2009 Air Quality Updating and Screening Assessment for the *City & County of Swansea*

In fulfillment of Part IV of the Environment Act 1995
Local Air Quality Management

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Executive Summary

The Environment Act 1995, Part IV established a national framework for air quality management that requires all local authorities to conduct air quality reviews of their areas having had regard to any guidance issued. If the reviews undertaken indicate that the objective for any of the identified pollutants will not be met by the date for compliance then an Air Quality Management Area must be declared.

The City and County of Swansea following the first round of review and assessment concluded that there was a requirement to declare the Hafod area as an Air Quality Management Area due to exceedences of the nitrogen dioxide annual mean objective. This area was declared in September 2001 and a map outlining the area can be seen within Annexe 1.

This report contains the latest Updating and Screening Assessment of air quality within the City and County of Swansea. The Updating and Screening Assessment looks at each pollutant source in light of current technical guidance contained within LAQM.TG(09). Should any significant changes be identified that are likely to give rise to a breach of the objectives then a Detailed Assessment must be carried out for the identified pollutant. The conclusions reached are that the objectives for carbon monoxide, benzene, lead and sulphur dioxide will be met and that there is no requirement to proceed to a detailed assessment for these pollutants. However, there is evidence that the annual mean objective for nitrogen dioxide of 40ug/m^3 will continue to be exceeded within the existing Hafod Air Quality Management Area. Latest monitoring undertaken also indicates newly identified areas of exceedences of the nitrogen dioxide annual mean objective outside of the Hafod Air Quality Management Area within the Sketty and Fforestfach areas of the authority. Several other areas also exhibit the potential to exceed the annual mean objective as the measured annual means are within the range 37-40 ug/m^3.

It is proposed to amend the existing Hafod Air Quality Management Area to include these newly identified nitrogen dioxide annual mean failing areas as all areas of failure have the same causes, need similar actions and are connected by road network issues.

Potential PM_{10} exposure has been identified at or from two poultry units within the rural area of Gower. In one case, there is relevant exposure to a dwelling within the farm complex itself. In the other case, there is relevant exposure at locations both on and off the farm complex. In neither case does the number of housed birds meet the assessment threshold. Following discussions with the Review and Assessment Helpdesk on how best to proceed given the relevant exposure, further advice on how to proceed is awaited following collation of local authority findings.

Potential PM_{10} exposure has also been identified resulting from proposed activity at a landfill site in Cwmrhydyceirw. However, the site at present although permited, remains dormant and further details on the operator’s future intentions are awaited

The City and County of Swansea participates in the UK Heavy Metals Monitoring Network and has monitoring stations within the Glais, Clydach and Morriston areas monitoring the high level stack discharge from the nickel refinery within Clydach. During late 2007 the company installed improved abatement management on the high level stack discharge. Additional monitoring stations had been established during 2007/2008 both upwind and downwind of the release point taking the total monitoring locations to four. Two of these stations have been adopted onto the UK Heavy Metals Monitoring network. Monitoring results for 2008 have indicated for the first time in recent year’s compliance with the 4^{th} Daughter Directive critical threshold monitoring target value for nickel at all monitoring stations. It is envisaged monitoring at all four stations will continue for the foreseeable future to confirm continued and ongoing compliance with the 4^{th} Daughter Directive critical threshold monitoring target value for nickel.

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1 Introduction

1.1 Description of Local Authority Area

The City and County of Swansea unitary authority covers a mixed area of extensive coastline, rural villages and the City of Swansea itself. The latest Census (June 2000) estimate for the population of Swansea is 230,300. The 2000 Census also indicates that 46,700 (20.3%) of the population were less than 17 years of age with 41,205 (17.9%) of the population being aged 65 or over.

To the west of the City of Swansea stands the gateway to the Gower Peninsula, an officially designated Area of Outstanding Beauty that boasts wide-open beaches and rugged shorelines. To the east of the City and County of Swansea lies the only major operational traditional “heavy industry” in the form of the Corus Steelworks complex at Port Talbot. Heavy industry has declined steadily within the boundaries of the authority during the last century. This former industrial activity has left its scars – most notably to the Lower Swansea Valley. From the early 1970’s the areas once blighted by slag heaps have undergone extensive remediation and greening. New “light industry” and retail outlets have moved back into the Lower Swansea Valley following the establishment of Enterprise Zone’s and industrial parks. Considerable regeneration is now ongoing within the Swansea area notably the docks re-development and within the city centre/marina area.

The major source of pollution is now vehicular. The topography of the Lower Swansea Valley is complex and it is thought that this aggravates pollution loading in the area. Swansea is connected to major road and rail links. The M4 motorway travels through northern area of the authority, connecting Swansea with Carmarthenshire in the west and to Cardiff and Bristol to the east. The major artery routes of the A483, A4067 and A48 connect Swansea city centre with the M4 motorway junctions to the north. Local traffic also use these routes as primary routes into the city centre.

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Swansea is well served with rail links to the majority of the UK. The Inter-City 125 service from London Paddington terminates at Swansea. Local services operate from Swansea to mid and West Wales. A major locomotive-servicing centre operates within Swansea at Landore Diesel Sheds, primarily to service the power units of the Inter City 125 service. The majority of diesel locomotives operated by First Great Western are also serviced and maintained at this facility.

The older and established areas of Swansea comprise of traditional terraced housing. These areas tend to be, but are not exclusively within approximately 3 miles of the city centre. Areas of high density terraced housing still exist around the centres of population established during the Industrial Revolution.

As would be expected, new housing provision tends to be either of detached, or semi-detached, and during the last 20 – 30 years these developments have mainly been located in areas greater than 3 miles away from the city centre. This trend is changing however and within the last 5 years Swansea has seen the SA1 development within the old docks area provide a springboard for new housing development both within the SA1 development site and more lately within the marina area. This regeneration is now also extending into the heart of the city centre with several residential developments taking the place of retail/business premises or occupying the upper floors of former wholly retail premises.

The Tawe Riverside Corridor Proposals will, if implemented see, the regeneration of a large section of the lower Swansea Valley from the Quay Parade bridges up to the Morfa Retail Park. This area is subject to past historical industrial contamination from primarily metals processing and has been in decline for several decades. Some sites have been developed for industrial use but large sections of land remained in the same state following the lower Swansea Valley project of the late 1970’s and early 1980’s. This project dealt with the legacy of contamination by clearing derelict sites and undertaking limited remediation with extensive landscaping.

1.2 Purpose of Report

This report fulfils the requirements of the Local Air Quality Management process as set out in Part IV of the Environment Act (1995), the Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2007 and the relevant Policy and Technical Guidance documents. The LAQM process places an obligation on all local authorities to regularly review and assess air quality in their areas, and to determine whether or not the air quality objectives are likely to be achieved. Where exceedences are considered likely, the local authority must then declare an Air Quality Management Area (AQMA) and prepare an Air Quality Action Plan (AQAP) setting out the measures it intends to put in place in pursuit of the objectives.

1.3 Air Quality Objectives

The air quality objectives applicable to LAQM in Wales are set out in the Air Quality (Wales) Regulations 2000, No. 1940 (Wales 138), Air Quality (Amendment) (Wales) Regulations 2002, No 3182 (Wales 298), and are shown in Table 1.1. This table shows the objectives in units of microgrammes per cubic metre $\mu g/m^3$ (milligrammes per cubic metre, $mg^/m^3$ for carbon monoxide) with the number of exceedences in each year that are permitted (where applicable).

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene	16.25 $\mu g/m^3$ 5.00 $\mu g/m^3$	Running annual mean Running annual mean	31.12.2003 31.12.2010
1,3-Butadiene	2.25 $\mu g/m^3$	Running annual mean	31.12.2003
Carbon monoxide	10.0 mg/m^3	Running 8-hour mean	31.12.2003
Lead	0.5 $\mu g/m^3$ 0.25 $\mu g/m^3$	Annual mean Annual mean	31.12.2004 31.12.2008
Nitrogen dioxide	200 $\mu g/m^3$ not to be exceeded more than 18 times a year 40 $\mu g/m^3$	1-hour mean Annual mean	31.12.2005 31.12.2005
Particles (PM_{10}) (gravimetric)	50 $\mu g/m^3$, not to be exceeded more than 35 times a year 40 $\mu g/m^3$	24-hour mean Annual mean	31.12.2004 31.12.2004
Sulphur dioxide	350 $\mu g/m^3$, not to be exceeded more than 24 times a year 125 $\mu g/m^3$, not to be exceeded more than 3 times a year 266 $\mu g/m^3$, not to be exceeded more than 35 times a year	1-hour mean 24-hour mean 15-minute mean	31.12.2004 31.12.2004 31.12.2005

Table 1 Air Quality Objectives included in Regulations for the purpose of Local Air Quality Management in Wales

1.4 Summary of Previous Review and Assessments

The local authority review and assessment process is multi-staged. This Authority carried out its first stage review in 1999. The conclusion reached was to progress to a second and third stage review for Benzene, Particulate Matter (PM_{10}), Sulphur Dioxide (SO_2) and Nitrogen Dioxide (NO_2).

In between these stages, the authority had to deal with, and resolve a burning, disused coal spoil tip at the former Brynlliw Colliery site. This absorbed most resources available between 1999 and 2000.

Along with all other local authorities, this authority has completed its stage 2 and stage 3 reviews. The third stage review and assessment concluded that despite the indication that the air quality objective for benzene would not be met that the declaration of an AQMA was not appropriate. Given the fundamental changes proposed to the Lower Swansea Valley's infrastructure and the technical improvements proposed in the reduction in the benzene content in fuel, it was recommended that a further benzene monitoring study be carried out for a period of at least 12 months. During the stage 3 process, it was determined that the authority would not breach the objectives laid down for Particulate Matter (PM_{10}) and Sulphur Dioxide (SO_2).

Section 83(1) of the Environment Act 1995 requires the Authority to designate as Air Quality Management Areas (AQMA's) those areas where it is likely that the standards for any of the identified pollutants would be exceeded. As a result of the detailed work carried out in the authorities' third stage review and assessment it was found that areas of the Hafod were likely to fail the NO_2 annual mean objective of $40\mu g/m^3$ by the compliance date of 31st December 2005.

On the 12th September 2001 the Authority declared The Hafod Air Quality Management Area (NO_2), cited as the City & County of Swansea (Hafod Air Quality

Management Area (NO_2)) Order 2001. The Order came into force on the 14th September 2001. Annexe 1 contains a map indicating the AQMA area.

The Stage 4 review required under Section 84(1) of the Environment Act 1995 confirmed the earlier findings and that the declaration of the Hafod AQMA was justified as several locations were projected to fail the nitrogen dioxide (NO_2) annual mean objective in 2005.

Section 84 of the Environment Act 1995 requires the formulation of a written plan in pursuit of the achievement of air quality standards and objectives within the designated AQMA and has become known as the "Action Plan". The City and County of Swansea have undertaken a considerable amount of feasibility and infrastructure work in formulating its Action Plan taking a few years to produce the completed Action Plan in December 2004.

In 2004, the authority commenced works on the second round of review and assessment. In accordance with the policy and technical guidance documents, the second round of review and assessment was carried out in two stages;

- An Updating and Screening Assessment (USA) - intended to identify aspects that have changed since the first round of review and assessment (from 1999 in Swansea's case) and identify those that require further assessment; namely
- A Detailed Assessment of those pollutants that have been identified as requiring further work and investigation

The Updating and Screening Assessment was submitted to the Welsh Assembly Government in July 2004 with a recommendation to proceed to a detailed assessment for nitrogen dioxide at identified narrow congested streets and busy junctions. The USA also concluded that particulate matter PM_{10} should also be investigated using real-time techniques at the identified narrow, congested streets and busy junctions, despite the then 2010 provisional objectives not being set in regulation.

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A brief summary of the results and conclusions of the Detailed Assessment into NO_2 levels can also be found within the Progress Report 2004 – section 2.3.2.3 page 95. The Detailed Assessment itself was submitted to the Welsh Assembly Government during December 2005. This assessment concluded that there was no justification in declaring additional AQMA's. At the time of submission, there was a debate with the auditors and Welsh assembly Government over the bias factor used to correct the nitrogen dioxide passive diffusion tube data. The authority used the bias factor quoted by Harwell Scientifics to correct for tube bias. Whilst the Detailed Assessment report was eventually accepted by the Welsh Assembly Government and the auditors as a result of the authority providing additional supporting information and justification for the use of the Harwell Scientific bias factor it was agreed that the authority would undertake co-location studies with its chemiluminescent analysers at 3 sites namely, the Swansea AURN on Carmarthen Road, and at the Morfa and Morriston Groundhog sites. This work commenced during December 2006 and was delayed until the Swansea AURN had been relocated and commissioned to prevent any additional uncertainties. The authority has now completed these co-location tasks at all three automatic sites within Swansea and has determined a local bias factor for the correction of the passive nitrogen dioxide diffusion tubes exposed within Swansea during 2008. Further details on this area of work can be found within section 2.1.13

The Progress Report for 2004/05 was submitted for consideration during July 2005

The infrastructure required for a real-time assessment of PM_{10} in Swansea, is still being developed. The authority have purchased ten Met One E-Type light scattering PM_{10} dust samplers and are in the process of deploying these at the identified narrow, congested roads and busy junctions mentioned within the USA submitted in July 2004 and the Detailed Assessment. Identification of suitable sites is now complete but what has proved time consuming are the practical considerations of the site location itself together with the provision of suitable services i.e. un-metered electricity feeds and suitable mounting points. Significant problems have been encountered with the operation of the EType samplers. It is recognised that these analysers do not have formal UK type approval but due to both the expense and considerable practical considerations of deploying Rupprecht & Patashnick Co., Inc.

FDMS/TEOM's, these E Type samplers will provide a more accurate assessment than use of the DMRB screening tool would be able to provide. It is thought that when the technical difficulties being experienced with the equipment are resolved that the modelling will supplement the data collected by the E Type samplers.

Additional works underway include the collection of real-time classified counts of traffic data via the Vodafone GPRS network together with the construction of an emissions database. It is these latter items, particularly communications problems with the GPRS system that have delayed the modelling capabilities to date. The USA dated April 2006 was submitted for consideration to the Welsh Assembly Government in July 2006.

The authority undertook a further Progress Report in 2007 which was submitted to the Welsh Assembly and the auditors during July 2007. The same issues arose from this report with the auditors – the rational behind the bias factor used to correct the passive diffusion tube was again raised despite the report clearly outlining the authorities' reasons for using the bias factor that was used to correct for tube bias. This issue as mentioned above should now have been resolved with the determination of a local Swansea bias factor

Details on the various stages completed by the authority in the Local Air Quality Management process are given below within table 2. Brynlliw Colliery remediation is shown for information purposes due to the delays in the LAQM process that this introduced. This was a long-term burning tip which required large scale monitoring and control. The Internet addresses (URL's) that these reports can be downloaded from are given where appropriate.

Report	Date Completed	Internet URL
1st Stage Review	1999	http://www.swansea.gov.uk/index.cfm?articleid=5563
Brynlliw Colliery Remediation	1999-2000	N/A
2nd & 3rd Stage Review	2001	http://www.swansea.gov.uk/index.cfm?articleid=5565
Declaration of Hafod AQMA	September 2001	http://www.swansea.gov.uk/index.cfm?articleid=5557
Stage 4 Review	October 2003	http://www.swansea.gov.uk/index.cfm?articleid=5568
2nd Round Review USA	July 2004	http://www.swansea.gov.uk/index.cfm?articleid=5561
Hafod AQMA Action Plan	December 2004	http://www.swansea.gov.uk/index.cfm?articleid=9930
Progress Report 2004	July 2005	http://www.swansea.gov.uk/index.cfm?articleid=9929
Detailed Assessment	December 2005	http://www.swansea.gov.uk/index.cfm?articleid=5561
Progress Report 2006	July 2006	http://www.swansea.gov.uk/index.cfm?articleid=9929
USA 2006	April 2006	http://www.swansea.gov.uk/index.cfm?articleid=5561
Progress Report 2007	July 2007	http://www.swansea.gov.uk/index.cfm?articleid=9929
Progress Report 2008	May 2008	

Table 2 Summary of LAQM Actions

2 New Monitoring Data

2.1 Summary of Continuous Real Time Monitoring Undertaken

The authority operates a network of monitoring stations, mainly located within the lower Swansea valley area. The network is a mixture of four, fixed point automatic stations, together with open path measurements from two DOAS (Differential Optical Absorption Spectroscopy) stations. Details of all automatic monitoring station are given below in table 3 with site by site operational details provided within section 2.1.1. Two of the fixed point stations (Morfa and Morriston) have datasets extending back to 2001. A summary of the commencement of measurement for each station is given below within section 2.1.8 as table 4

Site Name	Site Type	OS Grid Ref	Pollutants Monitored	IN AQMA	Relevant Exposure	Distance to kerb of nearest road	Worst-case Location
Swansea Roadside AURN	Road side	X 265322 Y 194447	NO_2,PM_{10}, $PM_{2.5}$ CO, SO_2	Y	Y (12m)	4m	N
Morfa Groundhog	Road side	X 266036 Y 195406	NO_2,PM_{10}, SO_2	Y	Y (34m)	5m	Y
Morriston Groundhog	Road side	X 267210 Y 197676	NO_2,PM_{10}, CO, SO_2 and Ozone	N	Y (22m)	4m	N
Cwm Level Park	Urban Backg round	X 265915 Y 195895	NO_2 and Ozone	Y	N (100m)	78m	N
Hafod DOAS	Road side	Transmitter X 265927 Y 194453 Receiver X 265991 Y 194706	NO_2 Ozone and Benzene	Y	Y (0.3m)	1.7m	N
St Thomas DOAS	Road side	Transmitter X 266191 Y 193655 Receiver X 266263 Y 193370	NO_2 Ozone and Benzene	N	Y(2m) Varies along path length	1.7m	N

Table 3 Details of Automatic Monitoring Sites

2.1.1 Automatic Continuous Real Time Monitoring Sites

2.1.2 Swansea Roadside AURN, Carmarthen Road, Waun Wen

The Swansea AURN was located in the heart of the city centre on the pedestrian area of Princess Way. Due to the redevelopment of the David Evans complex, the monitoring station was scheduled for decommissioning on the 14th August 2006. The data logger failed on the 3rd August 2006 following a power surge at the site and in effect, data from the site ceased on this date as it was decided not to undertake any repairs to the data logger. Every effort had been made to re-establish the monitoring station within the city centre. However, DEFRA had amended the siting criterion which has resulted in a suitable site being unable to be identified. The station has now been relocated roadside on Carmarthen Road at Waun Wen. The ADDT is approximately 19,000 vehicles. The relocated site is detailed and outlined below and is now sited within the boundary of the Hafod Air Quality Management Area. The site has receptors close by with additional sensitive receptors in close proximity - a Nursing Home and a Primary School are within 100m of the monitoring location..

The AUN station at Princess Way had been affiliated onto the UK National Network during late 1994 and had been operational ever since until 3rd August 2006. The new roadside site has also been affiliated onto the UK National Network with data capture commencing on the 20th September 2006 at 13:00hrs. The station has been given a site classification Roadside[1]. Map 1 below is an aerial view of the site and the surrounding locations. The site is located in an open aspect approximately 55m above sea level with direct views over Swansea Bay. It is therefore more exposed to the prevailing south westerly winds than the monitoring sites located on the valley floor (Morfa, Morriston and Hafod DOAS). It is thought probable that this site may well sit above any inversion that forms within the lower Swansea Valley and therefore, does not experience the elevated concentrations seen at the other monitoring stations during such conditions.

[1] *Source LAQM.TG(09) Appendix A page A1-20 Table A1.4*

Map 1 – Aerial view of Swansea Roadside AURN

All equipment is housed within an air-conditioned unit and operated continuously. The equipment comprises of Advanced Pollution Instruments (API) real-time analysers measuring NO_x CO and SO_2, with Thermo FDMS units measuring PM_{10} and $PM_{2.5}$. The API gas analysers have been configured so that daily automatic calibration is carried out (between 00:30 hours and 01:00 hours). This calibration data is automatically logged as invalid by the analyser. In addition officers from this authority performed routine monthly manual calibrations. The analyser's are subjected to scrubbed internal generated zero air to assess the analyser's response to zero air. The analysers are also subjected to traceable calibration gases at a known concentration and the response of the analyser recorded. All manual calibration data is then forwarded to AEA Energy and Environment to perform data management procedures. The data is then further subjected to full network QA/QC procedure's undertaken by AEA Energy and Environment on behalf of the Department of Environment, Food and Rural Affairs (DEFRA). The station is serviced and maintained twice yearly by Enviro Technology Services Plc. In addition, the authority has a 48 hour call out response for any on-site equipment problems with Enviro Technology Services Plc. All equipment on site is fully audited twice yearly by AEA Energy & Environment together with the calibration gases stored on site

Hourly ratified data for the period 2008 covering the pollutants Nitrogen Dioxide and Particulate Matter PM_{10} and $PM_{2.5}$ (FDMS) has been downloaded from the Air Quality Archive at http://www.airquality.co.uk/archive/flat_files.php?site_id=SWA1&zone_id=9. These data have then been imported into the OPSIS Enviman Reporter databases allowing analysis and graphical presentation.

During 2007, the UK Automatic Network underwent a review by DEFRA. During this review, numerous stations were either decommissioned from the network, or, as in the case of the Swansea AURN, a limited number of analysers from the station were kept within the UK monitoring framework. This review was undertaken by DEFRA in response to their changing EU commitments. Whilst data from the CO and SO_2 analysers are no longer collected (post 1st October 2007) or ratified by DEFRA (AEA Energy and Environment), this authority has decided to continue to fund their operation and data collection. The dataset from 1st October 2007 onwards for the above mentioned pollutants will therefore be ratified by the authority.

The ozone analyser that was surplus to requirements at the site following the DEFRA review has been relocated at the Cwm Level Park urban background monitoring station during December 2008.

2.1.3 Morfa Groundhog

The Morfa station has been operational since August 2000 and is located in a fairly open area on a grass bank to the Morfa / Normandy roundabout which acts as a major intersection to the road network in the lower Swansea Valley. The station is within the boundary of the Hafod AQMA and has been given a site classification Roadside[2].

As with the majority of monitoring stations, the location finally chosen for monitoring has to be a compromise between the ideal desired location and the practicalities of siting a station of this size. It is recognised that this station having being sited adjacent to a roundabout is not ideally placed. However, in saying this, the station satisfies the majority of the monitoring criteria required by this authority with receptor locations (dwellings) being located within 35m. Due to its location in a fairly open aspect of the lower valley area, this station does not truly reflect the conditions experienced within the narrow congested streets within the Hafod Air Quality Management Area.

All equipment is housed within an air-conditioned unit and operates continuously. The equipment comprises of Advanced Pollution Instruments (API) real-time analysers measuring CO, SO_2 and $NO_{x,.}$ The R&P TEOM measuring PM_{10} was upgraded to a Thermo FDMS unit again measuring PM_{10} on the 28th November 2006 with data capture for the FDMS unit commencing at 13:00. The API gas analysers have been configured so that a daily automatic calibration is carried out (between 00:30 hours and 01:00 hours). This calibration data is automatically logged as invalid by the data-logger. In addition officers from this authority perform routine monthly manual calibrations. The analyser's are subjected to scrubbed internal generated zero air to assess the analyser's response to zero air. The analysers are also subjected to traceable calibration gases at a known concentration and the response of the analyser and data-logger is recorded. All manual calibration data is recorded as invalid data by the data-logger and is removed from any subsequent analysis.

The station is operated and calibrated in accordance with the UK National Network Local Site Operators manual. Data is re-scaled by the authority according to the calibration factors (monthly span and overnight/monthly zeros). The station is serviced and maintained twice yearly by Enviro Technology Services Ltd. In addition, the authority has a 48 hour call out response for any on-site equipment problems

[2] *Source LAQM.TG(09) Appendix A page A1-20 Table A1.4*

with Enviro Technology Services Plc. Since the awarding of the contract by the Welsh Assembly Government to AEA Energy & Environment to run the Welsh Air Quality Forum in April 2004, all equipment on site is fully audited yearly by AEA Energy & Environment together with the calibration gases stored on site. The L10 span gas cylinders are replaced on a regular basis and are to a certified and traceable standard.

A map showing the location of the Morfa Groundhog station is given below as map 2. The boundary of the existing Hafod Air Quality Management Area is shown as the black/yellow dashed line.

Map 2 Location of Morfa Groundhog Station

2.1.4 Morriston Groundhog

Morriston Groundhog has been operational since September 2000 and is located adjacent to the southbound slip road to the busy A4067 dual carriageway at Morriston Underpass. The Hafod AQMA boundary is approximately one mile south of this location. Receptor locations can be found to the right of the station in the form of terraced housing. To the left of the site and on the opposite side of the dual carriageway is Morriston Primary School. The school buildings abut the red brick retaining wall to the northbound Morriston slip road exit. The A4067 carries on for approximately one mile northbound where it meets the M4 motorway at junction 45. The station has been given a site classification Roadside[3]. Map 3 below is an aerial view of the site and the surrounding locations.

All equipment is housed within an air-conditioned unit and operates continuously. The equipment comprises of Advanced Pollution Instruments (API) real-time analysers measuring O_3, H_2S, CO, SO_2 and $NO_{x,}$.The R&P PM_{10}TEOM was upgraded to a Thermo FDMS PM_{10} unit on the 27th October 2006 with data capture for the FDMS unit commencing at 17:00 . The API gas analysers have been configured so that a daily automatic calibration is carried out (between 00:30 hours and 01:00 hours). This calibration data is automatically logged as invalid by the data-logger. In addition officers from this authority perform routine monthly manual calibrations. The analyser's are subjected to scrubbed internal generated zero air to assess the analyser's response to zero air. The analysers are also subjected to traceable calibration gases at a known concentration and the response of the analyser and data-logger is recorded. All manual calibration data is recorded as invalid data by the data-logger and is removed from any subsequent analysis.

The station is operated and calibrated in accordance with the UK National Network Local Site Operators manual. Data is re-scaled by the authority according to the calibration factors (monthly span and overnight/monthly zeros). The station is serviced and maintained twice yearly by Enviro Technology Services Ltd. In addition, the authority has a 48 hour call out response for any on-site equipment problems with Enviro Technology Services Plc. Since the awarding of the contract by the Welsh Assembly Government to AEA Energy & Environment to run the Welsh Air Quality Forum in April 2004, all equipment on site is fully audited yearly by AEA Energy & Environment together with the calibration gases stored on site. The L10 span gas cylinders are replaced on a regular basis and are to a certified and traceable standard.

[3] *Source LAQM.TG(09) Appendix A page A1-20 Table A1.4*

Map 3 - Aerial view - Morriston Groundhog

2.1.5 Cwm Level Park, Landore

The authority established a NO_x and Ozone urban background monitoring station [4] at Cwm Level Park, Landore during late November/ early December 2008 within the compound of its 30m Meteorological monitoring mast. The details are reported here for information purposes only as the dataset collected to date does not provide the opportunity to meaningfully analyse any of the data collected.

All equipment is housed within an air-conditioned unit and operates continuously. The equipment comprises of Advanced Pollution Instruments (API) real-time analysers measuring NO_x and Ozone. The API gas analysers have been configured so that a daily automatic calibration is carried out (between 00:30 hours and 01:00 hours). This calibration data is automatically logged as invalid by the data-logger. In addition officers from this authority perform routine monthly manual calibrations. The

[4] *Source LAQM.TG(09) Appendix A page A1-20 Table A1.4*

analyser's are subjected to scrubbed internal generated zero air to assess the analyser's response to zero air. The NO_x analyser is subjected to traceable calibration gases at a known concentration and the response of the analyser and data-logger is recorded. The internal span calibration is used with the ozone analyser. All manual calibration data is recorded as invalid data by the data-logger and is removed from any subsequent analysis.

The station is operated and calibrated in accordance with the UK National Network Local Site Operators manual. Data is re-scaled by the authority according to the calibration factors (monthly span and overnight/monthly zeros). The station is serviced and maintained twice yearly by Enviro Technology Services Ltd. In addition, the authority has a 48 hour call out response for any on-site equipment problems with Enviro Technology Services Plc. Since the awarding of the contract by the Welsh Assembly Government to AEA Energy & Environment to run the Welsh Air Quality Forum in April 2004, all equipment on site will be fully audited yearly by AEA Energy & Environment together with the calibration gases stored on site. The L10 span gas cylinders (NO and NO_2) will be replaced on a regular basis and are to a certified and traceable standard.

A map showing the location of the Cwm Level Park station is given below as map 4. The boundary of the existing Hafod Air Quality Management Area is shown as the black/yellow dashed line.

There are no "major" sources close by as would be expected with the site classification, with the nearest road being nearly 80m away, having an AADT of 14,500 vehicles. Some light industry / warehouse front the site but are insignificant as a source. Receptor dwellings are within 100m of the site.

Map 4 Cwm Level Park Monitoring

2.1.6 The OPSIS Hafod Differential Optical Absorption Spectroscopy (DOAS) Monitoring Station

The OPSIS DOAS open path light source measures the pollutants Nitric Oxide, Nitrogen Dioxide, Ozone and Benzene along a 250-metre section of Neath Road, within the Hafod district of the lower valley area within the existing Hafod Air Quality Management Area. These measurements take place at first floor level - a height of approximately 3 - 4 metres and less than 0.3m away from the front facade of the terraced dwellings. The DOAS transmitter ❶ is fixed externally to the front wall of a terraced dwelling that fronts onto Neath Road at one end of the open path measurement. The receiver module ❷ is located on the front wall of another dwelling that also fronts onto Neath Road at the other end of the open path measurement length. The receiver focuses the light received and transmits the light via fibre optic cable into a spectra analyser. Map 5 below shows an aerial photograph of the location of the transmitter and receiver heads. This section of Neath Road has an annual average daily traffic flow (AADT) of approximately 16,500 vehicles and forms the “traditional” route up/down the Swansea Valley. The whole length of Neath Road through the Lower valley area is characterised by slow moving traffic through the narrow, congested, B route corridor. Habits of a lifetime may prove difficult to break!

The transmitter emits a light beam from a xenon lamp and contains a range of wavelengths, from ultraviolet to visible. Different pollutant molecules absorb light at different wavelengths along the path between the emitter and receiver. The receiver is connected to the analyser that measures the intensity of the different wavelengths along the entire light path and converts this into concentrations for each of the gaseous pollutants being monitored.

Map 5 Hafod Opsis DOAS Monitoring

The monitoring location is allowing measurements' running parallel to the carriageway to be made of the above pollutants, as the carriageway is approximately 2 metres away from the front facade of these dwellings. The highway at this location can loosely be referred to as a "street canyon". Valid data capture commenced on the 8th January 2004 at 16:00hrs. The station has been given a site classification Roadside[5].

The DOAS system returns data in the form cyclonic means, not always of the same averaging period - the system has been configured to measure each pollutant for a set period of time: 1 minute each for NO and Benzene and 30 seconds each for nitrogen dioxide and ozone. This gives a cycle time of approximately 3 minutes. The system stores the information as a cycle period of measurement for each pollutant within a “logger value” dataset. During the QA/QC processes that have been completed, conditions were imposed on the minimum acceptable light levels and maximum standard deviations of the measurements permitted on the individual cycled means for each pollutant. The validation process produces the same cyclonic means within a separate database. All individual measurement points that have not met the QA/QC conditions (detailed below) are replaced with null values within the new dataset. The user can then compile 5 minute means from the validated dataset and undertake analysis.

- **QA/QC for NO, Nitrogen Dioxide and Ozone**

  If (C1 >0 and C1 > 2 * C2 and C3 > 10) then result: = C1 else result: = C0

  C0 – Null value
  C1 – Pollutant Concentration
  C2 – Standard Deviation of pollutant
  C3 – Light Level of pollutant

- **QA/QC for Benzene**

  If (C1 >0 and C1 > 2 * C2 and C3 > 40) then result: = C1 else result: = C0

  C0 – Null value
  C1 – Pollutant Concentration
  C2 – Standard Deviation of pollutant
  C3 – Light Level of pollutant

It should be noted that the data presented here represents the spatial average over the whole of the 250-meter measurement path and not a "point measurement" as seen within other "traditional or conventional" monitoring equipment/locations. It should also be noted that the DOAS methodology of monitoring does not comply

[5] *Source LAQM.TG(09) Appendix A page A1-20 Table A1.4*

with the EU Directive methods of measurement (chemiluminescent for NO_2, UV fluorescence for SO_2 etc) at present but the system has recently achieved MCERTS certification and TUV certification.

Monitoring data from the site has been subject to interruption as the property owner at the transmitter site ❶ undertook extensive renovation works to the property. The transmitter head was removed from the front façade during these works to prevent damage. Data is therefore absent for significant periods of 2005 and 2006. The equipment was removed from the façade of the property at 11:00 on the 22nd April 2005 and was replaced at 10:00 16th May 2006. There is therefore significant data loss for both 2005 and 2006 with in total just over a years worth of monitoring data being lost. This is frustrating and regrettable but the loss is outside of the control of this authority.

To compound and frustrate matters further an Area Renewals Project commenced during January 2008 to properties at the receiving end ❷ of the open path measurement. This renewal project resulted in scaffolding erected to the front facades of the terrace properties blocking the light path to the receiver between the 3rd January 2008 and July 2008. Full functionality was not restored until the site had been serviced and calibrated on the 26th August 2008.

The station is subject to Xenon lamp changes and zero calibration on a quarterly basis with span calibration taking place yearly. These works are undertaken by Enviro Technology Plc, the UK distributor for Opsis of Sweden. The frequency of zero/span calibration has been subject to discussions with Opsis as noticeable drop of lamp intensity was noticed for the NO channel (which is deep down in the spectrum) during the 5th and 6th months after renewal. Changing the Xenon lamps every 4 months has resolved this data issue concern.

2.1.7 The Opsis St.Thomas Differential Optical Absorption Spectroscopy (DOAS) Monitoring Station

The St.Thomas OPSIS Differential Optical Absorption Spectroscopy (DOAS) has been installed during September 2005 along a 280m path length of Pentreguinea Road within the St.Thomas area to measure the pollutants sulphur dioxide, nitrogen dioxide, and ozone. Valid data capture commenced on the 12th September 2005 at 09:30am. This section of Pentreguinea Road has an annual average daily traffic flow (AADT) of approximately 22,500 vehicles and forms the eastside link up/down the Swansea Valley from Whiterock bridge to Quay Parade bridges. This route is intended for use within the Action Plan to attempt traffic management during forecast pollution episodes by diverting traffic from the central Neath Road corridor

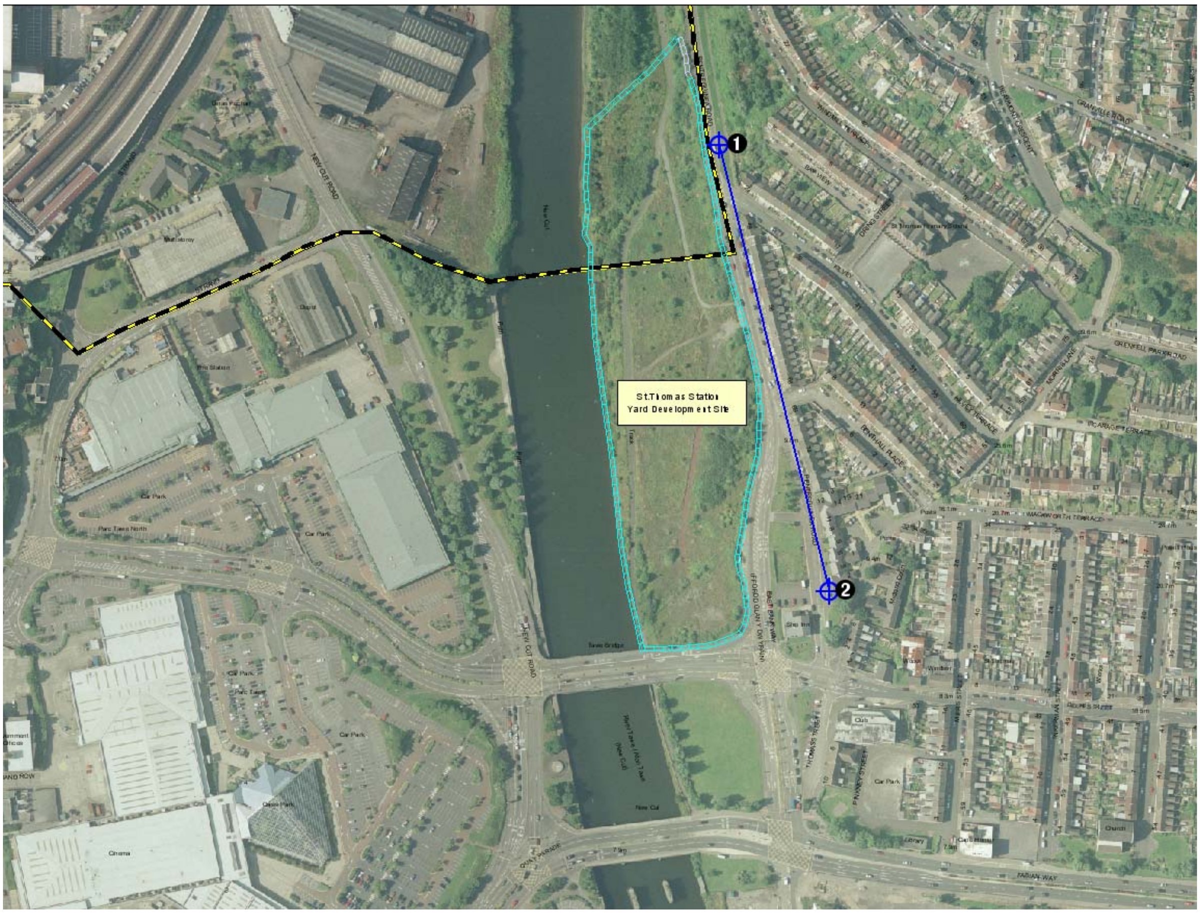
Measurements take place at a height of approximately 3-4 metres and less than 2m away from the front facade of the majority of terraced dwellings. The DOAS transmitter ❶ is fixed on top of a concrete column located north of the junction of Kilvey Terrace and Pentreguinea Road as shown in photo 1 below. The receiver module ❷ is located on top of a concrete column and site housing at the other end of the open path measurement length as shown in photo 2 below.

Photo 1 - St Thomas DOAS Transmitter

Photo 2 - St Thomas DOAS Receiver Station

The transmitter emits a light beam from a xenon lamp that contains a range of wavelengths, from ultraviolet to visible. Different pollutant molecules absorb light at different wavelengths along the path between the emitter and receiver. The receiver is connected to the analyser that measures the intensity of the different wavelengths along the entire light path and converts this into concentrations for each of the gaseous pollutants being monitored. The station has been given a site classification Roadside[6].

The monitoring location is allowing measurements' running parallel to the carriageway to be made of the above pollutants. The location of the open path monitoring can be seen within map 6 below. The site of the transmitter lies just outside of the southern boundary of the existing Hafod Air Quality Management Area. The extent of the existing order can be seen within map 6.



Map 6 – Aerial View of St.Thomas OPSIS DOAS and surrounding area

Quay Parade Bridges are to the south of this location. Congestion extends from Quay Parade bridges up Pentreguinea Road with congestion being seen as far north as the Morfa Shopping Parc in Landore. There are numerous dwellings located

[6] *Source LAQM.TG(09) Appendix A page A1-20 Table A1.4*

along this section of Pentreguinea Road with an application already received for residential development on the former St.Thomas Station Yard Site located between Pentreguinea Road and the River Tawe (see map 6 above). An application for formal planning consent was received during 2005 but was rejected due to the intensity of the development. A modified scheme will be resubmitted shortly to include an element of social housing as a result of the appeal process. The WAG Planning Panel are yet to issue its formal decision.

The DOAS system returns data in the form cyclonic means, not always of the same averaging period - the system has been configured to measure each pollutant for a set period of time: 1 minute each for NO and Benzene and 30 seconds each for nitrogen dioxide and ozone. This gives a cycle time of approximately 3 minutes. The system stores the information as a cycle period of measurement for each pollutant within a “logger value” dataset. During the QA/QC processes that have been completed by this authority, conditions were imposed on the minimum acceptable light levels and maximum standard deviations of the measurements permitted on the individual cycled means for each pollutant. The validation process produces the same cyclonic means within a separate database. All individual measurement points that have not met the QA/QC conditions (detailed below) are replaced with null values within the new dataset. The user can then compile 5 minute means from the validated dataset and undertake analysis.

- **QA/QC for NO, Nitrogen Dioxide and Ozone**

  If (C1 >0 and C1 > 2 * C2 and C3 > 10) then result: = C1 else result: = C0

  C0 – Null value
  C1 – Pollutant Concentration
  C2 – Standard Deviation of pollutant
  C3 – Light Level of pollutant

- **QA/QC for Benzene**

  If (C1 >0 and C1 > 2 * C2 and C3 > 40) then result: = C1 else result: = C0

  C0 – Null value
  C1 – Pollutant Concentration
  C2 – Standard Deviation of pollutant
  C3 – Light Level of pollutant

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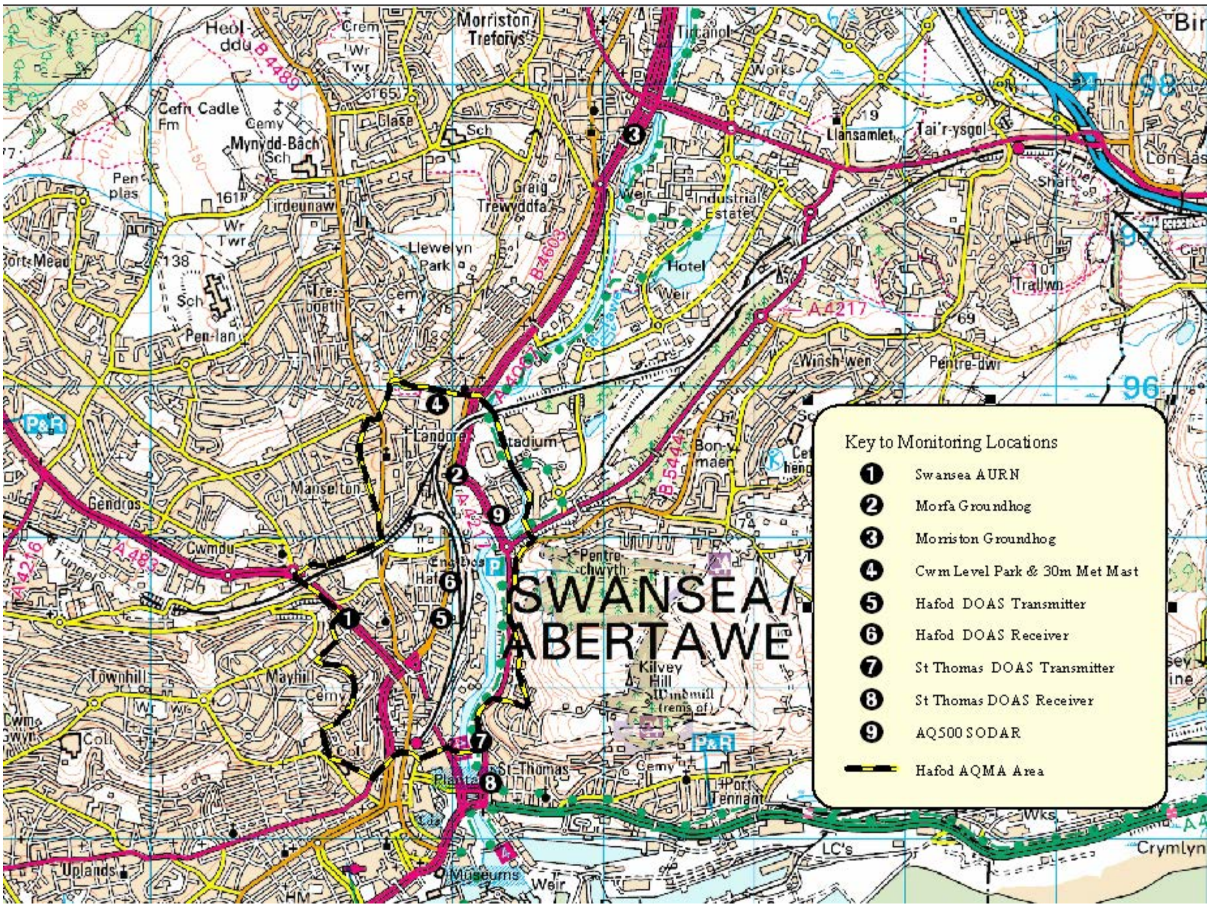
The station is subject to Xenon lamp changes and zero calibration on a 6 monthly basis with span calibration taking place yearly. These works are undertaken by Enviro Technology Plc, the UK distributor for Opsis of Sweden. The frequency of zero/span calibration differs to that of the Hafod DOAS as this station does not measure the NO channel and as such does not suffer the drop of lamp intensity during the 5th and 6th months of operation. Changing the Xenon lamps every 6 months does not invoke any data issue concerns at this site.

It should be noted that the data presented here represents the spatial average over the whole of the 280-meter measurement path and not a "point measurement" as seen within other "traditional or conventional" monitoring equipment/locations. It should also be noted that the DOAS methodology of monitoring does not comply with the EU Directive methods of measurement (chemiluminescent for NO_2, UV fluorescence for SO_2 etc) at present but the system has recently achieved MCERTS certification and TUV certification.

2.1.8 Summary of Automatic Continuous Real-Time Monitoring Locations.

For ease of reference and in order for the reader to familiarise themselves spatially with the locations that the City and County of Swansea undertake automatic continuous monitoring, all such sites are presented below within map 7. Also included within map 7 is the existing extent of the Hafod Air Quality Management Area which was declared during September 2001.

Included with this spatial view is the meteorological monitoring that is currently being undertaken within the lower Swansea Valley area. This currently includes a dedicated 30m mast at Cwm Level Park and a SODAR remote sensing instrument capable of wind speed/direction measurements every 15m up to its maximum height range of 300m located at the Morfa TA Centre. It is envisaged that these meteorological monitoring will provide the air quality modelling that is currently under development with sufficient details of the meteorological conditions experienced within the complex topographical area that exists in the lower valley area.



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Map 7 – Overview of continuous monitoring locations

Site Name	Site ID	Site Type	Commencement Date of Measurements	Pollutants Monitored	IN AQMA	Relevant Exposure	Distance to kerb of nearest road	Worst-case Location
Swansea Roadside AURN	**1**	Road side	**20th September 2006**	NO_2, PM_{10}, $PM_{2.5}$ CO, SO_2	Y	Y (12m)	4m	N
Morfa Groundhog	**2**	Road side	**24th July 2000**	NO_2, PM_{10}, SO_2	Y	Y (34m)	5m	Y
Morriston Groundhog	**3**	Road side	**11th October 2000**	NO_2, PM_{10}, CO, SO_2 and Ozone	N	Y (22m)	4m	N
Cwm Level Park	**4**	Urban Background	**(O_3) 28th November 2008 (NOx) 21st January 2009**	NO_2 and Ozone	Y	N (100m)	78m	N
Hafod DOAS	**5**	Road side	**8th January 2004**	NO_2 Ozone and Benzene	Y	Y (0.2m)	1.7m	Y
St Thomas DOAS	**6**	Road side	**4th May 2005**	NO_2 Ozone and Benzene	N	Y(2m) Varies along path	1.7m	N

Table 4 Automatic Continuous Measurements Commencement Dates

2.1.9 Additional Continuous Monitoring

2.1.10 Heavy Metals Monitoring

The Department of the Environment, Transport and the Regions (DETR) is funding a monitoring study to determine ambient concentrations of lead, cadmium, arsenic, mercury and nickel in the vicinity of a wide-variety of industrial processes.

The City and County of Swansea were requested to participate in this study from its inception during 1999/2000 due to the nickel refinery at INCO Europe being located within the authority's area at Clydach.

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On the 16th July 2003 the European Commission adopted a proposal for a Directive relating to arsenic, cadmium, nickel, mercury and ploycyclic hydrocarbons (PAH) in ambient air[7]. The target values of this Directive are not to be considered as environmental quality standards as defined in Article 2(7) of Directive 96/61/EC and which, according to Article 10 of that Directive, require stricter conditions than those achievable by the use of Best Available Technique (BAT). There are therefore, as yet, no binding obligations to reduce these pollutants. Ambient air concentrations of these substances only have to be monitored once emissions have passed a critical threshold.

Annexe 1 of the Directive details the target values for arsenic, cadmium, nickel and bezo(a)pyrene and these are reproduced below as table 5.

Pollutant	Target value ng/m^{-3}
Arsenic	6
Cadmium	5
Nickel	20
Benzo(a)pyrene	1

Table 5 - Target Values 4th Daughter Directive - Heavy Metals Monitoring

Glais Primary School, School Road, ❷ was chosen as the initial monitoring location due to its proximity to the refinery ❶ and for additional security issues with the equipment at the time. A Rupprecht & Patashnick Co., Inc. Partisol 2000 sampling unit, fitted with a PM_{10} sampling inlet with a flow rate of 16.7 l/min, had been installed on a flat roof at Glais School.

During July 2006, two additional monitoring locations were added: one at Coed-Gwilym Cemetery ❸ upwind of the high level stack release and one at the Morriston Groundhog ❺ some 4.1 kilometres downwind of the stack release point (see section 2.1.4 for site location of the Morriston Groundhog and section 2.1.8 for spatial location). Both additional units were Partisol 2025 units with automatic filter cartridge exchange and are fitted with PM_{10} sampling inlets with flow rates of 16.7 l/min. Four filters are housed in the main exchange drum and the unit automatically regulates weekly exposure of each filter.

[7] *COM 2003 (423)*

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During July 2007, the building that the Partisol 2000 unit was located on at Glais Primary School was demolished due to subsidence. The site was therefore decommissioned and did not become operational again until December 2007. Whilst the site was recommissioned during 2007 it ceased to form part of the UK Heavy metals monitoring Network from the 1st January 2008. However, this authority will continue to fund heavy metals monitoring at this site for the foreseeable future and have contracted NPL to undertake all analysis work.

A further site has been established to the north of the high level stack release point during November 2007 at YGG Gellionnen ❹ (Welsh Primary School). The site is located on top of a flat roof within the school complex and has an uninterrupted view down to the refinery complex. This authority will continue to fund heavy metals monitoring at this site for the foreseeable future and have contracted NPL to undertake all analysis work.

During December 2007, there were changes made to those sites that form part of the UK Heavy Metals Monitoring Network – these changes took effect on the 1st January 2008. Two monitoring locations now form part of the UK network within Swansea – these are the site upwind of the high level stack release at Coed-Gwilym Cemetery ❸ and the site located downwind of the release point at the Morriston Groundhog❺. Both the sample units deployed at these sites are Rupprecht & Patashnick Co., Inc. Partisol 2000 sampling units.

The authority as stated above will continue to fund heavy metals monitoring at the Glais primary School ❷ and at the YGG Gellionnen ❹ (Welsh Primary School) sites. Monitoring is undertaken using Partisol 2025 units with automatic filter cartridge exchange. NPL will continue to undertake all analysis from filters exposed at these sites to maintain comparability with the analysis undertaken from the two sites that form part of the UK heavy Metals Monitoring Network.

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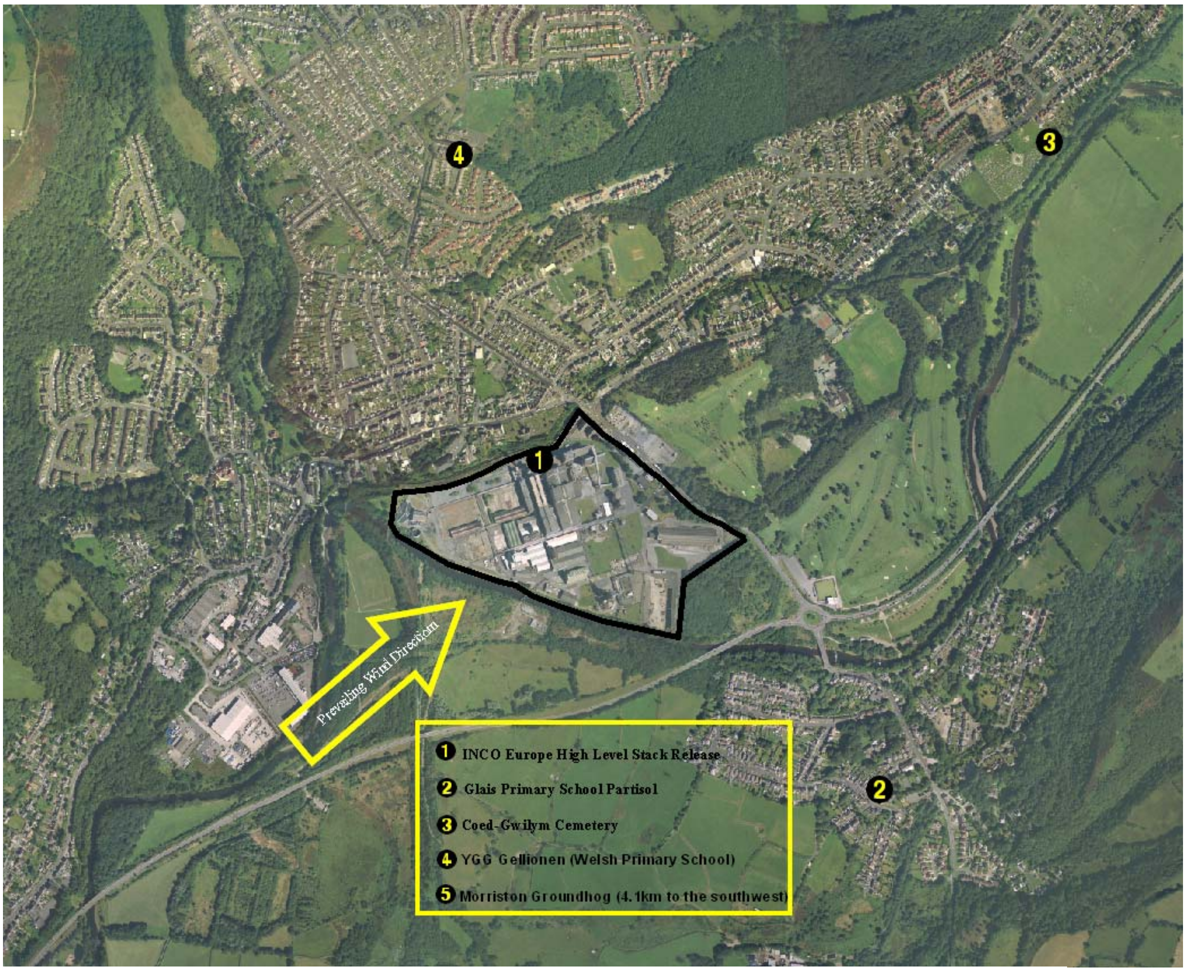
All monitoring locations (both UK Network sites and the two Swansea funded sites) have an Industrial classification [8]. Data is now being captured covering the four compass points around the high level stack release point.

The location of INCO Europe and the sampling locations can be seen within map 8.



Map 8 Heavy Metals Monitoring INCO Mond Europe, Glais

Filters are exposed on a weekly basis and sent to the National Physics Laboratory (NPL) for analysis. The analysed parameters are: Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Magnesium (Mn), Nickel (Ni), Lead (Pb), Platinum (Pt), Vanadium (V), Zinc (Zn) and Mercury(Hg). Analysis for particulate-phase metals took place at NPL using a PerkinElmer Elan DRC II ICP-MS, following

[8] *Source LAQM.TG(09) Appendix A page A1-20 Table A1.4*

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NPL's UKAS accredited procedure, which is fully complaint with the requirements of EN 14902:2005.

Upon arrival at NPL, the filters were cut accurately in half, and each portion digested at temperatures up to 220°C using a CEM Mars X microwave. The digestion mixtures used were:

- Hg & Pt: 5 ml of nitric acid and 5 ml hydrochloric acid.
- All other metals: 8 ml of nitric acid and 2 ml hydrogen peroxide.

ICP-MS analysis of the digested solutions took place using at least four gravimetrically-prepared calibration solutions. A QA standard was repeatedly analysed (after every two solutions), and the change in response of the QA standard was mathematically modeled to correct for the long-term drift of the instrument. The short-term drift of the ICP-MS was corrected for by use of an internal standards mixture (containing Y, In, Bi, Sc, Ga & Rh) continuously added to the all samples via a mixing block. Each sample is analysed in triplicate, each analysis consisting of five replicates.

The amount of each metal in solution (and its uncertainty) was then determined by a method of generalised least squares using XGenline (an NPL-developed program) to construct a calibration curve[9].

The uncertainty weighted mean for a series of N measurements, where the i^{th} measurement produces a value, x_i, with a measurement uncertainty, u_i, the uncertainty-weighted mean of the measurement, $\bar{x}_u$, would be given by:

$$\bar{x}_u = \frac{\sum_{i=1}^{i=N} \left(x_i / u_i^2 \right)}{\sum_{i=1}^{i=N} \left(1 / u_i^2 \right)}$$

[9] 2008 NPL Report-AS 34 (March 2009) Annual Report for 2008 on the UK Heavy Metals Monitoring Network

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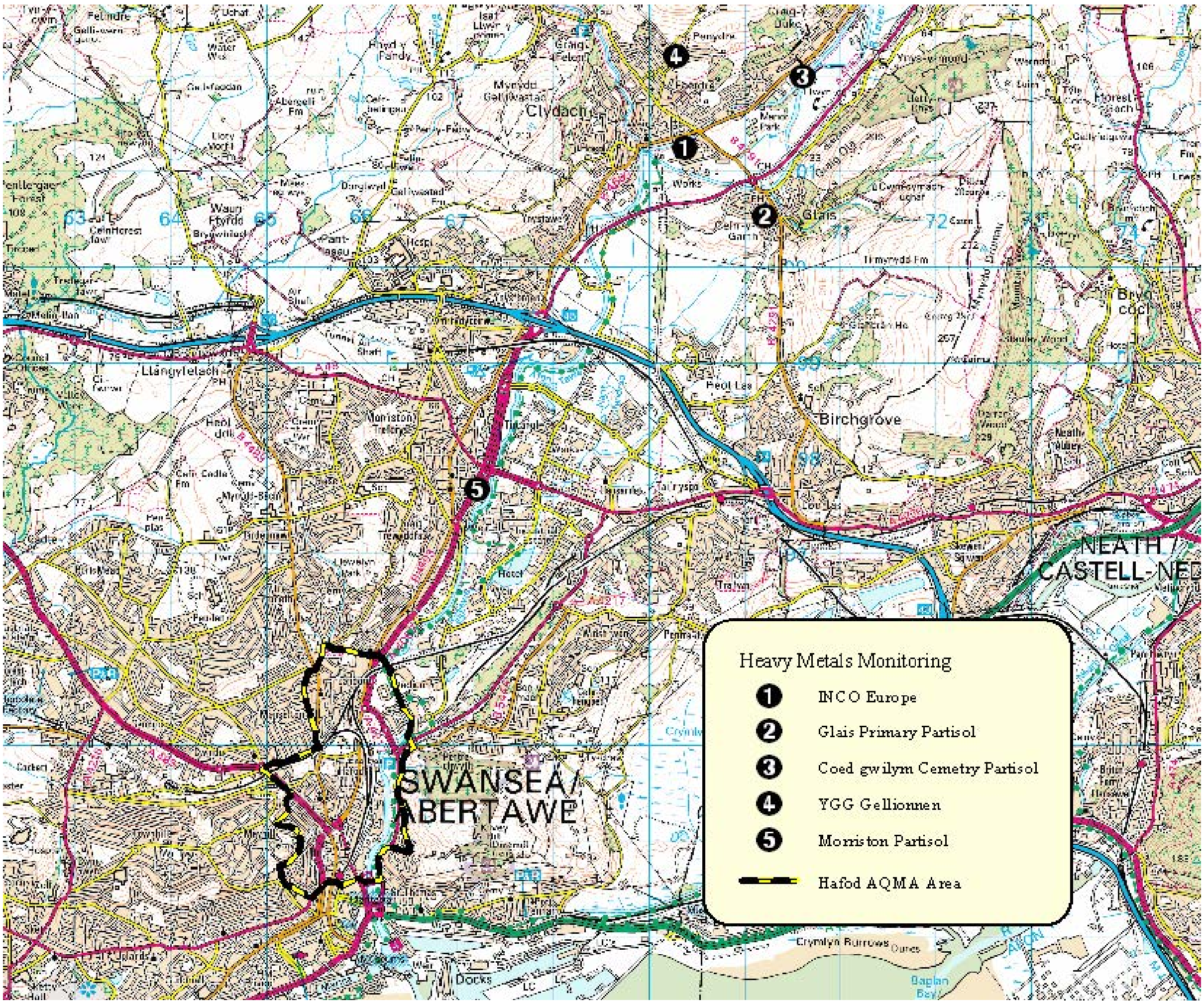
Again, in order for the reader to be aware spatially of the UK Heavy Metal Monitoring sites within Swansea, the monitoring locations are presented below within map 9, with the Hafod AQMA indicated for reference purposes.



Map 9 Swansea *UK Heavy Metal Monitoring Sites*

2.1.11 Continuous PAH Monitoring

The authority operate a continuous PAH monitoring site at the Cwm Level Park station (see 2.1.8 for location) on behalf of DEFRA and the Welsh Assembly Government using a Digitel DHA-80 Air sampling System with PM_{10} inlet. This network has been upgraded during 2007 to provide fully complaint data for assessment of PAH under the 4th Daughter Directive and the National Assembly for Wales Statutory Instrument 2007 W 63 Environmental Protection Wales and the Air Quality Standards (Wales) Regulations 2007. The site has been designated as urban background, [10] with the purpose of the site to assess the levels of PAH before / as a consequence of, the influence of industry to the east and North of the Swansea area.

2.1.12 Non-Automatic Monitoring

The authority has operated a network of passive nitrogen dioxide diffusion tubes for several years. Some sites have provided data to the UK Non-Automatic (NO_2) Network until this network ceased to operate on a weekly and monthly basis in December 2005. The remainder of the sites form part of specific studies within areas of concern. The datasets from these studies may therefore be for a limited time frame whilst conditions are assessed.

The authority has expanded coverage of monthly exposure of passive NO_2 tubes from 71 sites to 134 sites during July 2008. The 63 sites added during July 2008 are included whilst analytical results are only available for the recommended minimum of 9 months exposure to calculate the resultant annual mean.

Monitoring is focused primarily on roadside locations with particular emphasis in determining NO_2 levels around several busy junctions and busy roads. Wherever possible, passive diffusion tubes are located directly on receptor locations – typically front façade of dwellings, mainly on front down pipes etc. Where this has not been possible, the tubes have been located on the nearest lamppost etc to the dwelling. Full details of the sites chosen are presented below within table 6 and a map showing the monitoring locations is included within Annexe 2.

[10] *Source LAQM.TG(09) Appendix A page A1-20 Table A1.4*

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Site Name	OS Grid Ref Easting	OS Grid Ref Northing	Site classification	Pollutants Monitored	In AQMA?	Relevant Exposure? *(Y/N with distance (m) to relevant exposure)*	Distance to kerb of nearest road *(N/A if not applicable)*	Worst-case Location?
1	262046	196420	Roadside	NO_2		Y (0.1m)		
2	262095	196500	Roadside	NO_2		Y (0.1m)		
3	262161	196513	Roadside	NO_2		Y (0.1m)		
4	262497	192857	Roadside	NO_2		Y (0.1m)		
5	262548	192943	Roadside	NO_2		Y (0.1m)		
6	262612	192995	Roadside	NO_2		Y (0.1m)		
7	262691	192852	Roadside	NO_2		Y (0.1m)		
8	262990	195820	Roadside	NO_2		Y (0.1m)		
9	263190	195205	Roadside	NO_2		Y (0.1m)		
10	263219	195513	Roadside	NO_2		Y (0.1m)		
11	263344	195474	Roadside	NO_2		Y (0.1m)		
12	263680	195103	Roadside	NO_2		Y (0.1m)		
13	264830	193066	Roadside	NO_2		Y (0.1m)		
14	265285	192696	Roadside	NO_2		Y (0.1m)		
15	265334	192608	Roadside	NO_2		Y (0.1m)		
16	265339	192534	Roadside	NO_2		Y (0.1m)		
17	265496	192408	Roadside	NO_2		Y (0.1m)		
18	265526	195807	Roadside	NO_2	**Y**	Y (0.1m)		
19	265597	194061	Roadside	NO_2	**Y**	Y (0.1m)		
20	265594	194175	Roadside	NO_2	**Y**	Y (0.1m)		
21	265634	195316	Roadside	NO_2	**Y**	Y (0.1m)		
22	265682	195374	Roadside	NO_2	**Y**	Y (0.1m)		
23	265728	195494	Roadside	NO_2	**Y**	Y (0.1m)		
24	265760	192420	Roadside	NO_2		Y (0.1m)		
25	265845	195547	Roadside	NO_2	**Y**	Y (0.1m)		
26	265876	194318	Roadside	NO_2	**Y**	Y (0.1m)		
27	265922	194428	Roadside	NO_2	**Y**	Y (0.1m)		
28	265949	194891	Roadside	NO_2	**Y**	Y (0.1m)		
29	265973	195222	Roadside	NO_2	**Y**	Y (0.1m)		
30	266080	192516	Roadside	NO_2		Y (0.1m)		
31	266153	196003	Roadside	NO_2		Y (0.1m)		
32	266209	193867	Roadside	NO_2		Y (0.1m)		
33	266236	193488	Roadside	NO_2		Y (0.1m)		
34	266272	196168	Roadside	NO_2		Y (0.1m)		
35	266314	193298	Roadside	NO_2		Y (0.1m)		
36	266455	193300	Roadside	NO_2		Y (0.1m)		
37	266515	193213	Roadside	NO_2		Y (0.1m)		
38	266662	193181	Roadside	NO_2		Y (0.1m)		
39	266905	193271	Roadside	NO_2		Y (0.1m)		
40	266951	198278	Roadside	NO_2		Y (0.1m)		
41	266953	198085	Roadside	NO_2		Y (0.1m)		
42	267084	198274	Roadside	NO_2		Y (0.1m)		
43	267093	198063	Roadside	NO_2		Y (0.1m)		
44	267639	199543	Roadside	NO_2		Y (0.1m)		
45	267661	199451	Roadside	NO_2		Y (0.1m)		
46	267752	193218	Roadside	NO_2		Y (0.1m)		
47	267908	199773	Roadside	NO_2		Y (0.1m)		
48	268011	193101	Roadside	NO_2		Y (0.1m)		
49	268501	197329	Roadside	NO_2		Y (0.1m)		
50	268530	197419	Roadside	NO_2		Y (0.1m)		
51	268593	197434	Roadside	NO_2		Y (0.1m)		
52	268643	197245	Roadside	NO_2		Y (0.1m)		
53	268652	197508	Roadside	NO_2		Y (0.1m)		
54	268693	197416	Roadside	NO_2		Y (0.1m)		

Site Name	OS Grid Ref Easting	OS Grid Ref Northing	Site classification	Pollutants Monitored	In AQMA?	Relevant Exposure? (Y/N with distance (m) to relevant exposure)	Distance to kerb of nearest road (N/A if not applicable)	Worst-case Location?
55	268789	197420	Roadside	NO_2		Y (0.1m)		
56 *	269306	198661	Roadside	NO_2		Y (166m)		
57	269395	199042	Roadside	NO_2		Y (0.1m)		
58	264052	192884	Roadside	NO_2		Y (8m)		
59	265900	194500	Roadside	NO_2	**Y**	Y (0.1m)		
60	265036	192931	Roadside	NO_2		Y (0.1m)		
61	264959	192878	Roadside	NO_2		Y (0.1m)		
62	266698	195335	Roadside	NO_2		Y (10m)		
63	262675	192775	Roadside	NO_2		Y (6.0m)		
64	262719	192840	Roadside	NO_2		Y (3.0m)		
65	262735	192855	Roadside	NO_2		Y (0.1m)		
66	262802	192829	Roadside	NO_2		Y (0.1m)		
67	265903	193683	Roadside	NO_2	**Y**	Y (5.0m)		
68	265573	193432	Roadside	NO_2		Y (0.1m)		
69	265543	193450	Roadside	NO_2		Y (4m)		
70	266649	195435	Roadside	NO_2		Y (7m)		
71 **	266514	195485	Roadside	NO_2		Y (138m)		
72	264091	192900	Roadside	NO_2		Y (0.1m)		
73	264138	192868	Roadside	NO_2		Y (0.1m)		
74	264163	192853	Roadside	NO_2		Y (0.1m)		
75	264072	192869	Roadside	NO_2		Y (0.1m)		
76	263968	192880	Roadside	NO_2		Y (0.1m)		
77	263856	192931	Roadside	NO_2		Y (0.1m)		
78	263819	192948	Roadside	NO_2		Y (0.1m)		
79	263842	192896	Roadside	NO_2		Y (0.1m)		
80	263558	192833	Roadside	NO_2		Y (0.1m)		
81	262940	192775	Roadside	NO_2		Y (0.1m)		
82	262851	192805	Roadside	NO_2		Y (0.1m)		
83	262785	192838	Roadside	NO_2		Y (0.1m)		
84	262714	192839	Roadside	NO_2		Y (0.1m)		
85	262702	192847	Roadside	NO_2		Y (0.1m)		
86	262704	192865	Roadside	NO_2		Y (0.1m)		
87	262697	192798	Roadside	NO_2		Y (0.1m)		
88	262605	192916	Roadside	NO_2		Y (0.1m)		
89	262587	192956	Roadside	NO_2		Y (0.1m)		
90	262631	192996	Roadside	NO_2		Y (0.1m)		
91	262534	192950	Roadside	NO_2		Y (0.1m)		
92	262545	192869	Roadside	NO_2		Y (0.1m)		
93	263406	195534	Roadside	NO_2		Y (0.1m)		
94	263444	195572	Roadside	NO_2		Y (0.1m)		
95	262815	196090	Roadside	NO_2		Y (0.1m)		
96	262922	195950	Roadside	NO_2		Y (0.1m)		
97	262946	195902	Roadside	NO_2		Y (0.1m)		
98	263142	195548	Roadside	NO_2		Y (0.1m)		
99	263387	195332	Roadside	NO_2		Y (0.1m)		
100	263470	195250	Roadside	NO_2		Y (0.1m)		
101	263843	195047	Roadside	NO_2		Y (0.1m)		
102	266379	193307	Roadside	NO_2		Y (0.1m)		
103	268526	197359	Roadside	NO_2		Y (0.1m)		
104	268538	197389	Roadside	NO_2		Y (0.1m)		
105	268562	197472	Roadside	NO_2		Y (0.1m)		

Site Name	OS Grid Ref Easting	OS Grid Ref Northing	Site classification	Pollutants Monitored	In AQMA?	Relevant Exposure? *(Y/N with distance (m) to relevant exposure)*	Distance to kerb of nearest road *(N/A if not applicable)*	Worst-case Location?
106	268496	197476	Roadside	NO_2		Y (0.1m)		
107	268765	197420	Roadside	NO_2		Y (0.1m)		
108	267608	199461	Roadside	NO_2		Y (0.1m)		
109	267510	199487	Roadside	NO_2		Y (0.1m)		
110	267369	199521	Roadside	NO_2		Y (0.1m)		
111	267705	199426	Roadside	NO_2		Y (0.1M)		
112	264868	192814	Roadside	NO_2		Y (6.0M)		
113	264654	192662	Roadside	NO_2		Y (0.1m)		
114	264622	192971	Roadside	NO_2		Y (0.1m)		
115	265031	193097	Roadside	NO_2		Y (0.1m)		
116	265192	193138	Roadside	NO_2		Y (0.1m)		
117	265288	193211	Roadside	NO_2		Y (0.1m)		
118⊗	265483	193385	Roadside	NO_2		Y (17M)		
119	265522	193390	Roadside	NO_2		Y (0.1M)		
120	265570	193366	Roadside	NO_2		N (6.0M)		
121	265706	193662	Roadside	NO_2	**Y**	Y (0.1M)		
122	265694	193505	Roadside	NO_2		Y (0.5M)		
123	265655	193423	Roadside	NO_2		Y (0.1M)		
124⊗	265651	193253	Roadside	NO_2		Y (2M)		
125 ***	265641	193162	Roadside	NO_2		Y (19m)		
126⊗	265475	193144	Roadside	NO_2		Y (10m)		
127⊗	265348	193110	Roadside	NO_2		Y(10m)		
128	265297	193085	Roadside	NO_2		N (>50m)		
129⊗	265153	193098	Roadside	NO_2		Y (5m)		
130⊗	265139	192912	Roadside	NO_2		Y (27m)		
131⊗	265137	192846	Roadside	NO_2		Y(30m)		
132⊗	265229	192753	Roadside	NO_2		Y (5M)		
133	265350	192566	Roadside	NO_2		Y (0.1m)		
134⊗	265113	192903	Roadside	NO_2		Y(0.1m)		

Table 6 Monitoring Location details

*** Site 56** is located on Ynysallan Road, Ynystawe to the frontage of a potential housing development site that would be 10-15m from the eastbound carriageways of the M4. Relevant exposure is given at present to the nearest existing dwelling within a separate development setback from the monitoring location.

**** Site 71** Copper Quarter 3 is on the frontage of an existing housing development site (construction ceased at present due to economic downturn) that will see dwellings fronting onto the access road to Morfa Retail Park and the Liberty Stadium. Relevant exposure is given at present to the nearest existing dwelling on the development site. The nearest potential dwelling within the development (setback from the monitoring location) will be within 10m of the monitoring location when construction is complete

***** Site 125** Army Careers Centre, City Centre – Relevant exposure is given to a block of flats over commercial premises on the opposite side of the road

⊗ City centre sites along busy roads – relevant exposure is given to either restaurants where there is a Café environment or to blocks of flats. Assessment where Café environment exists is for 1 hour NO_2 objective

City & County of Swansea

The contract for the supply and analysis of all passive diffusion tubes has been awarded to Harwell Scientifics of 551 South Becquerel Avenue, Harwell International Business Centre, Didcott, Oxon.

This contract laboratory has been operating for over 19 years and has extensive UKAS accreditation. In addition, all work is accredited to BS EN ISO 9001. Its predecessor the EMS Division, Harwell, carried out Swansea's original NO_2 mapping in 1985/86.

All samples have been analysed in accordance with the Harwell Scientifics standard operating procedure HS/GWI/1015 issue14. All tubes are prepared by spiking acetone:triethanolamine (50:50) onto grids prior to the tubes being assembled. The tubes were desorbed with distilled water and the extract analysed using a segmented flow autoanalyser with ultraviolet detection. The analytical methods employed by Harwell Scientifics follow the procedures set out in the Harmonisation Practical Guidance.

Harwell Scientifics take part in the Workplace Analysis Scheme for Proficiency (WASP) operated by HSL. The WASP scheme is an independent proficiency testing scheme operated by the Health and Safety Laboratory (HSL). Each month a diffusion tube doped with nitrite is distributed to each participating laboratory; participants then analyse the tube and report the results to HSL. The nominal mass of nitrite on the doped tubes is different each month, and is intended to reflect the range encountered in actual monitoring. The latest results from Harwell Scientifics participation in the WASP scheme are enclosed as Annexe 3. For the purpose of diffusion tube QA/QC in the context of Local Air Quality Management, NETCEN carry out an assessment of laboratory performance for each full calendar year. This was based on the following criteria, which were agreed with DEFRA and HSL:

1. Participating laboratories must complete at least 10 of the 12 monthly WASP rounds.
2. The year's single worst result is ignored: this makes some limited allowance for one-off problems with analytical equipment etc.

3. Each laboratory's monthly standardised results are then combined to give a standard uncertainty for the full year, expressed as a relative standard deviation (%RSD)
4. The RSD must be within 15%.

2.1.13 Determination of a “Swansea” bias factor

There has been great debate surrounding the use of a locally derived bias factor when correcting diffusion tubes for bias. Indeed, previous auditor’s comments have indicated that such a local derived correction factor should be obtained for Swansea. The auditor’s comments have been taken on board and as such tri located diffusion tubes were located on the sample intake at each of the authority’s chemiluminescent analyser sites at the Swansea Roadside AURN, Morfa and Morriston Groundhog sites between 4th January 2008 and 7th January 2009. These co-location studies will be extended during 2009 to include the urban background site at Cwm Level Park and will operate for the foreseeable future. This co-location work would appear to be required to be repeated yearly given the advice within section 6.3.1 of the report prepared by AEA Energy and Environment on behalf of DEFRA and the Devolved Administrations: NO_2 Diffusion Tubes for LAQM: Guidance note for Local Authorities[11]. Whilst the 2008 bias correction factor(s) that have been derived for Swansea would appear to be valid only for the correction of diffusion tubes exposed during 2008, there is little alternative available at present but to use the 2007 bias correction factor for those diffusion tubes exposed during 2006.

The results of the tri-location studies are provided below. The NO_x chemiluminescent analyser data from the Morfa and Morriston Groundhog stations has been rescaled and ratified by the QA/QC procedures undertaken by the authority and cross checked with the ratified datasets produced by AEA Energy and Environment as part of their contract with the Welsh Assembly Government to run the Welsh Air Quality Forum. Ratified data has also been obtained for the Swansea Roadside AURN via the UK Air Quality Archive at
http://www.airquality.co.uk/archive/flat_files.php?site_id=SWA1&zone_id=9

[11] http://www.airquality.co.uk/archive/reports/cat13/0604061218_Diffusion_Tube_GN_approved.pdf

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AEA Energy and Environment undertake the QA/QC work on behalf of DEFRA at this site.

- ## Swansea Roadside AURN tri-location

Tri located tubes were exposed on the sample intake, synchronised for exposure for the monthly period to match the exposure on/off timings as suggested by the Welsh Air Quality Forum exposure calendar (mirrors the old UK monitoring network). All results were entered into the spreadsheet provided by AEA Energy and Environment[12] to determine tube bias as well as checking the accuracy and precision of the diffusion tube measurements. The results can be seen below.

Checking Precision and Accuracy of Triplicate Tubes

AEA Energy & Environment
From the AEA group

Diffusion Tubes Measurements									Automatic Method		Data Quality Check	
Period	Start Date dd/mm/yyyy	End Date dd/mm/yyyy	Tube 1 μgm^{-3}	Tube 2 μgm^{-3}	Tube 3 μgm^{-3}	Triplicate Mean	Standard Deviation	Coefficient of Variation (CV)	95% CI of mean	Period Mean	Data Capture (% DC)	Tubes Precision Check	Automatic Monitor Data
1	04/01/2008	30/01/2008	35.00	40.00	40.60	39	3.1	8	7.6	28.89	98	Good	Good
2	30/01/2008	26/02/2008	60.00	59.80	59.20	60	0.4	1	1.0	46.42	98	Good	Good
3	26/02/2008	02/04/2008	34.70	33.60	36.10	35	1.3	4	3.1	26.85	99	Good	Good
4	02/04/2008	07/05/2008	40.70	40.70	38.20	40	1.4	4	3.6	29.85	100	Good	Good
5	07/05/2008	28/05/2008	54.90	53.00	54.50	54	1.0	2	2.5	40	84	Good	Good
6	28/05/2008	08/07/2008	28.60	29.60	25.00	28	2.4	9	6.0	24	100	Good	Good
7	08/07/2008	30/07/2008	21.90	30.30	30.20	27	4.8	18	12.0	23	89	Good	Good
8	30/07/2008	03/09/2008	29.70		29.10	29	0.4	1	3.8	21	99	Good	Good
9	03/09/2008	01/10/2008	44.10	40.00	43.90	43	2.3	5	5.7	37	100	Good	Good
10	01/10/2008	29/10/2008	41.80	41.70	40.60	41	0.7	2	1.7	29	100	Good	Good
11	29/10/2008	03/12/2008	37.10	41.00	45.90	41	4.4	11	11.0	32.6	100	Good	Good
12	03/12/2008	07/01/2009	41.70	57.80	55.70	52	8.8	17	21.7	49.3	100	Good	Good
13													
											Overall survey -->	Good precision	Good Overall DC

It is necessary to have results for at least two tubes in order to calculate the precision of the measurements

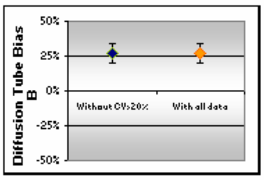
(Check average CV & DC from Accuracy calculations)

Site Name/ ID: Swansea AURN Roadside

Precision 12 out of 12 periods have a CV smaller than 20%

Accuracy (with 95% confidence interval)	
without periods with CV larger than 20%	
Bias calculated using 12 periods of data	
Bias factor A	0.8 (0.75 - 0.84)
Bias B	26% (19% - 33%)
Diffusion Tubes Mean:	41 μgm^{-3}
Mean CV (Precision):	7
Automatic Mean:	32 μgm^{-3}
Data Capture for periods used:	97%
Adjusted Tubes Mean:	33 (31 - 34) μgm^{-3}

Accuracy (with 95% confidence interval)	
WITH ALL DATA	
Bias calculated using 12 periods of data	
Bias factor A	0.8 (0.75 - 0.84)
Bias B	26% (19% - 33%)
Diffusion Tubes Mean:	41 μgm^{-3}
Mean CV (Precision):	7
Automatic Mean:	32 μgm^{-3}
Data Capture for periods used:	97%
Adjusted Tubes Mean:	33 (31 - 34) μgm^{-3}



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Bias correction factor 1 – Swansea Roadside AURN

The derived bias correction factor of 0.8 (0.75-0.84) has been determined with good tube precision as all diffusion tube data periods have a coefficient of variation below 20%. Accuracy (with 95% confidence interval) indicates a bias B factor of 26% (19% - 33%)

[12] http://www.airquality.co.uk/archive/laqm/tools/AEA_DifTPAB_v03.xls

- **Morfa Groundhog tri-location**

Tri located tubes were exposed on the sample intake, synchronised for exposure for the monthly period to match the exposure on/off timings as suggested by the Welsh Air Quality Forum exposure calendar (mirrors the old UK monitoring network). All results were entered into the spreadsheet provided by AEA Energy and Environment[13] to determine tube bias as well as checking the accuracy and precision of the diffusion tube measurements. The results can be seen below

Checking Precision and Accuracy of Triplicate Tubes

AEA Energy & Environment
From the AEA group

Diffusion Tubes Measurements										Automatic Method		Data Quality Check	
Period	Start Date dd/mm/yyyy	End Date dd/mm/yyyy	Tube 1 μgm^{-3}	Tube 2 μgm^{-3}	Tube 3 μgm^{-3}	Triplicate Mean	Standard Deviation	Coefficient of Variation (CV)	95% CI of mean	Period Mean	Data Capture (% DC)	Tubes Precision Check	Automatic Monitor Data
1	04/01/2009	30/01/2008	60.10	63.80	61.90	62	1.9	3	4.6	41.73	99	Good	Good
2	30/01/2008	26/02/2008	64.10	52.60	64.80	61	6.9	11	17.0	54.2	96	Good	Good
3	26/02/2008	02/04/2008	43.20	38.60	43.30	42	2.7	6	6.7	35.79	99	Good	Good
4	02/04/2008	07/05/2008	45.40	40.50	43.40	43	2.5	6	6.1	34.31	100	Good	Good
5	07/05/2008	28/05/2008	47.00	47.30	48.90	48	1.0	2	2.5	28	96	Good	Good
6	28/05/2008	08/07/2008	34.50	34.10		34	0.3	1	2.5	21	100	Good	Good
7	08/07/2008	30/07/2008	33.90	35.30	36.20	35	1.2	3	2.9	23	100	Good	Good
8	30/07/2008	03/09/2008	39.20	41.50	41.30	41	1.3	3	3.2	27	99	Good	Good
9	03/09/2008	01/10/2008	38.20	38.40	43.70	40	3.1	8	7.7	37	97	Good	Good
10	01/10/2008	29/10/2008	44.60	43.80	44.50	44	0.4	1	1.1	39	100	Good	Good
11	29/10/2008	03/12/2008	43.30	40.60	30.80	38	6.6	17	16.3	45.19	100	Good	Good
12	03/12/2008	07/01/2009	63.30	60.30	63.60	62	1.8	3	4.5	57.15	100	Good	Good
13													
											Overall survey -->	Good precision	Good Overall DC

It is necessary to have results for at least two tubes in order to calculate the precision of the measurements

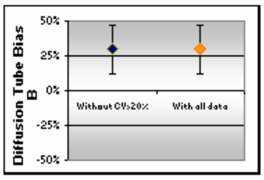
(Check average CV & DC from Accuracy calculations)

Site Name/ ID:	Morfa Groundhog

Precision	12 out of 12 periods have a CV smaller than 20%

Accuracy (with 95% confidence interval)
without periods with CV larger than 20%
Bias calculated using 12 periods of data
Bias factor A 0.81 (0.71 - 0.94)
Bias B 24% (7% - 41%)
Diffusion Tubes Mean: 46 μgm^{-3}
Mean CV (Precision): 5
Automatic Mean: 37 μgm^{-3}
Data Capture for periods used: 99%
Adjusted Tubes Mean: 37 (33 - 43) μgm^{-3}

Accuracy (with 95% confidence interval)
WITH ALL DATA
Bias calculated using 12 periods of data
Bias factor A 0.81 (0.71 - 0.94)
Bias B 24% (7% - 41%)
Diffusion Tubes Mean: 46 μgm^{-3}
Mean CV (Precision): 5
Automatic Mean: 37 μgm^{-3}
Data Capture for periods used: 99%
Adjusted Tubes Mean: 37 (33 - 43) μgm^{-3}



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Bias correction factor 2 –Morfa Groundhog

The derived bias correction factor of 0.81 (0.71-0.94) has been determined with good tube precision as all diffusion tube data periods have a coefficient of variation below 20%. Accuracy (with 95% confidence interval) indicates a bias B factor of 24% (7% - 41%)

[13] http://www.airquality.co.uk/archive/laqm/tools/AEA_DifTPAB_v03.xls

- ## Morriston Groundhog tri-location

Tri located tubes were exposed on the sample intake, synchronised for exposure for the monthly period to match the exposure on/off timings as suggested by the Welsh Air Quality Forum exposure calendar (mirrors the old UK monitoring network). All results were entered into the spreadsheet provided by AEA Energy and Environment[14] to determine tube bias as well as checking the accuracy and precision of the diffusion tube measurements. The results can be seen below:

Checking Precision and Accuracy of Triplicate Tubes

AEA Energy & Environment
From the AEA group

Diffusion Tubes Measurements										Automatic Method		Data Quality Check	
Period	Start Date dd/mm/yyyy	End Date dd/mm/yyyy	Tube 1 μgm^{-3}	Tube 2 μgm^{-3}	Tube 3 μgm^{-3}	Triplicate Mean	Standard Deviation	Coefficient of Variation (CV)	95% CI of mean	Period Mean	Data Capture (% DC)	Tubes Precision Check	Automatic Monitor Data
1	04/01/2008	30/01/2008	48.40	48.50	43.90	47	2.6	6	6.5	32.2	95	Good	Good
2	30/01/2008	26/02/2008	54.60	56.00	58.30	56	1.9	3	4.6	43.17	100	Good	Good
3	26/02/2008	02/04/2008	44.80	44.70	46.90	45	1.2	3	3.1	29.27	79	Good	Good
4	02/04/2008	07/05/2008	33.10	37.00	39.40	37	3.2	9	7.9	28.4	99	Good	Good
5	07/05/2008	28/05/2008	24.00	35.10		30	7.8	27	70.5	24	96	Poor Precisior	Good
6	28/05/2008	08/07/2008		28.90	31.50	30	1.8	6	16.5	19	100	Good	Good
7	08/07/2008	30/07/2008		28.90	29.20	29	0.2	1	1.9	18	91	Good	Good
8	30/07/2008	03/09/2008	26.10	29.30	28.60	28	1.7	6	4.2	17	96	Good	Good
9	03/09/2008	01/10/2008	42.50	44.00	42.90	43	0.8	2	1.9	21	18	Good	or Data Capture
10	01/10/2008	29/10/2008	47.00	44.40	45.50	46	1.3	3	3.2	30	80	Good	Good
11	29/10/2008	03/12/2008	49.10	54.80	40.80	48	7.0	15	17.5	36.3	100	Good	Good
12	03/12/2008	07/01/2009	50.00	54.20	55.40	53	2.8	5	7.0	45.4	100	Good	Good
13													
											Overall survey -->	Good precision	Poor Overall DC

It is necessary to have results for at least two tubes in order to calculate the precision of the measurements

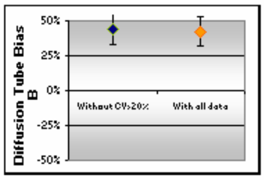
(Check average CV & DC from Accuracy calculations)

Site Name/ ID: Morriston Groundhog

Precision 11 out of 12 periods have a CV smaller than 20%

Accuracy	(with 95% confidence interval)
without periods with CV larger than 20%	
Bias calculated using 10 periods of data	
Bias factor A	0.71 (0.66 - 0.77)
Bias B	40% (29% - 51%)
Diffusion Tubes Mean:	42 μgm^{-3}
Mean CV (Precision):	6
Automatic Mean:	30 μgm^{-3}
Data Capture for periods used:	94%
Adjusted Tubes Mean:	30 (28 - 32) μgm^{-3}

Accuracy	(with 95% confidence interval)
WITH ALL DATA	
Bias calculated using 11 periods of data	
Bias factor A	0.72 (0.67 - 0.78)
Bias B	39% (29% - 49%)
Diffusion Tubes Mean:	41 μgm^{-3}
Mean CV (Precision):	8
Automatic Mean:	29 μgm^{-3}
Data Capture for periods used:	94%
Adjusted Tubes Mean:	29 (27 - 32) μgm^{-3}



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Bias correction factor 2 –Morfa Groundhog

A bias correction factor of 0.71 (0.66-0.77) has been determined with 10 periods of data without periods of coefficient of variation greater than 20%, and a bias correction of 0.72 using all data. There have been significant problems experienced at the Morriston Groundhog site during 2008 both with the diffusion tubes themselves and also the chemiluminescent NOx analyser. To compound matters further, the station suffered from power failures and repeated air conditioning failures – the station was shut down between 7th September 2008 and 7th October whilst a

[14] http://www.airquality.co.uk/archive/laqm/tools/AEA_DifTPAB_v03.xls

new air conditioning system was installed and the site fully re-serviced and re-calibrated. These problems resulted in both poor data and poor data capture rates. As a consequence of the operational difficulties with the Morriston site during 2008 it has been decided not to include the derived bias factor of 0.71 within the overall "Swansea bias" for 2008.

The bias correction to be used for Swansea during 2008 is therefore 0.81 being the worse of the Morfa tri-location (0.81) and the Swansea AURN tri-location (0.80)

The derived Swansea bias for 2008 compares very favourably to the overall mean of 0.80 from the national database results[15] using Harwell Scientifics from 7 studies during 2008. The range of the 7 studies during 2008 was between 0.74 and 0.89. The overall national bias mean using Harwell Scientifics during 2007 was 0.82 to further demonstrate the consistency with this laboratory. Mean bias results for Harwell Scientifics between 2000 to 2008 ranged from 0.78 (2001) to 0.88 (2004 and 2005) with the mean of all results between 2000-2008 being 0.83

[15] http://www.uwe.ac.uk/aqm/review/R&Asupport/diffusiontube310309.xls

2.2 Comparison of Monitoring Results with AQ Objectives

This section has been divided by pollutant and also whether the automatic monitoring location is either within, or outside of an existing AQMA as recommended in Box 5.2 of Chapter 5 of TG(09).

2.2.1 Nitrogen Dioxide

Measurements are undertaken with Advanced Pollution Instrumentation (API) real-time NO_x analysers and also by the DOAS systems at Hafod and St Thomas. The logged 15-minute means have been compiled into hourly averages by the software package OPSIS Enviman Reporter. In order to compile a valid hourly mean, a minimum of 3, 15-minute means were specified[16]. Data capture of less than 75% for the hour therefore excludes that hour from any analysis. The derived hourly means have then been used to calculate the annual mean.

Following rescaling works using the factors derived from the routine calibration of the analyser, NO_2 is determined by NO_x - NO = NO_2. All existing stored NO_2 data is overwritten (within the working ASCII file only) with the rescaled derived NO_2 data.

All results are presented in $\mu g/m^3$ by multiplying the logged result in ppb by the conversion factor of 1.91[17] to produce results expressed in $\mu g/m^3$.

In the case of the Swansea AURN, the QA/QC procedures undertaken by NETCEN have resulted in ratified hourly data expressed in $\mu g/m^3$ being provided. The ratified hourly means have been used to calculate the objectives for the hourly and annual means. Hourly ratified data has been downloaded from the Air Quality Archive at http://www.airquality.co.uk/archive/flat_files.php?site_id=SWA1&zone_id=9. These data have then been imported into the OPSIS Enviman Reporter databases allowing analysis and graphical presentation.

[16] LAQM.TG(09) Appendix A1 - Reporting of Monitoring data – Calculation of Exceedence Statistics A1.216 page A1-47
[17] *LAQM.TG(09) Appendix A1 - Data Processing- Box A1.5 page A1-36*

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Sections 2.1.6 and section 2.1.7 refer to the data collection methodology for the Hafod and St.Thomas DOAS systems.

Site ID (see table 4 above)	Location	Within AQMA	Data Capture 2008 %	Annual mean (ug/m^3)		
				2006	2007	2008
1	Swansea AURN ** (12m)	Y	98.6	*	**26.7** (31.0)	**25.6** (31.8)
2	Morfa Groundhog ** (34m)	Y	97.5	**25.8** (38.1)	**24.3** (36.1)	**23.2** (36.5)
3	Morriston Groundhog ** (22m)	N	86.4	**25.6** (31.8)	**27.6** (36.1)	**23.6** (29.0)
5	Hafod DOAS	Y	46.6	**40.27**	**52.19**	**58.64**
6	St.Thomas DOAS	N	99.5	**44.6**	37	34.94

Table 7 Results of Automatic Monitoring for Nitrogen Dioxide: Comparison with Annual Mean Objective
**Site relocated to present location during September 2006*

** The distance to the nearest receptor location is given in brackets after the site name in the above table. The NO_2 annual mean at the nearest receptor location has been derived following guidance within TG.09 box 5.2(2) page 5-5 and also box 2.3 page 2-6. The resulting calculated NO_2 annual mean at the receptor location due to fall off in concentration with distance from the road is given in bold for the year of consideration. The measured roadside concentration is given in brackets.
Background 1k by 1k NO_2 concentrations were downloaded from http://www.airquality.co.uk/archive/laqm/tools.php?tool=background06 and overlain on a GIS background map within ArcView3.3. The background concentration required for the calculation was obtained from the nearest 1k grid square to the monitoring station. The background concentrations shown in table 8 below were used:

Site ID (see table 4 above)	Location	Background NO_2 Concentrations (ug/m^3)		
		2006	2007	2008
1	Swansea AURN)	*18.2	16.9	16.9
2	Morfa Groundhog)	17.5	16.4	16.3
3	Morriston Groundhog	18.8	18.2	17.6

Table 8 background NO_2 concentrations
* Site relocated to present location during September 2006

From table 7 it can be seen that the Hafod DOAS is experiencing an increase in annual mean NO_2 concentrations whilst other sites mainly see a decline in concentrations. However, data capture for 2008 at the Hafod DOAS dictates that the derived annual mean be treated with caution.

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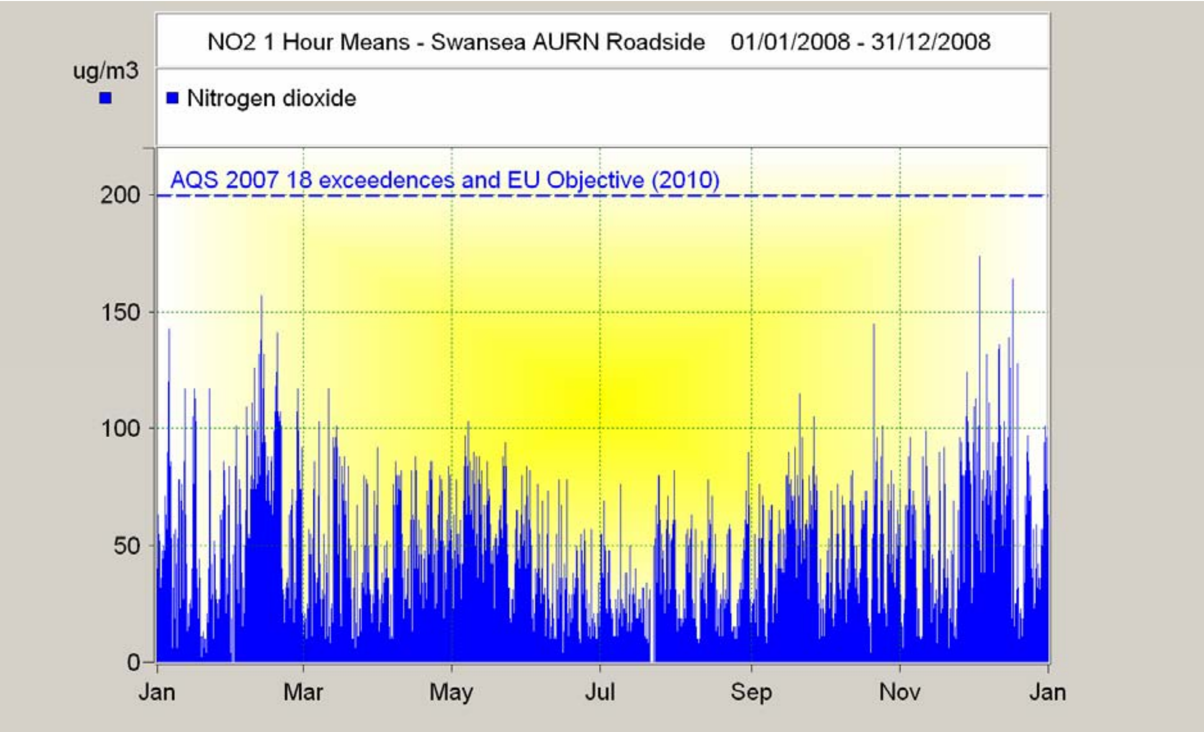
Site ID (see table 4 above)	Location	Within AQMA	Data Capture 2008 %	Number of Exceedences of hourly mean (200 µg/m^3)		
				2006	**2007**	**2008**
1	Swansea AURN	**Y**	98.6	*	0	0
2	Morfa Groundhog	**Y**	97.5	0	2	1
3	Morriston Groundhog	**N**	86.4	0	1	1** **(123.95)**
5	Hafod DOAS	**Y**	46.6	****(140.48)**	7	7****(199.54)**
6	St.Thomas DOAS	**N**	99.5	0	0	0

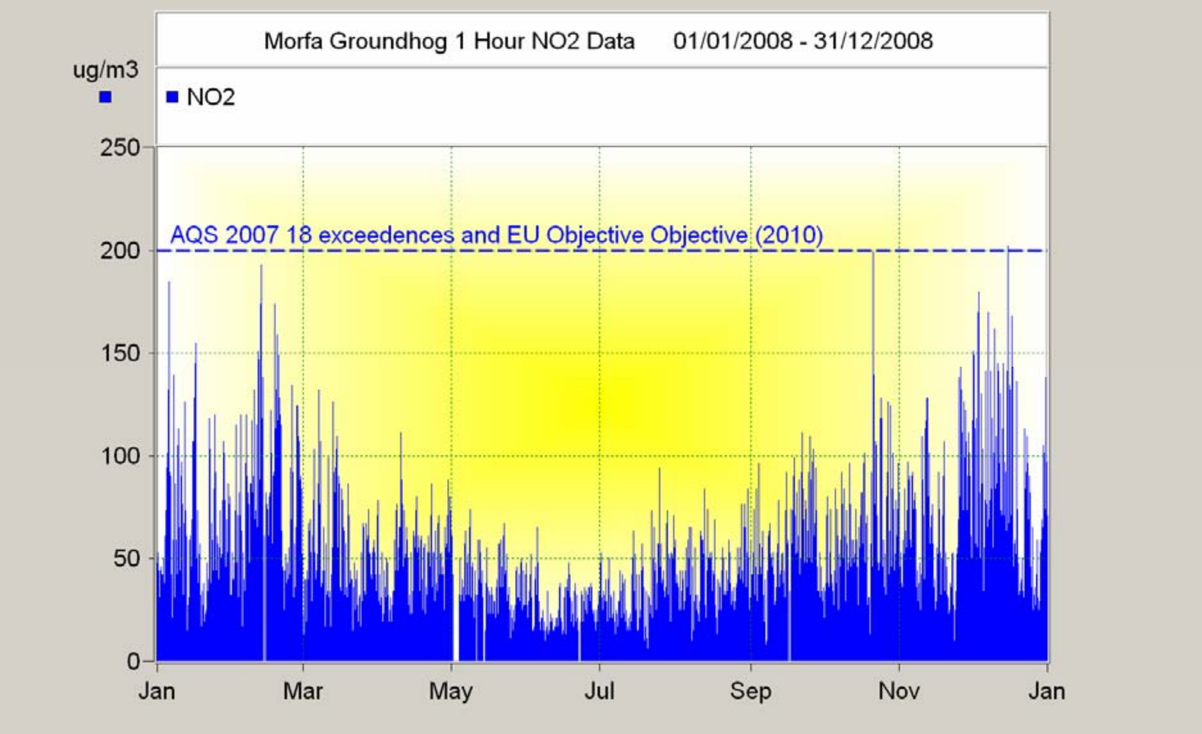
Table 9 Results of Automatic Monitoring for Nitrogen Dioxide: Comparison with 1-hour Mean Objective
*Site relocated to present location during September 2006
** Data capture rate below 90% 99.8th percentile presented in brackets

Whilst the data capture for the Hafod DOAS was only 46.6% due to building works along the open path measurement, the annual mean and 99.8th percentile are indicating elevated levels of NO_2. From the percentile calculation it is clear that the Hafod DOAS also has the potential to exceed the hourly objective.

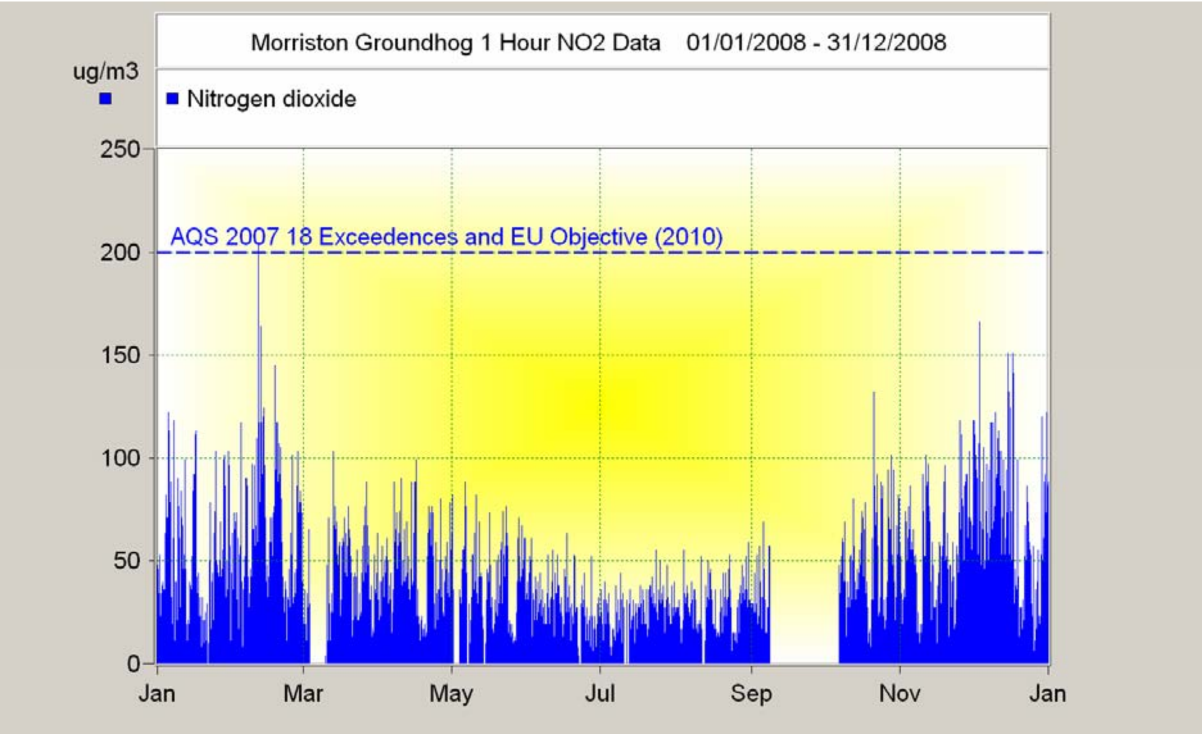
Graphs 1-5 below show the NO_2 1 hour means for 2008 from the 5 automatic and continuous sites within Swansea



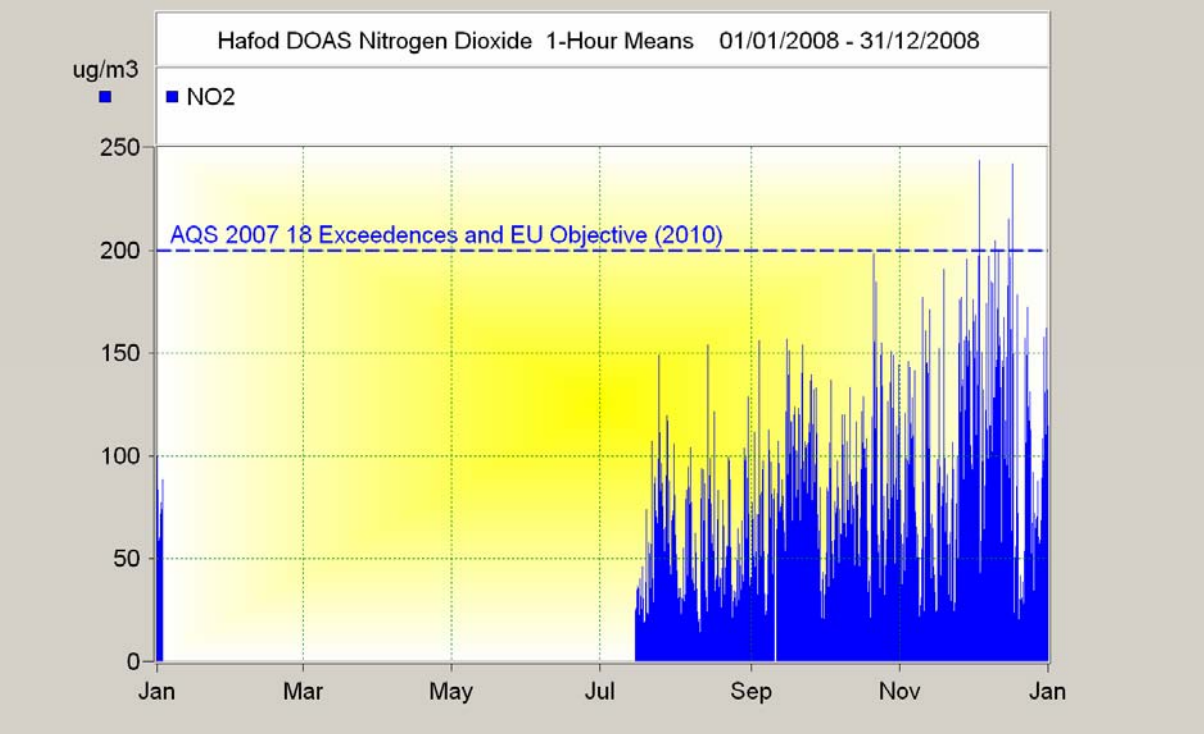
Graph 1 NO_2 1- hour means Swansea Roadside AURN 2008



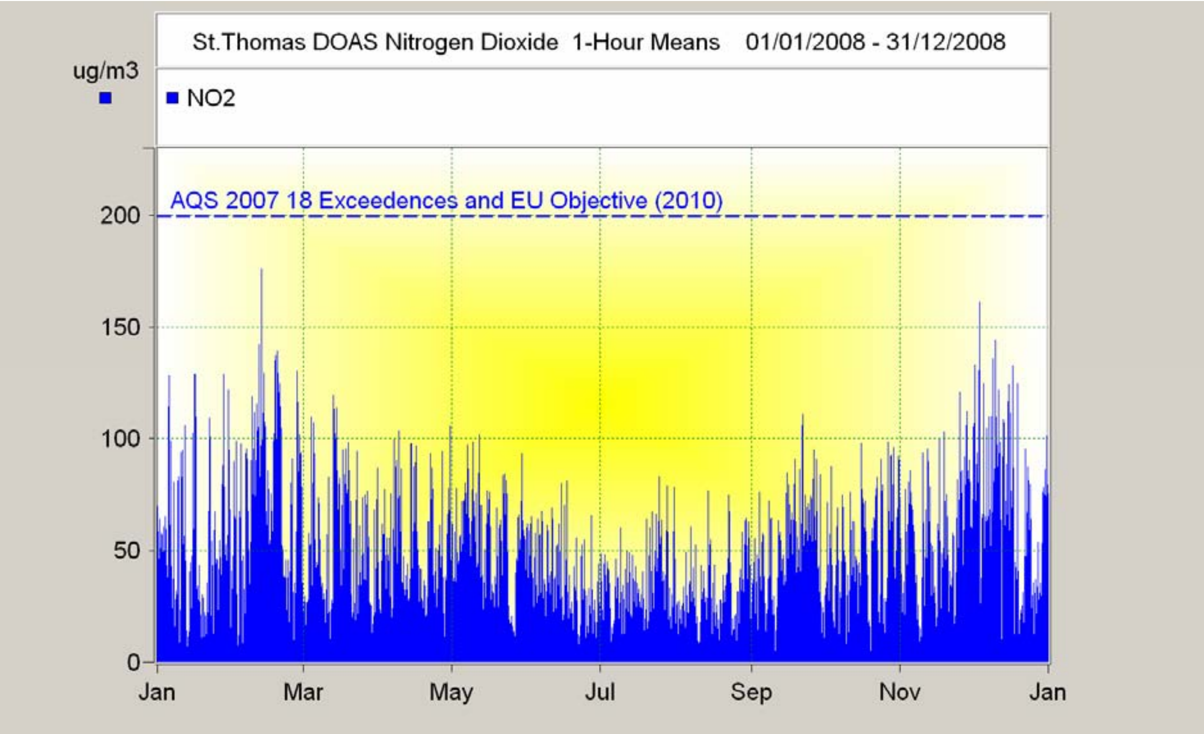
Graph 2 NO_2 1-hour means Morfa Groundhog 2008



Graph 3 NO_2 1-hour means Morriston Groundhog 2008



Graph 4 NO_2 1-hour means Hafod DOAS 2008
**Data Capture 46.6% due to renovation works along open path*



Graph 5 NO_2 1-hour means St Thomas DOAS 2008

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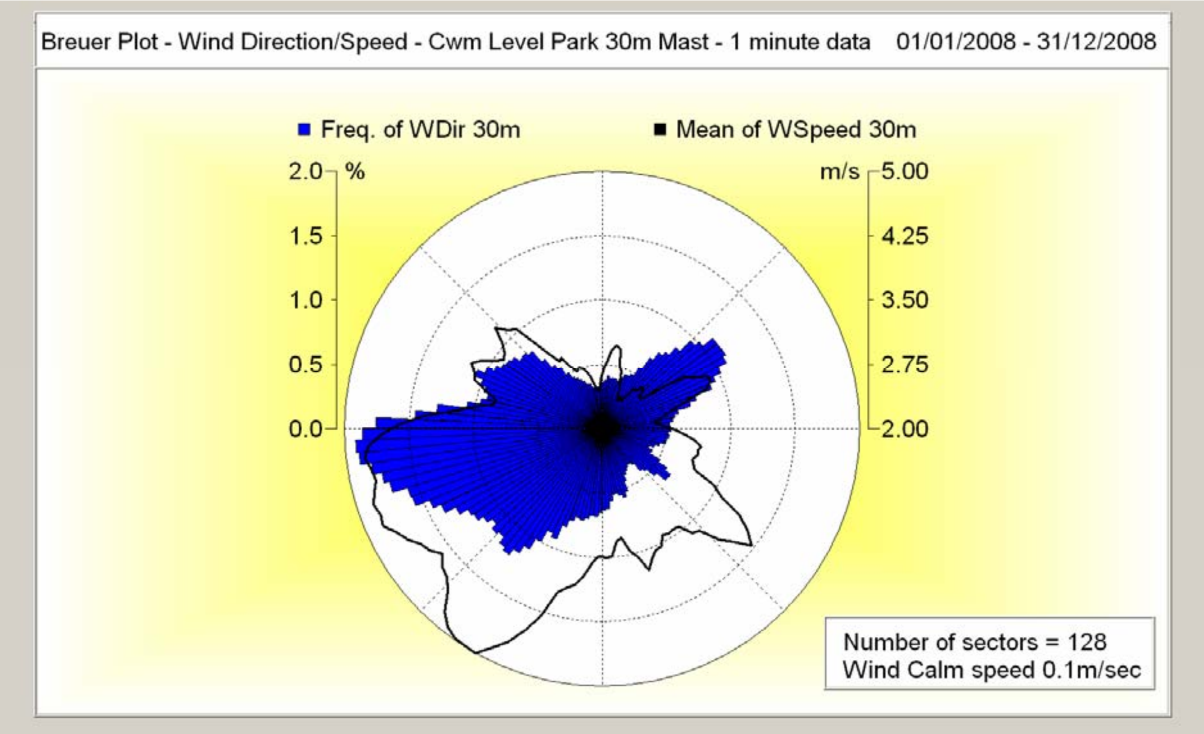
Examination of the meteorological data from the 30m mast located at Cwm Level Park, Landore is provided below as Breuer Plot 1. As can be seen, the plot indicates the typical and dominating prevailing westerly/south westerly winds but interestingly, there are significant periods of north-easterly and south easterly winds. These periods have been looked at in relation to the NO_2 data but it is thought that these periods are more significant in relation to regional PM_{10} episodes seen during January and February 2008. These issues are discussed within section ?? below.



Breuer Plot 1 – Meteorological conditions 2008

Scatter Plots 1 and 2 below indicate the spread of data by wind direction/speed (data from the Cwm Level Park 30m mast was used). As would be expected at these roadside locations there is no indication of a dominant source as the data is relatively tightly clustered indication sources of local origin.

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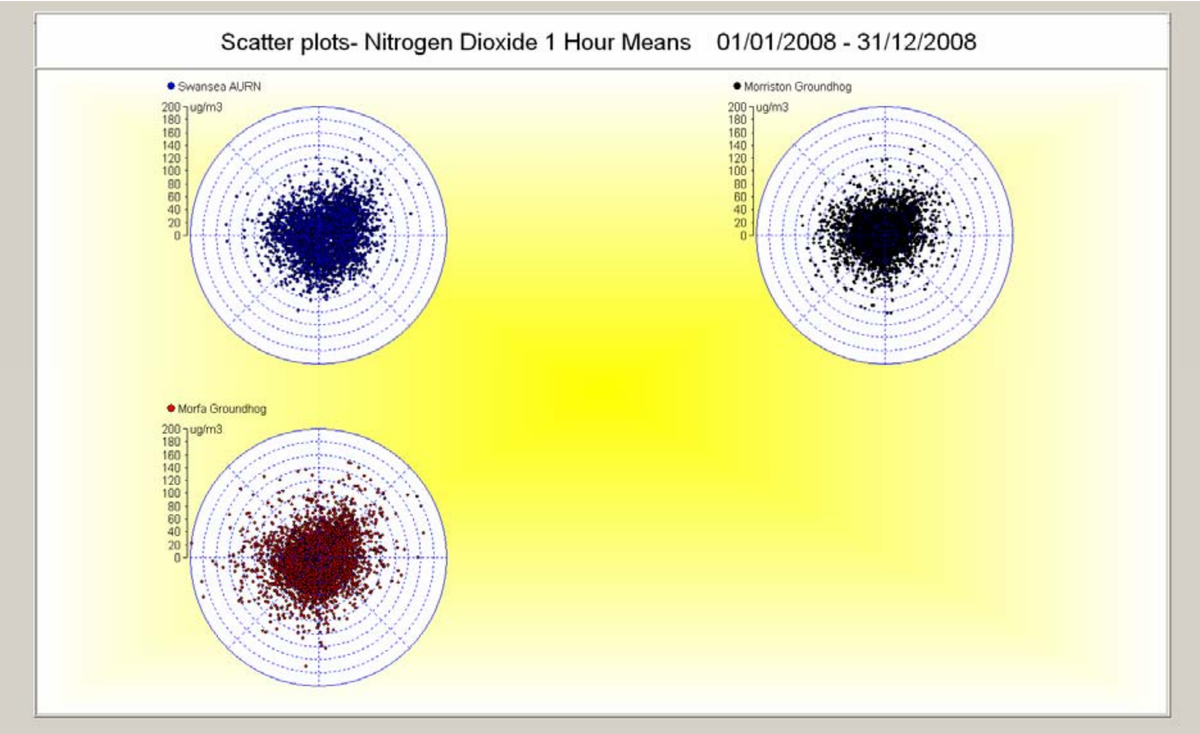
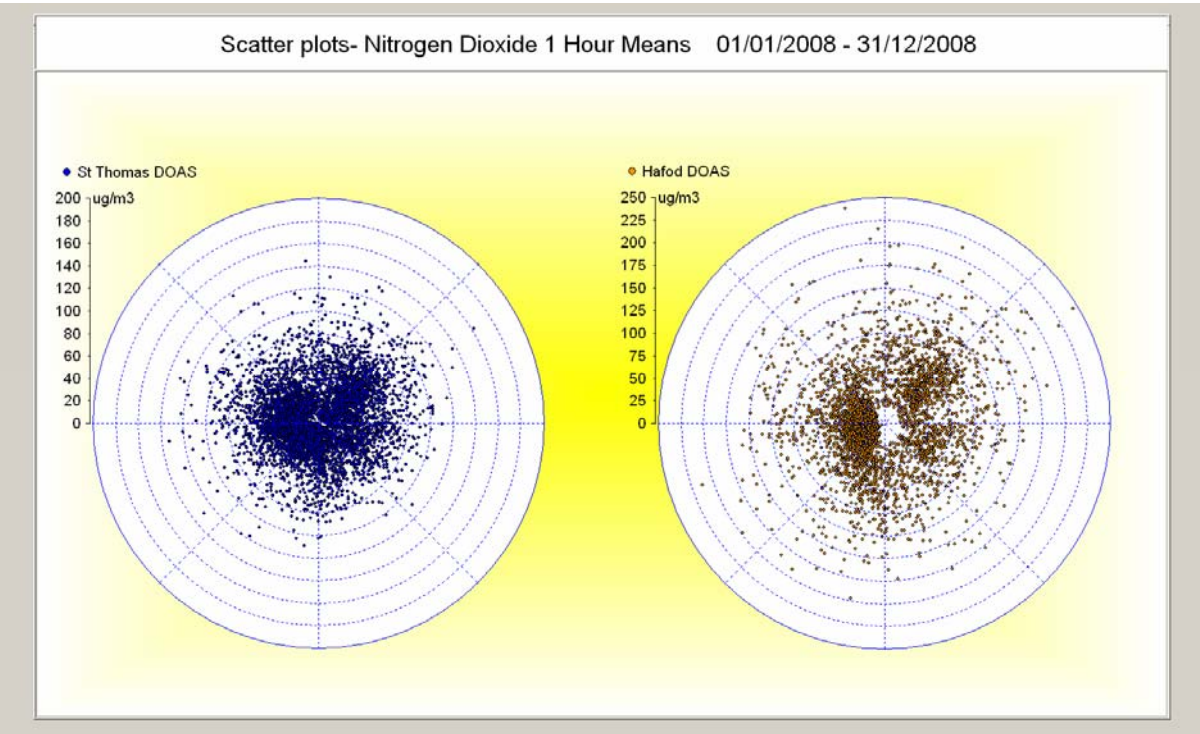


Scatter Plot 1 – Automatic Chemiluminescent NO_2 Monitoring 2008



Scatter Plot 2 – DOAS Open Path NO_2 Monitoring 2008

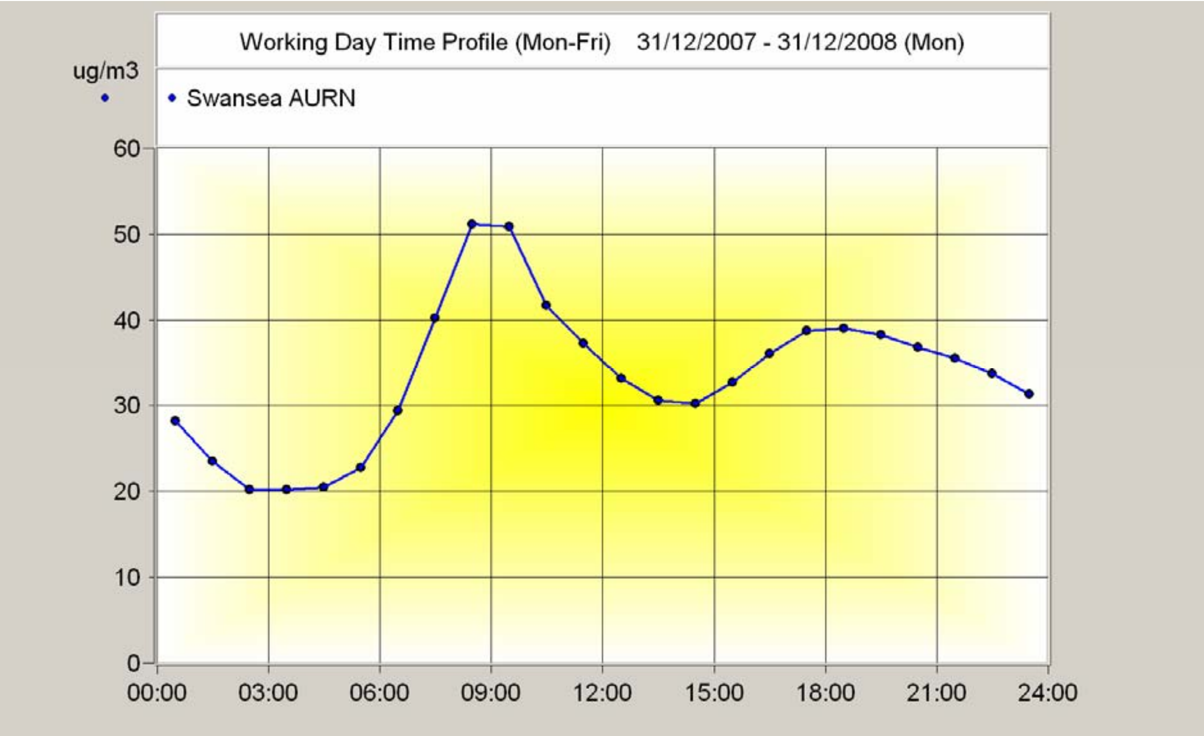
Diurnal NO_2 profiles for each site are provided below within diurnal plots 1-5. Again, as would be expected, the weekday peak concentrations are seen at each site during the am period with the pm period being much smoother. The only exception to this observation is that a definite peak rather than smoothing can be seen at the Morfa Groundhog site during the pm period.

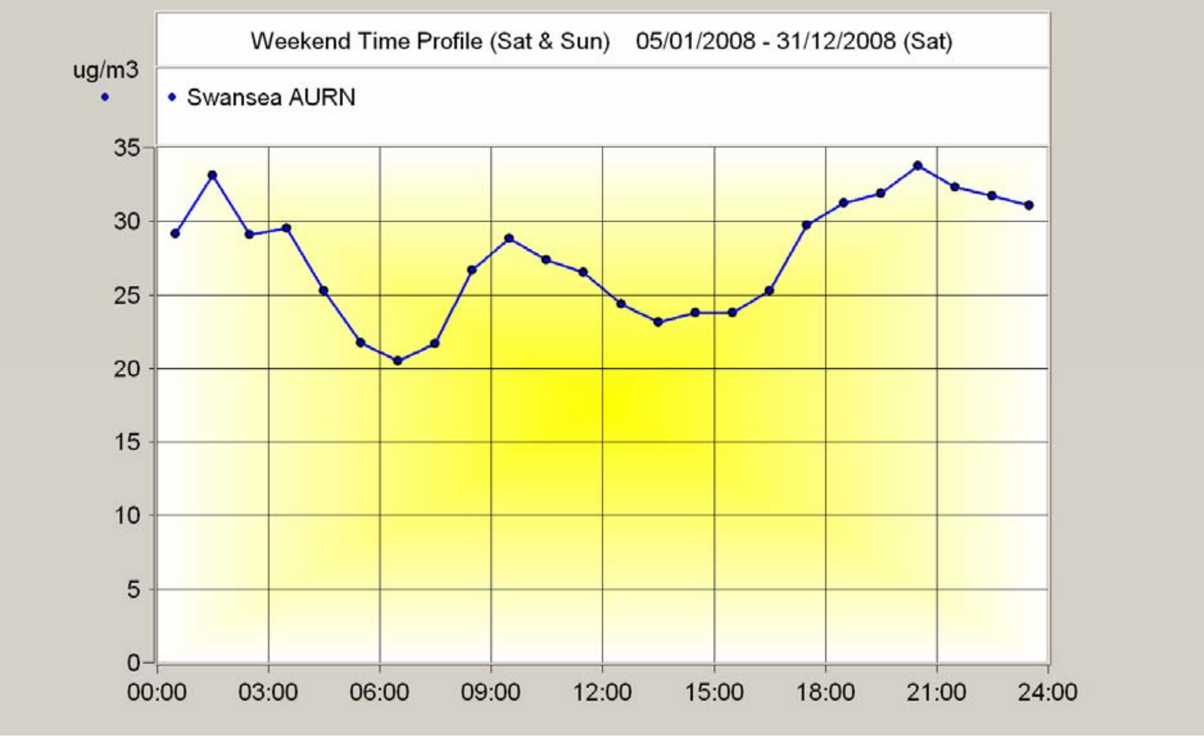
The am peak is thought likely to be influenced more by the prevailing meteorological conditions during the morning period which are then dispersed before the pm period i.e. wintertime inversions. A completely different profile is obtained for the weekend period.

The weekday profiles raise the question whether the authority should, as part of its Hafod Air Quality Action Plan, concentrate efforts on reducing the NO_2 impact solely around the am peak traffic period of 7-10am. A view is being investigated as to what effect this may have on the overall NO_2 annual mean and 1 hour objectives and what practical traffic management measures can be introduced into the Nowcaster forecast system being developed for such situations to achieve widespread compliance with the objective.

It is worth re-emphasising that the Swansea AURN is located in an open aspect on the A463 Carmarthen Road, approximately 55m above sea level with direct views over Swansea Bay. It is therefore more exposed to the prevailing south westerly winds than the monitoring sites located on the valley floor (Morfa, Morriston, Hafod DOAS and St Thomas DOAS systems). It is thought probable that this site may well sit above any inversion that forms within the lower Swansea Valley and therefore, does not experience the elevated concentrations seen at the other monitoring stations during such conditions. The site experiences the influence from transportation with the nearest GPRS ATC (Automatic Traffic Counter) which is approximately 50-60m away from the monitoring station returning an AADT (Annual Average Daily Traffic) of 18216 and an AWDT (Annual Weekday Daily Traffic) of 18840 vehicles.

Profiles presented for the Hafod DOAS for 2008 should be used with care as the data capture for 2008 falls well below the 90% required for LAQM purposes due to renovation works along the terraced properties blocking the light path..





NO_2 Diurnal Profile 1 – Swansea AURN (top weekday profile, bottom weekend profile)

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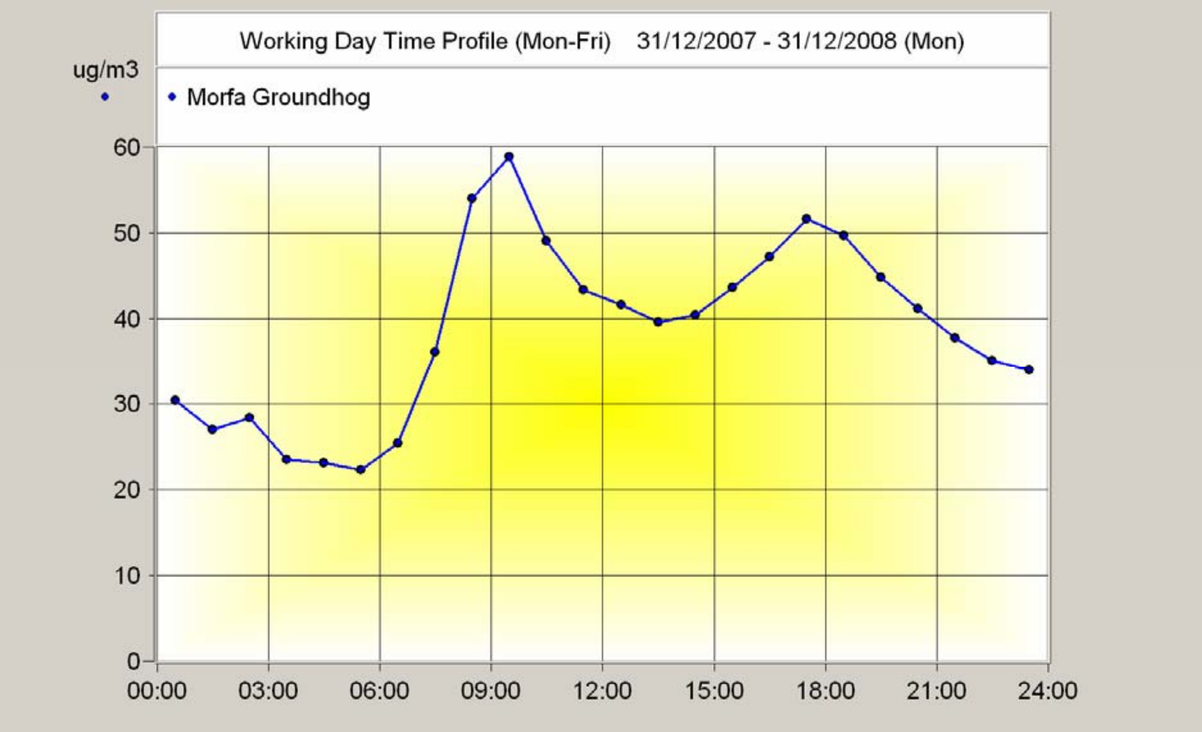

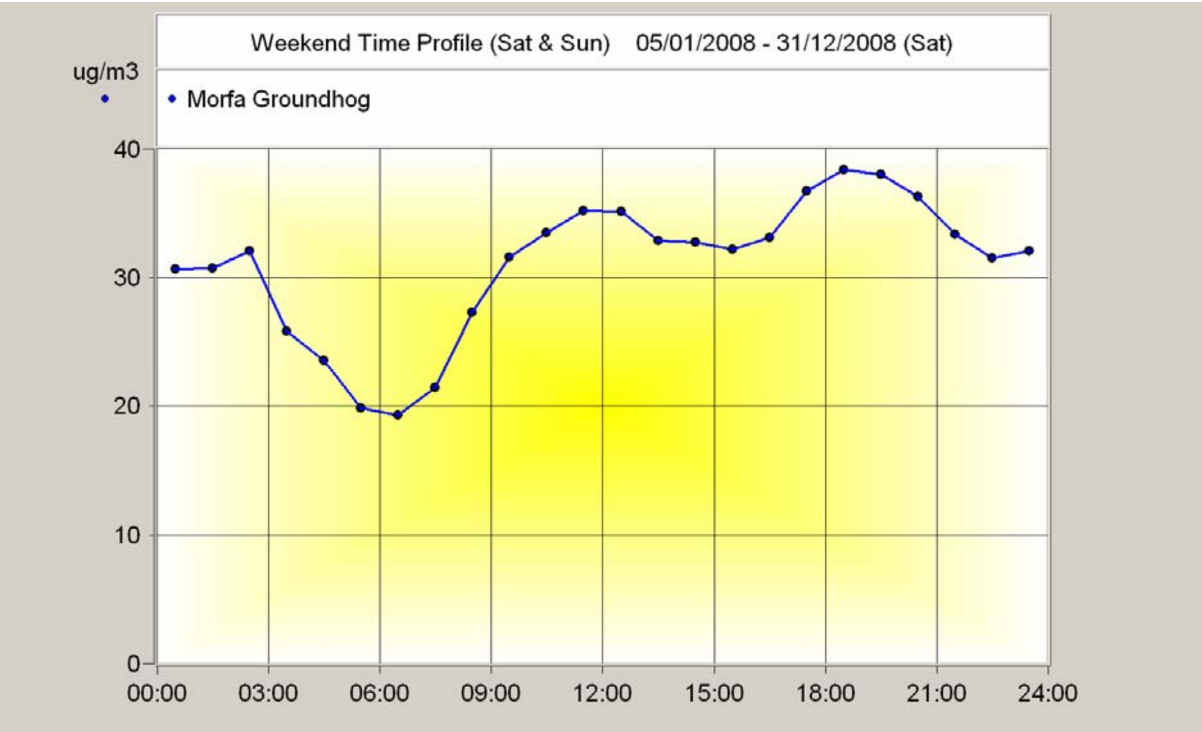

NO_2 Diurnal Profile 2 – Morfa Groundhog (top weekday profile, bottom weekend profile)

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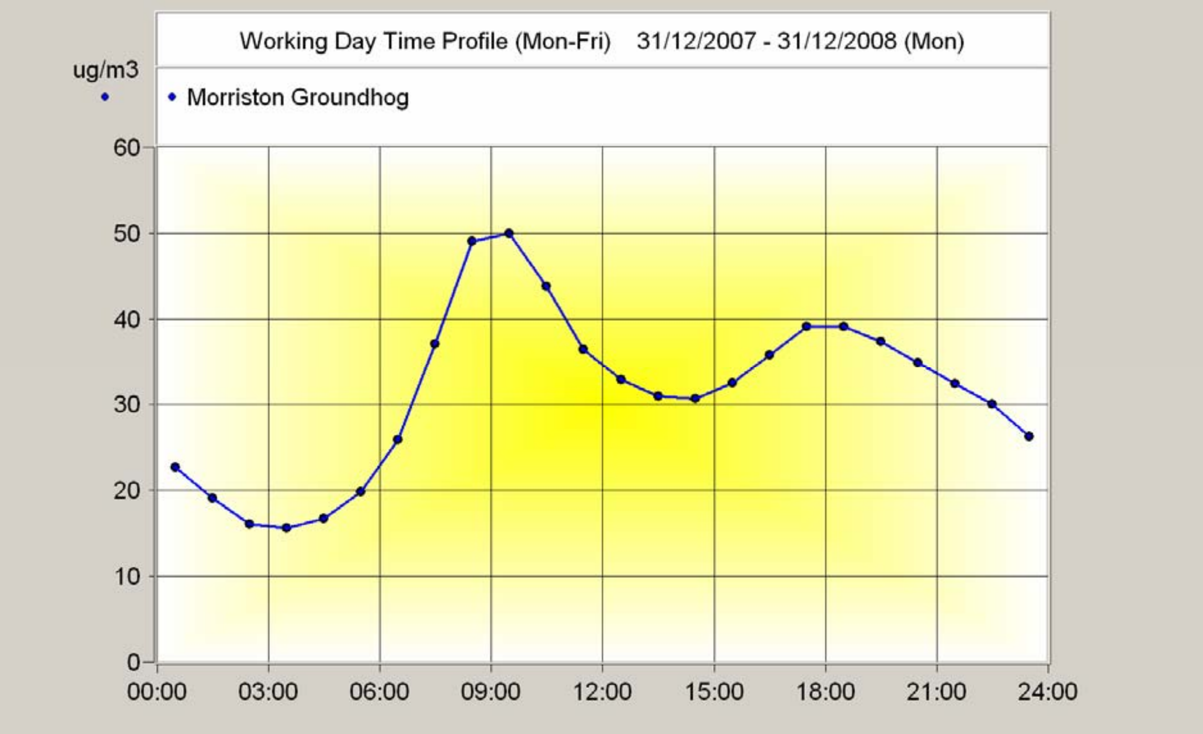

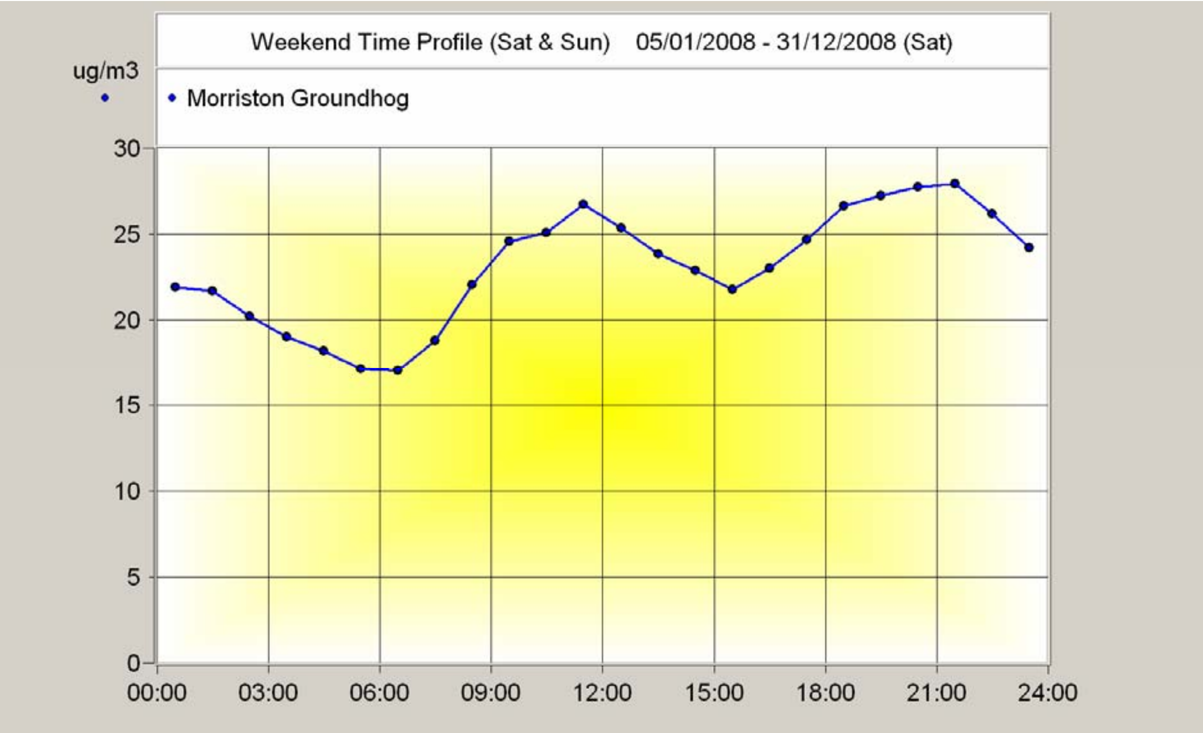

NO_2 Diurnal Profile 3 – Morriston Groundhog (top weekday profile, bottom weekend profile)

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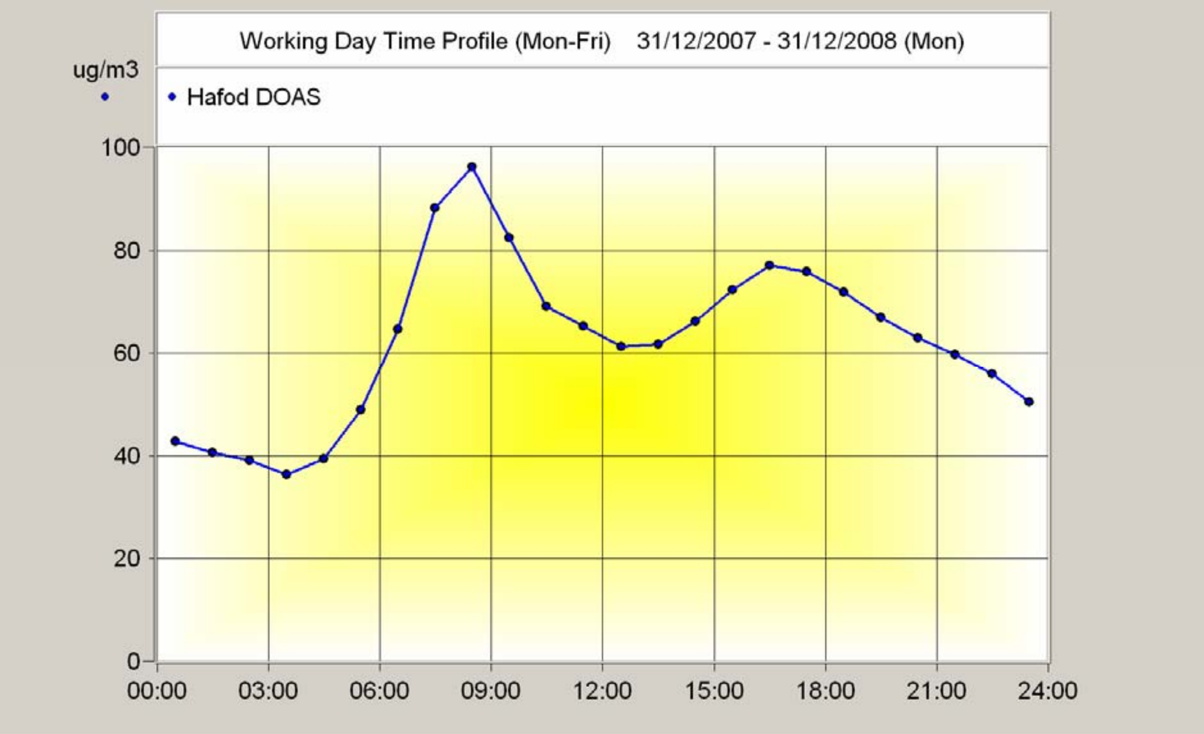

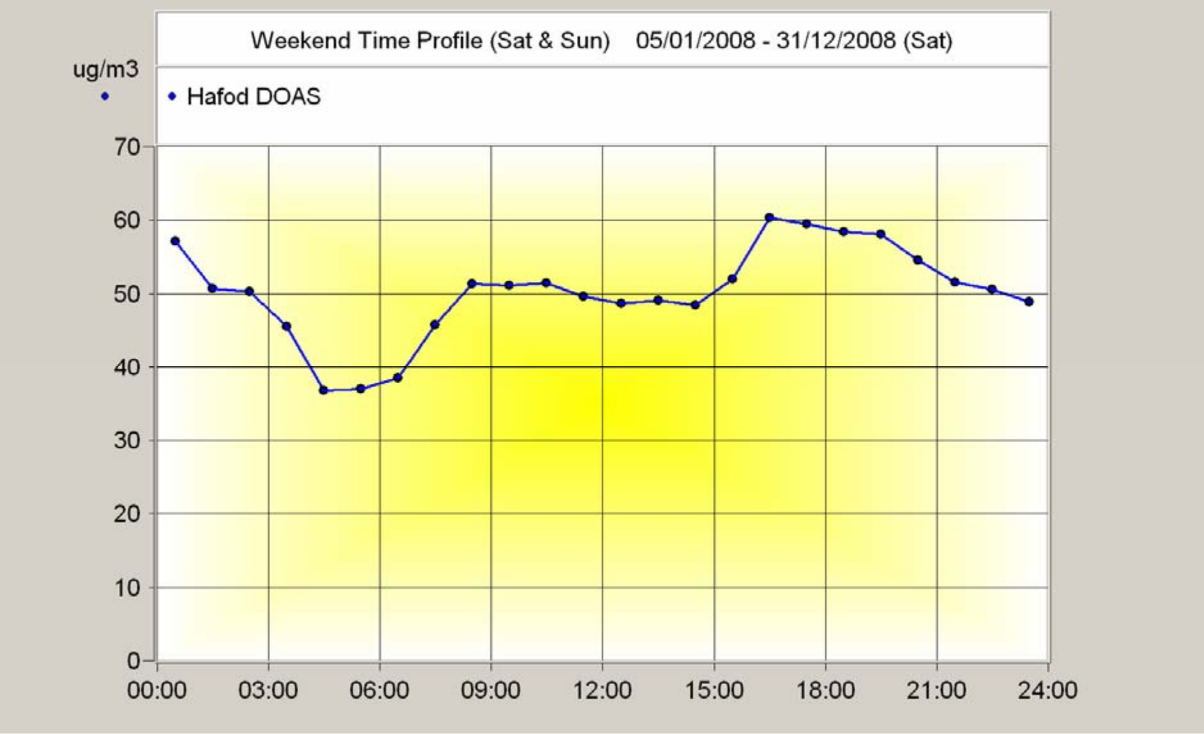

NO_2 Diurnal profile 4 – Hafod DOAS (top weekday profile, bottom weekend profile)

*** Data capture for 2008 falls below the recommended 90% due to renovation works. Profiles to be used with care*

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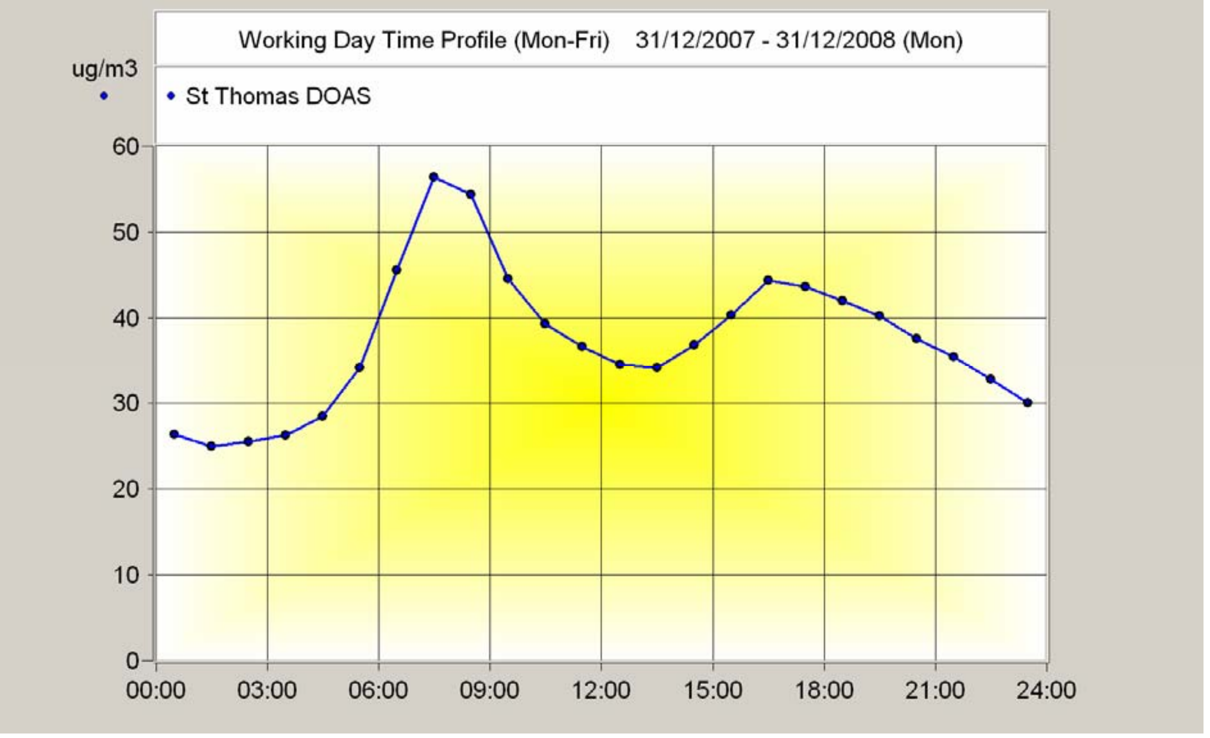

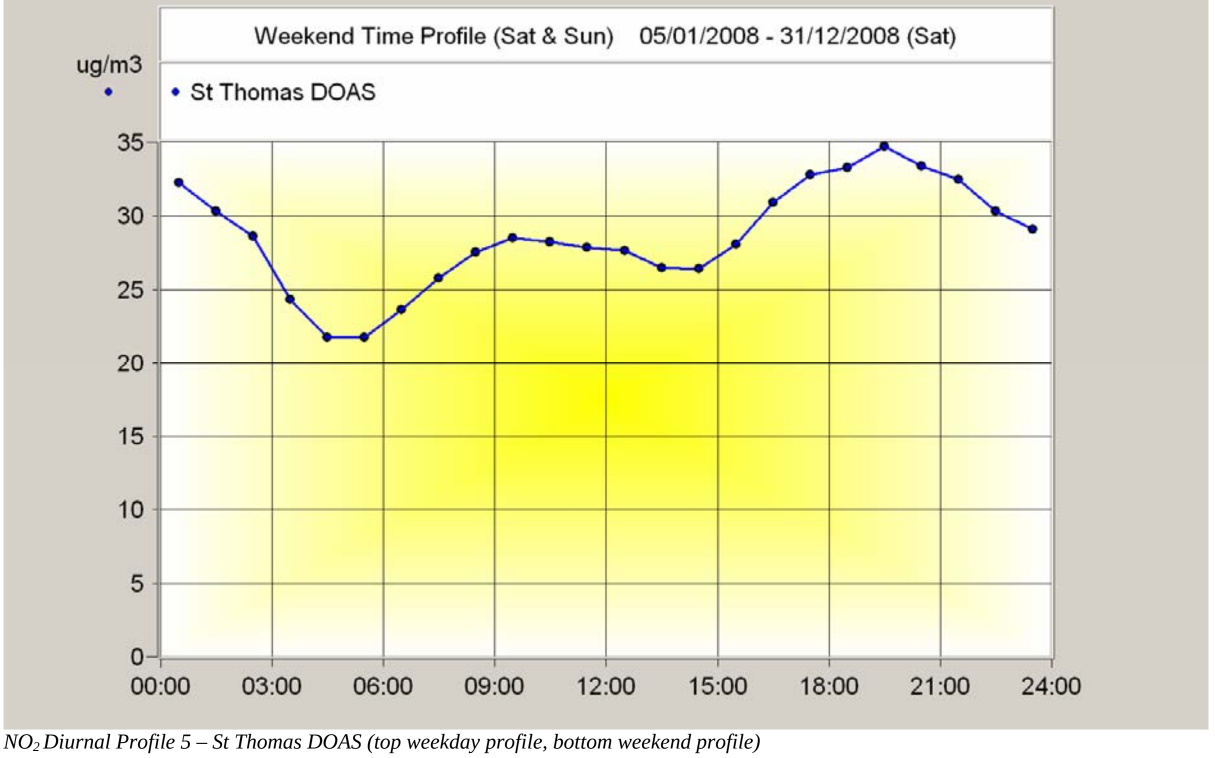

NO_2 Diurnal Profile 5 – St Thomas DOAS (top weekday profile, bottom weekend profile)

Detailed traffic flow data for the authorities GPRS network of 44 ATC's is presented in subsequent chapters.

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LAQM.TG (09) provides a method within box 2.1 page 2-4 to project measured annual mean roadside nitrogen dioxide concentrations to future years. Table 10 indicates predicted concentrations in 2010 and 2015 for the 5 automatic sites in Swansea. Where applicable, the correction derived for distance from the roadside measurement location to the nearest receptor location is given in bold within table 10. It is this figure in bold that has been used to calculate the future year projections. The actual measured roadside concentration is given in brackets for information.

Site ID	Location	Within AQMA?	Annual mean adjusted for distance from road to nearest receptor where applicable	Future Years Projections (at nearest receptor location)	
			2008	2010	2015
1	Swansea AURN	Y	**25.6** (31.78)	23.6	19.1
2	Morfa Groundhog	Y	**23.2** (36.49)	21.4	17.3
3	Morriston Groundhog	N	**23.6** (29.07)	21.7	17.6
4	Hafod DOAS *	Y	**58.64**	**54.0**	**43.7**
5	St.Thomas DOAS	N	34.94	32.2	26.0

Table 10 – Predicted Future Years Roadside NO_2

**Use with caution as data capture during 2008 46.6%*

The City & County of Swansea facilitated a research study by a group comprising: School of Earth and Ocean Sciences Cardiff University, School of Biosciences Cardiff University, and the Centre for Health and Environment Research, Department of Primary Care and Public Health, Neuadd Meirionydd into ultrafine and nanoparticles using a Dekati™ Electrical Low Pressure Impactor within a street canyon environment. The site chosen for measurements was the Hafod Post Office, Neath Road, Hafod, Swansea. This site is located within the Hafod Air Quality (NO_2) Management Area and is opposite the Hafod DOAS monitoring station.

Full details of the study are reproduced with the permission of the group within Annexe 4. The study confirmed the existence of an early morning diurnal pattern within the ultrafine fraction which appears to match the diurnal NO_2 pattern highlighted above, seemingly confirming the traffic source for these two pollutants.

2.2.2 Diffusion Tube Monitoring Data

All data presented within table 11 below has been corrected for tube bias only. No correction for tube chemistry has been applied as a result of the tri-location studies carried out at the three roadside chemiluminescent analysers[18]. In any event, all passive diffusion tubes are located roadside and no correction has been made using a roadside tri-location study derived bias correction to a passive diffusion tube with an urban background classification.

Sites 72 to 134 are reported below and form the additional monitoring outlined within the Progress Report 2008. As these sites commenced monitoring during July 2008 only the minimum recommended data capture of 9 months are currently available (July 2008 – March 2009) to provided an indication of the annual mean.
Data is presented as if it were a full year of monitoring for 2008.

Sites with a full year monitoring data (1-71) that exceed the annual mean are highlighted in bold red as are the additional sites (72-134) that have the minimum 9 months exposure periods. Those sites that are close to exceeding the annual mean (between 37-40ug/m^3) are highlighted in bold blue.

Table 11 indicates the bias corrected annual means prior to correction for distance to nearest receptor from the sampling location - see table 6 for distance to nearest receptor. The relevant correction (where applicable) is given within table 12

Site ID	Location	Within AQMA?	Data Capture 2008 %	Annual mean concentrations 2008 (μg/m^3) Adjusted for bias
1	12 Ystrad Road, Fforestfach		100.0	24.19
2	1332 Carmarthen Road, Fforestfach		91.7	16.26
3	2 Ffordd Cynore, Fforestfach		83.3	20.06
4	26 Dillwyn road, Sketty		100.0	30.77
5	108 Gower Road, Sketty		100.0	32.22
6	21 Vivian Road, Sketty		100.0	29.83
7	15 Gower Road, Sketty		100.0	**48.54**

[18] http://www.uwe.ac.uk/aqm/review/manswers.html#ROAD11 Nitrogen Dioxide -Question 8

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8	1034 Carmarthen Road, Fforestfach		100.0	**42.44**
9	41 Station Road, Fforestfach		100.0	28.64
10	932 Carmarthen Road, Fforestfach		91.7	24.23
11	18 Ravenhill Road, Fforestfach		100.0	**37.79**
12	747 Carmarthen Road, Gendros		100.0	**40.68**
13	Brunel Court, Walter Road		83.3	28.90
14	14 Clarence Street		100.0	25.22
15	56 Westway		91.7	26.11
16	136 Osytersmouth Road		100.0	30.69
17	1-7 Arethusa Quay, Marina		91.7	22.80
18	6 Cwm Level Road, Landore	**Y**	100.0	**44.93**
19	49 Dyfatty Street, Dyfatty	**Y**	100.0	**42.56**
20	30 Carmarthen Road, Dyfatty	**Y**	100.0	**39.85**
21	33 Plough Road, Landore	**Y**	100.0	31.65
22	114 Pentreharne Road	**Y**	100.0	35.73
23	15 Mysydd Road, Landore	**Y**	100.0	34.05
24	126-149 Trawler Road, Marina		100.0	20.57
25	53 Mysydd Road, Landore	**Y**	100.0	27.66
26	1399 Neath Road, Landore	**Y**	100.0	**41.66**
27	1379 Neath Road, Landore	**Y**	100.0	**37.75**
28	119 Neath Road, Landore	**Y**	100.0	29.39
29	5 Morfa Terrace, Landore	**Y**	91.7	**56.30**
30	34-41 Trawler Road, Marina		100.0	20.10
31	289 Neath Road, Landore		91.7	32.37
32	6 Pentreguinea Road, St.Thomas		100.0	31.26
33	69 Pentreguinea Road, St.Thomas		100.0	31.00
34	1184 Neath Road, Landore		100.0	32.68
35	50 Delhi Street, St.Thomas		100.0	35.86
36	24 Delhi Street, St.Thomas		100.0	30.96
37	2 Sebastopol Street, St.Thomas		100.0	24.19
38	5 Port Tennant Road, Port Tennant		100.0	33.11
39	69 Port Tennant Road, Port Tennant		100.0	25.22
40	19 Pentrepoeth Road, Morriston		100.0	28.24
41	Fountain Inn, Woodfield Road		100.0	**37.31**
42	32 Sway Road, Morriston		75.0	34.79
43	17 Clase Road, Morriston		100.0	34.39
44	4 Ian's Walk, Ynysforgan		100.0	29.03
45	52 Glyncollen Drive, Ynysforgan		100.0	35.53
46	63 Wern fawr Road, Port Tennant		100.0	16.01
47	505 Clydach Road, Ynysforgan		100.0	23.95
48	5 Bevans Row, Port Tennant		100.0	25.18
49	34 Nantyffin Road, Llansamlet		100.0	29.57
50	6 Nantyffin Road, Llansamlet		91.7	35.34
51	138 Samlet Road, Llansamlet		100.0	32.20
52	87 Midland Place, Llansamlet		100.0	22.52
53	16 Church Road, Llansamlet		91.7	22.94
54	12 Peniel Green Road, Llansamlet		100.0	34.61
55	38 Peniel Green Road, Llansamlet		100.0	35.29

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56	Ynysallan Road, Birchgrove		75.0	36.84
57	18 Coed Fedwen, Birchgrove		100.0	15.41
58	L/post outside 16 Uplands Crescent, Uplands		100.0	**38.17**
59	Hafod Post Office	**Y**	91.7	**53.86**
60	10 St.Helens Road		100.0	**37.10**
61	Pacos, St.Helens Road		100.0	**38.02**
62	Copper Quarter 1		83.3	28.99
63	6 De La Beche Road		91.7	25.06
64	7 Gower Road		100.0	**51.25**
65	Stewart Hall, Gower Road		108.3	26.98
66	60 Sketty Road		50.0	32.85
67	Newcut Road	**Y**	100.0	**44.00**
68	Orchard Street		100.0	34.41
69	Llys Glas		100.0	**46.93**
70	Copper Quarter 2		91.7	26.17
71	Copper quarter 3		100.0	30.80
72	10/12 Uplands Crescent		100.0	25.1
73	1 Uplands Crescent		75.0	34.0
74	4 Nyanza Terrace		75.0	28.9
75	15 Uplands Crescent		75.0	35.1
76	36/38 Uplands Crescent		75.0	26.1
77	6/8 Glanmor Road		75.0	22.8
78	16/18 Glanmor Road		66.6	27.5
79	Alexandra Hotel 3 Sketty Road		75.0	33.0
80	Orthadontic Clinic 63 Sketty Road		75.0	24.8
81	24/26 Gower Road (zebra crossing)		75.0	23.3
82	48/50 Gower Road		75.0	26.0
83	64/66 Gower Road (above garages)		75.0	29.8
84	9 Gower Road		75.0	**37.3**
85	13 Gower Road		75.0	**38.6**
86	72 Gower Road		75.0	30.8
87	1/2 De La Beche Road		75.0	21.3
88	96/98 Gower Road (Sketty Travel)		75.0	**37.3**
89	5 Vivian Road		75.0	22.4
90	18/20 Vivian Road		75.0	34.2
91	114 Gower Road		75.0	31.7
92	Pole outside HSBC Bank 15 Dillwyn Road		75.0	32.0
93	48 Ravenhill Road		75.0	29.9
94	64/66 Ravenhill Road		66.6	29.6
95	1123 Carmarthen Road		75.0	29.1
96	1078 Carmarthen Road		75.0	27.9
97	1068 Carmarthen Road		75.0	36.6
98	953 Carmarthen Road		75.0	**40.5**
99	860 Carmarthen Road		50.0	32.5
100	824 Carmarthen Road		58.3	28.7
101	692 Carmarthen Road		75.0	29.8
102	13 Delhi Street		75.0	29.4
103	13 Nantyffin Road		75.0	33.4

104	7/9 Nantyffin Road		75.0	29.4
105	135 Samlet Road		75.0	32.3
106	120 Samlet Road		75.0	33.8
107	30/32 Peniel Green Road		75.0	35.0
108	38/40 Glyncollen Drive		75.0	31.4
109	33 Glyncollen Drive		75.0	28.1
110	Anchorage 57 Cefn Glas		75.0	27.7
111	391 Clydach Road		75.0	32.9
112	L/Post outside Wilks 33 St Helens Road		75.0	32.6
113	Age Concern 69 St Helens Road		75.0	21.8
114	38 Walter Road		33.3	32.5
115	36 Mansel Street		75.0	**38.8**
116	Gas Service Wales, 16 Mansel Street		75.0	**41.5**
117	Friends of Blind 3 De La Beche Street		75.0	**39.4**
118	Breast Screening Centre 24 Alexandra Road		75.0	29.3
119	3/4 Pleasant Street (behind old Police Station)		75.0	32.2
120	L/Post outside Orchard St Clinic, 21 Orchard		75.0	**46.5**
121	outside CK's 73 High Street	**Y**	75.0	**79.3**
122	Emperor Restaurant, 206 High Street		75.0	**39.5**
123	The Bays, Mackworth Court,High Street,		75.0	**54.4**
124	L/Post between Argos/Uniterian Church, High		75.0	**44.1**
125	L/Post outside Army Careers/Opium Den, High		75.0	**51.4**
126	InfoNation (CCS Drop in Centre), 47 The Kingsway		66.7	**38.9**
127	D/Pipe side of Lloyds TSB 30 The Kingsway		75.0	**40.9**
128	The Money Shop 28a The Kingsway		50.0	**41.1**
129	Graham Evans Solicitors, Christina Street		75.0	36.1
130	D/Pipe fronting Dillwyn Street, Cecil Jones		75.0	**53.5**
131	EasyTan 4 Dillwyn Street		66.7	**58.3**
132	Etype, Westway		75.0	32.7
133	51 Bathurst Street		75.0	26.8
134	Amor restaurant, 13 Dillwyn Street		75.0	**50.5**

Table 11 Results of Nitrogen Dioxide Diffusion Tube Monitoring 2008

The distance to the nearest receptor location is given in brackets after the site name in table 6. The NO_2 annual mean at the nearest receptor location has been derived following guidance within TG.09 box 2.3 page 2-6 and use of the spreadsheet at http://www.airquality.co.uk/laqm/tools/NO2withDistancefromRoadsCalculatorIssue2.xls. The spreadsheet calculator has been setup to work from 0.1 to 50m only. As can be seen from table 6, the authority is aware of, and planning for future proposed domestic housing developments, by making measurements at the current nearest possible monitoring position to those developments. Unfortunately, an indication can at present only be gained to a distance of 50m from the measurement point due to the setup of the provided spreadsheet tool. Table 6 and table 11 indicate two monitoring sites (site 56 and 71) that are utilised to provide an indicative annual mean to the **nearest existing dwelling** within the development sites. Receptor locations when additional dwellings are constructed to the remainder/potential sites will be considerably closer. It could be argued that at present there is no relevant exposure at present in LAQM terms from these two monitoring locations but it is anticipated due to the developments underway that these receptor locations will be realised at some stage in the near future. Both of these locations are at a distance greater than the spreadsheet will produce corrections for. These two sites are therefore presented with corrected annuals means as if they were 50m away.

The resulting calculated NO_2 annual mean at the receptor location due to fall off in concentration with distance from the road is given below within table 12. Background 1k by 1k NO_2 concentrations were downloaded from http://www.airquality.co.uk/archive/laqm/tools.php?tool=background06 and overlain on a GIS background map within ArcView3.3. The background concentration required for the calculation was obtained from the nearest 1k grid square to the monitoring site.

Sites 118,120,124,125,126,127,128,129,130 and 134 were sited with the main intention of assessing concentrations against the NO_2 1-hour objective. As discussed later, Swansea city centre has seen great change in the road network to accommodate the Metro Service. It is thought reasonable to access exposure to the 1 hour objective to the general population within the city centre area especially where this exposure can be related to an external café area environment. These café environments are not set back at a distance from the kerb/road where the measurement has been made but are on the same road, at the same distance from the kerb as the measurement site, albeit at a distance either right or left from the monitoring point. Due to some siting issues, measurements were not always directly possible at the café environment. It is not thought that the method within box 2.3 of TG(09) is relevant or applicable to these locations as the café environments are at an identical distance from the kerb of the same road.

Site ID	Distance of Measurement Site from Kerb	Distance of Receptor from Kerb	NO_2 Background Concentration	Measured 2008 Annual Mean Corrected for bias	Predicted Annual Mean at Receptor
56	2	*166	18.5	36.8	23
58	4	8	14.3	38.2	33.6
63	2	6	11.6	25.1	21.6
64	1	3	11.6	51.2	**42.4**
67	2	5	17.1	44	**38.2**
69	2	4	17.1	46.9	**42.1**
70	2	7	16.3	26.2	23.3
71	2	*138	16.3	30.8	19.9
112	1	6	14.2	32.6	26

Table 12 – Correction of NO_2 for distance from road

* Calculated as if 50m

From the advice on using passive diffusion tube annual mean results[19] to assess compliance with the 1 hour objective for NO_2 it is clear from the above results that it is unlikely that the 1 hour objective has been exceeded at the majority of the above sites as all annual means (those with a full year of monitoring data) are below 60ug/m^3. However, site 121 is at present indicating the possible breach of the 1-hour objective in addition to the annual mean. Site 131 is close to providing the same indication but relevant exposure is some distance away at a café environment.

Table 13 below now summarises previous years of measurement with the full corrected data for 2008

Site ID	Location	Within AQMA?	Annual mean concentrations (µg/m^3) Adjusted for bias			
			2005	2006	2007	2008
1	12 Ystrad Road, Fforestfach	-	29.0	25.7	26.7	24.2
2	1332 Carmarthen Road, Fforestfach	-	24.8	17.6	18.1	16.3
3	2 Ffordd Cynore, Fforestfach	-	29.9	21.3	22.2	20.1
4	26 Dillwyn road, Sketty	-	**39.2**	33.7	33.9	30.8
5	108 Gower Road, Sketty	-	**43.5**	34.0	35.1	32.2
6	21 Vivian Road, Sketty	-	35.3	31.9	32.0	29.8
7	15 Gower Road, Sketty	-	**56.1**	**51.1**	**50.0**	**48.5**
8	1034 Carmarthen Road, Fforestfach	-	**47.9**	**42.2**	**46.0**	**42.4**
9	41 Station Road, Fforestfach	-	**37.6**	29.9	30.3	28.6
10	932 Carmarthen Road, Fforestfach	-	33.3	25.6	24.8	24.2
11	18 Ravenhill Road, Fforestfach	-	**45.2**	**40.8**	**39.1**	**37.8**
12	747 Carmarthen Road, Gendros	-	**49.7**	**41.8**	**42.3**	**40.7**

[19] http://www.airquality.co.uk/archive/reports/cat18/0806261511_TG_NO2relationship_report_draft1.pdf

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13	Brunel Court, Walter Road	-	34.7	29.8	30.8	28.9
14	14 Clarence Street	-	34.5	25.2	30.0	25.2
15	56 Westway	-	36.6	25.7	27.7	26.1
16	136 Osytersmouth Road	-	36.9	30.8	34.5	30.7
17	1-7 Arethusa Quay, Marina	-	28.1	22.4	26.0	22.8
18	6 Cwm Level Road, Landore	**Y**	**52.4**	**43.1**	**46.4**	**44.9**
19	49 Dyfatty Street, Dyfatty	**Y**	**56.1**	**44.9**	**48.2**	**42.6**
20	30 Carmarthen Road, Dyfatty	**Y**	**52.0**	**40.7**	**40.7**	**39.9**
21	33 Plough Road, Landore	**Y**	**38.3**	32.4	32.8	31.7
22	114 Pentreharne Road	**Y**	**44.3**	36.6	36.6	35.7
23	15 Mysydd Road, Landore	**Y**	**40.1**	32.6	36.0	34.1
24	126-149 Trawler Road, Marina	**-**	28.3	21.7	23.6	20.6
25	53 Mysydd Road, Landore	**Y**	**37.1**	29.6	28.9	27.7
26	1399 Neath Road, Landore	**Y**	**42.4**	**43.7**	**42.1**	**41.7**
27	1379 Neath Road, Landore	**Y**	**55.4**	**43.5**	**41.3**	**37.8**
28	119 Neath Road, Landore	**Y**	**39.9**	28.5	31.6	29.4
29	5 Morfa Terrace, Landore	**Y**	**70.9**	**58.4**	**58.4**	**56.3**
30	34-41 Trawler Road, Marina	**-**	31.4	22.3	24.6	20.1
31	289 Neath Road, Landore	**-**	**40.0**	33.9	33.4	32.4
32	6 Pentreguinea Road, St.Thomas	**-**	**39.1**	32.6	34.0	31.3
33	69 Pentreguinea Road, St.Thomas	**-**	**42.8**	32.4	32.7	31.0
34	1184 Neath Road, Landore	**-**	**38.7**	35.1	36.1	32.7
35	50 Delhi Street, St.Thomas	**-**	**49.3**	**39.0**	**38.6**	35.9
36	24 Delhi Street, St.Thomas	**-**	**42.7**	33.0	34.0	31.0
37	2 Sebastopol Street, St.Thomas	**-**	35.7	26.1	26.5	24.2
38	5 Port Tennant Road, Port Tennant	**-**	**42.2**	33.7	35.5	33.1
39	69 Port Tennant Road, Port Tennant	**-**	**38.5**	27.4	26.7	25.2
40	19 Pentrepoeth Road, Morriston	**-**	34.8	28.1	29.7	28.2
41	Fountain Inn, Woodfield Road	**-**	**47.3**	**39.7**	33.4	**37.3**
42	32 Sway Road, Morriston	**-**	34.1	28.4	31.3	34.8
43	17 Clase Road, Morriston	**-**	**40.4**	35.8	35.1	34.4
44	4 Ian's Walk, Ynysforgan	**-**	32.8	29.9	28.3	29.0
45	52 Glyncollen Drive, Ynysforgan	**-**	**42.9**	34.6	**39.4**	35.5
46	63 Wern fawr Road, Port Tennant	**-**	23.1	17.0	16.7	16.0
47	505 Clydach Road, Ynysforgan	**-**	26.9	24.4	24.1	23.9
48	5 Bevans Row, Port Tennant	**-**	31.3	24.8	24.3	25.2
49	34 Nantyffin Road, Llansamlet	**-**	32.8	28.7	29.9	29.6
50	6 Nantyffin Road, Llansamlet	**-**	**48.4**	**39.4**	**39.7**	35.3
51	138 Samlet Road, Llansamlet	**-**	36.9	32.3	30.7	32.2
52	87 Midland Place, Llansamlet	**-**	26.0	27.3	20.9	22.5
53	16 Church Road, Llansamlet	**-**	30.0	23.7	23.4	22.9
54	12 Peniel Green Road, Llansamlet	**-**	**40.1**	**38.6**	34.3	34.6
55	38 Peniel Green Road, Llansamlet	**-**	**39.9**	**37.1**	36.2	35.3
56	Ynysallan Road, Birchgrove	**-**	**42.4**	**39.4**	**39.1**	**23**
57	18 Coed Fedwen, Birchgrove	**-**	21.3	16.3	15.9	15.4
58	16 Uplands Crescent, Uplands	**-**	**52.0**	**41.3**	**41.7**	**33.6**
59	Hafod Post Office	**Y**	**69.0**	**56.8**	**60.5**	**53.9**
60	10 St.Helens Road	**-**	**-**	**37.4**	**38.7**	**37.1**
61	Pacos, St.Helens Road	**-**	**-**	**38.3**	**38.2**	**38.0**

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62	Copper Quarter 1	-	-	-	**38.4**	29.0
63	6 De La Beche Road	-	-	-	35.4	**21.6**
64	7 Gower Road	-	-	-	**65.1**	**42.4**
65	Stewart Hall, Gower Road	-	-	-	**37.1**	27.0
66	60 Sketty Road	-	-	-	**44.3**	32.8
67	Newcut Road	**Y**	-	-	**69.3**	**38.2**
68	Orchard Street	-	-	-	**42.0**	34.4
69	Llys Glas	-	-	-	**60.8**	**42.1**
70	Copper Quarter 2	-	-	-	**38.1**	23.3
71	Copper quarter 3	-	-	-	**41.8**	19.9
72	10/12 Uplands Crescent	-	-	-	-	25.1
73	1 Uplands Crescent	-	-	-	-	34.0
74	4 Nyanza Terrace	-	-	-	-	28.9
75	15 Uplands Crescent	-	-	-	-	35.1
76	36/38 Uplands Crescent	-	-	-	-	26.1
77	6/8 Glanmor Road	-	-	-	-	22.8
78	16/18 Glanmor Road	-	-	-	-	27.5
79	Alexandra Hotel 3 Sketty Road	-	-	-	-	33.0
80	Orthadontic Clinic 63 Sketty Road	-	-	-	-	24.8
81	24/26 Gower Road	-	-	-	-	23.3
82	48/50 Gower Road	-	-	-	-	26.0
83	64/66 Gower Road	-	-	-	-	29.8
84	9 Gower Road	-	-	-	-	**37.3**
85	13 Gower Road	-	-	-	-	**38.6**
86	72 Gower Road	-	-	-	-	30.8
87	1/2 De La Beche Road	-	-	-	-	21.3
88	96/98 Gower Road (Sketty Travel)	-	-	-	-	**37.3**
89	5 Vivian Road	-	-	-	-	22.4
90	18/20 Vivian Road	-	-	-	-	34.2
91	114 Gower Road	-	-	-	-	31.7
92	Pole outside HSBC Bank 15 Dillwyn Road	-	-	-	-	32.0
93	48 Ravenhill Road	-	-	-	-	29.9
94	64/66 Ravenhill Road	-	-	-	-	29.6
95	1123 Carmarthen Road	-	-	-	-	29.1
96	1078 Carmarthen Road	-	-	-	-	27.9
97	1068 Carmarthen Road	-	-	-	-	36.6
98	953 Carmarthen Road	-	-	-	-	**40.5**
99	860 Carmarthen Road	-	-	-	-	32.5
100	824 Carmarthen Road	-	-	-	-	28.7
101	692 Carmarthen Road	-	-	-	-	29.8
102	13 Delhi Street	-	-	-	-	29.4
103	13 Nantyffin Road	-	-	-	-	33.4
104	7/9 Nantyffin Road	-	-	-	-	29.4
105	135 Samlet Road	-	-	-	-	32.3
106	120 Samlet Road	-	-	-	-	33.8
107	30/32 Peniel Green Road	-	-	-	-	35.0
108	38/40 Glyncollen Drive	-	-	-	-	31.4
109	33 Glyncollen Drive	-	-	-	-	28.1

110	Anchorage 57 Cefn Glas	-	-	-	-	27.7
111	391 Clydach Road	-	-	-	-	32.9
112	L/Post outside Wilks 33 St Helens Road	-	-	-	-	**26**
113	Age Concern 69 St Helens Road	-	-	-	-	21.8
114	38 Walter Road	-	-	-	-	32.5
115	36 Mansel Street	-	-	-	-	**38.8**
116	Gas Service Wales, 16 Mansel Street	-	-	-	-	**41.5**
117	Friends of Blind 3 De La Beche Street	-	-	-	-	**39.4**
118	Breast Screening Centre 24 Alexandra Road	-	-	-	-	29.3
119	3/4 Pleasant Street (behind old Police Station)	-	-	-	-	32.2
120	L/Post outside Orchard St Clinic, 21 Orchard	-	-	-	-	**46.5**
121	CK's 73 High Street	**Y**	-	-	-	**79.3**
122	Emperor Restaurant, 206 High Street	-	-	-	-	**39.5**
123	The Bays, Mackworth Court,High Street,	-	-	-	-	**54.4**
124	L/Post between Argos/Uniterian Church, High	-	-	-	-	**44.1**
125	L/Post outside Army Careers/Opium Den, High Street	-	-	-	-	**51.4**
126	Info Nation (CCS Drop in Centre), 47 The Kingsway	-	-	-	-	**38.9**
127	D/Pipe side of Lloyds TSB 30 The Kingsway	-	-	-	-	**40.9**
128	The Money Shop 28a The Kingsway	-	-	-	-	**41.1**
129	Graham Evans Solicitors, Christina Street	-	-	-	-	36.1
130	D/Pipe fronting Dillwyn Street, Cecil Jones	-	-	-	-	**53.5**
131	EasyTan 4 Dillwyn Street	-	-	-	-	**58.3**
132	Etype, westway	-	-	-	-	32.7
133	51 Bathurst Street	-	-	-	-	26.8
134	Amor restaurant, 13 Dillwyn Street	-	-	-	-	**50.5**

Table 13 – NO2 Monitoring 2005-2008

It is clear from table 13 above, that those sites requiring correction for distance from road (with the background cell highlighted) were not corrected for during previous years (2005 – 2007). This is regrettable, as predicted concentrations are, in some cases, markedly different to the measured means presented in previous LAQM reporting. The error in reporting is tempered by the knowledge that correction during 2008 for sites 56, 70 and 71 has been made to existing dwellings. When construction works are complete at these development sites, relevant exposure will be considerably closer than that used to calculate the 2008 value. Despite this now obvious error, there remains a clear downward trend over the years in measured NO_2 concentrations while at the same time numerous sites remain above the annual mean objective level with several having the potential to exceed the annual mean being in the range 37- 40ug/m^3. A map of those failing sites and those with the potential to fail the annual mean objective is given below as map 9a.

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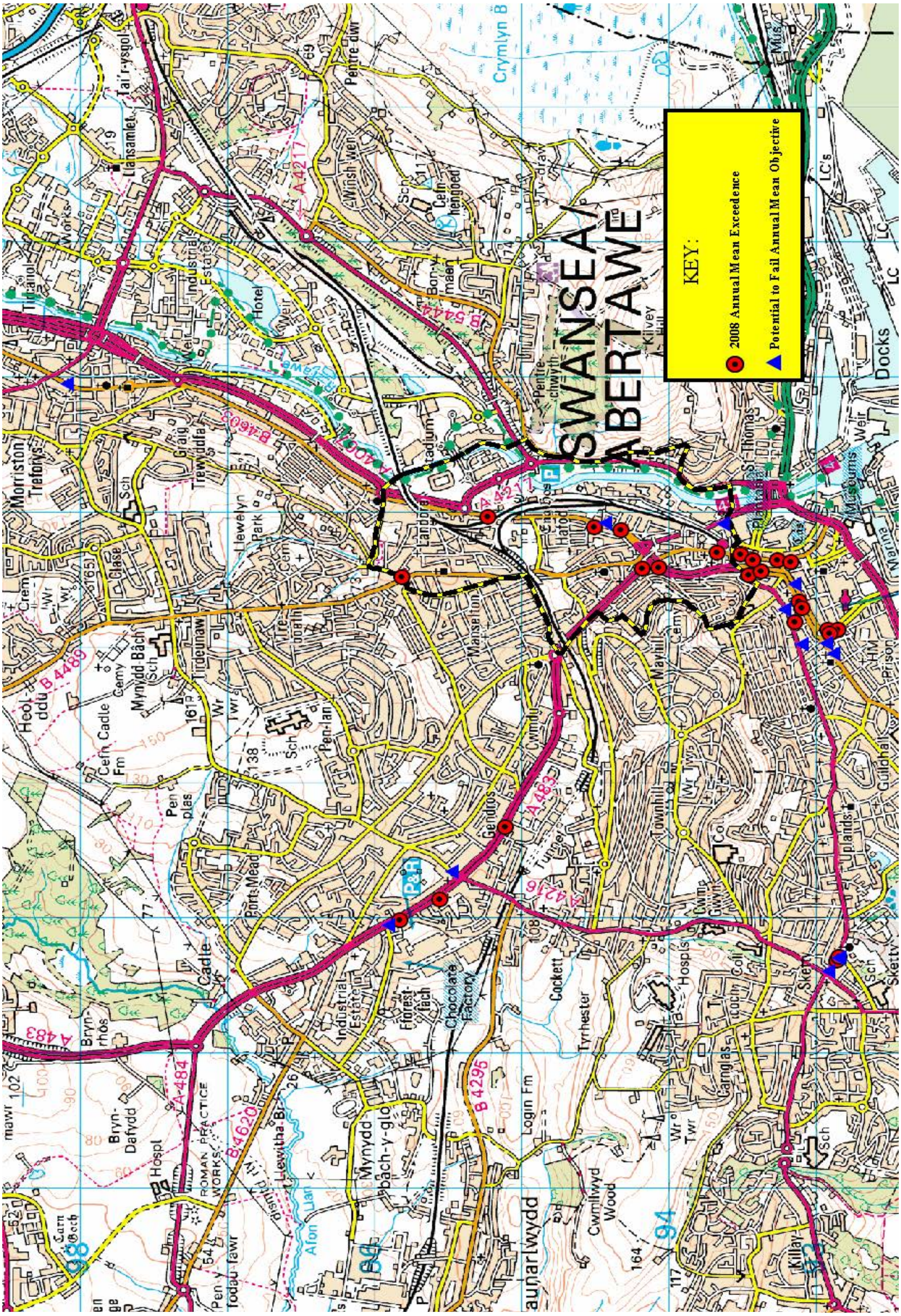

Map 9a – Annual Mean 2008 Failing NO_2 sites and those sites with potential to fail the annual mean objective

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TG (09) provides a method within box 2.1 page 2-4 to project measured annual mean roadside nitrogen dioxide concentrations to future years. Table 14 indicates predicted concentrations in 2010 and 2015.

Site ID	Location	Within AQMA?	Annual mean Adjusted for bias (µg/m^3) and distance from road	Future Years Projections	
			2008	2010	2015
1	12 Ystrad Road, Fforestfach	-	24.2	22.3	18.0
2	1332 Carmarthen Road, Fforestfach	-	16.3	15.0	12.2
3	2 Ffordd Cynore, Fforestfach	-	20.1	18.5	15.0
4	26 Dillwyn road, Sketty	-	30.8	28.4	23.0
5	108 Gower Road, Sketty	-	32.2	29.7	24.0
6	21 Vivian Road, Sketty	-	29.8	27.4	22.2
7	15 Gower Road, Sketty	-	**48.5**	**44.7**	36.2
8	1034 Carmarthen Road, Fforestfach	-	**42.4**	**39.0**	31.6
9	41 Station Road, Fforestfach	-	28.6	26.3	21.3
10	932 Carmarthen Road, Fforestfach	-	24.2	22.3	18.0
11	18 Ravenhill Road, Fforestfach	-	**37.8**	34.8	28.2
12	747 Carmarthen Road, Gendros	-	**40.7**	**37.5**	30.3
13	Brunel Court, Walter Road	-	28.9	26.6	21.5
14	14 Clarence Street	-	25.2	23.2	18.8
15	56 Westway	-	26.1	24.0	19.5
16	136 Osytersmouth Road	-	30.7	28.3	22.9
17	1-7 Arethusa Quay, Marina	-	22.8	21.0	17.0
18	6 Cwm Level Road, Landore	Y	**44.9**	**41.3**	33.5
19	49 Dyfatty Street, Dyfatty	Y	**42.6**	**39.2**	31.8
20	30 Carmarthen Road, Dyfatty	Y	**39.9**	36.7	29.7
21	33 Plough Road, Landore	Y	31.7	29.2	23.6
22	114 Pentreharne Road	Y	35.7	32.9	26.6
23	15 Mysydd Road, Landore	Y	34.1	31.4	25.4
24	126-149 Trawler Road, Marina	-	20.6	19.0	15.4
25	53 Mysydd Road, Landore	Y	27.7	25.5	20.6
26	1399 Neath Road, Landore	Y	**41.7**	**38.4**	31.1
27	1379 Neath Road, Landore	Y	**37.8**	34.8	28.2
28	119 Neath Road, Landore	Y	29.4	27.1	21.9
29	5 Morfa Terrace, Landore	Y	**56.3**	**51.8**	**42.0**
30	34-41 Trawler Road, Marina	-	20.1	18.5	15.0
31	289 Neath Road, Landore	-	32.4	29.8	24.2
32	6 Pentreguinea Road, St.Thomas	-	31.3	28.8	23.3
33	69 Pentreguinea Road, St.Thomas	-	31.0	28.5	23.1
34	1184 Neath Road, Landore	-	32.7	30.1	24.4
35	50 Delhi Street, St.Thomas	-	35.9	33.1	26.8
36	24 Delhi Street, St.Thomas	-	31.0	28.5	23.1
37	2 Sebastopol Street, St.Thomas	-	24.2	22.3	18.0
38	5 Port Tennant Road, Port Tennant	-	33.1	30.5	24.7
39	69 Port Tennant Road, Port Tennant	-	25.2	23.2	18.8
40	19 Pentrepoeth Road, Morriston	-	28.2	26.0	21.0
41	Fountain Inn, Woodfield Road	-	**37.3**	34.3	27.8

42	32 Sway Road, Morriston	**-**	34.8	32.0	25.9
43	17 Clase Road, Morriston	**-**	34.4	31.7	25.6
44	4 Ian's Walk, Ynysforgan	**-**	29.0	26.7	21.6
45	52 Glyncollen Drive, Ynysforgan	**-**	35.5	32.7	26.5
46	63 Wern fawr Road, Port Tennant	**-**	16.0	14.7	11.9
47	505 Clydach Road, Ynysforgan	**-**	23.9	22.0	17.8
48	5 Bevans Row, Port Tennant	**-**	25.2	23.2	18.8
49	34 Nantyffin Road, Llansamlet	**-**	29.6	27.3	22.1
50	6 Nantyffin Road, Llansamlet	**-**	35.3	32.5	26.3
51	138 Samlet Road, Llansamlet	**-**	32.2	29.7	24.0
52	87 Midland Place, Llansamlet	**-**	22.5	20.7	16.8
53	16 Church Road, Llansamlet	**-**	22.9	21.1	17.1
54	12 Peniel Green Road, Llansamlet	**-**	34.6	31.9	25.8
55	38 Peniel Green Road, Llansamlet	**-**	35.3	32.5	26.3
56	Ynysallan Road, Birchgrove	**-**	23	21.2	17.1
57	18 Coed Fedwen, Birchgrove	**-**	15.4	14.2	11.5
58	16 Uplands Crescent, Uplands	**-**	33.6	30.9	25.0
59	Hafod Post Office	**Y**	**53.9**	**49.6**	**40.2**
60	10 St.Helens Road	**-**	**37.1**	34.2	27.7
61	Pacos, St.Helens Road	**-**	**38.0**	35.0	28.3
62	Copper Quarter 1	**-**	29.0	26.7	21.6
63	6 De La Beche Road	**-**	21.6	19.9	16.1
64	7 Gower Road	**-**	**42.4**	**39.0**	31.6
65	Stewart Hall, Gower Road	**-**	27.0	24.9	20.1
66	60 Sketty Road	**-**	32.8	30.2	24.5
67	Newcut Road	**Y**	**38.2**	35.2	28.5
68	Orchard Street	**-**	34.4	31.7	25.6
69	Llys Glas	**-**	**42.1**	**38.8**	31.4
70	Copper Quarter 2	**-**	23.3	21.5	17.4
71	Copper quarter 3	**-**	19.9	18.3	14.8
72	10/12 Uplands Crescent	**-**	25.1	23.1	18.7
73	1 Uplands Crescent	**-**	34.0	31.3	25.3
74	4 Nyanza Terrace	**-**	28.9	26.6	21.5
75	15 Uplands Crescent	**-**	35.1	32.3	26.2
76	36/38 Uplands Crescent	**-**	26.1	24.0	19.5
77	6/8 Glanmor Road	**-**	22.8	21.0	17.0
78	16/18 Glanmor Road	**-**	27.5	25.3	20.5
79	Alexandra Hotel 3 Sketty Road	**-**	33.0	30.4	24.6
80	Orthadontic Clinic 63 Sketty Road	**-**	24.8	22.8	18.5
81	24/26 Gower Road	**-**	23.3	21.5	17.4
82	48/50 Gower Road	**-**	26.0	23.9	19.4
83	64/66 Gower Road	**-**	29.8	27.4	22.2
84	9 Gower Road	**-**	**37.3**	34.3	27.8
85	13 Gower Road	**-**	**38.6**	35.5	28.8
86	72 Gower Road	**-**	30.8	28.4	23.0
87	1/2 De La Beche Road	**-**	21.3	19.6	15.9
88	96/98 Gower Road (Sketty Travel)	**-**	**37.3**	34.3	27.8
89	5 Vivian Road	**-**	22.4	20.6	16.7

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90	18/20 Vivian Road	**-**	34.2	31.5	25.5
91	114 Gower Road	**-**	31.7	29.2	23.6
92	Pole outside HSBC Bank 15 Dillwyn Road	**-**	32.0	29.5	23.9
93	48 Ravenhill Road	**-**	29.9	27.5	22.3
94	64/66 Ravenhill Road	**-**	29.6	27.3	22.1
95	1123 Carmarthen Road	**-**	29.1	26.8	21.7
96	1078 Carmarthen Road	**-**	27.9	25.7	20.8
97	1068 Carmarthen Road	**-**	36.6	33.7	27.3
98	953 Carmarthen Road	**-**	**40.5**	**37.3**	30.2
99	860 Carmarthen Road	**-**	32.5	29.9	24.2
100	824 Carmarthen Road	**-**	28.7	26.4	21.4
101	692 Carmarthen Road	**-**	29.8	27.4	22.2
102	13 Delhi Street	**-**	29.4	27.1	21.9
103	13 Nantyffin Road	**-**	33.4	30.8	24.9
104	7/9 Nantyffin Road	**-**	29.4	27.1	21.9
105	135 Samlet Road	**-**	32.3	29.7	24.1
106	120 Samlet Road	**-**	33.8	31.1	25.2
107	30/32 Peniel Green Road	**-**	35.0	32.2	26.1
108	38/40 Glyncollen Drive	**-**	31.4	28.9	23.4
109	33 Glyncollen Drive	**-**	28.1	25.9	20.9
110	Anchorage 57 Cefn Glas	**-**	27.7	25.5	20.6
111	391 Clydach Road	**-**	32.9	30.3	24.5
112	L/Post outside Wilks 33 St Helens Road	**-**	26.0	23.9	19.4
113	Age Concern 69 St Helens Road	**-**	21.8	20.1	16.3
114	38 Walter Road	**-**	32.5	29.9	24.2
115	36 Mansel Street	**-**	**38.8**	35.7	28.9
116	Gas Service Wales, 16 Mansel Street	**-**	**41.5**	**38.2**	30.9
117	Friends of Blind 3 De La Beche Street	**-**	**39.4**	36.3	29.4
118	Breast Screening Centre 24 Alexandra Road	**-**	29.3	27.0	21.8
119	3/4 Pleasant Street (behind old Police Station)	**-**	32.2	29.7	24.0
120	L/Post outside Orchard St Clinic, 21 Orchard	**-**	**46.5**	**42.8**	34.7
121	CK's 73 High Street	**Y**	**79.3**	**73.0**	**59.1**
122	Emperor Restaurant, 206 High Street	**-**	**39.5**	36.4	29.4
123	The Bays, Mackworth Court,High Street,	**-**	**54.4**	**50.1**	**40.6**
124	L/Post between Argos/Uniterian Church, High	**-**	**44.1**	**40.6**	32.9
125	L/Post outside Army Careers/Opium Den, High Street	**-**	**51.4**	**47.3**	**38.3**
126	Info Nation (CCS Drop in Centre), 47 The Kingsway	**-**	**38.9**	35.8	29.0
127	D/Pipe side of Lloyds TSB 30 The Kingsway	**-**	**40.9**	**37.7**	30.5
128	The Money Shop 28a The Kingsway	**-**	**41.1**	**37.8**	30.6
129	Graham Evans Solicitors, Christina Street	**-**	36.1	33.2	26.9
130	D/Pipe fronting Dillwyn Street, Cecil Jones	**-**	**53.5**	**49.3**	**39.9**
131	EasyTan 4 Dillwyn Street	**-**	**58.3**	**53.7**	**43.5**
132	Etype, Westway	**-**	32.7	30.1	24.4
133	51 Bathurst Street	**-**	26.8	24.7	20.0
134	Amor restaurant, 13 Dillwyn Street	**-**	**50.5**	**46.5**	**37.6**

Table 14 – Projected NO_2 annual means 2010 and 2015

Table 14 would appear to indicate a much improving situation in 2015. However, what is not known is the continued impact of the newer EURO category diesel vehicles and how the adjustment factors within TG(09) account for the additional primary NO2 emitted by these vehicles as their impact and numbers within the fleet increases. A query was raised with the LAQM Review and Assessment Helpdesk to address this question. An answer has been received which stated “AEA Technology, who are responsible for producing these factors, have confirmed that the impacts of Euro standards are included in the projections up to Euro 6 for LDVs and Euro Vi for HDVs and that the impact of expected changes in primary NO2 emission fractions is also included ”. Given the above, it is reasonable to assume that widespread exceedences will remain during 2010 but with an ever increasing reduction in NO2 annual mean concentrations being seen during 2015. However, previous LAQM experience has shown that future year projections have not always materialised due to unforeseen circumstances, so the projections obtained by using the method within LAQM.TG(09) should be treated with caution.

2.2.3 Particulate Matter PM_{10}

Thermo FDMS system are installed at all 3 sites (Swansea AURN, Morfa and Morriston Groundhogs), providing equivalency with the EU reference gravimetric method[20].

Brief operational issues that have been identified are outlined here for information as the operation of the FDMS units differs substantially from that of the R&P Teom units.

The FDMS units are required to operate within an ambient enclosure temperature range between 18-22°C[21]. Opinions vary as to the exact optimum temperature but Swansea’s experience indicates around 18-20°C to be adequate and one that is capable of being maintained relatively stably by the installed air conditioning system.

[20] DEFRA and devolved administrations report UK Equivalence Program for Monitoring of Particulate Matter section 5.5.2 dated 5th June 2006 at http://www.airquality.co.uk/archive/reports/cat05/0606130952_UKPMEquivalence.pdf

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The FDMS units provide hourly integration data and have all been configured as per DEFRA's FDMS parameter protocol (as amended during February 2008). The RS232 port on the FDMS control unit allows the collection of up to 8 parameters via telemetry. The parameters collected from the FDMS units are: Volatile Mass, Non Volatile Mass, External Dew Point, Sample Dew Point, Filter loading, Pressure, Status, External Ambient Air temperature. The control unit refers to these parameters in different terminology. The PM_{10} mass concentration is obtained via post processing of the volatile and non volatile mass parameters by creating a calculated channel within the database to subtract volatile mass from the non volatile mass.

Data collected from the FDMS units has an integration period of 1-hour. Hourly ratified Particulate Matter PM_{10} data for 2008 has been downloaded from the Air Quality Archive at http://www.airquality.co.uk/archive/flat_files.php?site_id=SWA1&zone_id=9 for the Swansea AURN and via the Welsh Air Quality Forum ratified datasets at http://www.welshairquality.co.uk/data_and_statistics.php for the Morfa and Morriston Groundhog sites. Since the Welsh Assembly Government awarded the contract to run the Welsh Air Quality Forum to AEA Energy and Environment in April 2004, all equipment and calibration gases stored on site is fully audited yearly by AEA Energy and Environment. These data have then been imported into the OPSIS Enviman Reporter databases allowing analysis and graphical presentation. The calculated hourly mean mass concentration data have then been further processed by the software package Opsis Enviman Reporter. In order to calculate the 24-hour mean a minimum of 75% (i.e. 18 out of 24) of the calculated hourly means were specified to be present[22]

The datasets collected from the FDMS systems are not directly comparable to the historical R&P PM_{10}TEOM datasets even given that the use of the advised interim default correction factor (1.3) was advised to estimate the EU reference gravimetric method. This correction factor has been called into dispute by various studies at diverse locations throughout the UK each deriving differing correction factors. TEOM PM_{10} data for 2006 has not therefore been included within table 15. These TEOM PM_{10} data have been reported within the authorities Progress Report during May

[22] *LAQM.TG(09) Annexe 1- Monitoring A1.216 page A1-48*

2008. It is not proposed to use the Volatile Correction Model for TEOM analysers developed by Kings College to "correct" the historical (2001-2006) R&P PM_{10}TEOM datasets at the Morfa and Morriston stations within this report. The dates that the PM_{10} FDMS systems were installed at each site are given below table 15 for information. Due to the limited available FDMS PM_{10} datasets for 2006 (which were also further compromised due to initial setup problems with the FDMS chiller units) no PM_{10} FDMS data has been presented for 2006

Site ID (see table 4 above)	Location	Within AQMA	Data Capture 2007 %	Data Capture 2008 %	Annual mean concentrations ($\mu g/m^3$)		
					2006	2007	2008
1	Swansea AURN	**Y**	82.2%	98.4%	*	18.29	17.49
2	Morfa Groundhog	**Y**	86.8%	50.0%	**	27	29.34
3	Morriston Groundhog	**N**	79.5%	60.1%	***	21.56	23.46

Table 15 Results of PM_{10} Automatic Monitoring: Comparison with Annual Mean Objective
* FDMS unit installed 26th September 2006
** FDMS unit installed 28th November 2006
*** FDMS unit installed 27th October 2006

Site ID	Location	Within AQMA	Data Capture 2007	Data Capture 2008	Number of Exceedences of 24-hour mean (50 $\mu g/m^3$)		
					2006	2007	2008
1	Swansea AURN	**Y**	82.2%	98.4%	**-**	7 (**32.53**)	6
2	Morfa Groundhog	**Y**	86.8%	50.0%	**-**	22 (**45.6**)	15 (**45.79**)
3	Morriston Groundhog	**N**	79.5%	60.1%	**-**	8 (33.1)	11 (37.21)

Table 16 Results of PM_{10} Automatic Monitoring: Comparison with 24-hour Mean Objective

The 90th percentile's of the daily mean of measurements made during 2007 and 2008 are presented within brackets in table 16 where appropriate, as the data capture rates in the majority of instances fall below the required 90%.[23] There have been numerous problems since the installation of the of the Thermo Inc FDMS PM_{10} analysers at the 3 sites during late 2006, resulting in significant periods of data loss**.** These issues have been both costly and time consuming to rectify. Problems have ranged from the inability to gain a stable frequency response within the tuner board, corruption of the software within the control unit, status error codes due to ice within the chiller unit, to complete sensor unit failures. These issues have extended over the whole period of operation but as the introduction of FDMS units has increased within the UK National AURN Network, additional problems have been identified with

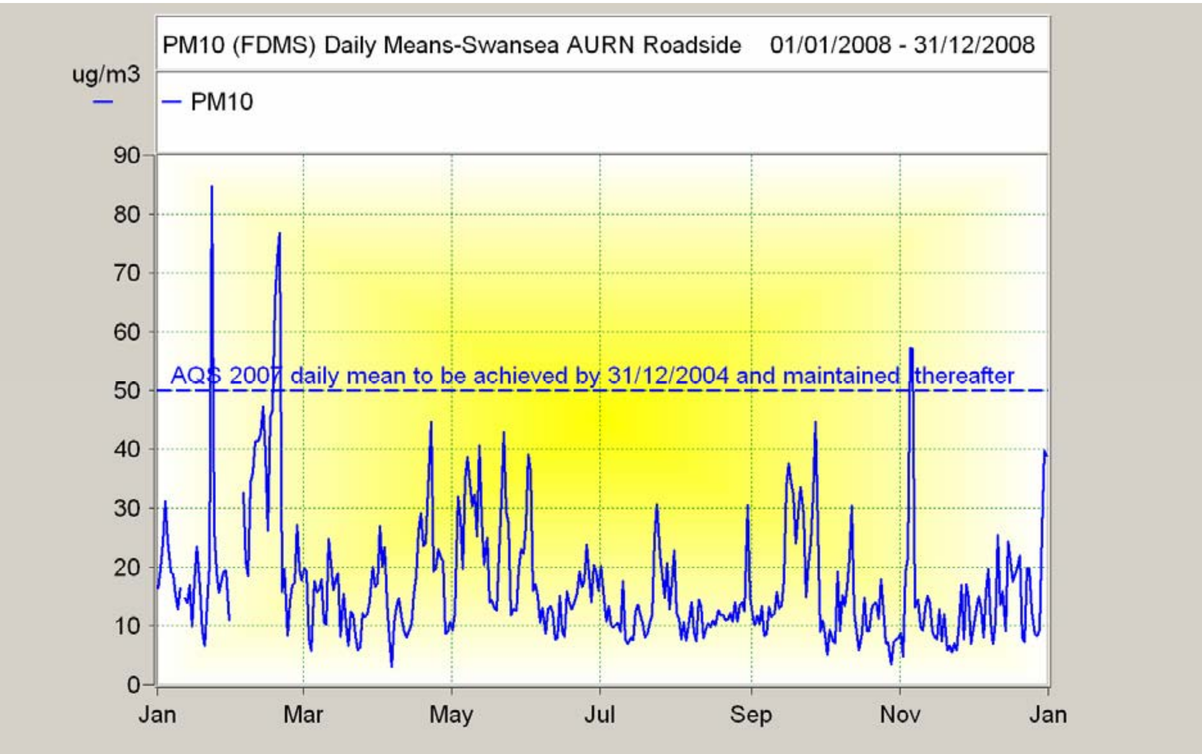
[23] LAQM TG(09) Annexe A1 – A1.157 page A1-34

their routine operation. It is now thought that these problems, have now in the main, been resolved as data capture for the first quarter of 2009 is looking at this early stage to be satisfactory at the Morfa and Morriston sites.

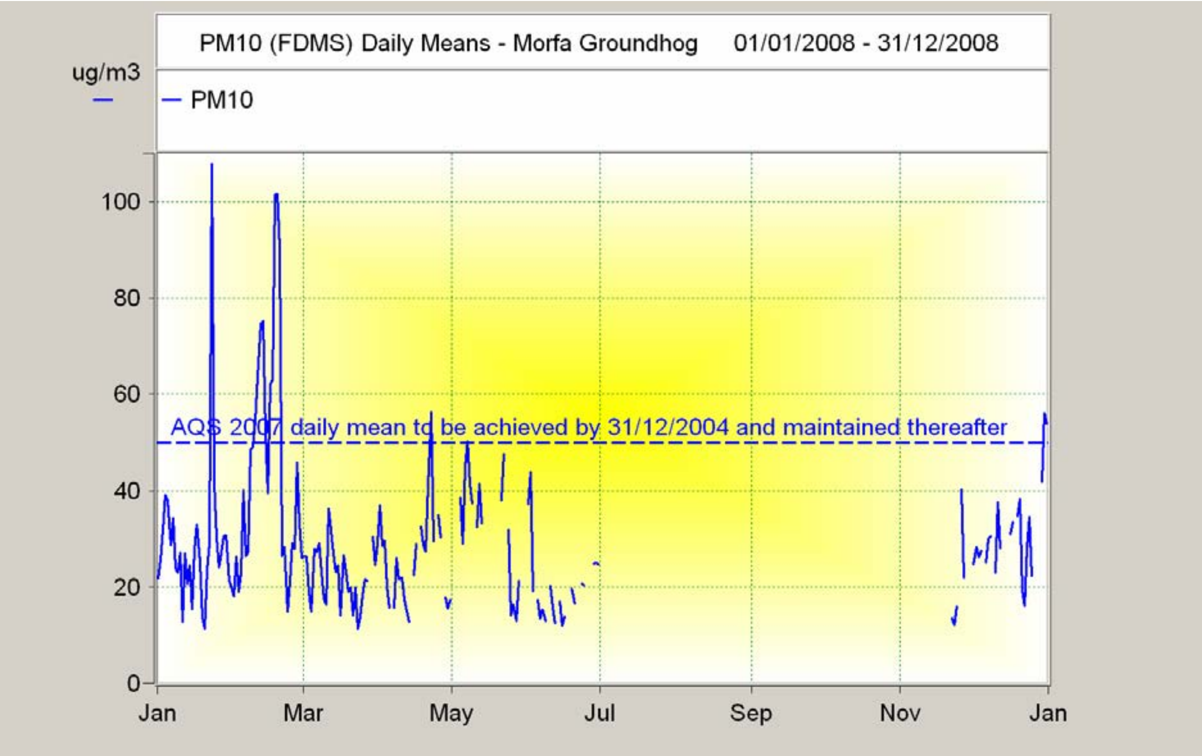
As can be seen from tables 15 and 16, **no exceedences of the annual mean objective** were seen at any of the monitoring stations. Similarly, **no breach of the 35 permitted exceedences of the 24 hour objective** was seen, **nor, where data capture was below 90% did the 90th percentile** (given in brackets after the number of exceedences) **exceed 50ug/m^3**.

Graphs 4-6 below, detail the monitoring undertaken during 2008 with a scatter plots of the daily means being shown within scatter plot 3.

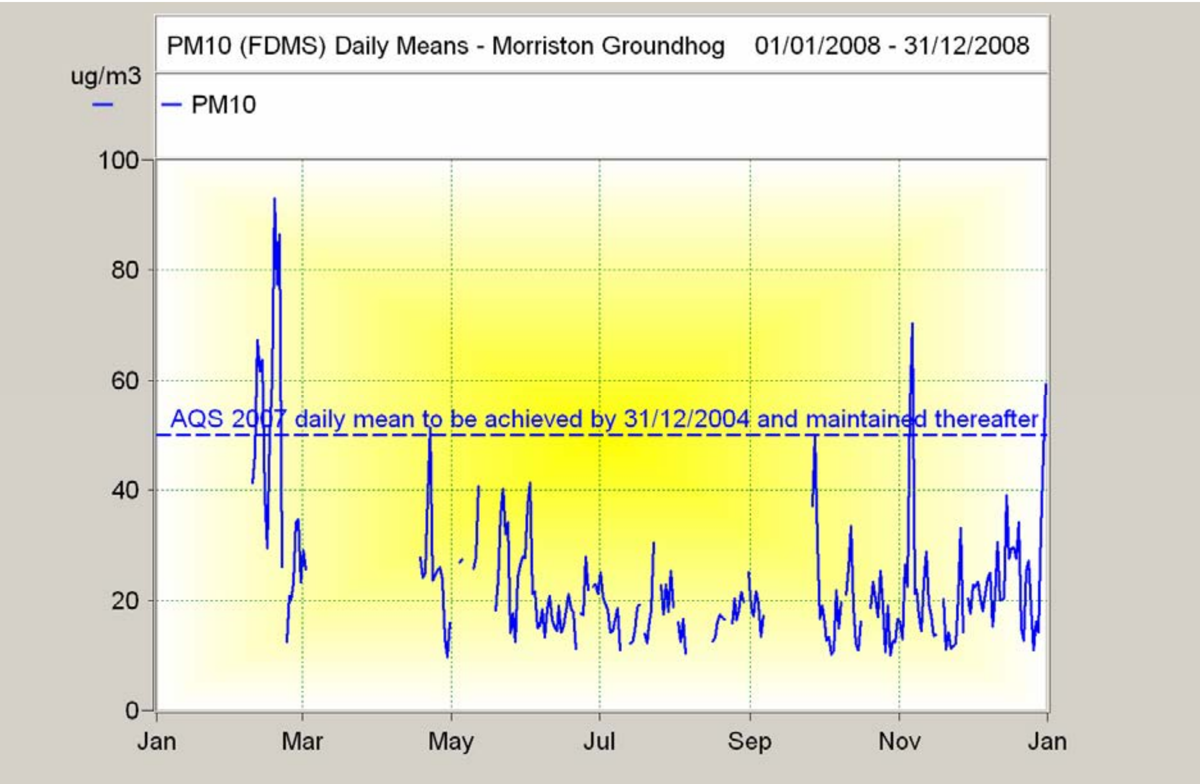
Table 4 details the distance to the nearest relevant exposure to these roadside sites (maximum distance of 34m).



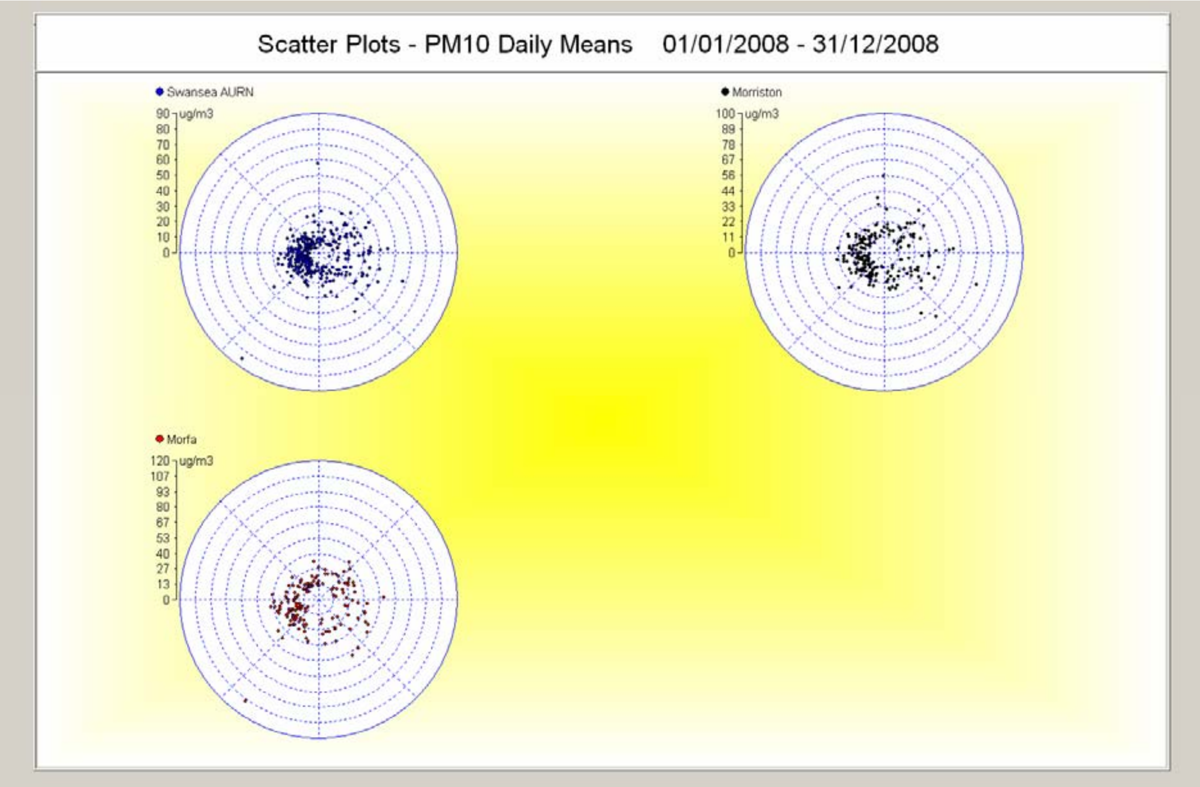
Graph 4 – Swansea AURN 24-hour FDMS PM_{10} concentrations 2008



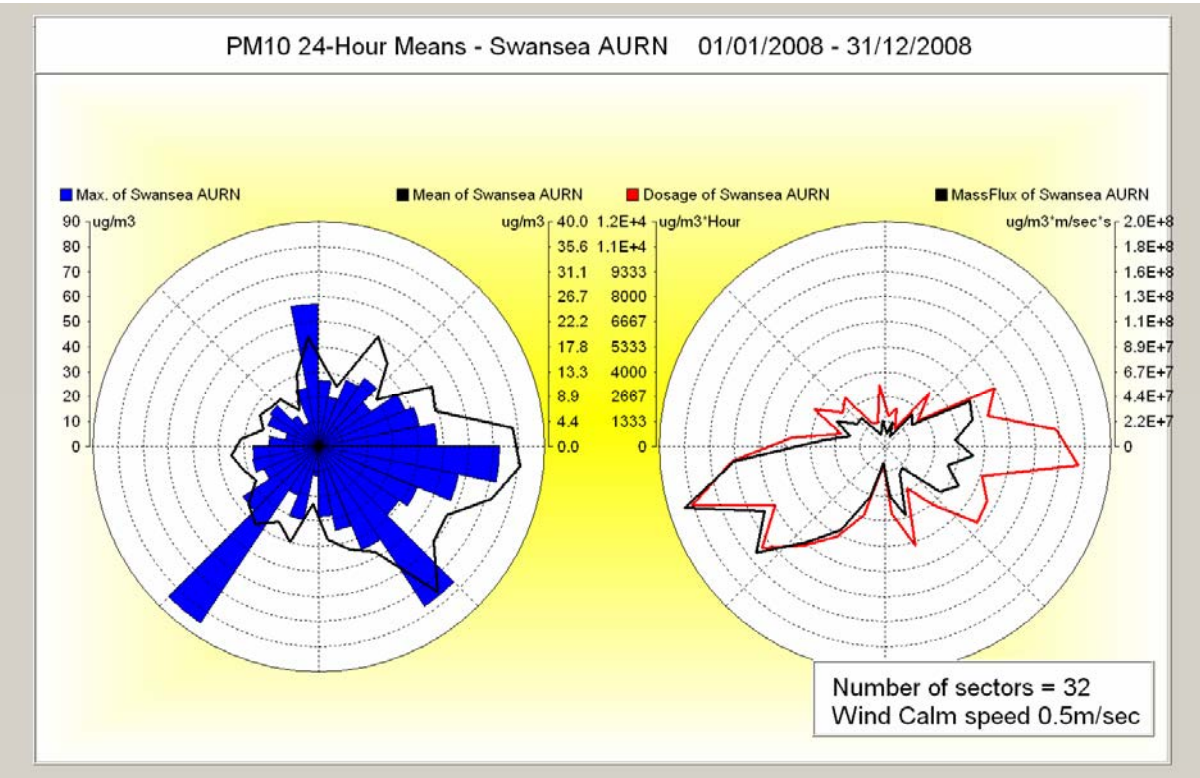
Graph 5 – Morfa Groundhog 24-hour FDMS PM_{10} concentrations 2008



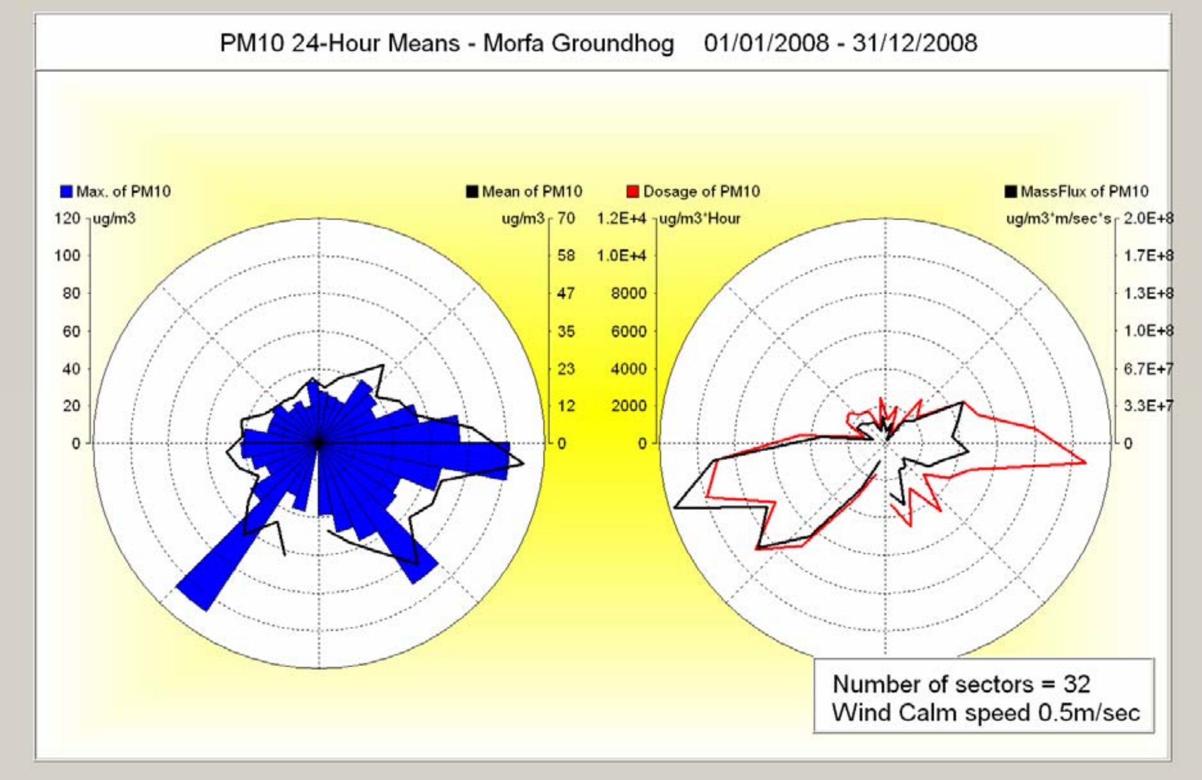
Graph 6 – Morriston Groundhog 24-hour FDMS PM_{10} concentrations 2008



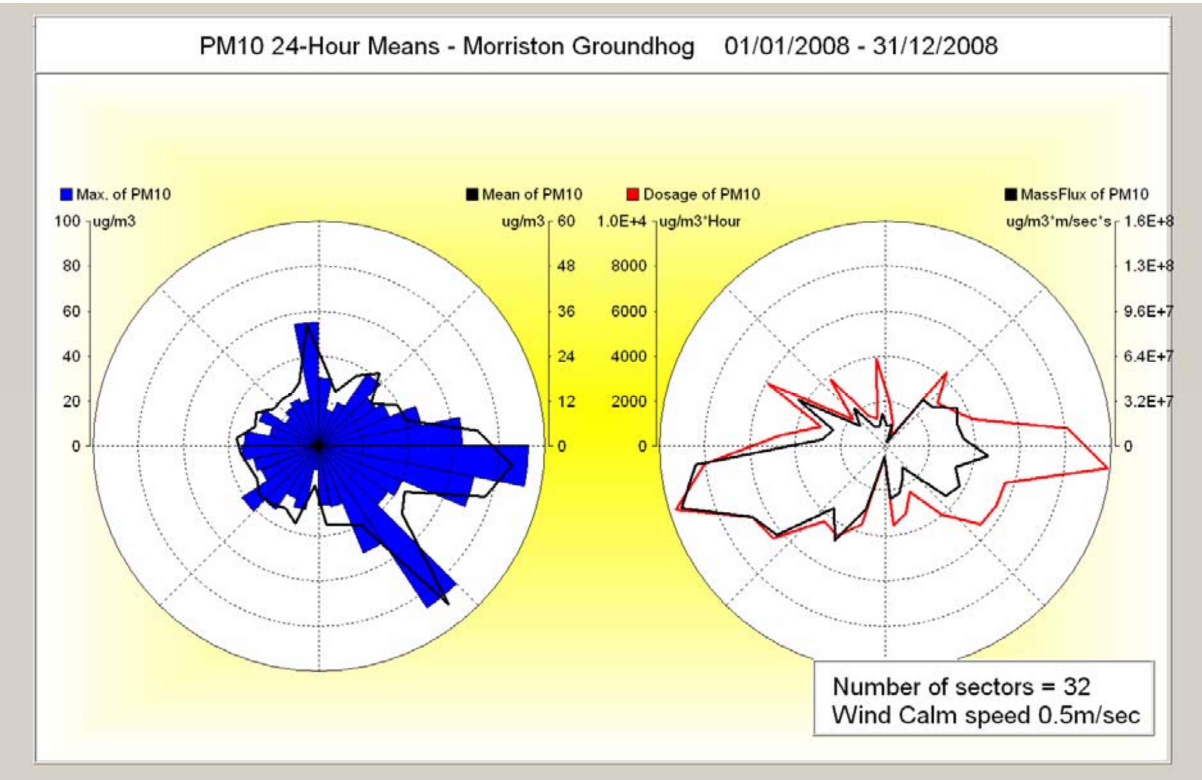
Scatter Plot 3 – PM_{10} daily Means 2008



Breuer Plot 2 – Swansea AURN PM_{10} 2008



Breuer Plot 3 – Morfa Groundhog PM_{10} 2008



Breuer Plot 4 – Morriston Groundhog PM_{10} 2008

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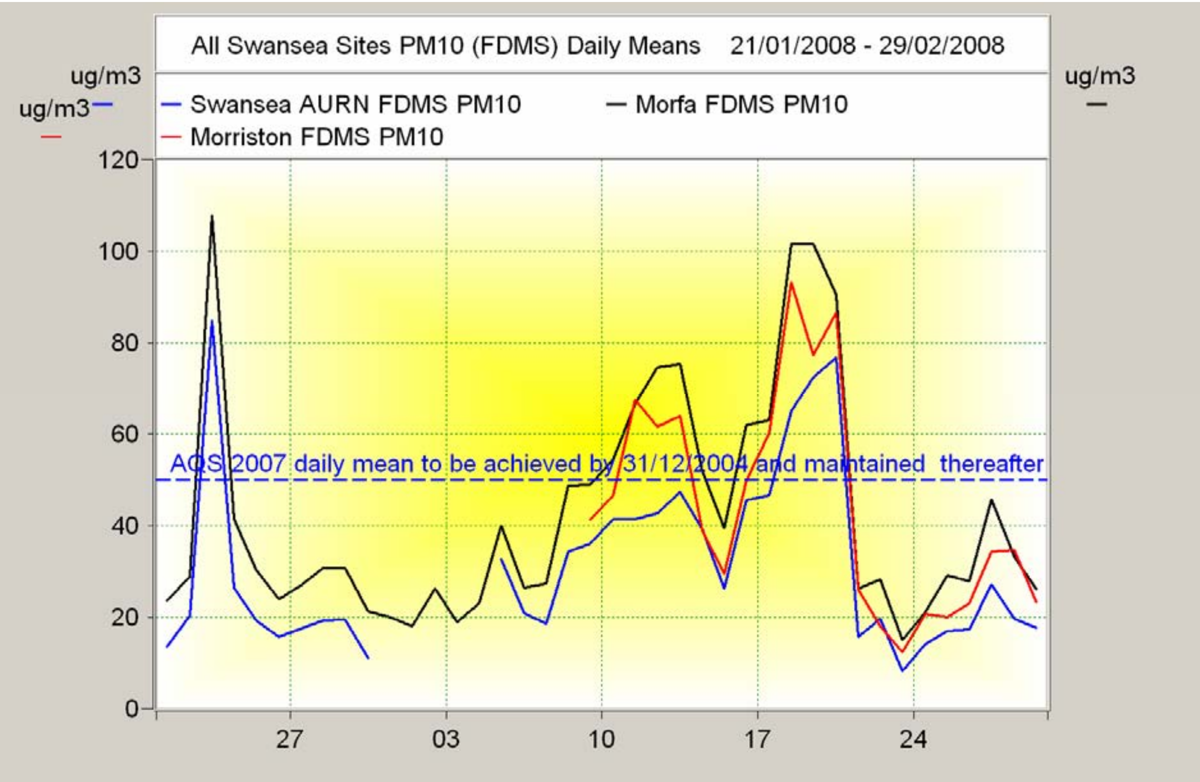
Breuer Plots 2-4 above indicate that the primary source of PM_{10} concentrations are from the south east as evident in the maximum and mean concentration plots. Interestingly, at the Swansea AURN and Morfa Groundhog sites there is an indication of maximum concentrations from a south westerly source. This however may be just one or two data points skewing the overall picture of maximum concentrations as the mean concentrations emanate primarily from a south easterly direction. There is heavy industry located to the south east of Swansea Bay in the form of the Corus steelworks at Port Talbot. This has been the traditional dominant source of localised and directionally apportioned PM_{10} seen within Swansea since measurement of PM_{10} commenced during the late 1990's.

Dosage is indicated within Breuer Plots 2-4. Dosage is taken to be the accumulated time multiplied with the average value of PM_{10}. This is useful for calculations of likely exposure at these locations. Mass Flux is also indicated within Breuer Plots 2-4 and is taken to be: Flux - the wind speed multiplied with the operand distributed over the wind direction. All data that has valid integrated data for all three positions are included in this calculation. (Note: The average distributed wind speed and the average distributed parameter (PM_{10}) are not used to calculate the result). The result is presented in the multiplied units of the wind speed and the parameter (PM_{10}). Mass flux is the same as flux, but the result is multiplied with the accumulated integration time. This gives the mass transport in different directions

It should be noted that during January and February 2008 there were regional / UK wide episodes seen in Swansea as a result of Saharan dust and/or Ukrainian Forest fires (22-23rd January) and also a period during 18th-22nd February of a stagnant air mass under a high pressure cell. The Swansea AURN site and Morfa Groundhog sites recorded both these episodes with the troubled operation at the Morriston site only managing to record the February episode. Interestingly, the period around the 10th to 15th February saw the early formation of high PM_{10} concentrations with the two monitoring stations located on the valley floor (Morfa and Morriston) recording higher concentrations during this initial phase. The Swansea AURN site is located in an open aspect approximately 55m above sea level with direct views over Swansea Bay. It is therefore more exposed, and it is thought probable that this site may well sit above any inversion that forms within the lower Swansea Valley and therefore, does not experience the elevated concentrations seen at the other monitoring stations during such conditions.

Graph 7 below shows the FDMS PM_{10} daily means from all 3 Swansea sites between the 21st January and 29th February 2008



Graph 7 – Swansea FDMS Site – Daily Means 21st January – 29th February 2008

LAQM.TG(09) provides a method to project measured annual mean roadside PM_{10} concentrations to future years[24]. Using this method, the following future year projections for 2010 and 2015 are presented below within table 16b. In order to reach the final calculation, the following steps were taken:

Steps 1-4	Measured 2008 Conc.	2008 Background Conc.	2008 Local Road Contribution	Road Cont. 2008	Road Cont 2010	Road Cont 2015
Swansea AURN	17.49	18.25	**-0.76**	-	-	-
Morfa	29.34	18	11.34	1.086611	0.990602	0.724368
Morriston	23.46	18	5.46	1.098525	1.000839	0.723783

[24] LAQM.TG(09) box 2.2 page 2-5

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As a negative local road contribution was produced for the Swansea AURN as the background was higher than the measured concentration, guidance within LAQM.TG(09) paragraph 2.12 was followed following an enquiry to the Review and Assessment Helpdesk. Ratios between the future projection years of 2010 and 2015 were made against that for 2008 which were then multiplied by the measured concentration in 2008. This method produced the projections for the Swansea AURN within table 16b.

Step 5	Year Adj. Factor 2010	Year Adj. Factor 2015
Swansea AURN	-	-
Morfa	0.911643633	0.666630468
Morriston	0.911075306	0.658868028

Step 6	Year Adj. Factor 2010	Year Adj. Factor 2015
Swansea AURN	-	-
Morfa	0.911643633	0.666630468
Morriston	0.911075306	0.658868028

Site ID	**Location**	**Within AQMA?**	**Measured Annual mean 2008**	**Future Years Projections**	
				2010	**2015**
1	Swansea AURN	Y	17.49	17.08	16.60
2	Morfa Groundhog	Y	29.34	28.27	25.02
3	Morriston Groundhog	N	23.46	23.02	21.17

Table 16b – PM_{10} Matter Future Projections 2010 and 2015

The City & County of Swansea facilitated a research study by a group comprising: School of Earth and Ocean Sciences Cardiff University, School of Biosciences Cardiff University, and the Centre for Health and Environment Research, Department of Primary Care and Public Health, Neuadd Meirionydd into ultrafine and nanoparticles using a Dekati™ Electrical Low Pressure Impactor within a street canyon environment. The site chosen for measurements was the Hafod Post Office, Neath Road, Hafod, Swansea. This site is located within the Hafod Air Quality (NO_2) Management Area.

Full details of the study are reproduced with the permission of the group, within Annexe 4. The study confirmed the existence of an early morning diurnal pattern within the ultrafine fraction which appears to match the diurnal NO_2 pattern highlighted above within section 2.2.1, seemingly confirming the traffic source for these two pollutants.

2.2.4 Sulphur Dioxide

Measurements are undertaken with Advanced Pollution Instrumentation (API) real-time SO_2 analysers at the Swansea AURN, Morfa and Morriston Groundhog stations and also by the DOAS system at St Thomas. The logged 15-minute means have been compiled into hourly averages by the software package OPSIS Enviman Reporter. In order to compile a valid hourly mean, a minimum of 3, 15-minute means were specified[25]. Data capture of less than 75% for the hour therefore excludes that hour from any analysis. The derived hourly means have then been used to calculate both the hourly and 24-hour objectives. In order to calculate the 24-hour mean a minimum of 75% (i.e. 18 out of 24) of the ratified hourly means were specified to be present[26]

The QA/QC procedures undertaken by AEA Energy and Environment resulted in ratified 15-minute and 1-hour data expressed in $\mu g/m^3$ being provided for the Swansea AURN up to 1st October 2007. Following the reorganisation of the UK National Network, data post 1st October 2007 has been ratified by this authority using its own QA/QC procedures. Ratified datasets have been downloaded from the Welsh Air Quality Forum at http://www.welshairquality.co.uk/data_and_statistics.php for both the 15 minute integration and 1 hour averaging periods at the Morfa and Morriston Groundhog sites. All data is ratified by AEA Energy and Environment under the contract awarded by the Welsh Assembly Government to run the Welsh Air Quality Forum.

All results are presented in $\mu g/m^3$ for the Swansea AURN by multiplying the logged result in ppb by the conversion factor of 2.66[27] to produce results expressed in $\mu g/m^3$. Graphs 8-11 are presented below representing time series measurements made during 2009 with the accompanying Scatter and Breuer plots providing an insight into the more likely sources.

[25] LAQM.TG(09) Appendix A1 - Reporting of Monitoring data – Calculation of Exceedence Statistics A1.216 page A1-47
[26] LAQM.TG(09) Appendix A1 - Reporting of Monitoring data – Calculation of Exceedence Statistics A1.216 page A1-48
[27] *LAQM.TG(09) Appendix A1 - Data Processing- Box A1.5 page A1-36*

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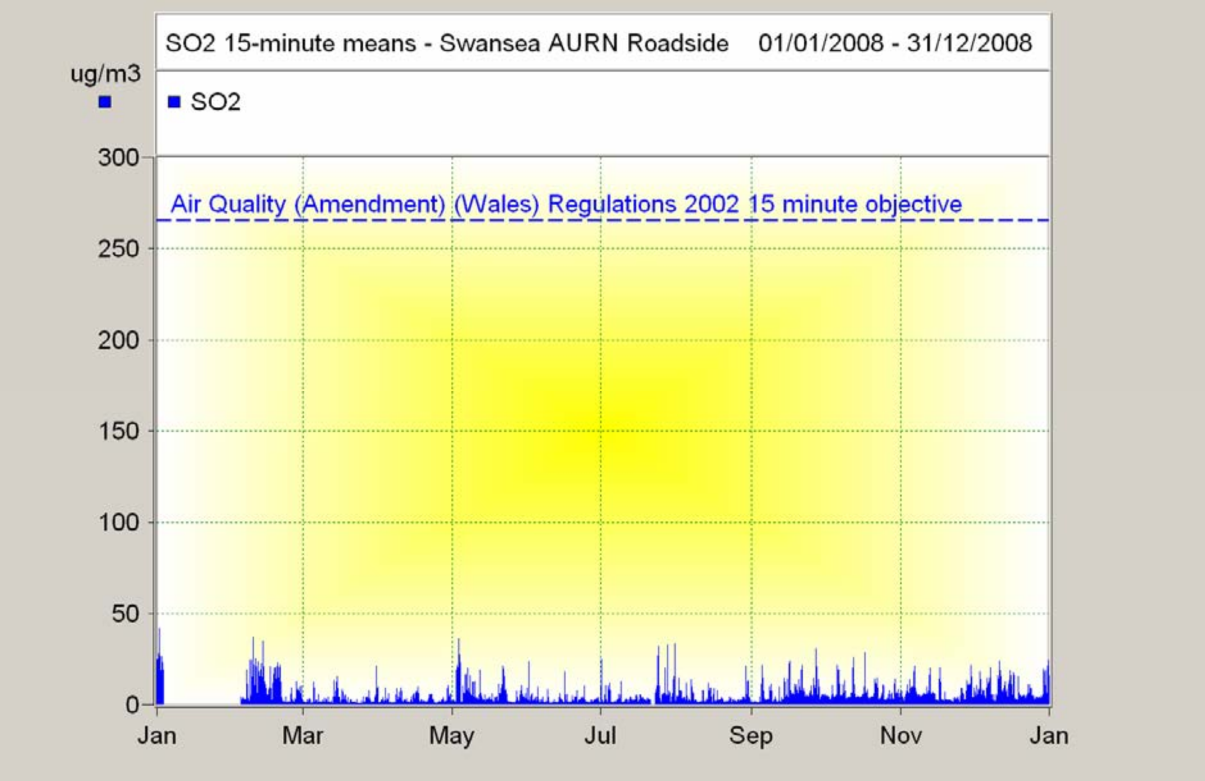
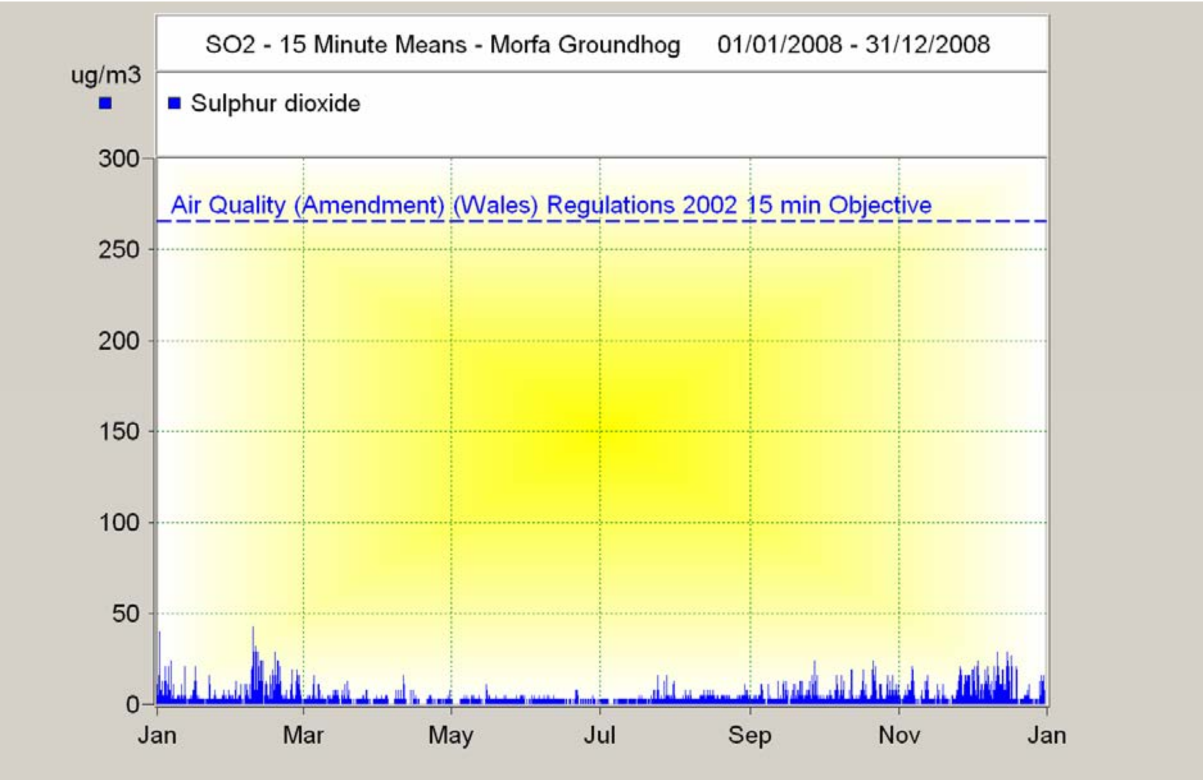
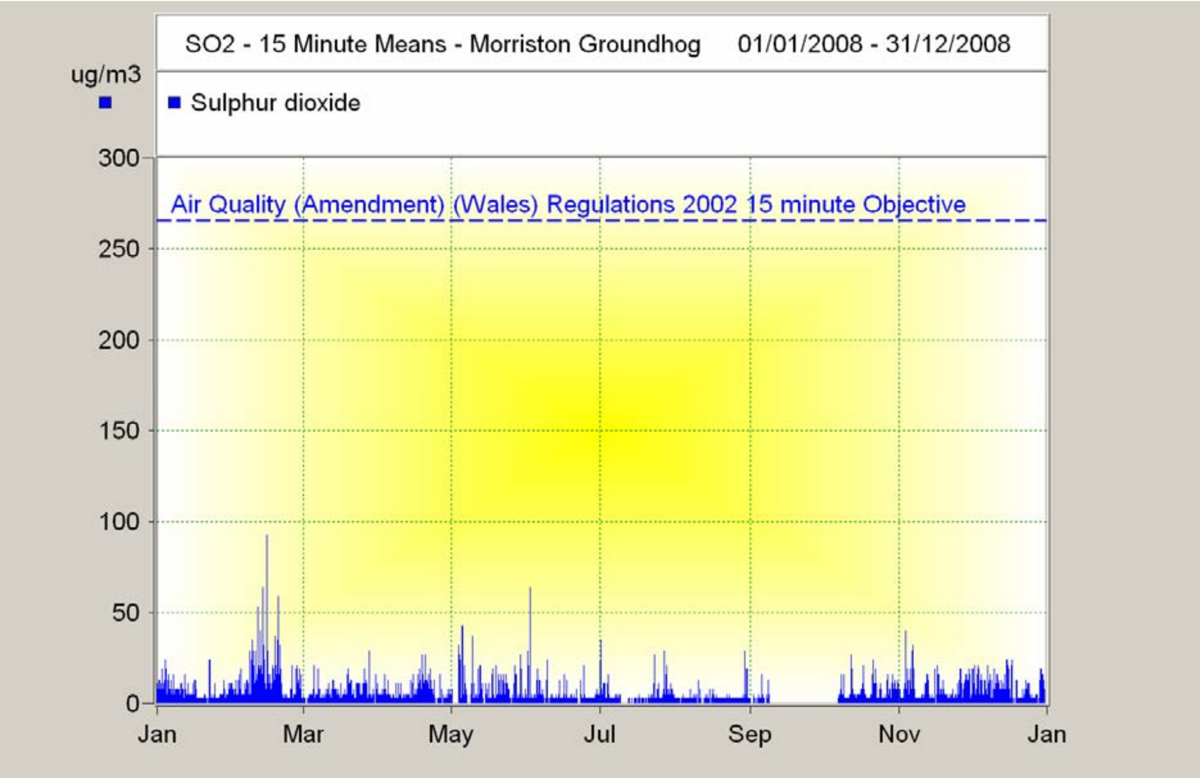


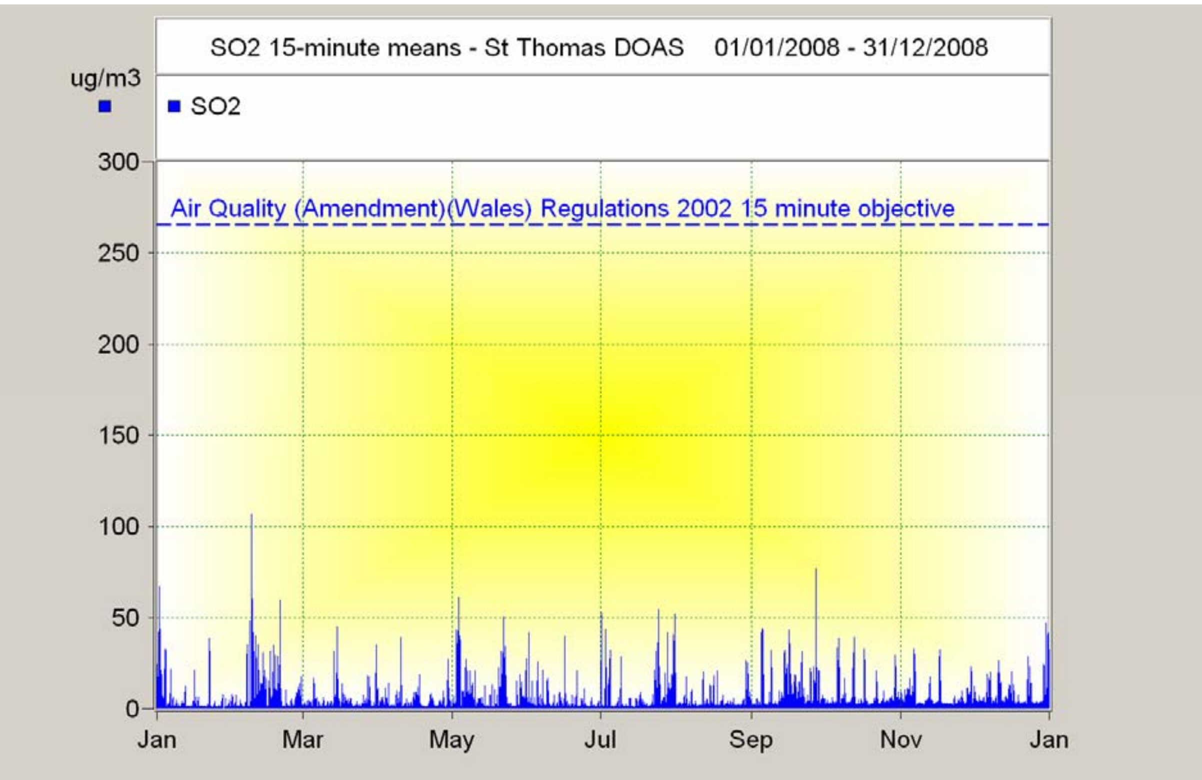
Graph 8 – Swansea AURN 15 minute SO_2 means 2008



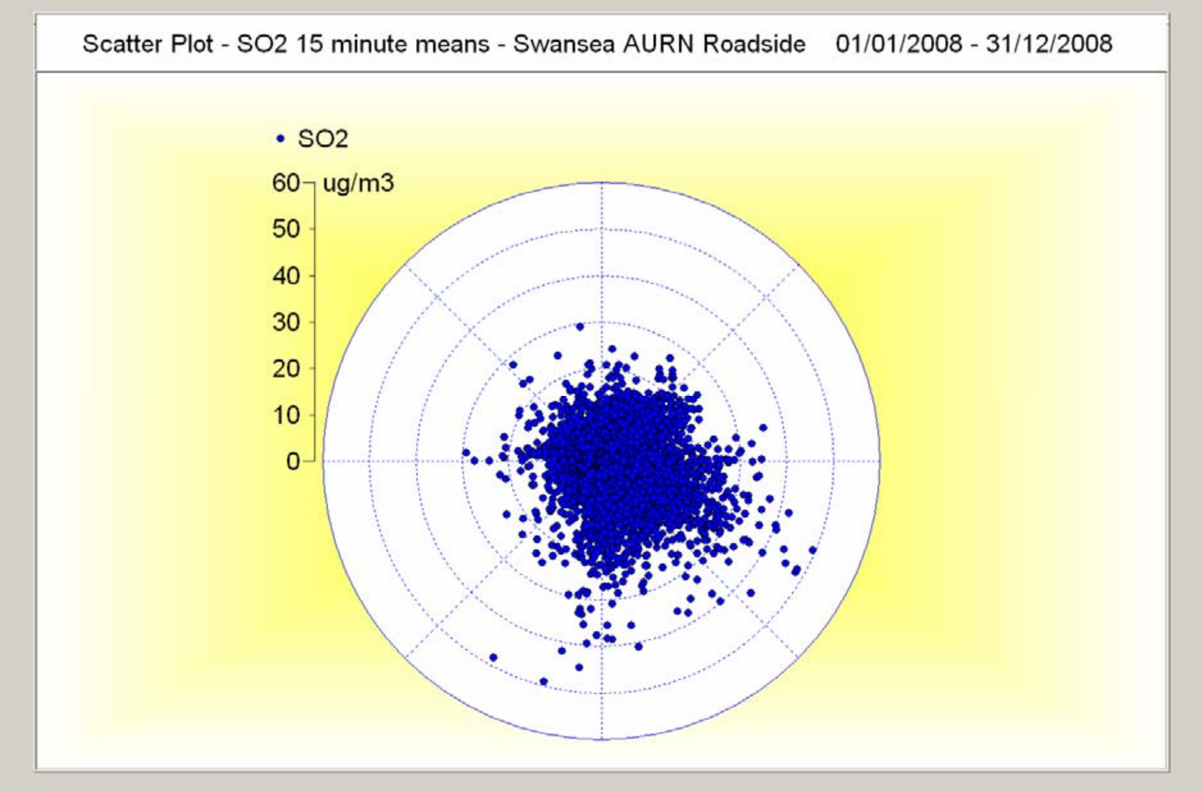
Graph 9 – Morfa Groundhog 15 minute SO_2 means 2008



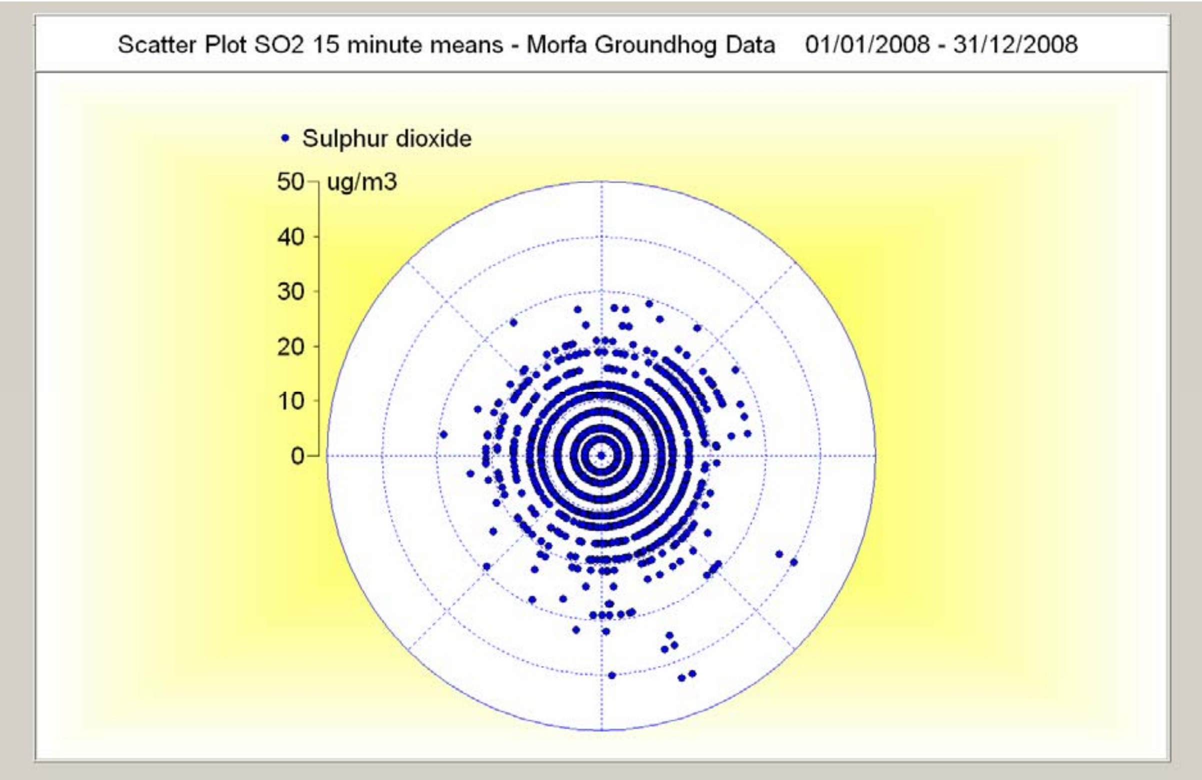
Graph 10 – Moriston Groundhog 15 minute SO_2 means 2008



Graph 11 – St Thomas DOAS 15 minute SO_2 means 2008

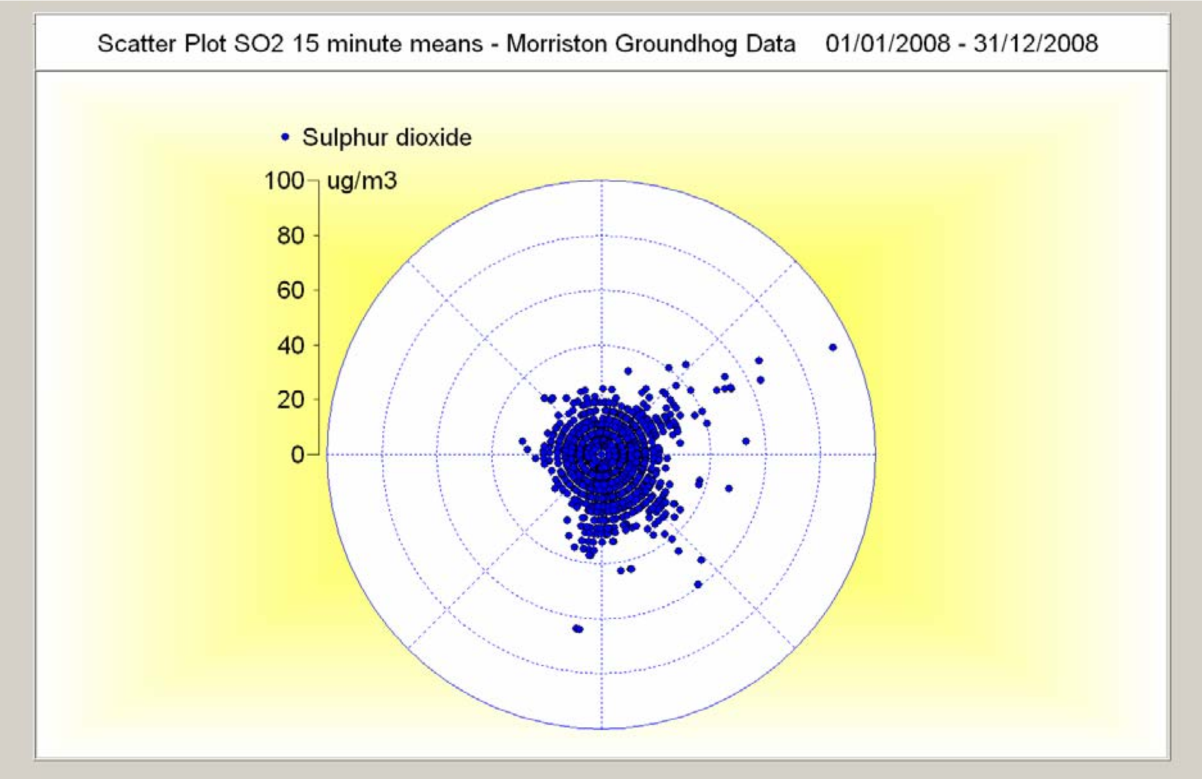


Scatter Plot 4 - SO_2 15 minute means Swansea AURN 2008

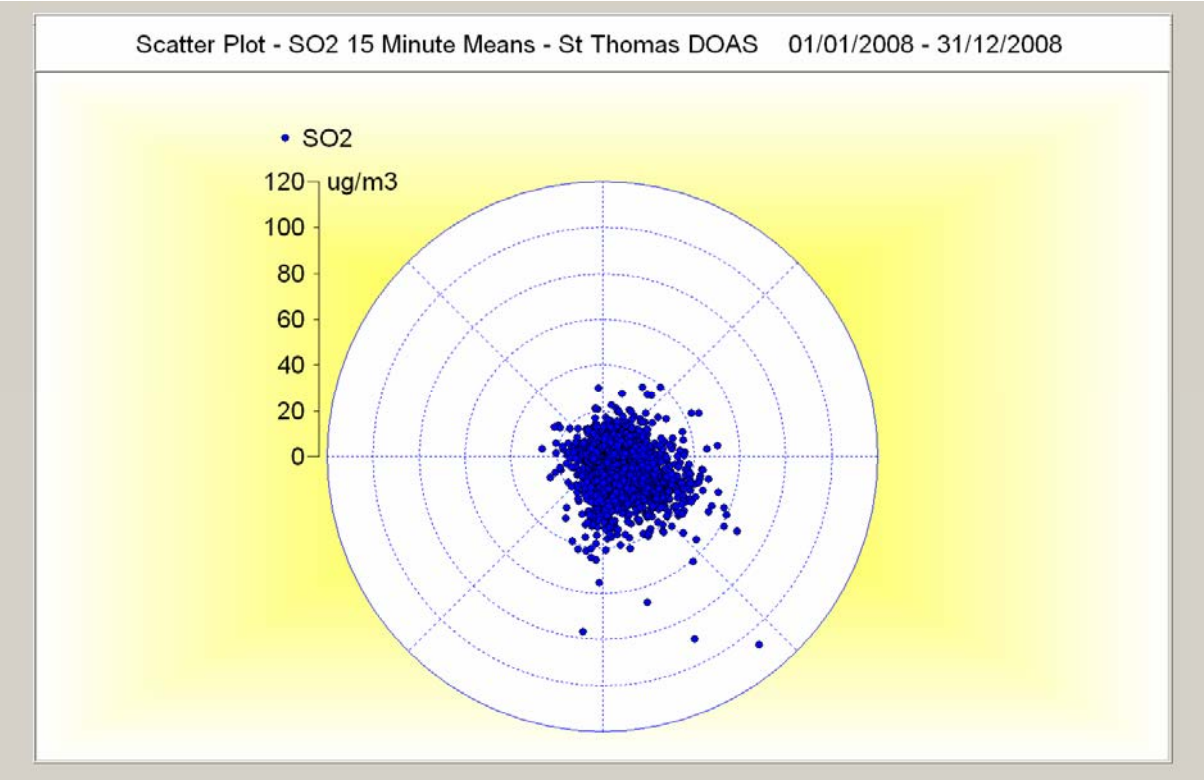


*Scatter Plot 5 - SO_2 15 minute means Morfa Groundhog 2008 **

** Elliptical effect in scatter plot 5 is thought to result from low ambient concentrations and that the ratified data points by appear to have been consistently rounded to the nearest whole number.*



Scatter Plot 6 - SO_2 15 minute means Moriston Groundhog 2008



Scatter Plot 7- SO_2 15 minute means St Thomas DOAS 2008

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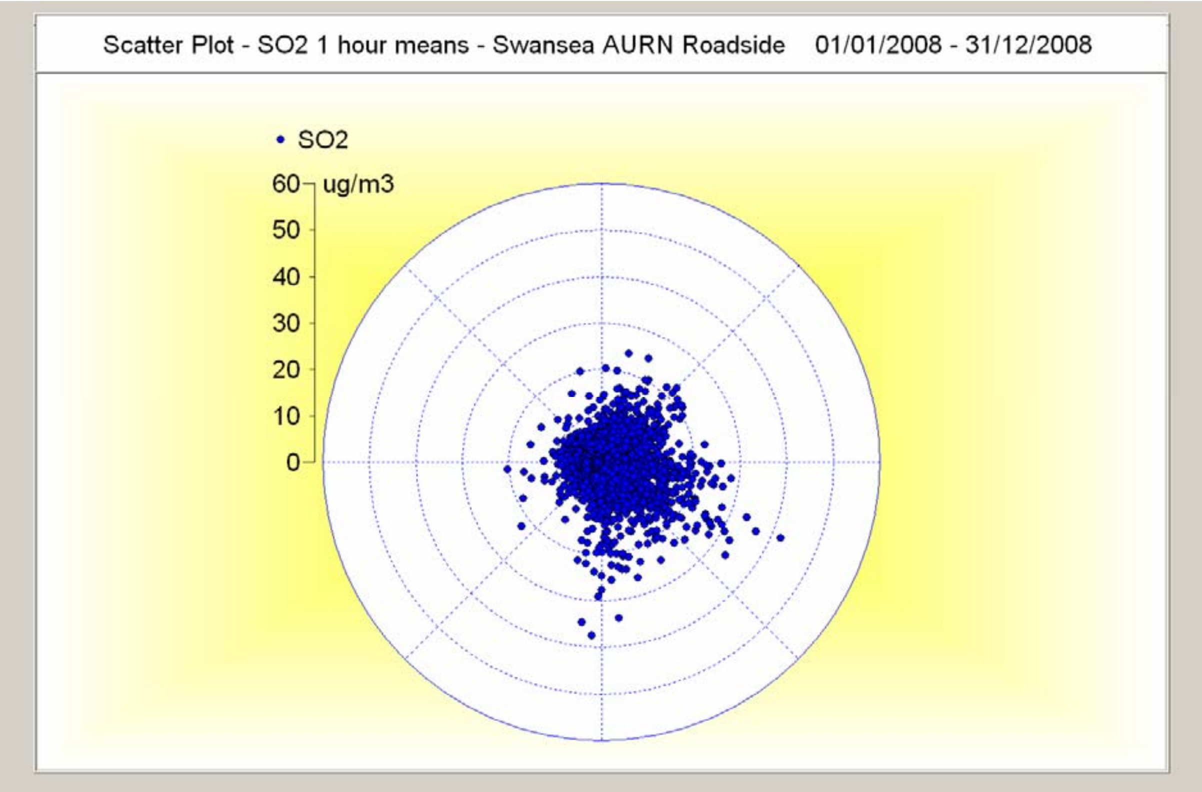
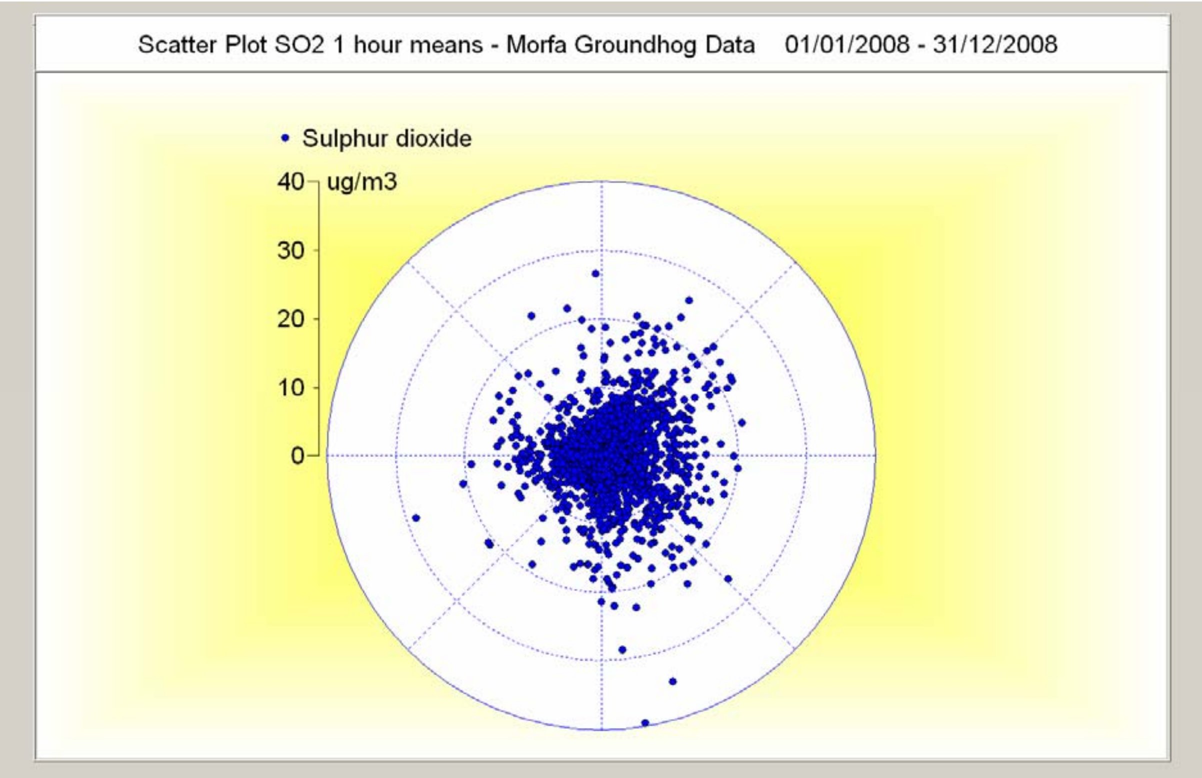
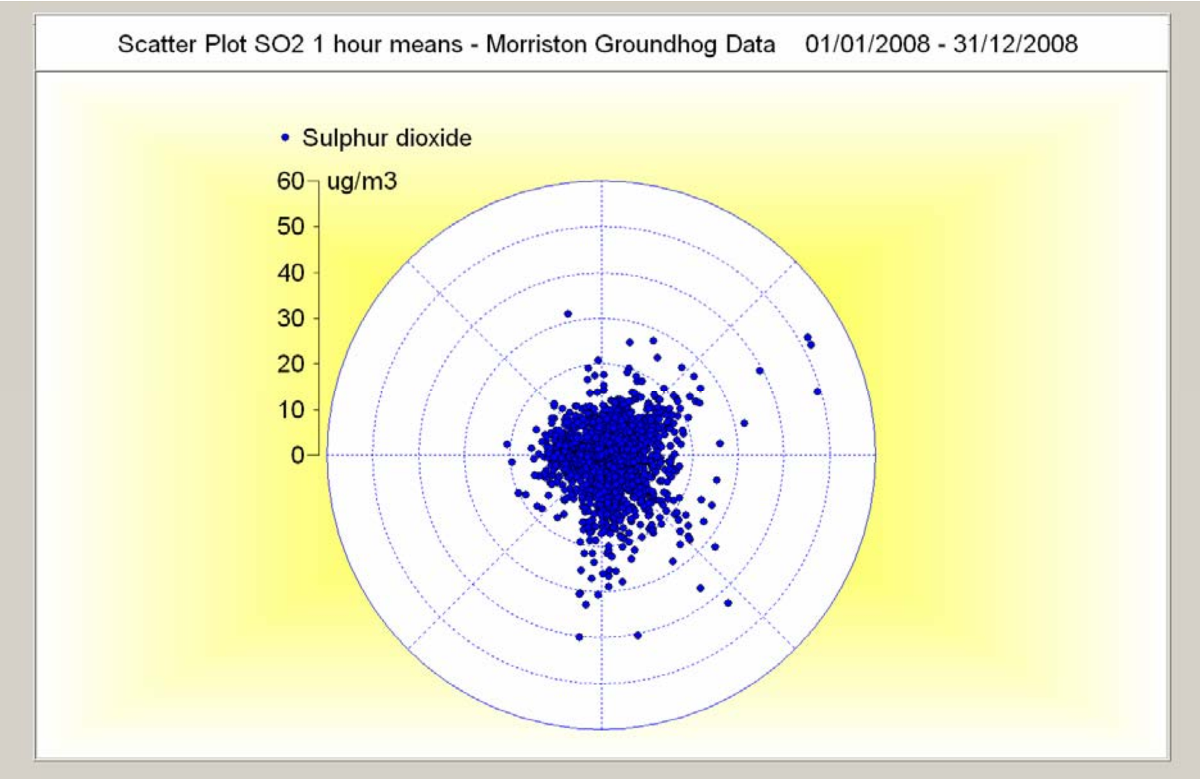


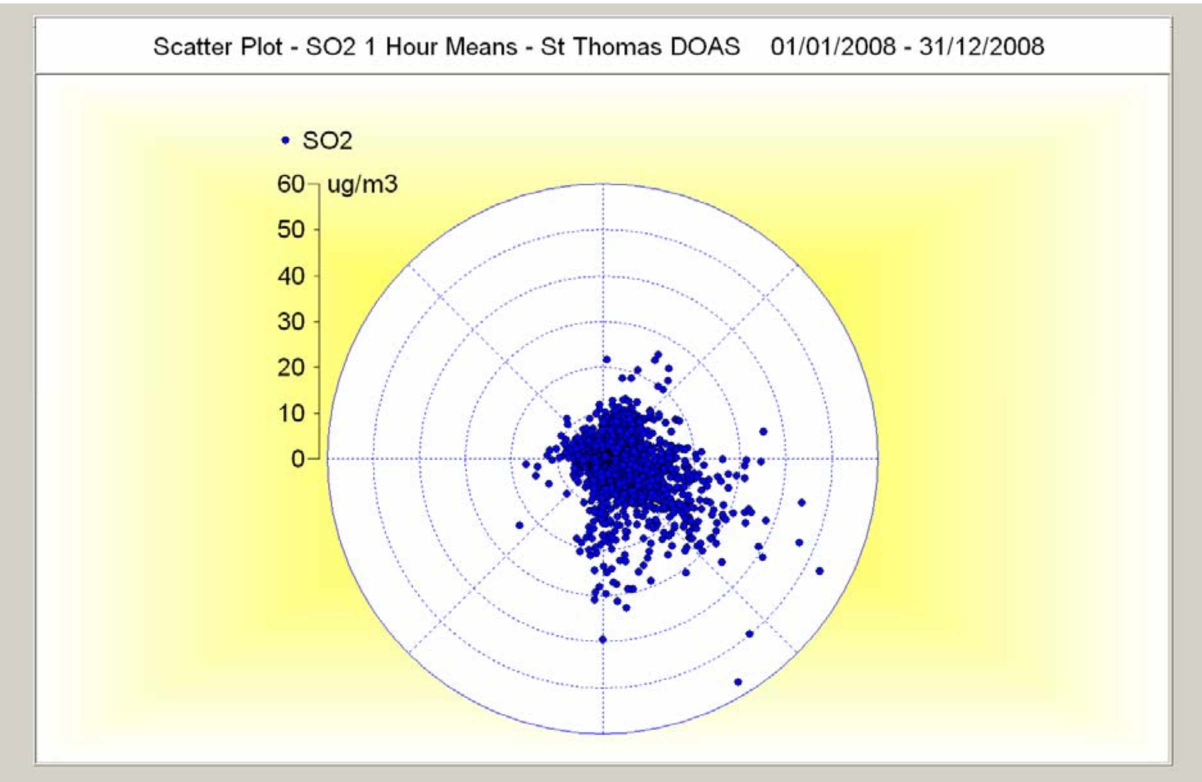
Scatter Plot 8 - SO_2 1-hour means Swansea AURN 2008



Scatter Plot 9 - SO_2 1-hour means Morfa Groundhog 2008



Scatter Plot 10 - SO_2 1-hour means Morriston Groundhog 2008



Scatter Plot 11 – SO_2 1-hour means St Thomas DOAS 2008

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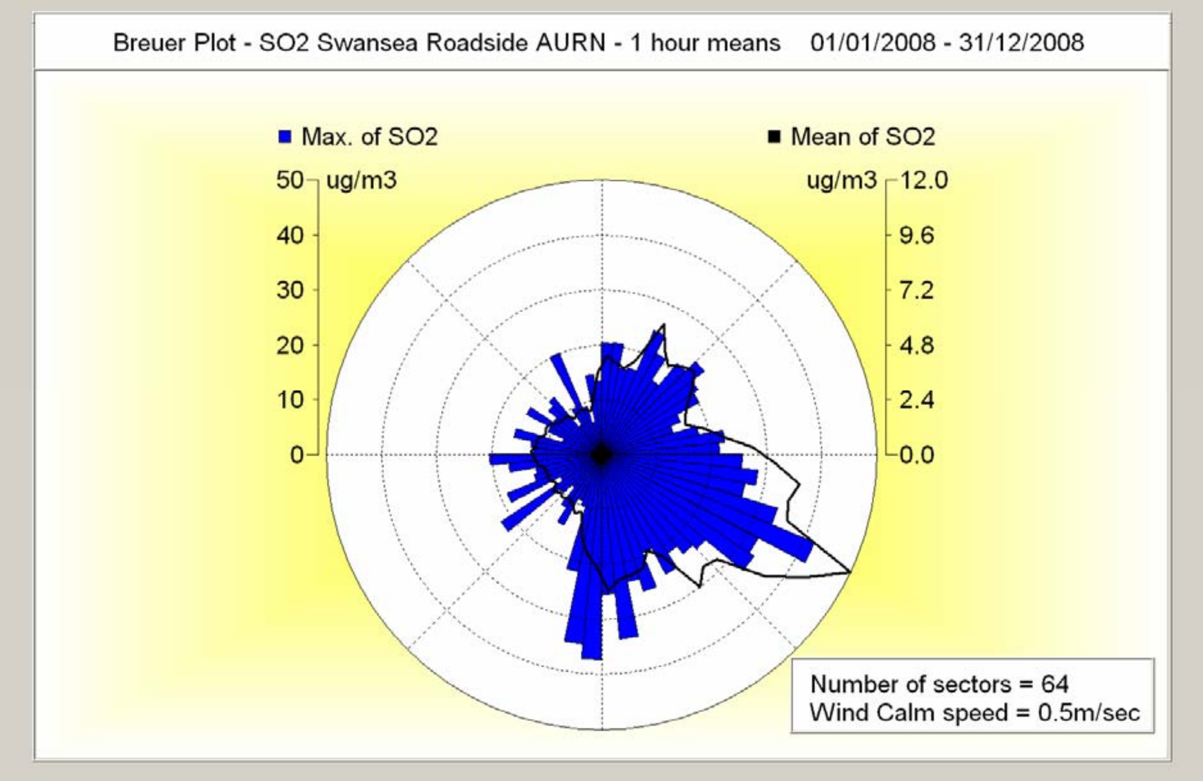
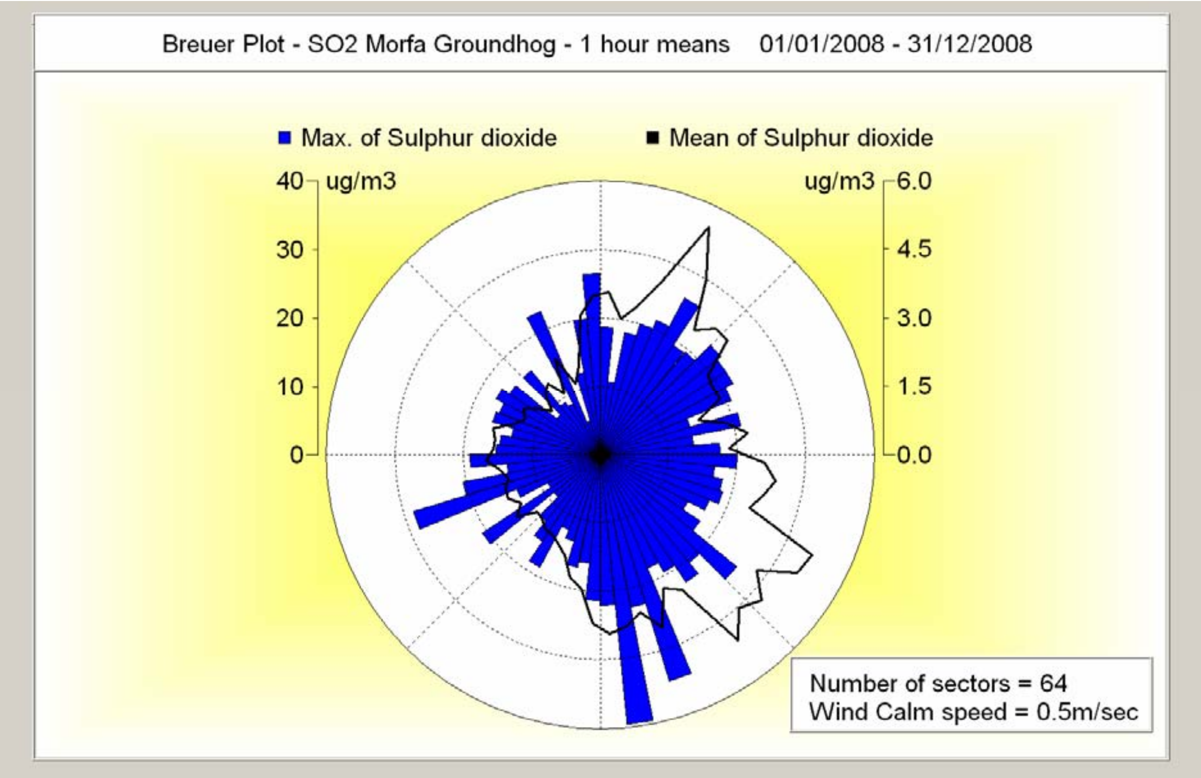
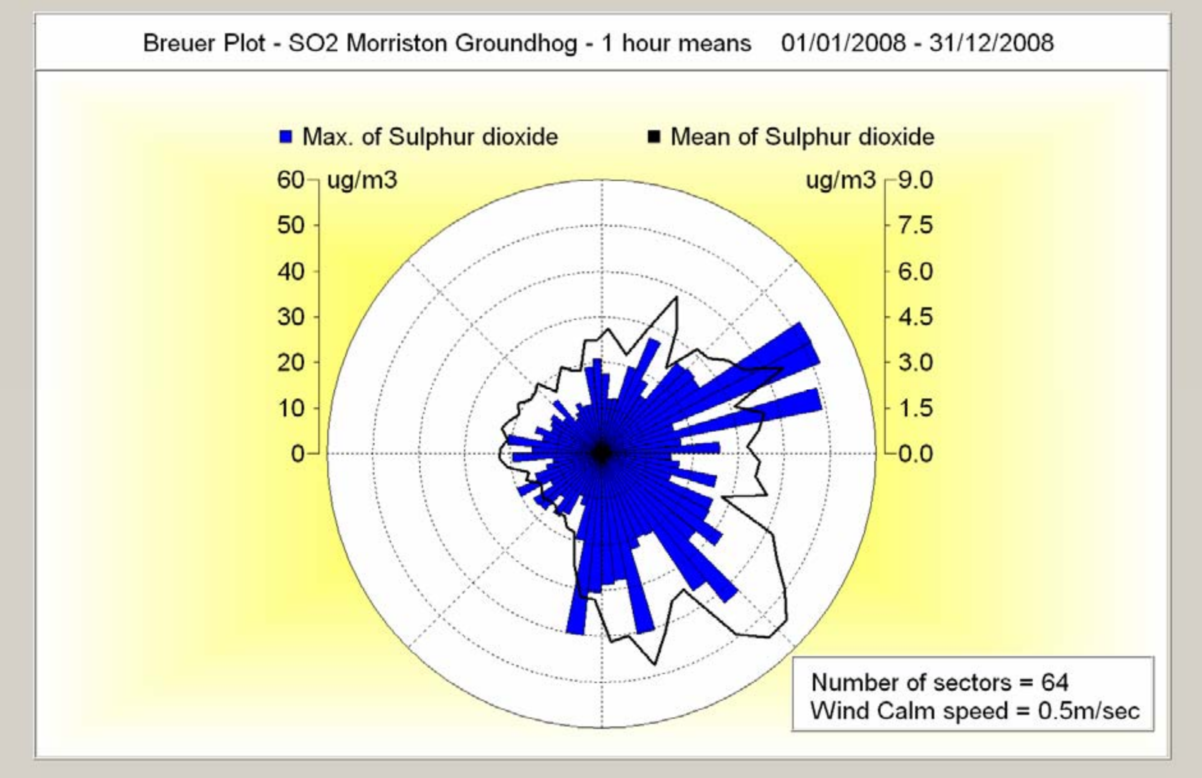


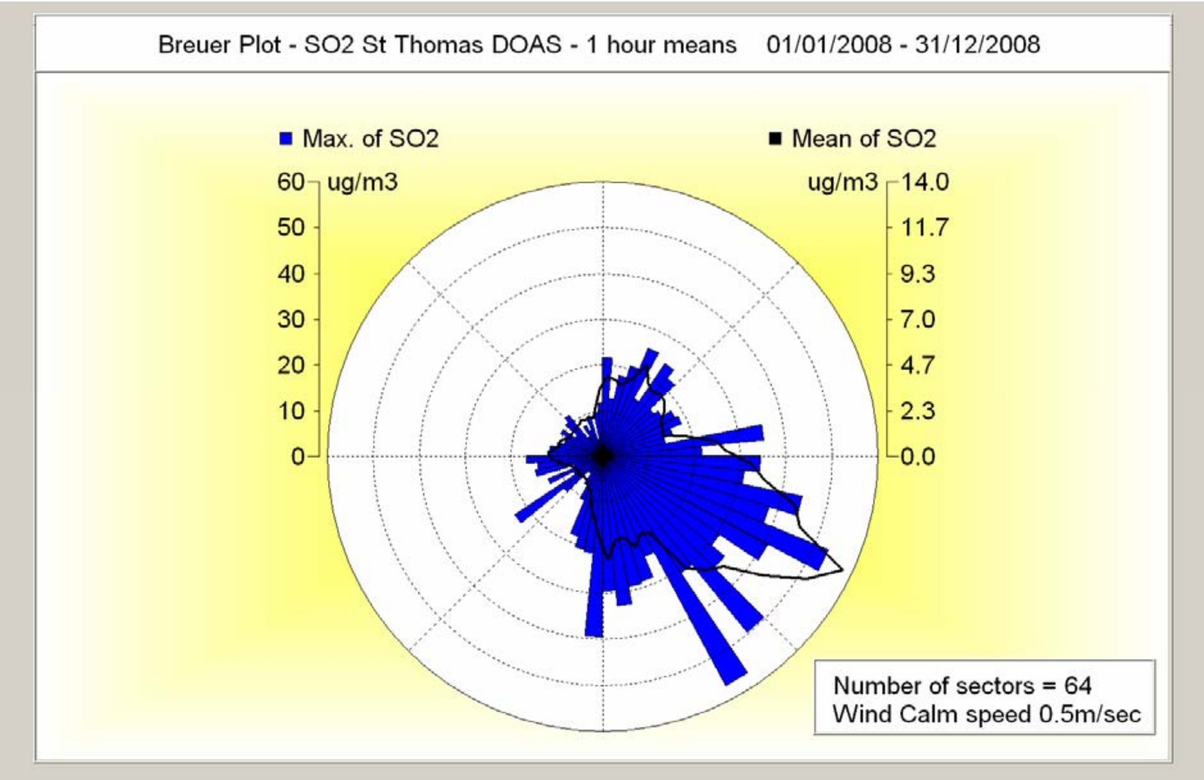
Breuer Plot 5 - Swansea AURN SO_2 1-hour means 2008



Breuer Plot 6 – Morfa Groundhog SO_2 1-hour means 2008



Breuer Plot 7 – Morriston Groundhog SO_2 1-hour means 2008



Breuer Plot 8 – St.Thomas DOAS SO_2 1 hour means 2008

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From the above Breuer and Scatter plots it is evident that whilst low SO_2 concentrations are evident in Swansea, it is clear that two directions/sources are contributing to these measured concentrations. All sites exhibit an influence from the south-east. The Swansea AURN whilst not indicating the north easterly source indicates a source from the south and this source is likely to be within the outskirts of the city centre or even the docks area which is directly visible from the site. The southerly source is also seen at the St Thomas DOAS station which is approximately half a mile from docks area so it would seem likely that the docks is the source of this southerly SO_2. There is heavy industry located to the south east of Swansea Bay in the form of the Corus steelworks at Port Talbot. This has been the traditional dominant source of SO_2 seen within Swansea since measurement of SO_2 commenced during the late 1970's. However, looking at the Scatter and Breuer plots for Morriston and also Morfa Groundhogs, a source is also evident from the north east. For the Morriston site, scatter plots 6 and 10 and Breuer Plot 7 refer, whilst Breuer Plot 6 for the Morfa Groundhog site also shows this source which is not easily appreciated from the scatter plots for Morfa. This source has been evident in prior analysis and reporting as originating from Morganite Electrical Carbon Ltd which is located within approximately 500m of the Morriston site - its location is shown below within map 10.

As part of the construction of the emissions database for Swansea which remains ongoing, 28 emission points to air have been identified within the Morganite complex. Of these, 6 emit SO_2. The latest data for 2006 (currently awaiting update from company) would indicate that approximately 175.37 tonnes of SO_2 are emitted annually from the various processes. Whilst this is a relatively small quantity compared to other "local" sources, the release is being identified within the monitoring data (See Progress Report 2007 and 2008). This source is now not as prominent within the dataset at the Morfa Groundhog site, as it is only just possible to see the influence of this source from the north-east sector within the latest analysis by use of the mean function, whilst the signal at the Morriston Groundhog site remains clear.

Map 10 – Location of Morriston Groundhog and Morganite Electrical Carbon Ltd

Tables 17 – 20 outline the SO_2 statistics from the four measurement sites. Data capture rates are presented and, where applicable, the percentile value corresponding to the objective exceedence value is given should the data capture rate fall below 90%[28]

Swansea AURN 2008	Max 15-Min Mean μg/m^3 (266μg/m^3)	Max 1-hour Mean μg/m^3 (350μg/m^3)	Max 24-Hour Mean μg/m^3 (125μg/m^3)
Data Capture	88.44%	90.31%	90.16%
Value	49.42	41.88	17.36
Exceedences	0	0	0
Date of Max	03:15	03:00	-
Time of Max	02/01/2008	02/01/2008	02/01/2008
2008 Percentiles	15 Minute	1 Hour	24-Hour
99.9th Percentile	35.81	-	-
99.7th Percentile	-	25.65*	-
99th Percentile	-	-	15.96*

Table 17 – Swansea AURN SO_2 monitoring 2008

[28] LAQM TG(09) Annexe A1 – A1.157 page A1-34

* Whilst the calculate data capture rate at the 15 minute objective falls below 90%, the calculated capture rates at 1 hour and 24 hour are slightly above 90%. The percentile value is therefore applicable to the 15 minute objective and for the sake of completeness, the percentile values are also given for the 1 hour and 24-hour objectives as it's unclear as why these data capture rates are calculated to be above 90%.

Morfa Groundhog 2008	Max 15-Min Mean μg/m^3 (266μg/m^3)	Max 1-hour Mean μg/m^3 (350μg/m^3)	Max 24-Hour Mean μg/m^3 (125μg/m^3)
Data Capture	95.36%	95.33%	96.72%
Value	43.00	39.50	13.23
Exceedences	0	0	0
Date of Max	09/02/2008	09/02/2008	15/12/2008
Time of Max	13:30	13:00	-

Table 18 – Morfa Groundhog SO_2 monitoring 2008

Morriston Groundhog 2008	Max 15-Min Mean μg/m^3 (266μg/m^3)	Max 1-hour Mean μg/m^3 (350μg/m^3)	Max 24-Hour Mean μg/m^3 (125μg/m^3)
Data Capture	86.19%	88.14%	87.70
Value	93.00	51	20.54
Exceedences	0	0	0
Date of Max	15/2/2008	15/02/2008	13/02/2008
Time of Max	04:45	06:00	-
2008 Percentiles	15 Minute	1 Hour	24-Hour
99.9th Percentile	35.00	-	-
99.7th Percentile	-	23.99	-
99th Percentile	-	-	15.42

Table 19 – Morriston Groundhog SO_2 monitoring 2008

St.Thomas DOAS 2008	Max 15-Min Mean μg/m^3 (266μg/m^3)	Max 1-hour Mean μg/m^3 (350μg/m^3)	Max 24-Hour Mean μg/m^3 (125μg/m^3)
Data Capture	99.92 %	99.90%	99.90%
Value	106.54	56.82	18.22
Exceedences	-	-	-
Date of Max	08/02/2008	08/02/2008	03/05/2008
Time of Max	21:45	22:00	-

Table 20 – St.Thomas DOAS SO_2 monitoring 2008

From tables 17-20 it can be seen that **all objectives, at all averaging periods, have seen compliance during 2008.** Historical real-time data analysis (back to 2001 in some cases) has been reported within the Progress Report 2008 and also earlier reporting undertaken by the authority. It is evident from the above, that monitored levels of sulphur dioxide continue to decline and there has not been an issue with compliance of any of the objectives since real-time continuous monitoring commenced in Swansea

2.2.5 Benzene

The Hafod and St Thomas DOAS sites measure benzene along open paths of approximately 250 and 280m respectively. Both sides are roadside[29] with the distance to the nearest receptor locations being 0.3m and 2m respectively. See table 3 and maps 5 and 6 for additional siting information and further details on the DOAS systems within sections 2.1.6 and 2.1.7.

The annual mean at the Hafod DOAS site for 2008 is 3.10ug/m^3 with a data capture rate of 18.27%. The annual mean at the St Thomas DOAS site for 2008 is 3.6 ug/m^3 with a data capture rate of 27.72%. Both sites have experienced significant data loss during 2008 for various reasons and the data presented above should therefore be treated with caution.

2.2.6 Other pollutants monitored

The authority monitors additional pollutants at the majority of the automatic sites currently operational. Ozone was measured at the Morriston Groundhog and the Hafod and St Thomas DOAS sites during 2008 but ozone monitoring ceased at the Swansea AURN site on the 27th November 2008 with the analyser being transferred to the Cwm Level Park monitoring site following the reorganisation of the UK Network. Carbon monoxide is monitored at the Swansea AURN, and the Morfa and Morriston Groundhog sites. Lastly, $PM_{2.5}$ is measured at the Swansea AURN Roadside station by way of the Thermo TEOM FDMS system (co-located with Thermo TEOM FDMS PM_{10})

In addition, the authority participate in the UK Heavy Metals Monitoring Network with The Department of the Environment, Transport and the Regions (DETR) monitoring study to determine ambient concentrations of lead, cadmium, arsenic, mercury and nickel in the vicinity of a wide-variety of industrial processes. The City and County of Swansea were requested to participate in this study from its inception during 1999/2000 due to the nickel refinery at Vale INCO Europe being located within the

[29] LAQM.TG(09) Table A1.4 page A1-20

authority's area at Clydach. Further details and information can be found within section 2.1.10. The analysed parameters are: Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Magnesium (Mn), Nickel (Ni), Lead (Pb), Platinum (Pt), Vanadium (V), Zinc (Zn) and Mercury(Hg)

2.2.6.1 Ozone

Whilst the objective for ozone has not been set in regulation as yet as it is seen as a national rather than local authority problem, details have been included here of the measurements made during 2008. The objective for ozone is an 8-hour mean not to exceed 100μg/m^3 on more than 10 occasions with a compliance date of 31st December 2005

Measurements are undertaken with an Advanced Pollution Instrumentation (API) real-time O_3 analyser at the Swansea AURN site and the Morriston Groundhog site with the DOAS measurements from the St Thomas and Hafod sites. The O_3 analyser from the Swansea AURN was decommissioned on the 27th November 2008 and relocated at Cwm Level Park. This has resulted in a data capture rate slightly below 90% during 2008 for the Swansea AURN ozone measurements.

The logged 15-minute means have been compiled into hourly averages by the software package OPSIS Enviman Reporter. In order to compile a valid hourly mean, a minimum of 3, 15-minute means were specified[30]. Data capture of less than 75% for the hour therefore excludes that hour from any analysis. The derived hourly means have then been used to calculate the 8-hour means. In order to form a valid 8-hour mean 75% of the hourly means were required to be present i.e. 6 out of every 8. Tables 21 – 24 detail the monitoring undertaken during 2008 and also that from 2006 and 2007.

Data ratification procedures undertaken at the Hafod and St Thomas DOAS sites are described in more detail within sections 2.1.6 and 2.1.7.

[30] LAQM.TG(09) Calculation of Exceedence Statistics A1.216 page A1-47

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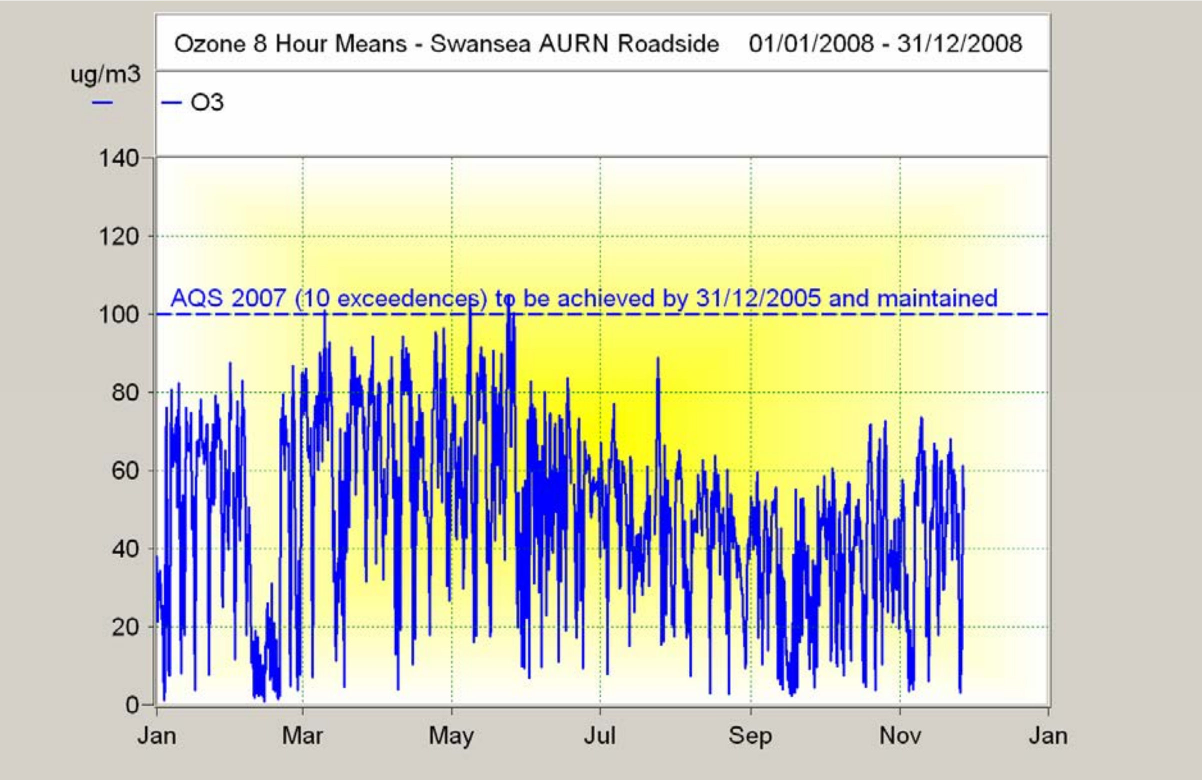

Chart 12 Swansea AURN Ozone 8-hour means 2008

Swansea Roadside AURN	Max 8-hour Mean ($\mu g/m^3$)	Data capture	Exceedences of 8-hour objective $100\mu g/m^3$ (10 permitted)
2007	115.25	98%	3
2008 **	104.88	89.71%	5

Table 21 – Ozone 8 hour means 2007 – 2008

** Station relocated from Princess Way to current location during September 2006. Data presented from first full year of measurement.*

*** Ozone analyser decommissioned from UK network and relocated to Cwm Level Park during November/December 2008*

Clearly, there is not a large enough dataset to assess trends within the dataset but the results from 2007 and 2008 are comparable with the other stations within Swansea. Ozone concentrations are dependant upon a number of circumstances and a re not wholly reflective of localised conditions.

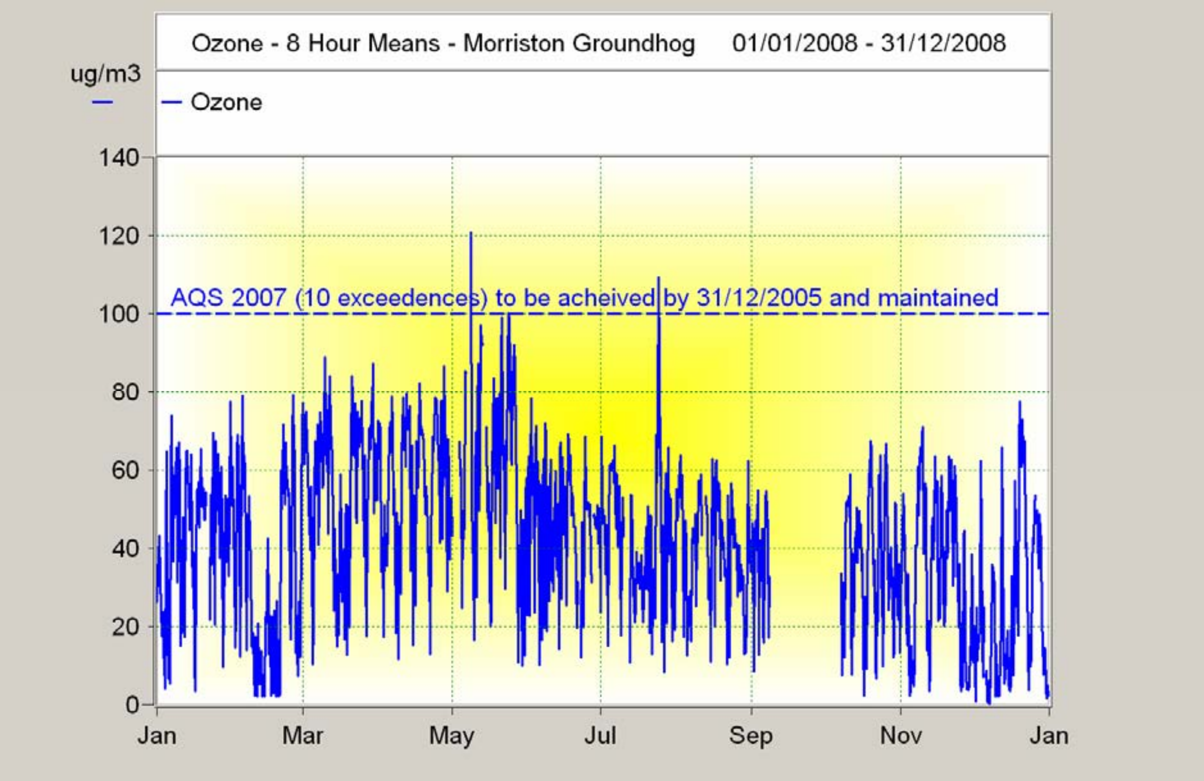

Chart 13 – Morriston Groundhog Ozone 8-hour means 2008

Morriston Groundhog	Max 8-hour Mean (µg/m^3)	Data capture	Exceedences of 8-hour objective 100µg/m^3 (10 permitted)
2002	109.50	83.3%	3
2003	169.25	95.71%	28
2004	142.75	98%	23
2005	113.00	97.6%	1
2006	152.20	98.8 %	15
2007	114	98%	4
2008	120.75	88.43%	3

Table 22 – Morriston Groundhog Ozone 8-hour means 2002-2008

What is apparent within the dataset summarised within table 22 is the effect that atypical meteorological conditions i.e. 2003 and 2006 have on ozone concentrations, further emphasising that direct action at local level is unlikely to resolve excessive number of exceedences of the objective.

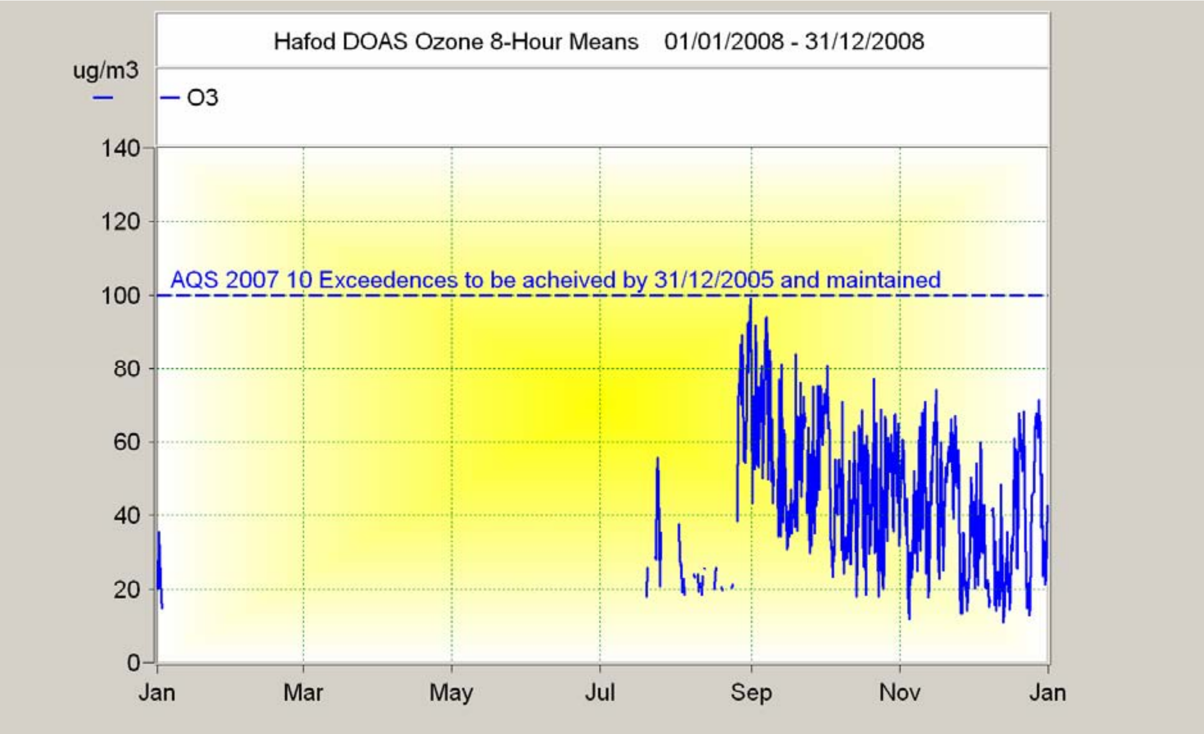

Chart 14 – Hafod DOAS *Ozone 8-hour means 2008*

Hafod DOAS	Max 8-hour Mean ($\mu g/m^3$)	Data capture	Exceedences of 8-hour objective $100\mu g/m^3$ (10 permitted)
2006	95.95	53.7%	0
2007	87.36	82.3%	0
2008	98.96	38.5%	0

Table 23 – Hafod DOAS *Ozone 8-hour means 2006-2008*

From the data capture rates presented within table 23, significant period's exhibit poor data capture rates. These data capture rates are directly attributable to extensive Area Renewals Projects undertaken within the Neath Road corridor. Sections of the open path have been blocked by scaffolding erected to permit building renovation works to the terraced properties. As a result, no conclusions can be drawn from the data presented within table 23.

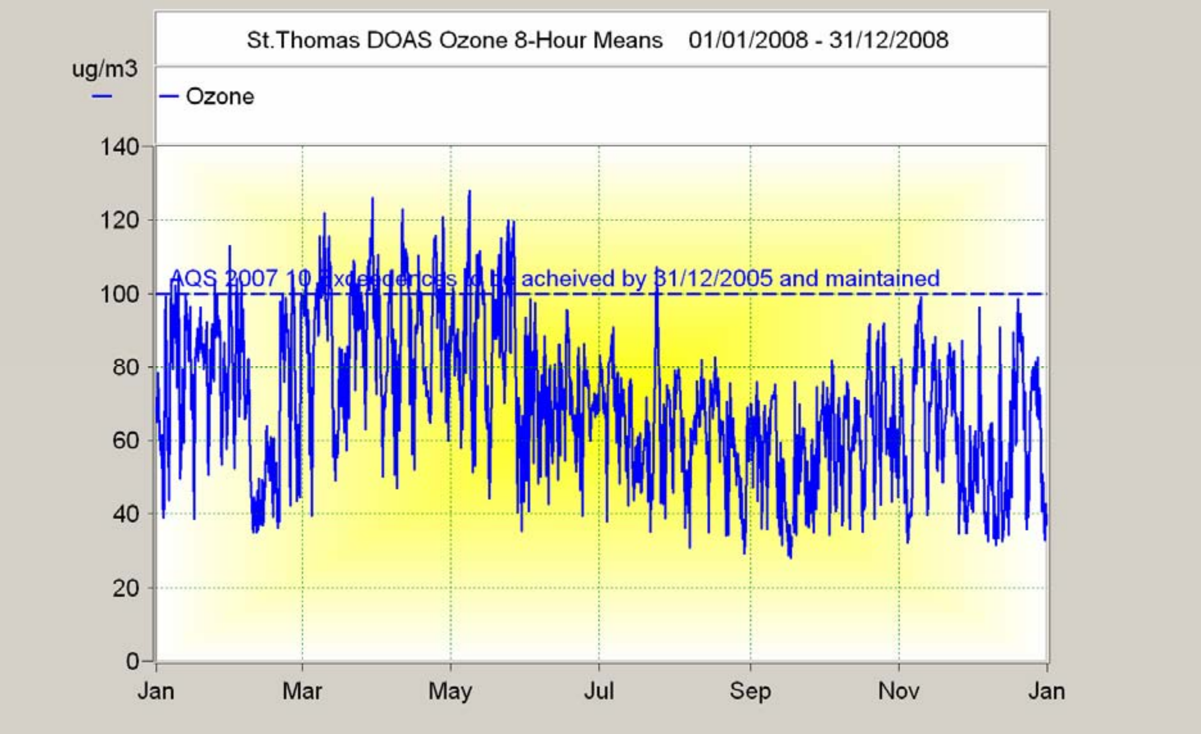

Chart 15 – St Thomas DOAS 8-hour Ozone means 2008

St Thomas DOAS	Max 8-hour Mean (µg/m^3)	Data capture	Exceedences of 8-hour objective 100µg/m^3 (10 permitted)
2006	150.6	94.9%	47
2007	106.4	98.7%	10
2008	127.9	99.9%	91

Table 24 – St Thomas Ozone 8-hour means 2006-2008

It should be restated here that the DOAS technique produces a spatial measurement across the 280m path length between the transmitter and receiver units at St.Thomas. Whilst being located alongside a road with an AADT of 21312 during 2008, it's clear that considerable photochemistry is evident at this location despite an open aspect to one side of the roadway not hindering dispersion. Clearly, significant exceedences of the objective have been seen during 2006 and also 2008. Whilst the 10 exceedences during 2007 indicates "compliance", the results from the open path measurements clearly differ from those made at the traditional fixed point stations and present a different picture as to what the actual levels over a much wider sampling area may actually be.

2.2.6.2 Carbon Monoxide

Measurements are undertaken with an Advanced Pollution Instrumentation (API) real-time CO analyser. The logged 15-minute means have been compiled into hourly averages by the software package OPSIS Enviman Reporter. In order to compile a valid hourly mean, a minimum of 3, 15-minute means were specified. Data capture of less than 75% for the hour therefore excludes that hour from any analysis. The derived hourly means have then been used to calculate the running eight hour means.

The running 8-hour mean for a particular hour, is the mean of the hourly average concentrations for that hour and the preceding 7 hours. The average period is stepped forward by one hour for each value, so running mean values are given for the periods 00:00 – 07:59, 01:00 – 08:59 etc. There are, therefore, 24 possible 8-hour means in a day (calculated from hourly data). In order for a running average to be valid, 75% data capture is required i.e. 6 hourly averages out of every 8 must be valid. The maximum daily running 8-hour mean is the maximum 8-hour running mean measured on any one day [31]

All results are presented in mg/m^3 by multiplying the logged result in ppm by the conversion factor of 1.16 [32] to produce results expressed in mg/m^3 where applicable.

[31] LAQM.TG(09) Calculation of Exceedence Statistics A1.216 page A1-47
[32] *LAQM.TG(09) Data processing - Conversion factors box A1.5 page A1-36*

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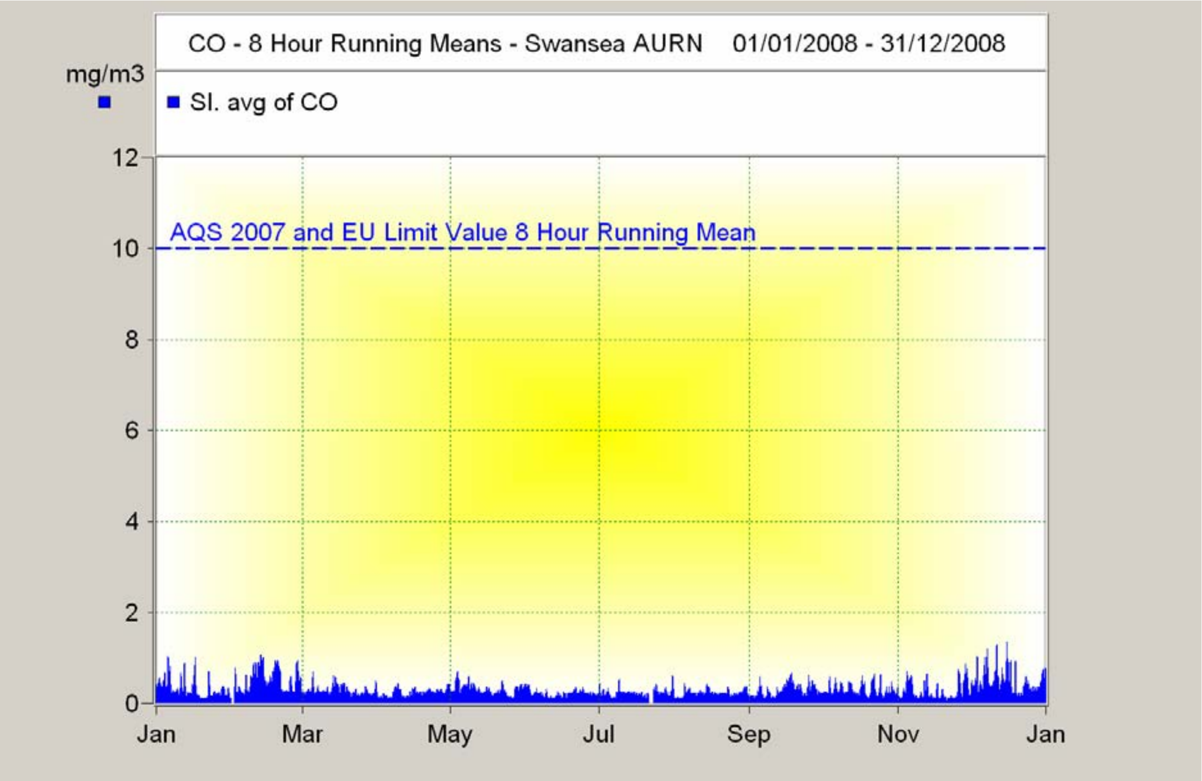

Chart 16 CO Running 8-hour means Swansea AURN

Year	Max 8-hour running mean
2007	0.74 mg/m^3
2008	1.35 mg/m^3

Table 25 Running 8-hour means Swansea AURN

Data capture during 2008 was 98.8%. There is not enough of a dataset as yet to assess any long term trend at present except to note:

- Concentrations have remained below the objective level of a maximum daily 8-hour running mean of 10mg/ m^3 recorded at this site since it was established in 2006
- 2007 saw the lowest maximum 8 hour running mean since monitoring commenced at this site.

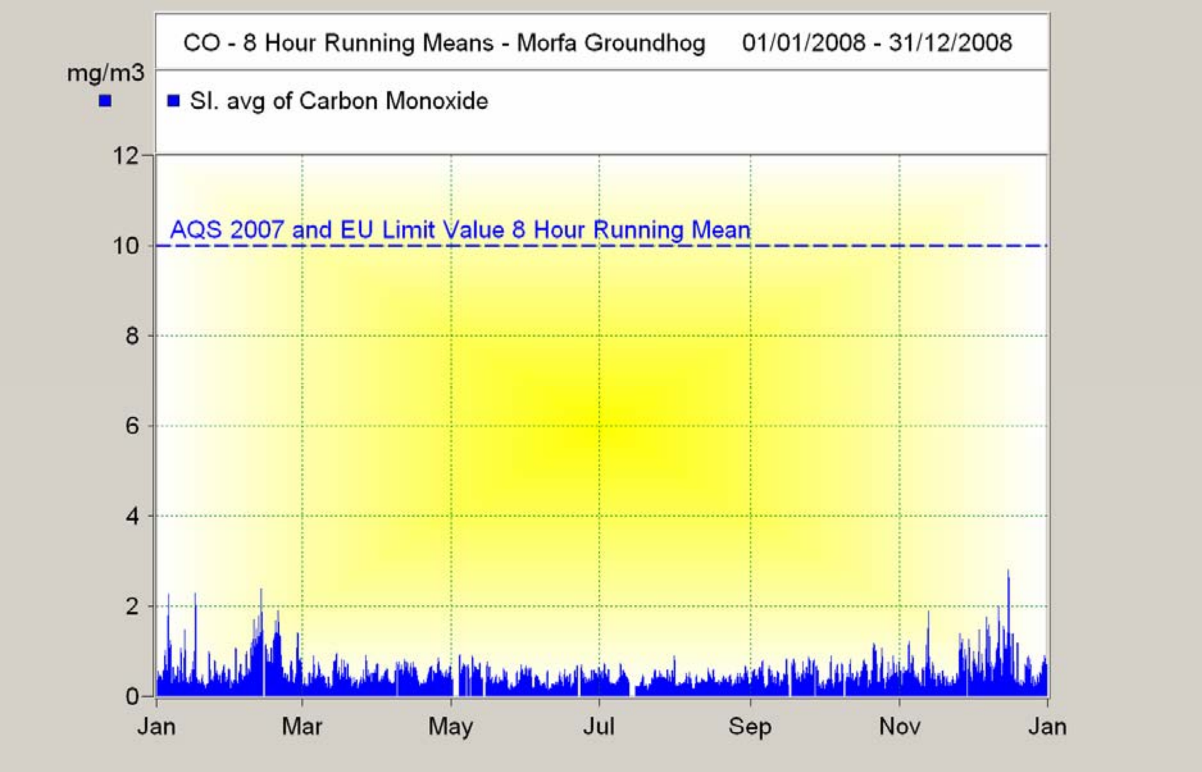

Chart 17 – CO 8-hour running means Morfa Groundhog 2008

Year	Max 8-hour running mean
2003	3.17 mg/m^3
2004	4.19 mg/m^3
2005	2.92 mg/m^3
2006	3.08 mg/m^3
2007	2.41 mg/m^3
2008	2.80 mg/m^3

Table 26 - CO 8-hour running means Morfa Groundhog 2003-2008

Data capture for 2008 was 95.90%. There appears no discernible trend with the overall dataset (2003-2008) at present except to say:

- Concentrations have remained below the objective level of a maximum daily 8-hour running mean of 10mg/ m^3 recorded at this site since it was established in 2000.
- 2007 saw the lowest maximum 8 hour running mean since monitoring commenced at this site.

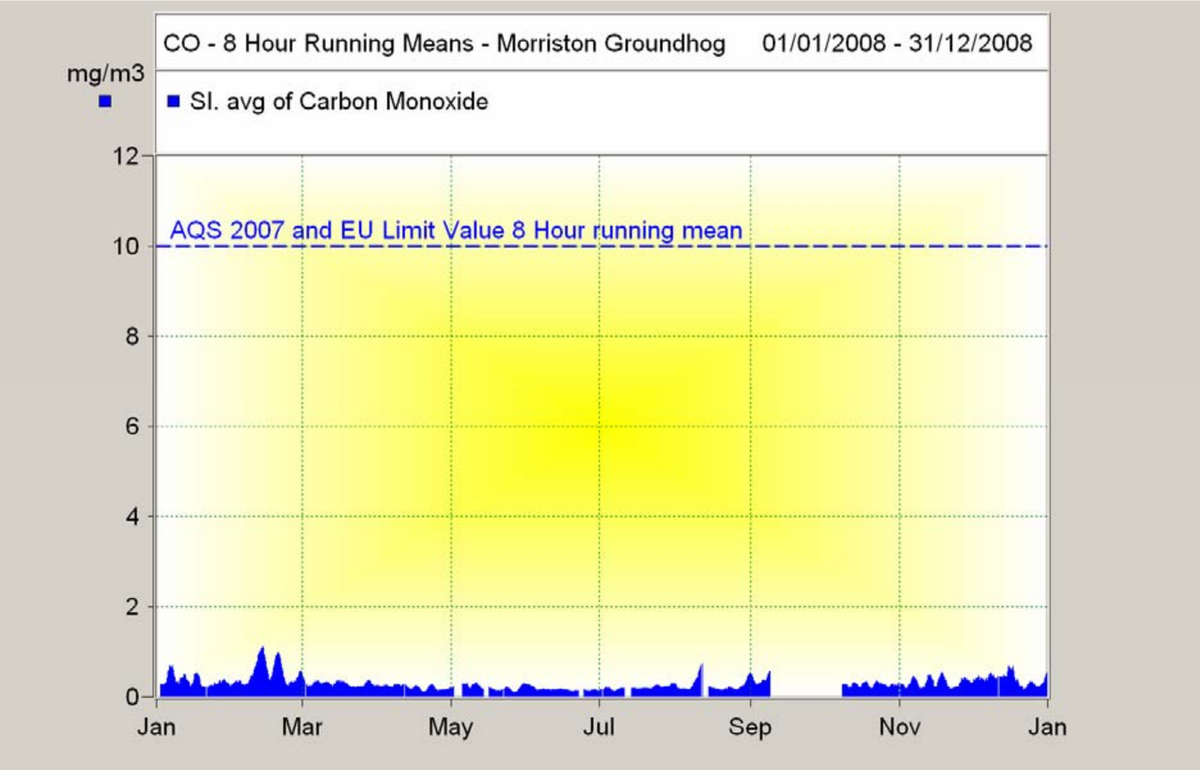

Chart 18 - CO 8-hour running means Morriston Groundhog 2008

Year	Max 8-hour running mean
2003	2.07 mg/m^3
2004	2.83 mg/m^3
2005	1.96 mg/m^3
2006	1.36 mg/m^3
2007	1.63 mg/m^3
2008*	1.13 mg/m^3 *

Table 27 - CO 8-hour running means Moriston Groundhog 2003-2008

* Data capture for 2008 was 88.16%. Percentile not presented as data is well below objective level.

There appears to be a downward trend in maximum running 8 hour means within the overall dataset (2003-2008). In addition:

- Concentrations have remained below the objective level of a maximum daily 8-hour running mean of 10mg/ m^3 recorded at this site since it was established in 2000.
- 2008 saw the lowest maximum 8 hour running mean since monitoring commenced at this site.

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In respect of carbon monoxide, the date for compliance with the Air Quality (Amendment)(Wales) Regulations 2002 objective standard was the 31st December 2003 and the EU objective of a maximum daily 8-hour running mean of 10mg/ m^3 was 2005. **It is evident from the datasets held for carbon monoxide that full compliance has been achieved with the objectives** since monitoring began.

2.2.6.3 Particulate Matter $PM_{2.5}$

The Thermo FDMS $PM_{2.5}$ system was installed upon commissioning of the Swansea Roadside AURN site, and went live on the 26th September 2006.

The data collected for 2006 from the FDMS $PM_{2.5}$ unit amounts to just over two months at best and is not reported here as the period was fraught with breakdowns and other issues. Brief operational issues that have been identified are outlined here for information as the operation of the FDMS units differs substantially from that of the R&P Teom units.

The FDMS units are required to operate within an ambient enclosure temperature range between 18-22°C[33]. Opinions vary as to the exact optimum temperature but Swansea's experience indicates around 18-20°C to be adequate and one that is capable of being maintained relatively stably by the installed air conditioning system.

The FDMS unit provides hourly integration data and has been configured as per DEFRA's FDMS parameter protocol (as amended during February 2008). The RS232 port on the FDMS control unit allows the collection of up to 8 parameters via telemetry. The parameters collected from the FDMS units are : Volatile Mass, Non Volatile Mass, External Dew Point, Sample Dew Point, Filter loading, Pressure, Status, External Ambient Air temperature. The control unit refers to these parameters in different terminology. However, the FDMS unit will not directly produce a $PM_{2.5}$ mass concentration. The $PM_{2.5}$ mass concentration is obtained via post processing of the volatile and non volatile mass parameters by creating a calculated channel within the database to subtract volatile mass from the non volatile mass.

[33] UK Equivalence Program for Monitoring of Particulate Matter dated 5th June 2006 section 5.5.2

AEA Energy and Environment has produced a new LSO operating procedure for the FDMS units. One of the more problematic issues with use of the FDMS units that this authority has found is the routine changing of both the purge filter (within the chiller unit) and the "normal" tapered element filter within the sensor unit. The chiller unit is held at approximately 4°C - upon removal of the filter housing, condensation can be seen on the filter holder. It is this authorities experience that should the new 47mm Pallflex TX40 MFAB filter be installed without ensuring the filter holder is dry then this can (and most certainly does) produce very noisy/spiky data. Correct orientation of the 47mm Pallflex TX40 MFAB filter within the filter holder is critical as incorrect orientation will result in poor quality data being returned. The 47mm filter and tapered element sensor unit filter should always be exchanged at the same time. Whilst the TEOM units did take up to 1-2 hours to stabilise after the sensor unit filter exchange and status code 4 OK being reached, the FDMS units can, and do, take even longer to stabilise. Should the site suffer a power failure or air conditioning failure then it is recommended that 3 hours data post resolution of either condition should be deleted from the dataset.

Data collected from the FDMS unit has an integration period of 1-hour. $PM_{2.5}$ mass concentration is obtained via post processing of the volatile and non volatile mass parameters by the software package Opsis Enviman ComVisioner. The calculated hourly mean mass concentration data have then been further processed by the software package Opsis Enviman Reporter. In order to calculate the 24-hour mean a minimum of 75% (i.e. 18 out of 24) of the calculated hourly means were specified to be present[34]. LAQM.TG(09) provides no direct guidance on $PM_{2.5}$,except for paragraphs 3.50 – 3.53.

There have been numerous problems since the commissioning of the site in September 2006 with the installation of the Thermo Inc FDMS $PM_{2.5}$ analyser, resulting in significant periods of data loss. During 2007, there were several periods where data has been removed from the dataset. There are: 1st – 5th January 2007; 16th - 18th January 2007; 24th – 26th January 2007; 1st -2nd March 2007; 7th – 21st May

[34] LAQM.TG(09) Calculation of Exceedence Statistics A1.216 page A1-48

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2007(leak test failure and uncertainty in data due to swap out of loan/replacement sensor units). These issues resulted in a ratified data capture rate of 90.7% for 2007.

Operation during 2008 saw a data capture rate of 94.81% with far fewer operational issues arising.

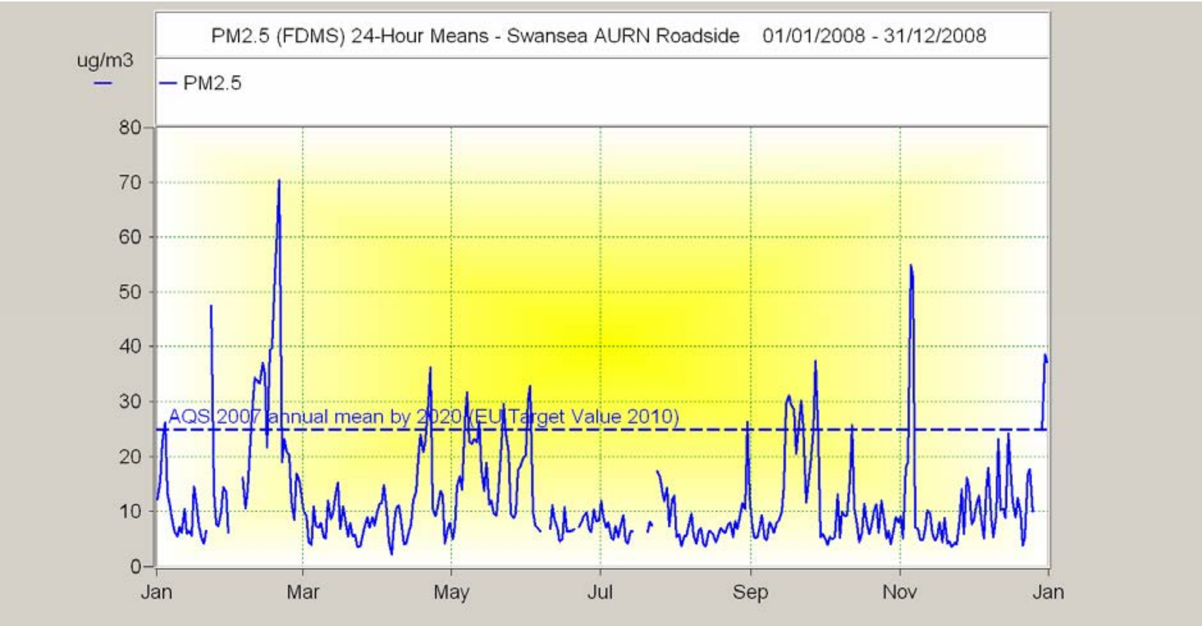

Chart 19 – $PM_{2.5}$ 24-hour Means Swansea Roadside AURN 2008

Swansea Roadside AURN $PM_{2.5}$ (FDMS)	Data capture	Annual Mean ($25\mu g/m^3$)	Max Daily Mean ($\mu g/m^3$)	Max 1-hour mean ($\mu g/m^3$)
2007	90.7%	13.84	68.9	262
2008	94.81%	12.53	70.42	202

Table 28 – Summary $PM_{2.5}$ data – Swansea Roadside AURN 2007-2008

Interestingly, the FDMS $PM_{2.5}$ also picked up the regional episodes of early 2008 (see section 2.2.3 detailing the measured PM_{10} during these episodes). If the volatile and non-volatile mass are also plotted within chart 20, it can be seen that during the second episode during February, that the volatile fraction steadily increases during this period. This is another indication that, as the air masses were coming from central Europe that there was a secondary PM component to the increase, but, there was probably also a significant local contribution due to the low wind speeds and temperatures during this episode (see Chart 21).

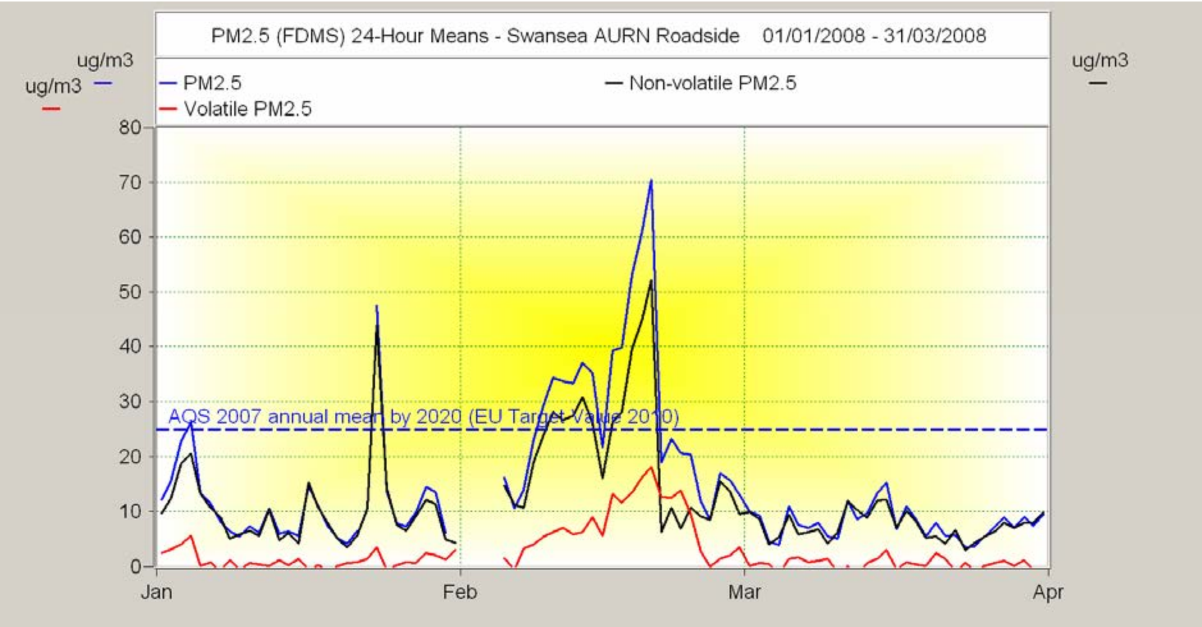

Chart 20 – FDMS $PM_{2.5}$ Volatile and Non Volatile fractions Jan – March 2008

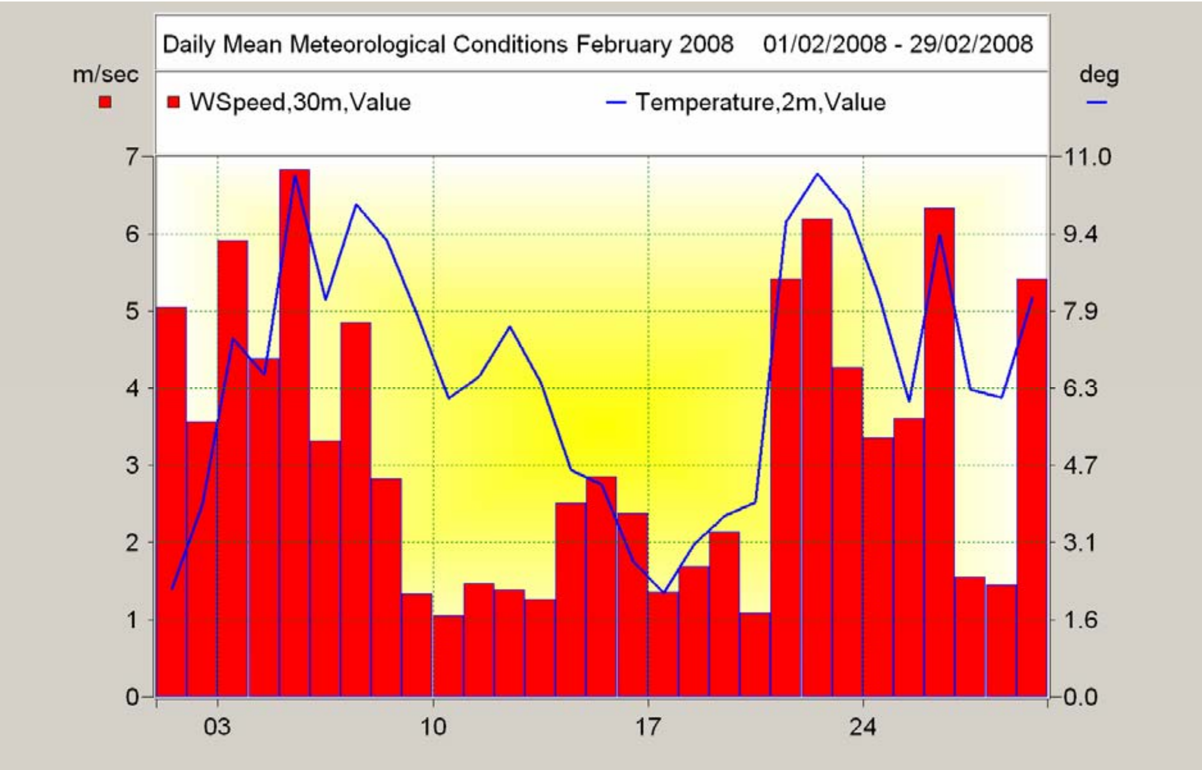

Chart 21 - Daily Mean Meteorological Conditions - Cwm Level Park Mast site - February 2008

On the 21st February 2008, the mean daily temperature and wind speed dramatically increased – this led to the almost immediate reduction in $PM_{2.5}$ concentrations as can be seen in chart 20 with the volatile fraction taking a couple of days to decay back to “background ambient” levels.

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The Air Quality Strategy 2007 focuses attention on $PM_{2.5}$ particulate matter to that of an exposure reduction approach. Between 2010 and 2020 for UK Urban Areas there is a target of 15% reduction in concentrations at urban background. The 25μg/m^3 is a cap to be seen in conjunction with the 15% reduction. The current policy framework and the legislative requirement to meet EU air quality limit values everywhere in the UK tends to direct LAQM attention to localised hotspot areas of pollution. There is clear and unequivocal health advice that there is no accepted threshold effect, i.e. no recognised safe level for exposure to fine particles $PM_{2.5}$. For $PM_{2.5}$, the current policy framework is therefore not going to generate the maximum improvement in public health for the investment made, as it focuses attention on localised hotspots only, despite much more widespread adverse effects on health being likely.

Therefore, an exposure reduction approach has been adopted for $PM_{2.5}$ to seek a more efficient way of achieving further reductions in the health effects of air pollution by providing a driver to improve air quality everywhere in the UK rather than just in a small number of localised hotspot areas, where the costs of reducing concentrations are likely to be exceedingly high. These measurements will act to make policy measures more cost-effective and is more likely to maximise public health improvements across the general population.

The City & County of Swansea facilitated a research study by a group comprising: School of Earth and Ocean Sciences Cardiff University, School of Biosciences Cardiff University, and the Centre for Health and Environment Research, Department of Primary Care and Public Health, Neuadd Meirionydd into ultrafine and nanoparticles using a Dekati™ Electrical Low Pressure Impactor within a street canyon environment. The site chosen for measurements was the Hafod Post Office, Neath Road, Hafod, Swansea. This site is located within the Hafod Air Quality (NO_2) Management Area.

Full details of the study are reproduced with the permission of the group, within Annexe 4. The study confirmed the existence of an early morning diurnal pattern within the ultrafine fraction which appears to match the diurnal

NO_2 pattern highlighted above within section 2.2.1, seemingly confirming the traffic source for these two pollutants.

2.2.6.4 Heavy Metals Monitoring

The Department of Environment, Food and Rural Affairs (DEFRA) is funding a monitoring study to determine ambient concentrations of lead, cadmium, arsenic, mercury and nickel in the vicinity of a wide-variety of industrial processes.

The City and County of Swansea were requested to participate in this study from its inception during 1999/2000 due to the nickel refinery at Vale INCO Europe being located within the authority's area at Clydach. Full details on this monitoring program can be found within section 2.1.10 above which outlines the overall monitoring program and sites chosen.

On the 16th July 2003 the European Commission adopted a proposal for a Directive relating to arsenic, cadmium, nickel, mercury and ploycyclic hydrocarbons (PAH) in ambient air[35]. The target values of this Directive are not to be considered as environmental quality standards as defined in Article 2(7) of Directive 96/61/EC and which, according to Article 10 of that Directive, require stricter conditions than those achievable by the use of Best Available Technique (BAT). There are therefore, as yet, no binding obligations to reduce these pollutants. Ambient air concentrations of these substances only have to be monitored once emissions have passed a critical threshold.

During August 2007, Vale INCO Europe commenced an abatement improvement program with the installation of particulate bag filters on the main high stack discharge point.

Annexe 1 of the Directive details the target values for arsenic, cadmium, nickel and bezo(a)pyrene and, for ease of reference these are repeated below as table 29.

[35] *COM 2003 (423)*

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Pollutant	Target value ng/m^{-3}
Arsenic	6
Cadmium	5
Nickel	20
Benzo(a)pyrene	1

Table 29- Target Values 4th Daughter Directive - Heavy Metals Monitoring

Tables 30 and 31 detail the monthly means (2007-2008) for the **Glais Primary School ❷** site. All results are expressed in ng/m^{-3}

Glais Primary School 2007

2007	As	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Pt	V	Zn	Hg
Jan	0.75	0.14	3.68	3.7	72	1.27	**29.39**	4.8	0.00	0.18	4.8	0.23
Feb	0.81	0.17	2.94	3.9	151	3.19	**27.01**	10.0	0.00	0.83	20.3	0.03
Mar	1.07	0.25	3.19	3.6	271	5.46	**20.72**	8.4	0.00	1.64	15.4	0.52
April	1.32	0.30	4.64	6.7	397	10.39	**16.47**	14.2	0.00	3.35	41.0	0.48
May	2.37	0.99	7.18	10.1	283	5.39	**21.33**	27.5	0.00	1.66	15.2	0.50
June	0.52	0.10	4.82	3.5	83	2.69	**50.21**	3.7	0.00	2.04	17.5	0.31
July	0.44	0.07	3.07	3.3	96	2.42	**46.97**	2.7	0.00	1.61	12.9	0.09
Aug	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	N/A	N/A	N/A	N/A	N/A
Sept	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	N/A	N/A	N/A	N/A	N/A
Oct	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	N/A	N/A	N/A	N/A	N/A
Nov	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	N/A	N/A	N/A	N/A	N/A
Dec	0.78	0.19	1.95	5.2	152	4.56	**12.25**	12.3	0.00	1.79	19.5	0.03
Ann Av.	**1.01**	**0.28**	**3.94**	**5.0**	**188**	**4.42**	**28.04**	**10.5**	**0.00**	**1.64**	**18.3**	**0.27**

Table 30 – Monthly Heavy Metals Concentrations Glais Primary School - 2007

Glais Primary School 2008												
2008	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**
Jan	0.71	0.11	0.05	3.5	195	3.59	**7.1**	5.9	<0.01	1.59	6.8	0.14
Feb	1.36	0.46	5.17	7.2	224	6.93	**21.0**	14.0	<0.01	2.82	23.5	0.06
Mar	0.26	0.11	1.19	2.9	96	1.94	**12.6**	6.5	<0.01	0.79	9.1	0.03
April	0.41	0.17	1.61	5.5	139	3.10	**10.6**	6.3	0.01	1.42	13.5	0.04
May	0.63	0.27	1.50	4.6	285	6.83	**5.7**	10.1	0.01	2.28	25.1	0.05
June	0.52	0.18	1.64	5.1	209	4.41	**16.9**	7.3	<0.01	0.80	20.6	0.06
July	0.37	0.15	0.42	3.9	175	3.45	**10.8**	10.2	<0.01	0.87	16.4	0.05
Aug	0.22	0.07	0.11	3.3	81	1.76	**2.9**	4.5	<0.01	0.37	9.8	<0.01
Sept	0.77	0.21	0.94	5.6	294	4.52	**8.6**	17.3	<0.01	1.26	18.1	<0.01
Oct	0.73	0.30	0.62	8.8	247	4.03	**9.8**	12.3	<0.01	1.62	17.2	<0.01
Nov	*1.07*	*0.41*	*0.30*	*9.8*	*109*	*2.96*	***7.7***	*17.9*	*<0.01*	*0.63*	*22.4*	*<0.01*
Dec	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	N/A	N/A	N/A	N/A	N/A
Ann Av.	**0.64**	**0.22**	**1.23**	**5.48**	**186.5**	**3.95**	**10.34**	**10.21**	**0.01**	**1.31**	**16.59**	**0.06**

Table 31 – Monthly Heavy Metals Concentrations Glais Primary School - 2008

Tables 32 and 33 detail the monthly means for the **Coed-Gwilym Cemetery site ❸** during 2007 and 2008. All results are expressed in ng/m^{-3}.

Coed-Gwilym Cemetery 2007												
2007	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**
Jan	1.08	0.39	4.02	2.9	56	1.41	**68.4**	4.3	<0.01	1.17	13.1	0.07
Feb	1.02	0.25	3.71	4.3	173	3.49	**39.2**	11.3	<0.01	1.32	28.6	0.13
Mar	1.20	0.57	2.97	7.1	331	9.23	**30.1**	17.5	<0.01	2.88	50.4	0.69
April	1.04	0.27	2.58	7.2	251	7.65	**9.0**	11.1	<0.01	3.09	39.2	0.82
May	6.19	0.22	7.57	2.7	175	4.88	**22.9**	7.5	<0.01	*100**	25.2	0.15
June	0.81	0.22	7.64	3.3	206	5.84	**39.9**	8.8	<0.01	4.24	18.5	0.08
July	0.19	0.12	3.45	2.7	69	2.19	**59.6**	3.7	<0.01	0.89	5.4	0.21
Aug	0.24	0.10	2.06	2.1	94	2.76	**39.9**	3.1	<0.01	1.22	4.5	0.32
Sept	1.06	0.23	7.20	3.9	145	4.36	**34.5**	27.6	<0.01	0.35	19.1	0.18
Oct	0.90	0.22	9.26	5.8	179	5.68	**50.2**	10.8	<0.01	1.08	18.9	0.08
Nov	1.33	0.27	4.92	8.1	112	3.06	**34.6**	13.0	<0.01	0.60	14.7	0.13
Dec	1.04	0.38	7.63	8.2	259	9.13	**19.4**	17.9	<0.01	2.56	31.0	0.09
Ann Av.	**1.34**	**0.27**	**5.25**	**4.88**	**171**	**4.97**	**37.31**	**11.38**	**0**	**1.77**	**22.39**	**0.25**

Table 32 Heavy Metals Monitoring Coed-Gwilym Cemetery 2007

** The vanadium levels measured during May were mostly extremely high. This is thought to be owing to an instrument fault affecting the first in the series of analytes to be measured, which is vanadium. These values should be treated with caution and should have a very high uncertainty attached to them. If these values appeared as part of the UK Heavy Metals Monitoring Network results they would most likely be excluded during ratification as extreme outliers*

Coed-Gwilym Cemetery 2008											
2008	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**
Jan	0.29	0.14	3.31	4.1	135	2.9	**16.66**	6.2	0.00	1.14	7.0	0.02
Feb	1.29	0.44	8.32	7.8	244	7.9	**31.69**	13.1	0.00	1.88	24.7	0.09
Mar	0.27	0.09	1.98	2.5	83	1.7	**22.79**	5.2	0.00	0.34	6.9	0.03
April	0.60	0.16	3.14	3.3	129	2.9	**17.02**	6.5	0.00	1.20	11.7	0.05
May	0.58	0.26	3.51	4.4	279	6.1	**15.61**	10.3	0.00	2.25	25.3	0.03
June	0.26	0.10	2.33	3.4	135	2.9	**20.43**	5.2	0.00	0.61	13.7	0.08
July	0.23	0.12	1.34	3.4	119	2.5	**17.00**	6.3	0.00	0.74	9.8	0.07
Aug	0.23	0.06	0.09	2.5	55	1.1	**9.28**	2.8	0.00	0.47	6.0	0.01
Sept	0.51	0.21	1.69	4.3	161	3.7	**14.92**	8.3	0.00	1.71	15.7	0.01
Oct	0.30	0.12	2.70	2.7	112	2.2	**15.13**	5.6	0.00	0.89	7.6	0.01
Nov	0.46	0.14	2.70	5.8	96	1.9	**30.56**	7.2	0.00	0.21	10.9	0.01
Dec	0.90	0.15	2.85	10.0	145	2.5	**24.26**	19.4	0.00	0.57	20.1	0.01
Ann Av.	**0.49**	**0.17**	**2.83**	**4.5**	**141**	**3.2**	**19.61**	**8.0**	0.00	**1.00**	**13.3**	**0.04**

Table 33 Heavy Metals Monitoring Coed-Gwilym Cemetery 2008

Tables 34 and 35 detail the monthly means for the **Morriston Groundhog ❺** site during 2007 and 2008. All results are expressed in ng/m^{-3}

Morriston Groundhog 2007												
2007	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg(p)**
Jan	1.11	0.41	4.31	21.6	399	5.02	**14.1**	20.7	<0.01	1.08	23.7	0.06
Feb	1.65	0.45	4.49	32.9	848	16.38	**22.2**	31.2	<0.01	1.83	77.7	0.14
Mar	0.92	0.37	3.74	20.8	524	8.35	**18.1**	16.2	<0.01	2.15	32.7	1.09
April	2.91	0.71	9.24	37.4	1073	24.25	**32.4**	43.0	<0.01	18.45	85.7	1.90
May	6.69	0.06	8.01	0.6	34	1.18	**0.3**	1.4	<0.01	*162****	9.3	0.07
June	0.84	0.29	5.10	18.1	539	10.91	**18.1**	18.3	<0.01	3.08	43.0	0.14
July	0.55	0.65	0.11	18.2	322	5.38	**24.6**	12.2	<0.01	1.19	16.5	0.23
Aug	1.04	0.57	2.21	19.1	374	6.09	**21.0**	11.5	<0.01	0.97	19.2	0.18
Sept	0.87	0.26	0.55	28.7	518	9.05	**15.5**	34.6	<0.01	1.11	29.4	0.16
Oct	0.97	0.38	1.79	34.7	617	11.56	**22.9**	26.7	<0.01	2.44	34.6	0.02
Nov	1.18	0.28	3.79	32.8	583	8.47	**22.6**	15.9	<0.01	1.12	27.9	0.03
Dec	1.29	0.39	2.65	43.4	518	8.65	**8.2**	36.6	<0.01	2.73	43.5	0.02
Ann Av.	**1.67**	**0.40**	**3.83**	**25.68**	**529**	**9.61**	**18.3**	**22.37**	**0**	**3.29**	**36.93**	**0.34**

Table 34 - Heavy Metals Monitoring Morriston Groundhog 2007

***** The vanadium levels measured during May were mostly extremely high. This is thought to be owing to an instrument fault affecting the first in the series of analytes to be measured, which is vanadium. These values should be treated with caution and should have a very high uncertainty attached to them. If these values appeared as part of the UK Heavy Metals Monitoring Network results they would most likely be excluded during ratification as extreme outliers.

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Morriston Groundhog 2008												
2008	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg(p)**
Jan	0.41	0.19	0.22	16.7	385	5.6	**3.16**	7.5	0.01	1.59	56.7	0.01
Feb	1.29	0.71	4.43	43.3	970	19.2	**14.20**	30.7	0.00	3.22	66.6	0.02
Mar	0.30	0.54	2.92	54.3	1223	14.5	**5.57**	44.9	0.00	0.93	83.1	0.04
April	0.44	0.27	1.69	32.5	399	6.0	**6.81**	26.3	0.01	1.25	24.4	0.05
May	0.70	0.38	1.87	54.9	471	9.7	**7.49**	32.5	0.01	1.93	41.9	0.05
June	0.24	0.13	1.13	19.1	331	5.0	**4.81**	15.3	0.00	0.65	17.5	0.11
July	0.31	0.12	0.89	12.1	348	5.7	**4.24**	8.1	0.00	0.72	17.2	0.05
Aug	0.18	0.09	0.82	15.5	285	3.6	**2.20**	6.9	0.00	0.64	12.1	0.01
Sept	0.18	0.24	2.40	18.7	463	7.0	**3.40**	15.3	0.00	1.88	32.8	0.01
Oct	0.38	0.25	2.20	30.8	556	8.5	**13.89**	16.6	0.00	1.82	26.9	0.01
Nov	0.69	0.45	3.12	34.1	568	6.7	**7.36**	20.4	0.00	0.35	26.3	0.01
Dec	0.94	0.22	3.08	39.9	686	8.6	**18.11**	21.2	0.01	0.62	32.0	0.01
Ann Av.	**0.51**	**0.30**	**2.06**	**31.0**	**557**	**8.3**	**7.60**	**20.5**	**0.00**	**1.30**	**36.5**	**0.03**

Table 35 - Heavy Metals Monitoring Morriston Groundhog 2008

As mentioned above within section 2.1.10 above, monitoring at the site **YGG Gellionnen** ❹ (Welsh Primary School) commenced during November 2007. There is little valid data that can be presented for 2007 so, for the sake of clarity, no data is reported here for 2007. Details of the monitoring undertaken during 2008 can be found below within table 36.

YGG Gellionnen 2008												
2008	**As**	**Cd**	**Cr**	**Cu**	**Fe**	**Mn**	**Ni**	**Pb**	**Pt**	**V**	**Zn**	**Hg**
Jan	0.38	0.16	1.87	4.7	202	3.59	**10.4**	6.2	<0.01	0.52	10.1	0.26
Feb	*0.01*	*0.14*	*1.49*	*7.3*	*157*	*2.83*	***9.4***	*5.5*	*<0.01*	*0.39*	*16.8*	*0.06*
Mar	0.06	0.08	0.61	2.8	84	1.52	**6.3**	4.8	<0.01	0.31	7.1	0.04
April	0.35	0.73	0.72	3.7	122	2.81	**6.3**	10.7	<0.01	1.13	17.4	0.07
May	0.70	0.27	1.59	5.6	350	7.37	**16.8**	14.3	0.01	1.97	38.0	0.05
June	0.24	0.20	1.03	3.0	133	3.01	**12.3**	10.5	<0.01	0.74	12.5	0.09
July	0.38	0.12	0.30	4.2	145	2.94	**10.0**	7.7	<0.01	0.76	11.3	0.05
Aug	0.16	0.11	1.86	2.9	77	1.36	**7.7**	4.3	<0.01	0.27	8.2	<0.02
Sept	0.42	0.29	0.10	4.1	188	4.23	**7.1**	9.7	<0.01	1.29	15.3	<0.01
Oct	0.45	0.20	0.14	5.2	144	2.90	**20.8**	8.8	<0.01	1.10	12.5	<0.01
Nov	0.32	0.11	0.34	4.2	76	1.54	**13.9**	5.3	<0.01	0.27	11.2	<0.01
Dec	0.64	0.16	0.59	4.2	129	2.08	**10.9**	20.8	<0.01	0.62	18.0	<0.01
Ann Av.	**0.34**	**0.21**	**0.89**	**4.33**	**150.6**	**3.01**	**10.99**	**9.04**	**0.01**	**0.78**	**14.86**	**0.09**

*Table 36 - Heavy Metals Monitoring **YGG Gellionnen** 2008*

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Table 37 presents the nickel annual means from all four monitoring sites for the years 2002-2008 where appropriate.

Year	Glais Primary School ❷	Coed-Gwilym Cemetery ❸	YGG Gellionnen ❹	Morriston Groundhog ❺
2002	**28.91**	-	-	-
2003	18.14	-	-	-
2004	**33.83**	-	-	-
2005	19.62	-	-	-
2006	**26.13**	-	-	-
2007	**28.04**	**37.31**	-	18.3
2008	10.34	19.61	10.99	7.6

Table 37 – Swansea Nickel Annual Means 2002 – 2008

From table 30 it would appear that the introduction of the bag filter system by Vale INCO Europe commencing late 2007, has seen a dramatic reduction in ambient nickel annual means during 2008. However, it must be appreciated that this reduction trend has only been evident in the first year so far following the introduction of the bag filter system. It is envisaged that monitoring will continue for several years to confirm the apparent reduction in ambient concentrations of nickel within the vicinity of the refinery.

Breuer Plot 9 shows the meteorological conditions experienced at the Morriston Groundhog site during 2008. Meteorological data from the Morriston site has been used as it is the most northerly station with reliable meteorological data within Swansea. The 30m mast at Cwm Level Park provides high quality data but its location in the lower valley area probably does not reproduce the conditions experienced just a further 2 miles north up the Lower Swansea Valley due to the change in surrounding topography. Even with use of the Morriston Groundhog meteorological data, Breuer plot 9 below cannot be guaranteed to fully reflect the meteorological conditions a further 4-5 miles north again within the Glais area. However, it is probably the best available meteorological data currently available for the north of Swansea.

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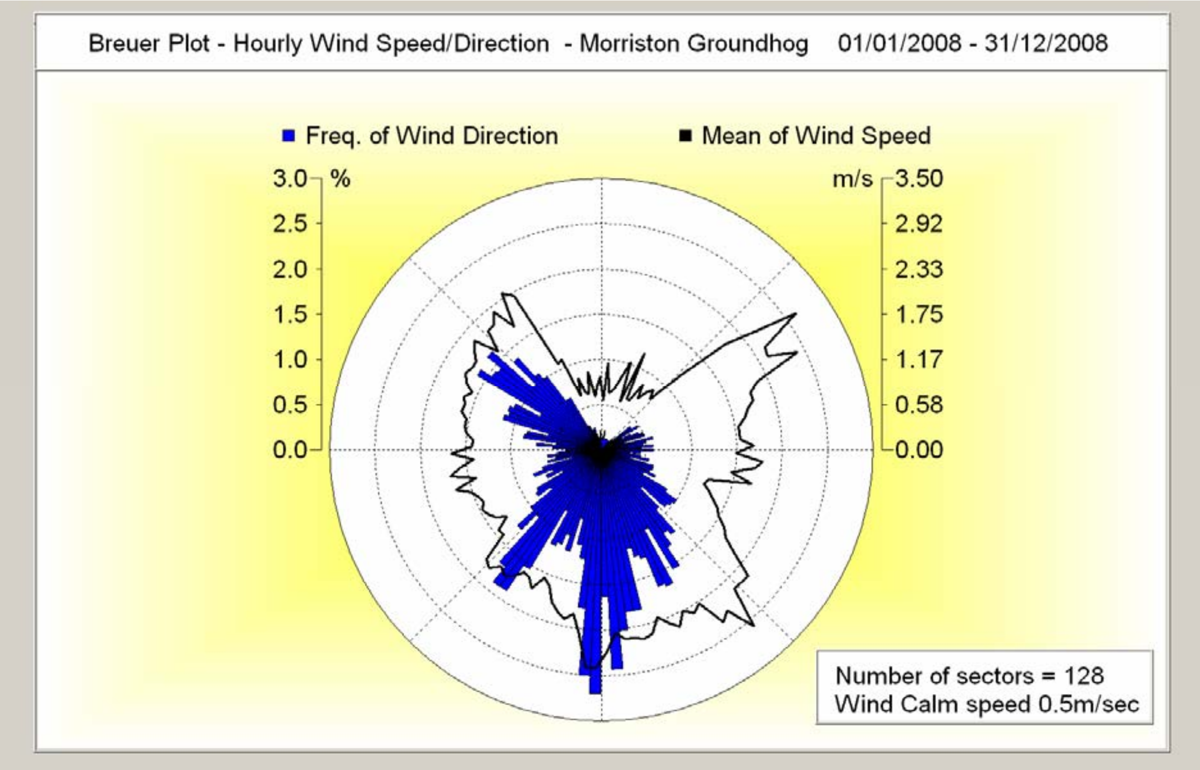

Breuer Plot 9 – Morriston groundhog Meteorological Data 2008

Accepting the above, and in combination with the improved abatement employed, it can be seen that the period is dominated by southerly/south westerly winds which would influence concentrations at the Coed-Gwilym Cemetery❸ site. However, the measured concentration for 2008 at the Coed-Gwilym Cemetery site is approximately half of that seen during 2007 and falls slightly below the directive annual mean of 20ng/m^{-3}. Additionally, there is a reduction during 2008 of greater than 50% than previously seen at the Morriston site during 2007 with approximately a 66% reduction in the annual mean seen at the Glais Primary School site over previous years of measurement. **The latest nickel monitoring results for 2008 indicate compliance with the Daughter Directive annual mean target value of 20ng/m^{-3} at all four sites.**

It is probably too early to fully attribute these marked reductions in nickel concentrations solely to the improved abatement employed on the high stack release point given the known fluctuations that atypical meteorology produce, but, if the trend should continue in future years then compliance with the Daughter Directive Target annual mean value of 20ng/m^{-3} may be assured at all sites.

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It is recommended that monitoring continues at all of the local authority funded sites for the foreseeable future to assess and confirm any changes in ambient nickel concentrations.

The authority commissioned CREH (Centre for Research into Environment and Health) to undertake a Statistical Analysis of Selected Heavy Metal Concentrations in Ambient Air Around Swansea following the introduction of improved abatement at the high stack discharge point at Vale Inco in August 2007. This report focuses on nickel concentrations but also copper, manganese and lead concentrations. The full report is reproduced as Annexe 5.

From the data available within tables 30-36, it is clear that annual mean concentrations for arsenic and cadmium at all monitoring locations fall well below the 4th Daughter Directive Target Values.

Additionally, from the data available within tables 30-36 for 2007 and 2008, it is clear that annual mean concentrations for lead at all monitoring locations fall well below the 0.25ug/m^3 required under the Air Quality (Amendment) (Wales) Regulations 2002 to be achieved by the 31st December 2008.

PAH data analysis/ratification from the monitoring site within the compound of the 30m meteorological mast at Cwm Level Park, Landore is not complete for 2008. Results of all compounds measured from 2007 up to June 2008 can be found at:
http://www.airquality.co.uk/data/pah/Compiled_Concentrations_PAH_Digitel_2006-June2008_v1.xls

3 Road Traffic Sources

3.1 Narrow Congested Streets with Residential Properties Close to the Kerb

In order to consider which streets fell within the definition of narrow congested streets with a traffic flow of 5000 vehicles per day,[36] the emissions database (EDB) which has been under development over the last several years was first examined. All road links within the EDB (circa 15,000) were exported into an Excel worksheet and index by the Annual Average Daily Traffic flow (AADT). Details held were examined where the AADT for individual road links was above 4,500 vehicles. This approach was taken as numerous counts from temporary or short duration surveys were held i.e. 1 week duration, where, underestimates of the flow could feasibly be possible due to the time of the year the survey was undertaken i.e. during the school holidays. Once individual road links were identified they were then cross referenced with those roads within the existing Hafod Air Quality Management Area (AQMA) and discounted[37] from further consideration.

Numerous road links were identified with flows in excess of an AADT of 4,500 but, these roads were discounted as they did not fit the fit the definition of a narrow congested street with residential properties within 2m of the carriageway on at least one side of the road.

Following this exercise, the streets listed below within table 38 were identified. These roads were not previously thought likely to present problems with the nitrogen dioxide annual mean objective but have been brought back into the scope of assessment due to the AADT requirement. The identified roads suffer congestion as defined within LAQM [38] to one extent or another mainly due to parked vehicles and restricted movements.

[36] LAQM.TG(09) USA Checklist Box 5.3 – A1 Narrow congested streets with residential properties close to the kerb
[37] LAQM.TG(09) USA Checklist Box 5.3 – (A) Overview
[38] LAQM.TG(09) USA Checklist Box 5.3 – A1 Narrow congested streets approach page 5-10

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Road Name	Area
Hebron Road	Clydach
High Street	Clydach
Lone Road	Clydach
Vardre Road	Clydach
Chemical Road	Morriston / Cwmrhydyceirw
Cwmrhydyceirw Road	Cwmrhydyceirw
Alexandra Road	Gorseinon
Belgrave Road	Gorseinon
Courtney Street	Manselton
Clyndu Street	Morriston
Morfydd Street	Morriston
Parry Road	Morriston
Newton Road	Mumbles
Highpool Lane	Newton
Parkmill Road	Parkmill
Beach Road	Penclawdd
Blodwen Terrace	Penclawdd
Sea View	Penclawdd
Station Road	Penclawdd
Bolgoed Road	Pontardulais
St Teilo Crescent	Pontardulais
Water Street	Pontardulais
Carnglas Road	Tycoch

Table 38 – Identified narrow Streets with AADT > 5000

The City & County of Swansea has identified congested streets with flows above 5,000 vehicles per day where residential properties are close to the kerb, that were not adequately considered in previous rounds of Review and Assessment, and **will proceed to a Detailed Assessment. This Detailed Assessment will focus on the use of passive nitrogen dioxide diffusion tubes to assess both the annual and 1 hour objectives for NO_2. It is not envisaged that use of chemiluminescent analysers will be employed.**

3.2 Busy Streets Where People May Spend 1-hour or More Close to Traffic

Assessments within the city centre have already commenced following the introduction of the Metro scheme and associated changes to the city centre road network. The details are included within section 2.2.2 above. Certain streets within Sec 3.1 table 38 also have the potential for people to spend 1-hour or more close to traffic. These locations will be assessed as described within section 3.1 above

The City & County of Swansea has assessed new/newly identified busy streets where people may spend 1 hour or more close to traffic, that were not assessed in previous rounds of Review and Assessment, and concluded that it will not be necessary to proceed to a Detailed Assessment..

3.3 Roads with a High Flow of Buses and/or HGVs.

The authority operate 44 GPRS traffic counters that have been configured to produce a vehicle classification split into the EUR 6 basic categories as detailed below within table 39. Their location can be seen within Annexe 6. These tend to be within the lower Swansea Valley area in and around the Hafod AQMA but latest deployment have seen this provision expand into other areas, mainly around some of the busier major traffic junctions. Funding is being sought to once again expand this monitoring program.

Vehicle class:	Description
0	Unclassified vehicles
1	Motorcycles
2	Cars or light Vans
3	Cars or light Vans with Trailer
4	Heavy Van, Mini bus, L/M/HGV
5	Articulated lorry, HGV+Trailer
6	Bus

Table 39 – EUR6 Classification scheme

Data from the ATC network has been analysed for the years 2004 – 2008 for the basic three categories from the EUR6 classification employed that are required to produce the composition of flow within LAQM.TG(09) box 5.3 Section A3 page 5-12. These details are provided separately for EUR6 classification categories 4-6 below within tables 40-43. Table 44 summarises the total HDV flows.

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Heavy Van, Mini bus, L/M/HGV	2004	2005	2006	2007	2008
Site 1	5.2	4	5.1	4.8	4.1
Site 2	6	5.9	6.4	6.1	6.6
Site 3	4.1	3.2	4.3	4.5	7.4
Site 4	4	3.9	4.4	4.4	4.4
Site 5	5.6	5.3	5.6	5.8	5.9
Site 6	6.1	6.3	6.9	7.4	7.4
Site 7	3.9	3.8	4.2	4.5	4.8
Site 8	29.4	30	29.9	29.8	30.3
Site 9	6.4	6.2	6.4	6.6	6.2
Site 10	5	4.8	4.8	4.8	4.6
Site 11	5.8	5.8	6	6.5	6.9
Site 12	5.2	4.7	5.1	4.9	4.8
Site 13	4.9	4.5	4.7	4.6	4.5
Site 14	5.2	5.2	5.6	5.7	5.9
Site 15	5.4	13.5	8.4	14.4	6.1
Site 16	5.7	4.7	4.6	4.8	4.8
Site 17	2.2	2	4.3	4.1	5.3
Site 18	5	11	6.7	6.4	6.3
Site 19	5.6	5.4	5.6	5.7	5.7
Site 20	6	5.7	4.9	4.6	4.3
Site 21	6.1	5.8	6.4	6.5	6.7
Site 22	6.1	6.2	6.9	7	6.9
Site 23	4.7	4.5	4.8	5	4.9
Site 24	-	5.5	5.7	5.7	5.5
Site 25	-	4.1	4.5	6.2	6.0
Site 26	4.8	5.1	5.5	5.7	5.6
Site 27	4.3	4.5	5.1	5.5	5.7
Site 28	4.2	4.3	4.8	4.9	4.9
Site 29	4.7	4.4	4.7	4.9	4.7
Site 30	-	12.6	6.6	4.1	4.2
Site 31	4.1	4.1	4.4	4.6	4.7
Site 32	-	16.8	8.2	3.8	3.8
Site 33	4.1	3.9	4.2	4.4	4.4
Site 34	-	13.2	6.8	4.3	4.4
Site 35	-	37.5	13.9	5.3	5.7
Site 36	-	-	-	-	-
Site 37	-	3.8	3.4	3.8	3.9
Site 38	-	5.9	6.4	6.5	6.3
Site 39	-	4.5	4.7	4.6	5.2
Site 40	3	3.1	3.5	3.8	3.9
Site 41	-	2.9	2.9	2.7	3.4
Site 42	-	10.9	6.9	5.2	5.1
Site 43	-	4.8	5.1	5.6	5.6
Site 44	-	-	-	6.1	6.1

Table 40 – EUR6 Classification scheme 2004-2008 Class 4

Comments

Site 8 located on Morfa Road, The Stand is directly outside the access road to the main City & County of Swansea transport depot and also to a small industrial estate further up Morfa Road, hence the consistent high percentage composition for this classification.

Site 35 suffered configuration problems during 2005 which failed to take into account the possibility of parked vehicles affecting the classification. This was identified but not fully understood as to why the configuration issues with loop tuning only affected this Class 4 scheme until some time later.

Artic HGV + trailer	2004	2005	2006	2007	2008
Site 1	0.3	0	0.2	0	0
Site 2	0.2	0.2	0.0	0.0	0.0
Site 3	0	0	0.0	0.0	0.0
Site 4	0	0	0.0	0.0	0.0
Site 5	0	0	0.3	0.3	0.3
Site 6	0.6	0.6	0.8	0.8	0.8
Site 7	0.2	0.1	0.1	0.1	0.1
Site 8	2.9	2.9	1.9	1.1	1.8
Site 9	0.5	0.5	0.6	0.4	0.4
Site 10	0.4	0.4	0.2	0.2	0.2
Site 11	0	0	0	0	0
Site 12	0.3	0.4	0.2	0.2	0.1
Site 13	0.5	0.4	0.4	0.4	0.2
Site 14	0.2	0.2	0.3	0.3	0.1
Site 15	0	0.3	0.1	0.3	0.1
Site 16	0.3	0.2	0.2	0.2	0.2
Site 17	0.1	0.2	0.2	0.2	0.2
Site 18	0.3	0.8	0.2	0.4	0.2
Site 19	0.3	0.4	0.2	0.2	0.1
Site 20	0.8	0.8	0.7	0.5	0.5
Site 21	0.4	0.3	0.2	0.2	0.2
Site 22	0.7	0.6	0.4	0.4	0.4
Site 23	0.3	0.2	0.2	0.2	0.2
Site 24	-	0	0.2	0.2	0.2
Site 25	-	1.1	0.5	0.4	0.3
Site 26	0.5	0.4	0.3	0.3	0.3
Site 27	0.2	0.3	0.3	0.2	0.4
Site 28	0	0.2	0.2	0.2	0.2
Site 29	0	0.3	0.2	0.2	0.2
Site 30	-	0.3	0.2	0.1	0.1
Site 31	0.3	0.2	0.3	0.3	0.2
Site 32	-	0	0.1	0	0
Site 33	0.2	0.2	0.2	0.2	0.2
Site 34	-	0.6	0.3	0.2	0.1
Site 35	-	1.2	0.7	0.2	0.4
Site 36	-	-	-	-	-
Site 37	-	0.4	0.4	0.5	0.5
Site 38	-	0	0.3	0	0.3
Site 39	-	0.2	0.3	0.3	0.3
Site 40	0	0	0	0	0
Site 41	-	0.2	0.2	0.2	0.2
Site 42	-	0.4	0.2	0.2	0.2
Site 43	-	1.1	0.9	0.9	1
Site 44	-	-	-	0.4	0.4

Table 41 – EUR6 Classification scheme 2004-2008 Class 5

Comments

Again, Site 8 is located on Morfa Road, The Stand directly outside the access road to the main City & County of Swansea transport depot and also to a small industrial estate further along Morfa Road, hence the consistent high percentage composition for this classification.

There are some sites (Sites 2, 3, 4, 11, 32 and Site 40 that see negligible artic trailer flow – these sites tend to be within areas that have no reason to see these type of vehicles within the area.

Bus	2004	2005	2006	2007	2008
Site 1	0.3	0.3	1.2	1.6	1.4
Site 2	0.2	0.2	0.2	0.2	0.3
Site 3	0.2	0.2	0.5	0.5	0.6
Site 4	0	0.3	0.5	0.7	0.7
Site 5	0	0	0.0	0.0	0.0
Site 6	1.4	1.3	1.8	1.9	1.7
Site 7	0.5	0.4	0.6	0.8	1
Site 8	1.5	1.4	0	1.1	0
Site 9	0.5	0.3	0.4	0.4	0.4
Site 10	0.4	0.3	0.7	0.9	0.5
Site 11	0.8	0.8	2.7	2.9	3.4
Site 12	0.3	0.4	0.1	0.1	0.1
Site 13	0.6	0.4	0.2	0.2	0.4
Site 14	1.5	1.3	2	2.2	1.9
Site 15	0.9	1	1.1	1.2	1.1
Site 16	0.7	0.2	0.3	0.3	0.4
Site 17	0.3	0.2	0.4	0.4	0.4
Site 18	1	1.6	2.1	2.1	1.7
Site 19	1.2	1.2	2.5	3.3	3.6
Site 20	1.1	1.1	1	0.9	0.9
Site 21	0.2	0.3	0.5	0.5	0.3
Site 22	3.6	3.2	6.7	8.4	8.7
Site 23	0.5	0.4	0.7	0.9	0.9
Site 24	-	0.6	0.7	0.7	0.7
Site 25	-	0.7	0.5	0.8	0.8
Site 26	0.5	0.4	0.4	0.5	0.5
Site 27	0.5	0.4	0.5	0.6	0.6
Site 28	0.4	0.4	0.5	0.5	0.5
Site 29	0	0.3	1.3	1.7	1.7
Site 30	-	0.8	0.8	0.8	0.8
Site 31	0.3	0.3	0.4	0.4	0.5
Site 32	-	1.3	1.3	1.4	1.4
Site 33	0.2	0.5	1.1	1.5	1.3
Site 34	-	1.5	1.5	1.7	1.7
Site 35	-	2	1.6	1.5	1.4
Site 36	-	-	-	-	-
Site 37	-	0.9	0.8	0.7	0.8
Site 38	-	0.7	1.6	2.1	1.8
Site 39	-	0.2	0.4	0.7	0.8
Site 40	0	0.3	0.7	0.7	0.7
Site 41	-	0.2	0.2	0.2	0.2
Site 42	-	0.8	1	1.1	1.1
Site 43	-	0.4	0.4	0.4	0.4
Site 44	-	-	-	0.9	0.9

Table 42 – EUR6 Classification scheme 2004-2008 Class 6

Comments

Site 11 exhibits a relatively low AADT but it is evident that the fraction of class 6 buses is “significant” within the overall flow. This increased following the opening of the Liberty Stadium and Morfa Shopping complex nearby.

Site 22 has shown increased composition of buses following the developments mentioned above and the fact that all bus services now use High Street (stopping outside the main railway station) as the primary access route leading into the city centre. This effect can also be seen at site 19 Carmarthen Road which leads directly into High Street.

City & County of Swansea

Total HDV as % of Traffic Flow	2004	2005	2006	2007	2008
Site 1	5.8	4.3	6.5	6.4	5.5
Site 2	6.4	6.3	6.6	6.3	6.9
Site 3	4.3	3.4	4.8	5	8
Site 4	4	4.2	4.9	5.1	5.1
Site 5	5.6	5.3	5.9	6.1	6.2
Site 6	8.1	8.2	9.5	10.1	9.9
Site 7	4.6	4.3	4.9	5.4	5.9
Site 8	33.8	34.3	31.8	32	32.1
Site 9	7.4	7	7.4	7.4	7
Site 10	5.8	5.5	5.7	5.9	5.3
Site 11	6.6	6.6	8.7	9.4	10.3
Site 12	5.8	5.5	5.4	5.2	5
Site 13	6	5.3	5.3	5.2	5.1
Site 14	6.9	6.7	7.9	8.2	7.9
Site 15	6.3	14.8	9.6	15.9	7.3
Site 16	6.7	5.1	5.1	5.3	5.4
Site 17	2.6	2.4	4.9	4.7	5.9
Site 18	6.3	13.4	9	8.9	8.2
Site 19	7.1	7	8.3	9.2	9.4
Site 20	7.9	7.6	6.6	6	5.7
Site 21	6.7	6.4	7.1	7.2	7.2
Site 22	10.4	10	14	15.8	16
Site 23	5.5	5.1	5.7	6.1	6
Site 24	-	6.1	6.6	6.6	6.4
Site 25	-	5.9	5.5	7.4	7.1
Site 26	5.8	5.9	6.2	6.5	6.4
Site 27	5	5.2	5.9	6.3	6.7
Site 28	4.6	4.9	5.5	5.6	5.6
Site 29	4.7	5	6.2	6.8	6.6
Site 30	-	13.7	7.6	5	5.1
Site 31	4.7	4.6	5.1	5.3	5.4
Site 32	-	18.1	9.6	5.2	5.2
Site 33	4.5	4.6	5.5	6.1	5.9
Site 34	-	15.3	8.6	6.2	6.2
Site 35	-	40.7	16.2	7	7.5
Site 36	-	-	-	-	-
Site 37	-	5.1	4.6	5	5.2
Site 38	-	6.6	8.3	8.6	8.4
Site 39	-	4.9	5.4	5.6	6.3
Site 40	3	3.4	4.2	4.5	4.6
Site 41	-	3.3	3.3	3.1	3.8
Site 42	-	12.1	8.1	6.5	6.4
Site 43	-	6.3	6.4	6.9	7
Site 44	-	-	-	7.4	7.4

Table 43 – HDV composition from EUR6 Classification scheme 2004-2008

City & County of Swansea

LAQM.TG(09) box 5.3 Section A3 page 5-12 defines roads with an unusually high proportion of HDV as ones with a HDV content greater than 20%. From table 43 it can be seen that only site 8 at Morfa Road meets this definition. However, as explained above, there is at present no relevant exposure at this location as Morfa Road leads into an industrial estate that also houses the main transport depot for the authority.

It should be noted that Morfa Road falls within the development proposals of The Tawe Riverside Development Corridor. These proposals include residential developments along the banks of the river Tawe, encompassing Morfa Road. These proposals have already seen the purchase and demolition of several commercial/industrial units in preparation for parts of the privately funded scheme. The economic downturn has not seen construction works commence as yet but it is inevitable that works will commence in the coming years. It is open to debate at present as to how long the whole scheme will take as it is inevitable that some commercial/industrial units will remain whilst development proceeds along Morfa Road. This ATC will allow monitoring of the composition during the transition of the area from a commercial/industrial area to primarily, a residential area.

Site 22 High Street is approaching the threshold but it should be noted that whilst relevant exposure exits within 10m along this section of High Street, the area already lies within the Hafod Air Quality Management Area.

The City and County of Swansea confirms that there are no new/newly identified roads with high flows of buses/HDVs.

3.4 Junctions

Guidance within LAQM.TG(09) box 5.3 Section A4 page 5-15 requires the identification of all “busy” junctions. A busy junction is defined within LAQM.TG(09) as one with more than 10,000 vehicles per day. An additional requirement is to determine if there is relevant exposure within 10m of the kerb (Swansea’s population of approx. 240,000 does not take it into the major conurbation category where relevant exposure would be within 20m of the kerb). Whilst as stated within the 2nd round of review and assessment there were several junctions that it was thought would meet the traffic volumes required, it was not thought there were receptor locations within 10m of the kerb. However, this situation has now changed with the construction of the new SA1 junction along Fabian Way and the construction of the new Tesco access road /junction following the reconstruction and expansion of its outlet at Nantyffin Road, Llansamlet.

Passive nitrogen dioxide measurements are already being made around several junctions mentioned within previous Review and Assessment works and these data are included within section 2.2.2 above.

It is thought that to measure PM_{10} at these locations would provide more meaningful data in preference to DMRB calculations. It has proved to be not economically viable or practical to deploy Thermo FDMS PM_{10} analysers at these locations. Therefore, alternative real-time instruments have been sourced to undertake the monitoring works that are desirable. The instruments chosen are Met One Instruments Inc. E-Type sampler (http://www.metone.com/documents/esamplerParticulate.pdf) It is recognised that these are not true gravimetric or type approved instruments for use on the UK network but current guidance indicates that use of the near forwards light scattering technique are suitable for screening assessments. This coupled with their ease of deployment make them an ideal alternative in these situations. It has not been possible to progress this matter since the original comments within the 2nd round USA due to technical difficulties with the operation of the monitoring equipment.

It has taken a considerable period of time to site and ensure reliable operation of the Met One E Type PM_{10} monitors close to the nearest receptor location to the identified junctions. It should be noted that the nearest monitoring location may in the majority of cases be greater than 10m away from the main junction. Practical considerations i.e. power requirements have also dictated the exact siting.

The proposed junctions with combined traffic volumes likely to be >10,000 AADT flow to be monitored by way of passive nitrogen dioxide diffusion tubes and/or PM_{10} measurements are:

a) Fforestfach Cross
b) Sketty Cross
c) Oystermouth Road
d) Llansamlet Cross
e) Quay Parade Bridges
f) Dyfatty Junction
g) Uplands Cross
h) SA1 junction, Fabian Way
i) Westway (opposite major bus station and major food retailer)

Whilst it has been possible to report the results of the NO_2 monitoring around several of these junctions, reliable PM_{10} monitoring has only recently commenced. These results will be reported in due course

3.5 New Roads Constructed or Proposed Since the Last Round of Review and Assessment

The City and County of Swansea confirms that there are no new/proposed roads within the authority's area.

3.6 Roads with Significantly Changed Traffic Flows

Data is available form 2006-2008 and these data are presented below within tables

40 - 42 to assess trends with the composition of the traffic flows being measured. Class 0 is intended to provide evidence of data capture as should problems be experienced within the traffic counter with classification then vehicles would manifest within this category. As can be seen within tables 40-42 very few operational issues have been experienced.

2006	Percentage Vehicle Classes							AADT	AWDT
	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6		
Site 1	0.8	0.8	91.5	0.4	5.1	0.2	1.2	**12072**	**12792**
Site 2	0.0	0.7	92.4	0.3	6.4	0.0	0.2	**14160**	**15288**
Site 3	0.0	0.4	94.6	0.2	4.3	0.0	0.5	**13272**	**14016**
Site 4	0.0	0.5	94.4	0.2	4.4	0.0	0.5	**10392**	**10848**
Site 5	0.0	0.9	92.9	0.3	5.6	0.3	0.0	**7728**	**8376**
Site 6	0.0	1.3	88.7	0.5	6.9	0.8	1.8	**14616**	**15240**
Site 7	0.0	0.7	94.2	0.2	4.2	0.1	0.6	**21576**	**22680**
Site 8	0.0	3.7	63.6	0.9	29.9	1.9	0	**2568**	**3264**
Site 9	0.0	0.6	91.7	0.4	6.4	0.6	0.4	**12984**	**13488**
Site 10	0.0	0.6	93.5	0.3	4.8	0.2	0.7	**21672**	**22992**
Site 11	0.0	0.5	89.6	1.1	6	0	2.7	**4368**	**4560**
Site 12	0.0	0.6	93.8	0.1	5.1	0.2	0.1	**19440**	**21144**
Site 13	0.0	0.5	93.9	0.4	4.7	0.4	0.2	**13320**	**15168**
Site 14	0.0	0.9	90.5	0.6	5.6	0.3	2	**15408**	**16128**
Site 15	0.0	0.5	89.6	0.2	8.4	0.1	1.1	**22032**	**23520**
Site 16	0.0	0.6	94.1	0.3	4.6	0.2	0.3	**27120**	**28968**
Site 17	0.0	1.2	93.6	0.3	4.3	0.2	0.4	**27336**	**28824**
Site 18	0.0	1.4	89.5	0.2	6.7	0.2	2.1	**15744**	**16608**
Site 19	0.0	0.6	90.6	0.5	5.6	0.2	2.5	**23232**	**24144**
Site 20	0.0	0.9	92.1	0.4	4.9	0.7	1	**32904**	**34488**
Site 21	0.0	0.6	92	0.3	6.4	0.2	0.5	**30528**	**32592**
Site 22	0.0	0.7	84	1.3	6.9	0.4	6.7	**10752**	**10896**
Site 23	0.0	0.4	93.4	0.4	4.8	0.2	0.7	**22656**	**24072**
Site 24	0.0	2.2	90.8	0.2	5.7	0.2	0.7	**9672**	**10272**
Site 25	0.0	2.3	91.9	0.3	4.5	0.5	0.5	**23160**	**24720**
Site 26	0.0	0.5	92.9	0.3	5.5	0.3	0.4	**22440**	**23664**
Site 27	0.1	0.5	93	0.4	5.1	0.3	0.5	**17496**	**18528**
Site 28	0.0	0.7	93.5	0.4	4.8	0.2	0.5	**13584**	**14352**
Site 29	0.0	0.9	92.3	0.6	4.7	0.2	1.3	**11208**	**11856**
Site 30	0.0	1	91.2	0.2	6.6	0.2	0.8	**21480**	**22728**
Site 31	0.0	0.9	93.6	0.4	4.4	0.3	0.4	**16416**	**16944**
Site 32	0.0	0.4	89.8	0.1	8.2	0.1	1.3	**16464**	**17352**
Site 33	0.0	0.7	93.4	0.4	4.2	0.2	1.1	**21864**	**22848**
Site 34	0.0	0.7	90.6	0.1	6.8	0.3	1.5	**17088**	**18048**
Site 35	0.0	4.2	78.9	0.7	13.9	0.7	1.6	**13656**	**14088**
Site 36	-	-	-	-	-	-	-	**-**	**-**
Site 37	5.4	2.7	86.9	0.4	3.4	0.4	0.8	**44088**	**45816**
Site 38	0.0	0.8	90.4	0.5	6.4	0.3	1.6	**8976**	**9576**
Site 39	0.0	1.9	92.4	0.3	4.7	0.3	0.4	**23664**	**24936**
Site 40	0.0	0.7	94.9	0.2	3.5	0	0.7	**10248**	**11040**
Site 41	0.0	2	94.5	0.3	2.9	0.2	0.2	**30768**	**32424**
Site 42	0.0	0.7	91.1	0.2	6.9	0.2	1	**14592**	**15624**
Site 43	0.0	1.4	91.7	0.5	5.1	0.9	0.4	**31248**	**33696**

Table 40 – GPRS ATC Classification split 2006

2007	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	AADT	AWDT
Site 1	0.0	0.6	92.8	0.2	4.8	0	1.6	**11976**	**12696**
Site 2	0.0	0.7	92.9	0.2	6.1	0.0	0.2	**13824**	**14904**
Site 3	0.0	0.4	94.4	0.2	4.5	0.0	0.5	**13272**	**14016**
Site 4	0.0	0.5	94.4	0.0	4.4	0.0	0.7	**10368**	**10848**
Site 5	0.0	0.9	92.6	0.3	5.8	0.3	0.0	**7800**	**8472**
Site 6	0.0	1.3	88.3	0.3	7.4	0.8	1.9	**14952**	**15576**
Site 7	0.0	0.7	93.8	0.1	4.5	0.1	0.8	**20424**	**21504**
Site 8	0.0	3.2	63.8	1.1	29.8	1.1	1.1	**2280**	**2880**
Site 9	0.0	0.5	92	0.2	6.6	0.4	0.4	**13536**	**13944**
Site 10	0.3	0.6	92.9	0.2	4.8	0.2	0.9	**21432**	**22584**
Site 11	0.0	0.6	89.4	0.6	6.5	0	2.9	**4056**	**4248**
Site 12	0.0	0.7	93.9	0.1	4.9	0.2	0.1	**19896**	**21504**
Site 13	0.0	0.6	93.6	0.4	4.6	0.4	0.2	**13080**	**14856**
Site 14	0.0	1.1	90.3	0.3	5.7	0.3	2.2	**15072**	**15672**
Site 15	0.0	0.5	83.3	0.3	14.4	0.3	1.2	**22368**	**23976**
Site 16	0.0	0.7	93.8	0.2	4.8	0.2	0.3	**27600**	**29304**
Site 17	0.0	1.3	93.7	0.3	4.1	0.2	0.4	**27360**	**28728**
Site 18	0.0	1.6	89.3	0.1	6.4	0.4	2.1	**16200**	**17112**
Site 19	0.0	0.7	89.9	0.1	5.7	0.2	3.3	**22704**	**23472**
Site 20	0.0	1.1	92.6	0.3	4.6	0.5	0.9	**32976**	**34896**
Site 21	0.0	0.8	91.8	0.2	6.5	0.2	0.5	**30984**	**33000**
Site 22	0.0	0.7	83.3	0.2	7	0.4	8.4	**10896**	**11040**
Site 23	0.0	0.5	93.1	0.2	5	0.2	0.9	**22344**	**23568**
Site 24	0.0	2.2	90.8	0.2	5.7	0.2	0.7	**9696**	**10296**
Site 25	0.0	1.0	91.4	0.2	6.2	0.4	0.8	**12000**	**12600**
Site 26	0.0	0.5	92.6	0.3	5.7	0.3	0.5	**22584**	**23808**
Site 27	0.0	0.9	92.6	0.2	5.5	0.2	0.6	**22320**	**23760**
Site 28	0.0	0.9	93.3	0.2	4.9	0.2	0.5	**13656**	**14424**
Site 29	0.0	0.8	92.2	0.2	4.9	0.2	1.7	**11328**	**12000**
Site 30	0.0	1	93.9	0.2	4.1	0.1	0.8	**22344**	**23712**
Site 31	0.0	1	93.3	0.3	4.6	0.3	0.4	**16056**	**16584**
Site 32	0.0	0.5	94.3	0.2	3.8	0	1.4	**15984**	**16896**
Site 33	0.0	0.7	93.1	0.1	4.4	0.2	1.5	**21312**	**22272**
Site 34	0.0	0.8	92.9	0.2	4.3	0.2	1.7	**15144**	**16032**
Site 35	0.0	3.6	89.2	0.2	5.3	0.2	1.5	**12696**	**13152**
Site 36	-	-	-	-	-	-	-	**-**	
Site 37	0.0	2.6	92	0.5	3.8	0.5	0.7	**47592**	**49728**
Site 38	0.0	0.8	90.6	0	6.5	0	2.1	**9240**	**9864**
Site 39	6.0	2.1	86.1	0.2	4.6	0.3	0.7	**23280**	**24384**
Site 40	0.0	0.7	94.8	0	3.8	0	0.7	**10200**	**10968**
Site 41	0.0	2.3	94.5	0.2	2.7	0.2	0.2	**30720**	**32280**
Site 42	0.0	0.8	92.6	0.2	5.2	0.2	1.1	**14904**	**15936**
Site 43	0.0	1.5	91.2	0.5	5.6	0.9	0.4	**30648**	**32976**
Site 44	0.0	0.9	91.4	0.2	6.1	0.4	0.9	**10944**	**11544**

Table 41 – GPRS ATC Classification split 2007

2008	Class 0	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	AADT	AWDT
Site 1	0.0	0.9	93.4	0.2	4.1	0	1.4	**10584**	**11232**
Site 2	0.0	0.7	92.2	0.2	6.6	0.0	0.3	**14472**	**15648**
Site 3	0.0	0.4	91.4	0.2	7.4	0.0	0.6	**12048**	**12720**
Site 4	0.0	0.5	94.4	0.0	4.4	0.0	0.7	**9936**	**10392**
Site 5	0.0	0.9	92.5	0.3	5.9	0.3	0.0	**7656**	**8304**
Site 6	0.0	1.2	88.6	0.3	7.4	0.8	1.7	**15528**	**16392**
Site 7	0.0	0.8	93.2	0.1	4.8	0.1	1	**20064**	**21264**
Site 8	0.0	4.6	62.4	0.9	30.3	1.8	0	**2616**	**3336**
Site 9	0.0	0.6	92.4	0.2	6.2	0.4	0.4	**12864**	**13272**
Site 10	0.0	0.3	93.7	0.7	4.6	0.2	0.5	**21312**	**22560**
Site 11	0.0	0.6	89.1	0	6.9	0	3.4	**4176**	**4344**
Site 12	0.0	0.6	94.2	0.1	4.8	0.1	0.1	**19440**	**21000**
Site 13	0.0	0.6	94.2	0.2	4.5	0.2	0.4	**12864**	**14616**
Site 14	0.0	0.9	90.9	0.3	5.9	0.1	1.9	**16368**	**17328**
Site 15	0.0	0.6	91.9	0.2	6.1	0.1	1.1	**22512**	**24192**
Site 16	0.0	0.7	93.8	0.2	4.8	0.2	0.4	**26976**	**28872**
Site 17	0.0	0.7	93.3	0.2	5.3	0.2	0.4	**27048**	**28680**
Site 18	0.0	0.4	91.2	0.3	6.3	0.2	1.7	**15744**	**16728**
Site 19	0.0	0.8	89.7	0.1	5.7	0.1	3.6	**18216**	**18840**
Site 20	0.0	1.1	92.9	0.3	4.3	0.5	0.9	**31560**	**33144**
Site 21	0.0	0.8	91.8	0.2	6.7	0.2	0.3	**30744**	**32976**
Site 22	0.0	0.7	83	0.2	6.9	0.4	8.7	**10728**	**10824**
Site 23	0.0	0.5	93.3	0.2	4.9	0.2	0.9	**22200**	**23544**
Site 24	0.0	4	89.3	0.2	5.5	0.2	0.7	**9672**	**10344**
Site 25	0.0	0.8	91.8	0.2	6.0	0.3	0.8	**14352**	**15192**
Site 26	0.0	0.5	92.8	0.2	5.6	0.3	0.5	**22440**	**23904**
Site 27	0.0	0.7	92.4	0.2	5.7	0.4	0.6	**19920**	**21288**
Site 28	0.0	0.7	93.3	0.4	4.9	0.2	0.5	**13248**	**14088**
Site 29	0.0	0.9	92.3	0.2	4.7	0.2	1.7	**11160**	**11832**
Site 30	0.0	1	93.8	0.2	4.2	0.1	0.8	**21936**	**23376**
Site 31	0.0	1.1	93.3	0.3	4.7	0.2	0.5	**15360**	**15888**
Site 32	0.0	0.5	94.2	0.2	3.8	0	1.4	**15792**	**16704**
Site 33	0.0	0.7	93.3	0.1	4.4	0.2	1.3	**21408**	**22488**
Site 34	0.0	0.7	92.9	0.1	4.4	0.1	1.7	**16824**	**17928**
Site 35	0.0	3.3	89.1	0.2	5.7	0.4	1.4	**12288**	**12744**
Site 36	-	-	-	-	-	-	-	**-**	**-**
Site 37	0.0	1.7	92.5	0.6	3.9	0.5	0.8	**45960**	**47712**
Site 38	0.0	0.8	90.3	0.5	6.3	0.3	1.8	**9144**	**9792**
Site 39	0.0	1.7	91.8	0.2	5.2	0.3	0.8	**23208**	**24360**
Site 40	0.0	0.7	94.7	0	3.9	0	0.7	**9936**	**10680**
Site 41	0.0	1	95	0.2	3.4	0.2	0.2	**29856**	**31512**
Site 42	0.0	0.8	92.6	0.2	5.1	0.2	1.1	**14976**	**16056**
Site 43	0.8	1.5	90.2	0.5	5.6	1	0.4	**29784**	**32232**
Site 44	0.0	0.9	91.5	0.2	6.1	0.4	0.9	**13344**	**14184**

Table 42 – GPRS ATC Classification split 2006

To assess if the AADT has changed significantly over the period 2005-2008, data is presented below in table 43

Site	AADT 2005	AADT 2006	AADT 2007	AADT 2008	% Growth 2008 over 2005 Base year	% Growth 2008 over 2006 Base year	% Growth 2008 over 2007 Base year
Site 1	7248	12072	11976	10584	46.0	-12.3	-13.2
Site 2	10608	14160	13824	14472	36.4	2.2	4.5
Site 3	10368	13272	13272	12048	16.2	-9.2	-10.2
Site 4	8616	10392	10368	9936	15.3	-4.4	-4.3
Site 5	5472	7728	7800	7656	39.9	-0.9	-1.9
Site 6	12552	14616	14952	15528	23.7	6.2	3.7
Site 7	19536	21576	20424	20064	2.7	-7.0	-1.8
Site 8	1632	2568	2280	2616	60.3	1.9	12.8
Site 9	9288	12984	13536	12864	38.5	-0.9	-5.2
Site 10	18888	21672	21432	21312	12.8	-1.7	-0.6
Site 11	2904	4368	4056	4176	43.8	-4.4	2.9
Site 12	12864	19440	19896	19440	51.1	0.0	-2.3
Site 13	12720	13320	13080	12864	1.1	-3.4	-1.7
Site 14	13344	15408	15072	16368	22.7	6.2	7.9
Site 15	16392	22032	22368	22512	37.3	2.2	0.6
Site 16	21120	27120	27600	26976	27.7	-0.5	-2.3
Site 17	22368	27336	27360	27048	20.9	-1.1	-1.2
Site 18	11784	15744	16200	15744	33.6	0.0	-2.9
Site 19	18240	23232	22704	18216	-0.1	-21.6	-24.6
Site 20	28392	32904	32976	31560	11.2	-4.1	-4.5
Site 21	23808	30528	30984	30744	29.1	0.7	-0.8
Site 22	8160	10752	10896	10728	31.5	-0.2	-1.6
Site 23	19776	22656	22344	22200	12.3	-2.0	-0.6
Site 24	-	9672	9696	9672	-	0.0	-0.2
Site 25	-	23160	12000	14352	-	**-**	16.4*
Site 26	19248	22440	22584	22440	16.6	0.0	-0.6
Site 27	18720	17496	22320	19920	6.4	13.9	-12.0
Site 28	11160	13584	13656	13248	18.7	-2.5	-3.1
Site 29	9240	11208	11328	11160	20.8	-0.4	-1.5
Site 30	-	21480	22344	21936	-	2.1	-1.9
Site 31	13896	16416	16056	15360	10.5	-6.4	-4.5
Site 32	-	16464	15984	15792	-	-4.1	-1.2
Site 33	19752	21864	21312	21408	8.4	-2.1	0.4
Site 34	-	17088	15144	16824	-	-1.5	10.0
Site 35	-	13656	12696	12288	-	-10.0	-3.3
Site 36	-	-	-	-	-	**-**	**-**
Site 37	-	44088	47592	45960	-	4.2	-3.6
Site 38	-	8976	9240	9144	-	1.9	-1.0
Site 39	-	23664	23280	23208	-	-1.9	-0.3
Site 40	7872	10248	10200	9936	26.2	-3.0	-2.7
Site 41	-	30768	30720	29856	-	-3.0	-2.9
Site 42	-	14592	14904	14976	-	2.6	0.5
Site 43	-	31248	30648	29784	-	-4.7	-2.9
Site 44	-	-	10944	13344	-	**-**	18.0 *

Table 43 AADT Percentage Growth 2005-2008

* Site 25 was counting 4 lanes (dual carriageway) of traffic in 2006. However, due to impending network changes (Carmarthen Road Park & Ride site) the site was relocated to count 2 lanes of outbound traffic only during January 2007. Site 44 was established at the same time on the other side of the dual carriageway to count inbound traffic on the remaining 2 lanes.

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What is clear from table 43 is the pronounced increase in flows between 2005 and 2006 to the first phase of GPRS ATC deployed (sites 1-23, sites 25-29, site 31, site 33 and site 40). The majority of these ATC's are sited in or around the Hafod Air Quality Management Area, within the Lower Swansea Valley area. During 2005 and 2006 saw the opening of the Morfa Retail Park and Liberty sports stadium which it is now apparent can be directly attributed to these substantial growth figures seen in this period. Post 2006, the AADT and therefore growth, appears to have settled down and remained relatively constant. There are however some surprising fluctuations of mainly negative growth seen at certain sites.

Guidance within LAQM.TG(09) box 5.3 Section A6 page 5-18 defines a "large" increase in traffic flow to be one greater than 25%. Clearly, this level of growth was seen between 2005 and 2006 at several sites but between 2007 and 2008, there is no evidence to determine that such an increase has been seen at any of the GPRS ATC's.

The Swansea Metro project aims to transform public transport in Swansea by introducing the new concept StreetCar vehicle, on a route with signalled priority at key sections between Morriston Hospital and Singleton Hospital, via the City Centre.

It will run on-street from Morriston Hospital to Singleton Hospital via the City Centre and Oystermouth Road stopping at many key destinations, including:

- Morriston Hospital,
- Woodfield Street, Morriston
- High Street Station,
- Kingsway,
- the new Quadrant Interchange (see section 3.7 below)
- County Hall,
- University and Singleton hospital**.**

Signalled priority will be provided at key locations, including:

- Martin Street roundabout,

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- Cwm Level roundabout,
- Normandy Road roundabout,
- the proposed Landore Express Route
- and in the City Centre, with the detailed design being carried out in-house

In order to enable the Swansea Metro to run, considerable works to the existing road network are required. Some of these works required at Cwm Level and Normandy Road roundabouts lie within the existing Hafod Air Quality Management Area. The road network surrounding these key roundabouts will be altered to provide priority to the Metro service by way of signal controlled access.

The first phase of these works started within the Kingsway area of the city centre during the summer months of 2006. Plans of the works completed as part of phase 1 can be seen below as maps 11 and 12

Phase 2 of the Metro scheme (see map 13) commenced during July 2007 and to extend the provision from the Kingsway down along Westway, linking into the Quadrant Transport Interchange (see section 3.7 below) and to the new Civic Centre on Oystermouth Road. Phase 2 was completed during late 2008/early 2009.

Phase 2 has seen major changes to the traffic flow within the city centre area. As yet, no GPRS ATC's have been installed along the affected routes to assess any pattern changes but discussions have already taken place and sites identified to enable suitable monitoring of traffic flows. Unfortunately, due to budgetary constraints no orders have been place with the equipment suppliers as yet, although it is hoped to start monitoring in the near future. Some of the work being undertaken with regard to the passive diffusion tube survey work is aimed at assessing what, if any impact this change in traffic flow within the city centre is having with NO_2 levels. This work is outlined within section 2.2.2 above.

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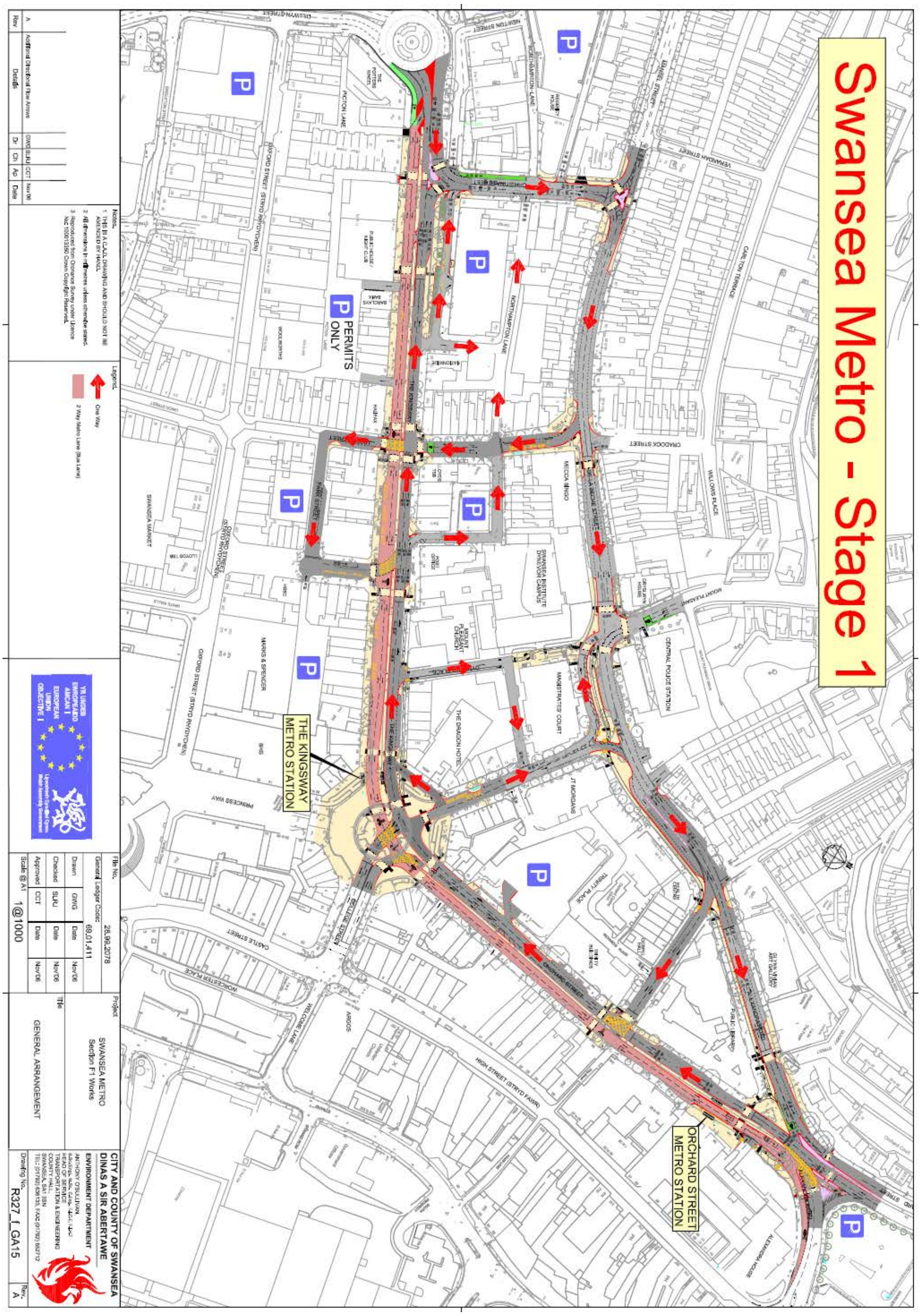
Installation of site 36 (Westway) is awaiting the completion of the redevelopment of the Quadrant Interchange (Sec 3.7 below) as access and egress roadways from the new interchange will require consideration and monitoring.



Map 11 – Swansea Metro Phase 1

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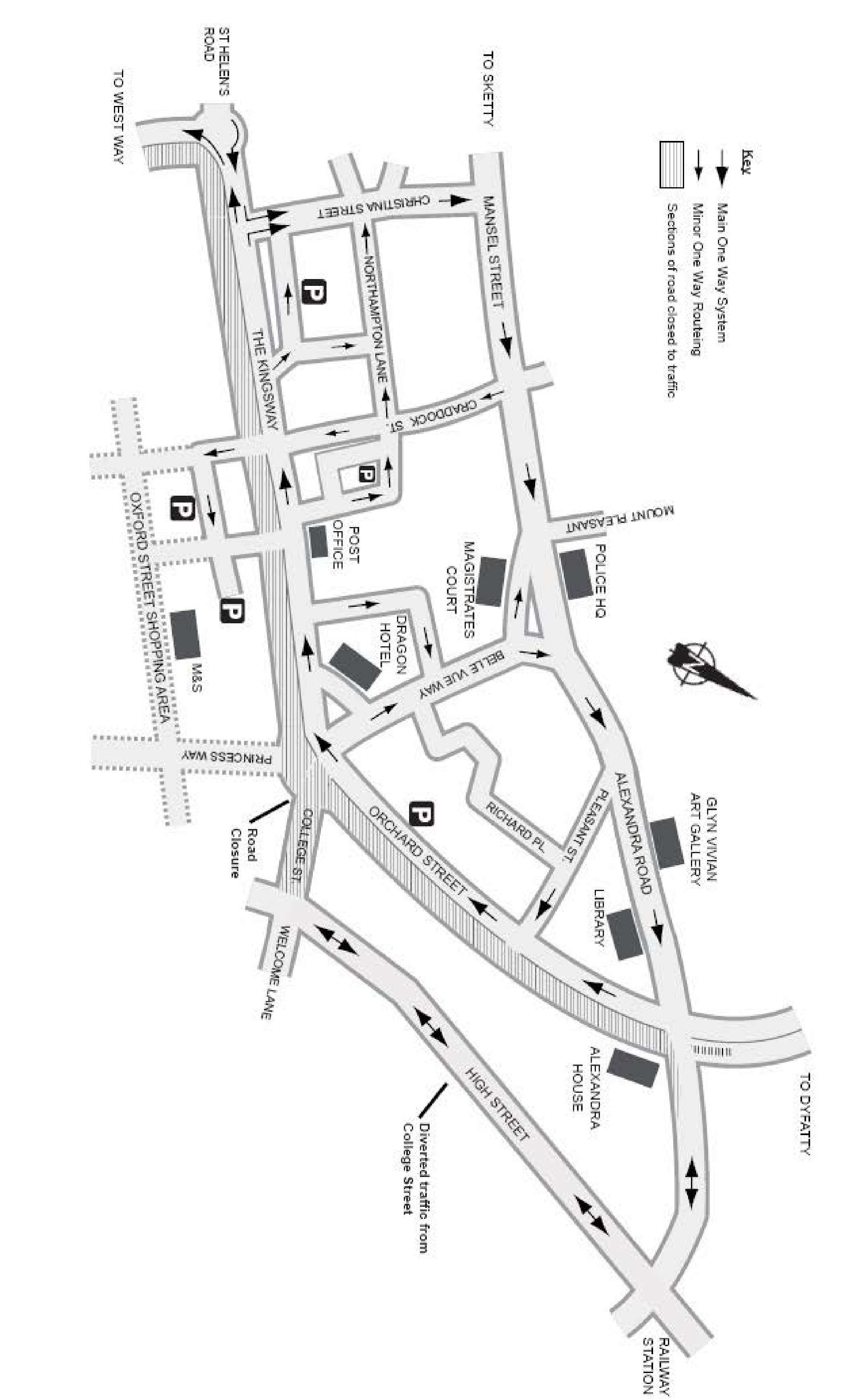

Map 12 Swansea Metro Phase 1

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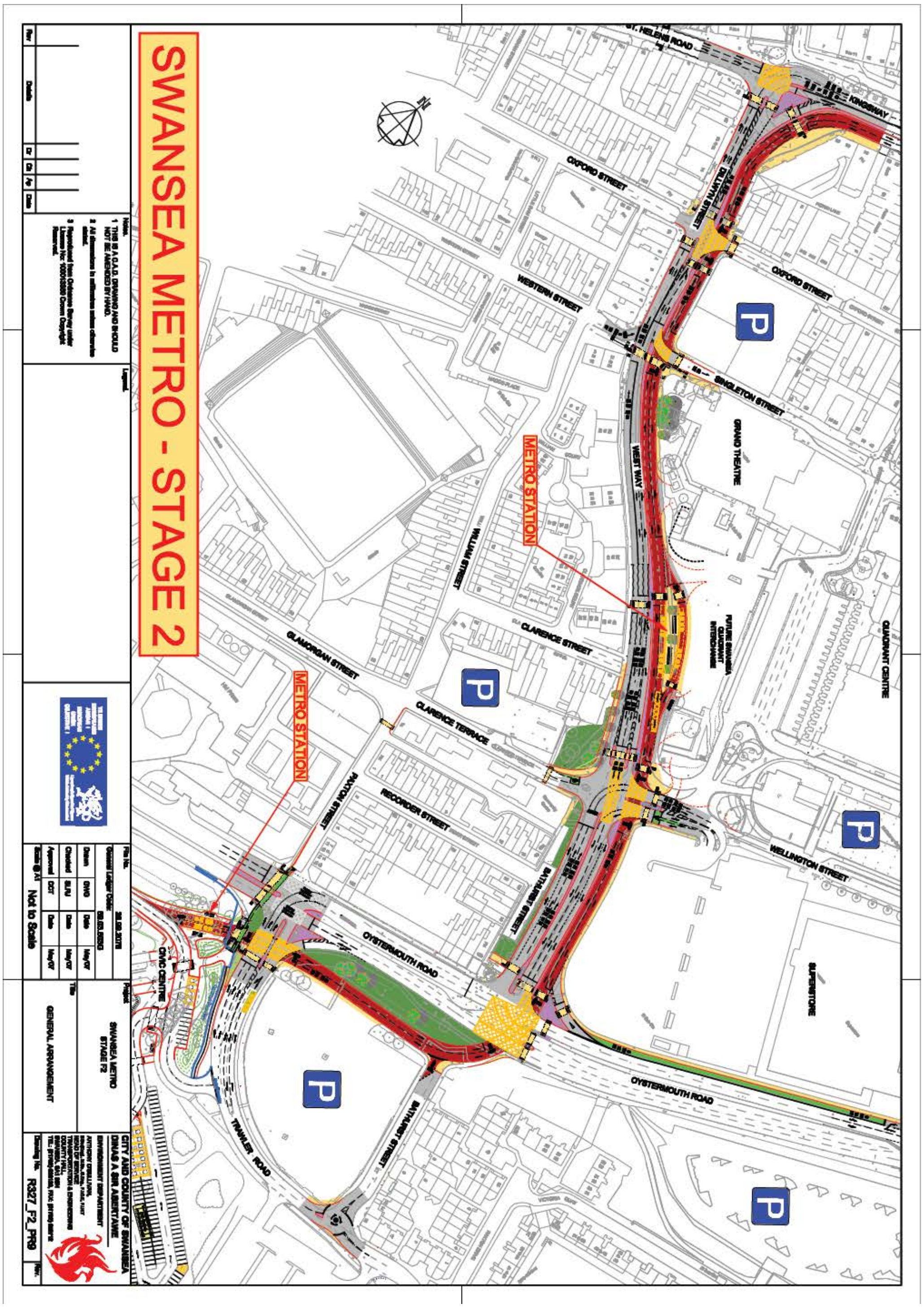

Map 13 – Phase 2 Swansea Metro Project

Funding is being sought to enable the installation of GPRS ATC's within the city centre area but with the current budgetary restraints being faced by the authority, this is unlikely to be realised in the near future.

The City and County of Swansea confirms that there are no new/newly identified roads with significantly changed traffic flows.

3.7 Bus and Coach Stations

The City and County of Swansea has prepared a scheme to replace the existing Quadrant bus station with a modern Transport Interchange to cater for both buses and coaches, including Swansea Metro vehicles, on a larger footprint. The Quadrant Interchange scheme has been accepted for Transport Grant funding by the Welsh Assembly Government. The current bus station is outdated in terms of passenger convenience, comfort and security. The Council's aspiration is for a modern transport interchange with high standards of cleanliness and security. The refurbishment of the Quadrant bus station was identified as a high priority in the Swansea Local Transport Plan 2000 – 2005. However, delays have been encountered with not only procedures involving the compulsory purchase of land but also with ensuring the necessary funding is fully in place prior to commencement of works. Sketch 1 indicates a schematic layout of the scheme with artist's impressions of the façade given below as sketches 2-3*.* A plan of the development area is given below as map 14.

Sketch 1 Quadrant Transport Interchange off Westway, Swansea

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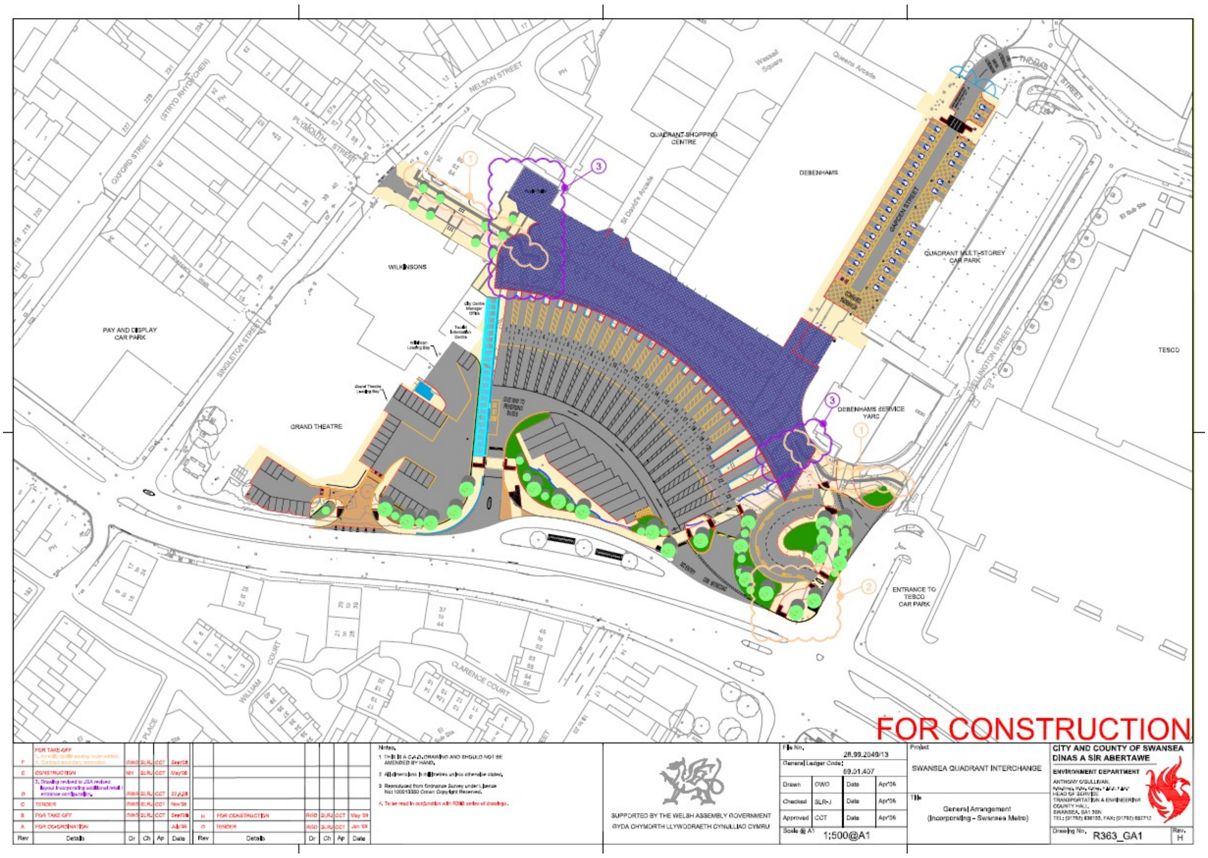

Map 14 – *Quadrant Transport Interchange off Westway, Swansea*

Blocks of flats can be seen opposite the proposed Quadrant Interchange. These blocks tend to be occupied by the elderly with warden accommodation. A basic Screening Assessment had been started during 2008 in front of one of the blocks of flats to assess both PM_{10} and NO_2. The PM_{10} light scattering analyser has suffered numerous breakdowns with the result that little data is available for 2008. Provision of a Thermo PM_{10} FDMS is not feasible due to the practical siting criteria issues to be resolved as well as the costs that would be incurred. It is thought that the light scattering analyser currently deployed when fully functional will permit a satisfactory screening of PM_{10} concentrations in the area when the interchange is complete.

Sketch 2 Quadrant Transport Interchange

Sketch 3 Quadrant Transport Interchange

Outline of scheme

The main components of the scheme comprised the following elements:

- 20 bus bays,
- 3 coach stands
- 2 Swansea Metro “stations” on Westway.
- 12 lay-over spaces
- Modern coach station facility to serve the long distance services,
- Enhanced passenger concourse with support facilities.
- Safe access to and from West Way
- New staff and office facilities
- Travel Shop (Information/ticket sales area.)
- Shopmobility Facility. In the Garden Street tunnel area
- Associated Retail Units.
- Enhanced links into the Quadrant shopping area.
- Improved access to the Grand Theatre and Wilkinson’s service areas
- Taxi rank for 9 vehicles
- Short stay parking for 5 cars (Passenger pick-up) adjacent to the coach area
- Passenger drop-off area

Programme

The authority had hoped to start construction of the Quadrant Interchange scheme in early 2007-08. However the Transport Grant allocation fell short of the bid. Moreover the Welsh Assembly Government has indicated that there should be a 20% private sector contribution. Meetings have taken place with Welsh Assembly Government officials and First Group to explain the scheme in detail and explore funding opportunities. First Group has indicated that they may be able to make a contribution.

All funding issues have now been addressed and work is due to commence during mid June 2009. The last day of operation of the existing bus station is Saturday 13th June. This date will mark significant changes to bus services, with services operating from a series of temporary bus stops across the city centre. Each bus service will have a single, dedicated bus stop in the city centre where passengers will be able to catch and get off the scheduled services. The existing Quadrant interchange will see demolition commence during mid June 2009.

It is clear, that composition of the traffic flows will change significantly within the city centre area during the 15 months of construction works to the new interchange. Therefore, to install fixed ATC's within the city centre as mentioned above within section 3.6 may present a false picture of conditions during these works. In addition, no assessment of the new facility will be made until the interchange is operational as final timetables and therefore the total number of bus movements is not known at this stage. Movements of buses in and out of the interchange will be capable of being monitored when GPRS ATC site 36 is installed along Westway upon completion of all works.

At present, there is existing relevant exposure within 20m of the curtilage of the existing site. From guidance contained within LAQM.TG(09) box 5.3 section A7 page 5-19 relevant exposure is required to be assessed either within 10m of any part of the bus station where buses are present or within 20m if the bus/coach station is within a major conurbation. Major conurbation is not defined within box 5.3 section

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A7 page 5-19 but it is defined as a population greater than 2 million within box 5.3 Sections A3 and A4 pages 5-12 to 5-15. Major conurbation is therefore, in this scenario, taken to be the same meaning given within sections A3 and A4, which in the case of Swansea, with a population of just under a quarter of a million clearly does not apply. Assessment when works are complete is likely to revolve around the issue of bus movements which is not known at this point.

The City & County of Swansea confirms that there are no relevant bus stations in the Local Authority area ***until at least 2011.***

4 Other Transport Sources

4.1 Airports

Swansea does have a small airport located at Fairwood Common, Upper Killay that has previously been used as a “regional airport”. However, guidance within LAQM.TG(09) box 5.4 Section B1 page 5-21 indicates that assessment for NO_2 will only be required should relevant exposure exist within 1000m of the airport boundary and if the total equivalent passenger throughput exceed 10 million passengers per annum. Freight traffic is minimal.

There are receptor locations within 500m of the airport boundary but clearly the airport does not see passenger numbers in excess of 10 million per annum.

The City & County of Swansea confirms that there are no airports meeting the criteria set out in LAQM.TG(09) box 5.4 page 5-21 in the Local Authority area.

4.2 Railways (Diesel and Steam Trains)

4.2.1 Stationary Trains

Landore Diesel Sheds is a major servicing centre primarily for Inter City 125 high-speed trains (HST) and is located within the Hafod Air Quality Management Area. The site operates on a 24 hour seven day a week basis. An aerial view of the site is shown below as map 15 indicating the proximity of domestic dwellings to the site

Site activities can be broadly classified into two categories: maintenance and servicing. Maintenance tends to occur within the sheds themselves. Here, engines are repaired, maintained and tested. It is not uncommon for several HST engine units to be under test at the same time. Exhaust emissions are vented through cowl housings to the roof of the sheds.

Map 15 – Landore Diesel Sheds and Surrounding Area

Maintenance operations involve the routine cleaning and refuelling of the HST units in dedicated sidings. Extensive warm up periods are mandated prior to movement of the HST train back out and onto the main line.

Guidance within LAQM.TG(09) requires the identification of locations where diesel locomotives are regularly stationary for periods of more than 15 minutes[39]. This is clearly the case at Landore Diesel Sheds but the guidance also indicates exposure potential for regular outdoor exposure to members of the public within 15m of the stationary locomotives. The nearest façade of any dwelling is approximately 35m from the servicing bay. There is also a public “open grassed area” within approximately 40 m of the servicing bays.

Observations at this location have indicated very infrequent use by the general public. Bearing in mind that the majority of servicing occurs during the night-time

[39] LAQM.TG(09) Box 5.4 Section B2 Approach 1 page 5-22

hours it is concluded that there is no relevant exposure from this activity at this location. A similar view has been formed over the use of the main shed complex.

An identical view has also been formed for the activities undertaken at Swansea Central railway Station. Inter City 125 units and other diesel locomotives are left running during periods leading up to the scheduled service departures. However, there is no regular outdoor exposure of members of the public within 15m of the stationary locomotives.

“Sprinter services” are offered to/from several local stations both on the mainline Swansea – Paddington London line and also the West Wales line. However, these sprinter services are not stationary at these very local stations for periods of 15 minutes or more. Consequently, their impact is minimal.

The City & County of Swansea confirms that there are no locations where diesel or steam trains are regularly stationary for periods of 15 minutes or more, with potential for relevant exposure within 15m.

4.2.2 Moving Trains

Guidance within LAQM.TG(09) box 5.4 Section B2 – Approach 2 page 5-23 indicates a number of criteria to determine suitable assessment. The main Swansea to Paddington London rail line is listed within table 5.1 indicating rail lines with heavy traffic of diesel passenger trains. In addition, approach 2 requires identification of whether the background annual mean NO_2 concentration is above 25ug/m^3. In order to answer this question, use has been made of the 1k by 1k background maps from http://www.airquality.co.uk/laqm/tools.php?tool=background06 . The text file for NO_2 background concentrations for 2008 has been imported into Arcview3.3 GIS and examined. If the background NO_2 1k by 1k concentrations are indexed in descending order it can be seen that the maximum 1k by 1k grid square for 2008 returns a value of 20.6ug/m^3. If this grid point is plotted it can be seen that the centre of the 1k by 1k grid square is just north of the main Swansea to Paddington London line in the Plasmarl area of Swansea.

Local knowledge of the path of the Swansea to Paddington London railway line would also indicate that that there is no potential for **long-term** exposure within 30m of the edge of the tracks.

The above views have been supplemented by examination of the LAQM Tools website at http://www.airquality.co.uk/laqm/tools.php which includes an item "**Additional Guidance on Consideration of Railways".** This link (http://www.airquality.co.uk/laqm/documents/FAQ_Railway_Locomotives_100209.pdf) contains an Adobe PDF document entitled FAQ – Guidance on Assessing Emissions from Railway Locomotives dated 10th February 2009. This document details 35 local authorities within table 2 where the 2008 background NO_2 concentration exceeds the threshold for assessment of 25 ug/m^3 and also where there are railway lines with a large number of movements of diesel locomotives. The City and County of Swansea were not one of the 35 local authorities identified.

In view of the above, there is no requirement to proceed further with a Detailed Assessment for NO_2 at locations within 30m of the Swansea to Paddington London railway line.

The City & County of Swansea confirms that there are no locations with a large number of movements of diesel locomotives, and potential long-term relevant exposure within 30m.

4.3 Ports (Shipping)

Swansea is Associated British Ports (ABP's) most westerly South Wales port and has developed a trade base with North and Western Europe, the Mediterranean and also with Northern Ireland and the Irish Republic. The port's major cargo-handling trade is receiving and shipping steel cargoes for Corus. It is equipped with a wide range of heavy-duty handling equipment offering quayside cranes and a range of forklift trucks with capacities of up to 40 tonnes. Other traffics include containers, forest products, bulk cargoes, liquid bulks and general/project cargoes. The port can accommodate vessels up to 30,000 dwt.

City & County of Swansea

Guidance within LAQM.TG(09) box 5.4 Section B3 Shipping page 5-24 requires the determination on the number of ship movements per year and also to establish if there is relevant exposure either within 250m of the quayside and manoeuvring areas should shipping movements be between 5000 – 15000 per year or exposure within 1km of the quayside and manoeuvring areas should shipping movements exceed 15000 per year. Enquiries with the Port Health Authority indicate that during 2008 there were a total of 780 vessels visiting the port which equates to 1560 total shipping movements. If the local tug fleet is also taken into consideration this would still not bring the number of movements to above the 5000 threshold required for assessment.

For sake of completeness, there are residential properties located on Bevans Row, Port Tenant within 230m of the Kings Dock quayside.

The City & County of Swansea confirms that there are no ports or shipping that meet the specified criteria within the Local Authority area.

5 Industrial Sources

5.1 Industrial Installations

5.1.1 New or Proposed Installations for which an Air Quality Assessment has been carried out.

There have been no new or proposed installations received by the City & County of Swansea.

In November 2007 the Secretary of State granted planning permission for Prenergy Power Limited to operate a renewable energy power station capable of generating some 350 MW of electricity within Neath Port Talbot.[40] The process will involve the combustion of approximately 2.5 to 3 million tonnes of woodchip per annum. The plant has not been constructed yet.

An environmental statement was provided and dispersion modelling was carried out using ADMS. This work stated that the impacts of carbon monoxide, nitrogen dioxide, PM_{10} and sulphur dioxide would be insignificant in respect of Air Quality Objectives.

Further dispersion modelling work was required as part of the Environment Agency permit application. Neath Port Talbot council have accepted the conclusions of the Environmental Statement. The location of the planned Prenergy Power Ltd site is shown below as map 15a

[40] Source Neath Port Talbot Council

City & County of Swansea

Map 15a Location of Prenergy site within Neath Port Talbot

The City & County of Swansea confirms that there are no new or proposed industrial installations for which planning approval has been granted within its area or nearby in a neighbouring authority.

5.1.2 Existing Installations where Emissions have Increased Substantially or New Relevant Exposure has been Introduced

City & County of Swansea confirms that there are no industrial installations with substantially increased emissions or new relevant exposure in their vicinity within its area or nearby in a neighbouring authority.

5.1.3 New or Significantly Changed Installations with No Previous Air Quality Assessment

City & County of Swansea confirms that there are no new or proposed industrial installations for which planning approval has been granted within its area or nearby in a neighbouring authority.

5.2 Major Fuel (Petrol) Storage Depots

There are no major fuel (petrol) storage depots within the Local Authority area.

5.3 Petrol Stations

Guidance contained within LAQM.TG(09) indicates that there is some evidence that petrol stations will emit sufficient benzene to put the 2010 5µg/m^3 objective at risk if the throughput exceeds 2000m^3 of petrol , especially if combined with higher levels from a nearby busy road[41]. A busy road is defined as one with more than 30,000 vehicles per day. The guidance goes on to indicate that relevant exposure within 10 m of the fuel pumps should also be present if the above criterion is met.

Details from the Authorisations held by the authority have been examined. There are thirty nine petrol filling stations within the authority's area, with fourteen of these having a throughput greater than 2000m^3. Of these fourteen stations, three are fitted with stage 2 vapour recovery, with the remainder being fitted with stage 1 vapour recovery. Relevant exposure was examined for each location using Arcview GIS ver 3.3, whereby 10m radius were plotted from the actual pumps to access if relevant exposure existed. Of the 14 petrol stations examined, relevant exposure does not exist at any, but, as in the case of previous rounds of review and assessment, two cases deserve explanation.

One petrol filling (Mumbles Road, Blackpill) station meets the above criteria (throughput, traffic flows and relevant exposure) to have warranted further investigation. For the sake of completeness the second station (Sketty Filling Station, Gower Road) partially meets the criteria (throughput and relevant exposure).

During previous assessment works (USA July 2004) it has been established that whilst both of these filling stations have dwellings located within 10m of the fuel pumps, these properties have been purchased by the fuel companies and have been

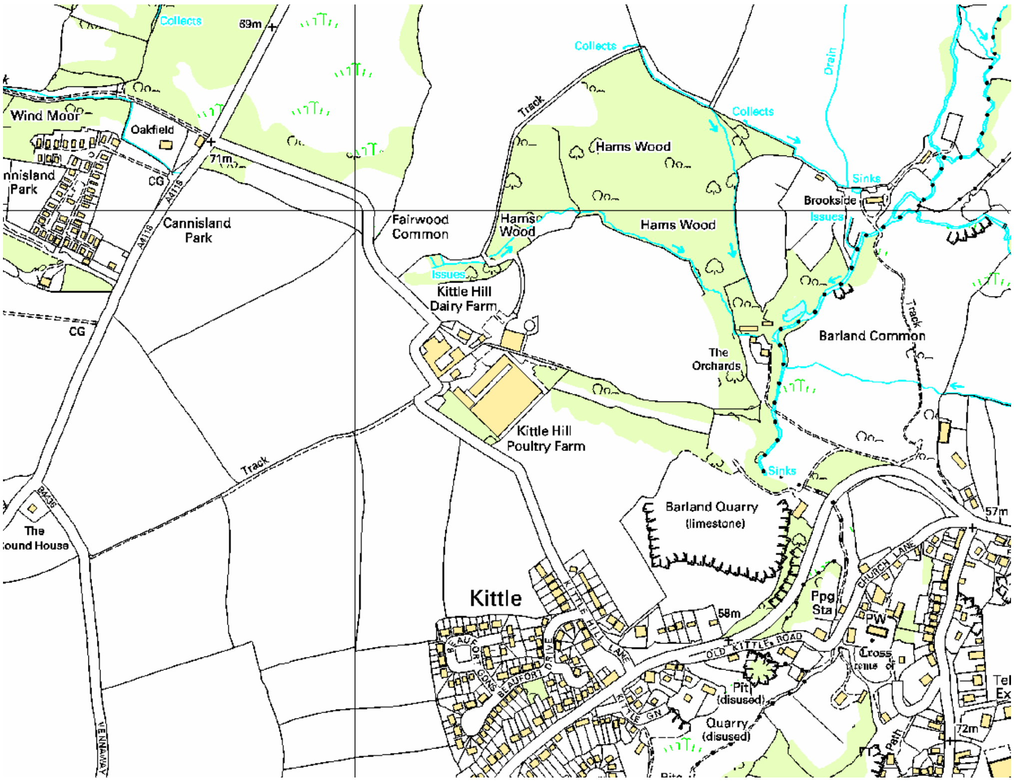
[41] LAQM.TG(09) Box 5.5 Section C3 petrol Stations page 5-40

left vacant. These arrangements were negotiated with the relevant fuel companies many years ago, particularly to resolve late night noise nuisance complaints.

The City & County of Swansea confirms that there are no petrol stations meeting the specified criteria within the local authority area

5.4 Poultry Farms

LAQM.TG(09) contains guidance on assessing potential exceedences of the PM_{10} objectives associated with emissions from poultry farms. Guidance is contained within box 5.5 Section C4 page 5-41. There are two poultry farms located within the authority's area. The first at Kittle Hill Farm is shown below within Maps 16 and 17.



Map 16 – Location of Kittle Hill Poultry Farm, Kittle, Gower, Swansea

Map 17 – Aerial view – Kittle Hill Poultry Farm, Kittle, Gower, Swansea

A total of **295,680** chicken laying hens are housed, split over 3 sheds containing approx. 100,000 birds each with a deep litter pit system of waste collection. As indicated within map 17 above, the direction of the **mechanical ventilation** of the sheds is in a south easterly direction between the sheds and then finally out, over a field adjacent to the premises. The nearest domestic receptor/dwelling is approximately 290m from the sheds. **However, there is relevant exposure from a residential property that forms part of the farm itself**. There is therefore, relevant exposure within 100m of the sheds housing the birds. There have been previous historical complaints regarding dust from local residents but these were not substantiated. Numerous complaints have also been received regarding noise from the ventilation system.

Whilst there is relevant exposure as defined by LAQM.TG(09) box 5.5 Section C4 page 5-41 at Kittle Hill Farm itself, the number of housed birds falls below the assessment threshold. In addition, a separate establishment at Highfield Poultry Farm, Parkmill, Gower, Swansea, breeds chickens for supply to the above mentioned establishment. Map 18 below indicates the proximity of this establishment to local residential properties.

City & County of Swansea

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Map 18 – Highfield Poultry farm, Parkmill, Gower.

A total of **105,000 birds** are housed within several sheds that are provided with **mechanical ventilation**. **Residential properties are within 80m of the sheds at Highfield Poultry Farm with the proprietor's residence being located within 15m of the sheds.**

There is, therefore, relevant exposure within 100m of the sheds housing the birds. There have been numerous historical complaints regarding noise from the ventilation system. Again, whilst there is relevant exposure as defined within LAQM.TG(09) box 5.5 Section C4 page 5-41 at Highfield Poultry Farm itself, the number of housed birds falls below the assessment threshold.

The City & County of Swansea has made enquiries with the Review and Assessment Helpdesk whereby the above relevant exposure was discussed. The view was formed that whilst the number of housed birds fell below the assessment threshold level in both cases, it was evident that relevant residential exposure existed at both farm complexes and also to "external" residential properties in the Parkmill area (from Highfield Poultry Farm). It is therefore intended to highlight the potential exposure from the poultry units and await further advice when all local authority responses have been collated.

6 Commercial and Domestic Sources

6.1 Biomass Combustion – Individual Installations

The authority was aware of one A2 process which was permitted during 2005-2006 at Ethnic Cuisine Ltd located on the Winch Wen Industrial Estate in Swansea. The biomass plant was used to treat waste food into bio-fuel, which was thermally treated in a bio-mass burner, with the heat generated being fed into a boiler to produce steam for use in the factory. The system was modular with the main components consisting of the bio-fuel converter, a bio-fuel silo, the bio-mass burner, a boiler to recover heat from the hot flue gases and a cyclone. However, the bio-mass installation suffered an explosion and was later determined to be dangerous due to design flaws and has not been put back into operation with litigation pending between the parties.

The City & County of Swansea confirms that there are no biomass combustion plant in the Local Authority area.

6.2 Biomass Combustion – Combined Impacts

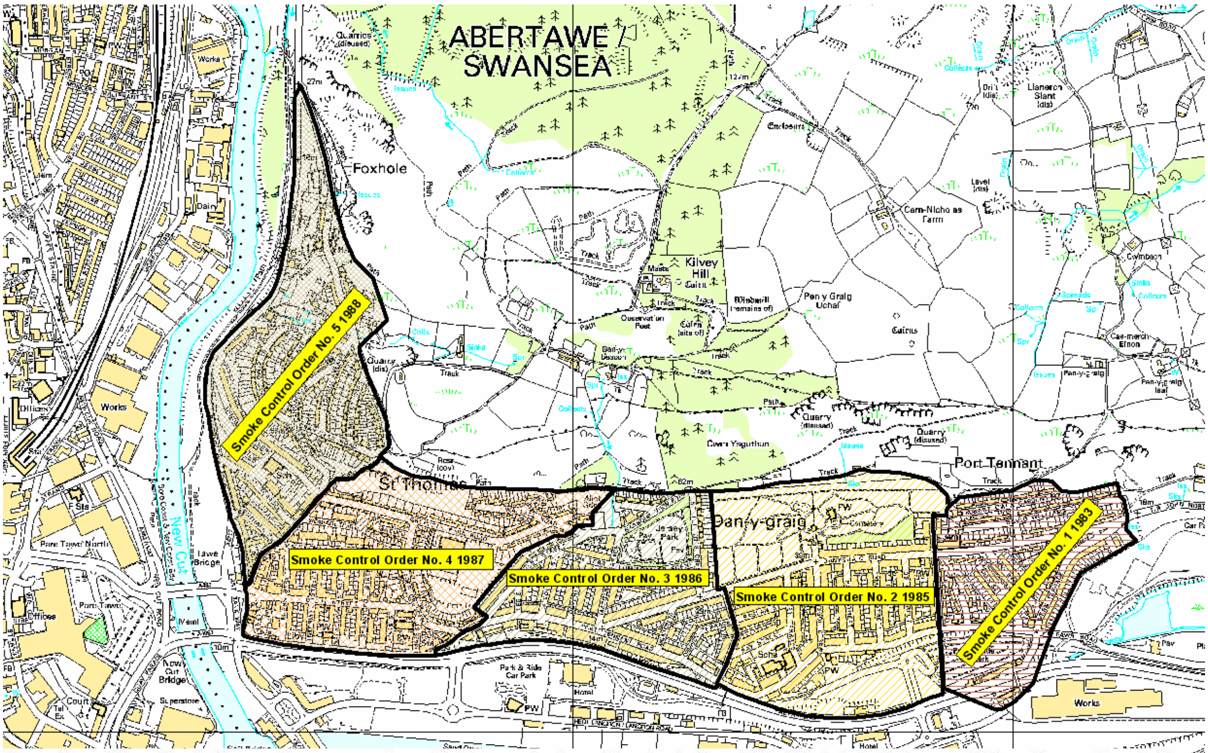
Local knowledge of areas of Swansea with the highest densities of housing and those areas dominated by commercial activities/service sectors would point to no area of 500 by 500m having sufficient quantities of solid fuel burning appliances or bio-mass combustion to impact on PM_{10} concentrations. This view is supported by the virtual lack of nuisance complaints from both sectors. The authority has received individual nuisance complaints from individual instances of domestic wood burning stoves/appliances but these have been few and far between.

The City & County of Swansea confirms that there are no biomass combustion plant in the Local Authority area.

6.3 Domestic Solid-Fuel Burning

Swansea City Council, the predecessor to the City and County of Swansea, declared 5 Smoke Control Areas within the Port Tennant and St.Thomas areas between 1983 and 1988 – these Orders can be seen below within Map 19.

Whilst these orders limited the burning of solid fuel in approved appliances to smokeless solid fuels, the tradition of burning solid fuel has dramatically declined within Swansea over the last two decades, not solely because of the declaration of the Smoke Control Areas but as part of the national trend away from coal to natural gas consumption as a domestic fuel. This trend continues to this day. Therefore, despite smokeless solid fuel having a similar sulphur content to coal, the burning of such fuels in any approved appliances that may remain in these areas is thought to be minimal.



Map 19 – City & County of Swansea Smoke Control Orders 1-5

Guidance within LAQM.TG(09) requires the identification of significant areas of domestic coal burning. Significant areas of domestic coal burning are given as a density of premises burning coal exceeding 50 per 500 by 500 meter area[42]. Local knowledge would indicate that there are no longer any areas within Swansea that have this density of domestic coal burning. This situation has not altered from the previous Updating and Screening Assessments submitted. However, the approach within LAQM.TG(09) box 5.8 section D2 page 5-51 then presents a conflicting “Question” which asks “Does the density of coal burning premises exceed **100** per 500 by 500m area”. This would appear to be an artefact from previous technical guidance.

The actual number of properties within the City and County of Swansea’s area that burn solid fuel as the primary fuel for central heating is given as 4,398 within the 1997 Welsh Household Information Survey published in 2000. This equates to 4.9% of properties within Swansea. For completeness, the number of properties burning fuel oil as their primary source of heating is given as 1,759, which equates to 2% of properties. The figures for the whole of Wales are 7.4% and 5.3% respectively.

In view of the above, it is therefore concluded that there will be no exceedence of the objectives for SO_2 resulting from domestic solid fuel burning within the authorities area.

The City & County of Swansea confirms that there are no areas of significant domestic solid fuel use in the Local Authority area.

[42] LAQM.TG(09) box 5.8 section D2 page 5-51

7 Fugitive or Uncontrolled Sources

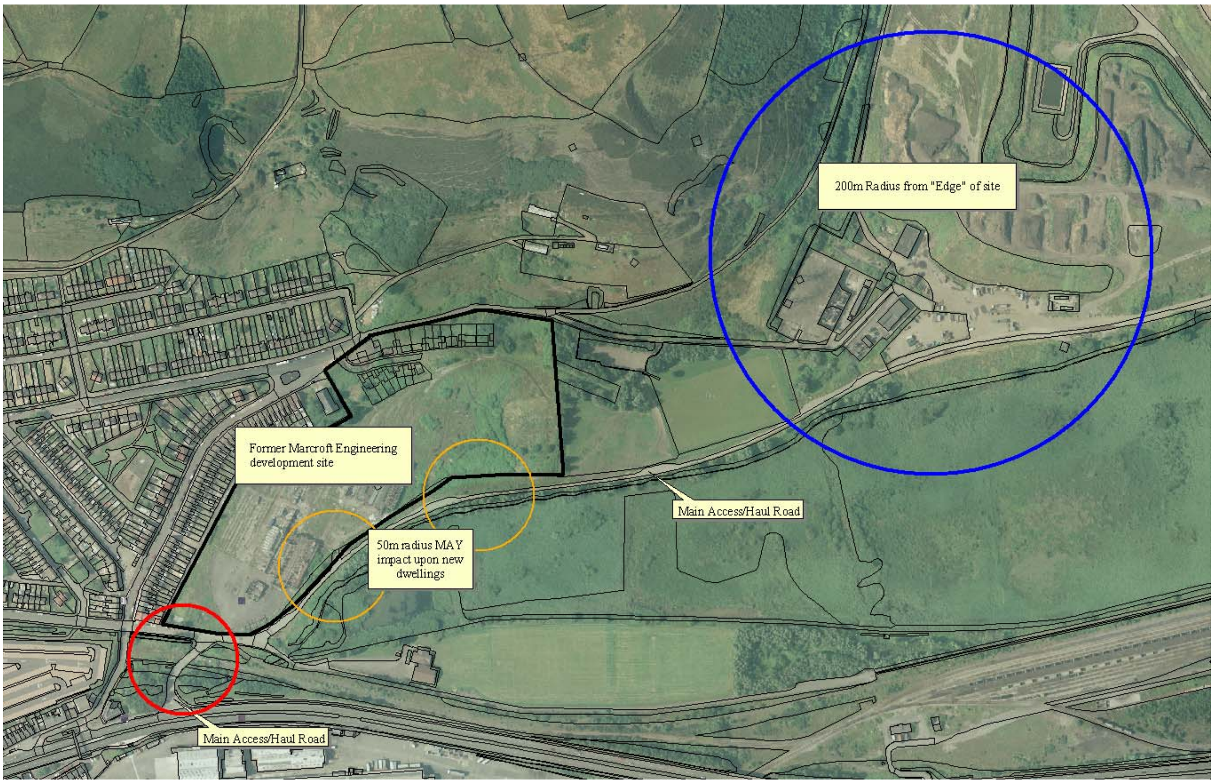
Guidance within LAQM.TG(09) box 5.10 Section E page 5-53 indicates an approach to adopt to assess fugitive sources of PM_{10} from a number of sources including quarrying, landfill sites, coal and material stockyards, or materials handling. Where dust is emitted, a proportion, (typically about 20%) will be present as PM_{10}. The guidance indicates that relevant exposure "near" to the sources of dust emission be established. Near is defined as within 1000m if the 2004 objective PM_{10} annual mean background concentration taken from background maps is greater than or equal to 28μg/m^3, within 400m if the 2004 objective PM_{10} annual mean background concentration taken from background maps is greater than or equal to 26μg/m^3, and within 200m for any background

Based on the 1k by 1k grid squares background PM_{10} maps downloaded for 2008 from http://www.airquality.co.uk/laqm/tools.php?tool=background06 , and after indexing the field Total_PM_{10} it can be seen that the maximum 1k by 1k grid square background concentration is 19.61 ug/m^3. Therefore, "near" is taken to be the latter distance i.e. 200m.

Tir John Landfill Site

LAQM.TG(09) Section E.1 of box 5.10 expands on the issue of relevant exposure if exposure is within 50m of an offsite road used to access the facility. These sections of road which may extend up to 1000m from the site entrance are considered to be near, as long as the background concentration is above 25ug/m^3 and there are visible deposits on the road. Map 20 below shows the situation currently at Tir John landfill site. There is very marginal relevant exposure within 50m from the main access road at properties on Wern Terrace, Port Tennant (shown by red circle). In addition, the former Marcroft Engineering site is in the process of being developed for housing. As of May 2009, several new properties have been constructed. These properties are outside of the 50m radius at present from the haul/ access road. Obviously, when constructed some new properties may fall within the radius (orange circle). At present, as the background PM_{10} concentrations do not exceed

City & County of Swansea



Map 20- Tir John landfill Site, Port Tennant, Swansea

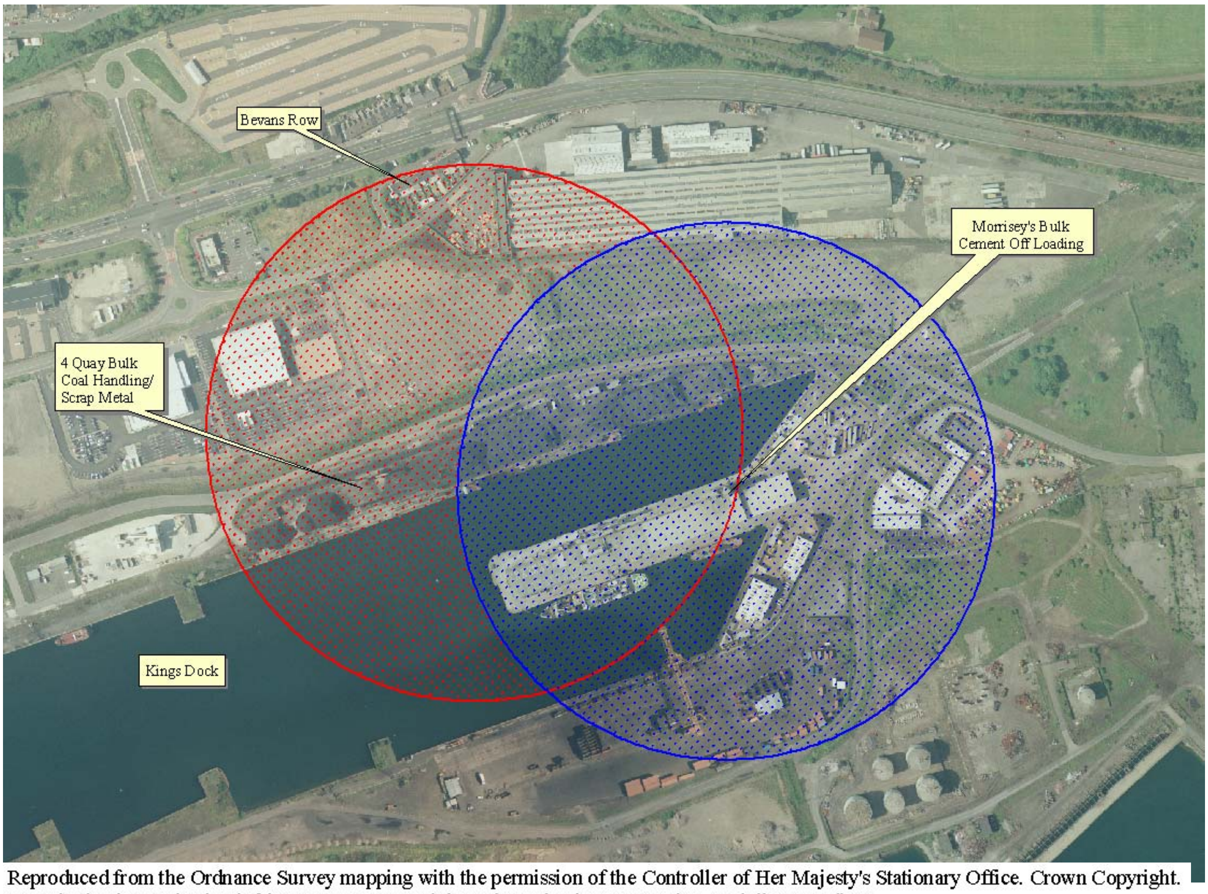
26ug/m3 and there are no visible deposits on the road, these locations can be discounted. There are no receptor locations within 200m of the main landfill area (blue circle). The Environment Agency refused to issue a permit for the ongoing use of Tir John to the LAWDC – Swansea Waste Disposal Company as a landfill site. The site therefore ceased operation several years ago, pending an appeal by the LAWDC. The LAWDAC subsequently won the appeal and are now undertaking preparatory works prior to the reopening of the site for domestic waste arising which is anticipated sometime during November 2009.

ABP Port of Swansea

There are operations carried out within the ABP Port of Swansea that have the potential for fugitive emissions i.e. 4 Quay bulk coal-handling facility and Morrisey's Cement Bulk off loading facility both located around the Kings Dock. The Port Health

Authority regulates both of these operations. Map 21 below identifies both these activities at Kings Dock.

4 Quay handles a bulk coal handling facility on the dock side. Lately stockpiles of scrap metal are also handled on 4 Quay. Receptor locations at Bevans Row, Port Tenant are located within 200m of the bulk coal/metal stockpiles (red circle). Litigation several years ago, resulting from an action from residents of the wider Port Tenant community resulted in a High Court judgement ruling in favour of the operators. It is not intended to revisit this issue in the light of the complete lack of dust complaints from Bevans Row.

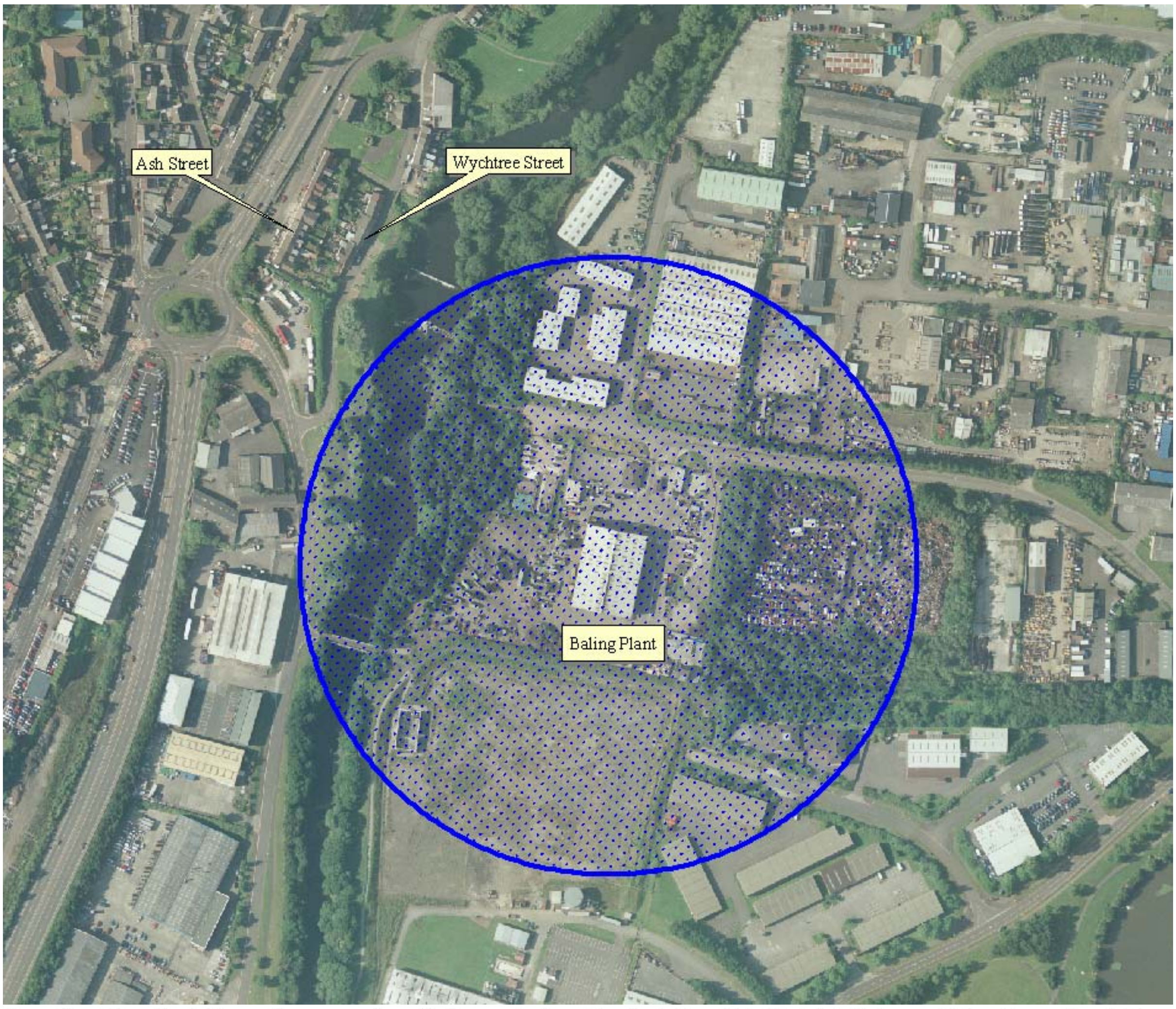


Map 21 – Location of 4 Quay and Morriseys Bulk Cement Kings Dock, Swansea

Morrisey's cement bulk off loading facility has been the subject of enforcement actions by the Port Health Authority to affect abatement techniques. Negative pressure systems, combined with a new bagging plant and construction of internal walls within the offload area have now negated the previous substantial fugitive emissions from the offload process. There is no relevant exposure within 200m of the bulk cement offload operations (blue circle).

Waste Management Facility – Baling Plant

The LAWDAC operate the Baling Plant off Ferryboat Close, Morriston Enterprise Park which handles all domestic waste arising within Swansea as well as being the main recycling centre within Swansea. Domestic waste is transported into the Baling plant pending its bulk transportation to Pembrokeshire and Carmarthenshire due to the continued closure of Tir John Landfill site. Map 22 shows the proximity of the facility to the nearest receptor locations.



Map 22 – Baling Plant, off Ferryboat Close, Morriston Enterprise Park

City & County of Swansea

There have been numerous complaints of odour resulting from the activities at the facility, but no substantive dust complaints. In any case, with reference to LAQM.TG(09) box 5.10, there are no receptors within 200m of the centre of the facility (blue circle).

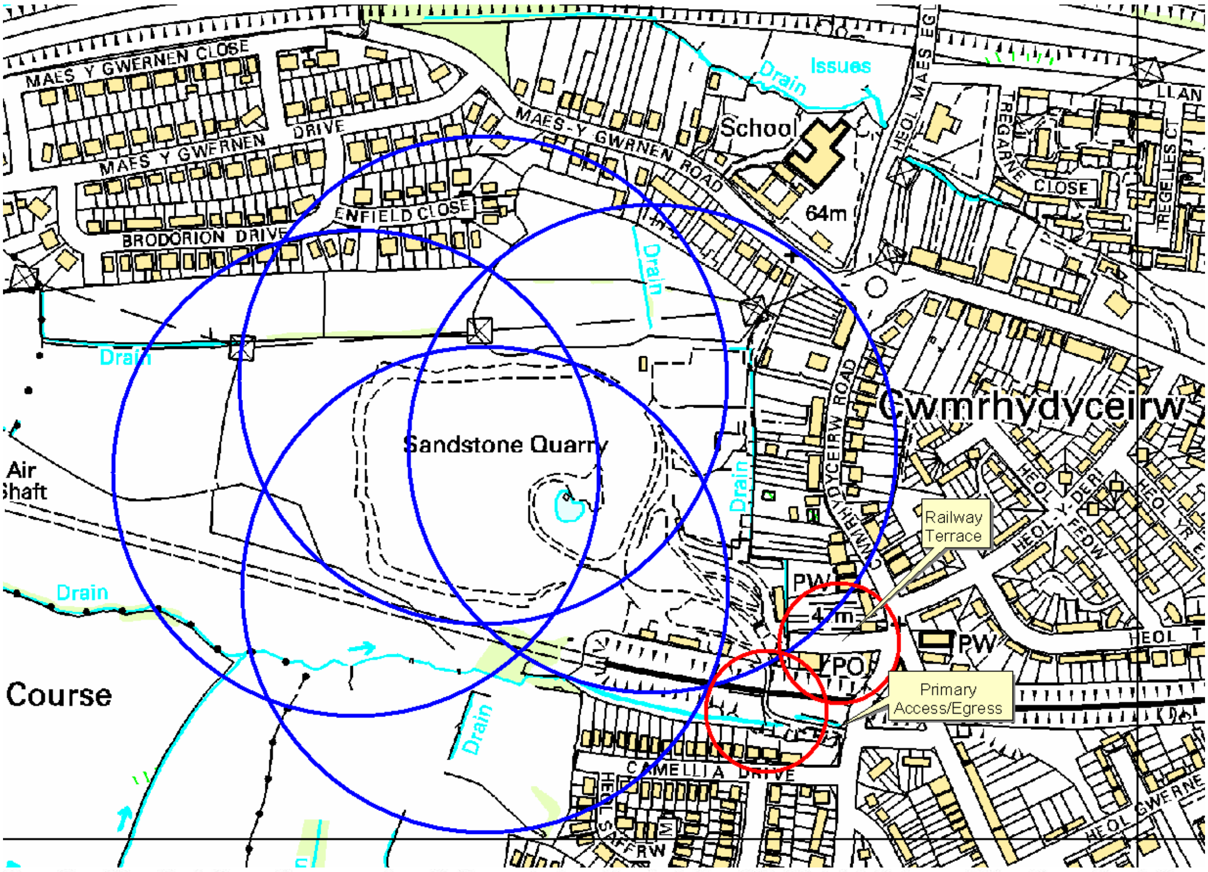
Waste Management Facility – Cwmrhydyceirw Quarry

Cwmrhydyceirw Quarry has previously been used as a landfill site up until the late 1990's for low grade industrial as well as domestic waste arising. However, following the refusal of the Environment Agency to issue a permit for its operation, the facility closed. The facility remained dormant with low maintenance aftercare operations being undertaken until the site was purchased by new operators. Following protracted negotiations between the Environment Agency and the new owners, a permit has now been issued for deposits of waste to recommence following extensive preparatory works. These preparatory works include the excavation of previously deposited material, construction of suitable lined cells with the excavated waste being replaced within the new lined cells. Following completion of the new cells, new waste will be permitted to be deposited.

These preparatory works obviously have the potential to emit substantial fugitive emissions as well as odour nuisance. Discussions have commenced with the operators to establish what monitoring and local liaison is required with local residents. Receptor locations are within 200m. Map 23 indicates the proximity of dwellings to the facility.

200m radiuses (blue circles) have been taken from the boundary of each side of the facility. Properties at Brodorion Drive, Enfield Close, Maes-y-Gwernen Drive, Cwmrhydyceirw Road, Railway Terrace, Camellia Drive and Heol Saffrwm are within 200m of the operations. For sake of completeness, the main access and egress from the site is from a lane just north of Camellia Drive. There is another access route into the site via Railway Terrace but, at this stage it is not envisaged that this route will be used due to terraced dwellings fronting directly onto this access route. 50m radius are indicated from these access/egress roads (red circles) but as the background PM_{10} levels (against the 2004 objective) are below 25ug/m^3 they are not considered to be “near”.[43]

It is not proposed to proceed to a detailed assessment at this stage as the timescale of operations (both remediation and active deposition) are not as yet known. Any fugitive emissions during excavation and relining are likely to be of a transitional/temporary nature. No works are currently underway at the site and it remains dormant.



Map23 – Cwmrhydyceirw Quarry, Cwmrhydyceirw

Operational Opencast Coal Mines or Quarries

There are no operational opencast coal mines or quarries within the Swansea area.

The City & County of Swansea confirms that there are, at present, no potential sources of fugitive particulate matter emissions in the Local Authority area.

[43] LAQM.TG(09) Box 5.10 Section E.1 Fugitive and uncontrolled sources page 5-53

8 Conclusions and Proposed Actions

8.1 Conclusions from New Monitoring Data

Nitrogen Dioxide (Passive Diffusion Tube Data)

Exceedences of the annual mean objective continue to be seen within the existing Hafod Air Quality Management Area along the Neath Road corridor, Cwm Level Road (Brynhyfryd Cross Roads) and Carmarthen Road (Dyfatty area). Additional monitoring within the Hafod AQMA area around the High Street Railway Station has highlighted the potential of exceedence of both the annual mean and 1-hour objectives.

Monitoring from outside of the existing Hafod AQMA has identified new areas that are failing the annual mean objective. These areas are along Gower Road in Sketty, along Carmarthen Road within Fforestfach, and at numerous sites within the city centre. The latter area is to be treated with caution at present as at the time of writing the minimum 9 months of data was available for analysis.

In addition, the additional monitoring undertaken outside of the exiting Hafod AQMA has identified sites with the potential to exceed the annual mean objective (being within the 37-40ug/m^3 range). These sites are within the Fforestfach, Morriston, Sketty and City Centre areas.

Projections made for 2010 and 2015 show continuance of annual mean exceedence both within the existing Hafod AQMA and the newly identified area within the city centre.

Nitrogen Dioxide Real Time Continuous Automatic Monitoring Data

Compliance with both the annual mean and hourly objectives were seen at the Swansea AURN, Morfa groundhog, Morriston Groundhog and St Thomas DOAS monitoring stations during 2008. Projections to 2010 and 2015 also indicate full compliance with both objectives at suitable receptor locations from these monitoring stations.

However, whilst the data capture rate at the Hafod DOAS monitoring station was severely affected by area wide renovation works to the terraced properties along Neath Road, there are indications that this street canyon site has the potential to exceed both the annual mean and 1-hour objectives. The 99.8th percentile value calculated from the 46.6% data capture that was possible during 2008 returned a value of 199.54ug/m^3. The Hafod DOAS monitoring station has seen increases in the nitrogen dioxide annual mean concentrations since 2006 with the projections to 2010 and 2015 also indicating continued exceedence of the annual mean objective.

Sulphur Dioxide Real Time Continuous Automatic Monitoring Data

No exceedences of any of the objectives have been observed within Swansea for several years

Carbon Monoxide Real Time Continuous Automatic Monitoring Data

No exceedence of the objective has been observed within Swansea since monitoring commenced.

Particulate Matter PM_{10}

No exceedences of the annual mean objective were seen at any of the monitoring stations during 2008. Similarly, no breach of the 35 permitted exceedences of the 24 hour objective was seen, nor, where data capture was below 90% did the 90th percentile (given in brackets after the number of exceedences) exceed 50ug/m^3.

Projections made to 2010 and 2015 indicate continued compliance with the objectives

City & County of Swansea

Benzene

No exceedence of the objective has been observed within Swansea since monitoring commenced

Ozone

Continued exceedences of the UK objective (not set in regulation) continue to be seen but ozone is considered as a national rather than local problem. Ozone will continue to be measured for the foreseeable future.

Heavy Metals Monitoring

Monitoring from 4 points around a high level stack release point at the Vale Inco, Clydach nickel refinery during 2008 have shown **nickel** concentrations below the 4th Daughter Directive annual mean target value for the first time following improved abatement at the release point. Previous years monitoring have shown exceedences

From the data available, it is clear that annual mean concentrations for **arsenic and cadmium** at all monitoring locations fall well below the 4th Daughter Directive Target Values**.**

Additionally, from the data available, it is clear that annual mean concentrations for **lead** at all monitoring locations fall well below the 0.25ug/m^3 required under the Air Quality (Amendment) (Wales) Regulations 2002 to be achieved by the 31st December 2008

8.2 Conclusions from Assessment of Sources

Potential exceedences of the nitrogen dioxide annual mean are to be assessed following the identification of new narrow congested streets within several areas of the authority. Additionally, several new busy streets where people are likely to spend 1-hour or more have been identified – in several cases the same street has been identified for both objectives.

City & County of Swansea

Measurements of PM_{10} are to be made around several junctions identified in previous rounds of review and assessment. Delays have been experienced due to technical difficulties with the instruments deployed.

Potential PM_{10} exposure has been identified at two poultry units. In one case, there is relevant exposure to a dwelling within the farm complex itself. In the other case, there is relevant exposure at locations both on and off the farm complex. In neither case does the number of housed birds meet the assessment threshold. Following discussions with the Review and Assessment Helpdesk on how best to proceed given the relevant exposure, further advice on how to proceed is awaited following collation of local authority findings.

Potential PM_{10} exposure has been identified resulting from proposed activity at a landfill site in Cwmrhydyceirw. However, the site at present remains dormant and further details on the operator's future intentions are awaited.

8.3 Proposed Actions

Provided suitable funding is made available, the authority will continue to undertake both passive and automatic real-time monitoring to assess compliance with each of the relevant objectives. There is a distinct possibility that real-time equipment will require decommissioning during the next financial year should budgetary pressures remain the same. In addition, should the financial pressure be such that even the passive nitrogen dioxide diffusion tube network consumes too many resources then a sliming down of the network is inevitable. This USA has also identified additional narrow, congested streets with an AADT >5000 vehicles that if the guidance within LAQM.TG(09) indicates will require assessment.

However, in the meantime, it is proposed to vary the existing Hafod Air Quality Management Area to encompass the newly identified nitrogen dioxide annual mean failing areas within the Sketty, and Fforestfach areas. A decision on the failing areas within the city centre will be made following the analysis of a full years worth of data.

City & County of Swansea

Detailed Assessments for PM_{10} around two poultry farms are a possibility once further advice has been received from WAG/ DEFRA. This advice, it is understood, will be formulated once local authority responses from this round of the review and assessment process for poultry farms have been collated and assessed. Should the advice be to proceed directly to a Detailed Assessment at each location it is highly likely that the authority will be financially unable to install Thermo FDMS units or any other compliant/equivalent gravimetric analysers in order to undertake the assessment.

The potential for a Detailed Assessment in respect of PM_{10} around Cwmrhydyceirw Quarry landfill site may be financially identical to that at the above poultry units.

9 References

i. City & County of Swansea Progress Report 2006

ii. City & County of Swansea Updating & Screening Assessment 2006

iii. City & County of Swansea Progress Report 2007

iv. City & County of Swansea Progress Report 2008

v. Technical Guidance LAQM.TG(09)

vi. Air Quality (Wales) Regulations 2000, No. 1940 (Wales 138)

vii. Air Quality (Amendment) (Wales) Regulations 2002, No 3182 (Wales 298)

viii. Analysis of the relationship between annual mean nitrogen dioxide concentration and exceedences of the 1-hour mean AQS Objective AEAT/ENV/R/264 Issue 1May 2008

Appendix 1

Hafod AQMA Boundary Map


Hafod Air Quality Management Area
400 0 400 800 1200 Meters
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Pollution Control Division
Environment Department
City & County of Swansea
SWANSEA/ABERTAWE
Hafod
Landore
Glandwr
Manselton
Cwmbwrla
Cwmdu
Mayhill
Townhill
Gendros
Brynhyfryd
Foxhole
Kilvey Hill
St Thomas
Pentre-chwyth
Bon-y-maen
Tir-Nest
Hanover Square
Plasmarl
B4489
A4118
B4603
A4067
A4217
B4444

Appendix 2

Nitrogen Dioxide Passive Diffusion Tube Sampling Locations 2008


Nitrogen Dioxide
Passive Difussion Tube
Locations 2008
Tube Location
Hafod AQMA Boundary
SWANSEA/
ABERTAWE

Appendix 3

Harwell Scientifics Ltd – WASP Scheme Results

Year	WASP Round	Period	Samples Dispatched	Results Deadline	Reported	HSL Calculations (Pre-Sendout) Sample A		Harwell Analysis Tubes A						HSL Calculations (Pre-Sendout) Sample B		Harwell Analysis Tubes B					
						Calculated Spiked Value	Measured Value	Result Tube 1	Result Tube 2	Average	Standard Deviation	RSD	Z-Score	Calculated Spiked Value	Measured Value	Result Tube 1	Result Tube 2	Average	Standard Deviation	RSD	Z-Score
2010	108		18/01/2010	05/03/2010	22/03/2010																
2009	107		26/10/2009	11/12/2009	04/01/2010																
	106		06/07/2009	28/09/2009	14/09/2009																
	105		27/04/2009	12/06/2009	29/06/2009																
	104	Jan-Feb				2.02	2.01	2.017	2.047	2.032	0.022	1.1%	0.0	1.22	1.19	1.269	1.23	1.252	0.024	1.9%	0.2
2008	103	Sept-Dec				1.22	1.22	1.242	1.234	1.238	0.006	0.5%	0.1	0.94	0.95	0.957	0.951	0.954	0.005	0.5%	0.1
	102	Jun-Aug				1.37	1.38	1.47	1.472	1.471	0.043	2.9%	0.5	2.28	2.3	2.435	2.386	2.411	0.035	1.5%	0.4
	101	Apr-Jun				0.92	0.94	0.974	0.991	0.983	0.013	1.3%	0.5	1.86	1.93	1.947	1.958	1.953	0.008	0.4%	0.4
	100	Jan-Mar				1.36	1.37	1.395	1.384	1.39	0.008	0.6%	0.2	1.47	1.45	1.511	1.516	1.514	0.004	0.3%	0.2
2007	99	Oct-Nov				2.15	2.16	2.242	2.235	2.239	0.005	0.2%	0.3	0.84	0.84	0.906	0.901	0.904	0.004	0.4%	0.6
	98	Jul-Sept				1.83	1.85	1.877	1.854	1.866	0.013	0.7%	0.2	1.19	1.2	1.229	1.223	1.226	0.005	0.4%	0.2
	97	Apr-Jun				0.89	0.87	0.92	0.918	0.919	0.002	0.2%	0.2	1.58	1.59	1.619	1.64	1.63	0.015	0.9%	0.2

All Results In ug

Appendix 4

AIRBORNE PARTICLES IN SWANSEA, UK: THEIR COLLECTION AND CHARACTERISATION

AIRBORNE PARTICLES IN SWANSEA, UK: THEIR COLLECTION AND CHARACTERISATION

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Abstract

Urban air particulate matter has previously been associated with a variety of adverse health effects. It is now the smallest particles, ultrafine or nanoparticles, which are linked to the greatest health effects. The physicochemistry of these particles is likely to provide information regarding their toxicity. Therefore, the aim of this study was to further the understanding of the heterogeneous and changing particle concentrations in urban air, in conjunction with gaining an understanding of the physicochemistry of the particles.

A Dekati™ Electrical Low Pressure Impactor was used to collect the particles and real-time data in a busy traffic corridor in Swansea, Wales over a period of ten non-consecutive weeks. Particle concentrations in the street canyon were analysed and particle physicochemistries investigated using a variety of techniques.

Particle number concentrations were found to vary both diurnally and from day to day in the traffic corridor. Of all particles, the nano–fine size fraction was consistently identified in the highest concentrations (maximum: 140,000 particles cm^{-3}). Particle physicochemistry was found to vary as a function of size, with larger particles exhibiting a greater variety of morphologies (and consequently particle types) and associated metals.

Background

Air pollution is not a new problem. Pollution episodes have been noted since Roman times, with evidence of small-scale scientific atmospheric pollutant investigations as early as the seventeenth century (Kretzschmar, 2007). However it took one-off events such as the Meuse Valley fog in Belgium, 1930 (Nemery et al., 2001) and the Great London smog of 1952 (Whittaker et al., 2004; Davis et al., 2002; Elsom, 1987) to incontrovertibly link airborne particle matter to adverse health effects. These events served as a wake-up call, leading to technological improvements, funding and research (Donaldson, 2003). It is now the smallest particles, nano- or ultrafine particles, generally defined as particles with at least one dimension below 100nm (Donaldson et al., 2001; Oberdörster et al., 2005), that are being linked with the greatest health effects in epidemiology studies, in vitro studies and to a large extent, in vivo studies (Donaldson et al., 2001; Brown et al., 2001, Oberdörster et al., 2005). Whilst this association is now well established, the actual causes of adverse health effects continue to be debated, and are not well understood.

Over the range of particle sizes, it is nanoparticles that have consistently been found in the highest concentrations in urban air (Tuch et al., 2003; Ketzel et al., 2004; Mejìa et al., 2007). Concentrations in urban air have repeatedly been found to reach levels of 104-5 particles cm-

3 (Kittelson et al., 2004) during peak traffic flow periods. This causes concern that at these high particle levels the human body clearance mechanisms cannot work efficiently at removing particles (Oberdörster, 1995); leading to particles remaining in contact with cell surfaces for longer periods of time. This persistent contact or “particle overload” has been highlighted as a potential contributing factor when assessing the toxicity of airborne particles.

The issue is complicated by the variety of particles that populations are exposed to on a daily basis. Urban air particles are a complicated and heterogeneous mix (e.g. Donaldson et al., 2005), combining a wide range of particle characteristics such as size, morphology, surface reactivity, biopersistence and chemistry in every sample. This emphasises the importance of fully characterising particulates in all investigations (e.g. Harrison and Yin, 2000).

This study used an interdisciplinary approach to investigate particle physicochemistry within a traffic canyon. Particles were collected using a DekatiTM Electrical Low Pressure Impactor (ELPI) into twelve size fractions. The collection was completed at two locations; an urban air traffic canyon and a rural background location. Due to the small masses in each of the collected size fractions, they were then combined into three analysable size fractions (7-615nm, 616- 2.39µm, 2.4µm- 10µm). The three size fractions were physicochemically evaluated using tools including Field Emission- Scanning Electron Microscopy (FE-SEM) and Inductively Coupled Plasma- Mass Spectrometry (ICP-MS).
Methods

Site details

Particle collection was completed at two localities; an urban air site, and a rural control site. Neath Road in Swansea, Wales, UK was the urban collection site. Neath Road is a main commuter traffic route into Swansea City, and a recognised traffic hotspot (Figure 1). The area has been designated an Air Quality Management Area (AQMA) based upon its pollutant concentrations. Traffic levels are high (~18,000 per day) due to the road forming a main commuter zone between Swansea and Neath. Swansea is also an old industrial port city, which has been undergoing a process of urban renewal for a number of years. The locality was therefore expected to consist of a cocktail of particle types that were contributed by the main sources; urban, industrial and marine. Sampling was completed over a period of ten non-consecutive weeks during one season (therefore reducing the impact of seasonal-related meteorological differences) between 05/12/07 and 28/02/08, resulting in both particle collections and real-time particle data.
The traffic corridor is orientated NNE- SSW, with the predominant wind direction in a similar trajectory (NE-SW). Small-scale industrial sites are located city-wide; however the predominant wind direction (blowing straight from the sea and onto the site) reduces the impact of local industry. Port Talbot to the south east represents the most substantial

industrial area in the vicinity, potentially contributing particles dependent upon the wind direction.

Brecon, the rural control site is located approximately 42km north-east of Swansea. Sampling lasted for a period of three weeks; producing only a one week usable sample due to an atypical dust storm (correlated to an event originating from the Sahara), and a neighbour's bonfire. While achieving the one week usable particulate sample, a local mains power failure resulted in no real-time data collection.

Instrumentation

Particles were collected using a DekatiTM Electrical Low Pressure Impactor (ELPI). The ELPI is an inertial-based cascade impactor, which accumulates both real-time particle data and particle collections onto substrates. It divides particle data into 12 size fractions, from 7nm to 10µm, 3 of which are within the 'nano' size range, and particle collections from 30nm to 10µm. ELPI cut-off diameters (Keskinen et al., 1992) and particle concentration profiles (Zervas and Dorlhène., 2006) have been confirmed in previous studies. A flow rate of 30 l/min was maintained using a Sogevac Leybold vacuum pump. The ELPI stages were loaded with 25mm aluminium foil substrates. Substrates were weighed using a microbalance (Sartorius Micro SC-2) pre- and post-sampling to determine the particulate mass. Substrates were not coated with grease (as recommended by the manufacturers) in order to reduce contamination during subsequent ICP-MS analyses (Fujitani et al., 2006). The equipment set-up on-site included the collection head, teflon tubing, ELPI, pump, and laptop for equipment control and data collection.

Statistical testing

Graphing and statistical testing was completed using Microsoft Excel, with SPSS (version 16) used for non-parametric particle analysis and Spearman's Rank Correlation Coefficient.

Particle characterisation

Analytical electron microscopy

In preparation for Field Emission- Scanning Electron Microscopy (FE-SEM), the aluminium foil substrates were cut into sections. Approximately one-eighth of each collection foil was used for analysis. Epoxy resin (AralditeTM) was used to attach the foil substrate sections to 12.5mm aluminium SEM stubs (Agar Scientific). Samples were then coated with gold using a sputter coater (Bio-Rad SC500). Samples were imaged using a Philips XL30 FE-SEM. A range of working conditions in secondary electron mode were utilised to maximise image quality, including a working distance of 5mm- 10mm, accelerating voltages 5- 20kV, spot size 4 and a gold foil aperture.

Particle extraction

Particles were removed from the foil substrates for further physicochemical analysis using a novel freeze-drying technique.

Onto each aluminium foil, 900µl of molecular biology grade water was pipetted. The foil and water were then frozen. Once fully frozen, the ice discs were peeled from the foils using ceramic tweezers. Samples were freeze-dried at -40oC (Model: Edwards Pirani 10) until no ice remained in the samples, a process taking varying lengths of time from overnight, to periods of two or three days depending upon sample size. Samples were combined into three size fractions (30nm- 615nm, 616nm- 2.39µm, 2.4µm- 10µm) in order to provide samples large enough for analysis, representing 'nano-fine', 'fine' and 'fine-coarse' particle size fractions. The accuracy of the particle removal technique has been assessed (Figure 2). Figure 2 compares the particle recovery efficiencies between the three size fractions. Percentage particle recovery is ascertained by weighing substrates before/ after sampling to find total particle mass, and after extraction to find the particle mass that has been removed from the substrate. Particle percentage recovery therefore represents the mass percentage removed from the substrate using the extraction, in comparison with the original particle mass.

Particle removal using this technique is proven to be efficient (up to 98% particle recovery), removing the majority of the particle mass from the collection substrates. These removal efficiencies are comparable (or more efficient than) than those from other studies. Hartz et al. (2005) obtained a 60- 85% mass recovery using a solvent- based extraction process. Jones et al. (2006) recovered 80% of particles with an initial wash of particles collected onto Polyurethane Foam (PUF) substrate. Further washing provides recoveries of up to 95%, comparable with this study.

Due to the high removal rates, particles removed using this methodology are considered to be representative of the particle sample as a whole. It is shown that particle removal is most effective in the middle size fraction, a factor likely to be closely related to a larger initial mass and volume in this size fraction, combined with similar substrate adherence areas to the smallest and largest size fractions, reducing the relative percentage of particles in contact with the substrate.

ICP-MS analysis

Samples were digested for ICP-MS analysis using a CEM MDS-200 microwave system. Particle samples (n=2) were washed into teflon-coated composite vessels using 5ml 70% nitric acid. The samples were digested using an existing programme developed for refractory carbon-based particulate matter (Jones et al., 2006). The microwave programme consists of a stepped increase in pressure to 80psi for a period of 20minutes, with a corresponding temperature rise to 180oC. The programme lasts for approximately 2.5 hours, including warm up and cool down periods. Samples were then diluted to a level of 10µg/ml (dependent upon their original weight) using deionised (>18ΩM) H_2O. Raw data was corrected for blanks and controls accordingly.

Results

Real-time particle data

After processing the raw data using ELPIvi software, it is seen that throughout the daily cycle, on both weekdays (Figure 3 [a- c]) and Sundays (Figure 3 [d- f]), particle number concentrations are consistently highest in the smallest size fraction (D50% 7nm). In this size fraction, particle number concentration peaks at 140,000 particles cm^{-3}.

During the weekday averages, there is a consistent daily concentration profile which is replicated in all three analysed size fractions. The profile is characterised by a steep rise in particle numbers during the morning rush hour. Interestingly, whilst all three size fractions show this trend, particle numbers in the coarse size fraction (2.4µm- 10µm; Figure 3c) do not begin to increase until 08:30am, compared to a 06:00am increase identified in the two smaller size fractions. Similarly, the evening rush hour signal identified in the two smaller size fractions (7nm- 2.39µm) which begins at 15:00pm, does not begin in the coarse size fraction until 17:00pm.

During weekdays, the “night-time” particle concentrations (18:30- 06:30) are significantly lower (95% conf.) than “daytime” particle concentrations (06:30- 18:30) in the two smaller particle size fractions (7nm- 2.39µm). When considering the coarse size fraction (2.4µm- 10µm), this statistical difference (95% conf.) is not identifiable.

In contrast to the weekday data, Sunday particle number concentrations peak at 38,000 particles cm^{-3} at 20:30pm. The smallest (7nm- 615nm) and largest (2.4µm- 10µm) measured size fractions do not show a significant difference in particle number concentrations between “daytime” and “night-time” hours (95% conf.). In contrast, the middle size fraction does indicate number concentration variation between day and night-time hours (95% conf.).

Averaged data across the week (Monday- Sunday; Figure 4) illustrates the daily particle concentration profile differences at Neath Road, Swansea. Outputs for Monday- Thursday are consistent in terms of profile shape and magnitude in the smallest size fraction (7nm- 615nm). This profile pattern begins to break down on Friday and Saturday, and by Sunday, the original number concentration profile has broken down completely, with smaller magnitudes and a different profile shape, with a particle concentration low during the morning replacing the number concentration high identified in the weekday data.

Fine (616nm- 2.39µm) and Coarse (2.4µm- 10µm) particles do not have a similar weekly concentration distribution to the smallest size fraction. The consistency of the number concentration profile (Monday- Thursday) identified in the smallest size fraction is not repeated in these size fractions. Instead, concentration profiles are generally more poorly defined, with occasional time periods appearing to be synchronised with the finest size fraction. In both larger size fractions, particle concentrations are higher from 12:00pm

Saturday to 00:00am Sunday than on the Wednesday and Thursday, which contain some extreme particle concentration lows, for example Thursday (14:30pm), potentially a product of meteorological conditions.Physicochemistry of collected particles

FE-SEM

As shown in Figure 5, particle morphology, and consequently type, increased in variability as particle size increased. Particles in the smallest size fraction (30- 615nm) have a consistent morphology of spherical to sub-spherical particles. In the middle size fraction, a combination of agglomerated spherical/ sub-spherical particles and more sheet-like platy grains dominate. The largest size fraction (2.4µm - 10µm) exhibits much greater particle variability, with a range of particle morphologies visible (Figure 5e, f), agglomerated spherical/ sub-spherical particles, platy grains, cubic morphologies, larger spherical particles and large near-spherical particles with nodules.

ICP-MS

The ICP-MS elemental analysis confirmed that iron, zinc and magnesium were the most abundant elements in the particles (Figure 6). Element concentrations were found to vary with respect to particle size, but differently between elements, for example, iron and magnesium were found to increase in concentration with increasing particle size, compared to nickel and lead, which had the highest elemental concentrations in the smallest size fraction.
In terms of average PM10 concentration, elements were identified in the descending concentration order Fe> Zn> Mg> Ni> Cu> Cr> Ba> Mo> Pb> Mn> Ti> V> Zr> Co> Cd. Associations were identified between a number of elements using Spearman's rank correlation coefficient including Fe and Cu, Fe and Ba, Fe and Mn, Mg and Co, Ni and Ba, Cu and Ba, Cu and Mn, Ba and Mn to a 0.01 confidence level.

Discussion

Particle data analysis

Throughout the 24-hour sampling period shown in Figure 3, the highest particle concentrations are found in the smallest particle size fraction, particles 7nm- 615nm. These findings reinforce work completed by others, for example in Brisbane (Mejìa et al., 2007) where peak particle concentrations were below 30nm (82- 90% of particles). A study in two German cities, Erfurt and Leipzig (Tuch et al., 2003), found the highest particle concentrations in the 10nm- 20nm size range; whilst an urban air study focussed upon Copenhagen (Ketzel et al., 2004) and lasting several years placed the particle concentration maximum between 20nm- 30nm. This particle concentration maximum is attributed to the traffic contribution at these urban sites (Mejìa et al., 2007; Ketzel et al., 2004; Shi et al., 1999). The findings within the Swansea traffic corridor are therefore comparable with those found in other locations, and the concentration maximum, combined with what is known about the street canyon can confirm that whilst the input of particles from other sources (for example industrial and marine) will contribute to the particle totals, vehicles are the dominant sources of particles at Neath Road in Swansea.

Particle concentrations throughout the day in the traffic corridor are high (mean: 52,000 particles cm-3) when compared against some urban areas sampled in similar studies. The German two city study (Tuch et al., 2003) found a particle concentration maximum of 40,000 particles cm-3, whilst the Copenhagen study (Ketzel et al., 2004) found an average of only 7,700 particles cm-3 during a three month investigation period. A study completed in Rouen, France (Gouriou et al., 2004) using an ELPI found average particle concentrations below 50,000 particles cm-3; if particular external factors were combined, concentrations in the range of 106 particles cm-3 were sometimes obtained. This distribution is similar to the situation in the Swansea traffic corridor. Whilst the mean averages at 52,000 particles cm-3, specific events happening over timescales as short as seconds are influencing and dramatically increasing the particle concentrations observed in the traffic corridor at particular times, leading to concentration peaks of up to 140,000 particles cm-3 in the nano-fine size fraction. A Three European City study (Ruuskanen et al., 2001) obtained similar results, with an Erfurt peak at 188,000 particles cm-3 during the morning rush hour.

On weekdays, days dominated by traffic, all size fractions are identified as having a traffic-responsive profile. That is, it is possible to identify a morning and afternoon rush hour signal. The coarse size fraction was found to have a later rush hour peak (both morning and afternoon). This finding could be explained by the rapid sensitivity of nanoparticles to vehicle exhaust particles, as previously identified by Rodriguez et al. (2007), in a study carried out in Milan, Barcelona and London. Nanoparticles were found to vary extremely quickly and significantly in response to traffic, a finding reinforced in a study of urban air particle concentrations in Helsinki (Buzorius et al., 1998), where individual vehicles were found to affect the observed particle concentrations.

A number of studies have found that particle concentrations are higher during the day, and are linked to the vehicular particle source and its predominance during daytime hours (Buzorius et al., 1998; Laasko et al., 2003); as seen in the Swansea traffic corridor. Some studies (for example Rodríguez et al., 2007) have investigated further to find that the difference between daytime and night-time concentrations is much more pronounced in the nano-fine range; a result also found in this study on weekdays. On days not dominated by traffic sources (Sunday), this nanoparticle day-night variation was not significant, reinforcing traffic as a source of the smallest particles. This continuity between day and night-time particle number concentrations on Sundays could also be contributed to by the lack of industry and other related sources of particles on the weekend.

The morning rush hour peak has been identified in this study, a finding also seen in a study at Marylebone Road (Harrison and Jones, 2005). A daily pattern, with nanoparticle peaks between 8am and 9am, and 4pm and 5pm identified in the German Two City study (Tuch et al., 2003) correlates with the nanoparticle morning and afternoon rush hour peaks identified in Swansea on weekdays. A link between nanoparticle concentrations and solar radiation has previously been identified (Shi et al., 2001); perhaps explaining the sustained nanoparticle numbers observed at Neath Road between morning and afternoon rush hour peaks.

The difference in particle concentrations and distributions identified at the Neath Road collection site between weekdays and weekends has also been identified in other studies (Buzorius et al., 1998), and is attributable to a reduction in commuter traffic and to an extent, industrial processes during the weekends. This result has not been consistent for all studies (Mejìa et al., 2007), perhaps due to a reduced importance of commuter traffic-sourced particles in the study, and the dominance of other sources.

Identifiable in the Neath Road data is reduced particle number concentrations in the fine and coarse size fractions during Wednesday and Thursday, and increased particle number concentrations on Saturday and Sunday. If the smallest size fraction (7nm- 615nm) is taken to be representative of the particle number profile predominantly as a result of traffic, this finding reinforces that particles in the middle and largest size fractions are contributed to by a variety of sources other than traffic exhaust, perhaps road dust, marine particles and industrial particles (Moreno et al., 2004).

The week-long study at Neath Road traffic corridor identified variability in particle concentration signals for different days of the week, especially emphasised in the smallest size fraction, particles between 7 and 615nm. Different particle signals were also identified in a study carried out in Milan, Barcelona and London (Rodríguez et al., 2007), a finding explained by the importance of semi-volatile compound condensation in urban areas. In contrast, a study at three sites within Birmingham, England (Shi et al., 1999) found that despite variable weather conditions, particle concentrations and distributions measured varied only negligibly. Day to day particle concentration and distribution variances at Neath Road can be assumed to be dependent upon traffic compositional, volume changes or meteorological differences. Further work is required to elucidate the relative contribution of each component.

Physicochemistry of collected particles

Carbonaceous material was found to be dominant in all size fractions; as identified from the FESEM imaging (nano-sized spherical to sub-spherical particles found singularly or in aggregates; Figure 5). Results from a characterisation analysis of particulate matter collected on the coast of Sicily (Rinaldi et al., 2007) agree with this finding, especially in the size range 50- 140nm. In this study, the smallest measured size fraction (30nm- 615nm) was also found to have the highest carbonaceous material of all the measured size fractions. These study findings are in agreement with others including those completed in Pasadena, California (Hughes et al., 1998), Milwaukee, Wisconsin (Lough et al., 2005), Belfast (urban), London (urban) and Harwell (rural) in the UK (Jones and Harrison, 2005). The large contribution of carbonaceous soot nanoparticles to the samples, whether as individual particles (or small groupings of particles) in the smallest size fraction, or larger agglomerates in the middle and largest size fraction reaffirms traffic exhaust particles as the main particle source in the street canyon. The large contribution of traffic exhaust particles to total particle concentrations in urban settings is well documented (e.g. BéruBé et al., 2008).

Particles of cubic morphology, as recognised using FESEM imaging (Figure 5), can be identified as marine-derived halite crystals (Jones and BéruBé, 2007), due to the proximity of the sampling site to the sea and the predominant wind direction (Figure 1). Those particles with perfect cubic morphology are likely to have grown in situ on the collection substrate, whilst more damaged particles are likely to have origins of either marine processes or road salting (Moreno et al., 2004). The combined factors of proximity to the sea and comparatively stable weather conditions suggests a predominance of marine-derived halite crystals.
Large (coarse size fraction) spherical particles with nodules covering the surface are attributed to biogenic processes, confirmed by their behaviour beneath the FESEM beam (BéruBé et al., 2008).

FESEM imaging identified sheet-like particles in the largest size fraction. These particles (2.4- 10μm) are identified as mineralogical particles, perhaps derived from local or more distant areas of exposed crust and soil (BéruBé et al., 2008).

Due to the naturally variable wind directions encountered during a sampling period, the origin of industrial- generated perfect spherical particles may be local (within Swansea) or wind-blown from a distance (for example Port Talbot to the south- east). Spherical particles are common in both urban and industrial air (Moreno et al., 2004).

The metals identified in the particle samples (ICP-MS analysis) were found to increase in variety with increasing particle size, as found also in the Milwaukee study (Lough et al., 2005). PM10 was found to contain more metals than PM2.5, perhaps due to the greater variety of contributing sources to the larger size fractions; including crustal, traffic, biological and technogenic-type sources. In another study, investigation of analytical SEM images identified that particles under 1μm predominantly consist of traffic-derived soot (Baulig et al., 2004). Other studies have found a more bimodal distribution of elements within particulate samples, for example a peak in the nano-size fraction, and a peak in the particle size range 3.2- 5.6μm as found in a study conducted in southern Taiwan (Lin et al., 2005).

Iron was found to be the most abundant metal in the particles in agreement with results from other physicochemical analysis studies (Hughes et al., 1998; Lough et al., 2005; Baulig et al., 2004).

Some elements identified by ICP-MS analysis can be identified as partly arising from diesel emissions, for example Fe, Ca, Si, Mg and Mn (Wang et al., 2003) a number of these elements are also associated with crustal components, for example Fe, Ca, Si, Mg (Lough et al., 2005). This highlights the fact that source apportionment is extremely complicated, with different studies identifying different tracers for the same source, and different sources for the same tracer or combination of tracers.

The elemental concentrations identified in this study (ICP-MS analysis; Figure 6) are much lower than in London 1950s particulate samples (Whittaker et al., 2004). Comparisons include 157ppm Fe concentration at Neath road and 19,294μg g-1 London 1955 sample, and 1.3ppm Mn concentration at Neath Road and 508 μg g-1 from the London 1955 samples. Additionally, in a paper by Shao et al. (2007), outdoor Beijing particulate matter was collected and analysed by ICP-MS. Levels of 17ppm Mn in the Beijing air can be compared with 39ppb (Neath Road). Therefore total metal concentrations of particulate matter from urban Swansea air are lower than concentrations identified in historic studies (Whittaker at al., 2004) and in rapidly developing countries (Shao et al., 2007). This finding is to be expected (Donaldson, 2003) due to improved legislation and current British technological requirements, and more local factors including meteorological conditions, road usages and the prevalence of local polluting industries.

Metal concentration ordering at the Neath Road collection site (Fe> Zn> Mg> Ni> Cu> Cr> Ba> Mo> Pb> Mn> Ti> V> Zr> Co> Cd) can be compared to those in the literature for urban locations (Whittaker et al., 2004 (Fe> Pb> Cu> Mn> V> As> Co); Chandra Mouli et al., 2006 (Fe> Mn> Ni> Cu> Pb> Co); da Silva et al., 2008 (Cu> Pb> Ni. Sb> Ce)). The difference between the concentration orders of metals at different sites highlights the importance of local factors; including geography, meteorology and variability of sources and source compositions. Correlations were identified between some of the metals analysed by ICP-MS ($p>0.01$). These correlations may indicate the same or similar elemental sources, for example correlation between Ba and Ni may be associated with road exhaust emissions (Dongarrà et al., 2007).

Summary and Conclusions

Particulate matter within the Neath Road street canyon, Swansea, Wales was studied for particle concentration variations and particle physicochemical properties. The particle concentrations within the traffic corridor were found to be consistently highest in the smallest size fraction, with particle concentrations and daily patterns comparable to previous studies in this field. Evening and weekend concentrations of particles were significantly lower than daytime particles, highlighting the role of traffic exhausts as a primary and influential provider of the smallest (and most abundant) particles.

Generally, with increasing particle size, particle morphology and type increased in variability, with particles in the nanoparticle-range being dominated by traffic exhaust particles. The associated metal content increased in both amount and variety of types with increasing particle size. The ICP-MS analyses generally added to and reinforced results from the FESEM and were useful in providing bulk elemental analysis.

Figures

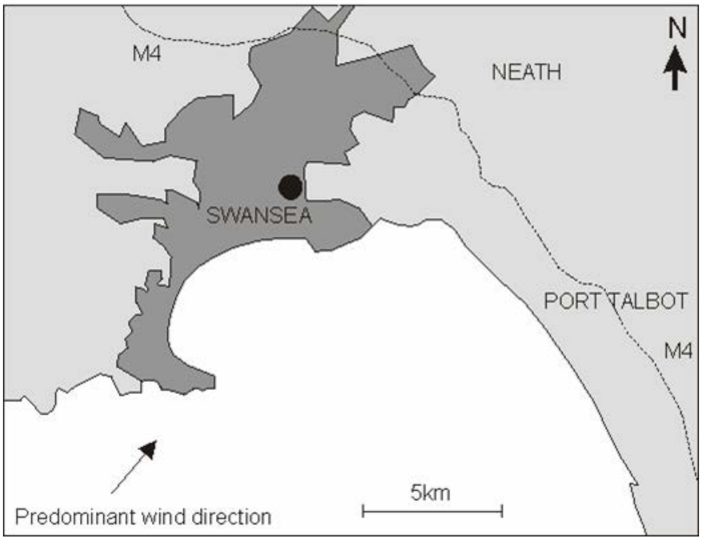

Figure 1. Location map showing the Neath Road, Swansea sampling site (black circle) in relation to surrounding feature

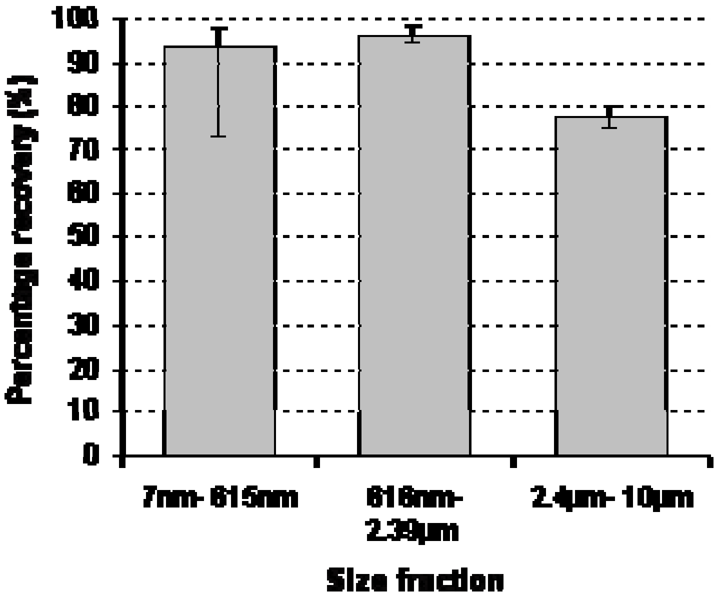

Figure 2. Particle mass extraction efficiency for the three analysed size fractions (30nm-615nm, 616nm- 2.39µm, 2.4µm- 10µm). Error bars indicate the range of recovery efficiencies measure

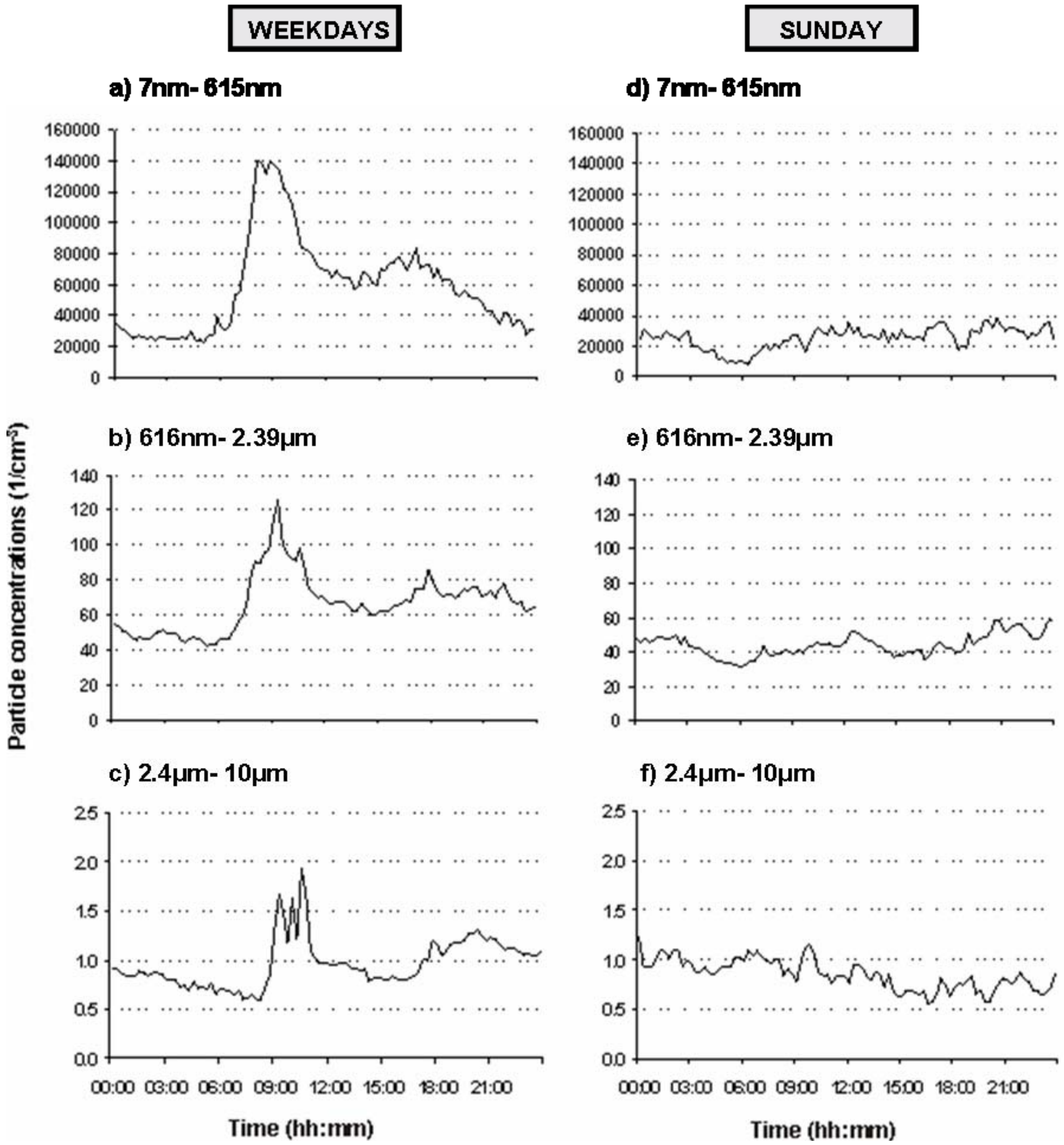

Figure 3. Average daily particle concentration profile in Neath Road traffic corridor for (1) weekdays and (2) Sundays in three size fractions (a) 7nm- 615nm, (b) 616nm- 2.39µm, (c) 2.4µm- 10µm

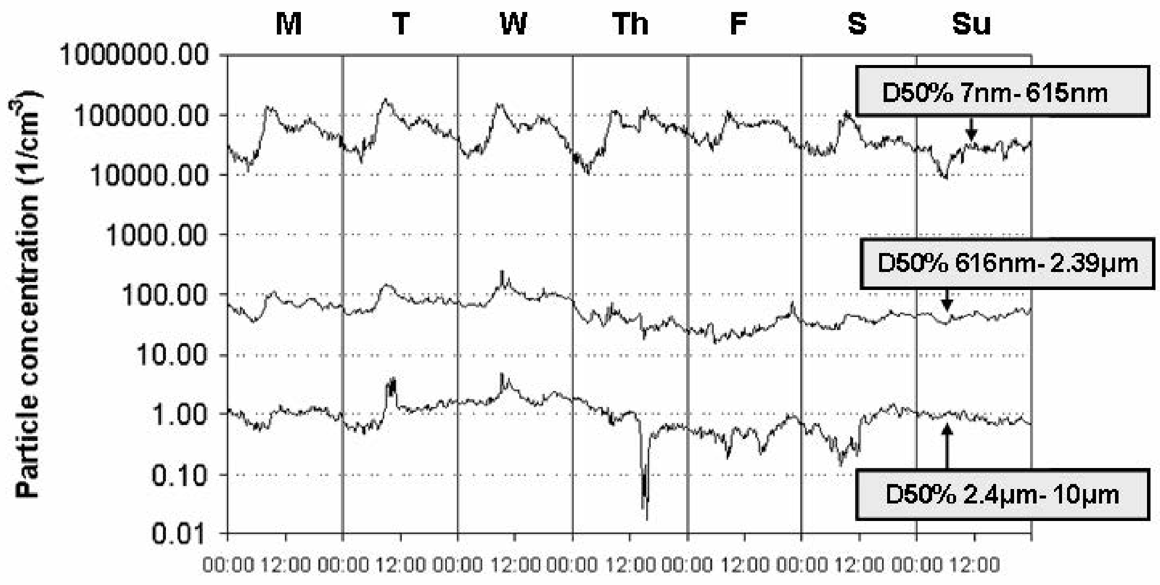

Figure 4. Average weekly particle concentration profile for Neath Road, Swansea

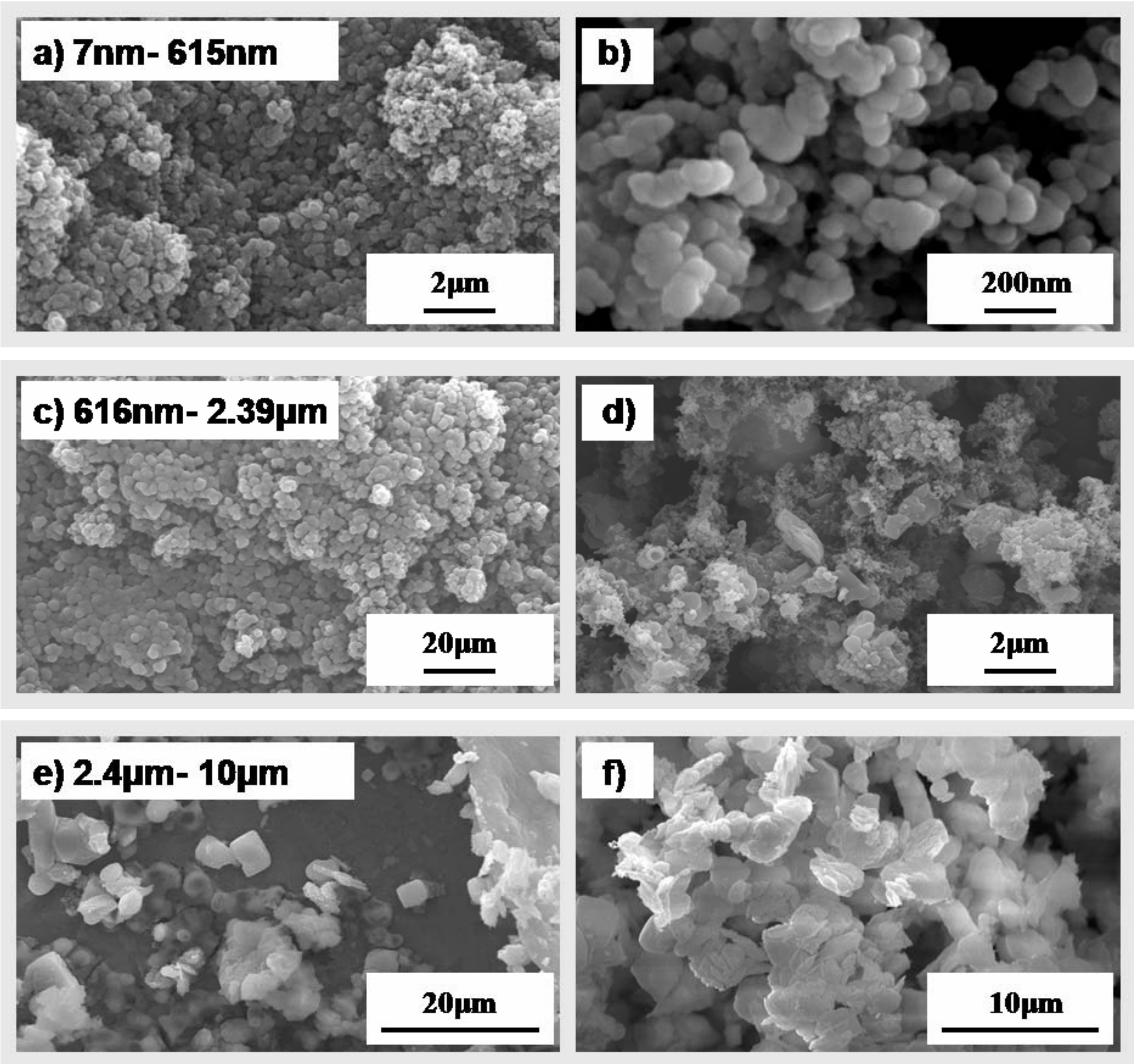

Figure 5. FE-SEM images of particles in the three measured size fractions collected in Neath Road, Swansea

(a) Particles in the 30- 615nm size range. (b) Close-up view of the 30- 615nm particle size range. (c) Particles in the middle size fraction (616nm- 2.39μm), at a large-scale view. (d) Closer view of particles in the middle size fraction. (e) Particles in the largest size fraction (2.4μm- 10μm). (f) Closer view largest size fraction

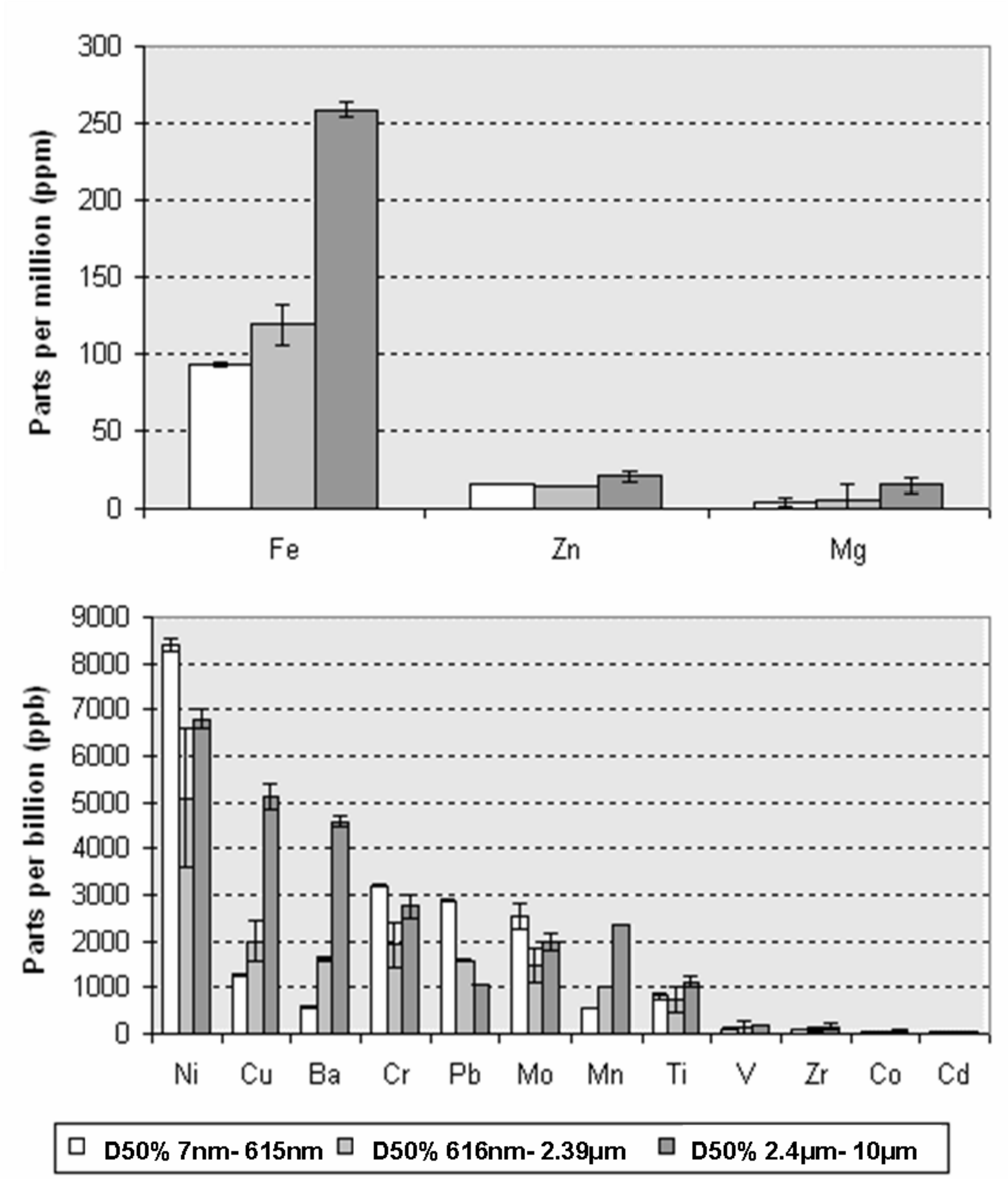

Figure 6. ICP-MS elemental analysis of the three analysed size fractions
Bars represent the three different analysed size fractions (white= D50% 30nm- 615nm; light grey= D50% 616nm- 2.39μm; dark grey= D50% 2.4μm- 10μm), top graph showing elements in parts per million (ppm) concentrations and bottom graph showing elements in parts per billion (ppb) concentrations. Error bars represent one standard deviation either side of the mean.

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Appendix 5

A Statistical Analysis of Selected Heavy Metals Concentrations in Ambient Air Around Swansea (CERH)

CREH

CENTRE FOR RESEARCH INTO ENVIRONMENT AND HEALTH

A Statistical Analysis of Selected Heavy Metal Concentrations in Ambient Air Around Swansea

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Final Report

Mark Wyer
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Executive summary

1. New additional emission controls were established at the Vale Inco nickel refinery Clydach, north of Swansea on 16th August 2007. This study investigates the efficacy of this intervention based on statistical analysis of ambient air quality data from the City and County of Swansea environmental monitoring network.

2. Heavy metal concentration data, from the PM_{10} fraction in ambient air, were available from four monitoring stations in the Swansea area, Glais Primary School, Coed Gwilym Cemetery, Y. G. G. Gellionen and Morriston Groundhog.

3. Initial analysis of nickel, copper, manganese and lead concentrations in ambient air showed these parameters generally to be $\log_{10}$-normally distributed. Data were, thus, $\log_{10}$ transformed prior to statistical analysis. Significance of all statistical tests was assessed at the 95% confidence level.

4. Student's t-test was used to examine the significance of differences in geometric mean concentrations in periods before and after installation of emission controls. The results demonstrate (i) statistically significant reductions in geometric mean nickel concentrations, of between two and three times, since emission control at all three monitoring sites. No such differences were evident for copper, manganese and lead. This provides strong circumstantial evidence that emission controls have had a positive, beneficial, effect on ambient air quality with respect to nickel.

5. Analysis of variance was used to explore the significance of differences in geometric mean concentrations between monitoring sites. Statistically significant differences were evident for all parameters. For nickel, these differences appear to reflect the proximity and location of monitoring stations to the refinery site. The geometric mean concentrations of the other parameters were all significantly elevated at one particular site, Morriston Groundhog, which is furthest away and frequently upwind relative to the refinery site. Such differences could be explored further in relation to meteorological conditions, using data from the City and County of Swansea meteorological monitoring stations.

6. Analysis of available annual arithmetic mean nickel concentrations since installation of emission controls at the nickel refinery suggests that the average nickel concentration at Coed Gwilym Cemetery (24.04 ng/m^3) is approaching the target value of 20 ng/m^3 in ambient air specified in the relevant European Directive (2004/107/EC). Encouragingly, the corresponding annual average nickel concentration at the Morriston Groundhog site (8.87 ng/m^3) is below this threshold. However, further monitoring is essential to confirm this pattern.

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1. Introduction

Heavy metals in the PM_{10} fraction (i.e. particulates ≤ 10 µm diameter) of ambient air can be of concern with respect to human health and, as such, have been included in relevant European legislation such as the air quality framework Directive 96/62/EC (CEU, 1996) and corresponding daughter Directives. The fourth daughter Directive, 2004/107/EC (CEU, 2005), specifically covers the heavy metals arsenic, nickel, cadmium and mercury, as well as polyaromatic hydrocarbons, and provides standards for their concentration in ambient air. Nickel has been of particular concern in the City and County of Swansea area due to the location of the Vale Inco refinery in Clydach, to the north of Swansea city (Figure 1.1). Filtration plant was commissioned at this refinery (16/08/2007) with the aim of reducing nickel emissions. The aim of the current study is to provide a statistical analysis of ambient air quality data before and after this installation and identify any significant improvements in ambient air quality with respect to nickel concentrations. Figure 1.1 also shows a potential secondary nickel source, at Wall Colmonoy, outside the City and County of Swansea boundary to the northeast. It is thought that nickel emissions from this site are likely to be minimal, however.

2. Materials and methods

2.1 Data sources

The City and County of Swansea Environment Department operate a network of air quality monitoring stations in the region. Four of these include Partisol PM_{10} analyzers (Figure 1.1 and Table 2.1). Material from these sites is analyzed for a range of heavy metal concentrations, including nickel, reported as ng/m^3. Three of these sites, Glais Primary School, Coed Gwilym Cemetery and Y.G.G. Gellionen, are within 1.5 km of the Vale Inco refinery stack. The fourth site, Morriston ”Groundhog” is just over 4km to the southwest of the nickel refinery. The department also gather meteorological data at sites shown in Figure 1.1.

Heavy metal concentration data are available from the Glais primary school site from 02/09/2004. However, data records were interrupted at this site between 12/07/2007 and 29/11/2007 due to building works (i.e. during the period when emission filtration was first installed at the Vale Inco site). Records for the Coed Gwilym Cemetery and Morriston Groundhog monitors commence from 26/07/2006. The Y. G. G. Gellionen monitor has been operating since 06/12/2007, i.e. since the installation of the emission filtration at the Vale Inco refinery. Thus, three sites, Glais Primary School, Coed Gwilym Cemetery and Morriston Groundhog, have data with which to explore air quality before and after the establishment of the new, additional, emission controls at the refinery.

2.2 Parameters

The PM_{10} air quality analysis covers a range of parameters measured at an approximate weekly interval. In addition to nickel, concentrations three metals that should not be affected by the emission controls were selected for parallel analysis. These are: copper, manganese and lead.

2.3 Statistical analysis

Any values below the limit of detection were assigned a value of 0.5 x the detection limit value for the purposes of statistical analysis. Statistical analyses were undertaken using the SPSS statistical software package (SPSS, 2007). Statistics, including the mean, 95% confidence interval for the mean (95% CI), standard deviation (SD), minimum, maximum and number of observations were used to provide statistical summaries of data. Exploratory analysis also examined the normality of these data using the Shapiro-Wilk (S-W) and Kolmogorov-Smirnov (K-S) tests and the skewness statistic. The skewness value indicates the degree of positive or negative skew in a distribution with normally distributed data typically exhibiting values in the range -1 to +1. Where distributions showed departures from normality, data transformations, such as $\log_{10}$, were examined.

Student's t-test (*t* statistic) and analysis of variance (ANOVA) were used to explore significant differences between mean values. Student's t-test was used where the comparison was bivariate and ANOVA when more than two group means were under comparison. In both cases, the Levene statistic was used to assess the homogeneity of variance between the groups under comparison. A separate variance t-test result was used when the Levene test indicated that variances could not be considered equal between groups and a pooled variance test result used when variances could be considered equal. In the case of ANOVA, the outcome of the Levene test was used to determine: (i) the test statistic used to assess significance and (ii) the *post-hoc* multiple comparison tests selected to indicate significant differences between pairs of mean values. Where variances could be considered equal and the numbers of results in each group were approximately equal then the significance of the *F* statistic was assessed. In cases where groups were of approximately equal size but variances could not be considered equal the Brown-Forsyth test statistic was used. Finally, where both group sizes and variances could not be considered equal the Welch statistic was used to assess the outcome of the ANOVA. In the case of *post-hoc* multiple range test selection, where variances could not be considered equal the Tamhane test result was selected whilst the Tukey honest significant difference (HSD) test was used in cases where variances could be considered equal. General linear model (GLM) was also employed to explore the significance of interactions between multiple factors.

Where data could not be considered normally distributed, non-parametric equivalent tests were applied. These tests are based on ranked values, the Mann-Whitney test (*U* - statistic) being used for bivariate comparisons and the Kruskall-Wallis test (χ^2 - statistic) used in cases with more than two groups.

The statistical significance of all tests was assessed at the 95% confidence level ($\alpha = 0.05$). This was achieved by comparing the calculated significance value for a particular test, *p*, with α. A statistically significant result (e.g. between mean values) is indicated when $p < \alpha$ (i.e. $p < 0.05$).

3. Results

Time series of weekly concentrations of the four heavy metals are shown in Figures 3.1 and 3.2. Nickel concentrations appear to have broadly decreased since installations of emission controls at the Vale Inco refinery (Figure 3.1A). The maximum concentration recorded prior to 16/08/2007 was 294.22 ng/m^3 at Coed Gwilym Cemetery, whilst the maximum since this date was 121.47 ng/m^3 at Y. G. G. Gellionen. The time series for nickel also shows some variation between the sites. In contrast, copper concentrations show marked variation between sites, with particularly elevated values associated with the Morriston Groundhog site (Figure 3.1B). This is also the case with the two remaining metals, manganese and lead (Figure 3.2). There appears to be no discernable pattern of temporal change in relation to the intervention at the nickel refinery with respect to copper, manganese and lead. However, it is difficult to assess the significance of temporal changes from the time-series plots alone.

Very few concentrations were reported as below the lower limit of detection (LLD), with just two cases for nickel and two cases for lead (0.42% of cases for each parameter). In each case a value of 0.05 ng/m^3 was assigned (0.5 x LLD). Normality was tested site by site and using all values, yielding five tests per parameter (i.e. 20 in total). The untransformed data showed pronounced positive skew for all four parameters, the only distribution showing a normal distribution being copper at Y. G. G. Gellionen. Log_{10} transformation reduced skewness to below an absolute value of one in the majority of cases (80% of 20 distributions tested) and demonstrated improved approximation to normality for all four parameters. A total of 10 distributions showed no statistically significant departure from normality (K-S or S-W $p > 0.05$). Statistical analysis was, thus, undertaken using $\log_{10}$ transformed concentration values. In the case of nickel, four cases had values of zero ng/m^3. A constant of 1 was, therefore, added to the nickel data prior to transformation.

As can be seen from Figures 3.1 and 3.2 and discussed in section 2.1, monitoring at the four sites has not been concurrent. Thus, a sub-set of concurrently monitored data were selected for pre/post emission control comparisons using the Glais Primary School, Coed Gwilym Cemetery and Morriston Groundhog sites. The periods covered approximately equal lengths of time in the pre and post intervention periods: pre-control – 26/07/2006 to 12/07/2007, post-control – 29/11/2007 to 06/11/2008, yielding roughly equal numbers of cases in each group. These periods were defined by (i) the commencement of monitoring at Coed Gwilym Cemetery and Morriston Groundhog sites and (ii) the extended break in monitoring at Glais Primary School due to building works. Statistical summaries are shown in Figures 3.3 and 3.4 and Table 3.1. Student's t-test was used to assess the significance of differences in the bivariate pre/post intervention comparisons at each site. The results demonstrate a statistically significant reduction in the GM nickel concentration post-emission control compared to the pre-control period at all three sites (Student's t-test $p < 0.05$). At Glais Primary School this amounts to an almost three fold reduction in GM concentration, from 23.21 ng/m^3 to 8.26 ng/m^3. The GM concentration at Coed Gwilym fell by approximately a half, from 31.30 to 15.66 ng/m^3. The reduction at the Morriston Groundhog was of a slightly higher order, falling from a GM of 13.13 ng/m^3 in the pre-emission control period down to 5.16 ng/m^3 post-control. In contrast, none of the other three metals showed any significant differences in GM concentrations between the two periods. This demonstrates that the emission control measures at the Vale Inco works have had a statistically significant, positive, effect on reducing nickel concentrations in ambient air at the monitoring stations.

GLM ANOVA was applied using this dataset to examine (i) the significance of differences in GM concentrations between the three monitoring sites and (ii) any interaction between site and pre/post emission factors in the model. The results showed statistically significant differences between sites ($p < 0.05$) for all parameters and no interaction between site and pre/post emission factors ($p > 0.05$). The latter result confirmed that between site differences were not associated with one particular period. The models also confirmed the significant pre/post emission control difference for nickel ($p < 0.05$), which was not repeated for the other three parameters ($p > 0.05$).

One-way ANOVA was used to explore between-site differences further. The results are summarized in Table 3.2. As nickel showed statistically significant pre/post emission control differences, separate ANOVAs were run for each period, shown in sections A and B of Table 3.2. Prior to emission control, the GM nickel concentration at Coed Gwilym Cemetery (31.30 ng/m^3) was significantly different from Morriston Groundhog (GM = 13.13 ng/m^3) (Table 3.2, section A). In contrast, the GMs at all three sites were significantly different from each other in the post-emission control period (Table 3.2, section B). Since no significant pre/post emission control effects were observed for the other parameters, between-site differences were examined using all cases, regardless of period. The results are consistent for all three parameters, and show the GM concentration at the Morriston Groundhog site to be significantly higher than at the other two sites (Table 3.2, sections C to E). This pattern contrasts with that for nickel, where the lowest GM is associated with the Morriston Groundhog monitor in both periods. This probably reflects the position of this monitoring station relative to the refinery emission, it being (i) the furthest monitor away from the refinery (4.2 km) and (ii) upwind of the prevailing wind direction (southerly) relative to the refinery (Figure 3.5). Likewise, the Coed Gwilym Cemetery monitor is directly northeast of the Vale Inco site (i.e. in the track of prevailing southerly/south-westerly winds) and displays the highest GM nickel concentrations (Table 3.2, section A and B). Reasons for the elevated copper, manganese and lead concentrations at the Morriston Groundhog site may relate to other local industrial activities and other emission sources in the vicinity involving these metals.

Table 3.3 summarizes and alternative analysis based on equal length periods before and after emission controls were established at the nickel refinery. For the Coed Gwilym Cemetery and the Morriston Groundhog monitors, the years prior to (i.e. 16-08/2006 – 15/08/2007) and following (i.e. 16/08/2007 – 15/08/2008) emission control were selected for comparison. For the Glais Primary School site the periods 29/11/2006 – 12/07/2007 (pre-control) and 29/11/2007- 12/07/2008. (post-control) were selected. The results confirm those from the previous analysis, demonstrating statistically significant reductions in GM nickel concentrations in ambient air at all three sites since emission controls were established (Student's t-test, $p < 0.05$). With the exception of one comparison, copper at the Morriston Groundhog site, Table 3.3 shows that the other parameters demonstrated no significant differences between the selected periods. In the case of copper at the Morriston Groundhog site, the GM concentration showed a significant increase, from 15.76 ng/m^3 to 25.87 ng/m^3, in the later period.

Directive 2004/107/EC specifies a target value for nickel content of 20ng/m^3 in the PM_{10} fraction averaged over a calendar year (CEU, 2005). This implies an arithmetic rather than geometric mean. The monitoring periods preclude a comparison of whole calendar years (i.e. January to December) before and after installation of the emission control at the Vale Inco refinery (i.e. a comparison of the years 2006 and 2008). However, Table 3.4 lists the arithmetic mean nickel concentrations for the twelve- month periods before and after emission control for the Coed Gwilym Cemetery and Morriston Groundhog monitors. At Coed Gwilym cemetery the annual average shows a decline of over 50% from 53.67 ng/m^3 to 24.04 ng/m^3, approaching the target level. The arithmetic mean at the Morriston Groundhog declined by over 66%, from 30.26 ng/m^3 to 8.87 ng/m^3, well below the target level. The differences in reduction reflect the proximity and location of the monitors in relation to the refinery site (Figure 1.1). This, again, illustrates the positive effect of the emission control strategy at the refinery with respect to nickel concentrations in ambient air. Annual values should be reviewed as further data become available in the future.

Finally, Table 3.5 shows the results of *post-hoc* multiple comparisons of GM heavy metal concentrations at all four air quality sites for the period of concurrent operation (06/12/2007 – 06/11/2008). One-way ANOVA indicated significant between-site differences for all parameters (Welch statistic, $p < 0.05$). In the case of nickel, the GM concentration at Coed Gwilym Cemetery was significantly higher than at the other three sites. This probably relates to the location of the monitor, to the north east of the refinery site (Figure 1.1), in the track of the prevailing southerly wind direction. The only remaining significant difference was the comparison between Y. G. G. Gellionen, which displayed a significantly higher GM (9.03 ng/m^3) compared to the Morriston Groundhog (5.16 ng/m^3). This difference may relate to the closer proximity of the Y. G. G. Gellionen site to the refinery site (0.7 km) and location (NW of the refinery). Such differences could be explored further in relation to meteorological conditions. The other parameters showed identical pattern, with GM concentrations being significantly higher at the Morriston Groundhog site compared to all other sites (Table 3.4).

4. Summary and conclusions

1. New additional emission controls have been established at the Vale Inco nickel refinery Clydach, north of Swansea. The brief for the current study is to investigate the efficacy of this intervention based on statistical analysis of ambient air quality data from the City and County of Swansea environmental monitoring network.

2. Initial analysis of nickel, copper, manganese and lead concentrations in ambient air showed these parameters broadly to be $\log_{10}$-normally distributed. Data were, thus, $\log_{10}$ transformed prior to statistical analysis.

3. Student's t-test was used to examine the significance of differences in GM concentrations in periods before and after installation of emission controls. The results demonstrate (i) statistically significant reductions in GM nickel concentrations, of between two and three times, since emission control at all three monitoring sites. No such differences were evident for copper, manganese and lead. This indicates that emission controls have had a positive, beneficial, effect on ambient air quality with respect to nickel.

4. Results of ANOVA showed statistically significant differences in GM concentrations of all parameters between monitoring sites. For nickel, these differences appear to reflect the proximity and location of monitoring stations to the refinery site. The GM concentrations of the other parameters were all significantly elevated at one particular site, Morriston Groundhog, which is furthest away and upwind relative to the refinery site. Such differences could be explored further in relation to meteorological conditions, using data from the City and County of Swansea meteorological monitoring stations (Figure 1.1).

5. Analysis of available annual arithmetic mean nickel concentrations suggests that average nickel concentrations have declined and are approaching (Coed Gwilym Cemetery) or below (Morriston Groundhog) the target value of 20 ng/m^3 in ambient air specified in Directive 2004/107/EC since installation of emission controls at the Vale Inco nickel refinery in Clydach.

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CREH
Centre for Research into Environment and Health

A Statistical Analysis of Selected Heavy Metal Concentrations in Ambient Air Around Swansea

A report to the City and County of Swansea Environment Department

Final Report

Tables

Mark Wyer
David Kay

July 2009

Table 2.1 Details of industrial nickel sources and meteorological and air quality monitoring stations around Swansea

Site	Description	NGR	Elevation (m)	Distance (km)/direction from Vale Inco	Comments/Monitoring
Vale Inco	Primary nickel source	SN694013	20	-	Emission filters installed -16/08/07
Wall Colmonoy	Secondary nickel source	SN727042	50	4.4/NE	-
Glais Primary School	Partisol 2025 gravimetric PM_{10} analyzer	SN702005	45	1.1/SE	02/09/04 - 12/07/07 29/11/07 -
Coed Gwilym Cemetery	Partisol 2020 gravimetric PM_{10} analyzer	SN706020	45	1.4/NE	26/07/06 -
YGG Gellionen	Partisol 2020 gravimetric PM_{10} analyzer	SN693020	70	0.7/NW	06/12/07 -
Wychtree Street Morriston	Groundhog - real-time PM_{10} and Partisol 2025 gravimetric PM_{10} analyzers, meteorological monitor	SS672977	15	4.2/SW	26/07/06 -
Morfa TA Centre	SODAR meteorological and boundary layer monitor	SS663951	10	6.8/SW	-
Cwm Level Park	Meteorological station	SS659959	30	6.4/SW	-

Table 3.1 Summary of weekly concentrations (ng/m^3) of selected heavy metals at three air quality monitoring stations around Swansea during concurrent monitoring periods before and after installation of emission filtering equipment at the Vale Inco works (16/08/07)

Paramter/Condition/Site	Geo. mean[a]	S.D.[b]	Min.	Max.	*n*[c]
A. Nickel, pre-filter (26/07/06 – 12/07/07)					
Glais Primary School	23.21	0.3964	0.28	96.53	48
Coed Gwilym Cemetery	31.30	0.5328	0.05	294.22	47
Morriston Groundhog	13.13	0.5869	0.03	251.69	45
B. Nickel, post-filter (29/11/07 – 06/11/08)					
Glais Primary School	8.26*	0.3181	0.97	32.86	48
Coed Gwilym Cemetery	15.66*	0.2478	1.94	54.72	47
Morriston Groundhog	5.16*	0.3358	0.00	22.61	40
C. Copper, pre-filter (26/07/06 – 12/07/07)					
Glais Primary School	3.95	0.3112	1.00	40.31	48
Coed Gwilym Cemetery	4.03	0.3289	0.72	39.40	47
Morriston Groundhog	15.83	0.5920	0.23	118.89	45
D. Copper, post-filter (29/11/07 – 06/11/08)					
Glais Primary School	4.56	0.2168	1.65	12.87	48
Coed Gwilym Cemetery	3.83	0.2164	1.73	14.23	47
Morriston Groundhog	25.30	0.3042	6.57	162.86	40
E. Manganese, pre-filter (26/07/06 – 12/07/07)					
Glais Primary School	3.12	0.3585	0.70	13.88	48
Coed Gwilym Cemetery	3.56	0.3303	0.73	15.78	47
Morriston Groundhog	6.08	0.5353	0.02	27.06	45
F. Manganese, post-filter (29/11/07 – 06/11/08)					
Glais Primary School	3.28	0.2932	0.78	13.38	48
Coed Gwilym Cemetery	2.82	0.3034	0.93	16.29	47
Morriston Groundhog	7.05	0.2601	3.09	41.87	40
G. Lead, pre-filter (26/07/06 – 12/07/07)					
Glais Primary School	7.65	0.3982	1.21	122.04	48
Coed Gwilym Cemetery	6.86	0.5015	0.05	87.66	47
Morriston Groundhog	11.17	0.6878	0.05	110.63	45
H. Lead, post-filter (29/11/07 – 06/11/08)					
Glais Primary School	8.16	0.2729	2.32	50.39	48
Coed Gwilym Cemetery	6.47	0.2845	2.25	29.37	47
Morriston Groundhog	16.25	0.3812	1.60	128.69	40

a Geometric mean, $(10^X) - C$ where X is the mean value of $\log_{10}$ transformed values and C is a constant ($C = 1$ for Nickel, $C = 0$ for all other parameters)

b Standard deviation of $\log_{10}$ transformed values

c n = number of observations

* post-filter geometric mean significantly reduced compared to the pre-filter geometric mean (Student's t-test, $p < 0.05$ (where p is significance))

Table 3.2 Summary of between-site differences in geometric mean (GM) weekly concentrations (ng/m^3) of selected heavy metals at three air quality monitoring stations around Swansea during concurrent monitoring periods

Site	**GM**[a]	***n***[b]	**Site** Glais Primary School	 Coed Gwilym Cemetery	 Morriston Groundhog
A. Nickel, pre-filter (26/07/06 – 12/07/07), Tukey HSD[c]					
Glais Primary School	23.21	48	-		
Coed Gwilym Cemetery	31.30	47		-	*
Morriston Groundhog	13.13	45		*	-
B. Nickel, post-filter (29/11/07 – 06/11/08), Tamhane[d]					
Glais Primary School	8.26	48	-	*	*
Coed Gwilym Cemetery	15.66	47	*	-	*
Morriston Groundhog	5.16	40	*	*	-
C. Copper, all data (26/07/06 – 12/07/07, 29/11/07 – 06/11/08), Tamhane[d]					
Glais Primary School	4.24	96	-		*
Coed Gwilym Cemetery	3.93	94		-	*
Morriston Groundhog	19.74	85	*	*	-
D. Manganese, all data (26/07/06 – 12/07/07, 29/11/07 – 06/11/08), Tukey HSD[c]					
Glais Primary School	3.20	96	-		*
Coed Gwilym Cemetery	3.17	94		-	*
Morriston Groundhog	6.52	85	*	*	-
E. Lead, all data (26/07/06 – 12/07/07, 29/11/07 – 06/11/08), Tamhane[d]					
Glais Primary School	7.90	96	-		*
Coed Gwilym Cemetery	6.66	94		-	*
Morriston Groundhog	13.33	85	*	*	-

a Geometric mean, $(10^{X}) - C$ where X is the mean value of $\log_{10}$ transformed values and C is a constant ($C = 1$ for Nickel, $C = 0$ for all other parameters)

b n = number of observations

c Tukey honest significant difference multiple comparison test, applied when group variances can be considered equal, based on the Levene test

d Tamhane multiple comparison test, applied when group variances cannot be considered equal, based on the Levene test

* indicates a significant difference in GMs between the two groups ($p < 0.05$ (where p is significance))

Table 3.3 **Summary of weekly concentrations (ng/m^3) of selected heavy metals at three air quality monitoring stations around Swansea during equal length monitoring periods before and after installation of emission filtering equipment at the Vale Inco works (16/08/07)**

Paramter/Condition/Site	Geo. mean[a]	S.D.[b]	Min.	Max.	*n*[c]
A. Nickel, pre-filter (Glais: 29/11/06-12/07/07, Coed Gwilym/Morriston: 16/8/06-15/08/07)					
Glais Primary School	22.74	0.4307	0.28	86.25	30
Coed Gwilym Cemetery	33.86	0.5215	0.05	294.22	50
Morriston Groundhog	14.30	0.5784	0.03	251.69	48
B. Nickel, post-filter (Glais: 29/11/07-12/07/08, Coed Gwilym/Morriston: 16/8/07-15/08/08)					
Glais Primary School	9.49*	0.3158	1.00	32.86	31
Coed Gwilym Cemetery	20.07*	0.2516	5.39	84.26	49
Morriston Groundhog	6.14*	0.3756	0.00	32.60	43
C. Copper, pre-filter (Glais: 29/11/06-12/07/07, Coed Gwilym/Morriston: 16/8/06-15/08/07)					
Glais Primary School	3.91	0.3201	1.08	40.31	30
Coed Gwilym Cemetery	4.05	0.3084	0.72	39.40	50
Morriston Groundhog	15.76	0.5696	0.23	118.89	48
D. Copper, post-filter (Glais: 29/11/07-12/07/08, Coed Gwilym/Morriston: 16/8/07-15/08/08)					
Glais Primary School	4.31	0.2060	1.65	11.07	31
Coed Gwilym Cemetery	3.97	0.2302	1.46	14.23	49
Morriston Groundhog	25.87†	0.2871	6.57	162.86	43
E. Manganese, pre-filter (Glais: 29/11/06-12/07/07, Coed Gwilym/Morriston: 16/8/06-15/08/07)					
Glais Primary School	2.95	0.3962	2.64	4.49	30
Coed Gwilym Cemetery	3.51	0.3237	0.73	15.78	50
Morriston Groundhog	6.09	0.5182	0.02	27.06	48
F. Manganese, post-filter (Glais: 29/11/07-12/07/08, Coed Gwilym/Morriston: 16/8/07-15/08/08)					
Glais Primary School	3.44	0.3141	1.36	8.69	31
Coed Gwilym Cemetery	3.03	0.3103	0.84	16.29	49
Morriston Groundhog	7.45	0.2630	2.91	41.87	43
G. Lead, pre-filter (Glais: 29/11/06-12/07/07, Coed Gwilym/Morriston: 16/8/06-15/08/07)					
Glais Primary School	7.75	0.3902	1.21	122.04	30
Coed Gwilym Cemetery	6.75	0.4846	0.05	87.66	50
Morriston Groundhog	11.11	0.6645	0.05	110.63	48
H. Lead, post-filter (Glais: 29/11/07-12/07/08, Coed Gwilym/Morriston: 16/8/07-15/08/08)					
Glais Primary School	7.63	0.2470	2.60	24.21	31
Coed Gwilym Cemetery	6.77	0.3561	1.05	98.41	49
Morriston Groundhog	15.64	0.4196	1.15	128.69	43

a Geometric mean, $(10^X) - C$ where X is the mean value of $\log_{10}$ transformed values and C is a constant ($C = 1$ for Nickel, $C = 0$ for all other parameters)

b Standard deviation of $\log_{10}$ transformed values

c n = number of observations

* post-filter geometric mean significantly reduced compared to the pre-filter geometric mean (Student's t-test, $p < 0.05$ (where p is significance))

† post-filter geometric mean significantly elevated compared to the pre-filter geometric mean (Student's t-test, $p < 0.05$ (where p is significance))

Table 3.4 **Arithmetic mean weekly concentrations (ng/m^3) of nickel at two air quality monitoring stations near Swansea during the years before and after installation of emission filtering equipment at the Vale Inco works**

Site	Pre-filter (16/08/06-15/08/07 Arithmetic Mean	*n*[c]	Post-filter (16/08/07-15/08/08) Arithmetic Mean	*n*[c]
Coed Gwilym Cemetery	53.67	50	24.04	49
Morriston Groundhog	30.26	48	8.87	43

Table 3.5 **Summary of between-site differences in geometric mean (GM) weekly concentrations (ng/m^3) of selected heavy metals at four air quality monitoring stations around Swansea during concurrent monitoring periods (06/12/07 – 06/11/08)**

Site/multiple comparison test	GM[a]	*n*[b]	Site: Glais Primary School	Site: Coed Gwilym Cemetery	Site: Y. G. G. Gellionen	Site: Morriston Groundhog
A. Nickel, Tamhane[d]						
Glais Primary School	8.26	48	-	*		
Coed Gwilym Cemetery	15.66	47	*	-	*	*
Y. G .G. Gellionen	9.03	44		*	-	*
Morriston Groundhog	5.16	40		*	*	-
B. Copper, Tamhane[d]						
Glais Primary School	4.56	48	-			*
Coed Gwilym Cemetery	3.83	47		-		*
Y. G .G. Gellionen	3.75	44			-	*
Morriston Groundhog	25.30	40	*	*	*	-
C. Manganese, Tukey HSD[c]						
Glais Primary School	3.28	48	-			*
Coed Gwilym Cemetery	2.82	47		-		*
Y. G .G. Gellionen	2.76	44			-	*
Morriston Groundhog	7.05	40	*	*	*	-
D. Lead, Tukey HSD[c]						
Glais Primary School	8.16	48	-			*
Coed Gwilym Cemetery	6.47	47		-		*
Y. G .G. Gellionen	7.28	44			-	*
Morriston Groundhog	16.25	40	*	*	*	-

a Geometric mean, (10^X) - C where X is the mean value of $\log_{10}$ transformed values and C is a constant (C = 1 for Nickel, C = 0 for all other parameters)

b n = number of observations

c Tukey honest significant difference multiple comparison test, applied when group variances can be considered equal, based on the Levene test

d Tamhane multiple comparison test, applied when group variances cannot be considered equal, based on the Levene test

* indicates a significant difference in GMs between the two groups ($p < 0.05$ (where p is significance))

CREH
Centre for Research into Environment and Health

A Statistical Analysis of Selected Heavy Metal Concentrations in Ambient Air Around Swansea

A report to the City and County of Swansea Environment Department

Final Report

Figures

Mark Wyer
David Kay

July 2009

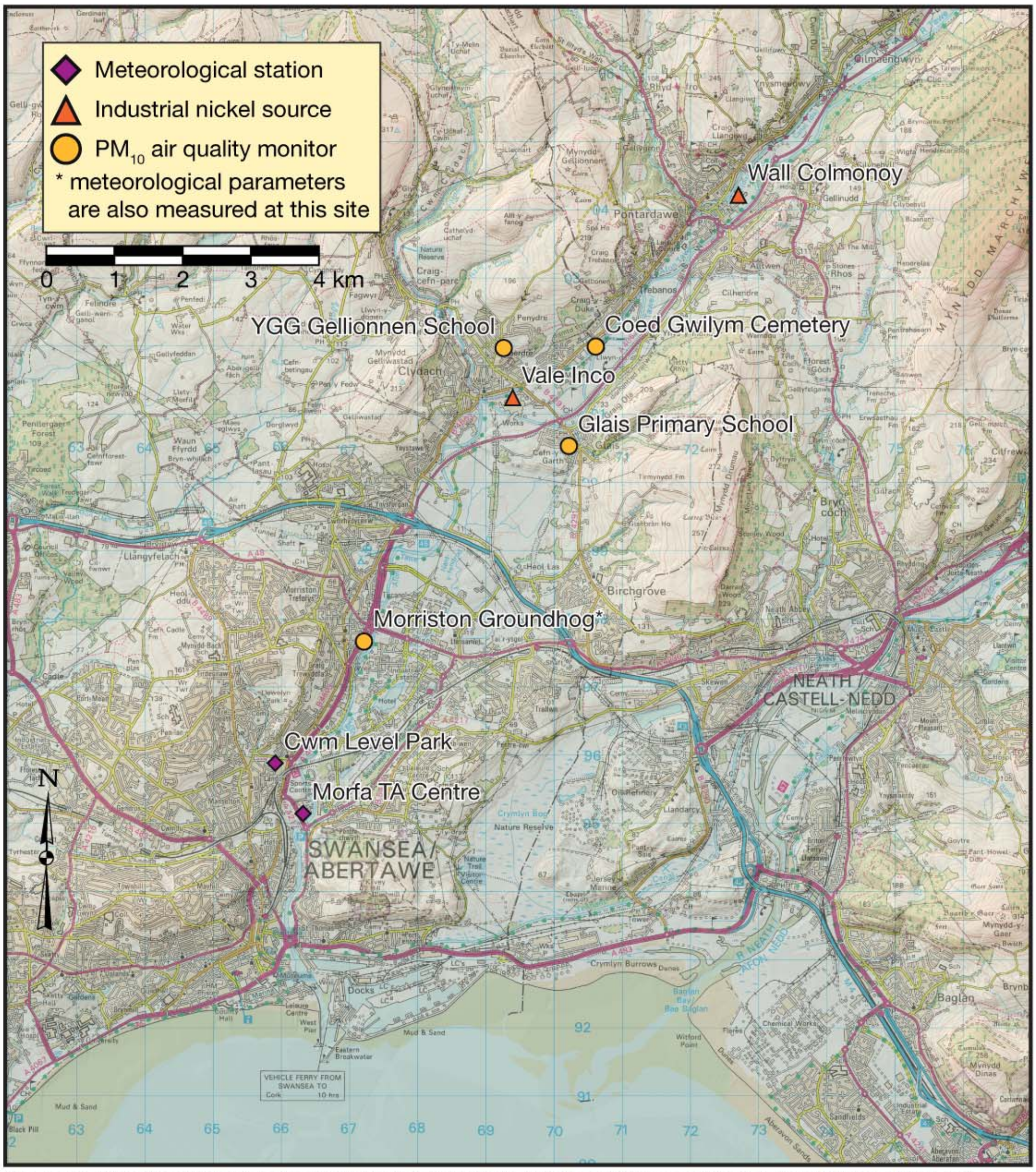

Figure 1.1 Locations of industrial nickel sources and air quality and meteorological monitoring stations in the Swansea area

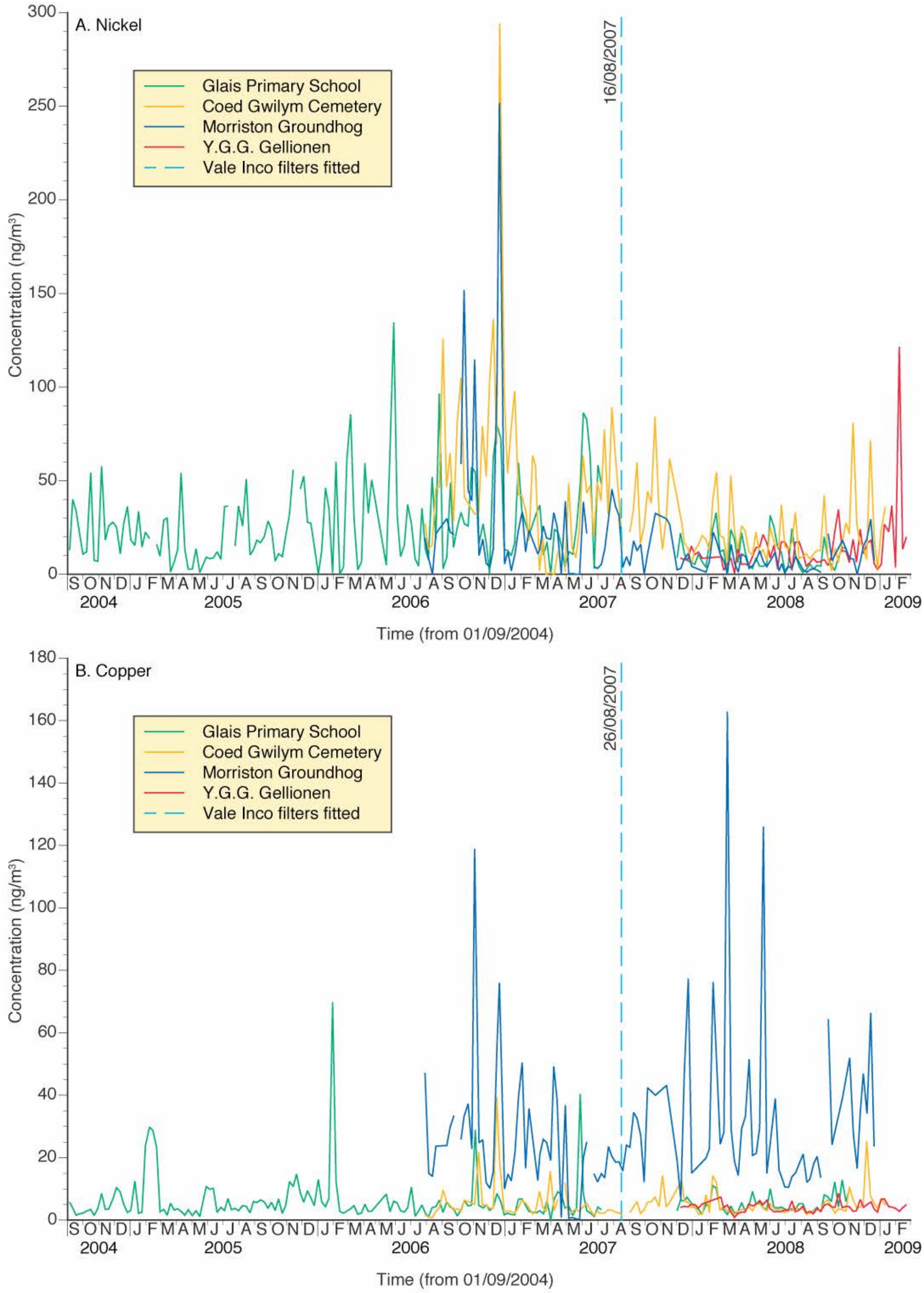

Figure 3.1 Weekly PM_{10} concentrations of nickel and copper (ng/m^3) in air quality samples from four monitoring stations in Swansea

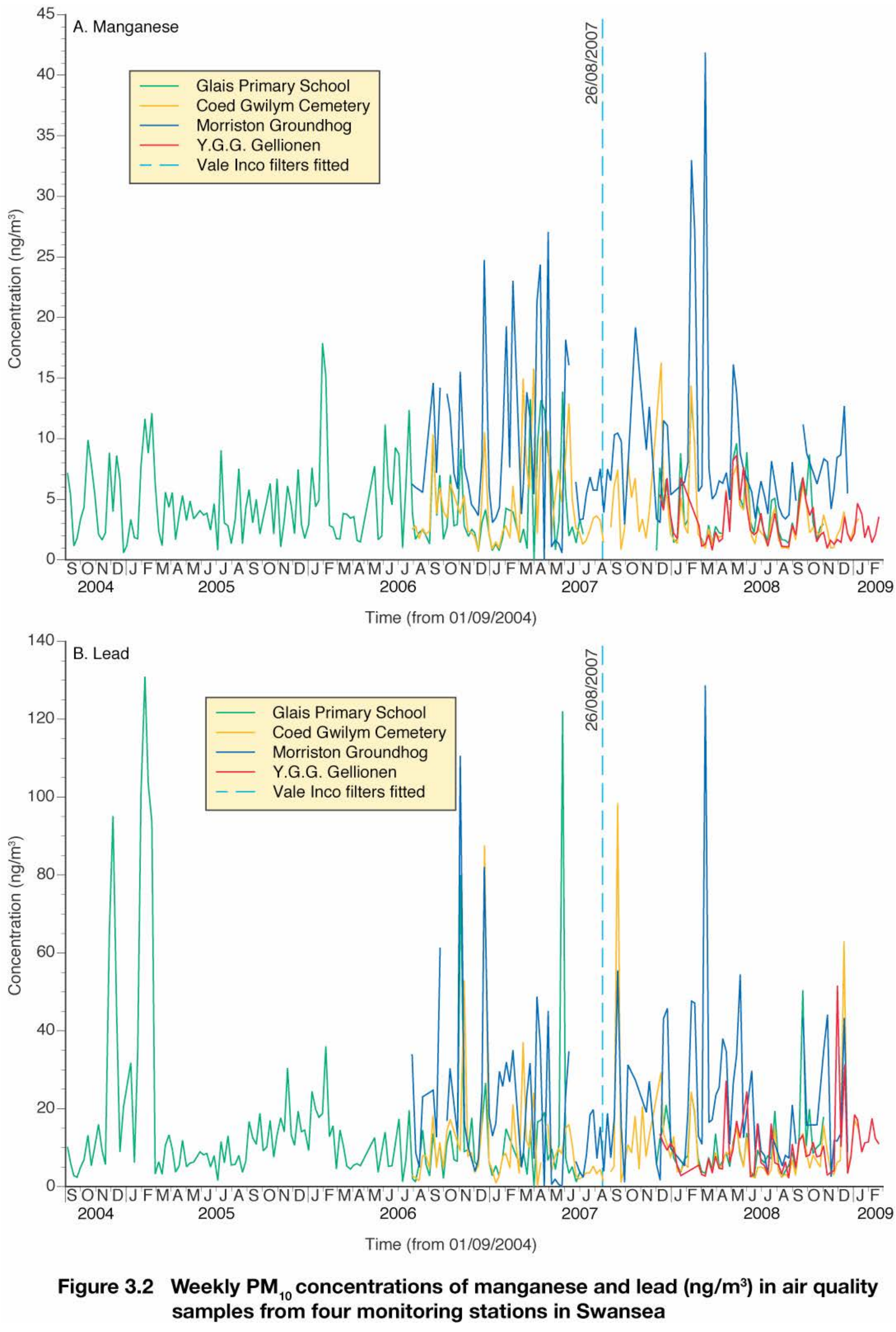

Figure 3.2 Weekly PM_{10} concentrations of manganese and lead (ng/m³) in air quality samples from four monitoring stations in Swansea

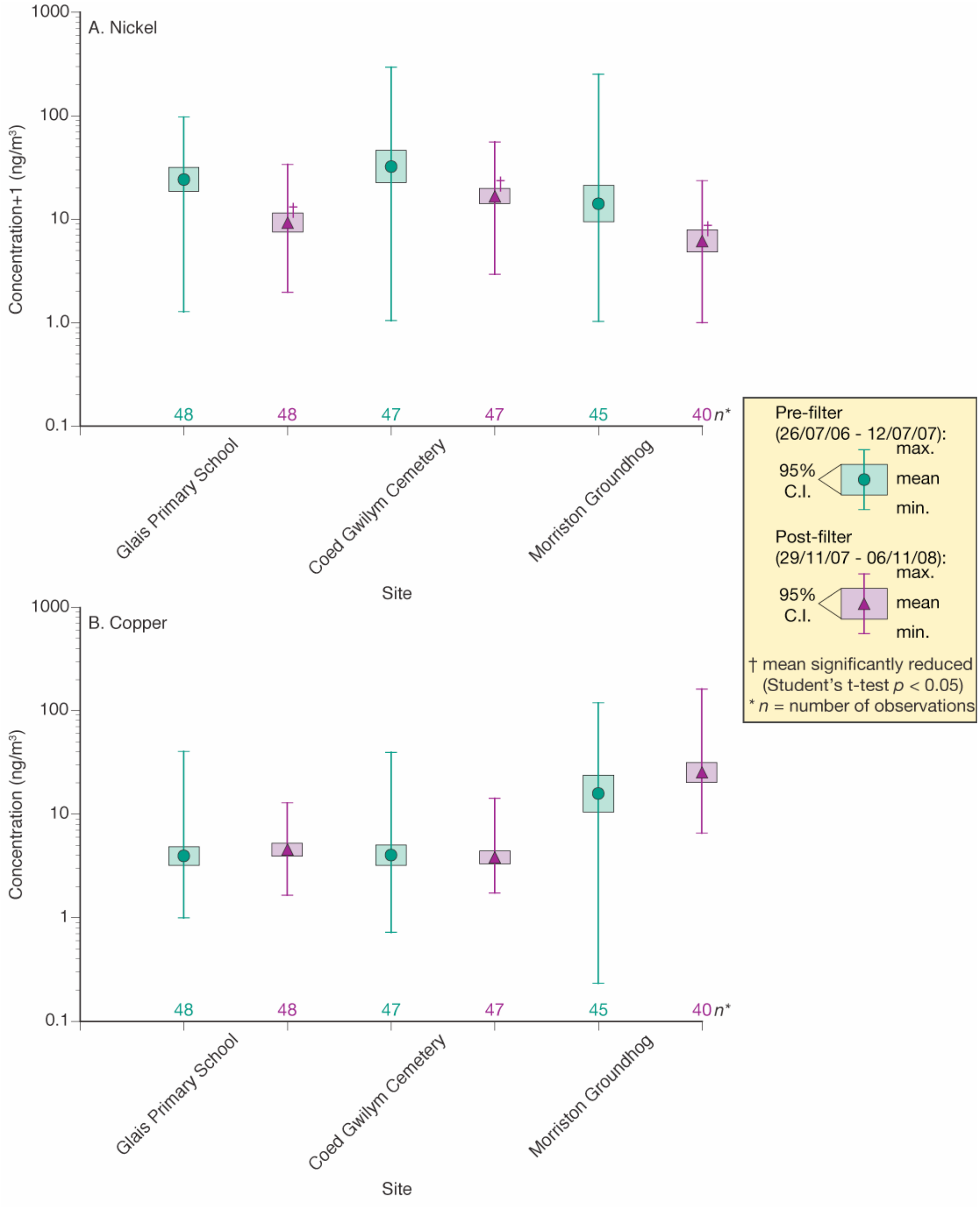

Figure 3.3 Geometric mean and associated 95% confidence interval (C.I.) and range of weekly PM_{10} nickel and copper concentrations (ng/m³) in air quality samples from three monitoring stations in Swansea before and after installation of emission control plant at the Vale Inco refinery

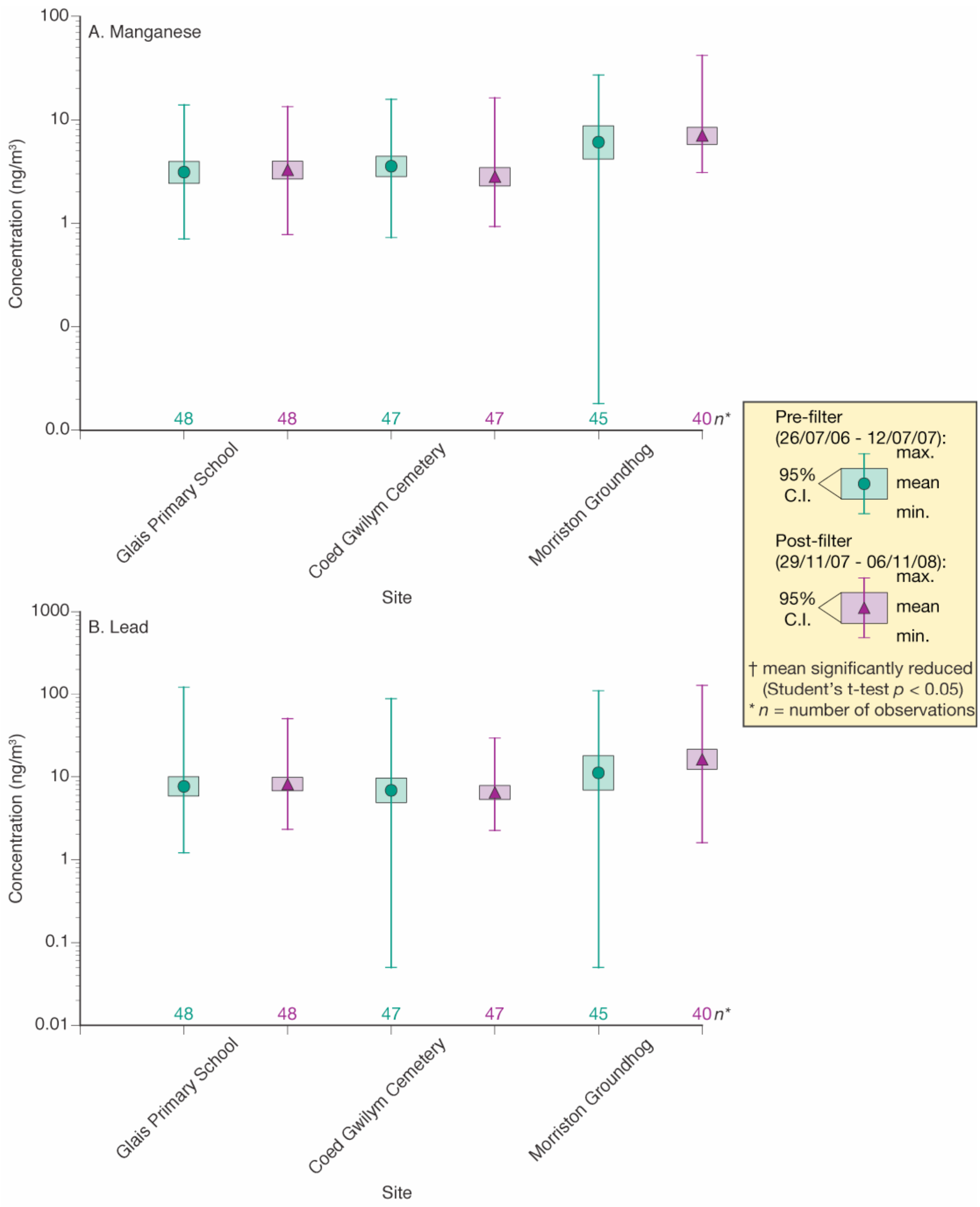

Figure 3.4 Geometric mean and associated 95% confidence interval (C.I.) and range of weekly PM_{10} manganese and lead concentrations (ng/m³) in air quality samples from three monitoring stations in Swansea before and after installation of emission control plant at the Vale Inco refinery

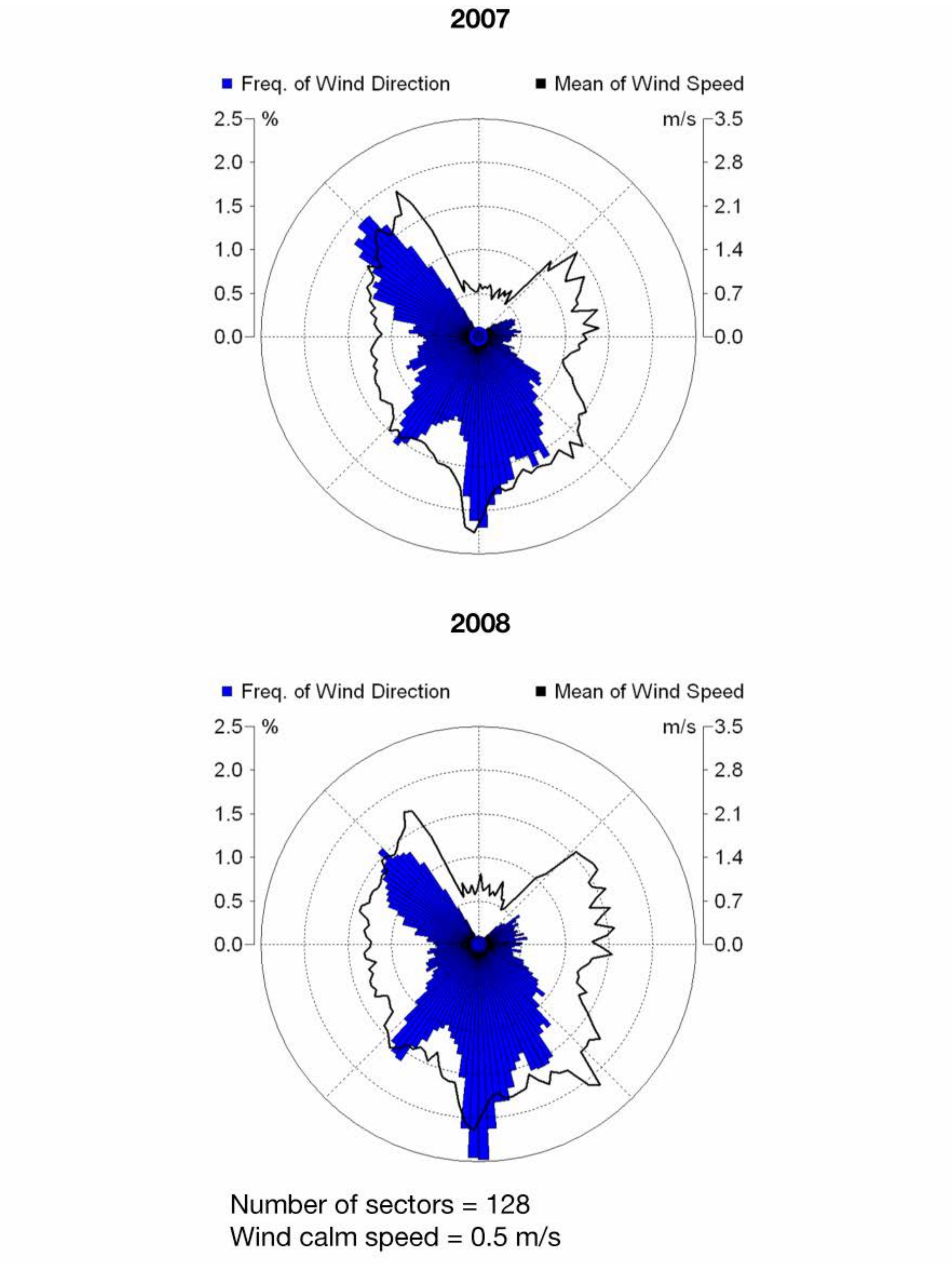

Figure 3.5 Annual Breuer plots of hourly wind speed (m/s) and direction at the Morriston Groundhog site, 2007 and 2008

Appendix 6

GPRS Automatic Traffic Counter Locations within Swansea as of April 2009


GPRS ATC Location
Hafod AQMA
SWANSEA/
ABERTAWE