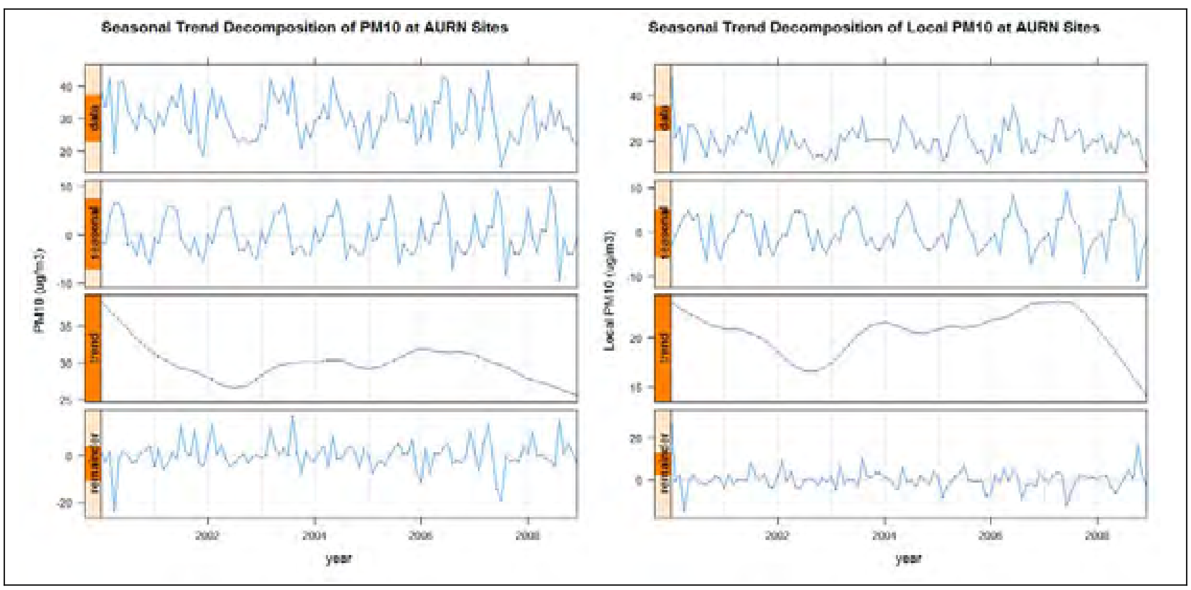
Figure 28: Summary of Daily Mean PM_{10} at AURN Sites

Figure 27 and Figure 28 show summaries of hourly and daily PM_{10} concentrations at the AURN sites since 2000. Again the vertical black line indicates the relocation of the AURN monitor from the Hospital site to the Fire Station. The figures are *box and whisker* plots. The red box indicates the upper and lower quartiles for concentrations in each month. The horizontal black line in each red box indicates the median (hourly or daily) value for each month. The lines represent the maximum and minimum values *excluding any outliers* (defined as values being 1.5 times greater or less than the quartiles). The dots represent those extreme concentrations that have been defined as the outliers. The graphs suggest that, following the relocation of the AURN site, average pollution concentrations (indicated by the red boxes) may have reduced, however extremes of both hourly and daily PM_{10} concentrations appear to be of approximately the same magnitude and frequency as they always were.

12.3 Seasonal Trends

Using *R* and *Openair* it is possible to identify trends within long time series and the *stl.plot* function analyses trends in monthly means and may identify seasonal variations and trends over time. These graphs each show four discrete plots:

- Raw data as monthly means.
- Seasonal trends in the data.
- Long term trends evident once seasonal trends have been removed.
- Remaining variations in monthly means once seasonal and long-term trends have been removed.



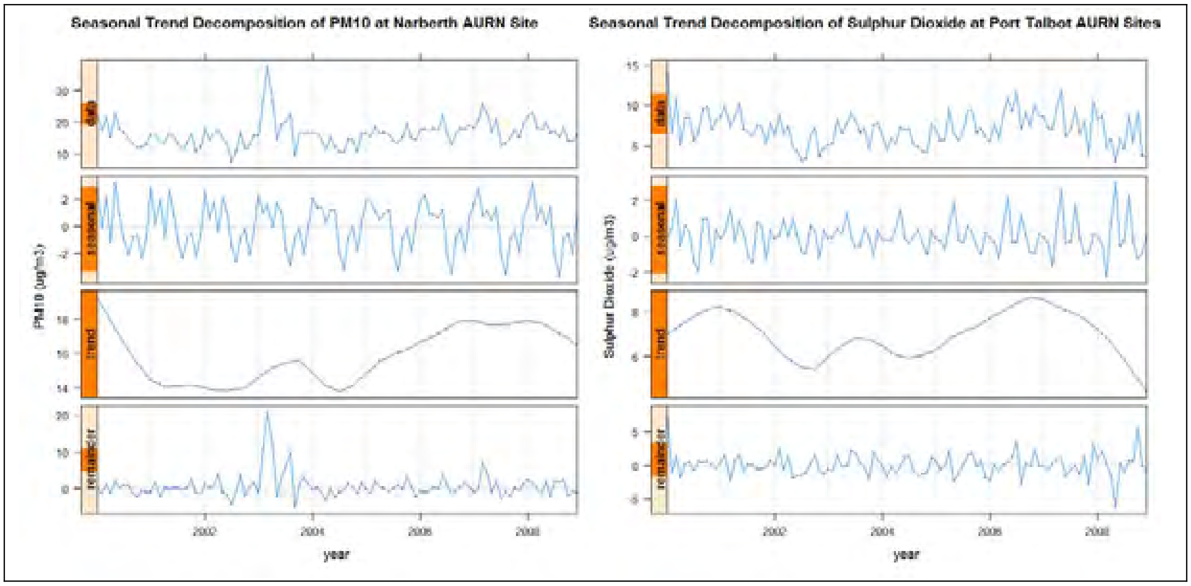


Figure 29: Seasonal Trend Decomposition for PM_{10} and PM_{local} at AURN Sites

Figure 29 shows seasonal and long-term trends for both total PM_{10} and PM_{local} (i.e. PM_{10} measured in Port Talbot minus background concentrations taken from the Narberth AURN site). The graphs suggest a number of points:

- All plots show a strong seasonal cycle (N.B. the difference in scale between the upper and lower plots indicating that local PM_{10} concentrations appear to have a cycle that greatly outweighs the seasonal cycle of regional secondary PM_{10})
- Both background and local PM_{10} concentrations tended to drop 2000-2001. Local sources began to rise again in 2003 (following resumption of dual blast furnace operation) whilst background concentrations remained low until beginning to rise again in 2005-2006 (aside from a peak in 2003 which is probably attributable to the summer heatwave that year).
- Although measured PM_{10}, $PM_{(local)}$ and SO_2 concentrations do appear to decline following the relocation of the AURN station in July 2007, it is also important to note that background concentrations also appear to reduce in 2008 which may over-emphasise this trend when it shows in other analyses.

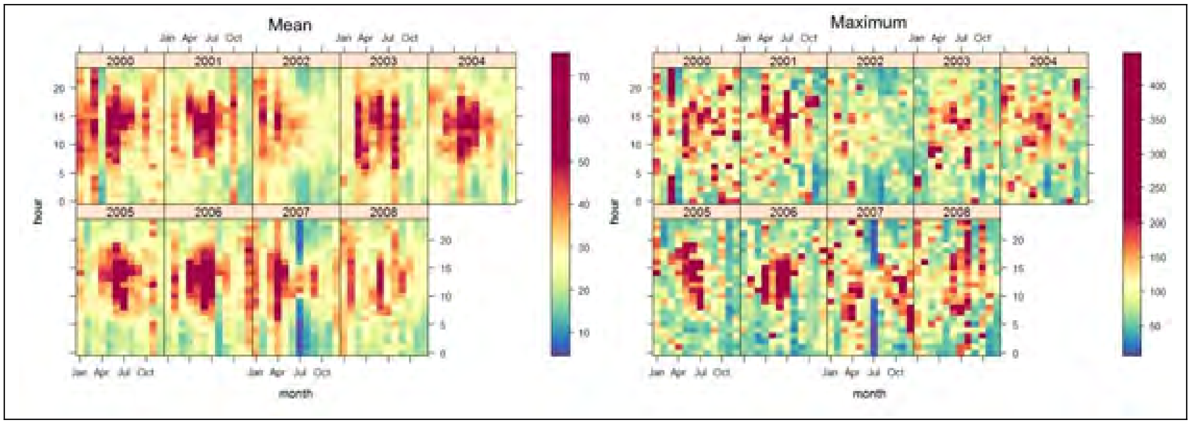


Figure 30: Variation of Mean and Maximum Hourly PM_{10} Concentration at AURN Sites by Month and Hour

Figure 30 plots the monthly mean and monthly maximum of hourly concentrations across the AURN time series. The plots tend to support the analysis of the box and whisker plots in Figure 27 and Figure 28 in terms of indicating a reduction in mean concentrations, but no easily discernable reduction in the peak concentrations. This is the first set of plots that presents pollution concentrations by hour (the vertical scale on each subplot). These plots indicate that although mean concentrations are highest in the middle of the day (approximately 10:00 to 16:00) the maximum hourly concentrations are less regularly distributed, with some years such as 2005 and 2006 showing the highest concentrations in the middle of the day, but other years such as 2008 showing them spread throughout the day.

The plots also indicate seasonal variations in PM_{10} concentrations. The highest mean values tend to cluster between April and July. In those years (such as 2005 and 2006) where maximum hourly concentrations are highest in the middle of the day, the peak values again tend to be between April and July. In other years they tend to occur in a less clustered pattern.

12.4 Variations in Average PM_{10} Concentrations

The following plots are created using the *time variation* function in Openair. This presents plots of how average concentrations of pollutants (or other data) vary over time – over an average day, by hour over a whole week, by day of the week and by month of the year. Where a shaded region surrounds the line, this indicates the boundaries of the 95% confidence interval for the averaging (in some plots this has not been included in order to make the graphs clearer). It should be kept in mind when viewing these plots that they represent average concentrations of pollution over the relevant time series and will not show up those peak-hours that will lead to exceedences of the daily mean PM_{10} objective. Data has also been corrected in this for local time so that under the diurnal cycles 8am during the winter under GMT is matched with 8am in the summer under BST so that patterns such as shift start times occur at the same time (N.B. all monitoring data provided as GMT).

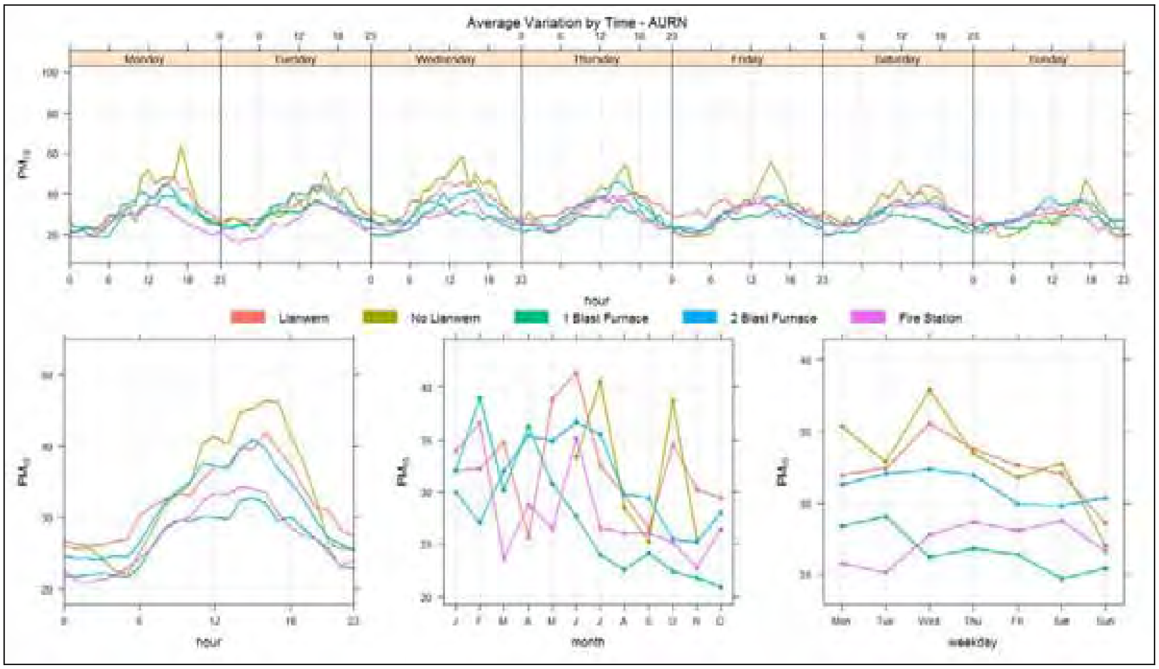


Figure 31: Variation in Average Concentration of PM_{10} by Different Activity Periods

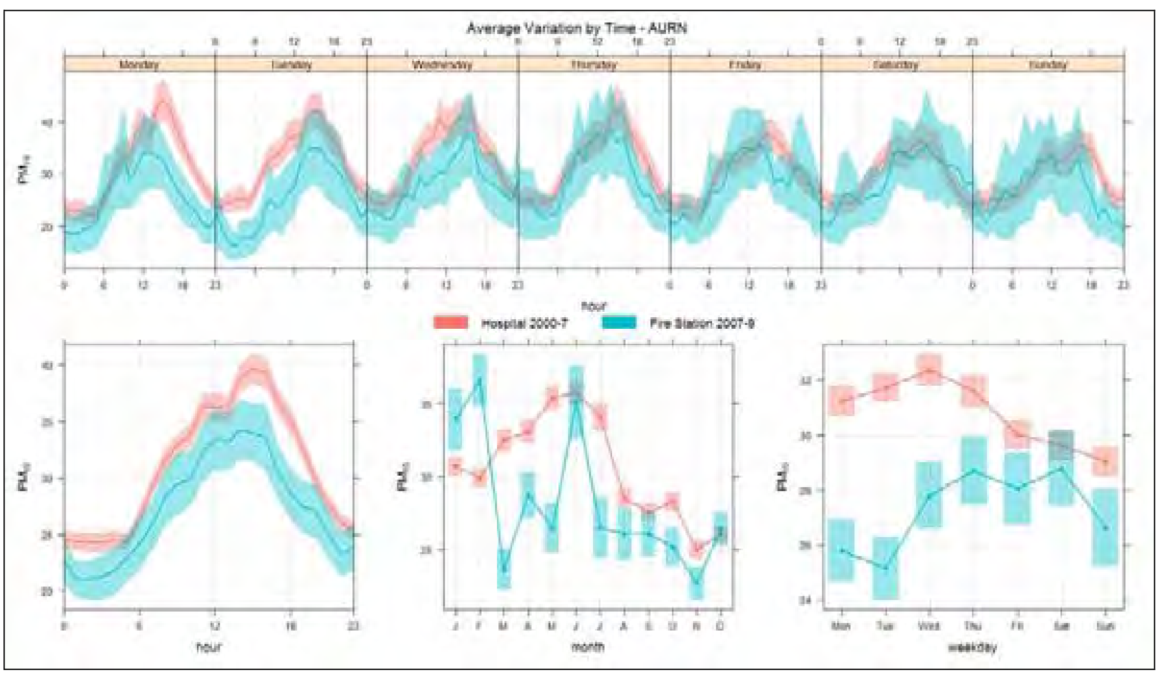


Figure 32: Time Variation in Average Concentration of PM_{10} for AURN Sites (with Confidence Intervals)

Figure 31 and Figure 32 show mean variation in PM_{10} concentration at the AURN sites by hour of the day, day of week and month of the year.

Figure 31 shows the differences between average concentrations in the periods between the 'landmarks' identified in Section 12.1.

- Average concentrations appear to have been at their highest during the period of 2 blast furnace operation when shipments were not being transferred to Llanwern.
- Average concentrations appear lowest in all graphs for the period of single blast furnace operation and for the period subsequent to the relocation of the AURN monitor to the Fire Station site.

Figure 32 shows the differences between overall averages for the Hospital site (2000 to July 2007) and the Fire Station site (July 2007 to March 2009).

- Overall, the average concentrations measured at the Fire Station site are lower than those at the Hospital site, this may be due, at least in part, to overall reductions both in background concentrations and emissions from the steelworks. Alternatively the site may be exposed to less pollution from the steelworks site.
- It is worth noting that the 95% confidence interval for the Fire Station data does sometimes exceed that of the Hospital data, suggesting (again) that though the average concentrations monitored at the Fire Station may be lower than those at the Hospital, the peak measurements may not be significantly different.
- The general diurnal pattern of pollution remains similar with concentrations rising sharply from about 6am to reach a peak between midday and 4pm. With regard to determining whether this may indicate pollution from stack plumes or dust sources, this pattern could be interpreted in two ways. The increase during the middle of the day could be associated with increased turbulence from the more unstable atmosphere due to solar insolation leading to increased risk of plume grounding. Alternatively the rise in concentrations during the morning, peak in the afternoon and steep drop off around 5-6pm could be associated with levels of activity on the site raising dust (for example vehicle traffic resuspending dust from roadways).

It is also interesting to note that for the Hospital dataset, there appears to be a reduction in average concentrations from Friday through to Sunday, indicating that some of the average pollution is influenced by week time shift activity.

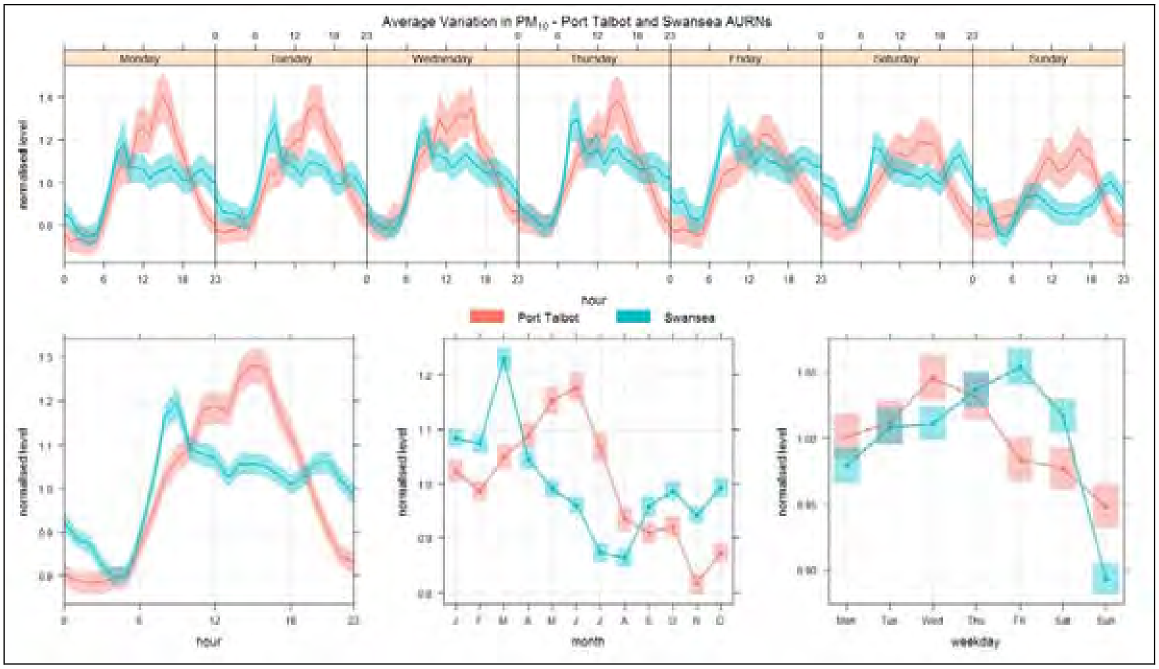


Figure 33: Variation in Average Concentration of PM_{10} at Port Talbot and Swansea AURNs

To further demonstrate the particular nature of the diurnal pattern of PM_{10} concentrations at the Port Talbot AURN monitoring sites, Figure 33 shows the patterns in time for the entire Port Talbot AURN data set (2000-9) with the similar time period at the roadside monitoring site in Swansea. The values on the graphs have been normalised. Whilst the Port Talbot data shows the afternoon peak, the data from Swansea demonstrates a more common profile: concentrations rise steeply in the morning associated with the morning rush hour, they then drop to a plateau in the afternoon, before rising again for a smaller peak around the evening rush hour. Concentrations at the Swansea site show a much more distinct reduction on Sundays. They also show higher concentrations in the winter period (January to March) where pollution from road vehicles tends to be highest due to poor dispersion. This plot again shows the tendency for weekend concentrations of PM_{10} at the AURN sites to be lower.

12.5 Time Variations in PM_{10} and $PM_{2.5}$

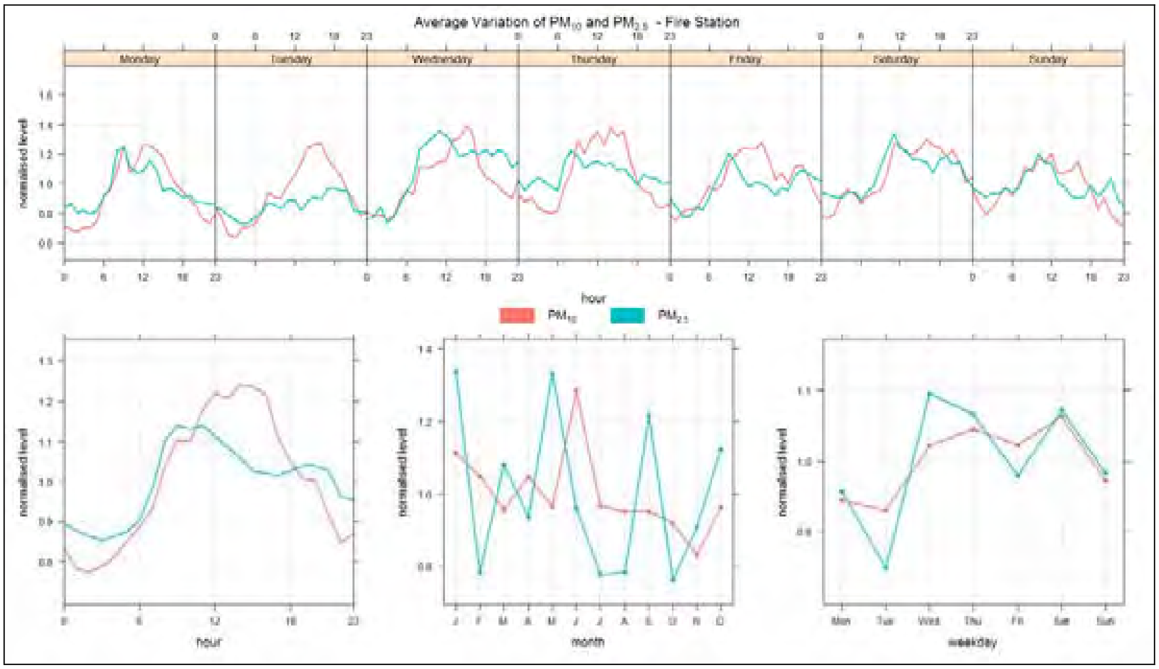


Figure 34: Variation in Average Concentration of PM_{10} and $PM_{2.5}$ at Fire Station Site

Figure 34 shows the variation by time at the Fire Station for PM_{10} and $PM_{2.5}$ (again the units have been normalised). The diurnal patterns differ significantly, with $PM_{2.5}$ showing the distinctive double peak associated with road sources whilst PM_{10} concentrations continue to rise after the morning rush hour. This tends to reinforce the evidence in Figure 14 and Figure 20 that indicate that PM_{10} and $PM_{2.5}$ are originating from very different directions (with road traffic being associated with $PM_{2.5}$).

12.6 Time Variations in Other Pollutants

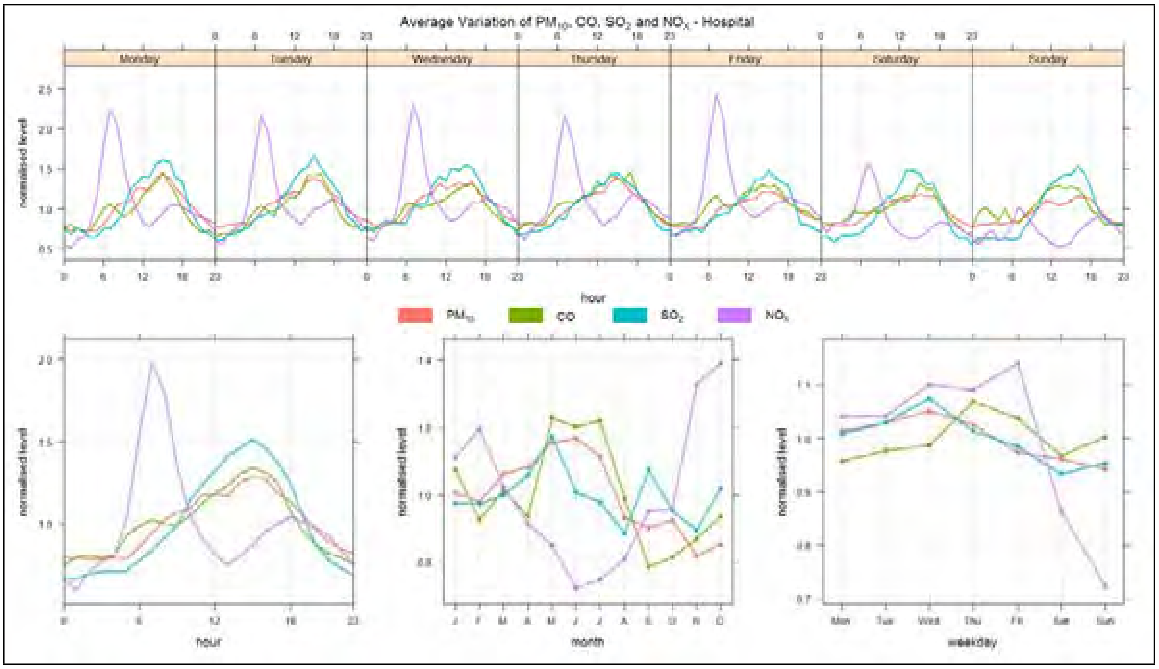


Figure 35: Variation in Average Concentration of PM_{10}, CO, SO_2 and NOx at Hospital Site

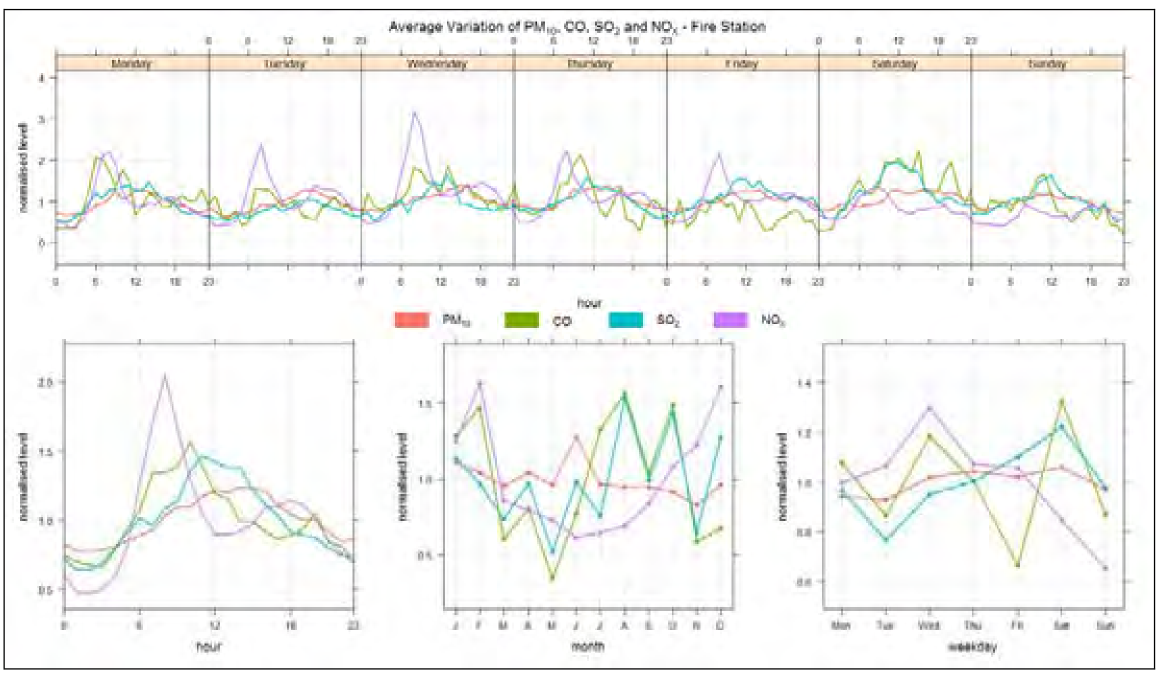


Figure 36: Variation in Average Concentration of PM_{10}, CO, SO_2 and NOx at Fire Station

Figure 35 and Figure 36 show the variation by time of PM_{10} compared to other key pollutants at the hospital and Fire Station sites. At both sites the distinctive double peak from road traffic is evident for NOx, but not for PM_{10} or CO and SO_2.

In Figure 35 showing data from the Hospital site (2000 – 2007), PM_{10} very closely matches CO and SO_2 suggesting that at this site (and at this time), PM_{10} was mainly related to combustion sources.

In Figure 36 showing the Fire Station data, the patterns appear very different. There appears to be a shift in the relation of CO and SO_2 so that the CO appears to be correlating better in some places with NOx (e.g. the morning peaks on Monday and Tuesday), and in fewer places with SO_2 (Saturday and Sunday afternoons – when traffic emissions are lower). Both CO and SO_2 correlate much less well with PM_{10}, which shows a much flatter day-time profile, peaking later in the day than the combustion pollutants. See Figure 34 for concentrations of $PM_{2.5}$ and the similar double peak to NOx.

12.7 Variation in PM_{10} at AURN by Wind Quadrant

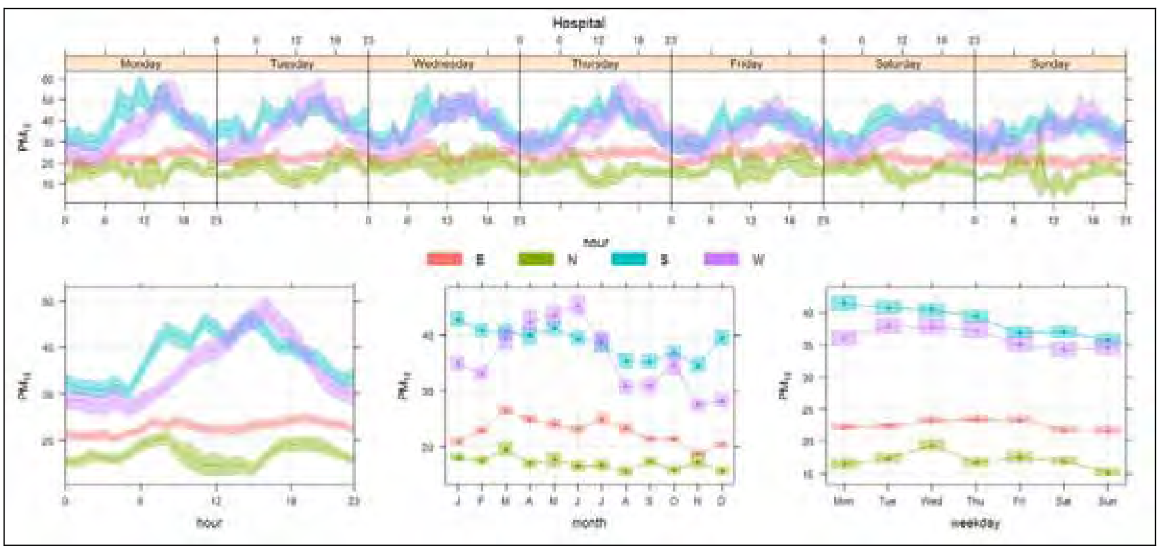


Figure 37: Time Variation of PM_{10} by Wind Quadrant (Hospital)

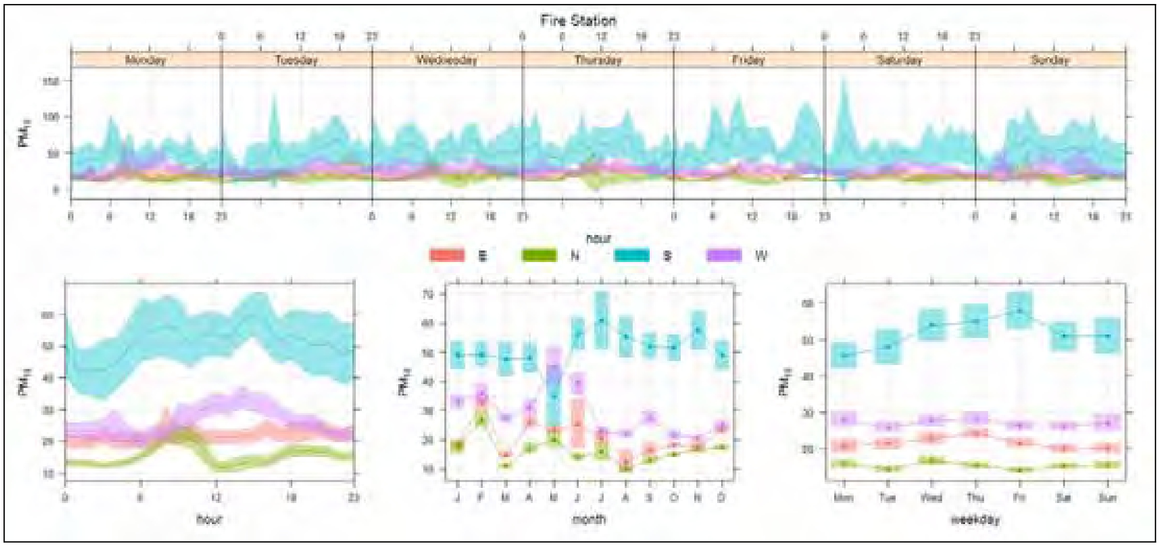


Figure 38: Time Variation of PM_{10} by Wind Quadrant (Fire Station)

Figure 37 and Figure 38 show how patterns of PM_{10} at the AURN sites vary depending on wind quadrant (N=315-45°,E=45-135°, etc). The Hospital data clearly shows that highest concentrations are coming from both the S and W sectors. It is interesting to note that the higher concentrations from the south commence slightly earlier in the day, potentially providing an indication of separate types of sources in different areas of the site.

The Fire Station data clearly shows that PM_{10} concentrations are highest from the south (as already shown in the polar plots such as Figure 8). It is interesting to note however that the southerly concentration tend to commence early in the day (around 6am), but westerly concentrations begin to rise later in the day.

12.8 Summary of Temporal Analyses

The analyses of temporal patterns in the pollution has focussed principally on the AURN data, as this forms the longest dataset from which trends and average patterns can be discerned. The analyses clearly show a number of changes in the long term trend in pollution relating to known activity changes on the steelworks site, indicating again, that the site is the predominant source of PM_{10}, CO and SO_2 in the local area.

Analysis of the diurnal profiles of pollution concentrations also show that CO and SO_2 at the Hospital site appear well related to PM_{10}, whilst NOx concentrations show a strong pattern normally associated with road traffic. $PM_{2.5}$ concentrations at the Fire Station also show this pattern. Concentrations of CO and SO_2 at the Fire Station site appear less well correlated with PM_{10}.

Concentrations of pollution from different wind quadrants clearly indicate that pollution patterns and concentrations differ significantly depending on wind direction.

Average PM_{10} concentrations at both AURN sites show two very distinctive patterns. Firstly, diurnal concentrations appear to begin to rise significantly at around 6am, peaking in the early afternoon, and then decreasing around 4pm. Secondly, mean concentrations appear to be highest from around April to July. Maximum concentrations sometimes coincide with these but often fail to show such a clear pattern.

13 Analysis of Data on the Basis of Exceedences

This section explores the datasets on the basis of exceedences of the air quality objectives. The principal objective of concern is the daily mean objective for PM_{10} which is set at 50µg/m^3 as a daily (24hr midnight to midnight) average of concentrations, with allowance for 35 exceedences of this daily mean per year. Within this report an 'Exceedence Day' will be counted as any day where the mean of all available data is greater than or equal to 50µg/m^3. N.B. for the purposes of official reporting of exceedences of the daily mean, there should be a 75% or greater data capture. However in the experience of the authors, it is not uncommon for monitoring to break down on days where concentrations are highest (due to filter clogging for example). Therefore it has been decided to consider the daily mean to simply be the mean average of all available data, this will in some cases prove a slightly more precautionary approach than that used in reporting data for the AURN.

In addition to identifying Exceedence Days, this section also reports on 'Exceedence Hours' and 'Hours>50".

- **Exceedence Hours** are those hours where concentrations of PM_{10} are >50µg/m^3 on **Exceedence Days** (i.e. they are the hours in which concentrations are specifically leading to exceedences of the daily mean objective concentration).
- **Hours>50** are those hours on *any* day (unless specified as 'Hours >50 (non-ex)') where concentrations are above the daily mean objective concentration. The reason for looking at these is in order to try and identify if there is anything special about the high hourly concentrations on days where the daily mean objective is exceeded.

13.1 Analysis of Number of PM_{10} Exceedence Days at AURN

Table 3: Summary of Exceedence Days at AURN by year and site

Site	Year	Total Days	PM_{10} Days	Mean PM_{10}	Exceedence Days*	% Exc. Days
Hospital	2000	366	360	33.2	66	18.3%
	2001	365	360	30	41	11.4%
	2002	365	363	27.8	24	6.6%[1]
	2003	365	364	31.8	44	12.1%
	2004	366	360	30.7	40	11.1%
	2005	365	329	29.6	30	9.1%
	2006	365	339	31.3	37	10.9%
	2007	173	169	33.1	30	17.8%[2]
Fire Station	2007	158	158	24.2	14	8.9%[3]
	2008	366	348	28.7	37	10.6%
	2009	90	89	25.5	4	4.5%[4]
Both	2007	331	327	28.8	44	13.5%
	All	3675	3566	30.1	411	11.5%

*Calculated on basis of available data – days with data capture <75% NOT disregarded

[1] Blast Furnace 5 not in operation

[2] Hospital site in operation until June

[3] Fire Station site in operation from July

[4] Data only available to 31/3/2009. Blast Furnace 4 offline from December 2008.

Table 3 shows the number of Exceedence Days per year since 2000, as well as the proportion of days where there was PM_{10} monitoring data (PM_{10} days) when exceedences occurred. For complete years the proportion of days when exceedences occur varies between 6.6% in 2002 to 18.3% in 2000. If we take the beginning of 2003 to represent the commencement of 'normal' current operation as it is when No.5 Blast Furnace came back on line, the average proportion of Exceedence Days per year is 10.9%. For 2008, the only complete year of data that is available for AURN monitoring at the Fire Station, the proportion of Exceedence Days is 10.6%, only fractionally below the overall average. Particularly in consideration of the tendency for both background and local PM_{10} concentrations to reduce over time, this suggests that the occurrence of exceedences at the Fire Station site may not be significantly lower than that which would be expected at the Hospital site.

It is of interest to note the much lower rate of Exceedence Days during the periods that No 4 and No 5 Blast Furnaces have been out of use. It is unclear whether this reduction might relate to reductions in emissions coming from the Blast Furnaces themselves, or from reductions in the activities related to either the supply of materials to the Blast Furnaces or treatment of materials coming out of the Blast Furnaces.

13.2 Analysis of Number of PM_{10} Exceedence Days at Other Monitoring Sites

In order to provide some indication of the relative level of pollution experienced at the other monitoring locations reported in this study, the relative proportion of Exceedence Days for the available data have been calculated.

Table 4: Summary of Exceedence Days at EAW monitoring sites

Site	Total Days	PM_{10} Days	Mean PM_{10}	Exceedence Days	% Exc. Days
Arts Centre	118	118	19.9	0	0.0%
Taibach 04	183	183	32.7	27	14.8%
Corus S&S	258	258	28.0	18	7.0%
Taibach 07	257	257	36.6	51	19.8%

Table 5: Summary of Exceedence Days at Corus Topas monitoring

Site	Total Days	PM_{10} Days	Mean PM_{10}	Exceedence Days	% Exc. Days
Harbour	204	204	26.8	26	12.7%
Blending Plant	206	206	29.3	30	14.6%
Fines Beds	188	188	31.8	30	16.0%
GCI	206	206	80.8	95	46.1%
Coke Ovens	206	206	17.1	9	4.4%

Table 4 shows the proportion of Exceedence Days at the EAW monitoring sites. There were no exceedences of the daily mean objective recorded at the Arts Centre site. For both the Taibach campaigns (at approximately the same location as the Fire Station) both sets of data show a much higher proportion of Exceedence Days than the AURN site in general. This again suggests that the Fire Station AURN location may not be significantly less exposed to exceedences of the daily mean objective than the Hospital.

Table 5 shows the proportion of Exceedence Days at the Corus Topas monitoring sites. It must be remembered that the Topas monitors have not been proved equivalent to the reference method and are therefore only indicative, particularly when calculating ‘Exceedence Days’. However, despite being located on the steelworks site itself and therefore potentially closer to a number of the sources (especially fugitive sources) most of the monitoring sites to not appear to be reporting a far higher number of Exceedence Days than the AURN or EAW sites. The one exception to this is the GCI (Granular Coal Injection) site which appears to be in a very polluted location (as previously identified in Section 11.7).

13.3 Seasonal Analysis of Number of Exceedence Days

Comparisons of the monitoring results from 2007, when the AURN was relocated, highlighted the potential for the differing number of Exceedence Days reported at each site to be influenced by season. As shown in Table 3, from January to June the Hospital site reported 17.8% of PM_{10} monitoring days as Exceedence Days, compared to only 8.9% of days at the Fire Station site between July and December. A seasonal analysis of Exceedence Days has therefore been undertaken, calculating the number of Exceedences Days for each year quarter over the time series.

Table 6: Number of Exceedence Days by Quarter

Year	Q1	Q2	Q3	Q4	Total*
2000	**22**	**17**	8	**19**	66
2001	7	**17**	8	9	41
2002	**11**	**11**	0	2	24[1]
2003	**14**	**13**	**13**	4	44
2004	**11**	**16**	6	7	40
2005	7	**13**	**8**	2	30
2006	3	**17**	**10**	7	37
2007	**11**	**19**	*5*	*9*	*44*
2008	***11***	***12***	*7*	*7*	37
2009	*4*[2]	-	-	-	-

[*]Calculated on basis of available data – days with data capture <75% NOT disregarded
[1] Blast Furnace 5 not in operation
[2] Blast Furnace 4 not in operation
Italic numbers indicate measurements at the Fire Station site
Bold numbers indicate quarters where exceedence days were >25% of the annual total.

Table 7: Mean PM_{10} Concentration by Quarter

	Q1	Q2	Q3	Q4
2000	**38.4**	33.9	29.6	31.5
2001	28.3	**34.3**	31.6	26.4
2002	**33.7**[1]	31.5[1]	23.5[1]	22.8[1]
2003	32.6	**36.8**	33.9	24.2
2004	31.1	**36.1**	30.2	25.4
2005	26.4	**32.6**	32.1	26.2
2006	26.9	**37.7**	30.1	29.7
2007	31.4	**34.9**	*22.5*	*25.4*
2008	***31.2***	*30.3*	*29.3*	*24.2*
2009	*25.5*[2]	-	-	-

[1] Blast Furnace 5 not in operation
[2] Blast Furnace 4 not in operation
Italic numbers indicate measurements at the Fire Station site
Bold numbers indicate quarters where exceedence days were >25% of the annual total.

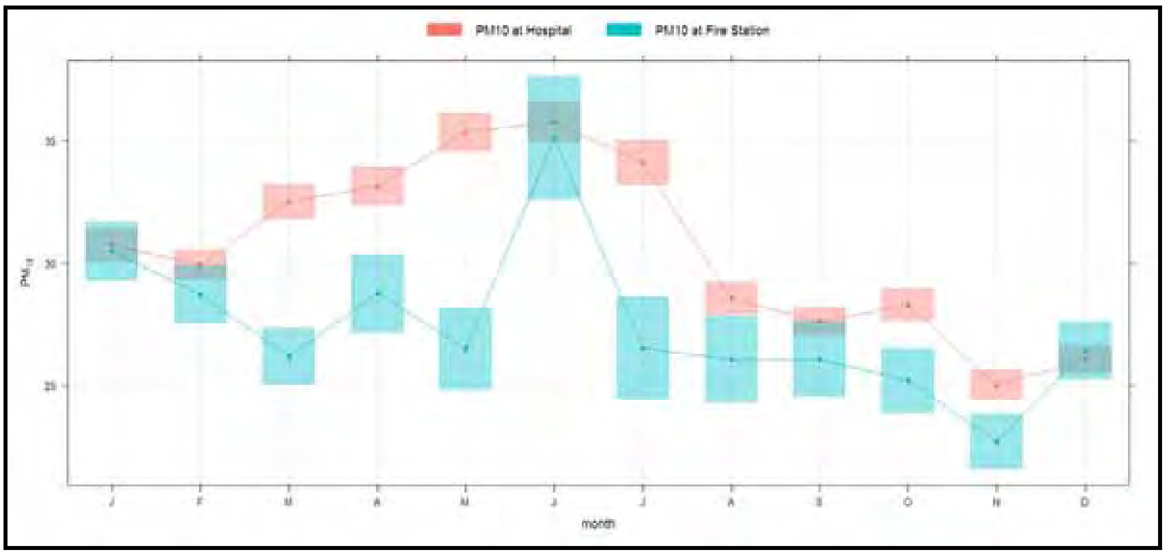


Figure 39: Variation of Average PM_{10} by Month (AURN: Both Sites)

Table 6 shows the number of Exceedence Days for each quarter, with figures indicated in bold where the total number of Exceedence Days exceeds 25% of the annual number (i.e. there were more days than would be expected by chance). The table clearly shows that for all years, Quarter 2 (April to June inclusive) has a disproportionate number of Exceedence Days. There is also a tendency for Quarter 1 (January to March inclusive) to have a higher number of Exceedence Days.

Table 7 shows mean PM_{10} concentration by Quarter and indicates that average concentrations also tend to be higher in Quarter 2.

These seasonal variations in pollution will require further analysis looking at both site activity, the nature of likely pollution sources and variations in meteorology in order to explain them further.

Figure 39 shows the variation of the average PM_{10} concentration at both AURN sites by month. For the Hospital there was clearly a strong seasonal pattern, with average concentrations from March to July being the highest. Concentrations at the Fire Station peak strongly in June, however, it should be noted here that the Fire Station data set is still very short and monitoring has only taken place during the 2nd Quarter of the year during 2008.

13.4 Analysis of Number of Hours>50 at AURN Sites

Whilst the analysis of Exceedence Days makes sense in terms of compliance with legislation, it is not that useful when used to assess the patterns of pollution more generally, as it may be fairly arbitrary as to whether enough polluted hours occur on the same day to trigger an exceedence of the daily mean objective concentration, particularly as the daily mean objective is now based on a midnight to midnight average rather than a rolling 24-hour mean. Therefore the proportion of successful PM_{10} monitoring hours that were > 50μg/m^3 have been calculated for each year (also accounting for the site relocation in 2007).

Table 8: Summary of Hours>50 at AURN by year and site

Site	Year	Total Days	PM_{10} Days	Hours>50	% Hours>50
Hospital	2000	8784	8366	1502	18.0%
	2001	8760	8478	1177	13.9%
	2002	8760	8542	968	11.3%[1]
	2003	8760	8595	1309	15.2%
	2004	8784	8420	1275	15.1%
	2005	8760	7569	1000	13.2%
	2006	8760	7859	1182	15.0%
	2007	4152	3960	769	19.4%
Fire Station	2007	3782	3729	363	9.7%
	2008	8784	8121	940	11.6%
	2009	2160	2045	164	8.0%[2]
Both	2007	7934	7689	1132	14.7%
	All	88180	83373	11781	14.1%

[1] Blast Furnace 5 not in operation
[2] Blast Furnace 4 not in operation

Using the same principle as used above for the analysis of Exceedence Days, if 2000 is discounted as a particularly polluted year prior to significant changes in the operation of the steelworks, the overall average is for 13.6% of PM_{10} monitoring hours to be above the 50µg/m^3 concentration. On the basis of this analysis there does not appear to be a significant reduction in the proportion of hours above the objective concentration over time at the Hospital site, however, the relocation of the site to the Fire Station appears to relate to a lower number of Hours>50 in 2008 (the only complete year of data at the Fire Station).

Again, the reduction in Hours>50 during the periods when Blast Furnace 4 and 5 were off-line should be noted. However, it is unclear whether this relates to reductions in emissions from the furnaces or from related reductions in material handling.

13.5 Seasonal Analysis of Number of Hours>50 at AURN Sites

The seasonal analysis has also been repeated looking at the number of hours where concentrations exceeded the daily mean objective concentration (referred to as 'Hours>50').

Table 9: Number of Hours>50 by Quarter

	Q1	Q2	Q3	Q4	Total
2000	**453**	**425**	278	346	1502
2001	265	**395**	**305**	212	1177
2002	**335**	**346**	278	112	968[1]
2003	322	**426**	**409**	152	1309
2004	307	**495**	265	208	1275
2005	203	**350**	**349**	98	1000
2006	166	**445**	**299**	272	1182
2007	**343**	**411**	*179*	*168*	1101
2008	***321***	***253***	*192*	*136*	*902*
2009	*156*[2]	-	-	-	-

[1] Blast Furnace 5 not in operation [2] Blast Furnace 4 not in operation
Italic numbers indicate measurements at the Fire Station site
Bold numbers indicate quarters where exceedence hours were >25% of the annual total.

Table 9 shows the number of Hours>50 for each quarter over the whole of the AURN time series. The same pattern is apparent as identified in the analysis of Exceedence Days, that is that Quarter 2 is the most polluted, however there is a similar tendency for Quarter 1 and Quarter 3 to be the next most polluted.

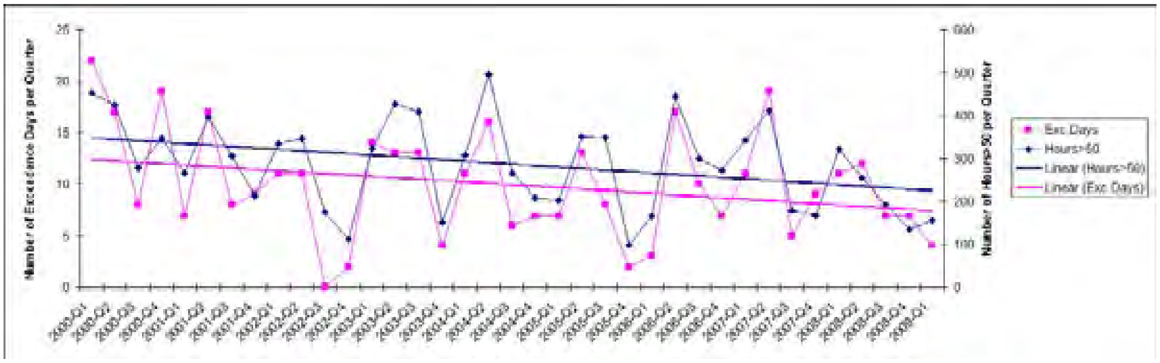


Figure 40: Plot of Exceedence Days and Hours>50 by Quarter (2000 to 2009)

Figure 40 shows a plot of both the number of Exceedence Days and Hours>50 for each quarter as a time series. Trend lines have been added showing a tendency for both statistics to be reducing at a similar rate. Based on the short dataset accumulated so far at the Fire Station, it is again not apparent that the site is always less polluted than the Hospital site.

13.6 Changes in Pollution Patterns Between Exceedence Days

In the process of compiling this report, a wide range of analyses were carried out in order to try and establish patterns of pollution relating to Exceedence Days and how they might differ from other days, or whether there were certain patterns of pollution evident. It was concluded that there was nothing readily apparent that could be used to distinguish an Exceedence Day itself from any other day, other than the fact that the daily mean exceeded 50µg/m^3. Exceedence Days tended to cover the full range between those days that exceeded the objective because of a single very high peak, and those that exceeded due to continually elevated concentrations throughout much of the day.

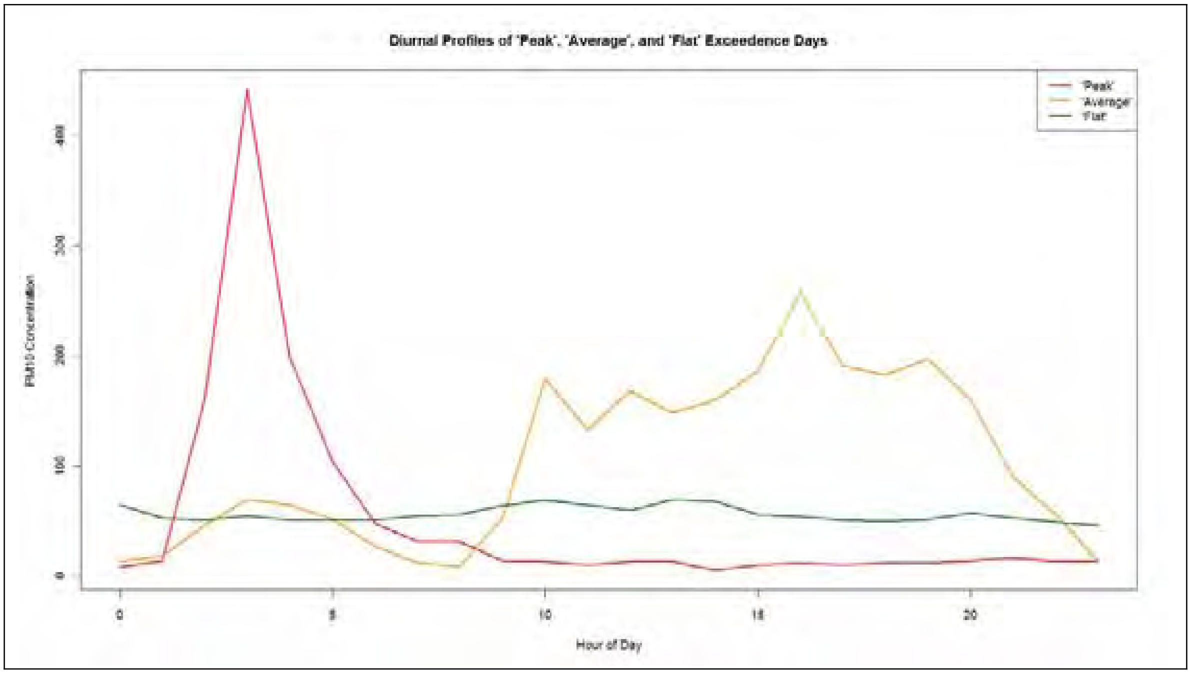


Figure 41: Diurnal profiles for Range of Exceedence Days

A methodology was designed to evaluate Exceedence Days on the basis of whether the exceedence of the objective was caused by a single high peak (termed ‘Peak Event’), elevated concentrations throughout the day (Flat’) or elevated concentrations for part of the day (‘Average’). This method calculates the ratio of the daily maximum concentration to the daily mean concentration. The greater the ratio, the more the daily mean is dominated by a single peak; the lower the ratio, the flatter the diurnal concentration profile for that day. Figure 41 shows plots of the diurnal patterns for 3 days: the strongest peak event, the Exceedence Day with the closest ratio to the mean, and the Exceedence Day (with 24 valid measurements) with the minimum ratio.

Given that there are over 400 Exceedence Days in the AURN dataset considered in this report, it has been impossible to carry out an extensive analysis of them to determine patterns in the type of day. It is possible that in future analyses, this may prove to be a useful tool for categorising days. This is illustrated in Table 10 which demonstrates the differences between these days, and in particular how the ‘Peak’ day, whilst appearing to be the least significant in terms of the daily mean concentration, actually has the greatest hourly pollution loading by almost a factor of 2. Once days have been categorised, it is then possible to begin to study each individual day in greater detail.

Table 10: Data Relating to Exceedence Days in Figure 41

	Date	Site	Daily Mean	Daily Max.	Ratio
Peak	05/01/2003	Hospital	50.8	442	8.709
Average	09/08/2008	Fire Stn.	103.7	258	2.489
Flat	20/03/2009	Fire Stn.	56.3	70	1.243

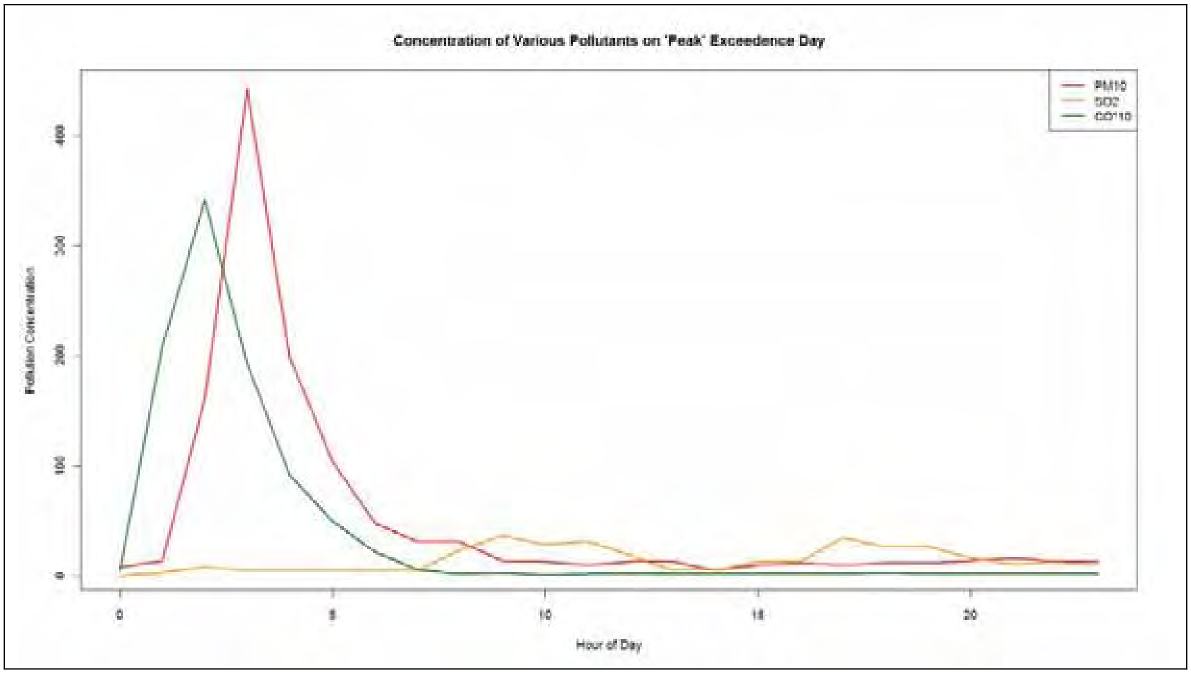


Figure 42: Comparison of Diurnal Profile for PM_{10}, CO and SO_2 on 'Peak' Exceedence Day

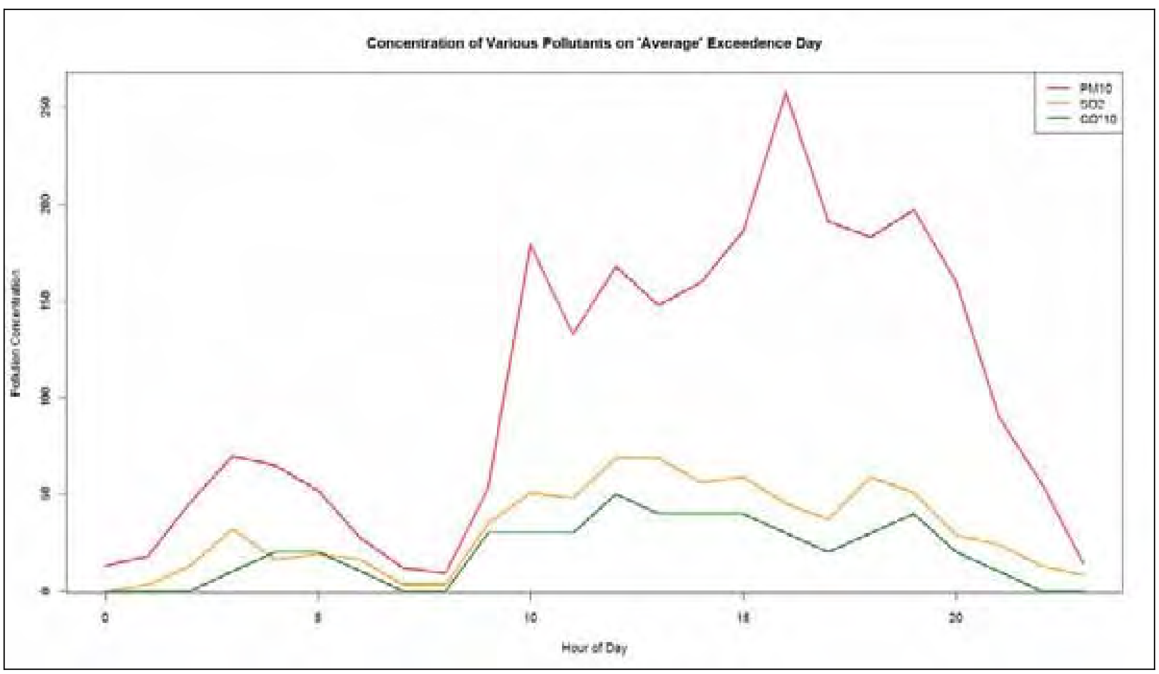


Figure 43: Comparison of Diurnal Profile for PM_{10}, CO and SO_2 on 'Average' Exceedence Day

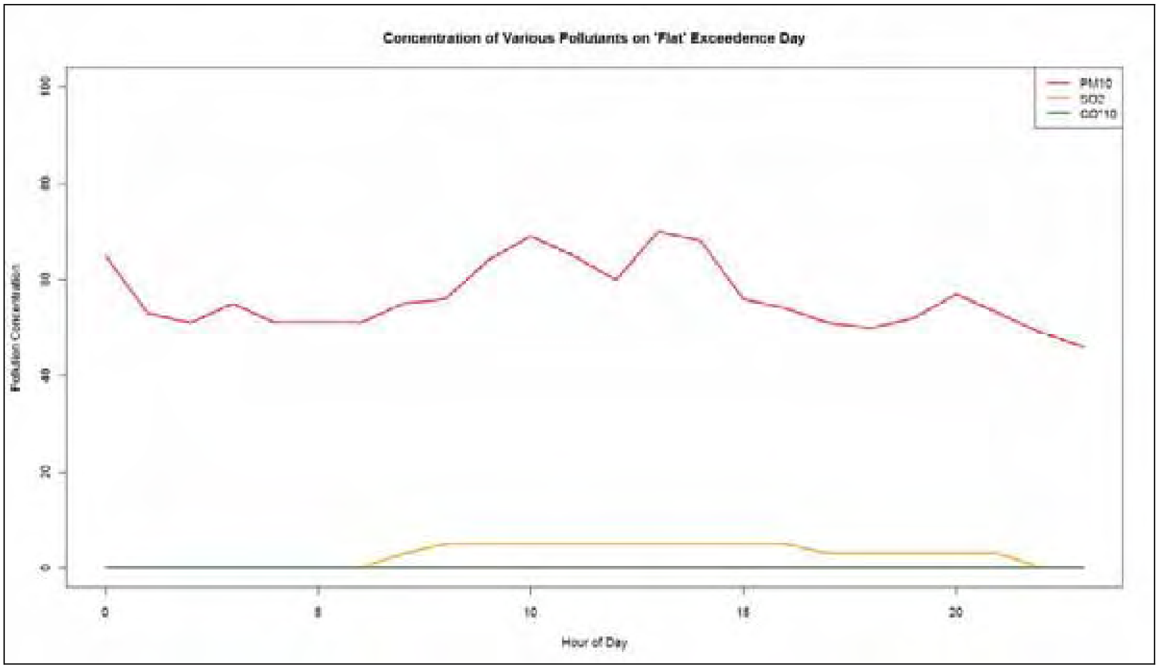


Figure 44: Comparison of Diurnal Profile for PM_{10}, CO and SO_2 on ‘Flat’ Exceedence Day

Figure 42, Figure 43, and Figure 44 show the relationships between PM_{10} and the other key combustion pollutants CO and SO_2 (N.B. CO has been multiplied by 10 so that it can be plotted on the same scale). Figure 42 showing the ‘Peak’ Exceedence Day, clearly shows that the single large peak occurring in the early hours of the morning, which appears at first sight to be an incidence of plume impacting on the monitor, is actually closely associated with a peak in CO, confirming the likelihood of this exceedence being related to stack emissions from a combustion source (It is interesting to note though that neither the peak in CO nor the peak in PM_{10} relate to an increase in SO_2 concentrations – this is discussed further in Section 13.9 below).

Figure 43, showing the diurnal profile for the ‘Average’ exceedence day shows that in this case, both SO_2 and CO appear to be closely related to the majority of the elevated PM_{10} concentrations during the day.

Figure 44 shows the diurnal profile for the ‘Flat’ Exceedence day. Here there appears to be little relationship with elevated concentrations of the combustion pollutants. Further investigation in this case might involve examination of relationships with regional background concentrations, time of day/year or meteorological parameters. N.B. Narberth data has not been put on this plot as it was unavailable on this particular day.

This framework provides a clear way to begin classifying the types of pollution events resulting in exceedences of the Daily Mean objective. This will allow each year’s Exceedence Days to be broken down into similar groups in order to allow sensible correlations to be made between PM_{10} concentrations, other pollutants and meteorological parameters. Without the use of a framework like this it will prove very hard to identify the likely causes of exceedences without with treating each day completely as an individual case, or conflating those exceedences related to peak (probably combustion related) events with those related to continually elevated PM_{10} concentrations caused by sources such as wind-raised dust.

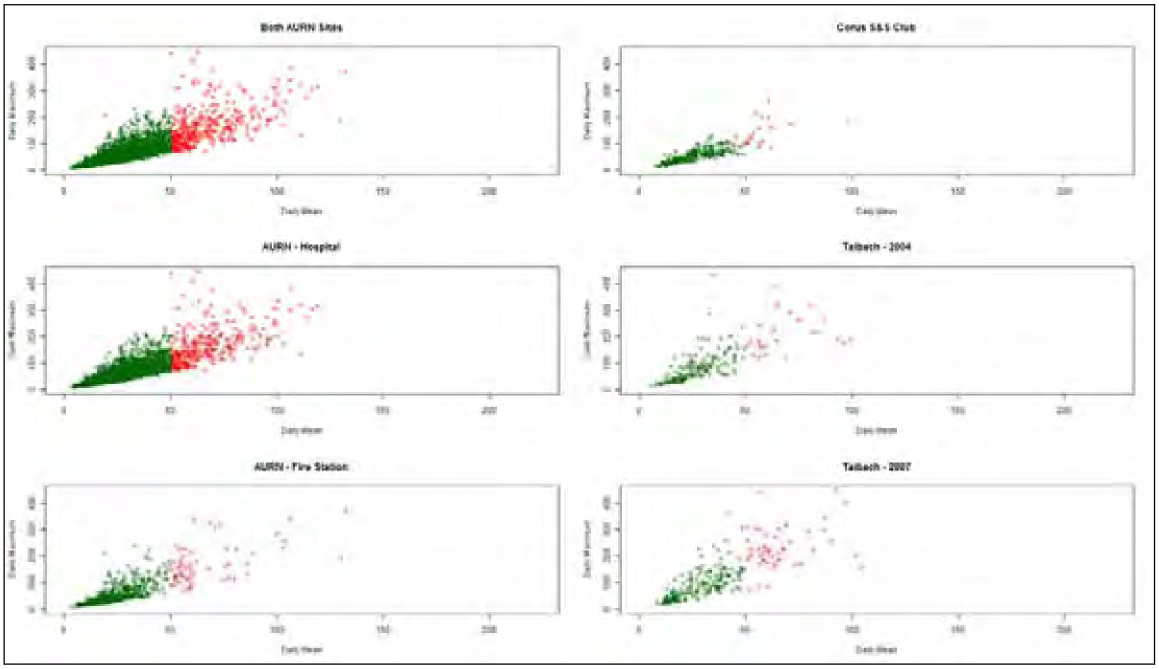


Figure 45: Relationship between Daily Mean and Daily Maximum PM_{10} at AURN and EAW Monitoring Sites (Red Indicates Exceedence Days)

Figure 45 shows scatter plots of the relationship between daily mean and daily maximum PM_{10} concentrations at the AURN and EAW monitoring sites. The plots clearly indicate the broad range of Exceedence Days, with no clear tendency for them to be driven by either strong peaks, or lower prolonged elevated concentrations.

13.7 Direction of Pollution Sources on Exceedence Days

Analysis was carried out using polar plots to try and determine whether the direction of pollution sources differed on Exceedence Days. The plots do not differ considerably from those produced for the entire data series.

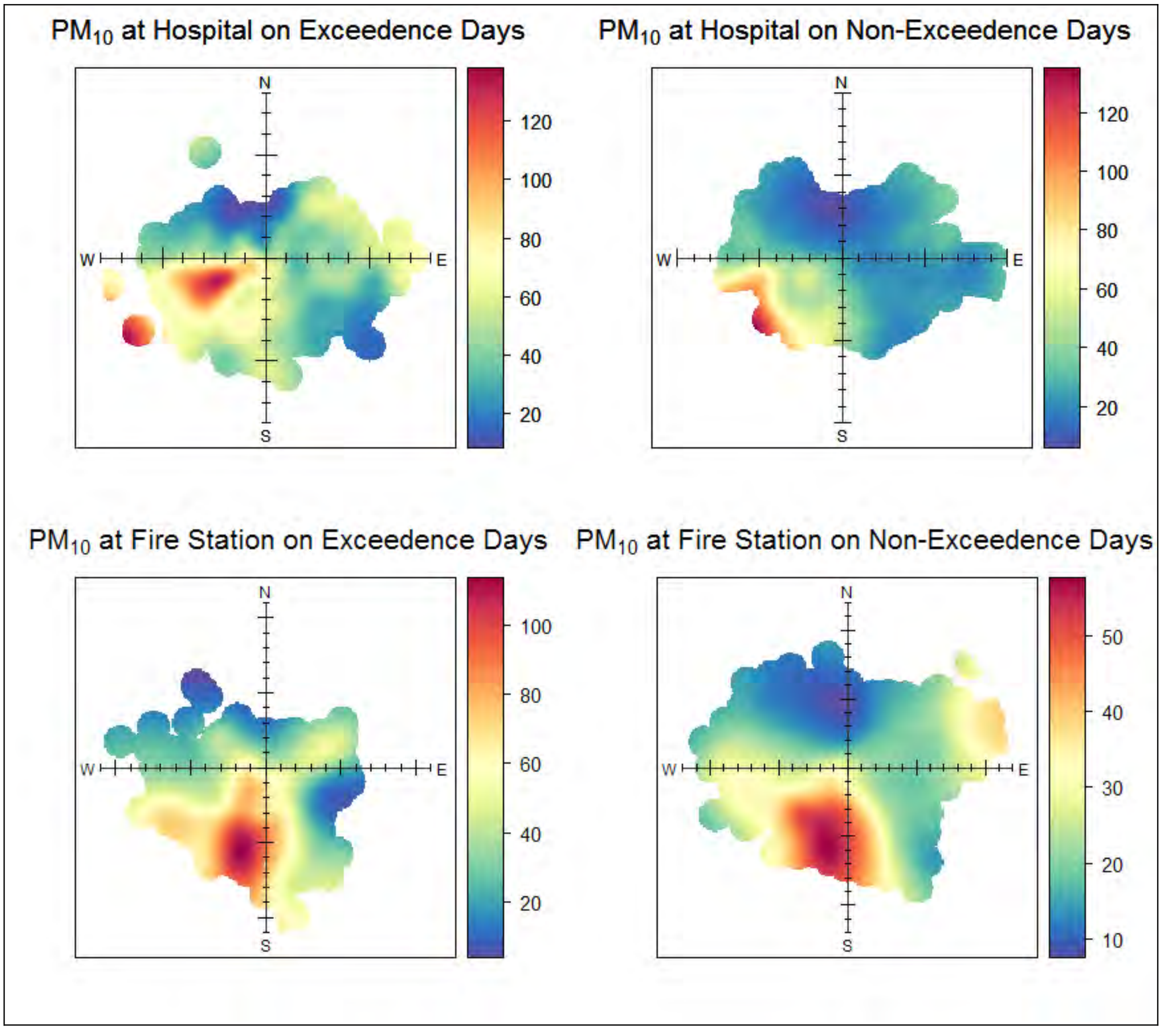


Figure 46: Polar Plots for AURN sites for Exceedence and Non-Exceedence Days (Different Scales)

Figure 46 shows polar plots for Exceedence and Non-Exceedence Days at both the Hospital and Fire Station AURN sites. The plots tend to suggest that whether the daily mean objective is exceeded or not, the highest concentrations come from very similar directions, which indicates that exceedences are probably due to differences in the magnitude of pollution concentrations from the same sources, rather than because of a special event where pollution is released from a usually non-polluting source.

Probably the most significant feature of these plots is the strong hotspot at medium to high windspeeds that occurs at the Hospital site only on Exceedence Days. Figure 47 (below) shows the patterns for Exceedence Days at the Hospital by year, indicating that this pattern was strongest in 2000 and 2001. It was however still present in 2006.

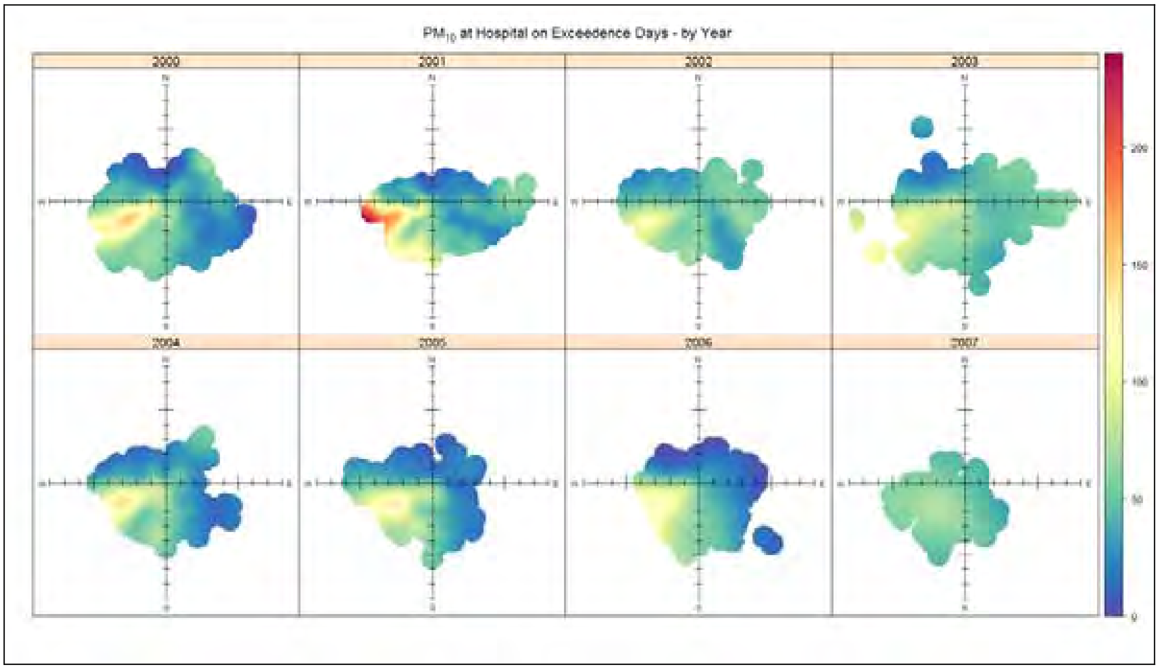


Figure 47: Polar Plots for Hospital Sites for Exceedence Days by Year

13.8 Analysis of Hours>50

The analysis of those hours where concentrations exceed 50µg/m^3 will be essential to determining the nature of the pollution problems. As discussed above, Exceedence Days are a fairly arbitrary legislative concept that does not relate well to a pollution problem of this kind, being more suited to problems with regional pollution, or smog type episodes. In the analyses that follow we focus specifically on those hours where concentrations exceeded the daily mean objective concentration of 50µg/m^3 irrespective of whether they occurred on Exceedence Days or not (future analyses could also potentially examine whether there is any discernable difference between the nature of Hours>50 that occur on Exceedence Days and those that occur on Non-Exceedence Days.

13.8.1 Time of Day of Hours>50

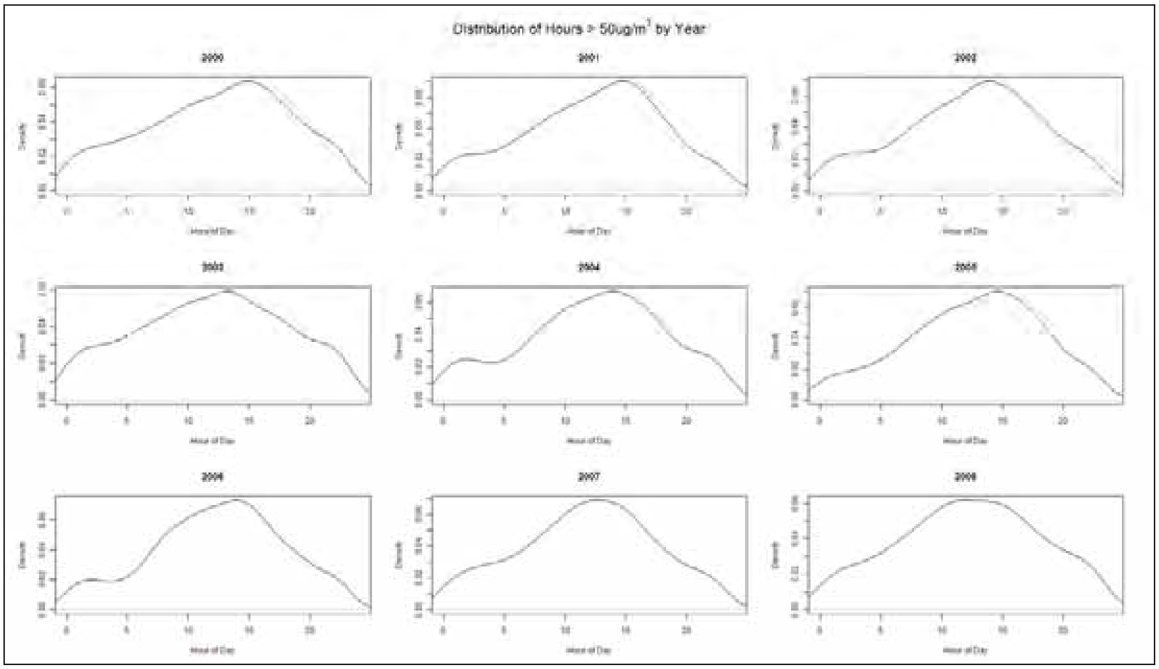


Figure 48: Probability Density Functions for Distribution of Hours>50 Across the Day

Figure 48 shows plots of the frequency with which Hours>50 occur throughout the day. The plots do not show a huge difference in shape over time, with inter-year variability tending to be greater than a discernable trend (for example the 'shoulder' in the curve visible in the early hours of the morning in 2001, 2002, 2004 and 2006). The most notable characteristics are that in all years, the greatest number of Hours>50 occur between around 10am and 4pm (matching the pattern for average concentrations to be higher at this time that was noted earlier in Section 12.4). There also appears to be a slight tendency for the peak to become broader over time – this is most evident in 2008, and may be related to differing patterns of pollution at the Fire Station Site.

13.8.2 Correlation of PM_{10} for Hours>50 with Other Pollutants

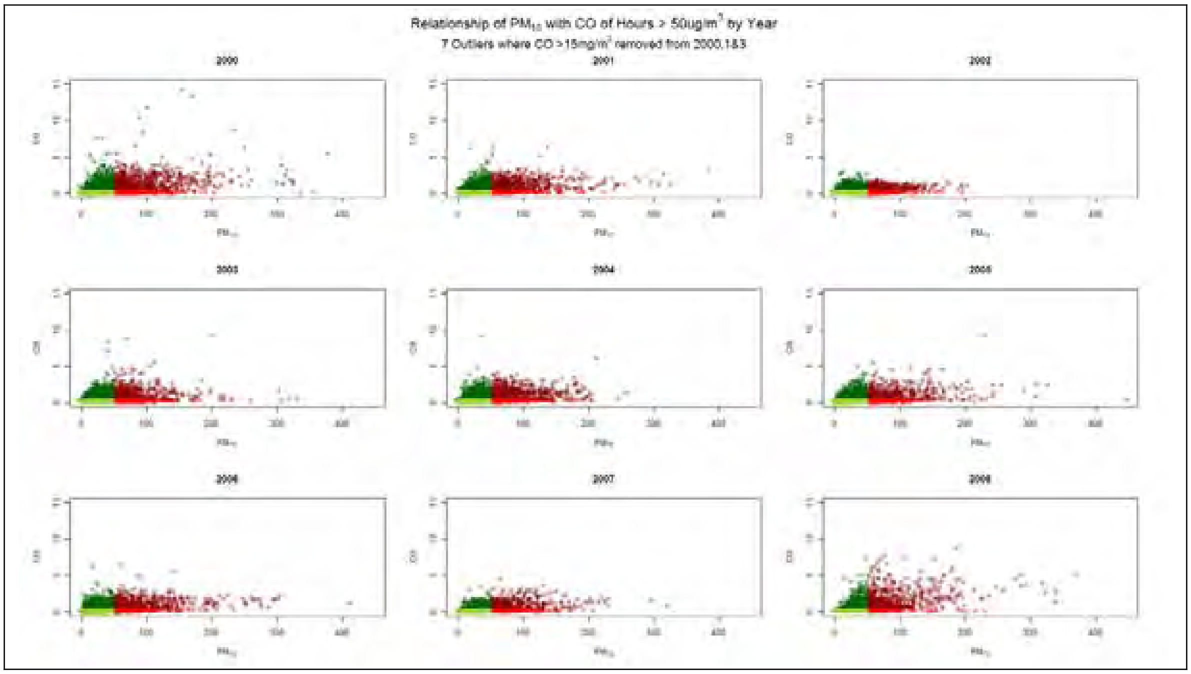


Figure 49: Scatter Plots of Hourly PM_{10} against CO (Highlighting Hours>50)

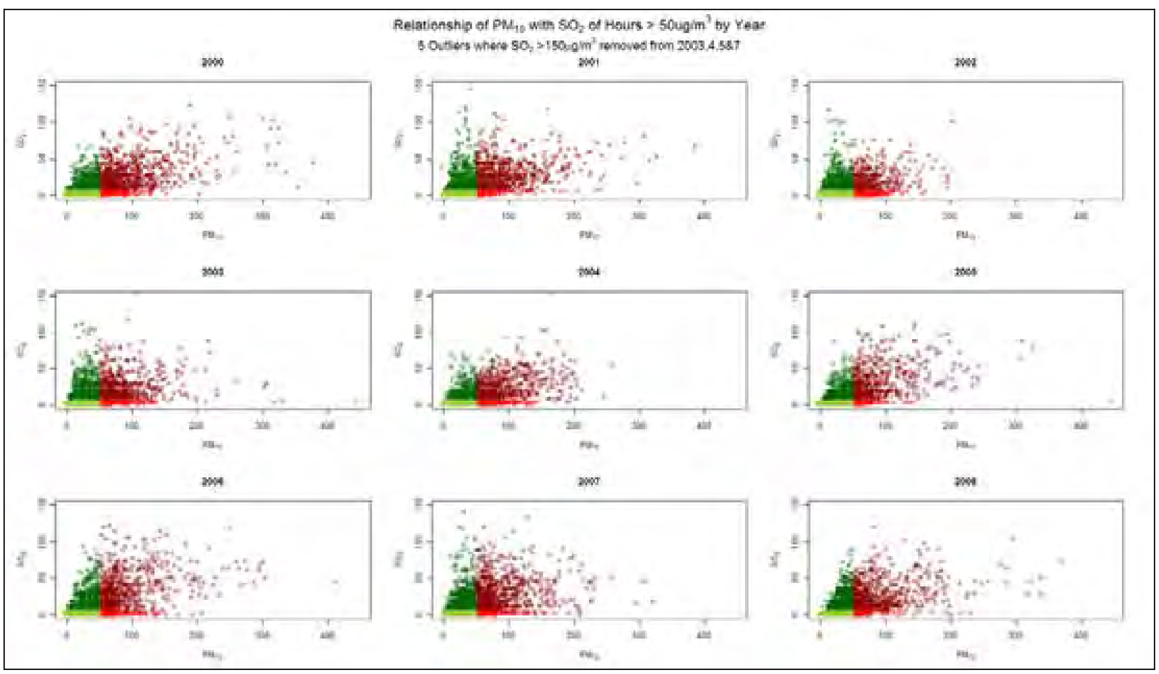


Figure 50: Scatter Plots of Hourly PM_{10} against SO_2 (Highlighting Hours>50)

Figure 49 and Figure 50 show scatter plots of hourly PM_{10} against the combustion pollutants CO and SO_2 (N.B. to preserve a sensible and comparable scale on all graphs, extreme outliers for CO and SO_2 have been removed from the dataset). Elevated SO_2 concentrations appear to be more strongly associated with higher PM_{10} concentrations, however, very high SO_2 concentrations occur more often in the absence of high PM_{10}, than very high CO concentrations do. It is worth noting that mean concentrations of CO and SO_2 over the entire 2000-2009 AURN time series are 0.4mg/m^3 and 7.0µg/m^3 respectively and so this could be considered as the point at which concentrations of these can be considered to significantly elevated (these have been highlighted on the graph using the darker shades).

Table 11: Proportion of Hours>50 Above or Below Mean of Combustion Pollutants (%s are of Hours>50 or <50)

PM_{10}	CO < 0.4mg/m^3	CO > 0.4mg/m^3	SO_2 < 7µg/m^3	SO_2 > 7µg/m^3
H>50	3,145	6,261	2,766	7,356
	33.4%	66.6%	27.3%	72.7%
H<50	42,312	12,696	48,872	12,716
	76.9%	23.1%	79.4%	20.6%

The percentages for the number of Hours>50 that are above or below the mean of the combustion pollutants are reported in Table 11. This shows that Hours>50 are slightly better related to 'above average' SO_2 concentrations than 'above average' CO concentrations. N.B. The mean of the combustion pollutants has been arbitrarily selected as the boundary for this analysis, it may be more appropriate to choose a lower concentration based more closely on background concentrations in the area.

This analysis suggests that there is a strong relationship between some of the Hours>50 and combustion pollutants, with well over half of hours exceeding the daily mean objective concentration showing 'above average' concentrations of the combustion pollutants.

13.9 Analysis of Correlation of CO with SO_2

The analysis of Exceedences Days by type (e.g. 'Peak', 'Average' or 'Flat') carried out in Section 13.6 highlighted an interesting pattern. It is often assumed that the combustion pollutants CO and SO_2 are likely to be closely correlated and related to stack emissions. The plot in Figure 42 however, clearly showed a significant peak in CO that closely relates to a peak in PM_{10} without any noticeable rise in SO_2. Whilst it may not be uncommon for gases and particles to disperse at different rates and in slightly different patterns due to their very different properties, it would be likely that CO and SO_2 dispersed in similar patterns, and that any initial emission containing both pollutants within a plume would, over a short distance continue to contain roughly the same proportion of the gases. Conversely, if a plume impacts on a monitor that contains only one of these gases, it may be reasonable to assume that it was the only one of the pair originally emitted. The relationship of CO to SO_2 has therefore been analysed in order to further assess the relationship between the 2 pollutants.

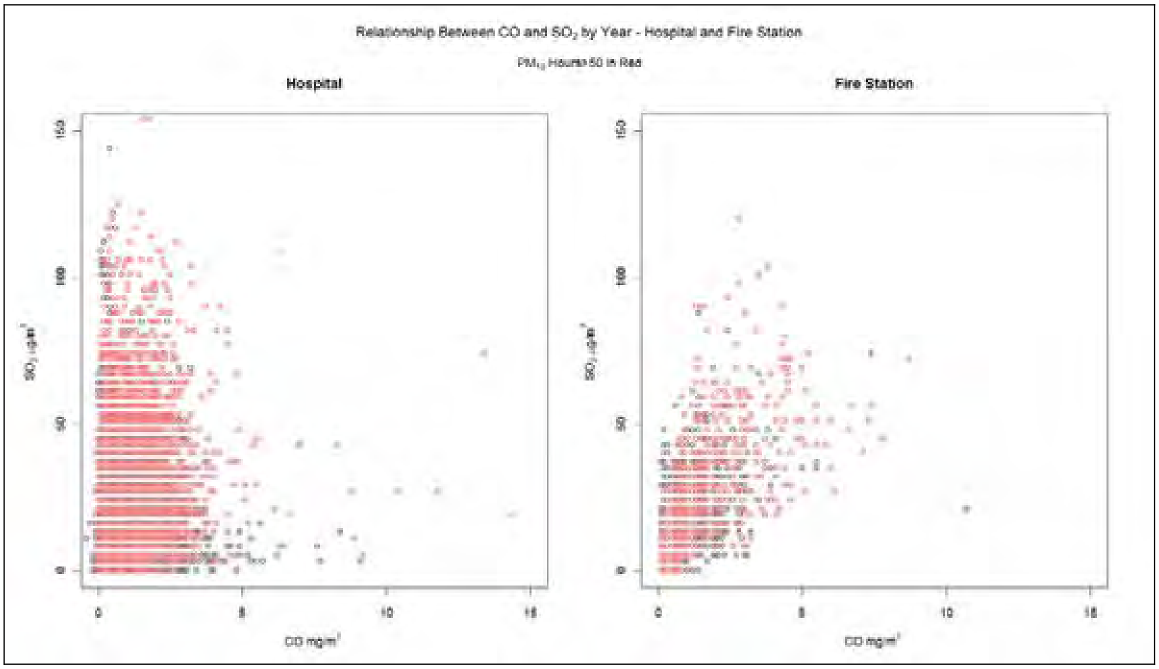


Figure 51: Relationship of CO to SO_2 at AURN Sites

Figure 51 shows the relationship between CO and SO_2 at the Hospital and Fire Station AURN sites (using the same cut-offs applied in Figure 49 and Figure 50). These show an interesting difference in the relationships between the two pollutants between the sites. As discussed above, from ‘conventional’ combustion sources, it might be expected that CO and SO_2 concentrations were reasonably well correlated, and that as concentrations of one rose, so would the other. The plot of data from the Fire Station shows this reasonably well, although there is a tendency for concentrations of SO_2 to rise with no increase in CO. However, in the plot of data for the Hospital data, there is a tendency for both pollutants to increase independently of the other, suggesting that there may be significantly different combustion sources at work here.

Figure 52 (below) shows how these patterns vary between different years at the Hospital site (N.B. The scales have been changed to focus on the main cluster of points). The tendency is for points to lie in the lower left quarter of the graph, or where concentrations of either pollutant are highest, for the other pollutant to be relatively low.

The distribution of the red points on the plots (indicating PM_{10} Hours>50) again indicates that elevated PM_{10} concentrations can be, but are not necessarily related to CO or SO_2.

These patterns suggest a need for potential sources of pollution on the steelworks site to be classified on the basis of whether emissions of PM_{10} are likely to be accompanied by either CO or, SO_2 or both. One potential conclusion may be that some CO is related not to a combustion source as such but may be related to a 'heat' source such as cooling slag.

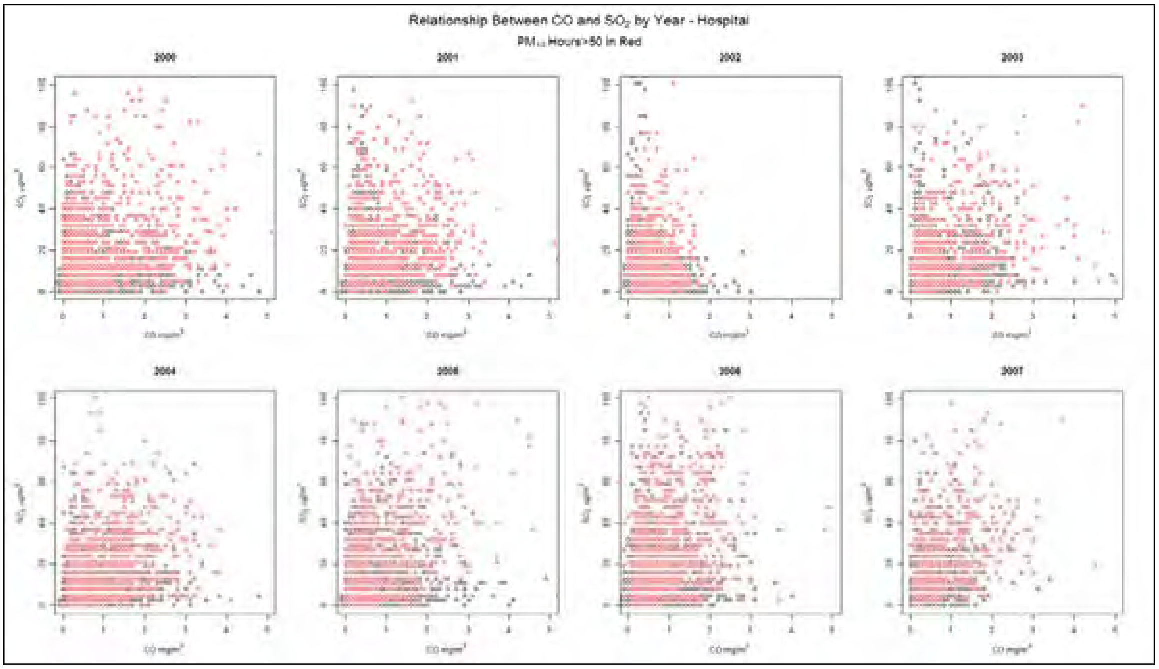


Figure 52: Relationship of CO to SO_2 at Hospital Site by Year (Scales Shrunk)

13.10 Summary of Analysis of Exceedences

This section has looked at patterns of both Exceedence Days and Hours where the daily mean objective concentration was exceeded (Hours>50). Following 2003 when Blast Furnace No.5 came back on line, the number of Exceedence Days does not appear to have dropped significantly beyond the year-on-year variability that would be expected. There appear to be significant reductions in both the number of Exceedence Days and Hours>50 during 2002 when Blast Furnace 5 was off-line, and 2009 subsequent to Blast Furnace No.4 going out of operation. No evidence has yet indicated whether these reductions might relate to reductions in emissions from the furnaces themselves, or from associated reductions in material handling or other activities.

Whilst some evidence indicates that the proportion of Exceedence Days measured by the AURN has been lower since it moved to the Fire Station site, the EAW monitoring at approximately the same location recorded a substantial number of Exceedence Days. This suggests that lower number of events being recorded by the AURN monitor may actually relate to lower emissions from sources, or more favourable meteorological conditions as opposed to being a less polluted location.

From the simple polar plot analysis of Hours>50, there does not appear to be a particularly clear difference in the direction of sources to other hours. There are some noticeable variations in the impacts with windspeed.

The distribution of temporal patterns of Hours>50 tends to follow a similar pattern to average diurnal patterns of PM_{10} concentration.

Analysis of the relationship of elevated PM_{10} to CO and SO_2 indicates no consistent relationship with either pollutant.

The simple analysis of Exceedence Days is not very fruitful, as a significant amount of evidence is pointing to a range of sources leading to elevated PM_{10} concentrations. There is therefore a need to analyse both Exceedence Days and Hours>50 much more closely, and particularly to attempt to categorise these events. One such means of classifying Exceedence Days is based on ratio of daily mean to daily maximum concentrations and has been set out in this section. Another possible method might be calculating the number of Hours>50 that occur within that day. For looking at individual Hours>50 it may be possible to categorise these in terms of other variables such as other pollutants, time of day or year, or a range of meteorological parameters (including past rainfall in order to estimate the likelihood that the ground and stockpiles may be dry enough or dust to become resuspended). Whilst being a potentially complex task, the use of statistical methods such as Principal Components Analysis may be helpful in determining more distinct patterns.

14 Comparisons Between the Hospital and Fire Station AURN Sites

One of the issues specifically identified in the project meetings, was whether available data suggested that pollution concentrations at the new AURN site at the Fire Station are comparable to those at the previous Hospital site. Throughout the previous analyses this issue has been touched upon as it arose, for example Figure 25 and Figure 26 showing trend in pollution by wind sector clearly indicated a shift in pollution patterns recorded at the AURN monitor between the two sites. This difference shows a reduction in pollution from the SW sector (and a slight reduction from the W sector), but a much more pronounced increase from the S sector. Whilst this indicates that the new Fire Station site is certainly being exposed to distinct periods of elevated pollution (and the correlation of PM_{10} with CO and SO_2 suggests that this is in part related to combustion sources at the steelworks site), these graphs did not provide an indication of the frequency with which these sites are impacted by the various wind sectors, and therefore the frequency that the monitors were exposed to high pollution concentrations.

In order to try and evaluate further the possible differences between the sites, a comparison has been carried out looking at patterns of pollution at the two monitoring sites. It is impossible to try and precisely compare two monitoring locations like-for-like even if they are operating concurrently. With the AURN dataset, the two sites operated consecutively with no overlap and so it is not possible to make an assumption of ‘all other things being equal’.

14.1 Comparison of Key Pollutant Statistics between AURN Sites

Section 13.1 has already looked at comparisons of the number of Exceedence Days and Hours>50 for both years and quarters. In this section a more detailed analysis is presented looking at a wider range of pollutants and statistics for each AURN site over two different sets of time periods.

In order to compare the data it was initially decided to take 18 months of data from each site in order to compare over the longest period possible: January 2006 to June 2007 (the last 18 months of the Hospital AURN data), and July 2007 to December 2008 (the first 18 months of the Fire Station site). These two periods have approximately the same number of recorded PM_{10} hours. In order to provide a further comparison, these two periods are also compared with the same statistics for the earlier monitoring period for the Hospital site from 2000 to 2005. It is important to note that although this comparison was over a similar number of monitored hours, the Hospital period covered the first two quarters of 2007, and previous analyses (see Section 13.5) have shown this to be the more polluted part of the year. A second analysis was then carried out looking at calendar years, comparing 2005 and 2006 at the Hospital site with 2008 at the Fire Station site in order to account for seasonal differences N.B the shorter the dataset the less valid any conclusions drawn from the comparison can be as they are more likely to be influenced by particular weather conditions, or source activities.

Table 12: Comparison Statistics for AURN Hospital and Fire Station sites (18 month comparison).

	Hours	H<50	H>50	Mean PM_{10}	Mean PM_{10} (H<50)	Mean PM_{10} (H>50)	Max PM_{10} (H>50)	Max DM* PM_{10}	Mean CO	Mean CO (H<50)	Mean CO (H>50)	Mean SO_2	Mean SO_2 (H<50)	Mean SO_2 (H<50)
Hospital 2000-5	49971	42875 (85.8%)	7231 (14.5%)	30.5	**22.3**	79.4	**447**	119.2	0.39	**0.32**	0.81	6.8	5.0	18.3
Hospital 2006-7	11818	**9912 (83.9%)**	**1951 (16.5%)**	**31.9**	**22.3**	80.6	411	116.5	0.38	0.31	0.78	**8.5**	**5.7**	23.5
Fire Station 2007-8	11832	10542 (89.1%)	1301 (10.9%)	27.3	20.1	**85.3**	370	**134.4**	**0.41**	0.29	**1.38**	6.6	4.3	**25.3**

Figures in **bold** indicate the highest values for each site.
* DM = Daily Mean

Table 13: Comparison Statistics for AURN Hospital and Fire Station sites (18 month comparison).

	Hours	H<50	H>50	Mean PM_{10}	Mean PM_{10} (H<50)	Mean PM_{10} (H>50)	Max PM_{10} (H>50)	Max DM* PM_{10}	Mean CO	Mean CO (H<50)	Mean CO (H>50)	Mean SO_2	Mean SO_2 (H<50)	Mean SO_2 (H>50)
Hospital 2005	7569	6589 (87.1%)	1000 (13.2%)	29.6	21.8	80.6	**447**	99.9	0.38	0.31	0.82	7.2	5.1	23.7
Hospital 2006	7859	**6705 (85.32%)**	**1182 (15.0%)**	**31.3**	**22.6**	80.6	411	116.5	**0.41**	**0.35**	0.81	**8.5**	**5.8**	**25.4**
Fire Station 2008	8121	7183 (88.5%)	940 (11.6%)	28.7	21.3	**84.9**	370	**134.3**	0.41	0.29	**1.38**	6.1	3.9	22.1

Figures in **bold** indicate the highest values for each site.
* DM = Daily Mean

Table 12 and Table 13 show summary statistics for PM_{10}, CO and SO_2 at the Hospital and Fire Station AURN sites over the two different sets of periods. The tables show information on the number and percentage of Hours>50 during the monitoring periods, along with maximum pollution concentrations, and overall means, along with means for both Hours>50 and Hours<50. This analysis is useful not just in terms of comparing the pollution at the two AURN sites, but also in terms of analysing pollution patterns across different time periods.

The significant conclusions from these tables are as follows:

- The Hospital site in both 2006 and 2006/7 was the most polluted period and site, in terms of both the number and percentage of Hours>50, and in terms of mean hourly PM_{10} concentrations.
- When looking at pollution events however, either Hours>50 or daily mean PM_{10} concentrations, the Fire Station is the most polluted site.
- The highest hourly PM_{10} concentration recorded occurs at the Hospital (during the early period).
- The highest mean concentrations of CO, both overall and during Hours>50, were recorded at the Fire Station site during the 19 month comparison. During the 12 month comparison mean CO concentrations during Hours>50 is still he highest (N.B. the similarity in the figures for CO at the Fire Stations site is due to poor data capture at that site in 2007).
- Mean SO_2 concentrations are highest at the Hospital site (later period) overall and during low PM_{10} hours (Hours<50) during both the 12 and18 month comparisons.
- For the mean of SO_2 concentrations during Hours>50, the Fire Station site comes out more polluted in the 18 month comparison, but the Hospital (later period) is worse in the 12 month comparison.

From this analysis it is hard to conclude whether either of the sites, or monitoring periods suffer from worse pollution than any other. A clear decision would have to be based on a very particular definition of both the pollutant and statistic that mattered most. As stated above, it is impossible to compare like-for-like in this situation due to changes in meteorological conditions and activities on the steelworks site.

From both these results and conclusions drawn from previous analyses in this report, it may be fair to say that, to date, whilst the Fire Station AURN monitor appears to be subject to lower average pollution, and less frequent pollution events, those events that do impact on the site appear to be worse than those that were experienced towards the end of the Hospital site's operation.

14.2 Analysis of Concurrent Monitoring by AURN and EAW

Another opportunity to try and assess pollution concentrations between the Hospital and Fire Station AURN monitoring sites is presented by the overlapping of the 2007 EAW monitoring campaigns with the relocation of the AURN site. In particular the EAW Taibach 2007 monitoring was undertaken in close proximity to the Fire Station AURN site. The concurrent monitoring periods allow 4 main comparisons to be made between AURN and EAW monitoring sites:

- Hospital AURN with Taibach07 (16/12/2006-22/06/2007)
- Fire Station AURN with Taibach07 (27/07/2007-29/08/2007)
- Hospital AURN with Corus S&S Club (18/01/2007-22/06/2007)
- Fire Station AURN with Corus S&S Club (27/07/2007-02/10/2007)

It should be noted that the AURN site changed from a standard TEOM (*1.3) to a TEOM FDMS unit on 13/02/2007, during this comparison period. As with the rest of the report, the initial analysis makes no special consideration of this change as the data is analysed as it was provided for the project. However a comparison of the relative impact of using the new Volatile Correction Model for adjusting the EAW monitoring data is discussed in Section 14.2.2.

14.2.1 Comparison of Reported Data

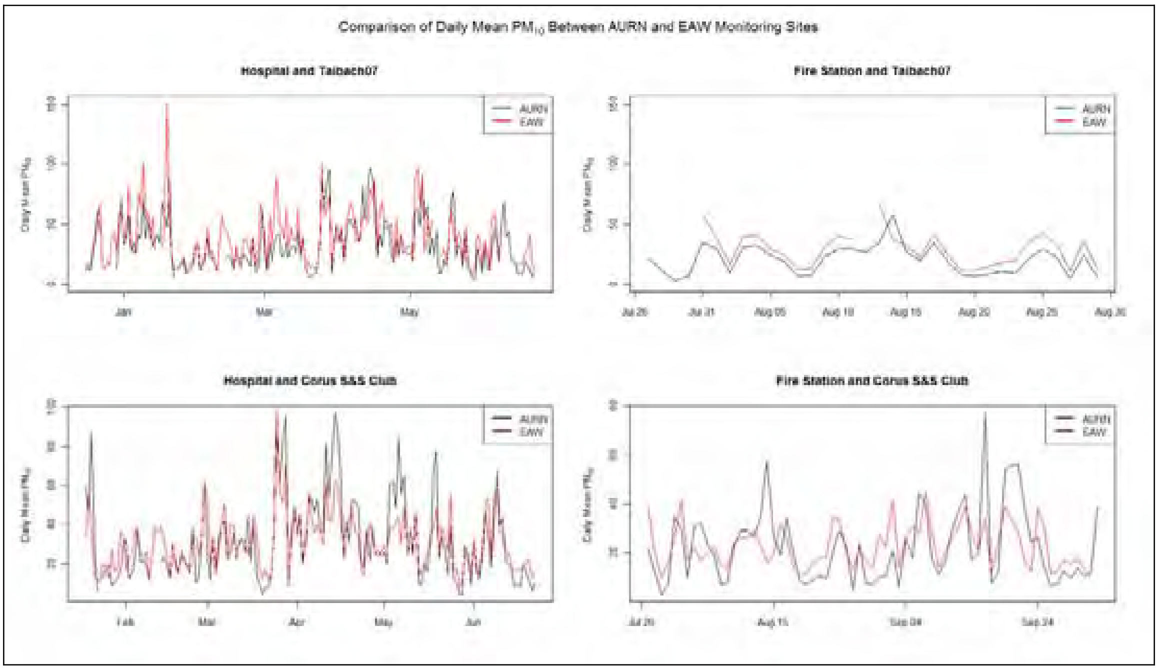


Figure 53: Daily Mean PM_{10} over Concurrent Monitoring Periods 2006-7

Figure 53 shows plots of daily mean PM_{10} concentrations for the AURN and EAW monitoring sites over the four identified comparison periods. The general pattern shows that the pollution patterns at each site generally follow each other. Further analysis could be done in determining the influence of regional background concentrations on this variation.

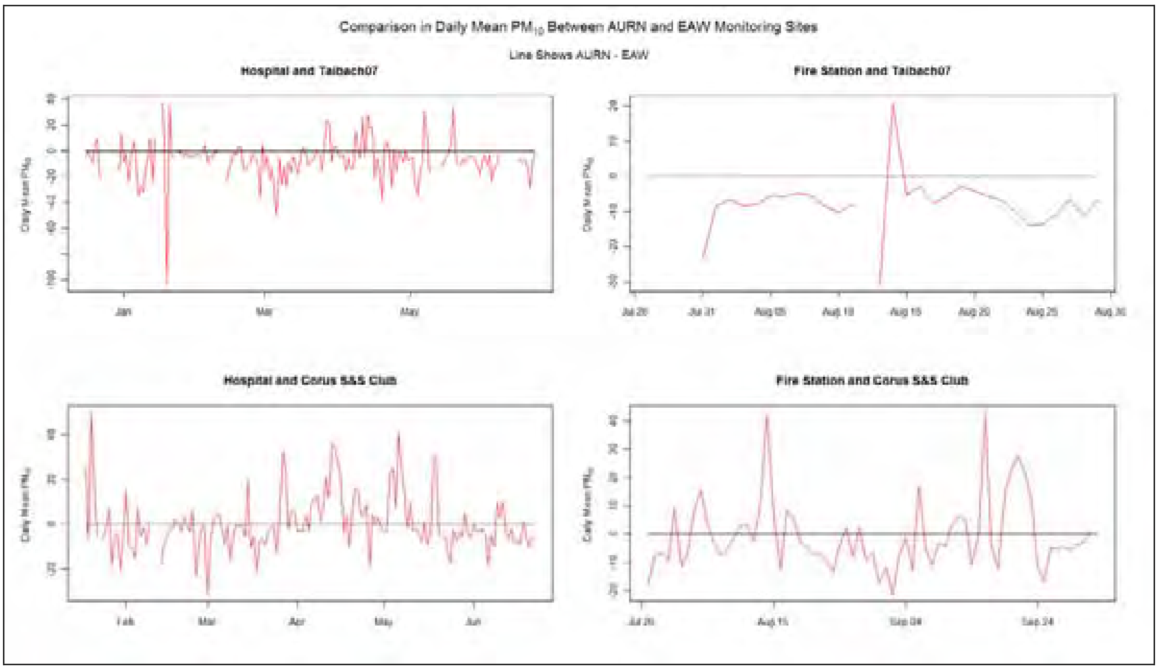


Figure 54: Difference Between Daily Mean PM_{10} AURN and EAW Monitoring Sites During Comparison Periods

Figure 54 shows the differences in daily mean PM_{10} concentrations between the AURN and EAW monitoring sites over each of the comparison periods. Where the red line is above the x-axis, this indicates the AURN site was reporting higher concentrations, where it is below the EAW site was recording higher concentrations. For most of the comparisons, differences in concentration fluctuate considerably. However, although only a very short data set, the comparison between the Fire Station and Taibach07 data, shows that quite consistently, daily mean concentrations at the Taibach station are higher than at the Fire Station AURN site despite being very closely located.

It is interesting to note though that the Taibach site appears to generally monitor higher concentrations than the Hospital AURN site, suggesting that if the Fire Station AURN site is less polluted than the Hospital site, it may be due to very local conditions at the new monitoring site (i.e. differences in concentration caused by local flow patterns, caused by obstacles such as the railway embankment or the nearby trees) rather than the site being located in a generally less polluted area of Port Talbot.

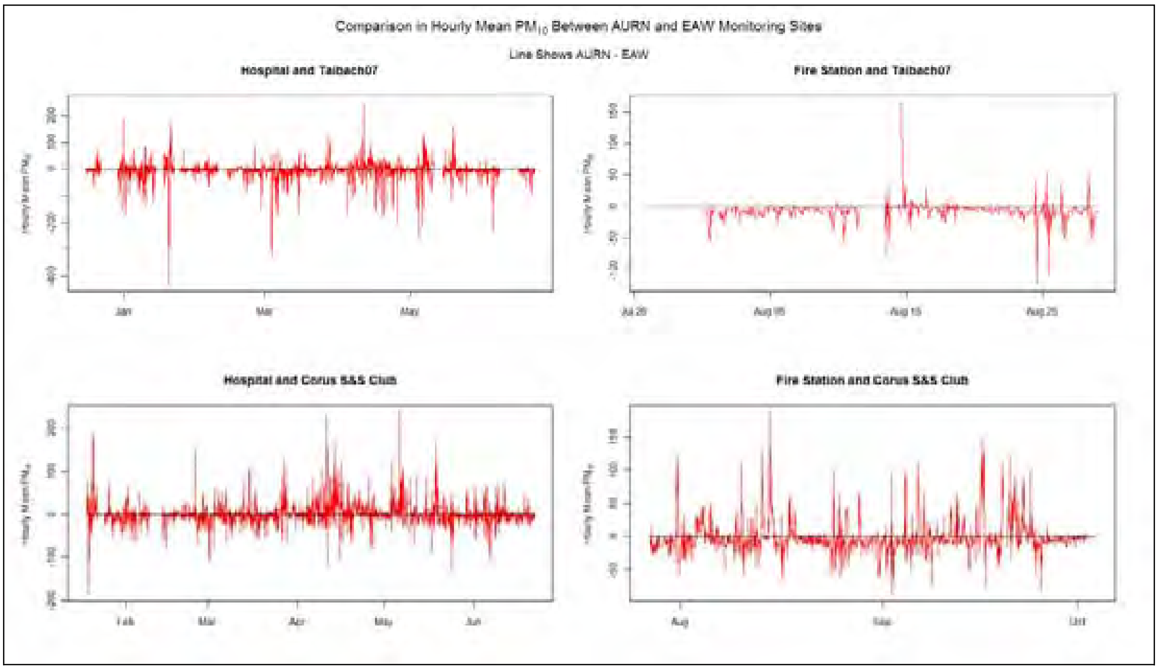


Figure 55: Difference Between Hourly Mean PM_{10} AURN and EAW Monitoring Sites During Comparison Periods

Figure 55 shows the differences in hourly mean PM_{10} concentrations between the AURN and EAW monitoring sites over each of the comparison periods. Where the red line is above the x-axis, this indicates the AURN site was reporting higher concentrations, where it is below the EAW site was recording higher concentrations. As with the comparison of daily mean concentrations, for most of the comparisons, differences in concentration fluctuate considerably. Again though, the comparison between the Fire Station and Taibach07 data shows that quite consistently, concentrations at the Taibach station are higher than at the Fire Station AURN site. The Taibach07 monitoring data also appears to be higher than the hospital site – again indicating that 'general' location of the Fire Station AURN monitor is unlikely to be resulting in lower concentrations of PM_{10} being recorded.

Table 14: Summary Data for Comparison of Concurrent Monitoring Periods

AURN	EAW	Mean AURN	Mean EAW	Max Hourly AURN	Max Hourly EAW	Hours >50 AURN	Hours >50 EAW	Exc. Days AURN	Exc. Days EAW
Hospital	**Taibach**	33.3	**39.3**	321	**484**	815	**965**	32	**48**
Fire Stn.	**Taibach**	20.7	**28.8**	198	**228**	74	**110**	1	**2**
Hospital	**Corus**	**32.3**	31.2	**321**	266	**646**	556	**26**	17
Fire Stn.	**Corus**	22.5	**22.7**	**198**	109	**187**	113	**5**	0

Table 14 shows four key summary statistics for the monitoring sites being compared: mean concentration, maximum hourly concentration, number of Hours>50 and number of Exceedence Days.

- The Taibach EAW site shows higher figures for all four statistics compared to the Hospital AURN site.
- The Taibach site also shows higher figures than the Fire Station AURN site.
- The Hospital AURN shows higher concentrations than the Corus Sports and Social Club EAW monitoring across all four statistics.
- The Fire Station shows higher figures than the Corus Sports and Social Club EAW monitoring for maximum hourly concentrations and both number of Hours>50 and number of Exceedence Days, whilst the EAW monitoring shows a marginally higher mean.

The Taibach monitoring location appears to be the most polluted of all the four sites in this comparison. Interestingly, despite their very similar location, the AURN monitor appears to record significantly less PM_{10} than the Taibach monitoring across all four statistics. This suggests, that unless there were any other reason to suspect that data were equivalent (e.g. known differences in monitor type and set up, and QA/QC treatment of the data) then the AURN site appears to be exposed to lower PM_{10} concentrations. This is potentially due to very local, micro-scale influences on the monitoring site such as obstacles to wind-flow leading to increased turbulence and greater mixing of pollution, or the diversion of polluted flow away from the monitors.

14.2.2 Comparison of TEOM*1.3 with Volatile Correction Method

In order to adjust TEOM data to compensate for volatile particles lost through evaporation due to the heated inlet on TEOM monitors, a factor of 1.3 has 'traditionally' been applied to TEOM data to make it "Gravimetric Equivalent". The general tendency has been found to be that the use of the 1.3 factor over-estimates PM_{10} concentrations, particularly in locations where a higher than average proportion of particles are non-volatile, such as locations close to either road or industrial sources. As a consequence of this problem, a new measurement system, the TEOM FDMS was designed. A further step within the UK has been the development of a method for using data from the TEOM FDMS monitors (the 'purge' measurement) to adjust conventional TEOM data instead of using the 1.3 factor. This method, the Volatile Correction Model or VCM, has been developed for use in the UK LAQM system. Full details can be found at the VCM website http://www.volatile-correction-model.info .

As stated above, the AURN site changed from using a standard TEOM monitor (applying a 1.3 adjustment factor) to a TEOM FDMS unit on 13/02/2007. This means that the comparison between datasets described above was between two equivalent datasets. The EAW have already undertaken some comparisons of the effects of these adjustment methods on the basis of daily mean data at both the Taibach 2007 and Corus Sports and Social Club monitoring sites. These found that there is evidence to suggest that the use of the 1.3 adjustment factor has been over-estimating recorded

numbers of exceedences at both sites. Details of the EAW comparisons can be found in the EAW Permit Review Document (Part c).
This section presents a separate analysis of the impact of the choice of adjustment factors, based on the intercomparison period outlined in the previous section. Within this comparison, it is important to note that the VCM method has not been used in its default mode (which is to use FDMS purge measurements from 3 monitoring sites within 130km of the TEOM site to be adjusted). The VCM adjustment has been based solely on data from the AURN FDMS monitor, initially when it was sited at the Hospital site, and then from July when it was sited at the Fire Station. This decision has been made because it is believed that due to the proximity of the Port Talbot FDMS units to the TEOMs being adjusted (in one case < 5-10 metres) the sole use of a local volatile measurement is likely to be much more appropriate than including the next nearest sites which are in Cardiff and Bristol. Whilst the previous section compared monitoring results between 16/12/2006 and 02/10/2007, this comparison can only begin at 13/02/2007 as this is when FDMS data became available for Port Talbot.

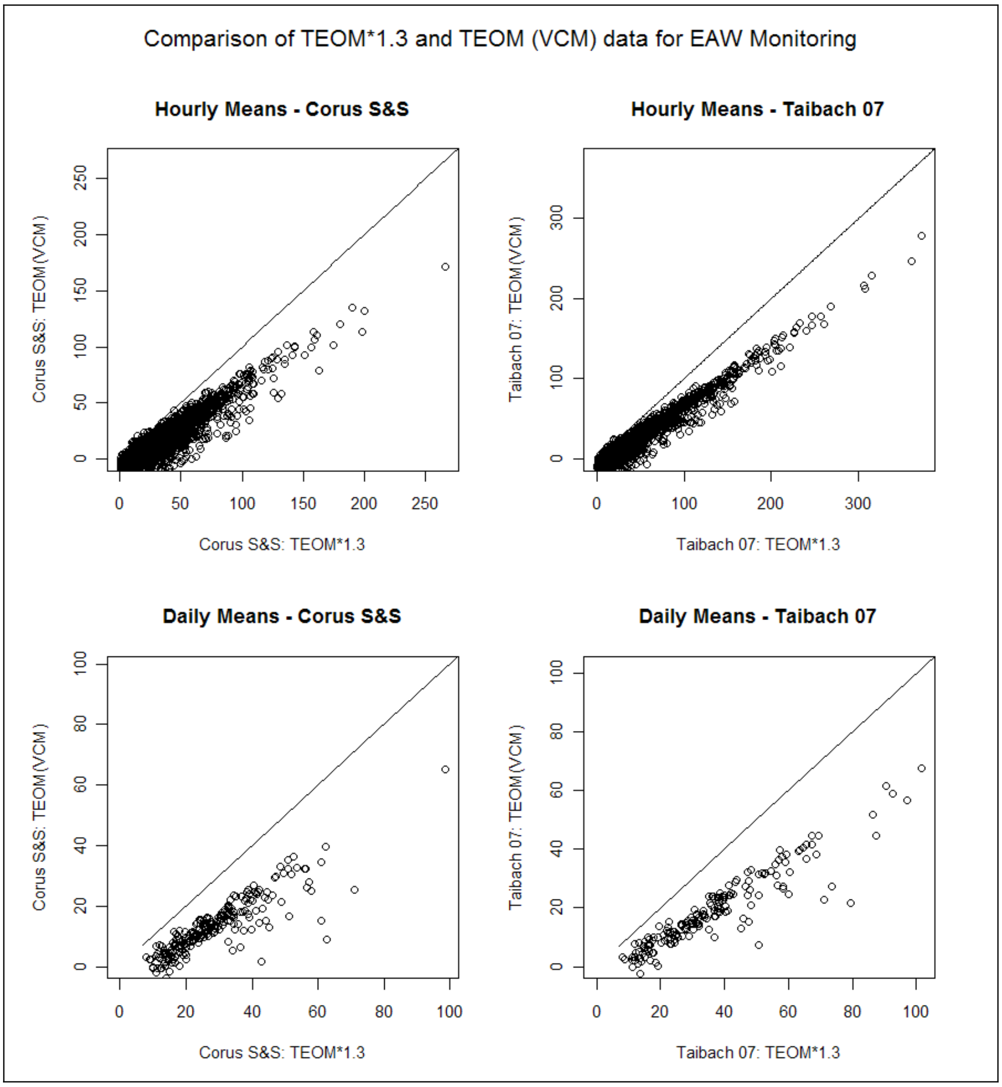


Figure 56: Comparison of Impact of 1.3 Adjustment Factor compared to Volatile Correction Model

Figure 56 shows a comparison of hourly and daily mean concentrations at the EAW Taibach and Corus S&S monitoring stations over the comparison periods. The graphs show, that as expected, the VCM method produces lower concentrations than the use of the 1.3 factor. In all plots it is notable that the difference appears greatest at the higher concentrations, indicating that these concentrations are probably dominated by non-volatile particles.

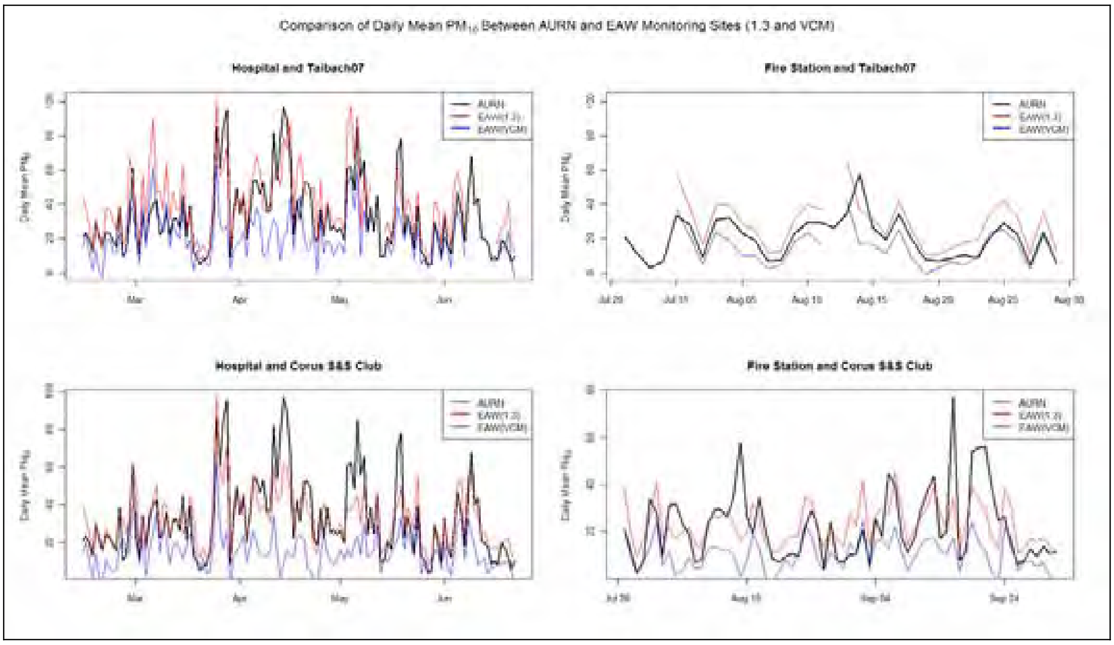


Figure 57: Daily Mean PM_{10} over Concurrent Monitoring Periods 2006-7 (EAW*1.3 and VCM)

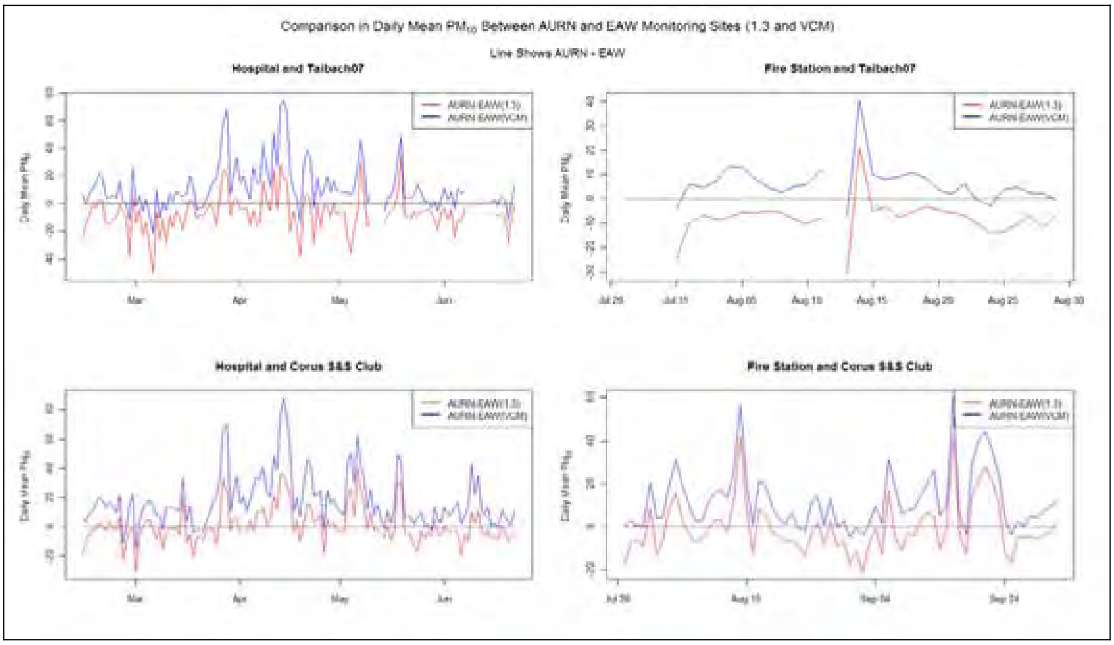


Figure 58: Difference Between Daily Mean PM_{10} AURN and EAW Monitoring Sites During Comparison Periods (EAW*1.3 and VCM)

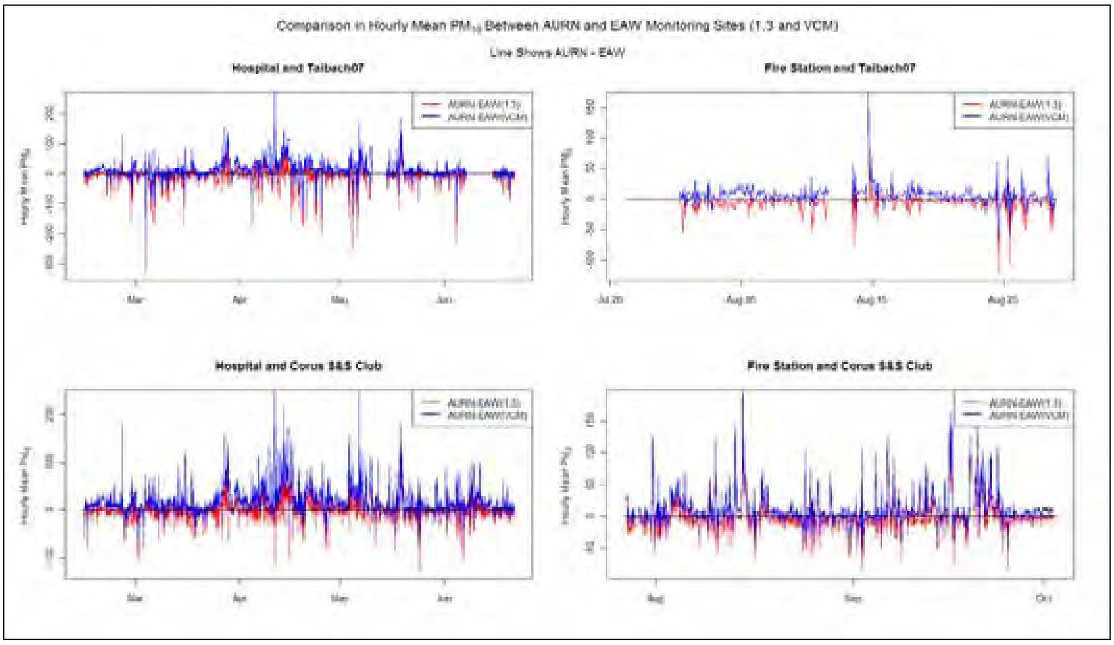


Figure 59: Difference Between Hourly Mean PM_{10} AURN and EAW Monitoring Sites During Comparison Periods (EAW*1.3 and VCM)

Figure 57, Figure 58 and Figure 59 show graphs similar to the ones in the basic comparison of the monitoring locations in the previous section (Figure 53, Figure 54 and Figure 55), however, in addition to the original TEOM*1.3 data (in red) the plots also show the EAW monitoring data converted using the VCM method (in blue). As with Figure 56, the graphs again clearly show the reduction in monitored concentrations if the VCM method is used.

In Figure 58 and Figure 59, where the lines are above the x-axis, this indicates that the AURN is measuring higher concentrations than the respective EAW monitor. One key plot to consider is the comparison between the AURN Hospital data and the EAW Taibach data (top left of each figure). Here, the change in the adjustment method used for the EAW TEOM data has led to the AURN Hospital site monitoring higher concentrations than the EAW Taibach monitor, as opposed to the situation using the 1.3 factor where the tendency is for the EAW Taibach monitor to record the highest concentrations. However, the other key plot to consider is the top right plot in these two figures, showing the comparison between the AURN Fire Station data and the EAW Taibach 2007 data. In these plots there appears to be an almost complete reversal, with the AURN consistently measuring higher concentrations than the EAW Taibach monitor when the latter is adjusted using the VCM rather than the 1.3 factor.

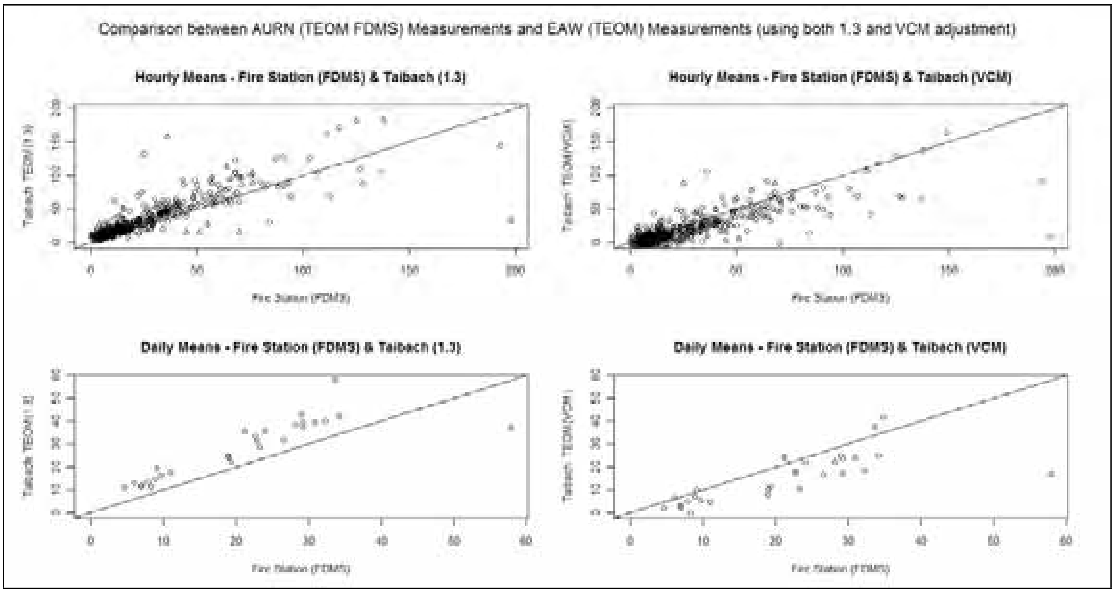


Figure 60: Comparison of AURN (Fire Station) and EAW (Taibach) PM_{10} Measurements using both 1.3 factor and VCM TEOM adjustment

Figure 60 shows scatter plots comparing the AURN Fire Station (TEOM FDMS) measurements with TEOM measurements from the EAW Taibach monitoring, adjusted using both the 1.3 factor and VCM method. These plots further illustrate the tendency for the use of the 1.3 factor to lead to higher concentrations being measured at the EAW Taibach site, and the VCM method to lead to lower concentrations.

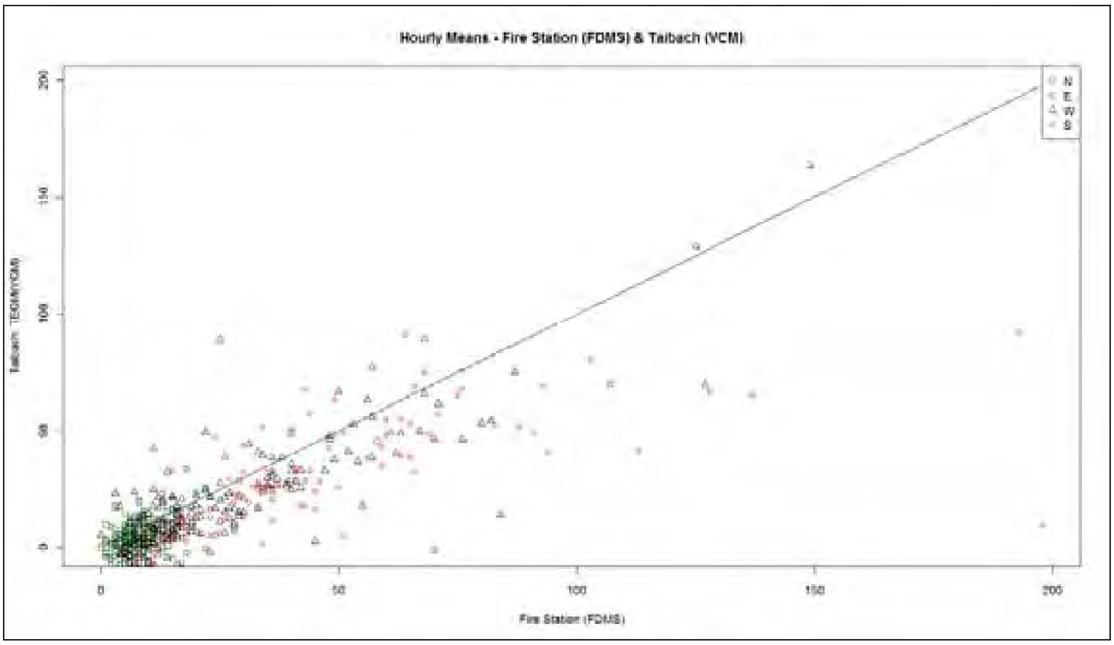


Figure 61: Comparison of AURN (Fire Station) and EAW (Taibach) PM_{10} Measurements using VCM TEOM adjustment by Wind Direction

As the VCM method was used only with the FDMS purge measurements from the Fire Station site, there is no obvious reason why this fairly consistent difference should occur. The only improvement that could be made to this comparison could be to use the temperature and pressure information for the TEOM which were unavailable for this study. Although the majority of measurements (77%) saw the AURN TEOM FDMS reading the highest, an analysis was undertaken to see if there was an identifiable difference between those hours where the TEOM (with VCM) over read the FDMS, and those where it under read. Figure 61 shows a scatter plot of the points by wind sector (N, E, W and S), whilst Table 15 shows the number and percentage of hours where the AURN FDMS measurements were greater and less than the EAW TEOM (VCM) measurements. There is no clear indication that the differences in measurements are related to wind direction as the distribution between wind sectors doesn't change by more than 10%.

Table 15: Number of hours by wind sector where TEOM (VCM) over/under read compared to FDMS.

Comparison of Monitors	N	E	W	S	Total
	Number of hours				
Total	255	22	201	98	576
AURN>EAW	188	20	151	84	443
EAW>AURN	67	2	50	14	133
	% of hours				
Total	44%	4%	35%	17%	100%
AURN>EAW	42%	5%	34%	19%	100%
EAW>AURN	50%	2%	38%	11%	100%

Table 16: Summary Data for Comparison of Concurrent Monitoring Periods (EAW VCM)

AURN	EAW	Mean AURN	Mean EAW	Max Hourly AURN	Max Hourly EAW	Hours >50 AURN	Hours >50 EAW	Exc. Days AURN	Exc. Days EAW
Hospital	**Taibach**	**33.2**	21.2	**321**	279	**591**	282	**24**	5
Fire Stn.	**Taibach**	**20.7**	14.7	**198**	164	**74**	47	**1**	0
Hospital	**Corus**	**33.2**	15.1	**321**	172	**591**	112	**24**	1
Fire Stn.	**Corus**	**22.2**	10.2	**198**	78	**182**	27	**5**	0

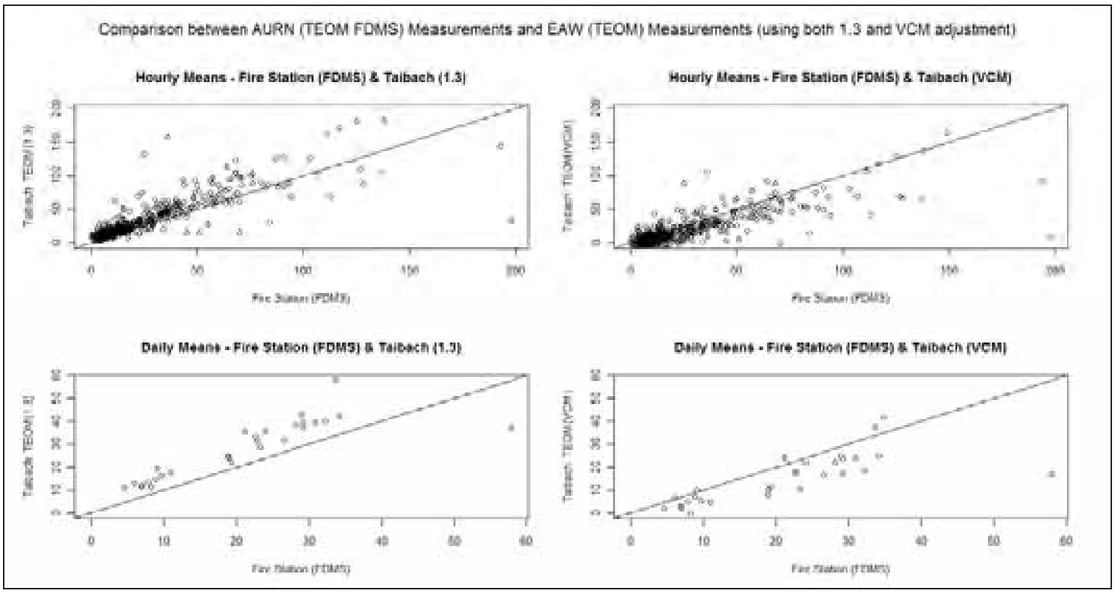
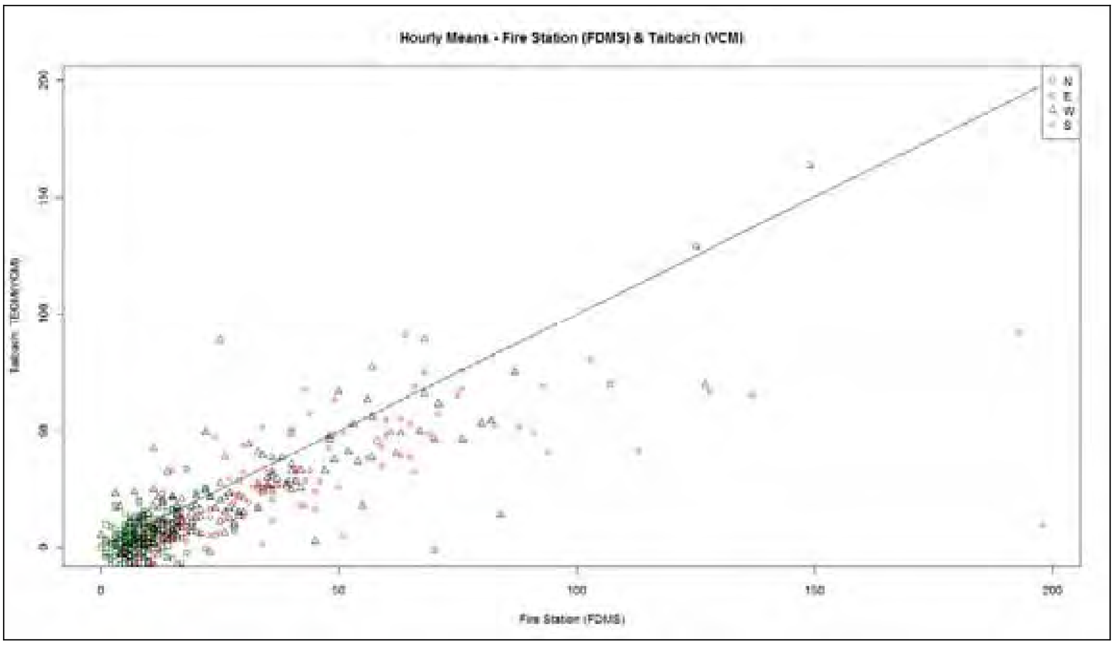


Figure 60: Comparison of AURN (Fire Station) and EAW (Taibach) PM10 Measurements using both 1.3 factor and VCM TEOM adjustment

60 shows scatter plots comparing the AURN Fire Station (TEOM FDMS) measurements with TEOM measurements from the EAW Taibach monitoring, adjusted using both the 1.3 factor and VCM method. These plots further illustrate the tendency for the use of the 1.3 factor to lead to higher concentrations being measured at the EAW Taibach site, and the VCM method to lead to lower concentrations.



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AURN>EAW	188	20	151	84	443
EAW>AURN	67	2	50	14	133
	% of hours				
Total	44%	4%	35%	17%	100%
AURN>EAW	42%	5%	34%	19%	100%
EAW>AURN	50%	2%	38%	11%	100%

Table 16 shows four key summary statistics for the monitoring sites being compared: mean concentration, maximum hourly concentration, number of Hours>50 and number of Exceedence Days, with the EAW data based on adjustment using the VCM method. The comparative table (Table 14) showed that there was a great deal of variation on which sites were the most polluted, depending on which statistic was chosen as the benchmark. Using the VCM method to correct the EAW monitoring data results, as previously discussed, in much lower concentrations at these monitors. This results in the AURN data predicting greater levels of pollution for all statistics under this analysis.

The Hospital site does appear here to be the most polluted monitor/location, however it is necessary to remember that this data covers the first two quarters of the year which have previously been shown to have higher pollution concentrations. It is also important to note that whilst the previous analysis (based on the 1.3 adjustment factor) suggested that the AURN Fire Station site might be recording lower concentrations than the Taibach monitor, in this analysis it appears to consistently monitor higher concentrations.

As the VCM adjustment is based solely on the FDMS purge measurements from the Fire Station AURN (around 5-10 metres away), this *may* be considered to be the most accurate comparison undertaken here. Whichever comparison between these two sites is taken as the most representative, there does appear to be a large but reasonably consistent difference between the two sets of data, which suggests that there may be issues regarding the homogeneity of air flow at this location.

14.3 Summary of Comparison of AURN Monitoring Locations

A range of comparisons have been carried out between the monitoring carried out at the Hospital AURN station and the Fire Station site. Any effort to establish whether one or other location best represents *the* 'worst-case' location is a fruitless task, particularly if there is a significant impact of plumes leading to exceedences of the PM_{10} objective. The data analysed suggests that there are a wide range of sources on the steelworks site contributing to exceedences of the objective, the worst-case location will move from hour to hour, day to day and year to year. Likewise, the definition of worst-case location also relies not just on a specific pollutant, but also on the statistic used to measure it.

On the basis of the analyses carried out there appears to be a tendency for the Fire Station to record lower average concentrations of PM_{10} and less exceedences of the daily mean than might be expected had monitoring continued at the Hospital site. However, maximum daily mean concentrations of PM_{10} occurring at the Fire Station site appear to be greater than would be expected at the Hospital, as is the means of hours above the objective concentration (Hours>50). These also appear to relate to higher concentrations of CO and SO_2 during the Hours>50 at the Fire Station.

Comparisons of the AURN and EAW monitoring also indicate that the EAW Taibach monitor, which was located in close proximity to the Fire Station AURN site, has tended to monitor higher concentrations than *both* the Hospital AURN and the Fire Station AURN over concurrent monitoring periods when adjusted using the 1.3 factor. This suggests that any issues regarding whether or not the Fire Station monitor is exposed to lower pollution levels than the Hospital site, result not from the new monitoring site being generally located in a less polluted area, but from micro-scale siting issues relating to differences in pollution concentrations over distances of a few metres.

It is also important to note that any comparison between concentrations monitored at the Fire Station and long-term patterns at the Hospital are invalid due to the change in monitoring method. The TEOM FDMS method employed at the Fire Station site is likely to record lower concentrations of PM_{10} than the TEOM*1.3 method that was used for all but the last 6 months of monitoring at the Hospital site.

This leaves the issue of the differences between the EAW Taibach 2007 monitoring and the Fire Station. The differences in reported concentrations between the two monitors may be caused by either very local features interrupting the direction of flow arriving at the monitor inlet, or features leading to increased turbulence and mixing of pollution. Two of the features that stand out as potential causes for disturbance in wind flow in this area might be the location of the railway line to the west of the monitoring site, and the proximity of the trees directly to the south and southwest of the monitor, particularly in light of the fact that the strongest impacts to this location in general are from the south).

Figure 62, Figure 63 and Figure 64 show photos of the AURN and EAW monitors at the Fire Station site. The TEOM FDMS monitor is located in the large walk in unit of the AURN. Comparison of the photos in Figure 64 show how close the two monitors were located. Note the location of the tree and the gap in the brick wall. Subsequent to the photo of the EAW monitor, the telegraph pole appears to have been relocated to the other side of the AURN station. The EAW monitor is located closer to the wall and the road than the AURN monitor, however the road is not subject to any significant traffic levels as that entrance to the steelworks is now closed and over the monitoring periods would only ever have operated as a shift entrance to the site.

Communication with the LA Support monitoring helpdesk has confirmed that the prescence of trees so close to the monitor may cause problems, not just by interrupting flow but by scrubbing out the more reactive gases (O_3, SO_2, NO_2) and particles "*quite effectively*"[2]. Directive 2008/50/EC (the "CAFÉ" Directive on ambient air quality and cleaner air for Europe) specifies that "*the flow around the inlet sampling probe shall be unrestricted (free in an arc of at least 270°) without any obstructions affecting the airflow in the vicinity of the sampler (normally some metres away from buildings, balconies, trees and other obstacles*". Under this stipulation the monitor may *just* be sited satisfactorily (the trees interrupt flow for <90°, however, it should be considered that the trees are directly southwest of the monitor and therefore directly in the line of both the prevailing wind and the direction of highest emissions from the steelworks site.

[2] Personal Communication - Lisa Beardmore & Brian Stacy, AEA Technology

Figure 62: Photos of Fire Station AURN Location (www.bv-aurnsiteinfo.co.uk)

Figure 63: Photos of Fire Station AURN Location (AQMRC@UWE)

Figure 64: Photos of EAW Taibach monitoring and Fire Station Monitor and (EAW and www.bv-aurnsiteinfo.co.uk)

15 Summary of Data Analysis Key Points and Recommendations

The intention of this part of the report has been to present an independent analysis of monitoring data relating to the Port Talbot area, focussing on PM_{10}, due to the issues with exceedences of the EU Limit Value for daily mean concentrations, but also taking into account other pollutants and meteorological parameters where relevant. These analyses provide a range of detailed observations on the PM_{10} pollution climate in the vicinity of the steel works. These observations lead to a series of conclusions and recommendations for further work by WAG and other agencies. However, given the rich nature of emission sources within the steelworks and the timescale of this enquiry, definitive conclusions on source/receptor relationships can not yet be provided. A range of further studies are recommended to improve our understanding of the complex relationship between emissions, meteorology, topography and the exceedence of PM_{10} regulations and limit values. The analyses of the data have therefore been presented in such a way as to highlight the most significant and important patterns that have been identified.

As they say, “a picture is worth a thousand words”, and the text accompanying the figures and tables is not intended to be able to completely describe everything that may be evident from the graphs, nor have all the possible graphs been included in the report (all data and code used to create the plots is available, as is the freely available open-source software used to do the analyses). The ability to investigate the nature of pollution in Port Talbot is currently undergoing a step change, as both Neath Port Talbot County Borough Council and the site operators continue to deploy new monitors, both within the steelworks site and in the town and surrounding area, and with the new availability of Openair as an analysis tool. The analyses presented here attempt to show a range of the ways in which the pollution data for the area can be analysed and provide indicators for where future studies should focus their attention. The analyses raise significant questions which could not be sufficiently addressed in this study due primarily to restrictions in time and budget. In some ways the timing of this study has been unfortunate, in that the relocation of the AURN monitoring site has resulted in a relatively short contemporary data set. In other ways though, the timing is very opportune as it has allowed this thorough and detailed analysis to be undertaken prior to the coming on-line of the much wider monitoring networks now established by NPTCBC and the site operators so that the analyses carried out here can be replicated on the new, large datasets. This report should therefore assist in the need identified in the 2009 EAW Permit Review for developing the ways in which data the monitoring data around the steel works can be handled and presented.

In carrying out the work presented in the report, it has been intended that a framework can be set out for carrying out further work and recommendations for this are also summarised below

15.1 Key Points Resulting from the Data Analyses

- Predominant sources of PM_{10} are not in immediate proximity to the monitoring locations (evidenced by negligible impact at low windspeed).
- The relationship of elevated concentrations with higher windspeed suggests that sources may include both/either stacks (where turbulence results in the grounding of plumes) or dust (where wind is able to resuspend it).
- PM_{10} concentrations are dominated by sources to the SW of the AURN stations, indicating sources on the steelworks site as the most likely cause of elevated PM_{10} concentrations in the area.
- There are strong correlations between the direction of the main PM_{10} sources, and sources of CO and SO_2. However, temporal analyses indicate that not all PM_{10} events are related to elevated concentrations of these combustion pollutants. This suggests that PM_{10} events may be being caused by either combustion sources, or dust sources or a combination of the two.
- In some cases, elevated PM_{10} is related to CO but not SO_2. There appears to be an almost inverse relationship between these pollutants at high concentrations, suggesting more than one possible combustion related source, and potentially a 'heat' rather than a combustion source leading to the high CO concentrations.
- Average concentrations of CO and SO_2 show similar fluctuations over time to PM_{10} at the AURN sites, particularly the increase in concentrations from the southern sector when the location moved to the Fire Station site.
- Neither NOx or Ozone appear to be associated with the steelworks site.
- $PM_{2.5}$ at the Fire Station AURN monitor and the EAW Taibach 2007 campaign indicate that $PM_{2.5}$ tends to be dominated by sources to the north-east, probably traffic and potentially the motorway. The EAW monitoring at the Corus Sports and Social Club indicated that $PM_{2.5}$ was dominated by sources to the north east, potentially the main A48 through Margam, or the northerly parts of the steelwork site.
- PM_{10} pollution related to the site follows a distinctive diurnal profile, with concentrations beginning to rise at around 6am, and continuing to rise until about noon. They then level out and then begin to drop sharply from around 4pm. This pattern may result from either daytime activities on-site resuspending dust, and/or increased daytime insolation leading to increased plume grounding due to convective turbulence.
- $PM_{2.5}$ follows a different diurnal profile to PM_{10} which much more closely matches that which would be expected from road sources (e.g. dual peaks matching peak traffic hours).

- The dominance the PM_{coarse} fraction in the PM_{10} monitored from the area of the steelworks tends to suggest dust (mechanically generated) particles rather than combustion sources particles as the major problem. However, if CO is coming from a heat or other non-conventional combustion source then this might also lead to non-dust coarse fraction particles.
- Average concentrations of PM_{10} associated with the steelworks site have reduced over time, however, the frequency and magnitude of peak hourly concentrations does not appear to have reduced markedly.
- Directional analysis of the monitoring data has identified these as the most likely potential source 'activities' on the steelworks site contributing to elevated PM_{10} concentrations at the AURN and EAW monitoring sites:
    - *Cambrian Stone granulation (AURN and Taibach07data)
    - *Metal plating pits (AURN and Taibach07data)
    - Furnace slag pits (AURN and Taibach07data)
    - Multiserv briquetting (AURN and Taibach07data)
    - Multiserv steel slag solidification/demetalling/cutting (AURN and Corus S&S data)
    - Multiserv scarfing activites (Corus S&S data only)
    - Hot and cold mills (Corus S&S data only)
    - Steel plant (Corus S&S data only)
    - Demetalled BOS slag storage (Corus S&S data only)
    - Furnace slag storage and crushing (Corus S&S data only)

  * Indicates these sources are the most likely ones identified by the triangulation of polar plots.
- The directional analyses suggest that the blast furnaces and sinter plant stack are unlikely to be significantly contributing to concentrations at the monitors.
- The Corus on-site Topas monitoring data indicate that there is a wide-range of particle sources on the steelworks site. The strongest of these is located to the NE of the GCI monitoring station. The next most significant source appears to be wind-raised dust in the blending plant. The various particle sources tend to vary considerably with regard to the size of particles they relate to.
- Diurnal variations at the Hospital site indicate that concentrations from the south followed a slightly different profile to concentrations from the west, rising more suddenly at 6am rather than showing a gradual increase across the morning.
- There appears to be a strong seasonal influence on the occurrence of elevated PM_{10} concentrations, with far more events in the 2^{nd} quarter of the year, followed by the 1^{st} and 3rd.

- Pollution events take a wide range of forms, with some exceedences of the daily mean objective being caused by a single very high hourly peak, others due to prolonged concentrations just above the objective concentration. The wide range of events between these two extremes suggests that exceedences may be being caused by a range of sources and conditions.
- There are indications that pollution events are often being caused by a difference in magnitude of concentrations coming from regular sources, rather than due to 'unusual' events.
- There is no clear evidence to suggest that the Fire Station AURN site is located in a significantly less polluted area than the Hospital site. Any description of it as a less polluted area would have to rely on very specific definitions of 'polluted'. In the short length of time that the AURN monitor has been operating the average PM_{10} concentrations have been lower than at the Hospital site and hourly and daily mean exceedences of the objective concentration have been less frequent. This is likely to be due to the change in monitoring method from TEOM*1.3 to TEOM FDMS. However, when pollution events have occurred they appear to have resulted in higher concentrations of PM_{10}, CO and SO_2. Evidence from comparisons of the AURN data with the EAW monitoring in the Taibach 2007 campaign suggest that where lower concentrations or fewer exceedences of PM_{10} are being recorded at the Fire Station AURN, then these may be being caused by micro-scale siting issues of the monitor affecting pollution concentrations over distances of a few metres rather than by its general location.

15.2 Key Recommendations Resulting from the Data Analyses

This report presents a rigorous and intensive analysis of existing data than had been previously carried out, and identifies a number of patterns in the pollution that require further analysis, along with some suggestions for the next key steps to be taken. Project limitations for the undertaking and presenting the results of these analyses, along with lack of opportunity to discuss analyses in detail with people who are much better acquainted with the site and processes, has meant that it has not been possible to relate the patterns of pollution identified by the analyses with specific activities on the steelworks site. Some of the key recommendations from the data analyses element of this study include:

- WAG, EAW and the site operators to provide official commentaries on the analyses of this report to determine whether they can provide any suggestions as to the cause of any of the pollution patters identified (e.g. known sources of CO and SO_2).
- Creation of a regularly updated database containing all locally collected monitoring data available for interrogation by all stakeholders. The wide range of analyses presented here indicate that there is no simple

and straight-forward way in which data can be presented. What is important is that a verified, common dataset is available to all parties, and that common tools are used to analyse this. Openair has a significant advantage over spreadsheet based tools in the reproducibility of graphs and plots as it is command line driven. This allows the analyses carried out on data to be recorded so that they can be verified by all interested parties, and re-run with different parameters if necessary. With the large increase in available data that is occurring, it is not the standardisation of final output that is important, but the standardisation of the base data and the methods for its analysis.

- Rather than trying to summarise the complexities of the problem using a number of plots and tables in a written report, tools like Openair should increasingly be used in a 'live' setting with local regulators and process operators so that they can ask specific questions of the data and interactively drive the analyses.
- Results from on-site monitoring need to be analysed in the context of off-site monitoring in order to identify pollution patterns during off-site pollution events and identify any events that may be unconnected to the steelworks emission sources. .
- Further analysis of hourly PM_{10} concentrations on individual exceedences days needs to be undertaken, including correlating them with other pollutants and meteorological conditions (including windspeed and rainfall). A categorisation system for Exceedence Days needs to be developed, potentially based on diurnal profiles and number of Hours>50, and subsequent analysis of individual Exceedence Days.
- The relationship between Hours>50 and exceedences of the Daily Mean objective should be investigated.
- Statistical analyses such as Principal Components Analysis or Cluster Analysis may be used for creating a typology of exceedences.
- Further analysis of the seasonal variations in pollution should be carried out, particularly with regard to any potential changes in source activities.
- Correlations between PM_{10} patterns and activities on the steelworks site (including daily and weekly shift patterns) should be identified.
- Further analysis of the occurrence of Hours>50 needs to be undertaken, particularly with regard to how concentrations of PM_{10} and other pollutants for these hours correlate with windspeed and direction as monitored at a number of the monitoring sites. Further in-depth analysis of the relationship of meteorological parameters and exceedences of Hours>50 may allow weather forecasts to be utilised, leading to alerts and stricter control of activities on-site. There have been examples, such as sources of SO_2 in the Avonmouth industrial area, where such strategies have been tested (Sevalco Ltd. – pers comm. Steve Crawshaw, EHO, Bristol City Council).

- The activities identified through the directional analyses should all be analysed for emission patterns – particularly with regard to what pollutants they emit and any diurnal, or other temporal patterns of emissions.
- The main analyses in the report have been undertaken using the local wind data from each pollution monitoring site as it is judged to be more representative of wind direction at both the monitoring sites and the steelworks. However, where further analysis (such as chemical analysis of filters, or correlation of PM_{10} with CO or SO_2) indicates that the likely source related to a *particular* pollution event is an elevated stack, then consideration should be given to incorporating the met data from the Mumbles site as it may be more indicative of wind conditions at height. For all other analyses the met data used should primarily be from the relevant pollution monitoring station as this is liable to be the most indicative of the direction of airflow arriving at the monitor inlet as it is likely to be more representative of ground-level windflow on the eastern side of the bay than the Mumbles data. Further work in terms of mapping wind-fields in the area may be prove useful, particularly around the steelworks site itself due to complex flow patterns due to building structures.
- There is a need to carry out a new chemical analysis study in order to be able to help differentiate between those events caused by high windspeed (i.e. plume grounding due to wind driven turbulence and wind-raised dust) as well as between those that might be associated with dust from daytime activity on the site and plume grounding due to convective turbulence. This could also be used to help determine the influence of sources not related to the steelworks site, such as road traffic, sea-salt and secondary particles. In this study, it might also be useful to try and analyse occasional filters from sites such as Swansea and Narberth, or from other local monitoring sites, in order to verify the constituents of roadside and regional PM_{10}, rather than relying on generalised evidence or previous studies.

16 Synopsis of All Conclusions and Recommendations

The following section provides a synopsis of all the key conclusions and recommendations from this study and they have been categorised according to the primary objectives of the project tender specifications as outlined in Section 2.1.

16.1 Objective 1 – Independent Review of Air Quality Data and Objective 2 – PM_{10} Source Identification.

Fulfilment of Objective 1 required a comprehensive independent review of all monitoring, dispersion modelling, source apportionment and atmospheric particle characterisation work that has been undertaken to support the declaration of the Taibach Margam AQMA.

Fulfilment of Objective 2 required a detailed analysis of available data to identify sources of PM_{10} that may contribute to concentrations within the vicinity of the Taibach Margam AQMA.

This study concluded that the predominant source of PM_{10} is the steelworks with modest contributions from other sources being identified. Even with an extensive data analysis, the identification of specific sources on the Port Talbot steelworks site and the apportionment of their contribution to PM_{10} concentrations have been difficult due to the integrated and complex nature of the site and the influence of meteorology and topography on concentrations. However, detailed analysis of monitoring and meteorological data has allowed for temporal and spatial analysis to be undertaken and an examination of exceedence days to be carried out. This analysis resulted in the examination of specific trends, events, influencing factors and pollutant relationships. The conclusions of this study substantially advance the understanding of the generation, dispersion and impact of PM_{10} in the Neath Port Talbot area and will assist and inform the future development of plans and programmes for the management of PM_{10} by the site operators, EAW, NPTCBC and WAG. The key conclusions are categorised according to the headings of this report and are outlined below.

16.1.1 NPTCBC Review and Assessment

All reports since the inception of LAQM produced by NPTCBC have been reviewed. While some improvements could be made to the quality information included in the reports submitted (e.g. Review and Assessment Progress Reports), NPTCBC have submitted their LAQM Review and Assessment reports in accordance with the Environment Act, 1995 and each of the reports have met the minimum reporting requirements of the Technical Guidance and Policy Guidance (existing at the time the Review and Assessment report was written).

16.1.2 Dispersion Modelling Studies

Three major dispersion modelling studies have been carried out, each with their own inherent limitations and assumptions (e.g. limited number of sources considered, assumptions in the representativeness of the meteorological data utilised, uncertainties associated with the emission factors utilised etc). While care should be taken in drawing any conclusions from these studies, they have provided a useful insight into the area of impact associated with the steelworks.

16.1.3 Source Apportionment Studies

While the usefulness of the chemical speciation studies undertaken in 1998-1999 is limited today due to the significant changes in emissions patterns on the site that have resulted from subsequent mitigation measures, they did provide a good indicator of the main source of PM_{10} in Neath Port Talbot and supported the prioritisation of options in the NPTCBC AQAP.

16.1.4 Justification for the Taibach Margam AQMA

Upon reviewing the supporting documents utilised in the declaration of the Taibach Margam AQMA the authors concur that the decision to declare an AQMA was, and continues to be, justified.

16.1.5 Taibach Margam Air Quality Management Area (PM_{10}) Air Quality Action Plan (NPTCBC AQAP)

The NPTCBC AQAP appears to have been developed with ample consultation and public dialogue, and has also established a commendable NPTCBC AQAP steering group (i.e. the AQAP Team) to oversee the implementation of the NPTCBC AQAP and the continued engagement of its stakeholders. It should be noted that the NPTCBC AQAP was developed at a time when there was a limited understanding of the various sources involved and when developed the NPTCBC AQAP met the minimum requirements as outline in the then current guidance documents. However, the following observations of the NPTCBC AQAP should not be view as criticisms but rather be considered as points to note should the NPTCBC AQAP be updated:

- Only limited quantitative consideration has been given to actual reductions in PM_{10} concentrations;
- There appears to be substantial effort and resources concentrating on options not directly associated with the main source of PM_{10} emissions (i.e. the steelworks sources). Whilst these options are commendable in terms of background pollution concentrations and general public health, they may bring about minimal reductions in PM_{10} concentrations and minimum improvements towards attaining the air quality objectives;

- There is limited attribution of responsibility for meeting the agreed actions therefore specific departments should be clearly identified for the implementation of options to reduce any ambiguity in terms of accountability;
- More detailed cost-benefit analysis may assist in identifying specific funding streams to assist in the implementation of actions; and
- More consideration should be given to identifying more detailed and appropriate suite of implementation indicators for each option i.e. indicators to track the implementation of specific options.

16.1.6 WAG Short-Term AQAP

The WAG short-term AQAP for the South Wales Zone consultation document incorporates the issue of PM_{10} in Port Talbot and clearly outlines the framework that the Welsh Ministers have established. In the short-term AQAP, WAG has a document which may be amended and utilised to create a 'future' AQAP document for the South Wales Zone. The 'future' AQAP may benefit from broadening the scope to include the consideration of air quality in future policy development to ensure continued compliance with the air quality objectives and improvements in local air quality in future years.

16.1.7 EAW PM_{10} Permit Review

The EAW PM_{10} Permit Review is a comprehensive document which provides detailed analysis of PM_{10} permitting, data analysis and supporting information pertinent to the Port Talbot steelworks. This document illustrates the complexity of regulating this site due to the geographical fragmentation of activities, operators and contractors around the site and the sharing of regulatory responsibility between EAW and NPTCBC. There is limited quantification of fugitive emissions of PM_{10} around the site and ultimately any impact of improvements on PM_{10} concentrations are difficult to determine.

16.1.8 NPTCBC Corus Permit Review

The NPTCBC Corus Permit Review considers the permitting of Civil & Marine Limited and Tarmac Western Limited. The review concludes that environmental and regulatory benefits may be gained by the transfer of the Part B Tarmac Western Limited process to EAW regulation.

16.1.9 Monitoring Data Analysis

The following bullet points summarise the key conclusions drawn by the authors from the analysis undertaken using Openair software package of the monitoring data supplied by the AURN, EAW and the site operators.

- The predominant sources of PM_{10} are not in immediate proximity to the monitoring locations (evidenced by negligible impact at low windspeeds).

- The relationship of elevated concentrations with higher windspeeds suggests that sources may include both/either stacks (where turbulence results in the grounding of plumes) or dust (where wind is able to resuspend it).
- PM_{10} concentrations are dominated by sources to the SW of the AURN stations, indicating sources on the steelworks site as the most likely cause of elevated PM_{10} concentrations in the area.
- There are strong correlations between the direction of the main PM_{10} sources, and sources of CO and SO_2. However, temporal analyses indicate that not all PM_{10} events are related to elevated concentrations of these combustion pollutants. This suggests that PM_{10} events may be being caused by either combustion sources, or dust sources or a combination of the two.
- In some cases, elevated PM_{10} is related to CO but not SO_2. There appears to be an almost inverse relationship between these pollutants at high concentrations, suggesting more than one possible combustion related source, and potentially a 'heat' rather than a combustion source leading to the high CO concentrations.
- Average concentrations of CO and SO_2 show similar fluctuations over time to PM_{10} at the AURN sites, particularly the increase in concentrations from the southern sector when the location moved to the Fire Station site.
- Neither NOx or Ozone concentrations appear to be associated with the steelworks site.
- $PM_{2.5}$ at the Fire Station AURN monitor and the EAW Taibach 2007 campaign indicate that $PM_{2.5}$ tends to be dominated by sources to the north-east, probably traffic and potentially the motorway. The EAW monitoring at the Corus Sports and Social Club indicated that $PM_{2.5}$ was dominated by sources to the north east, potentially the main A48 through Margam, or the northerly parts of the steelwork site.
- PM_{10} pollution related to the steelworks site generally follows a distinctive diurnal profile, with concentrations beginning to rise at around 6am, and continuing to rise until about noon. They then level out and then begin to drop sharply from around 4pm. This pattern may result from daytime activities, on-site resuspended dust and/or increased daytime insolation leading to increased plume grounding due to convective turbulence.
- $PM_{2.5}$ follows a different diurnal profile to PM_{10} which much more closely matches that which would be expected from road sources (e.g. dual peaks matching peak traffic hours).
- The dominance of the PM_{coarse} fraction in the PM_{10} monitored from the area of the steelworks tends to suggest dust (mechanically generated) particles rather than combustion source particles as the major problem. However, if CO is coming from a heat or other non-conventional combustion source then this might also lead to non-dust coarse fraction particles.

- Average concentrations of PM_{10} associated with the steelworks site have reduced over time, however, the frequency and magnitude of peak hourly concentrations does not appear to have reduced markedly.
- Directional analysis of the monitoring data has identified the following as the most likely potential source 'activities' on the steelworks site contributing to elevated PM_{10} concentrations at the AURN and EAW monitoring sites:
  - *Cambrian Stone granulation (based on AURN and Taibach07 monitoring data)
  - *Metal plating pits (based on AURN and Taibach07 monitoring data)
  - Furnace slag pits (based on AURN and Taibach07 monitoring data)
  - Multiserv briquetting (based on AURN and Taibach07 monitoring data)
  - Multiserv steel slag solidification/demetalling/cutting (based on AURN and Corus S&S monitoring data)
  - Multiserv scarfing activities (based on Corus S&S monitoring data only)
  - Hot and cold mills (based on Corus S&S monitoring data only)
  - Steel plant (based on Corus S&S monitoring data only)
  - Demetalled BOS slag storage (based on Corus S&S monitoring data only)
  - Furnace slag storage and crushing (based on Corus S&S monitoring data only)

  * Indicates these sources are the most likely ones identified by the triangulation of polar plots.
- The directional analyses suggest that the blast furnaces and sinter plant stack are unlikely to be significantly contributing to concentrations at the monitors.
- The Corus on-site Topas monitoring data indicate that there is a wide-range of particle sources on the steelworks site. The strongest of these is located to the NE of the GCI monitoring station. The next most significant source appears to be wind-raised dust in the blending plant. The various particle sources tend to vary considerably with regard to the size of particles they relate to.
- Diurnal variations at the Hospital site indicate that concentrations from the south followed a slightly different profile to concentrations from the west, rising more suddenly at 6am rather than showing a gradual increase across the morning.
- There appears to be a strong seasonal influence on the occurrence of elevated PM_{10} concentrations, with far more events in the 2nd quarter of the year, followed by the 1st and 3rd.

- Pollution events take a wide range of forms, with some exceedences of the daily mean objective being caused by a single very high hourly peak, others due to prolonged concentrations just above the objective concentration. The wide range of events between these two extremes suggests that exceedences may be being caused by a range of sources and conditions.
- There are indications that pollution events are often being caused by a difference in magnitude of concentrations coming from regular sources, rather than due to 'unusual' events.
- There is no clear evidence to suggest that the Fire Station AURN site is located in a significantly less polluted area than the Hospital site. Any description of it as a less polluted area would have to rely on very specific definitions of 'polluted'. In the short length of time that the AURN monitor has been operating there, although average PM_{10} concentrations have been lower than at the Hospital site and hourly and daily mean exceedences of the objective concentration have been less frequent, when pollution events have occurred they appear to have resulted in higher concentrations of PM_{10}, CO and SO_2. Evidence from comparisons of the AURN data with the EAW monitoring in the Taibach 2007 campaign suggest that where lower concentrations or fewer exceedences of PM_{10} are being recorded at the Fire Station AURN, then these are more likely to be caused by micro-scale siting issues of the monitor (i.e. differences in concentration caused by local flow patterns, caused by obstacles such as the railway embankment or the nearby trees) than by its general location in the AQMA. It is important to note that the monitoring method used at the AURN changed in February 2007 shortly before the relocation of the AURN site. The new method (TEOM FDMS) will tend to record lower concentrations than the previous method using a conventional TEOM multiplied by a factor of 1.3.

16.2 Objective 3 – Future Studies

Fulfilment of this objective necessitates advice to WAG and other project stakeholders on further studies that may be undertaken to pinpoint exact sources of particulate matter in the area, improve their understanding of PM_{10} from the steelwork site and assist in the management of PM_{10} in the future. The following recommendations are suggested:

- **Recommendation 1 – Better use of data available in NPTCBC Review and Assessment reports**: WAG should encourage NPTCBC to make better use of the data available to the authority in future Review and Assessment Reports, in particular Progress Reports, and this information could be could be reported in a more integrated format.
- **Recommendation 2 – Generation of an emissions database and undertaking a new dispersion modelling study**: Advances in dispersion modelling software, improvements in the understanding and quantification of the sources in the Neath Port Talbot area and improvements in the understanding of particulate science may result in

a more accurate assessment of PM_{10} should a new dispersion modelling study be undertaken. The scope and structure of any new dispersion modelling study should be clearly established though continued engagement with the various stakeholders and there may be some benefit in creating a dispersion modelling steering group to oversee this work. However, any new dispersion modelling study would also have inherent uncertainties and assumptions particularly in the estimation of emissions from stockpiles and other fugitive sources, therefore, the generation of an emissions database to collate input data for any dispersion modelling study would be a logical initial step. Additionally, any dispersion modelling study should follow all relevant guidance, in particular in relation to model verification, and should be fully transparent with regards to any assumptions, all input data utilised and any adjustments made to the model output (the expansion of the monitoring network in the vicinity should assisting substantially with model verification). Undertaking a new dispersion modelling study, particularly in conjunction with any future monitoring data analysis, may assist in providing a better understanding of the contribution of specific sources on the steelworks site, may allow more detailed consideration of the cumulative impact of future sources on local PM_{10} concentrations and may allow for a comprehensive assessment of the point of maximum impact to determine the appropriate siting of monitoring equipment. A new study may also assist with the updating of NPTCBC AQAP and the development of a WAG 'future' AQAP. It is vital that any new modelling study is based on a thorough analysis and quantification of all potential on-site fugitive dust sources and any other PM_{10} emissions. This in itself will play a vital role in further analysis of monitoring data. The feasibility of the generation of an emissions database and a full and comprehensive dispersion modelling study of existing and future PM_{10} sources should be investigated by WAG.

- **Recommendation 3 – Undertaking new chemical analysis of particulates in the area**: While the original studies of particulates in 1998-1999 provide a good indication of the main source of PM_{10} in Neath Port Talbot (i.e. the steelworks), they are now quite dated and advances in particulate speciation methodologies, improvements in the understanding of the sources involved and improvements in our understanding of particulate science since this study has been undertaken may result in a more accurate composition analysis of particles. Especially considering the significant range of changes that have occurred on the steelworks site that may have changed the balance of particulate composition, it is therefore recommended that consideration be given to carrying out a programme of particle speciation studies to be undertaken concurrently with local monitoring. To accompany the future chemical analyses of filters at ambient monitoring stations, it may also be useful to undertake compositional analysis of emissions from a wide range of processes on the site in order assist in 'fingerprinting' of individual activities on the site (also see Recommendation 7(m) below).

- **Recommendation 4 – Updating NPTCBC AQAP**: The NPTCBC AQAP is now a dated document and while most of the options identified in the NPTCBC AQAP have either been implemented or are ongoing, the understanding of PM_{10} sources in the vicinity has advanced substantially. It is recommended that WAG engage with the NPTCBC Air Quality Action Plan Team to investigate the possibility of the NPTCBC AQAP being updated in light of the advanced information contained in reports such as the EAW PM_{10} Permit Review and this review document. Additionally, this update should also act upon any updated national guidance and the feedback received from the consultants employed by WAG who have formally appraised the original NPTCBC AQAP and subsequent NPTCBC AQAP-PR. In updating the NPTCBC AQAP, an important step would be attempting to quantify the reductions in emissions which should have occurred as a result of the measures being put in place.
- **Recommendation 5 – Utilising the WAG Short-Term AQAP**: It is recommended that WAG incorporate the findings of this independent review into the utilisation of their short-term AQAP for the South Wales Zone to generate a 'future' AQAP. Additionally, WAG should ensure that their 'future' AQAP is a dynamic and evolving document so that the findings from any future studies recommended from this review can be incorporated.
- **Recommendation 6 – Further information on agreed course of actions following the EAW PM_{10} Permit Review and NPTCBC Corus Permit Review**: Following on from these Permit Reviews and subsequent discussions with the various stakeholders, WAG may wish to request a summary document outlining the agreed course of actions i.e. which of the recommendations are being taken forward or conversely which recommendations are not being taken forward and the reasons for this from both the EAW and NPTCBC. Additionally, it may be useful to have a full and concise list collated of all known (or potential) sources of PM_{10} on the steelworks site (See Recommendation 2). The EAW and the site operators may be best placed to identify and collate this information.
- **Recommendation 7 – Additional analysis of data**: Following the extensive data analysis undertaken as part of this review, WAG should explore the possibility of undertaking the following actions with their project stakeholders:
    - **Recommendation 7(a) - Official feedback from WAG, EAW, the site operators and NPTCBC on analysis undertaken as part of this study:** WAG, EAW, NPTCBC and the site operators should provide official technical commentaries on the analyses presented in this report to determine whether they can provide any suggestions as to the cause of any of the pollution patterns identified (e.g. known sources of CO and SO_2).
    - **Recommendation 7(b) - Creation of a regularly updated database containing all locally collected monitoring data available for interrogation by all stakeholders.** The wide

range of analyses presented here indicate that there is no simple and straight-forward way in which data can be presented. What is important is that a verified, common dataset is available to all parties, and that common tools are used to analyse this. Openair has a significant advantage over spreadsheet based tools in the reproducibility of graphs and plots as it is command line driven. This allows the analyses carried out on data to be recorded so that they can be verified by all interested parties, and re-run with different parameters if necessary. With the large increase in available data that is occurring, it is not the standardisation of final output that is important, but the standardisation of the base data and the methods for its analysis.

- **Recommendation 7(c) – Use of tools such as Openair in a 'live' setting:** Rather than trying to summarise the complexities of the problem using a number of plots and tables in a written report, tools like Openair should increasingly be used in a 'live' setting with local regulators and process operators so that they can ask specific questions of the data and interactively drive the analyses.
- **Recommendation 7(d) – Comparative analysis of on-site and off-site monitoring:** Results from on-site monitoring need to be analysed in the context of off-site monitoring in order to identify pollution patterns during off-site pollution events and identify any events that may be unconnected to the steelworks emission sources. .
- **Recommendation 7(e) – Further analysis of hourly PM_{10} concentrations on individual exceedences days needs to be undertaken**: This should include correlating them with other pollutants and meteorological conditions (including windspeed and rainfall). A categorisation system for Exceedence Days needs to be developed, potentially based on diurnal profiles and number of Hours>50, and subsequent analysis of individual Exceedence Days. This can then be used as a framework in which to manage some of the specific analyses set out below.
- **Recommendation 7(f) – The relationship between Hours>50 and exceedences of the Daily Mean objective should be investigated.**
- **Recommendation 7(g) – Statistical analyses such as Principal Components Analysis or Cluster Analysis may be used for creating a typology of exceedences.**
- **Recommendation 7(h) – Further analysis of the seasonal variations in pollution** should be carried out, particularly with regard to any potential changes in source activities.
- **Recommendation 7(i) – Correlations between PM_{10} patterns and activities on the steelworks site (including daily and weekly shift patterns) should be identified.**

- **Recommendation 7(j) – Closer analysis of the occurrence of Hours>50 needs to be undertaken**, particularly with regard to how concentrations of PM_{10} and other pollutants for these hours correlate with wind speed and direction as monitored at a number of the monitoring sites. Further in-depth analysis of the relationship of meteorological parameters and exceedences of Hours>50 may allow weather forecasts to be utilised, leading to alerts and stricter control of activities on-site. There have been examples, such as sources of SO_2 in the Avonmouth industrial area, where such strategies have been trialled.
- **Recommendation 7(k) – The activities identified through the directional analyses should all be analysed for emission patterns** – particularly with regard to what pollutants they emit and any diurnal, or other temporal patterns of emissions.
- **Recommendation 7(l) – Analysis of Meteorological data:** The main analyses in the report have been undertaken using the local wind data from each pollution monitoring site as it is judged to be more representative of wind direction at both the monitoring sites and the steelworks. However, where further analysis (such as chemical analysis of filters, or correlation of PM_{10} with CO or SO_2) indicates that the likely source related to a *particular* pollution event is an elevated stack, then consideration should be given to incorporating the met data from the Mumbles site as it may be more indicative of wind conditions at height. For all other analyses the met data used should primarily be from the relevant pollution monitoring station as this is liable to be the most indicative of the direction of airflow arriving at the monitor inlet as it is likely to be more representative of ground-level wind flow on the eastern side of the bay than the Mumbles data. Further work in terms of mapping wind-fields in the area may prove useful, particularly around the steelworks site itself due to complex flow patterns caused by building structures and heat sources on the steelworks site, and the general coastal location close to the large hills to the east.
- **Recommendation 7(m) – There is a need to carry out a new chemical analysis study** in order to be able to help differentiate between those events caused by high windspeeds (i.e. plume grounding due to wind driven turbulence and wind-raised dust) as well as between those that might be associated with dust from daytime activity on the site and plume grounding due to convective turbulence. This could also be used to help determine the influence of sources not related to the steelworks site, such as road traffic, sea-salt and secondary particles. In this study, it might also be useful to try and analyse occasional filters from sites such as Swansea and Narberth, or from other local monitoring sites, in order to verify the constituents of roadside and regional PM_{10}, rather than relying on generalised evidence or previous studies.

- **Recommendation 7(n) – Continued stakeholder engagement:** The recommendations generated in this study are not a definitive list and WAG may identify further opportunities and studies through the findings of future work and continued stakeholder engagement.

17 Appendix A: Summaries of available data

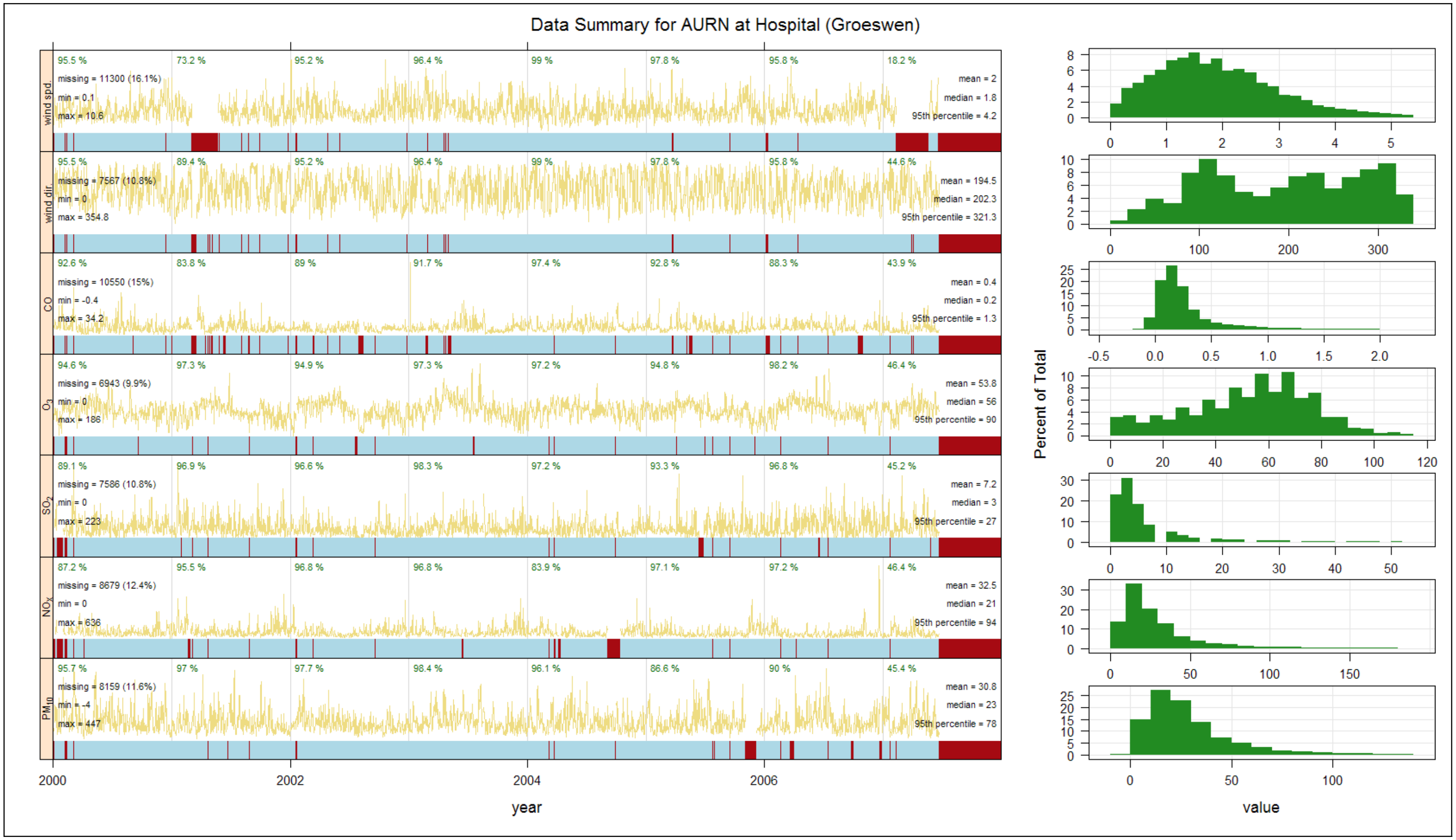

Figure 65: Data summary for AURN (Hospital)

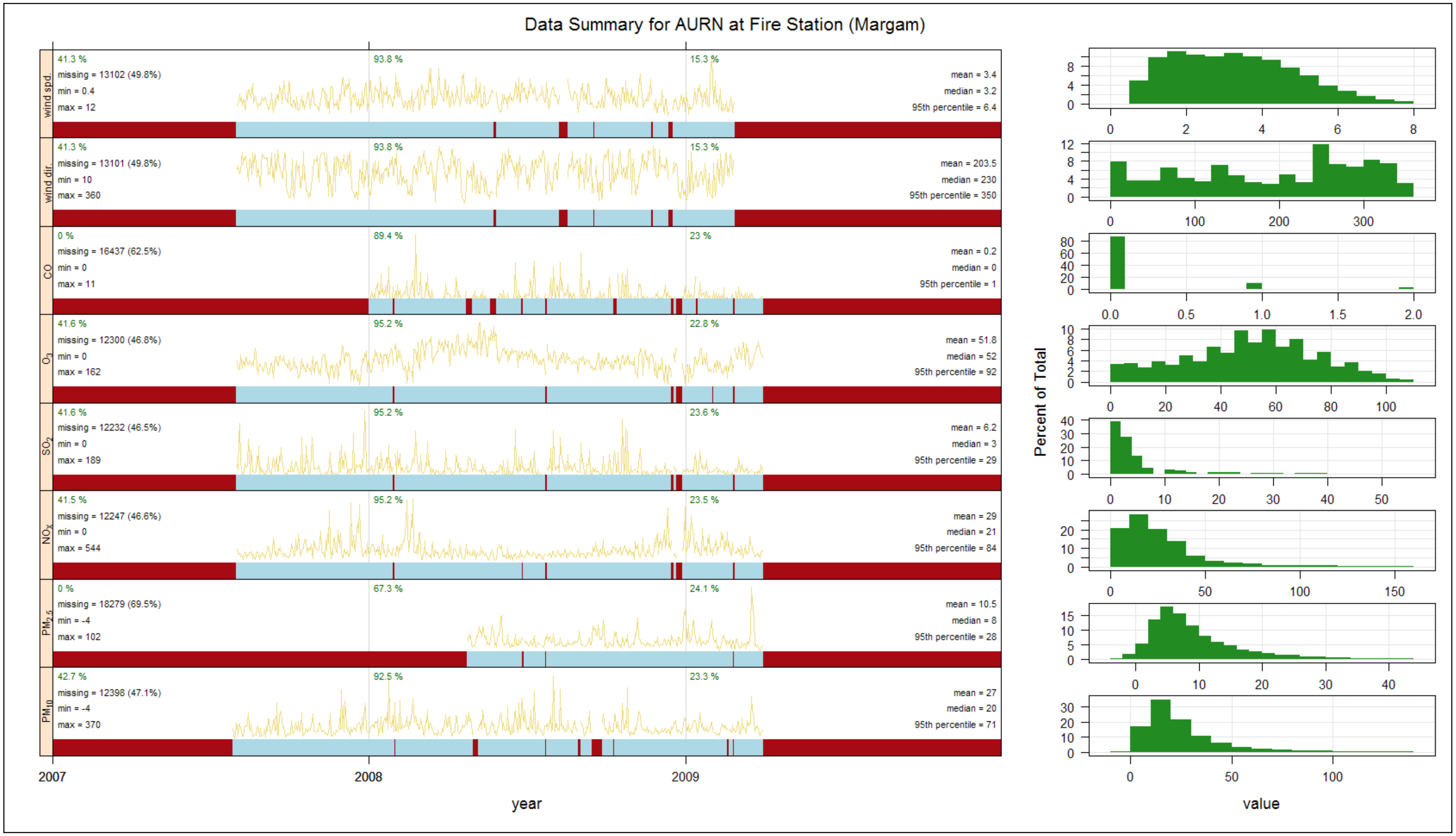

Figure 66: Data summary for AURN (Fire Station)

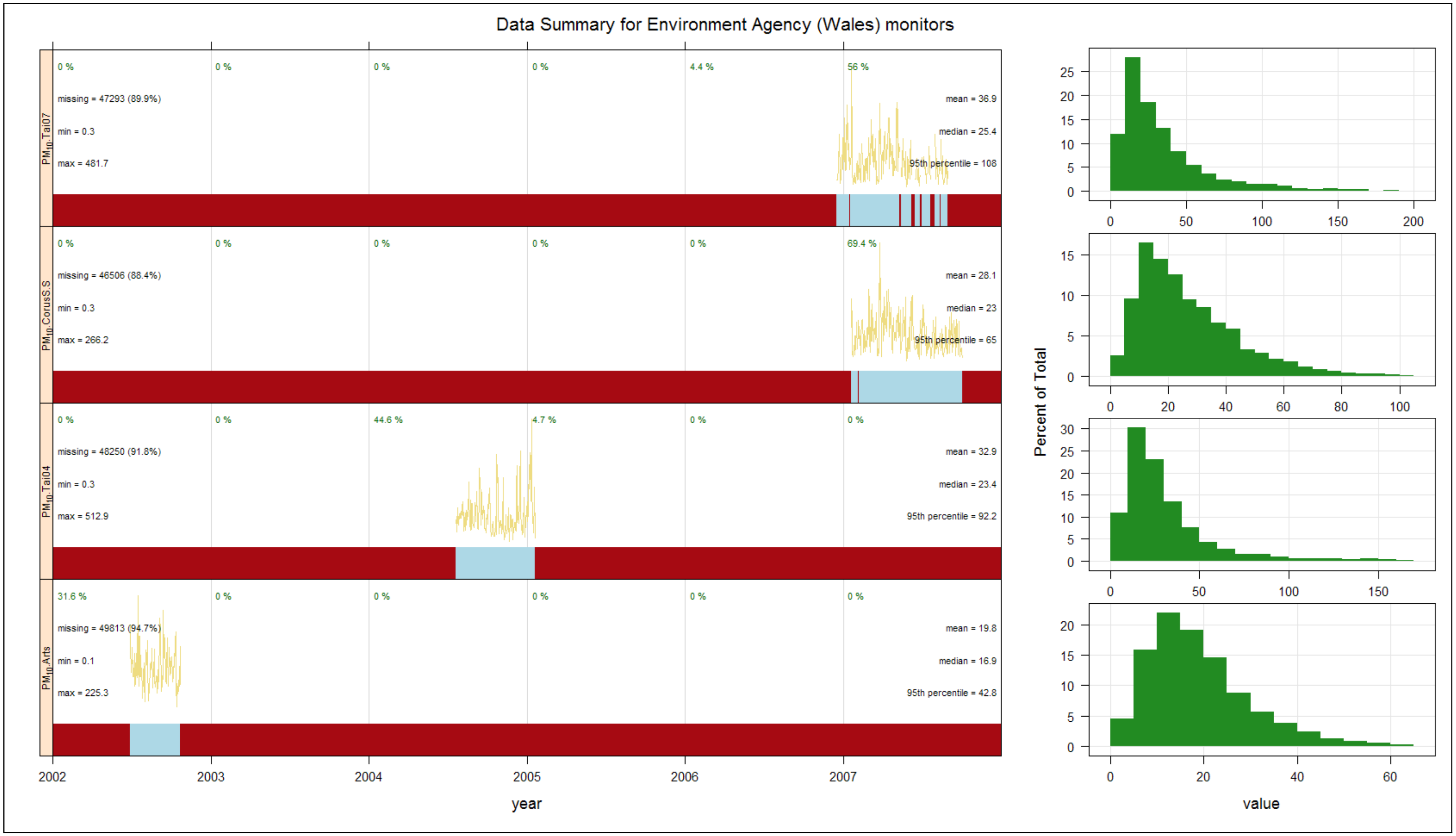

Figure 67: Data summary for Environment Agency monitors (PM_{10} only)

Figure 68: Data summary for Corus Topas monitors (PM_{10} only)

18 Appendix B: Comparison of Mumbles Meteorological Data with Pollution Monitoring Site Data

Where wind direction or windspeed have been used in the report, all analyses have used meteorological data collected from the same monitoring station as the pollution data. These stations have all used 10m masts to collect the data.

Some previous analyses of pollution in Port Talbot have relied upon meteorological data from the Met Office monitoring station located across Swansea Bay at Mumbles Head. Local monitoring data has been used for these analyses in preference to Met Office data as it is considered far more representative of local wind conditions for 2 key reasons:

- The Mumbles Head site is located on a headland on the opposite side of the bay to Port Talbot, therefore the impact of land-sea breezes along with the potential impact of the topology on the Port Talbot side of the bay, are likely to create very different flows.
- The Mumbles Head site is located at 32m above sea-level, compared to the Fire Station/Taibach location which is approximately 10m above sea level.

Comparisons of met data from the various sites have been undertaken and some results have been presented on the following pages. The comparisons undertaken and presented have again been limited by time to carry them out and analyse them, and space to present them. However the following conclusions can be drawn from them:

- Mumbles met data correlates fairly poorly with that from the pollution monitoring stations. For wind direction, only the Hospital-Mumbles comparison shows a correlation coefficient greater than 0.5 (=0.56). windspeed tends to correlate better, however the windspeed recorded at Mumbles are an average of 3.7 times stronger, indicating a potentially very different wind regime at that site.
- Comparisons of the wind direction looking at both all hours on Exceedence Days and Exceedence Hours (i.e. Hours>50 on Exceedence Days), shows that in almost all cases the correlation is weaker, suggesting that for the analysis of pollution events the Mumbles data is even less representative of local conditions.
- Whilst there is little difference evident in the polar plots of data from the hospital site for the wind directions associated with peak PM_{10} concentrations, there is a noticeable swing in peak concentrations further to the south-west (rather than south) for the Mumbles data. This may merit further analyses.
- Correlations between the local monitoring sites over the 2006-7 concurrent monitoring periods are stronger for all comparisons of AURN and EAW site than between those sites and Mumbles data, suggesting that despite potential local impacts on wind there is a greater uniformity of flow in the local area than in comparison to the other side of the bay.

In terms of carrying out future analyses, it is recommended that in the first instance pollution data is analysed using meteorological data from the same site. If this is not possible then careful consideration should be given to the next most representative site (it may not necessarily be the nearest one).

It may be worth carrying out a detailed analysis of wind fields in the local area to determine whether any of the monitors indicate that there are significant perturbations to flow across parts of the site – particularly between sources and monitors.

As the majority of PM_{10} sources identified are ground level sources rather than elevated stack releases, the local met data is likely to be the most representative data to use. However, where future analyses, such as chemical analysis of filters, or patterns of PM_{10} with other pollutants, suggest that elevated stack sources may be implicated, then Mumbles met data should also be considered as it may additional information on the possible direction of sources.

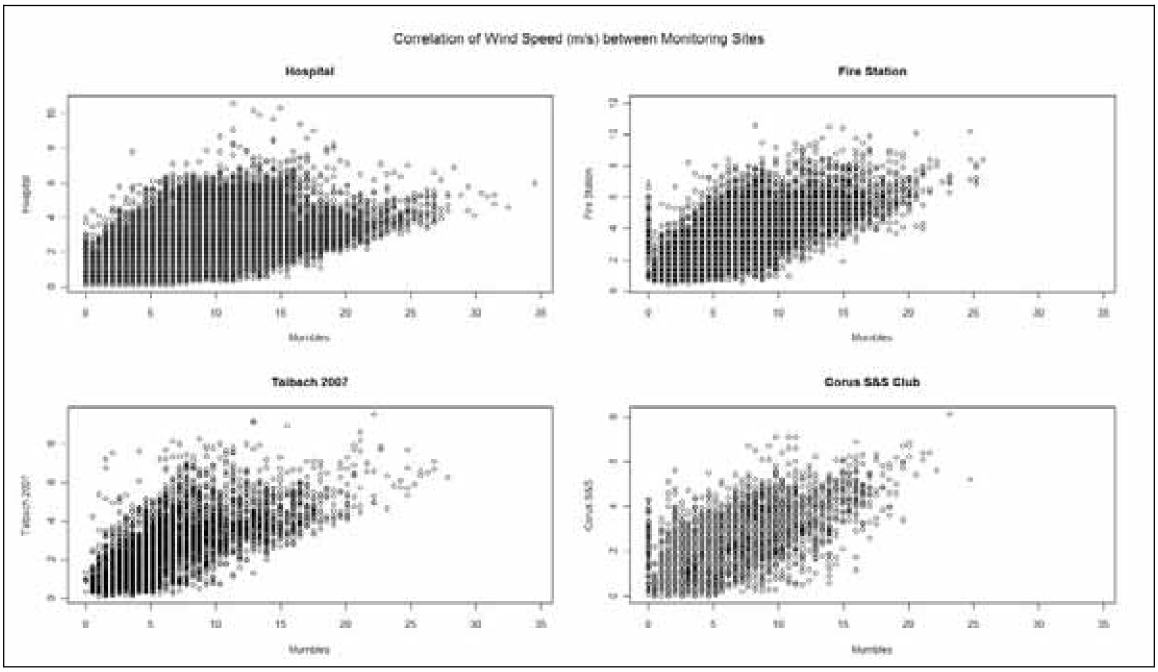

Figure 69: Plots Showing Relationships between Wind Speed at Mumbles Head, and AURN and EAW monitoring stations

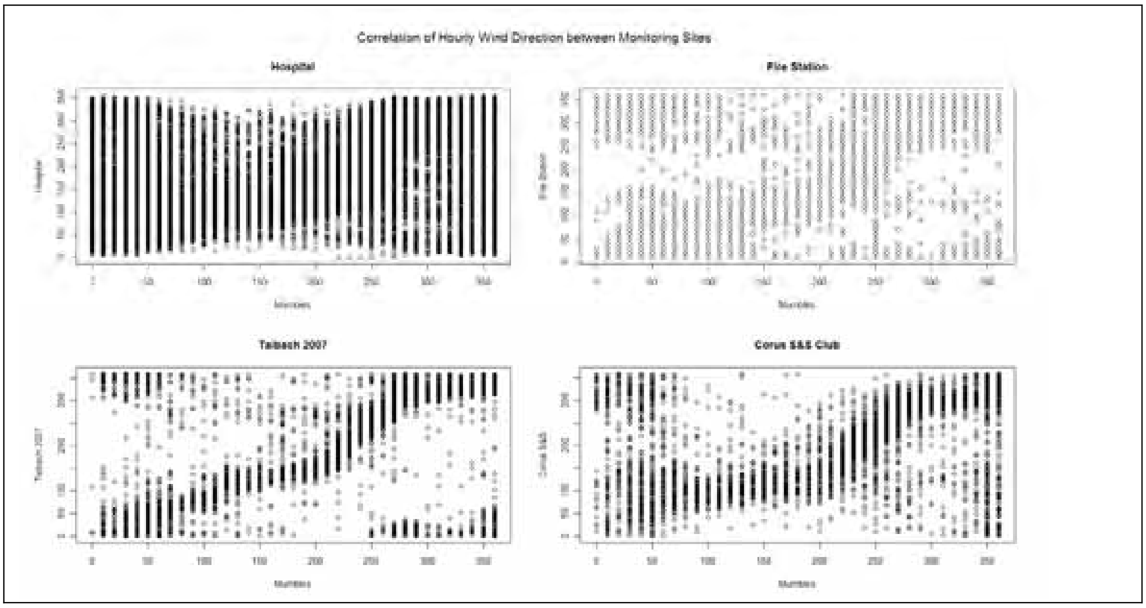

Figure 70: Plots Showing Relationships between Wind Direction at Mumbles Head, and AURN and EAW Monitoring Stations

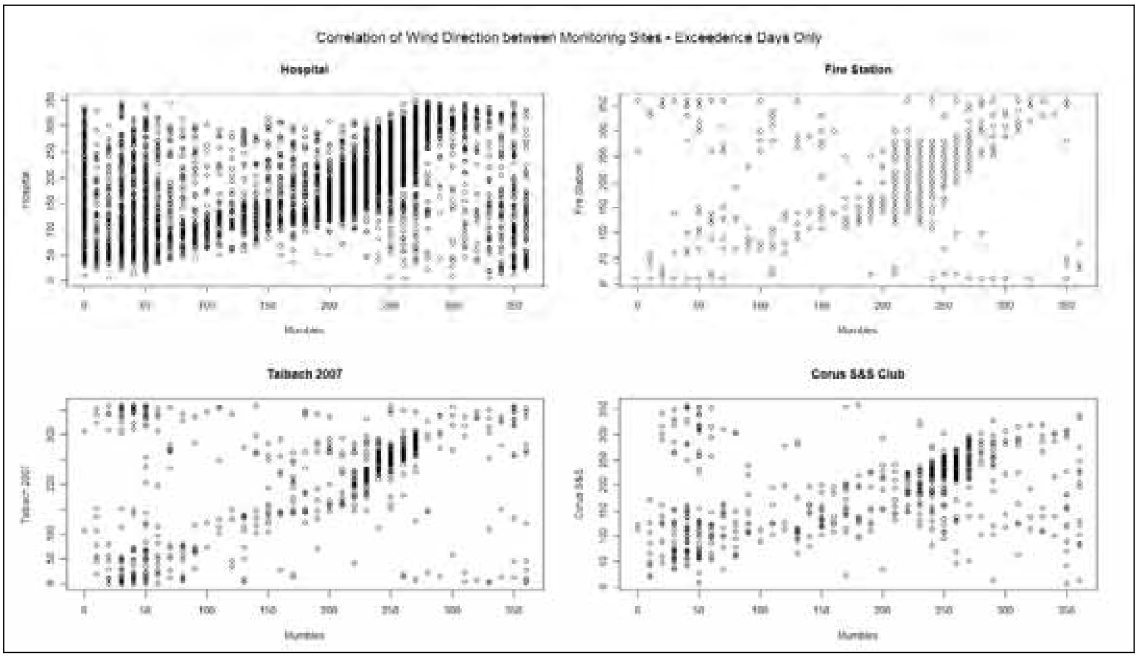

Figure 71: Plots Showing Relationships between Wind Direction Monitoring Stations - Exceedence Days Only

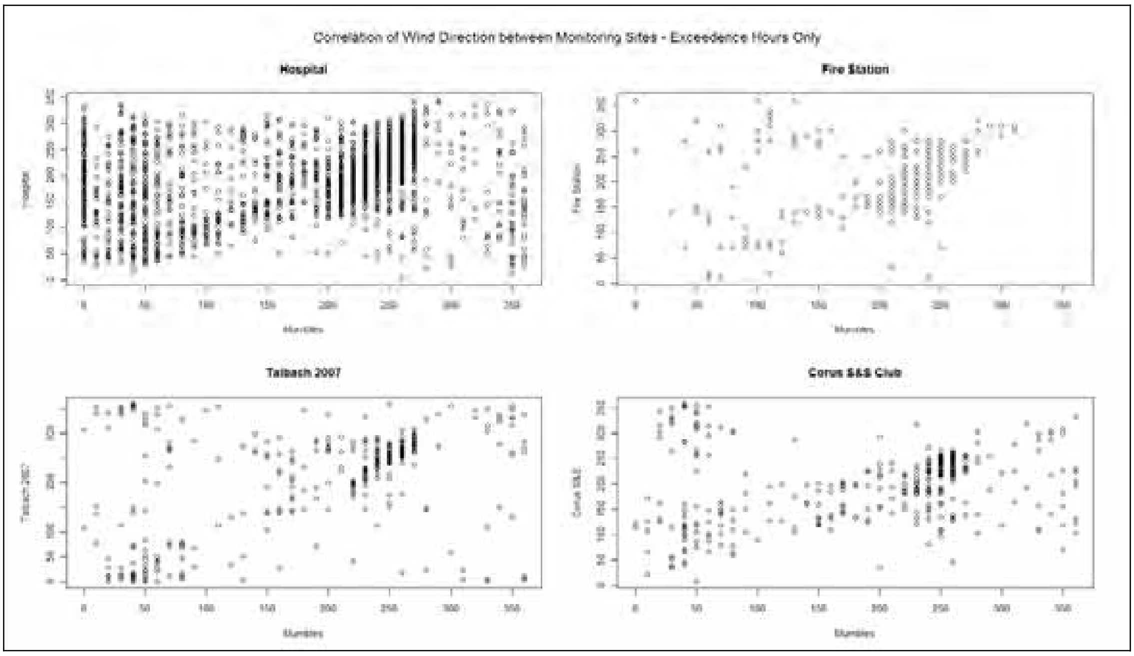

Figure 72: Plots Showing Relationships between Wind Direction Monitoring Stations - Exceedence Hours Only

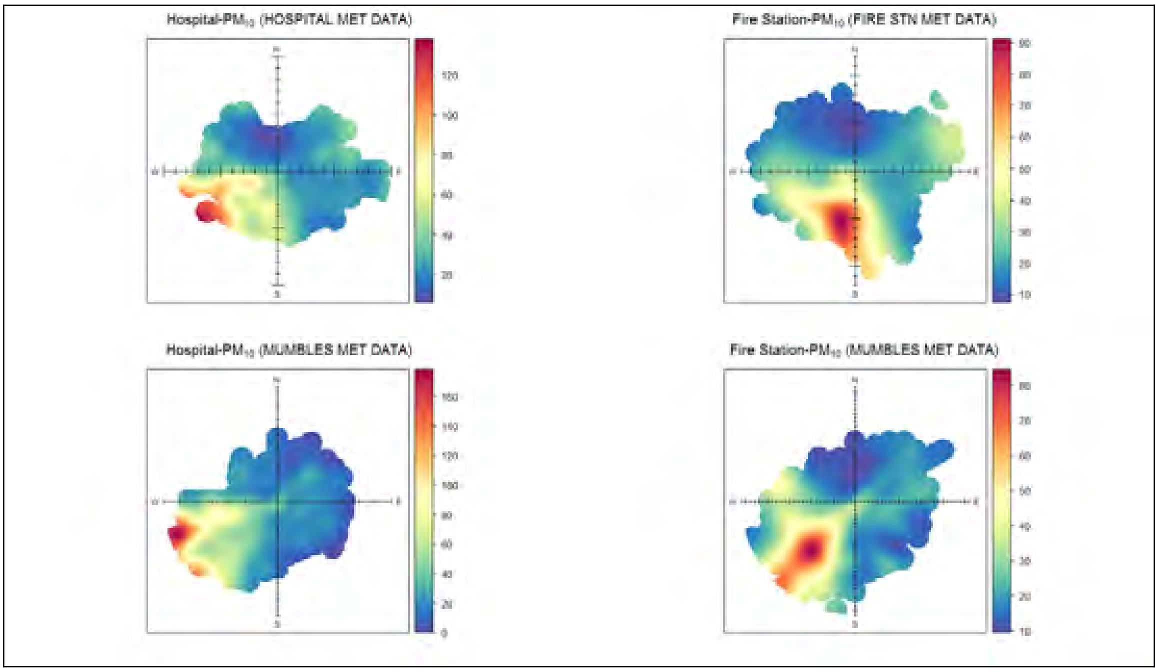

Figure 73: Polar Plots Based on Mumbles and AURN Site Wind Data

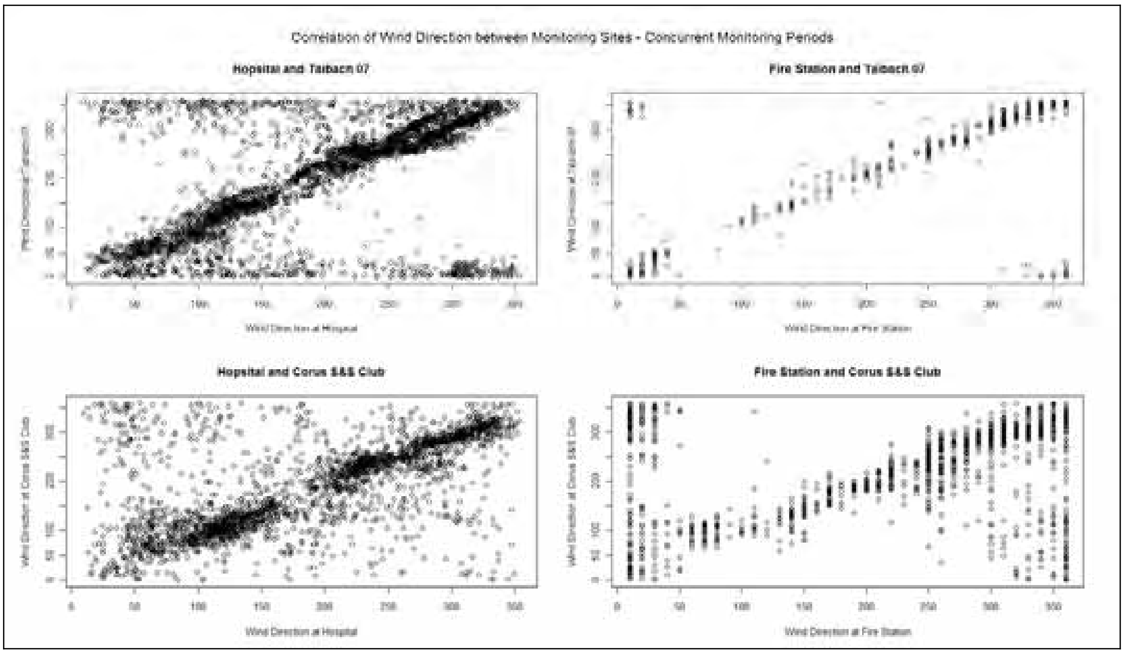

Figure 74: Plots Showing Relationships between Wind Direction at AURN and EAW Monitoring Stations during Comparative Monitoring Period 2007

Table 17: Correlation Coefficients for Comparison of Mumbles Met Data with AURN/EAW Data

All Hours					
		Hospital	Fire Station	Taibach07	Corus S&S
Mumbles	Wind Dir	0.56	0.49	0.48	0.41
	Wind Sp.	0.59	0.70	0.67	0.67
Exceedence Days					
		Hospital	Fire Station	Taibach07	Corus S&S
Mumbles	Wind Dir	0.44	0.37	0.40	0.42
	Wind Sp.	0.71	0.86	0.83	0.77
Exceedence Hours					
		Hospital	Fire Station	Taibach07	Corus S&S
Mumbles	Wind Dir	0.38	0.33	0.37	0.29
	Wind Sp.	0.75	0.86	0.85	0.80

Table 18: Correlation Coefficients for Comparison of Mumbles Met Data with AURN/EAW Data

		Hosp	**Fire**	**Mumbles**
Taibach 2007	Wind Dir	0.58	0.66	0.48
	Wind Sp.	0.82	0.94	0.67
Corus S&S Club	Wind Dir	0.64	0.36	0.41
	Wind Sp.	0.72	0.81	0.67
Mumbles	Wind Dir	0.55	0.28	-
	Wind Sp.	0.53	0.62	-

19 Appendix C: Investigation of Northerly Pollution Sources

Within the progression of the study, it was noticed that some analyses were indicating a relationship between elevated PM_{10} concentrations and northerly wind directions. Although initial examinations of results suggested that these might be being exaggerated in importance by some of the statistical smoothing techniques, it was decided that it merited further investigation as there was no apparent knowledge of any likely pollution sources to the north.

The one potential hypothesis that seemed plausible was that these northerly peaks may be related to either dust being blown off the top of the hillsides, or occasional brushfires on the hilltops.

Table 19: Statistics for PM_{10} at AURN Sites by Wind Quadrant

		All	N	E	S	W
Hours	n	79,344	10,951	20,902	19,081	24,830
	%	-	13.8	26.3	24.0	31.3
	Mean	30.1	16.6	22.5	40.4	34.6
Hours>50	n	10,533	197	827	4,743	4,362
	% Hours>50	-	1.9	7.9	45.0	41.4
	% All Hours	13.3	0.2	7.6	22.7	22.9
	Mean	80.3	71.4	65.7	75.9	88.4
	Max	447	246	442	447	411

Table 19 shows key statistics for PM_{10} concentrations over the entire AURN dataset (01/01/2000 to 28/03/2009 – both sites). Wind quadrants are 90° sectors centred on north, south, east and west. The data show that only 13.8% of hours are associated with northerly windflow, and that only 1.9% of Hours>50 are associated with northerly winds. In total only 0.2% of all monitored hours are Hours>50 with northerly flow.

Mean concentrations associated with northerly flow is lower than associated with other wind quadrants, and maximum concentrations are also much lower.

Mean concentrations for Hours>50 however are greater for northerly flows than those from the easterly quadrant.

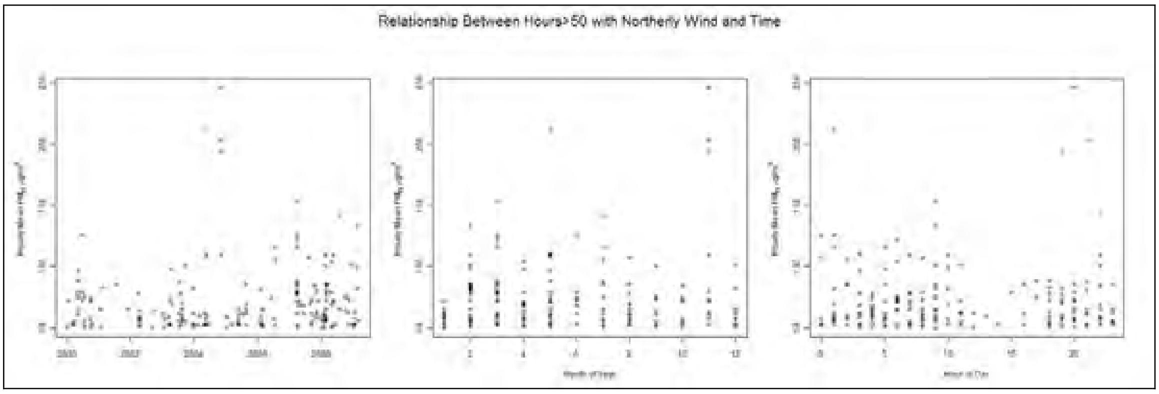

Figure 75: Relationship of Hours>50 with Northerly Wind and Time

Figure 75 shows the relationship of those Hours>50 associated with a northerly wind direction, with date, month and hour of day. There appears to be a tendency for these northerly peaks to appear more frequent at the Fire Station site (post-July 2007). There is no distinct pattern with regard to the month of the year, although high concentrations in November could potentially be related to fireworks. Most interestingly, the peaks are least common during the middle of the day, from about 10am to 4pm. This could indicate that if dust from the hills is the source of these peaks, daytime convective mixing could be sufficient to prevent the PM_{10} fraction of the dust settling over Port Talbot.

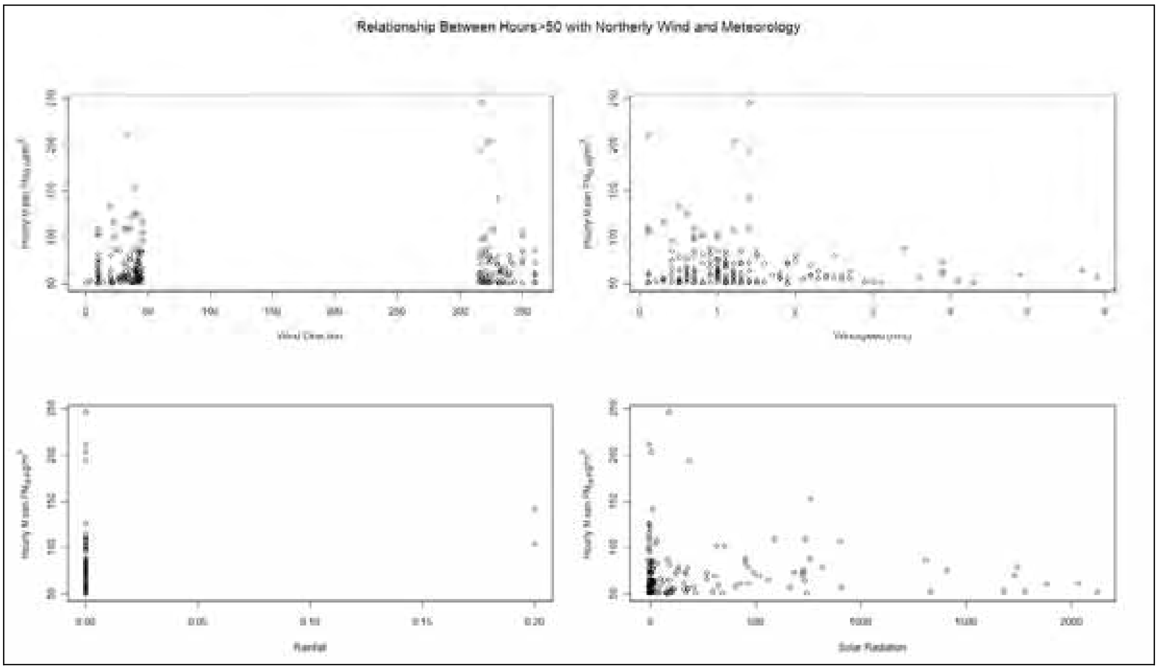

Figure 76: Relationship of Hours>50 with Northerly Wind and Meteorology

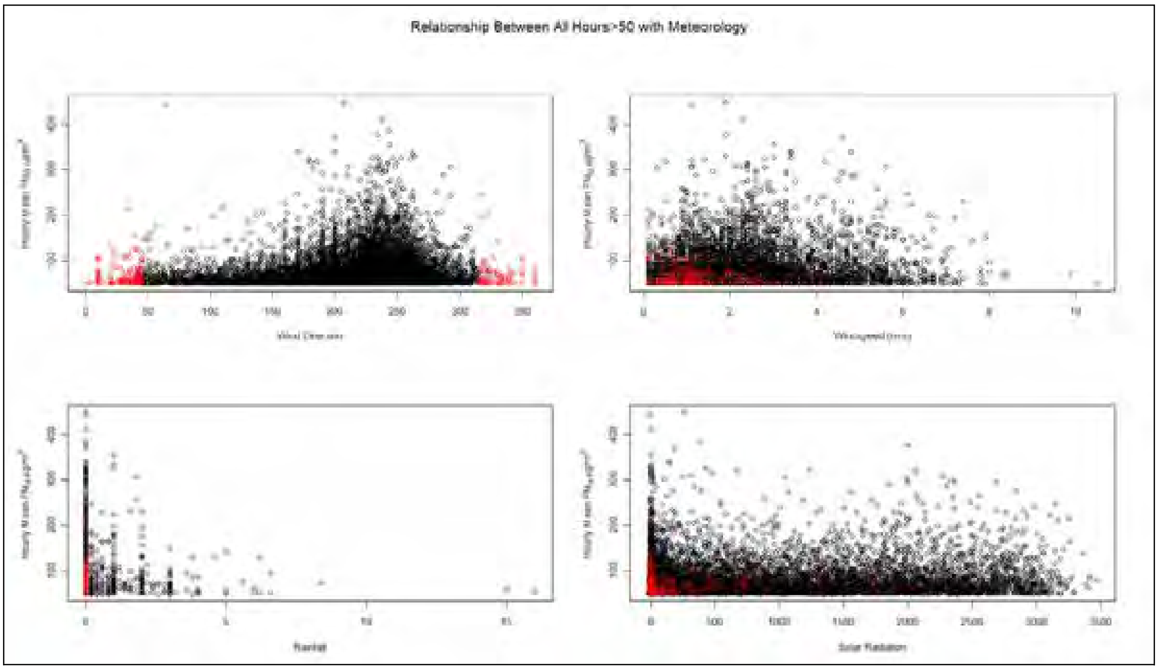

Figure 77: Relationship of All Hours>50 with Meteorology (Northerly Hours in Red)

Figure 76 shows the relationships of the northerly peak hours with wind direction, windspeed, rainfall and solar radiation. Figure 77 shows these same points alongside all other Hours>50.

- o There is no distinct direction in the northerly quadrant associated with these peaks.
- o Peaks occur most commonly at windspeed around 1 m/s, with few occurrences in completely calm conditions or at windspeed over 3 m/s.
- o All northerly peaks are associated with zero (or very close to zero) rainfall.
- o Most northerly peaks are associated with low levels of solar radiation.

These analyses suggest that the hypothesis regarding the source being wind-blown dust from the hillsides may be correct. The association with zero rainfall indicates dry conditions (further analysis could be down looking at rainfall in the past hours or days, but time has not been sufficient). Windspeed indicate some wind, but not a great deal. Remembering that this is the PM_{10} component of any windblown dust, it is fine and would need to settle rapidly in order to be picked up by the AURN sites as they are not a considerable distance from the foot of the hills. High windspeed may therefore keep the dust lifted carry it over Port Talbot.

Similarly, the lack of northerly peaks in the middle of the day, and the association with relatively low solar radiation suggests that these peaks are experienced when there is not much convective turbulence. This again suggests that the peaks occur when conditions would allow the dust to settle rapidly after leaving the hilltops, rather than being kept suspended by convection.

20 Appendix D: Investigation of Relationship between PM_{10} and Rainfall

Aside from windspeed and direction, one of the key meteorological parameters that may affect pollution concentrations is rainfall. As with the problem with windspeed, where higher speeds will increase the likelihood of elevated concentrations of both wind-raised dust and turbulent plume grounding leading to elevated pollution concentrations, rainfall is likely to reduce concentrations from both these types of emissions. However, a simple exploratory analysis has been undertaken to assess any potential relationship between PM_{10} concentrations and rainfall.

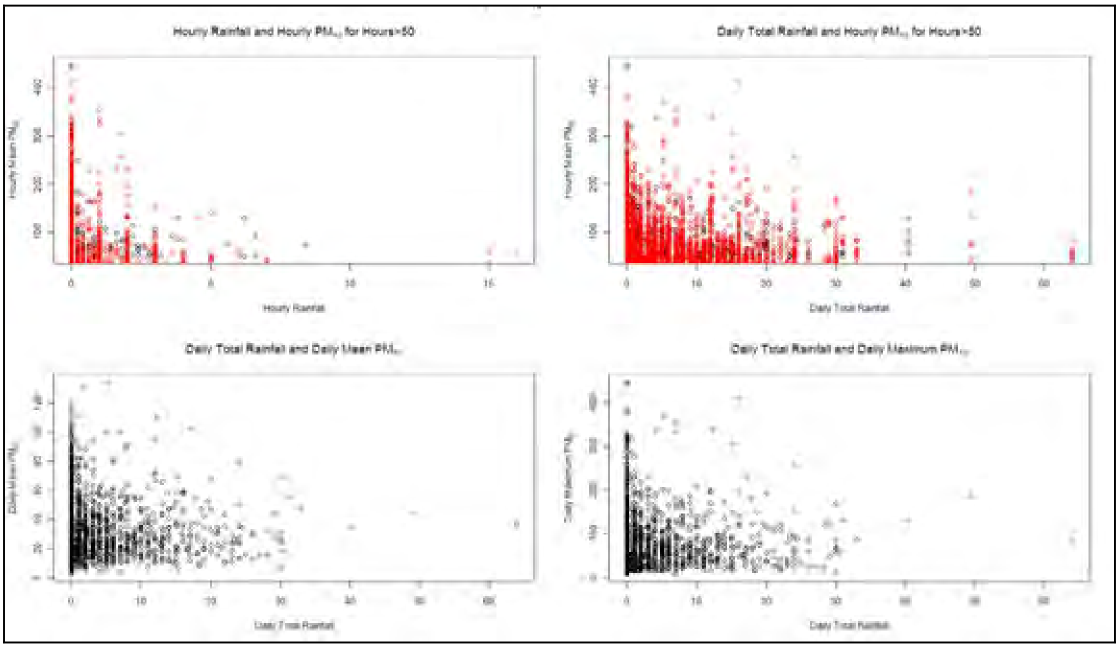

Figure 78: Plots Indicating Relationship Between PM_{10} and Rainfall

Figure 78 shows four plots indicating the relationship between rainfall (hourly and daily total) with PM_{10} (Hours>50, daily mean and daily maximum). In the upper plots, red dots represent point with south-westerly wind direction, and black points from the other sectors. These initial plots tend to show that the highest concentrations of PM_{10} do occur under dry (or at least drier) conditions. In these analyses, no accounting has been made for when rainfall has occurred in relation to the peak PM_{10} concentrations. Further analysis needs to be carried out using a system to calculate rainfall, not just on the same day, but on previous days. This will help enable assessments to be made regarding the dampness of the ground and the probability that elevated concentrations are coming from combustion sources rather than resuspended dusts. It is recommended that an analysis of previous rainfall is incorporated into further investigation of individual exceedence days.